Food Waste and Municipal Solid Waste as a source of Renewable Energy

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ABSTRACT

Due to the urbanization, municipal waste is increasing day by day. So it is a big challenge nowadays to handle it and generate the alternative energy. Generation of energy from MSW is recognized as a source of renewable energy, which can be used in heating, electricity generation purpose. So the waste management plays an important role for generation of renewable energy. In this article we try to give a review of several process of waste-to-energy (WTE). In this work we discuss several processes such as food waste to energy conversion and municipal waste to energy conversion. Food waste to energy conversion is also divided to anaerobic digestion, ethanol fermentation, biodiesel. Municipal waste to energy is divided to three groups pyrolysis, gasification, bio refineries. Further we have discussed different process of WTE in India and USA.
Keywords: Renewable Energy; Municipal Waste; Waste-to Energy; Food Waste; Municipal Waste.

I. INTRODUCTION

In the last few decades, the usability of renewable energy has increased exponentially. Renewable energy is a kind of energy that specifically received from natural sources like – solar energy, wind etc. and it is replenished every time. This is one of the most popular energy sources to regenerate electricity, heating power. From 2010 to now, 42% more energy sources comes from renewable energy in USA and also globally, the transportation, power, & heating being moderated by 11.2% of renewable energy. Geothermal, biomass, biofuels, wind, solar is popular resources for this energy [1]. Bio Diesel, Bio Gas , Bio Ethanol etc. has more essential benefits when compared to conventional Gas, diesel because , it's produced from renewable energy. But, Solid Waste is one of the remarkable resources for renewable energy in the present time. There are different kinds of wastes – medical waste, food waste, municipal waste, nuclear waste etc. Solid waste is a most remarkable resource for renewable energy.

There are efficient techniques for conversion of energy from Solid waste; especially from organic waste, Municipal waste. There are different thermal treatments like – pyrolysis, gasification for conversion of renewable energy from MSW. Basically, pyrolysis transforms food waste in an anaerobic environment, bio oil. Also, in Gasification by partial oxidation renewable energy is produced from Solid waste. From, renewable energy ; different organic products are formed. Even, there are Ethanol fermentation & Anaerobic digestion is effective way to extraction renewable energy from organic wastes. Anaerobic Digestion specially uses microorganism for production of high percentage of energy. This is one of the most remarkable techniques worldwide. Bio Ethanol is one of the products that replace natural gas that, reduced the dependencies of fossil fuel [2]. For, sustainable progress of world, Waste-to-energy routes (WTERs) mostly channelize these conversion of energy form Agriculture waste, domestic wastes etc. [3].

Waste-to-energy (WTE) incineration is one of the remarkable processes for conversion of energy from municipal waste. There are mostly two futuristic approach of WTE method is WTE incineration & Land Fill Gas(LFG).These are one of the potential promising technology, that extract renewable energy from both bio-degradable & non-bio degradable matters[4]. There is a proper hierarchical process to generate energy from the disposed wastes. This energy is being uses to produce electricity & heating. WTE incineration facility mainly present in China [5].

Also, there are different kinds of techniques to regenerate energy from organic waste ; mainly food waste. Now, the current technologies are, Biological Technology – Anaerobic digestion & Ethanol fermentation and Thermochemical technology – incineration, pyrolysis etc. [6] Also, there are different types of procedure to convert energy from organic waste, nuclear waste, animal waste etc. Presently, USA, China, India, Russia, Pakistan leading the growth of Waste management worldwide. Therefore, for sustainable development in future; researchers constantly show their dependencies on Renewable Energy Technologies (RET).

II. PROS AND CONS OF RENEWABLE ENERGY FROM WASTE MANAGEMENT

PROS	CONS
• Biomass is one of the remarkable Waste-to-energy products. ENERGY from biomass currently contributes 10–12% of the total worldwide energy. In the rich countries usage of bio fuel is very rare in cooking but bio fuel has a significant use for warming up the regions with access to forest [7].	• Even though it may pay a huge amount to the contributors, the WTE process needs a lot of money, time and land to set up an industry and run. As the amount of waste that is being contributed to the waste product unit increases, so the number of industries that process these resources also increase [14].
• International experience shows that by anaerobic digestion, energy and nutrients could be recovered from human waste. Biogas digester could produce biogas from septage which could be used directly as cooking fuel and indirectly through conversion to electricity. Among the constituents of biogas, methane and hydrogen are the two combustible gaseous components, which are mixed with two gases (Carbon Dioxide and Nitrogen) and water vapour. Apart from livestock waste, human waste is also a valuable resource which could provide energy and fertiliser [8].	• One of the severe disadvantages of WTE is that, it increases CO2 emission when it's burned for energy conversion. Obviously, WTE recovers more metals, fuels but, also it simultaneously damage more recovery materials [15].
• Wet Anaerobic Digestion is an effective Waste-to-Energy (WTE) technology for conversion of renewable energy from low solid waste. After extraction of energy, this digestion technique releases less sludge; that's is effectively beneficial in manufacturing area [9-11].	• There is low investment, low subsidies for Wet Anaerobic Digestion technique by the Government of respective countries [15].
• Dry Anaerobic Digestion is mainly used for high solids. There are different benefits of this WTE technique for higher conversion of energy like – higher removal rate of organic matter, accumulation of Volatile acids is very less etc.[9,12,13]	• Waste-to-Energy (WTE) incineration is very much expensive technology for renewable energy conversion.
• The main advantages of Waste-to-energy(WTE)-T are reduction of 80-90 % volume & mass of waste, regeneration of heat & electricity, recycling of metals from waste, reduction of greenhouse gases [9].	• Thermopile Dry Anaerobic Digestion WTE has mostly the accumulation of Fatty Acids, Specific growth rate of microorganism is high [12,13]

III. DIFFERENT WASTE MANAGEMENTS TO RENEWABLE ENERGY

FOOD WASTE TO ENERGY CONVERSION

With rapid urbanization, the daily production of food waste is increasing. Food waste is emitted from various sources, including rice, meat, vegetables, fruits, bakeries, dairy products, homes, restaurants, and food industry waste consisting of leftover food and food preparation waste [16]. The various ways by which it can be implemented are given below:

A. ANAEROBIC DIGESTION

Food waste is perfect for anaerobic digestion [17], because of its composition and moisture content. During the anaerobic degradation process, the OM content of FW (or any substrate) is mainly converted to biogas in a chain process involving four consecutive steps [18], they are: 1. Hydrolysis, 2. Acidogenesis, 3. Acetogenesis and 4. Methanogenesis [19]. Anaerobic digestion occurs naturally in the absence of oxygen as bacteria break down organic matter to produce biogas. This process reduces the amount of material and produces biogas, which can be used as a renewable energy source. Anaerobic digestion to produce biogas is done in closed containers called reactors [20].

B. ETHANOL FERMENTATION

Ethanol fermentation is an effective biological process that converts food waste into renewable energy. Various food wastes such as banana peels , pineapple wastes , grape waste, potato peel waste and household food waste [21-28], can be used for bioethanol production. Enzymatic hydrolysis is probably the most common pre-treatment method in producing ethanol from food waste [25].

C. BIODIESEL

Biodiesel, a renewable energy resource is mainly produced from food wastes such as soybean, cottonseed, vegetable and animal fat [29]. It is suggested that about 5-30% of lipids in food waste are an ideal source for biodiesel feed [30]. There are six steps for the biological conversion of food lipids to biodiesel.1) Selection of optimal microbial species, 2) Cultivation conditions, 3) Harvesting, concentration and dehydration of microalgae, 4) Extraction and purification of intracellular lipids, 5) Esterification of lipids for biodiesel production, and 6) Biodiesel production [31].

MUNICIPAL WASTE TO ENERGY CONVERSION

The amount of municipal solid waste generation is expected to be 2.2 billion tons per year worldwide by 2025. However, while developing countries still face problems in collecting, transporting and disposing of waste, developed countries are using new technologies to produce a variety of by-products such as heat, electricity, compost and biofuels [32]. In developed countries, waste is used by resources to produce energy, heat, fuel, and compost, while in developing countries, waste collection, transportation, and disposal are current issues [33,34]. Waste-to-energy technology (WTE-T) is a promising technology for converting waste into usable forms of renewable energy, especially in developing countries. The ways for the conversion are:

A. PYROLYSIS

Pyrolysis transforms food waste, in an anaerobic environment, into bio-oil as the main product along with solid bio-char and syngas. This technique requires pre-treatment of waste [35]. The final biological products of pyrolysis are gaseous, liquid and solid residues which are source of renewable energy resources.

B. GASIFICATION

Gasification processes for renewable energy production from waste have been developed in the last 30 years [36]. This biological process involves partial oxidation, the main product of which is fuel gas. A recent study showed that heat treatment of these wastes is a viable option for WTE conversion that limits greenhouse gas emissions and reduces landfill disposal options [37]. It is a chemical process where trash is heated in a low oxygen environment so that it turns into its constituent molecules. This process has two products: syngas and char which are renewable energy resources.

C. BIOREFINERIES: WASTE-TO-BY-BIOPRODUCTS

A waste refinery integrates the biomass conversion process Municipal Solid Waste with the production of biofuels, electricity, heat, bio-fertilizers and value-added chemical. Bio refineries can convert MSW into liquid and gaseous biofuels. In this facility, the organic fraction can be converted into biogas and the mineral fraction into solid recycled fuel (SRF) to produce syngas [38]. An integrated gasification system with a fuel synthesis facility can convert the synthesis gas into biodiesel, bio-jet fuel, bio methanol or bioethanol [39].

IV. DIFFERENT COUNTRY WASTE MANAGEMENT TO RENEWABLE ENERGY

A. INDIA

India is a developing country therefore it faces problems regarding waste management on daily basis. Waste management is a matter of concern for cities with denser population. The growth in the fields of urbanization, economic growth and industrialization have resultant into increment of waste [40]. The structure of waste management in India is very different from other developed countries. Environmental management, advance productivity, resource rehabilitation, controlled population, and so on can help in managing waste management in India [41]. The solution for this issue can be WTE technologies which are eco-friendly and can efficiently treat wastes [42]. Mechanical or biological treatment of non-recyclable materials can be generated from the process of WTE [43]. Quantity cutting down, pollution control and considerable energy production are the main boon behind the Waste-to-Energy technology. It requires more attention from both the government of India [44]. Mixed wastes may be treated in any way but its impurities will cause air, water and land pollutions. But it has zero useful output that's wrong thermal energy can be converted to energy is the only way to manage mixed wastes [45].

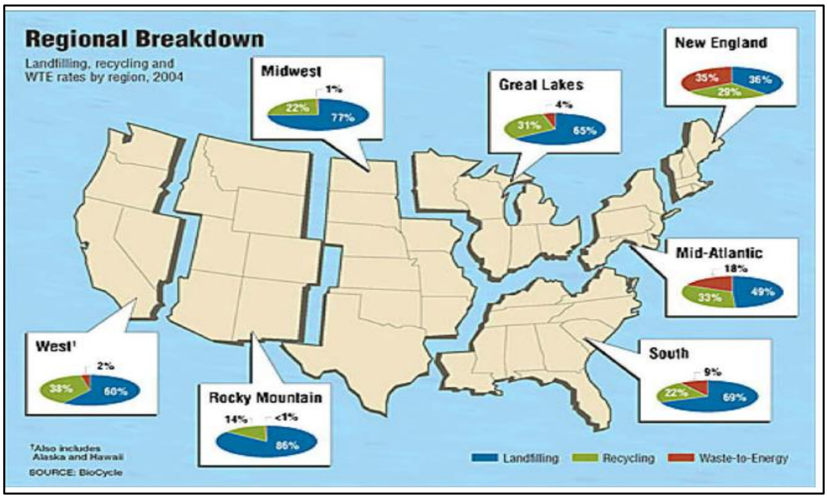

Fig 1: Regional Breakdown of Land filling, recycling & WTE in U. S., 2004 [58]

B. UNITED STATES OF AMERICA (USA)

Till 1800s, American cities did not care on water treatment, waste removal of human, street cleaning and also public works. The environment and the public health is improved later after the severe effects of diseases and frequent epidemics [46, 47]. At the rate of 2.5% per year, the growth of MSW is increased 351.90 million tonnes in 2014 [48-50]. In USA 225.53 million tonnes landfilling or 64% of the MSW , electricity is generated 7.4% and also recycling is done 28.5%. East coast of USA are doing most of the WTE and costal states are doing most of the recycling (Fig. 1, Fig. 2). 25 US states is operating Waste-to-energy power plants. [51-54]. In USA, Anaerobic Digestion is one of the popular techniques for production of renewable energy from food waste. Basically, this technique use microorganism for consumption of waste. From 1970, the interest around this technique increases for higher conversion of renewable energy from waste. Basically, it provides reliable and local Renewable energy from Municipal waste.

So, not only in U.S. worldwide it's a popular technique [55]. In U.S., renewable energy is being produces as much like 10% of Nuclear power. For, modern technology for Renewable energy production is currently in developing stage that mainly uses Sun & Wind energy resource. Also, in renewable energy research sector in U.S., produces bioethanol from Corn Waste, rice straw, crop wastes etc. Bioethanol is popular fuels that are specially produced from renewable energy. Also, most abundant element hydrogen is produced from Renewable energy now-a-days. In USA, higher percentage of Electricity, domestic heat is produces from renewable sources. Now, they have generating the electricity of 2500MW capacity that is fuelled by 26.3 million tons of MSW. Therefore, researchers from U.S. mainly focus on Anaerobic Digestion technique for higher production of energy from waste in future [56, 57].

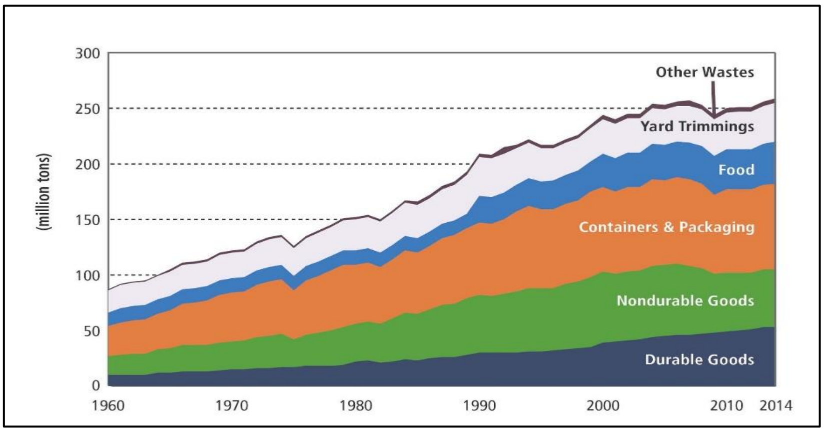

Fig.2: Generation of Solid Waste Categories in U. S. from 1960 to 2014[59]

V. CONCLUSION

Waste management is one of the most efficient techniques for conversion of Renewable energy from Solid Waste. Now-a-days, solid waste is the most recyclable waste to produce heating power, electricity etc. As, most of the solid waste comes from the Municipal & Industrial waste; so, waste management is mainly required for MSW & ISW. Food waste, Organic waste , animal waste, medical waste are the main supplies for generation of power. For the present scenario; Incineration, Ethanol fermentation, Pyrolysis etc. is the most effective ways. Also, waste management is very much requires for reduction of GFG (Green House Gases) – CH4, N_2O. Recycling apps, solar powered track compactors, AI Recycling robots, IOT based smart dustbin is the popular revolutionizing techniques to control waste management. Therefore, the affective of waste management continues to be an intriguing arena of research and study to empower the recycling methods in future for better conversion of energy.

VI. FUTURE SCOPE

The world is now interested in Waste-to-Energy, it is one of the possible best way to use waste as an energy. If this plan of WtE (Waste-to-Energy) works, electricity will be reached to every corner of the globe. In the current scenario where one out of ten people has no access of electricity this can be resultant as a boon. It is believed by 2030 the target will be achieved [60]. Other than that Biofuel which is derived from food waste can also be considered as a help. We can define Biofuel as energy (heat, electrical or work) that can be used for cooking purposes, illumination of lights, and many more. The major benefit of Biofuel is, it can replace the other conventional energy in future [61].

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