FOOD WASTE AND MUNICIPAL SOLID WASTE AS A SOURCE OF RENEWABLE ENERGY

Abstract

Due to urbanization, municipal waste is increasing day by day. So it is a big challenge nowadays to handle it and generate alternative energy. Generation of the energy from MSW is recognized as a source of renewable energy, which can be used in heating, electricity generation purposes. So waste management plays an important role in the generation of renewable energy. In this article we try to give a review of several processes 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 into anaerobic digestion, ethanol fermentation, and biodiesel. Municipal waste to energy is divided into three groups such as pyrolysis, gasification, bio refineries. Further we have discussed different processes of WTE in India and USA.

Keywords: Renewable Energy; Municipal Waste; Waste-to Energy; Food Waste.

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I. INTRODUCTION

In the last few decades, usability of renewable energy has increased exponentially. Renewable energy is a kind of energy that is 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. Nowadays in the USA 42% more energy comes from renewable energy. The transportation, power and heating being moderated by 11.2% of renewable energy. Geothermal, biomass, biofuels, wind, solar are popular resources for this energy [1]. BioDiesel, Bio Gas , Bio Ethanol, etc. have 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 wastes 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. Ethanol fermentation & Anaerobic digestion is an effective way to extract renewable energy from organic wastes. Anaerobic Digestion specially uses microorganisms for production of a 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 reduces the dependencies of fossil fuel [2]. For sustainable progress of the world, Waste-to-energy routes (WTERs) mostly channelize these conversions of energy from 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 approaches of WTE method: WTE incineration & Landfill Gas (LFG).These are one of the potential promising technologies that extract renewable energy from both biodegradable & non-bio degradable matters[4]. There is a proper hierarchical process to generate energy from the disposed wastes. This energy is being used to produce electricity & heating. WTE incineration facilities are 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 Thermo chemical technology – incineration, pyrolysis, etc. [6] Also, there are different types of procedures to convert energy from organic waste, nuclear waste, animal waste etc. Presently, the USA, China, India, Russia, Pakistan lead the growth of Waste management worldwide. Therefore, for sustainable development in the future; researchers constantly show their interest in Renewable Energy Technologies (RET).

II. THE PROS AND CONS OF RENEWABLE ENERGY FROM WASTE MANAGEMENT

PROS	CONS
● Biomass is a remarkable Waste-to-energy product which contributes 10-12% energy in the whole world. In rich countries biofuel, is used for warming up the regions with access to forest [7].	● In developing countries Waste to energy technology is a challenging technology. It is very difficult to convert waste to energy and in the developed country WTE-T also produces heat which causes global warming and climate change [9,14].
● Human waste is a major source of energy and nutrients. Biogas can be produced from human waste which can be used for cooking purposes, and can be converted into electricity also. Human waste can also be used as a fertilizer [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 it simultaneously damages more recovery materials [15].
● Wet Anaerobic Digestion is a significant technology to convert low solid waste to renewable energy. After extraction of energy, this digestion technique releases less sludge; that is effectively beneficial in the manufacturing area [9-11].	● There is low investment, low subsidies for Wet Anaerobic Digestion technique by the Government of the 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 expensive technology for renewable energy conversion [14].
● 80-90% volume & mass of waste are reduced in waste to energy technology along with regeneration of heat & electricity and recycling of metals from waste reduced greenhouse gases [9].	● Fatty Acids are accumulated in Thermopile Dry Anaerobic Digestion and the specific growth rate of microorganisms is high [12, 13].

III. DIFFERENT WASTE MANAGEMENTS TO RENEWABLE ENERGY

1. **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:

- **Anaerobic digestion:** Due to the composition and moisture content, food waste is perfect for anaerobic digestion [17]. In four consecutive steps, the organic matter (OM) of food waste (FW) is converted to biogas in the anaerobic degradation process [18]. Hydrolysis, Acidogenesis, Acetogenesis and Methanogenesis are the four consecutive processes [19]. The organic matter of FW is broken down in the anaerobic digestion process with the help of bacteria and in the absence of oxygen. As a result, biogas is produced which is a renewable energy. So FW can be considered as a source of renewable energy [20].

- **Ethanol fermentation:** Ethanol fermentation is an effective biological process that converts food waste into renewable energy. Various wastes such as banana peels , pineapple wastes , grape waste, potato peel, etc. can be used for bioethanol production [21-28]. The most common pre-treatment method to produce ethanol from FW is enzymatic hydrolysis [25].

- **Biodiesel:** Biodiesel, a renewable energy resource, is mainly produced from food wastes such as soybean, cottonseed, vegetable and animal fat [29]. Biodiesel can be produced from the lipids of food waste [30, 31].

2. **Municipal waste to energy conversion:** It is expected that by 2025, 2.2 billion tons of municipal solid waste will be generated per year. The developing countries still face problems in collecting, transporting and disposing of waste [33, 34], whereas developed countries are using new technologies to produce heat, electricity, compost and biofuels [32]. Nowadays 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:

   - **Pyrolysis:** In an anaerobic environment, Pyrolysis transforms food waste into bio-oil along with solid biochar and synthesis gas [35]. The final biological products of pyrolysis are gasses, liquid and solid residues which are sources of renewable energy resources.

   - **Gasification:** Gasification processes have been developed in the last 30 years to produce renewable energy from waste [36]. This biological process involves partial oxidation and fuel is the main product of this process. Heat treatment of the wastes is a feasible 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: synthesis gas and char which are renewable energy resources.

   - **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 chemicals. Municipal Solid Wastes are converted into liquid and gaseous biofuels. In this process organic part of MSW is

converted to biogas, mineral part is converted into solid recycled fuel (SRF) [38]. The synthesis gas is converted to biodiesel in an integrated gasification system [39].

IV. DIFFERENT COUNTRY WASTE MANAGEMENT TO RENEWABLE ENERGY

1. **India:** India is a developing country therefore it faces problems regarding waste management on a daily basis. Waste management is a matter of concern today for cities with denser populations. The growth in the fields of urbanization, economic growth and industrialization have resulted in an increase of waste [40]. The structure of waste management in India is very different from other developed countries. Environmental management, advanced 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 boons 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 pollution. 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].

2. **United States of America (USA):** Until the 1800s, American cities did not care about water treatment, waste removal of humans, street cleaning and also public works. Environmental and 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 increased 351.90 million tonnes in 2014 [48-50]. In the USA, 225.53 million tonnes are landfilled of the MSW, electricity is generated 7.4% and also recycling is done 28.5%. The East coast of the USA is doing most of the WTE and coastal states are doing most of the recycling (Fig. 1, Fig. 2). 25 US states are operating Waste-to-energy power plants. [51-54]. In the USA, Anaerobic Digestion is one of the most popular techniques for production of renewable energy from food waste. Basically, this technique uses microorganisms for consumption of waste. From 1970, the interest around this technique increased for higher conversion of renewable energy from waste. Basically, it provides reliable and local Renewable energy from Municipal waste.

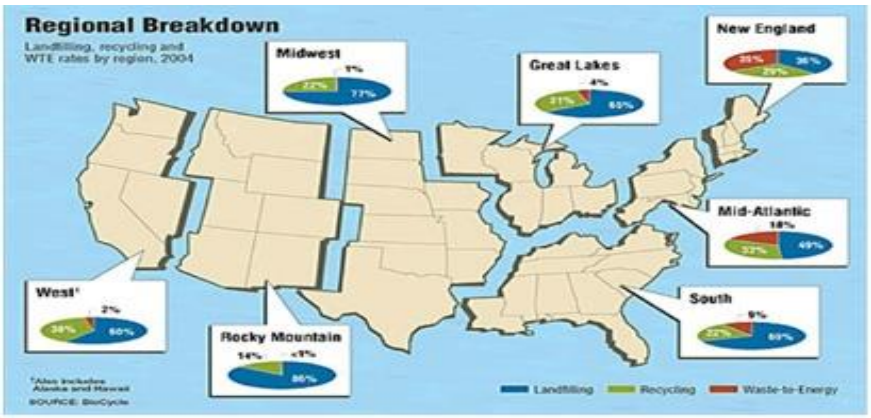

Figure 1: Regional Breakdown of Land filling, recycling & WTE in U. S., 2004 [58]

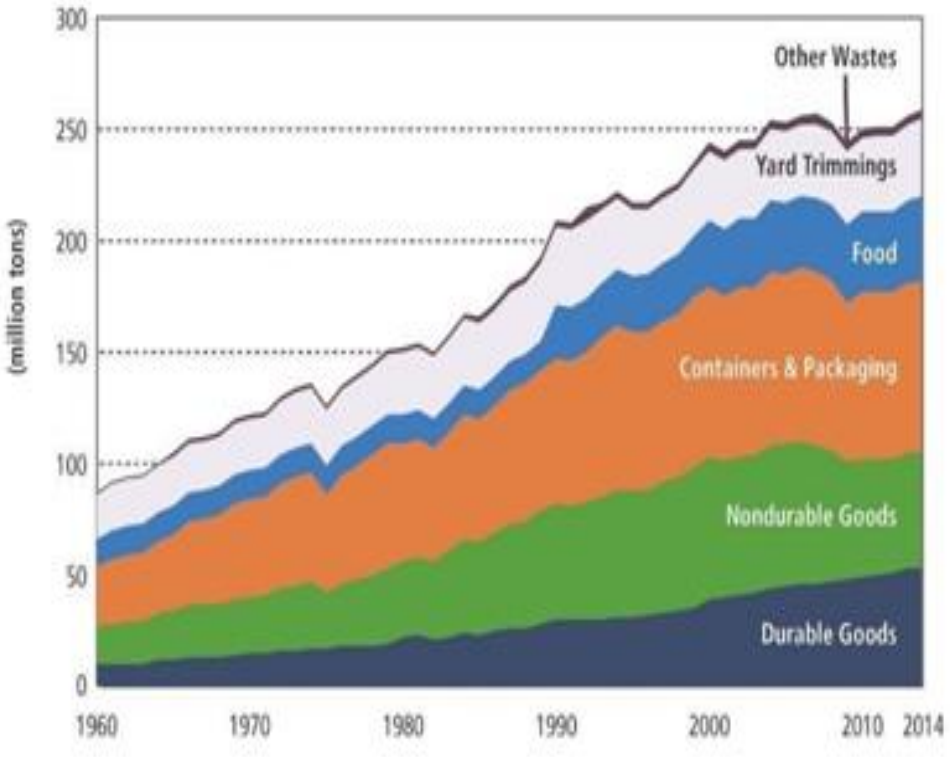

Figure 2: The Generation of Solid Waste Categories in the U. S. from 1960 to 2014[59]

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

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 sources for the generation of power. For the present scenario; Incineration, Ethanol fermentation, Pyrolysis etc. are the most effective ways. Also, waste management is very much required for the reduction of GFG (GreenHouse Gases) such as CH4, N_2O. Recycling apps, solar powered track compactors, AI Recycling robots, IOT based smart dustbin are popular revolutionizing techniques to control waste management. Therefore, the effectiveness of waste management

continues to be an intriguing arena of research and study to empower the recycling methods in the future for better conversion of energy.

VI. FUTURE SCOPE

The world is now interested in Waste-to-Energy, it is one of the best possible ways to use waste as 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 to electricity, this can be resultant as a boon. It is believed that the target will be achieved by 2030 [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 other conventional energy in future [61].

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