

# WASTE TO ENERGY PROSPECT TOWARDS SUSTAINABILITY: A REVIEW

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**Abstract-** This paper is an attempt made to calculate the estimate quantity of solid waste that can be generated in India as well as other countries of the world. This data estimates the generation potential of energy through combustion of solid waste. Huge amount of waste production shows a big problem in many nations. Disposals of waste is done in lands and this gives a rise to an urgent issue related to resource managing consumers. Recycling, safe disposal of waste and using of material with low calorific value comes in waste management to produce energy. This concept of waste to energy is economically good and have environmental benefits and introduce a renewable energy resource as well. Environmental sustainability can be achieved by using waste as renewable resource and shortage in energy sources can be compensated. The drastic change in energy consumption can be seen over few years which is increasing day by day, 261 billion cubic of gas and 85.4 million barrels of oil is being used per day. By the year 2009 the consumption of gas reached to 335 billion cubic feet and same for oil it increased up to 91.2 million barrels, 28% increase in gas consumption and 7% increase in oil consumption was noted in year 2013. In 2015 the oil consumption reached to 95 million barrels, by this data we have an idea that utilization of waste for producing energy to satisfy the increasing demand is very much needed. The main objective of this study is to compare the efforts done by different countries to overcome this huge waste problem as well as to overcome the second huge demand of energy. As we can compare the efforts made by Egypt for the aim to produce energy by managing of waste and efforts done by Indian city in A.P. named as ELURU. Adoption of the best way to solve these huge problems are compulsory as to secure the future of our country.

**Keywords:** Solid waste, waste production, water waste, recycling, Biofuel and renewable sources.

## 1. INTRODUCTION

### 1.1 Problems Caused by Waste

Every year all countries in world suffers from a huge amount of waste produced. This waste causes serious impacts on environment and surrounding landscapes [1]. The waste is categorized in different types like industrial waste, domestic waste, agricultural waste, solid municipal waste etc. on the basis of their structure they can be further classified on sub-categories like solid, semi-solid (organic), plastic and other hazardous waste. Roots, leaves etc. are agricultural waste. Many health, hygiene, air quality and pollution impacts are caused due to different types of wastes dumped at one place without any planning [2].

### 1.2 Overviews on Waste Management

Safe disposal transportation, segregation and processing of solid waste is the beginning of waste management. This is done using a plan of waste to energy processing. After the segregation of the organic from MSW processing is done, which may be composted, recyclable material like glass and plastic must be recycled, and those which can't be recycled but have high calorific value must be directed to profitable products as refused derived fuel RDF which are used as alternating fuel by industries [3]. Production of fertilizers and animal feeds can be generated by using agricultural waste [4]. Used oil and semi-solids can be treated physically and chemically after which they can be reused, or being used by biodiesel production as renewable energy source.

Hazardous and non-recyclable are generally landfilled and incinerated. Waste such as: radioactive, medical, leather tanning etc. though medical waste is separated and useless id disposed [5].

### 1.3 Need of New Resources and Energy Related Problems

As the population is increasing yearly and there is rapid rise in living standard the demand of energy has been increased simultaneously the demand of new energy resource have also been increased. As we can see the consumption of natural gas and oil has shown increment from 261 billion cubic feet to 335 billion cubic feet and 91.2 million barrels by 2009. Through 2013 one million barrels. Increase in natural gas and oil respectively around 28 per cent and 7 percent [6]. Further 4.2% oil consumption increment in consumption has been noticed by the end of 2015 as compared to 2013. New energy resources should be introduced as we can see from the above estimate and assume, the shortage that will be occurring in fossil fuel over the upcoming decades.

## 2. WASTE TO ENERGY CONCEPT FOR SUSTAINABLE ENERGY PRODUCTION

Using different waste for energy production is a simple definition of waste to energy concept instead of using conventional resources. Waste material having low calorific value after sorting, shredding or thermochemical processing transesterification and pyrolysis can be made in use directly. Products made due to the elimination of non-combustible material by thermo-chemical processing the products generated have high calorific value but they must watch the international standards. Energy produced by waste can play a vital role in providing sustainable energy as waste is something which is generated by most of the sectors on daily basis. Different types of methods are discussed for conversion of a kind of waste to a particular kind of energy.

### 3. EXAMPLES OF WTE METHODS

#### 3.1 Direct Methods

Cement plants use RDF for energy production which is the best example of direct WTE process. MSW must be further processed to be used for energy production as RDF remains in the parts of non-recyclable. RDF must be done with the processes like shredding, screening and drying; energy per unit of mass in RDF when compared to natural gas is just one-third which makes it as valuable alternate for conventional resource [7]. materials like used tires and activated sludge can be used directly for the production of energy but by using rubber type of material it produces gases like Sox and NO<sub>x</sub> after combustion and inactivated sludge due to the presence of heavy metal it can be harmful.

Pulp industries and industries producing animal feed have a huge demand of agricultural and farm waste [8], but the optimistic between different uses of waste material can resolve the problem.

#### 3.2 Indirect Methods

##### 3.2.1 Transesterification of Waste Oil (WO)

Biodiesel can be formed from WO through transesterification when WO is treated with alcohol to produce fatty acids alkyl ester with the help of catalyst, such as biodiesel or glycerol which comes in the category of valuable products. Usually homo-generous base catalyst transesterification in method is used in which catalyst with alkali base such as potassium hydroxide KOH, is used [9]. If more than 2% of free fatty acid content weight is found in waste oil then alcohol in high excess is used to perform esterification step in the presence of mineral acid as a catalyst so as to decrease the free fatty acid content to perform transesterification step. After all the reactions takes place, separation of different phase is done and further to achieve ASTM and EN standard up gradation is done.

##### 3.2.2 Pyrolysis and Gasification of Waste Material

At high temperature pyrolysis in an endothermic reaction takes place in an inert atmosphere in which cutting of trees or material having higher calorific value and cellulose content are transformed into high valuable products, for example burning gases, bio-oil, char-coal etc. [10]. Different products are produced according to the reaction temperature, residence time, heating rate. Now if we see gasification takes place in the presence of air and on higher temperature then pyrolysis. After the syngas, carbon monoxide and water vapour are the final products after partial oxidation occurs, then higher hydrocarbons are synthesized with the help of this gas mixture through the well-known Fischer-Tropsch process [11].

##### 3.2.3 Biofuel Production using Biological Processes

By anaerobic fermentation and using micro-organisms under controlled condition like temperature and pH value etc. digestion is done to obtain biogas [12]. CO<sub>2</sub> Methane are main components of bio gas that results from anaerobic fermentation of organic material by bacteria. waste like agricultural waste, animal waste, food waste, industrial waste and water waste are the main sources used for the production of bio-gas.

Bio-ethanol can be produced by using cellulosic waste, which can replace fossil gasoline, through fermentation [13]. Energy can be produced from the residue left. Solid particles, water content associated sour gas must be removed before using the gasoline produced for vehicle engines [14]. Before the fermentation process the waste is pre-treated and conditioned, so that the waste gets ready for the conversion to the desired bio-ethanol product. Physical and chemical processes like reduction, screening are steps used for pre-treatment and conditioning.

### 4. WTE CONCEPTS OPTED BY DIFFERENT COUNTRIES

WTE concept gives two benefits as it solves the problem of shortage of fossil fuels and the problem caused by untreated waste which gives harmful impact on the environment. WTE is increased by 50% and will reach up to 37.6 billion by 2020 which was 25.3 billion in 2013 [15].

#### 4.1 WTE opted in EGYPT

Low priority is given to the concept of waste to energy through Egyptian energy policy and no estimate of the waste share to the total energy sources potential. In Egypt there is a huge production of waste through agriculture, sludge from municipal treatment plants and organic material like house hold garbage. 20.5 million tons per year is the total production of MWS by Egyptians. Types of organic materials and quantities generated in EGYPT is shown in Table 4.1 while on the other hand Table 4.2. Show the composition of Egyptian MWS. Waste like these can be considered as carbon based material and types of energy resources like char-coal; bio-oil, bio-ethanol, etc.

**Table -4.1 Types of Wastes and Amount [28]**

Waste	Amount in million tons/ year
Sewage plants	4.3 dry sludge
Agricultural organic waste	25 dry material
Municipal solid waste (MSW)	6.6 Of dry and 11 of wet O.W.

**4.4.1. Biogas Production**

Except the global Al-Asfar plant, all the small scale plants with digester volume of 5-50-meter cube are only used for biogas activities. 1 million tons of energy per day is noticed as the total energy potential of centralized biogas plants.

**Table-4.2 Composition of MSW by Egyptians [29]**

Components	Paper	textile	leather	Plastic	metal	glass	Combustibles	others
<b>Percentage%</b>	5.8	3.6	0.9	3.9	1.9	2.2	41.7	40.5

An estimate says Egypt is capable of using biogas to produce 40% of its present electricity consumption and can save a substantial amount of chemical fertilizer [16]. 4% of today electricity consumption can be covered by biogas application. The sites having more potential for the production of biogas are food producing industries, city and farms, some old and villages communities, plants treating sewage and organization of organic municipal waste etc.

**4.1.2. RDF Production**

Companies like SCGC an Egyptian cement producer company, are producing waste derived fuel from pre-sorted waste by introducing waste processing facility at its Kattameya cement plant. A 5 million euros worth project, in which companies are using refuse-derived fuel to enhance the amount of energy generated [17]. 20 percent of plants energy requirement can be fulfilled by using estimate 35000 tons of waste.

**Table-4.3 Total India’s MSW**

Component	Paper	Organic	Plastic	Metals	Glass	others
<b>Percentage%</b>	<b>8</b>	<b>54</b>	<b>13</b>	<b>14</b>	<b>6</b>	<b>5</b>

Table 4.3 represents the average composition of MSW production in India.

**4.1.3. Bio-diesel Production**

Bio-diesel is produced by transesterification in some plants present in Egypt WO. The first plant named as tagaddod having relatively small production capacity exported to European countries [18].

**4.1.4 WOE in India**

Some papers have discussed the potential of using these types of waste. A power of 28 MW can be expected from swage water and liquid municipal waste while it can be increased up to 1457 MW by using solid wastes, so that the total potential of power produced from the waste is about 1700 MW [19]. 1300 mw of power can be recovered by using industrial waste, this data is given by ministry of new and renewable energy, which is expected to reach up to 2000 by 2017. MNRE in 2011 gave a report in India, shown in table 4.4. Projects having a capacity of 135 MW were so far installed in some industries in paper, pulp mills, food etc. A plant producing 12.6 MW was installed in Nalgonda in Telangana beside two plants producing same power of 11mw were planted in jodhpur and Hyderabad in 2015 where as a plant of 3mw capacity was planted in Chennai and were commissioned in 2016 [20].

**Table–4.4 WTE installed in India by 2011**

Grid-interactive power generated		
Area	Capacity MW	Contributed %
Rural	20.22	27.6
Industries	53.49	72.62
<b>Total</b>	<b>73.88</b>	
Off-grid power generated		
Area	Capacity MW	Contributed %

<b>Rural</b>	<b>3.50</b>	<b>4.6</b>
<b>Industries</b>	<b>72.30</b>	<b>95.4</b>
<b>Total</b>	<b>75.8</b>	

Bio-methanation, pyrolysis and combustion are the most allied technologies used in India for converting energy from waste. Table 4.5 represents the specific WTE needs of every type of waste.

**Table -4.5 WTE Processes Ccorresponding to Waste Types**

<b>Waste types</b>	<b>Process included</b>
Solid type	Pyrolysis and combustion
Liquid type	Bio-methanation
Semi-solids	Bio-methanation, pyrolysis and combustion

**4.1.5 WTE Production in United States of America**

Around 378 million tons of power from WTE was produced in USA per year from which 28% was utilized by we plant composted around 25% and rest was given to the sanitary land -ills. Average MSW composition produced in USA is shown in table 4.6.

The general WTE process used is the moving grate technology and a new technology named as two-stage gasification process [21]. The new process consists of two processes, firstly the gasification of waste is done to produce syngas and then the produced syngas is combusted to generate energy. This process offers a better way to control the emission of harmful gases like nitrogen oxides.

**Table-4.6 Average MWS composition in USA**

<b>Elements</b>	paper	Textile LEATHER and Rubber	Wood -en mate -erial	plastic	metal	Glass Mate -erial	Yard Trim-mings	Food	Others
<b>Percentage%</b>	27	9	6.2	12.8	9.1	4.5	13.5	14.6	<b>3.3</b>

**4.1.6 WTE Methods used in Germany**

48 million tons of MSW is produced by Germany every year. As Germany is one of the high income countries, the average composition MSW generated in German is represented in table 4.7 [49]. Around 44.5% of produced MSW are recycled, 37.8% is incinerated and around 17.3% waste is composted while the remaining 0.4% is landfilled.

**Table-4.7 Average MSW Production in German**

<b>Elements</b>	paper	organic	plastic	metals	glass	others
<b>Percentage%</b>	32	27	12	7	7	19

Some technologies used in Germany for bio-gas production are mono-incineration, co-incineration, RDF production, and bio-methanation. If we see around in Germany there are 900 fermentations, 62 mechanical-biological and 67 waste incineration plants and one pyrolysis plant and around 36 RDF plants.

**4.1.7 WTE methods used in China**

154 million tons of MSW production is done by china per year [22]. Table 4.8 represents the average composition of MSW produced by three Chinese cities.

**Table-4.8 MSW Composition in China**

<b>Place</b>	<b>Eatables</b>	<b>Paper</b>	<b>Polymer</b>	<b>Textile</b>	<b>Wooden</b>	<b>Glass</b>	<b>Metal</b>	<b>others</b>
Beijing	64.50	6.8	8.16	1.27	0.07	2.55	0.37	17.80
Shanghai	62.90	8.60	10.98	4.37	0.98	2.19	0.01	10.8
Hangzhou	67.15	7.87	9.68	1.06	3.77	0.99	0.38	9.69
<b>Average</b>	64.66	7.88	9.59	2.75	1.69	1.78	0.28	12.70

23 million tons of WTE is used to produce energy. The waste is processed in 100 WTE plants. Great combustion of as-received MWS and circulating fluidized bed is the most used technology in these plants [23].

## CONCLUSION

From the above study we can conclude that planning for municipal solid waste management must be done by the decision makers as to account waste of energy alternatives according to economic, technical and environmental aspects etc. The purpose of this research paper is to introduce multi-objective WTE recovery system to achieve a desired output. This review depicts that to get the energy from the waste there are better ways available for the municipal solid waste management. More than fifty thousand Metric tons of waste is still dumped in India as per the data collected by Housing and Urban Ministry. Time to time government releases funds for this solid waste management which can be utilized in effective manner and as output can provide energy in abundance for mankind.

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