

WASTE TO ENERGY (WTE) TO SAVE THE GREEN PLANET

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Abstract

Global warming, the increase in the temperature of the earth's near-surface air, is the greatest challenge the world is confronting with and world grave concern for earth's all living creations. Every nation, including large & small, wealthy & poor, developed & developing, is under the impact of the ravage. Since 2009 global average surface temperature has been increasing by 0.6°C every year and the acceleration is even being faster gradually. It has been indicated that by the end of 21st century world's average surface temperature will increase by 2.4-6.4°C, might exceed the earth's ability to adapt. The potential consequences of global warming will be devastating, such as rising sea level, increased occurrence of severe weather events, changing pattern of diseases, more frequent of wildfire & drought, severe food & water shortage and lose of tropical forests and many species. The effect of global warming is already in earth and having significant & costly consequences on our climate, our health and our environment. Acceleration of earth atmosphere's greenhouse gas (GHG) which includes CH₄, CO₂, CO, N₂O emitted through fossil fuel combustion and municipal solid waste (MSW) landfill are responsible for this. On the other hand, there are huge shortage of energy in developing countries like Bangladesh, Nepal, Pakistan where energy shortage is hindering the financial growth, investment opportunities and employment creation and increasing social depression, poverty & illiteracy rate. In addition, 1.3 billion of the world population that is about 20% of the total population still out of the electricity supply facilities and an overwhelming of 2.5 billion people that is around 43% of the total population still rely on biomass as their every day's cooking fuel, causing household air pollution, many diseases, massive escalation of deforestation & global climate changes.

Changing pattern of energy, for example, carbon neutral or carbon negative, easy accessible & cheap sources of energy only can confront the challenges the world is facing today with global warming, global climate changes and

rapidly growing energy demand. Waste to energy (WTE) as a green & cheap source of energy could be a viable alternative.

Keywords: Municipal solid waste, Fossil fuel, Greenhouse gases, Environment pollutions, Global warming, Alternative sources of energy, Waste to energy

Introduction

Alternative sources of energy is one of the most current & widely discussed global issues that is due to rapidly growing energy demand, massive consumption of conventional energy and its devastative impacts on our eco-system, our economy & our environment.

Global average surface temperature is increasing anxiously. This temperature rising event is cause of concern for earth's all living creations. It will affect hydrology & biology of earth-everything including economy, eco-system and substances. Earth's atmospheric GHG acceleration through human activities is mainly accountable for such as unusual global warming.

Global population growth, massive consumption of fossil fuel and mounting of MSW stockpile are closely linked with it-

Global population is growing shortly. World population will multiply to 9 billion by 2050 from current 7.093 billion in 2013 (World Bank 2013). With the rapidly growing population a relatively silent problem is soaring up daily that is skyrocketing enhancement of MSW landfill. Global generation of MSW will accelerates from 1.3 billion tons in 2013 to 2.2 billion tons in 2050 that is when the more dominant part of MSW will be organic fractions will accelerate the MSW related GHG emission more frequent than what is today, will creates new problems with global warming, global climate changes and ecological casualty that have to be faced (World Bank 2013).

This is concern with the other challenge that with the industrialization, urbanization and population growth in short order, world energy demand & consumption are increasing sharply. World energy consumption is estimated to increase from current 560 quadrillion Btu (British thermal unit) in 2013 (524 in 2010) to 630 Btu in 2020 and 820 quadrillion Btu in 2040, will play an extreme role of uncongenial acceleration of GHG in earth's atmosphere (IEO Reference case 2013).

The challenges with conventional energy & MSW are becoming more challenging, the challenges the current world are experiencing with global warming & global climate changes.

In this very condition when earth's atmospheric GHG emitted by combustion of fossil fuel & MSW landfill is accountable for global warming, global climate changes & ecological catastrophe, carbon negative 'Waste to Energy (WTE)' technology could be a viable component to confront the

upcoming challenges. The technology will play an intensive role to accomplish two interrelated challenges the world is currently confronted with: incremental energy demand and rapidly increasing global temperature (CCOB-2010).

Rapidly Acceleration of municipal solid waste (MSW) & Global Challenges:

Countries around the world today are confronting with overwhelming ecological, economic & social problems of processing and containment of MSW.

Due to globalization & global economic affairs people are moving from rural & remote areas to urban areas either for better opportunities, better employment & incomes, better living facilities or education. People who are once shifting in cities are not very often leaving, accelerating the urban population. Today 3.78 billion people that are 54% of total world population live in urban areas & the figure is expected to increase to about 6 billion that is 66% of the total population (9 billion) by 2050, more than the total world population lived in 2000 (World Bank 2012).

Since the world hurtles toward urban future, the volume of MSW, one of the most significant byproducts of urbanization, is soaring up ever quicker than the proportion of urbanization. A study conducted by the World Bank's Urban Development department 2013, revealed that just a decade before 0.68 billion tons of MSW were generated annually is an average of 0.64kg/capita/day by 2.9 billion urban populations. Today the volume has been increased to 1.3 billion tones by about 3 billion urban populations in 2013 and by 2025 the generation of MSW is projected to accelerate to 2.2 billion tons annually by about 4.3 billion urban populations. Report simply indicated that by 2025 the more dominate part of MSW will be the organic fractions as the demand for agricultural goods will increase by 70% and meat will double which will accelerate global GHG emission more frequent than what is today, will create new problems that have to be faced.

The extreme generation of MSW will multiply the expenditure of MSW management, MSW oriented environmental damage and ecological casualty. The report indicated that by 2025 the annual expenditure of MSW management is projected to increase from current \$205 billion in 2013 to \$375 billion. The landfill food waste will accelerate global GHG emission from current 34 million tons to 48 million tons. Diseases carrying vectors such as insects and rodents are proliferated due to uncontrolled waste as they get proper breeding environment and feeding over it. According to Dan Hoorn Weg, the leading urban specialist in the Finance, Economic & Urban Development Department of World Bank, 5% of the total global GHG and 12% of the total global CH₄ are emanated from post-consumer waste and

landfill methane respectively & the landfill shares of global anthropogenic emissions from 8% to 10%.

Report simply spells out that this is due to massive generation of MSW and nonscientific treatment of it, especially in large cities in developing countries where very common practices of MSW treatment are just kicking off on road sides and open dumping areas or uncontrolled burning.

A consumer based life-style which is driving force of much of the global economy, is primarily accountable for excessive generation of MSW. So, reduction of economic activities is the quicker option to slash the generation of MSW, is not an attractive option.

Growing demand of energy & global challenges:

The world today is consuming massive conventional energy and the demand is growing in short order, accelerating earth atmospheric GHG and global surface temperature.

With the rapid growing population, urbanization, industrialization and a projected doubling of the global economy growth, global energy demand & consumption are rising rapidly. Improved living standard; comes through urbanization & rising income, lead to increase household & industrial energy consumption through wider penetration of electronic appliances, modern transportations and other conveniences. According to BP's Energy Outlook 2035, global energy demands continue to grow further beyond 2030 to 2035. The consumption is expected to soar up by 41% in between 2012 and 2035. According to International Energy Outlook (IEO) Reference case 2013, world energy consumption will enhance to 630 quadrillion Btu in 2020 and 820 quadrillion Btu in 2040 from current 560 quadrillion Btu in 2014 (524 in 2010). Per capita energy consumption will increase by 25% by 2040.

The World Energy Outlook (WEO) 2013 projected that by 2050 the world would have to generate enough electricity for an additional 3.3 billion people as 2 billion will be multiplied between 2013 & 2050. The Exxon Mobil's outlook for Energy 2013 project that between 2013 & 2040, global chemical energy demand projected to rise by 55% is an account for 35% of growth in industrial sector. Energy used for power generation is expected to grow by more than 50% by 2040, will continue to be the largest source of energy demand. The largest source of energy consumption will come through the industrial sector which will continue to consume over half of the global energy by 2040. The International Energy Outlook 2013 projected that fossil fuel, including oil, natural gas and coal, will supply 80% of the global energy through 2040.

World total energy consumption, 1999-2040

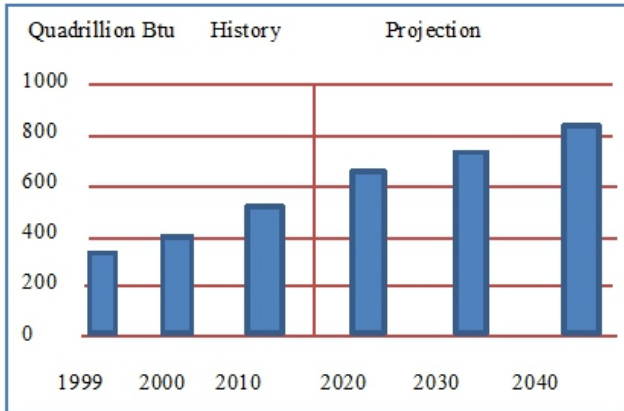


Figure 1: Shows world total energy consumption, 1990-2040 (Source: IEO)

The aftermath of massive consumption of conventional energy would be excessive global warming & global climate changes. Global energy-related CO₂ emission will become worse than expected. According to International Energy outlook (IEO) 2010 reference case, global CO₂ emission from fuel combustion continue to grow from 31.2bmt (billion metric tons) in 2010 to 45.5bmt in 2040, living the world on the track for a long-term average global temperature increase of 3.6°C or more. Scientists of National Oceanic & Atmospheric Administration say that during the 21st century the earth could warm by an additional 7.2°F if we fail to reduce GHG emission from burning fossil fuel. Fatih Birol, the chief economist of the International Energy Agency, said that despite the global agreement to stay below 2°C, the world is on the track that, without action, leads to an increase of 4°C or more by 2050, indicated that such a rise might exceed the world's ability to adapt.

The impact of such an unusual global warming & global climate changes would be extremely devastating for the earth's all living beings. Global warming will affect the hydrology & biology of earth-everything including economy, ecosystem & subsistence. This phenomenon (incremental temperature rising) will be causes of unusual acceleration of ecological catastrophe such as acid precipitation, stratospheric ozone depletion, rising sea levels, increased occurrences of several weather events, more frequent of wildfire & drought, food shortage, changing patterns of diseases, severe water shortage, the loss of tropical forests and many species.

Rising temperature will hamper global food security due to sharp production drop affected by frequent heat waves and more severe drought. A research conducted by U.S Department of agriculture found that by 2050 reduction of crops yielding will accelerate by 10% of 2000 levels, eventually

decreasing global food security. They argue that to plants ground-level O₃ (ozone) performing more damages than all combined air pollution.

Moreover, vulnerability of the aging electricity is increasing seriously to rising consequence of global warming.

Dr. Margaret Chang, the director general of WHO in 2014, states that "This is already evidence that overwhelming climate changes endanger human health". (27-29 Aug. 2014, WHO conference, Geneva, Switzerland, Report: RIA Novesti 27.08.2014)

Sir David King, the chief scientist of Blair, described the threat of global climate changes as greater than global terrorism.

This is evidence that natural disasters were cause of displacing same 22 million people, three times more than from conflicts & wars in 2013, were twice as many people were displaced in 1970s (Report: RT News 17.09.2014).

Energy & Sustainability:

Energy is one of the most crucial components for economic, educational, science & technological development in the modern world. It is an integral part of every sphere of modern life and indispensable for almost all of the economic development ranging from farm irrigation to manufacturing of goods and heavy industrial activities. At the World Summit for Sustainable Development (WSSD) in Johannesburg, South Africa 2002, leaders from around the world emphasis the intensive role of energy on alleviation of poverty and sustainable development. On the contrary, industrial growth is hindered, cost of products & services is intensified and financial growth is limited if energy service is not highly reliable & of sufficient quantity. This is the evidence that China loses 1% of average output for textile & electronic industries to power outage every fiscal year when the figure is around 10 folds higher to 9.7% for their Indian counterpart (World Bank 2002). Moreover, there are huge shortage of energy in developing countries like Bangladesh, Nepal, Pakistan where energy shortage hindering the financial growth, investment opportunities and employment creation and increasing social depression, poverty and illiteracy rate. The letter undermines and limits their capabilities and their opportunities to secure employments aftermath prolonging and confinement of poverty cycle.

Cooking fuel & environmental embezzlement:

This is another factor to be concern that 1.3 billion of the world population that is about 20% of the total population still out of the electricity supply facilities and an overwhelming of 2.5 billion people that is around 43% of the total population still rely on biomass that include fuel woods,

charcoal, agricultural waste & animal dung as their every day's cooking fuel. The number is reported to multiply to 2.6 billion in 2015 and to 2.7 billion in 2030, concerning the massive escalation of deforestation, household air pollution & global climate changes through emitting CO₂ and atmospheric bromine in the form of methyl bromine lead to the chemical destruction of ozone in the stratosphere. Currently deforestation is accountable for an estimated 15 to 20 percent of atmospheric CO₂ emission.

Indoor smoke, mostly produce by the combustion of biomass for cooking or house hitting cause of death of an estimated 4.3 million /year and reduction of an average life expectation of by 8.6 months. More than 50% of premature death among the children under 5 is due to pneumonia caused by particulate matter inhaled from household air pollution.

Potential ways to avoid the danger:

Rapid population growth, industrialization, urbanization, severe economic growth activities & consumption based life-style are the driving forces for rapid growing global temperature and global climate changes; pushing the green planet to the devastation day by day. These aforementioned events are the ways of lives of world's 9 billion people in the modern global arena. People of today's world cannot start living in the forest or go back to the cave lives. But some measures can be taken to alleviate the human caused GHG emission to lessen the global warming and global climate changes to survive and sustain and keep the green planet remain habitable for the future generation.

Alternative sources of energy which are low, neutral or negative GHG emitted; for example, wind power, solar power, hydroelectric power, waste-to-energy etc. could be viable alternative. According to WHO 2014, change in energy & transportation policies could save "millions of lives" as in 2012 air pollution alone resulted in the death toll of seven millions worldwide (27-29 Aug. 2014,WHO conference , Geneva, Switzerland, Report: RIA Novesti 27.08.2014).

Together with other sources of green energy, WTE could be very effective component to overcome the upcoming challenges the world going to confront with rapid growing global temperature & global climate changes. The WTE technology on one hand will reduce the acceleration of earth atomospheric Greenhouse gases emitted through combustion of fossil fuel & MSW land fill and on the other hand will meet the rapid growing energy demand.

According to US Environmental Protection Agency, WTE is a clean, renewable and reliable source of energy.

According to the estimation of U.S Environmental Protection Agency, "Every ton of MSW can contribute to prevent 1.3 tons of CO₂ emission when it goes to WTE plant due to the following factors:

- Eliminate CH₄ emission from landfill: WTE facilities avoid the emission of CH₄ that would have been generated if MSW were sent to landfill.
- Eliminate CO₂ from fossil fuel combustion: when WTE facilities generate a megawatt of electricity it avoids emission that would have been generated by fossil fuel power plant.
- Eliminate CO₂ from mining & metal plants: WTE facilities recover ferrous metals & reduce the mining of fossil fuel. So, WTE facilities avoid the emission of CO₂ that would have been emitted by production of metals and mining of fossil fuel.

Moreover, WTE facilities contribute to abundant emission & fuel consumption by reducing transportation of MSW to distant landfill.

The Davos report produced by the World Economic Forum 2009 suggest that WTE facilities can hold lead the way to a clean and more energy independent future. The report simply indicated that WTE facilities are emerging green technology that can contribute to reduce GHG emission and change the world's energy consumption pattern.

The remarkable welfares of Waste to Energy:



Benefits:

- Decrease landfill waste
- Reduce GHG emission
- Accelerate recycling objects & rate
- Slash the reliance of fossil fuel
- Diversify the energy industries
- Ensure green & cheap source of energy
- Create new employments

Existance Waste-to-Energy Technologies Worldwide:

A. Thermal technologies:

- Incineration
- Gasification
- Thermal depolymerization

- Pyrolysis
- Plasma arc gasification
- B. Non-thermal technologies:
 - Anaerobic digestion
 - Fermentation production
 - Mechanical biological treatment

Through the existance technologies either MSW are mass combusted which is eco-destructive or only organic matters of MSW are processed to generate energy.

Incineration, the mass combustion of MSW, is the most common Waste-to-energy implementation, is cause of mass pollutions. Combustion of MSW produce CO₂, N₂O, SO₂, furans & other dangerous pollutions including ground water quality pollution, and a host of air, water & soil pollution. Ash of the combusted MSW is hazardous. Bottom ash which is around 10% of the volume and about 20-30% by weight of MSW input is less harmful but the fly ash, relatively a tiny portion of MSW input, is extremely hazadous. Moreover, the ashes contribute for further landfill. Incineration of MSW generates two types of CO₂: Biogenic (67%) & anthropogenic (33%).

Biogenic, the largest portion of generated CO₂, is the part of earth's natural carbon cycle and earth can absorb it but the anthropogenic, the remaining 33% of the generated CO₂, is the additional GHG to the earth's automosphere, come from man-made substances in the waste that is combusted, such as unrecycable plastic & rubbers.

Advanced Neo-digestion technology (proposed):

Unlike old fashioned mass incineration of MSW or digestion of only organic matters of MSW, the Advanced Neo-digestion Recycling & Energy conversion of MSW technology digests a very wide range of MSW which includes both organic and solid matters ranging from industrial camical liquid to wood waste & tember.

Specific types of waste that are processed:

- Municipal solid waste (MSW)
- Industrial & commercial waste
- Hospital waste
- Construction waste
- Cafe & restaurant waste
- Household waste
- Wood & garden waste
- Abattoir waste
- Toxic waste

- Animal waste & agricultural waste
- Contaminated oil & Oil sludge
- Industrial liquid chemical waste

Range of waste:

- Hydrocarbon such as oil
- Complex sugar such as vegetable waste
- Organic chemical such as animal fats
- Veterinary waste such as animal tissue, blood etc.
- Hospital waste: blood, human tissues, wounded dressing, disposable instruments etc.
- Contaminated oil such as used oil from engines, transformers & other machineries
- Construction waste: wooden doors and windows, timbers framing, waste wood etc.
- Biomass: household & gardening waste, agricultural waste, dung, forestry waste, energy crops etc.
- MSW: discarded food, paper, fabrics etc.
- Industrial liquid waste
- Any other disposable waste

Procedure:

In Neo-digestion Technology, waste materials are decomposed in biogas plant by bacteria in the absence of oxygen and converted into energy-known as biogas that consists of 60% CH₄ & 40% CO₂. The generated biogas is then used to generate electricity. The waste of the biogas plant is used as eco-friendly compost fertilizer.

The digestion process begins with the bacterial hydrolysis of the input materials in order to break down insoluble organic polymers such as carbohydrate & make them available for other bacteria. Acidogenic bacteria then convert the sugar & amino acid into CO₂, H₂, ammonia, & organic acids. Acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, H₂, & CO₂. Finally methanogens convert these products into CH₄ & CO₂.

Implementation:

Collecting MSW from dumping sites the disposable waste materials are sorted out from undisposable materials such as concrete, bricks, stones and other valuable materials that can be recycled, such as cans, irons, aluminum, plastic etc. Then the disposable waste materials are ground and delivered to the biogas plant with waste water or chemical liquid waste to generate biogas.

In the plant biogas is generated by series of natural biological digestion process.

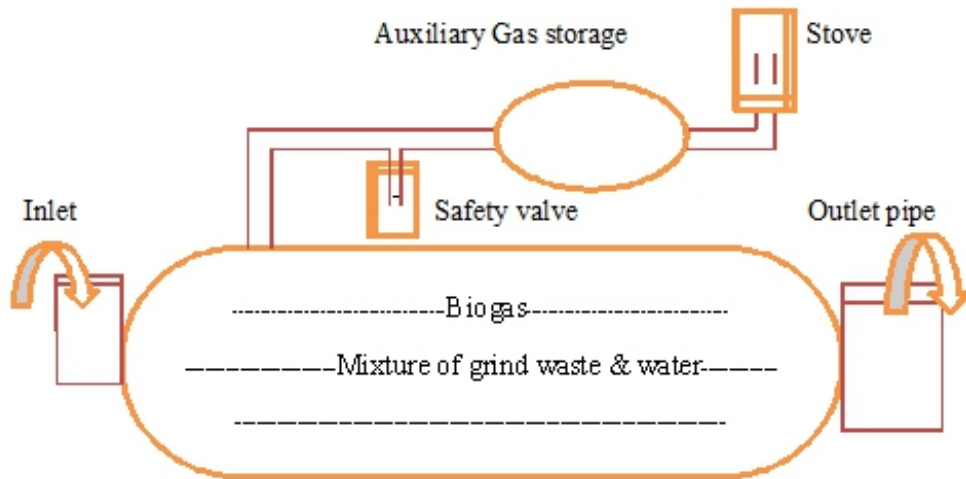


Figure 2: An Idial Biogas Plant

The digestion process consists of two basic stages:

- A) The acid producing stage &
- B) The Methane production stage

At the initiative stage raw sludge is attacked by fermentative bacteria that break the sludge down into organic acids, aldehydes and alcohols under anaerobic condition. The organic fatty acids are produced in the greatest quality.

At the following stage the organic acids, aldehydes and alcohol are decomposed by acetogenic bacteria and converted into CH₄ & CO₂

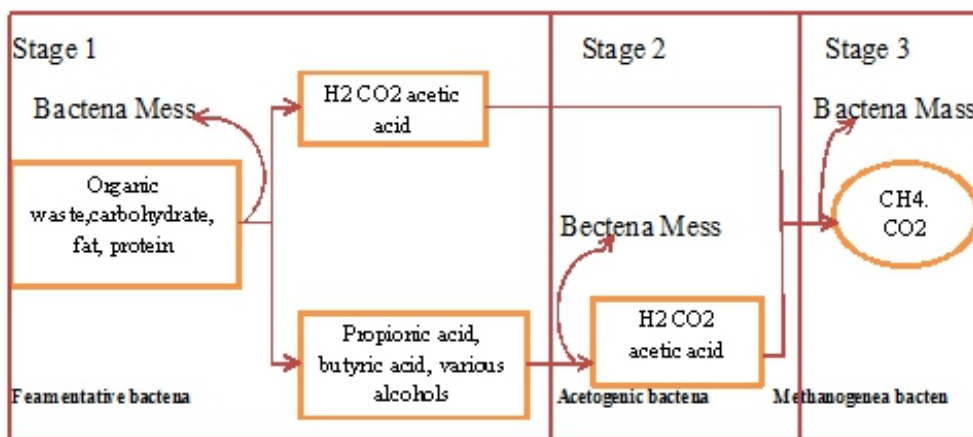


Figure 3: Biogas generation procedures in the plant

Electricity By Biogas:

Electricity is generated by the produced biogas in combined cycle electricity generation unit which is the combination of both gas turbine unit & steam turbine unit.

In this technology gas is first heated and hot gas is used to turn the gas turbine unit to generate electricity and then the waste gas is used to boil the water to produce steam to spin the steam turbine unit to generate electricity.

This technology is most effective and cheap. By the technology 60% more electricity can be generated by the same amount of gas and same expenditure of conventional single turbine unit.

Ecological welfare of the proposed technology:

It is a carbon negative source of energy. The technology produce electricity at a negative emission rate of GHG when compared to allow CH₄ to form in landfill & fossil fuel combustion to generate electricity.

The technology is primarily a CH₄ processing technology that turns landfill CH₄ into gas form.

When CH₄ is burned in the electricity generation unit to generate electricity, CH₄ is converted into H₂O & CO₂. The latter is 25 times less environment destructive than CH₄. Moreover, the emitted CO₂ of the plant is biogenic that is part of the earth's natural carbon cycle-while trees & plants grow up through photosynthesis process they remove earth atmosphere's CO₂ that is return to the atmosphere back while paper, food & biogenic waste are burnt.

The WTE facilities opposed to the emission of GHG into earth's atmosphere by combustion of fossil fuel for mission of many years. Such substitution of energy from WTE facilities cut down the GHG emission associated with energy production from combustion of fossil fuel.

The waste of the WTE facility is used as ecofriendly compost fertilizer that recycled back valuable nutrients to the land through the production of digestion.

Conclusion

Carbon neutral or carbon negative, easy accessible & cheap WTE technology of this type is the demand of time when energy is an integral part of every sphere of our lives and changing pattern of energy is extremely indispensable to keep the earth's atmospheric GHG in adaptable level to avoid the potential ecological catastrophe. The proposed technology on one hand will rein the acceleration of earth atmospheric greenhouse gases and on the other hand will meet the rapid growing energy demand in developed

and developing countries. Worldwide appliance of this technology can save the green planet from the upcoming danger.

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