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Waste to Energy: The Energy for the Future

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Abstract: The continuing interest to alternative sources of energy is increasing gradually as the world today is very much concern about global warming, global climate changes and growing energy demand in short order. Rapidly growing world population, urbanization, industrialization and consumption based economy are accelerating incremental energy demand & municipal solid waste (MSW) generation which are being cause of mass pollutions & rising the earth atmospheric greenhouse gases (GHG), resulting global warming & ecological catastrophe. Global warming, the increase in the temperature of the earth's neon-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 21th century world's average surface temperature will increase by 2.4-6.4°C, might exceed the earth's ability to adapt. Unusual temperature will affect hydrology & biology of earth-everything including economy, ecosystem & substances. The potential consequences of global warming will be devastative, such as raising the 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. The excessive acceleration of greenhouse gases (GHG) in earth's atmosphere, generated through the combustion of fossil fuel & waste landfill, is mainly accountable for these unusual weather events. Changing pattern of energy, more specifically, carbon neutral or carbon negative sources of energy only can save the world from the upcoming devastation.

Key words: global warming; global climate changes; municipal solid waste; fossil fuel; greenhouse gases; alternative sources of energy; waste to energy

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1. Introduction

Global warming is one of the most current & widely discussed global issues which represent a serious and growing threat to earth's all living beings. The consequences of global warming & global climate changes are extremely devastative the world going to confront with. Earth's atmospheric GHG acceleration through human activities is mainly accountable for this.

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Rapidly growth world population, massive combustion of fossil fuel & mounting of municipal solid waste (MSW) landfill are closely linked with it.

World population is growing rapidly. During the period between 2013 & 2025 the world population is estimated to increase by 20% to 8 billion which will multiply to around 9 billion by 2050 (World Bank 2012).

With the rapidly growing population a relatively silent problem is soaring up daily that is skyrocketing enhancement of municipal solid waste (MSW). The generation of MSW is projected to be increased to 2.2 billion tons/year by 2025, from 1.3 billion tons/year in 2013 (World Bank report-2013). By 2025 the more dominant part of MSW will be the organic fractions which will increase the greenhouse gas emission from current 42 billion tons/year to around 80 billion tons/year, will be a serious cause of global surface temperature rising.

This is concern with the other challenges that with the rapidly growing industrialization, urbanization and population growth, world energy demand & consumption are increasing sharply. World energy consumption is estimated to increase from 560 quadrillion Btu (British thermal unit) in 2014 (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).

The growing demand of conventional energy & MSW generation 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 are responsible for global warming, global climate changes & ecological catastrophe, carbon negative "Waste to Energy (WTE)" technology could be a viable alternative 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).

2. 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 to cities are not very often leaving, accelerating the urban population. Today 3.78 billion people that is 54% of total world population live in urban areas & the figure is expected to increase to about 6 billion that will be 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 was an average of 0.64kg/capita/day by 2.9 billion urban populations. The volume was 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 $205 billion in 2013 to $375 billion. The landfill food waste will accelerate global GHG emission from 34 million tons in 2013 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 damping 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.

3. 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 by 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, world energy consumption will enhance to 630 quadrillion Btu in 2020 and 820 quadrillion Btu in 2040 from 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.

3.1 World Total Energy Consumption, 1999-2040

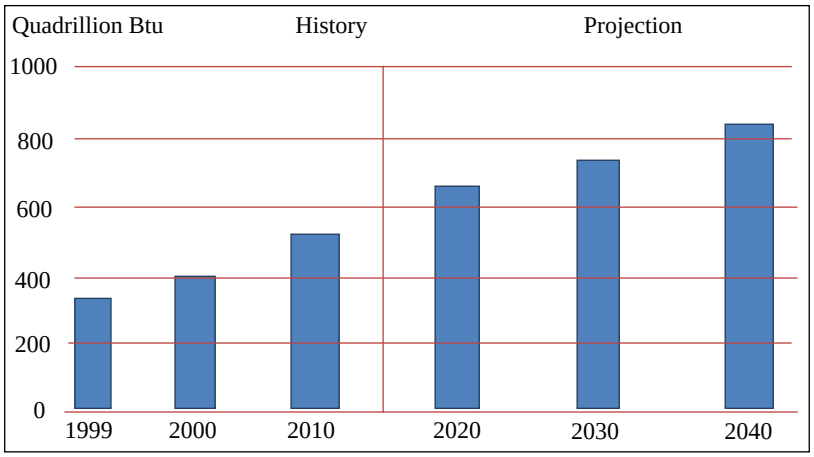


Figure 1 Shows World Total Energy Consumption, 1990-2040

Source: IEO

The aftermath of massive consumption of conventional energy would be unusual global warming & global climate changes. Global energy-related CO_2 emission will become worse than expected. According to International Energy outlook (IEO) 2013 reference case, global CO_2 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 said 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 devastative for the earth's all living beings. Global worming 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, increasing 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 O_3 (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).

3.2 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, which includes 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 CO_2 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 CO_2 emission.

Indoor smoke, mostly produced by the combustion of biomass for cooking or house hitting, is the 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.

4. Potential Ways to Avoid the Danger

Rapid population growth, industrialization, urbanization, severe economic growth activities & consumption based life-style are the driving forces for rapidly 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 alternatives. According to World Health Organization (WHO) report 2014, changes 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 rapidly growing global temperature, global climate changes and energy demand in short order. 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 rapidly 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 CO_2 emission when it goes to WTE plant due to the following factors:

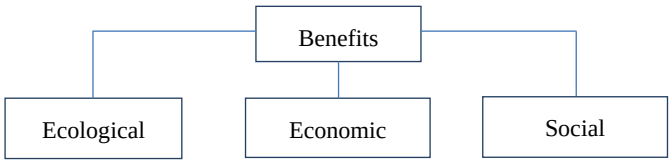
- Eliminate CH4 emission from landfill: WTE facilities avoid the emission of CH4 that would have been generated if MSW were sent to landfill.

- Eliminate CO_2 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 CO_2 from mining & metal plants: WTE facilities recover ferrous metals & reduce the GHG emission from mining for metals. So, WTE facilities avoid the emission of CO_2 that would have been emitted by mining & production of metals.

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.

4.1 The Remerkable 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

4.2 Existance Waste-to-Energy Technologies Worldwide

(1) Thermal technologies:

- Incineration
- Gasification
- Thermal depolymerization
- Pyrolysis
- Plasma arc gasification

(2) 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 CO_2, N_2O, SO_2, furans & other dangerous pollutions including ground water quality pollution, and a host of air& 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 ashs contribute for further landfill. Incineration of MSW generates two types of CO_2: Biogenic (67%) & anthropogenic (33%).

Biogenic, the largest portion of generated CO_2, is the part of earth's natural carbon cycle and earth can absorb it. But the anthropogenic, the remaining 33% of the generated CO_2, 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.

4.2.1 Advanced Neo-digestion Technology (Proposed)

Unlike the 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 include both organic and solid matters ranging from industrial camical liquid to wood waste & tember.

4.2.2 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
- Animel waste & agricultural waste
- Contaminated oil & Oil sludge
- Industrial liquid chemical waste

4.2.3 Range of Waste

- Hydrocarbon such as oil
- Complex suger such as vegetable waste
- Organic chemical such as animel 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 & garding waste, agricultural waste, dung, forestery waste, energy corps etc.
- MSW: discarded food,paper, fabrics etc.
- Industrial liquid waste
- Any other disposable waste

4.2.4 Procedures

In Neo-digestion Technology, waste materials are decomposed in biogas plant by bacteria in the absence of oxigen and converted into energy-known as biogas that is consist of 60% CH_4 & 40% CO_2. 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 suger & amino acid into CO_2, H, ammonia, & organic acids. Acetogenic bacteria then convert these resulting organic acids into acetic acid, along with additional ammonia, H, & CO_2. Finally methanogens convert these products into CH_4 & CO_2.

4.2.5 Implementation

Collecting MSW from dumping sites, disposable waste materials are sorted out from undisposable materials, such as concrite, bricks, stons and other valuable materials which are recycled, for example, cans, irons, aluminum, plastic etc. Then the disposable waste materials are grind and deliver to the biogas plant with waste water or chemical liquied waste to generate biogas. In the plant biogas is generated by series of natural biological digestion process.

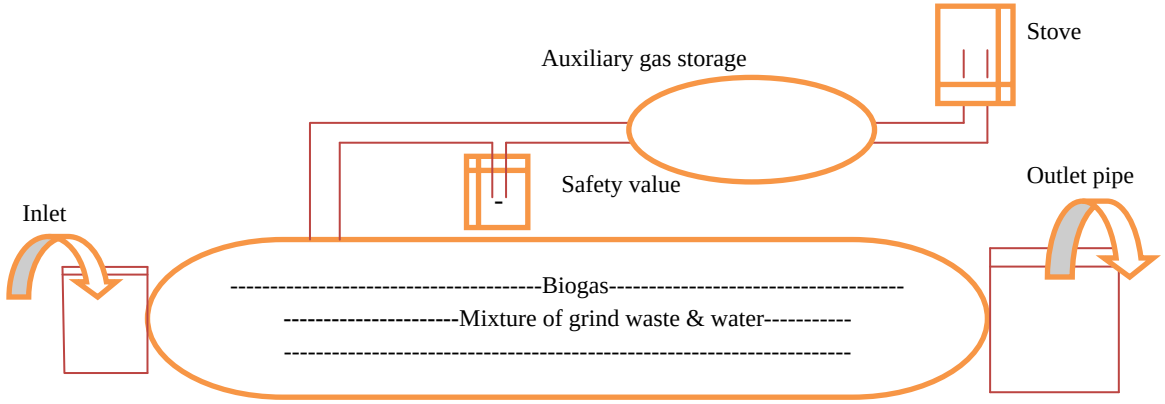


Figure 2 An Idial Biogas Plant

4.3 The Digestion Process Consists of Two Basic Stages:

(1) The acid producing stage &

(2) The Methane production stage

At the initiative stage, raw sludge is attacked by ferm entative bacteria that break the sludge down into organic acids, alde-hydes 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 dicomposed by acetogenia bacteria and converted into CH_4 & CO_2.

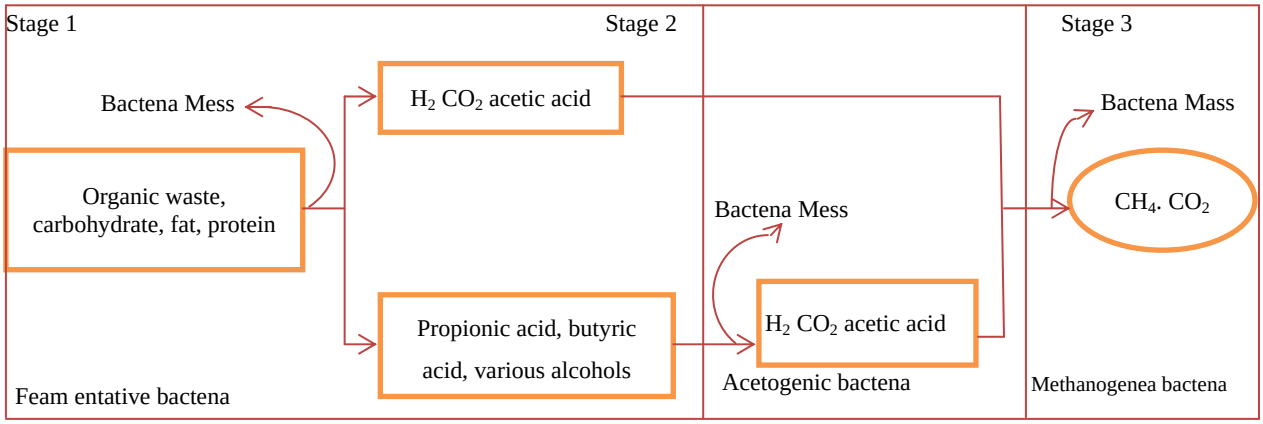


Figure 3 Biogas Generation Procedures in the Plant

4.3.1 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 & streem 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 steem to spin the steem turbine unit to generate electricity.

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

4.3.2 Ecological Welfear of the Proposed Technology

It is a carbon negative source of energy. The technology produces electricity at a negative emission rate of GHG when compared to allow CH_4 to form in landfill & fossil fuel combustion to generate electricity.

The technology is primarily a CH_4 processing technology that turns landfill CH_4 into gas form.

When CH4 is burned in the electricity generation unit to generate electricity, CH_4 is converted into H_2O & CO_2. The latter is 25 times less environmental destructive than CH_4. Moreover, the emitted CO_2 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 CO_2 that is return to the atmosphere back while paper, food & biogenic waste are burnt.

The WTE facilities opposed to the emittion of GHG into earth's atomosphere by combustion of fossil fuel for the 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.

5. Conclusion

Carbon neutral or carbon negative WTE technology of this type is the demand of time when changing pattern of energy is extremely indispensible to keep the earth's atomospheric GHG in adaptable level to avoid the potential ecological catostrophe. The proposed technology on one hand will rein the acceleration of earth atomospheric greenhouse gases and on the other hand will meet the rapidly growing energy demand. Worldwide appliance of this technology can save the green planet from the upcoming danger.

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