CHAPTER V

Global Warming- Role of Biogas Plants

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GLOBAL WARMING-ROLE OF BIOGAS PLANTS

The performance of biogas plant in the real environment is analyzed to find out its role in the ongoing effect of Global Warming. On one side it is contributing to the global warming by trapping the solar radiation by the biogas. But the utilization of the biogas produced inside the plant, otherwise it may be released to the atmosphere during degradation of biomass, is contributing for the mitigation of global warming.

5.1 Introduction

Earth is the known unique planet of this universe blessed with biotic as well as abiotic components. In biotic components, man is responsible for the protection of our Mother Earth. Regional and global variability in the earth’s climate has been part of the natural phenomenon throughout the Holocene (dcMencol et al 2000, Gupta et al 2003, Anderson et al 2002, Moy et al 2002 and Panday et al 2003) and earlier shaping interactions of life with the biosphere and adaptations to global change (Bowen et al 2002). However, recent anthropogenic warming of climate system and its projected impacts are clearly discernible from the accumulating recent evidence (Levitus et al 2001, Barnett et al 2001 and Parmesan and Yohe 2003).

The World Watch Institute pointed out in a recent study that the atmospheric changes and Global warming are the most dangerous draconian effect of tomorrow. Global Warming is the increase in the average temperature of the earth's near-surface air and oceans since the mid-twentieth century and its projected continuation. The term global warming is a specific example of global climate change. The term Anthropogenic Global Warming (AGW) is used when focusing on human induced changes. The average
global air temperature near the earth's surface increased $0.74 \pm 0.18$ °C ($1.33 \pm 0.32$ °F) during the hundred years ending in 2005. It is almost contributed by the Green House Gas (GHG) emission. Out of the eight distinct sectors of GHG emission the fossil fuel retrieval processing and distribution, agricultural byproducts and waste disposal and treatment are taken together for impact assessment.

The Forth Assessment Report of Intergovernmental Panel on Climate Change (IPCC) concludes that warming of the climate system is unequivocal and most of the observed increase in globally averaged temperatures since the mid-twentieth century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations via the greenhouse effect\(^5\). Natural phenomena such as solar variation combined with volcanoes probably had a small warming effect from pre-industrial times to 1950 and a small cooling effect from 1950 onward. These basic conclusions have been endorsed by at least thirty scientific societies and academies of science, including all of the national academies of science of the major industrialized countries. While individual scientists have voiced disagreement with some findings of the IPCC, the overwhelming majority of scientists working on climate change agree with the IPCC's main conclusions\(^13\).

Climate model projections summarized by the IPCC indicate that average global surface temperature will likely rise a further $1.1$°C to $6.4$°C ($2.0$°F to $11.5$°F) during the twenty-first century (IPCC1996, IPCC 2001). The range of values results from the use of differing scenarios of future greenhouse gas emissions as well as models with differing climate sensitivity. Although most studies focus on the period up to 2100, warming and sea level rise are expected to continue for more than a thousand years even if greenhouse
gas levels are stabilized. The delay in reaching equilibrium is a result of the large heat capacity of the oceans.

5.2 Effects of Global Warming

Short Term Impacts

- Climate Change: Changes in the pattern of rain fall and seasonal cycles
- We have had 7 of the 8 hottest years in the past 10 years in the last century
- Decline in some plants & animals, early flowering in trees.
- Earlier emergence of insects, earlier egg laying in birds
- Affects the biological clock in human.

Long Term Impacts

- The glaciers of the Great Mountains like Himalayas etc. and the Polar ice may melt and the sea water level may increase.
- The habitat areas of the human beings may go to underwater.
- The inhabitants of this beautiful heaven are going to starve and draconian diseases will come more effectively and will conquer us.

Other effects of global warming include changes in agricultural yields, trade routes, glacier retreat, species extinctions and increase in the ranges of disease vectors. Extensive climate changes may alter and threaten the living conditions of much of mankind. They may induce large-scale migration and lead to greater competition for the earth's resources. Such changes will place particularly heavy burdens on the world's most vulnerable countries. There may be increased danger of violent conflicts and wars, within and between states. Remaining scientific uncertainties include the amount of warming expected in the future, and how warming and related changes will vary from region to region around the globe.
Increasing global temperature will cause sea level to rise, and is expected to increase the intensity of extreme weather events and to change the amount and pattern of precipitation. Warming by CO$_2$ produces water to evaporate into the atmosphere. Since water vapour itself act as a GHG, the atmosphere warms further. Ice around the poles melts and the water flows into open lands. Lands are of average less reflective than ice and thus absorb solar radiation.

5.3 **Green House Gases and Green House Effect**

The greenhouse effect was discovered by Joseph Fourier in 1824 and was first investigated quantitatively by Svante Arrhenius in 1896. It is the process by which absorption and emission of infrared radiation by atmospheric gases warm a planet's lower atmosphere and surface. When sunlight reaches Earth’s surface some is absorbed and warms the earth and most of the rest is radiated back to the atmosphere at a longer wavelength than the sunlight. Some of these longer wavelengths are absorbed by the GHGs in the atmosphere before they are lost to space. This warms the atmosphere. Thus GHGs hold back to the earth some of the heat energy which would otherwise be lost to space. The trapping of heat energy by the atmosphere is called the Green house effect. Existence of the greenhouse effect as such is not disputed. Naturally occurring greenhouse gases have a mean warming effect of about 33°C (59°F), without which Earth would be uninhabitable. On Earth, the major greenhouse gases are water vapor, which causes about 36–70% of the greenhouse effect (not including clouds), CO$_2$, which causes 9–26%, CH$_4$, which causes 4–9%; and ozone, which causes 3–7%. The issue is how the strength of the greenhouse effect changes when human activity increases the atmospheric concentrations of some greenhouse gases.
Table 5.1 Green house gases and their global warming potential[^8]

<table>
<thead>
<tr>
<th>Gas</th>
<th>GWP</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ (Carbon Dioxide)</td>
<td>1</td>
<td>Fossil fuel combustion, forest clearing, cement production, etc.</td>
</tr>
<tr>
<td>CH₄ (Methane)</td>
<td>21</td>
<td>Landfills, production and distribution of natural gas and petroleum, fermentation from digestive system of livestock, rice cultivation, fossil fuel combustion, etc.</td>
</tr>
<tr>
<td>N₂O (Nitrous Oxide)</td>
<td>310</td>
<td>Fossil fuel combustion, fertilizers, nylon production, manure, etc.</td>
</tr>
<tr>
<td>HFC's (Hydroflurocarbons)</td>
<td>140-11700</td>
<td>Refrigeration gases, Aluminium smelting, semiconductor industry, etc.</td>
</tr>
<tr>
<td>PFC's (Polyflurocarbons)</td>
<td>6500-9200</td>
<td>Aluminium production, semiconductor industry, etc.</td>
</tr>
<tr>
<td>SF₆ (Sulfur hexafluoride)</td>
<td>23900</td>
<td>Electrical transmissions and distribution systems, circuit breakers, magnesium production etc.</td>
</tr>
</tbody>
</table>
Human activity since the industrial revolution has increased the concentration of various greenhouse gases, leading to increased radiative forcing from Carbon dioxide (CO₂), methane (CH₄), tropospheric ozone (O₃), Chlorofluorocarbons (CFC's) and nitrous oxide (N₂O). Methane is a more effective greenhouse gas than carbon dioxide, but its concentration is much smaller so that its total radiative forcing is only about a fourth of that from carbon dioxide. Some other naturally occurring gases contribute very small fractions of the greenhouse effect; one of these, nitrous oxide (N₂O), is increasing in concentration owing to human activity such as agriculture.

The atmospheric concentrations of CO₂ and CH₄ have increased by 31% and 149% respectively since the beginning of the industrial revolution in the mid-1700s. These levels are considerably higher than at any time during the last 650,000 years, the period for which reliable data has been extracted from ice cores. From less direct geological evidence it is believed that CO₂ values this high were last attained 20 million years ago. Fossil fuel burning has produced about three-quarters of the increase in CO₂ from human activity over the past 20 years. Most of the rest is due to land-use change, in particular deforestation.

The present atmospheric concentration of CO₂ is about 385 parts per million (ppm) by volume. Future CO₂ levels are expected to rise due to ongoing burning of fossil fuels and land-use change (Martinot and McDoom 2000). The rate of rise will depend on uncertain economic, sociological, technological, and natural developments, but may be ultimately limited by the availability of fossil fuels.

The IPCC Special Report on Emissions Scenarios gives a wide range of future CO₂ scenarios, ranging from 541 to 970 ppm by the year 2100. Fossil fuel reserves are
sufficient to reach this level and continue emissions past 2100, if coal, tar sands or methane clathrates are extensively used.

Based on estimates by NASA’s Goddard Institute for Space Studies, 2005 was the warmest year since reliable, widespread instrumental measurements became available in the late 1800s, exceeding the previous record set in 1998 by a few hundredths of a degree. Estimates prepared by the World Meteorological Organization and the Climatic Research Unit concluded that 2005 was the second warmest year, behind 1998. Temperatures in 1998 were unusually warm because the strongest El Niño in the past century occurred during that year (Barnett et al 2001). Though the percentage emission of methane by different sectors is accounted to 18% of the total emission it is playing a vital role in the Global Warming. According to the report of Intergovernmental Panel on Climate Change (IPCC) methane, whose global warming potential 21 times that of CO$_2$ and the life span in the atmosphere (4-7 years) is increasing in the atmosphere unpredictably.

5.4 Environmental Trends and Policy Perspectives

Environmental quality represents the basic life support systems of society and their relationships to one another and as such and it is one of society’s most important assets. Thus understanding complex scientific and technical issues related to existing environmental technologies and future trends based upon research and engineering practice is important. Environmental technologies are applied over a wide variety of public services such as water supply, water and wastewater treatment, air pollution control, solid waste management, hazardous waste treatment and disposal (Wigley and Raper 2001)
Figure 5.1  Carbon Dioxide Levels. 72% of Global Warming\cite{16}

![Graph showing CO₂ levels from 600,000 YBP to present.]

Muana Loa Readings
CO₂ Levels Since 1958

CO₂ (ppm)

Time (YBP)

Figure 5.2  Worldwide Carbon Emissions\cite{16}

![Graph showing worldwide carbon emissions from 1750 to 2000.]

- Total
- Liquid fuel
- Solid fuel
- Gas fuel

Year
Figure 5.3  Cumulative carbon emission, 1950-1996[16]

<table>
<thead>
<tr>
<th>Country</th>
<th>Carbon Emission (Million tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>15,715</td>
</tr>
<tr>
<td>Germany</td>
<td>11,651</td>
</tr>
<tr>
<td>Japan</td>
<td>8,504</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>7,415</td>
</tr>
<tr>
<td>India</td>
<td>4,235</td>
</tr>
<tr>
<td>Canada</td>
<td>4,054</td>
</tr>
<tr>
<td>South Africa</td>
<td>2,331</td>
</tr>
<tr>
<td>Mexico</td>
<td>2,118</td>
</tr>
<tr>
<td>Australia</td>
<td>2,080</td>
</tr>
<tr>
<td>Brazil</td>
<td>1,557</td>
</tr>
<tr>
<td>Korea, Rep.</td>
<td>1,361</td>
</tr>
<tr>
<td>Indonesia</td>
<td>966</td>
</tr>
<tr>
<td>United States</td>
<td>50,795</td>
</tr>
</tbody>
</table>
Figure 5.4 Annual GHG Emissions in Different Sectors

**Annual Greenhouse Gas Emissions by Sector**

- Industrial processes: 16.8%
- Power stations: 21.3%
- Transportation fuels: 14.0%
- Waste disposal and treatment: 3.4%
- Agricultural byproducts: 12.5%
- Land use and biomass burning: 10.0%
- Fossil fuel retrieval, processing, and distribution: 11.3%
- Residential, commercial, and other sources: 10.3%

**Pie Charts**

- **Carbon Dioxide** (72% of total)
  - Industrial: 20.6%
  - Power stations: 29.5%
  - Transportation fuels: 19.2%
  - Agricultural byproducts: 12.9%
  - Waste disposal and treatment: 9.1%

- **Methane** (18% of total)
  - Industrial: 40.0%
  - Power stations: 29.6%
  - Transportation fuels: 18.1%
  - Agricultural byproducts: 6.6%
  - Waste disposal and treatment: 4.8%

- **Nitrous Oxide** (9% of total)
  - Industrial: 62.0%
  - Power stations: 1.1%
  - Transportation fuels: 1.5%
  - Agricultural byproducts: 2.3%
  - Waste disposal and treatment: 5.9%
5.5 Holistic Approach to Environmental Problems

Many environmental scientists and engineers propose a holistic approach to understanding and solving environmental problems. The traditional piecemeal approach treats each environmental problem as an isolated entity, in most cases involving a single medium (water, air, soil, etc.). Solutions are often proposed to address these isolated problems, without further examination of the entire context of the problem. It would be prudent to view environmental problems in their larger contexts and solutions would then involve a multimedia approach.[17]

5.6 Mitigation Strategy- World Scenario

Under the pollution prevention Act of 1990, Congress established as a national policy that

Pollution should be prevented or reduced at the source whenever feasible.

Pollution that cannot be prevented should be recycled in an environmentally safe manner whenever feasible.

Pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible and

Disposal or other release into environment should be employed only as a last resort and should be conducted in an environmentally safe manner.

Mitigation of global warming involves taking actions aimed at reducing the extent of global warming. This is in contrast to adaptation to global warming which involves taking action to minimize the effects of global warming. Scientific consensus on global warming, together with the precautionary principle and the fear of non-linear climate
transitions is leading to increased effort to develop new technologies and sciences and carefully manage others in an attempt to mitigate global warming\[^4\].

Mitigation of global warming gained international attention and the evidence is the 2007 Nobel Peace Prize. It was jointly shared by Intergovernmental Panel on Climate Change (IPCC) and former U.S. Vice President Albert Arnold (Al) Gore Jr. for their efforts to build up and disseminate greater knowledge about manmade climate change and to lay the foundation for the measures that are necessary to counteract such change.

As a need to adopt eco-friendly life style every nation is promoting green technology. One recent example is from California, the most populous state in U.S. The pledge taken by Governor Arnold Schwarzenegger to reduce GHG emission gained international attention. Another interesting work was a campaign called Earth Hour organized by World Wildlife Forum (WWF) Denmark which is to be celebrated every year. Up to 30 million persons participated in the run by turning off their lights for 60 minutes. Landmarks such as Sydney Opera House and the Golden Gate Bridge in San Francisco went dark by moving into this. The motto of the campaign was that Energy Efficiency is a low hanging fruit and is the easiest thing we can do to reduce global warming. Scientists at the Lawrence Berkeley National Laboratory in California have suggested a plan to drastically reduce global warming by painting the world white. If implemented successfully, it would be the equivalent of taking the world's 600 million cars off the road for 18 years.

Hashem Akbari and Surabi Meno, along with Art Rosenfeld, California Energy Commissioner and Professor Emeritus at the University of California, Berkeley, are so convinced that their idea will work, that they have proposed a Cool World plan that
would use white roofs, and solar-reflective roofs of other colors, to reduce greenhouse
gas emissions and help delay atmospheric heating effects.

The 2008 Beijing Olympic itself got the name Green Olympic in order to adapt
eco-friendly life style. The recently concluded conference on climate change at Poznon in
Poland was also a promising step to fight against the wide spread impacts of global
warming\textsuperscript{[20]}.

5.6.1 The Kyoto Protocol

The treaty negotiated in Kyoto, Japan in December 1997, is a historic step in
building sustained global action to reduce greenhouse gas emissions and ultimately
stabilize concentrations of such gases in the atmosphere. It is also a major victory for the
United States approach of harnessing the power of the free market to protect our
environment. The essential elements of the Kyoto Protocol include binding emissions
targets for developed countries and flexible market mechanisms for achieving those
targets. Both the structure of the targets and the means for reaching them closely
resemble U.S. proposals. Follow-up work is under way to secure stronger commitments
from developing countries. Kyoto is a cap and trade system that imposes national caps on
the emissions of developed countries Kyoto created a framework and a set of rules for a
global carbon market.

- The Kyoto Protocol to the United Nations Framework Convention on Climate
  Change is an amendment to the international treaty on climate change, assigning
  mandatory targets for the reduction of greenhouse gas emissions to signatory
  nations.
- Reduction of 5% of GHG emission from 1990 level during the period 2008-2012
- Provide flexibility in how countries meet their targets
- Further recognize that commitments under the Protocol would vary from country to country

5.6.2 USA's "Carbon Credit" Protocol

- Once the Kyoto Protocol was set up, the USA and other developed countries realized that it was next to impossible for them to reduce their carbon emission rates.
- It was then they brought in the concept of Carbon Credits.

Carbon credits are measured in units of certified emission reductions (CERs). Each CER is equivalent to one tonne of carbon dioxide reduction.

5.6.3 Standard Measures to be Adopted

- Increasing energy efficiency standard
- Encouraging use of renewable energy sources
- Protecting and restoring forests which are the storehouses of CO₂
- Discouraging the over use of coal and oil
- Less driving, & driving more fuel efficient & less polluting cars
- Using energy efficient appliances
- Insulating homes
- Using less electricity in general
Figure 5.6  Projected Emission Reduction by Implementing Kyoto Protocol\cite{13}

![Graph showing projected emission reduction](image)

Figure 5.7  The Kyoto Protocol Signatory Nations\cite{20}

![Map of signatory nations](image)

Participation in the Kyoto Protocol, where dark green indicates countries that have signed and ratified the treaty, yellow is signed, but not yet ratified, grey is not yet decided and red is no intention of ratifying.
5.6.4 Carbon Trading

Emissions trading are an administrative approach used to control pollution by providing economic incentives for achieving reduction in the emission of pollutants. In such a plan, a central authority (usually a government agency) sets a limit or cap on the amount of a pollutant that can be emitted.

Companies or other groups that emit are required to hold an equivalent number of credits or allowances which represent the right to emit a specific amount. The total amount of credits cannot exceed the cap, limiting total emissions to that level.

Companies that need to increase their emissions must buy credits from those who pollute less. The transfer of allowances is referred to as a trade. In effect, the buyer is being fined for polluting, while the seller is being rewarded for having reduced emissions.

One credit is equivalent to one tone of CO$_2$ emission reduced. The concept of carbon credit trading encourages countries to reduce their GHG emission, as it rewards those countries which meet their targets and provides financial incentives to others to do so as quickly as possible.

Surplus credit collected by overshooting the emission target can be sold in the global market Carbon Credit is mainly available for companies engaged in developing renewable energy projects that offset the use of fossil fuels.

Environmentalist R.K. Pachauri, who heads the IPCC has quoted that the future is going to be a low carbon society and those who accept the fact are going to be winners and those who don’t are going to be left behind.
5.6.5 Carbon Sequestration

It is the term describing process that removes CO₂ from the atmosphere. To help mitigate global warming, a variety of means of artificially capturing and storing carbon- as well as of enhancing natural sequestration processes are being explored. A carbon dioxide sink is a carbon reservoir that is increasing in size, and is the opposite of a carbon dioxide source. The main natural sinks are (1) the oceans and (2) plants and other organisms that use photosynthesis to remove carbon from the atmosphere by incorporating it into biomass and release oxygen into the atmosphere.

5.7 Mitigation of climate change by developing world

Independent studies suggest that developing countries are already making massive reductions to their GHG emissions. Although not required under the Kyoto Protocol, several developing countries including India are already taking actions that have remarkable impact for global climate change mitigation. A study published by Pew Center on Global Climate Change, USA (Chandler et al 2002, Brunfiel 2002 and Shukla et al 2002) notes that policies and schemes implemented by Brazil, China, India, Mexico, South Africa and Turkey have together reduced the growth of their GHG emissions by ~300 million tones per year over the past 30 years. The savings are the result of a wide range of programs from local renewable energy schemes to market reforms. For instance in China alone, CO₂ emissions from fossil fuel combustion declined from 2950Tg (teragram of CO₂, 1Tg= 1 million tones) in 1996 to 2690Tg in 2000, a reduction of 8.8%
(about 1% of the global CO₂ emissions amounting to 25300Tg from fossil fuel combustion in 2000).

5.7.1 Emission Trends – India

With a population of more than 1 billion people India's per capita electricity use averages only one half that of China and one-sixth of the world average (Chandler 2002). India with 17% of the world’s population, accounts for only 4.2% of the total world GHG emissions. Moreover, per capita emissions in India are also significantly lower than those in USA, Germany, Japan, UK and several developing countries such as China and Brazil. However, with the country’s ambitious development plans, there are concerns with regard to future energy consumption patterns and increase in emissions. India ratified the UNFCCC in 1993 and Kyoto Protocol in 2002\(^1\).

The energy sector accounted for 65 per cent of the total GHG released in 1994. The total CO₂ emitted from all sectors in the country was 817,023 Gega gram, with activities related to the energy sector accounting for around 85% of the CO₂ emissions, while industrial processes and land use, land use change and forestry accounted for 13% and 2% of the emissions respectively.

CO₂ emissions resulting from energy use in the Indian economy are estimated to increase from 917 million tonnes in 2001 to around 7267 million tonnes by 2031 if current trends continue\(^1\)\. 

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5.7.2 Clean Development Mechanism (CDM) Potential in India

India emits only 3% of the world’s total emission of CO$_2$ and our per capita emission are only one-fifth of the global average. However Indian electricity utilities and industries are very CO$_2$ emissions intensive due to their large coal use and somewhat absolute technologies. National Strategy study (NSS) on CDM, estimates the GHG mitigation potential in India till 2012 as 417 million CERS. These include technological and management options to mitigate the GHG emission in the key sectors like conventional power, renewable energy, industry and transport, municipal solid waste and industrial gas.

According to India’s first National Communication on climate change in 2004, the energy sector contributes the highest share of the total GHG emission in the country (61%). India’s growth in energy related CO$_2$ emissions, was reduced over the last decade through economic restructuring, enforcement of existing environmental legislations, and programs on renewable energy (Panday et al 2003). As a result in the year 2000 alone, energy policy initiatives reduced carbon emissions growth by 12 Mt which is about 6% of India’s gross energy related Carbon emissions (Chandlers et al 2002). The GHG mitigation potential in the sector lies in first and foremost renovation and modernization of old plants, adoption of technologies such as Super Critical Power plant technology and Integrated Gasification Combined Cycles (IGCC) and through all of these taken together, a cumulative GHG emission reduction of about 102 million CERS can be achieved by 2012. The renewable energy forecast till 2012 estimates a mitigation potential of 154 million CERs, which include biomass based power generation, wind energy and small hydropower. Municipal Solid Waste to energy conversion has a future mitigation
potential of 63 CERs. The mitigation potential of industry sector is 57 CERs. The sector-wise mitigation potential stated above is only the technological potential based on various interventions that are at different stages of planning\textsuperscript{[10][13][16]}. However, their economical revaluation and CDM eligibility needs to be analysed in detail. Thus, these may at best represent a theoretical short-term potential for CDM. The long-term mitigation potential is significantly larger and was identified at 865-1080 MT CO\textsubscript{2} eq. by the Asia Least cost Green House Gas Abatement Strategy India (ALGAS) study in 1998.

Recent discovery of the largest natural gas reserve in Krishna-Godavari basin, Andhra Pradesh, equivalent to ~1.2 billion barrels or 165 Mt of crude oil is 40 times larger than Bombay High reserves and would further reduce energy-related carbon emission in India (Panday et al 2003).

5.8 Mitigation Strategy- Kerala Scenario

How we produce energy is as important as how we use it. Using less energy and more energy-efficient appliances can reduce the GHG emission. To achieve an energy future without serious global warming, we need to turn to clean, renewable energy sources like the wind, the sun, rivers, and the oceans. Even using biomass for fuel, which does release CO\textsubscript{2} into the air, does not contribute to global warming, because energy crops absorb carbon as they grow.

As far as Kerala, the God’s Own Country is concerned; one of the proposed steps to mitigate global warming is the implementation of biogas plants. They not only produce energy for cooking and other purposes but also stand as an effective means for waste treatment in an eco-friendly way thereby reducing the ongoing effects of global warming.
Each and every individual can contribute to the mitigation of this gas by adopting waste treatment for energy recovery. All the agricultural byproducts can be used in decentralized fuel production in one way or other. This will lead to the conservation of conventional energy sources and hence mitigation of GHG emission in these sectors[11].

5.8.1 Role of Biogas plants

The experiment is conducted at Kayamkulam (Latitude 9.1616°N, Longitudes 76.4606°E), Kerala using a 1m$^3$ KVIC model biogas plant. Though the concrete wall of the digester together with soil, serves as insulated cabin for the substrate, there is heat exchange with the atmosphere through the exposed gas holder. Temperature readings reveal the trapping of solar radiation by the biogas produced inside the plant during different seasons of Kerala and is explained in Chapter III. Temp3, temperature of biogas inside the biogas plant shows a variation of about 20°C with the variation in solar radiation falling on the plant during summer season. Figures 5.8a-d correspond to the temperature of the biogas (Temp3) and atmospheric temperature (Temp6) during the summer period. For all other season the increase in temperature is less than 10°C.

The measurements are taken around Kadakkal plant, 25m$^3$ capacity (air temperature, solar radiation, temperatures on the surface of the plant) Figure 5.8e showed similar results. Sensors kept on the surface of the gas holder insulated from direct solar radiation recorded temperatures corresponding to the temperature of biogas. All the results point to the large amount of heat trapped by the biogas and its transaction with surroundings. Hence it can be considered that biogas plants are green houses contributing to Global Warming.
Figure 5.8(c) Temp. of Biogas/ Ambient Temp (°C) – March

Figure 5.8(d) Temp. of Biogas/ Ambient Temp (°C) – April
The conventional biogas digesters like floating gas holder-type installed by KVIC have exposed areas, from which CH\textsubscript{4} is emitted continuously to the atmosphere. Methane is the second most important anthropogenic greenhouse gas after carbon dioxide and contributes substantially to warming of the atmosphere, with the continuous increase in atmospheric carbon ratio (Bowden et al., 2000).

Among the various identified CH\textsubscript{4} sources, emissions from community biogas plants have not been estimated. The highest rate of CH\textsubscript{4} emission was recorded during June, when the slurry temperature reached a maximum (32°C). The CH\textsubscript{4} fluxes were considerably reduced during winter. The lowest rate of CH\textsubscript{4} emission occurred during December and January, when the ambient and slurry temperatures went down below 20°C (Khoiyangbam 2003).
Frequent field observation of different community plants in southern Kerala gave valuable information in this regard. During summer the high pressure developed inside the plant due to trapping of solar radiation by biogas caused brisk effervescence of biogas to the atmosphere through the peripheral exposed area (Figure 5.9b). The enhanced gas formation also caused leakage of biogas into atmosphere. Detailed region specific measurements are required for accounting the quantity of emission.

Figure 5.9b shows the twist of gas holder due to high pressure developed inside it. It is caused by the trapping of solar radiation. Under this condition large amount of biogas is released to the atmosphere.

Taking into account the exposed surface areas around the floating gas holder and slurry pit the annual contribution to global CH₄ budget from the plants under consideration should be accounted. The lowest rate of CH₄ emission during a day was observed in the early morning hours at 6.00 am, when the ambient and slurry temperatures were lowest. Emission rates were observed to be highest during early afternoon at 2.00 pm. Diurnal variation of CH₄ flux was more pronounced in the slurry pit compared to the exposed area of a plant (Khoiyangbam 2003).

The results of the study revealed that changes in seasonal and diurnal temperature affect CH₄ emission from biogas plants to the atmosphere. Methane emission was maximum around 2 pm during summer months, and decreased to a minimum around 6 am during winter months. If we take into account the life time of methane in atmosphere (4-7 years) and the engineered environment inside the plant as well as the utilization of the produced gas, biogas plant is contributing to the mitigation of Global Warming. MSW dumped without treating at any place generates methane and is released to atmosphere.
The total rate of biogas production from all installed plants (KVIC model) is estimated to be about 16,000 m$^3$/day, which replaces the equivalent of about 3.7 tonnes/day or 1,400 tonnes/year of LPG and diesel. The plants therefore directly avoid the emission of about 3,700 tonnes/year of CO$_2$, with further savings from the reduction in methane production from the uncontrolled decomposition of waste, and from the transport of LPG.
Figure 5.9a  Community based Biogas plant for Electricity Generation-Locaiton

Oachira- Kerala
This report is based on information provided to the Ashden Awards judges by BIOTECH and findings from a visit by one of the judges, Dr. Anne Wheldon, Technical Director of the Ashden Awards Jeremy Rawlings, to see their work in India, April 2007.

5.9 Conclusion

- Any Technology Development is replicating nature and it will add to nature. When technology is very close to nature it is adding less to nature. Anaerobic digestion being natural process can be used effectively to treat waste as well as to recover energy from waste.
- Ongoing contribution of biogas plants towards global warming can be eliminated by proper maintenance.
- The responsible Authorities should be more alert about their controlling measures and can convey the necessity of mitigation of Global Warming to the society. Every one should stretch their hands for the effective implementation of all the correlated activities.