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Contribution of Carbon Credits for Financial Feasibility of a Biogas Project

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Abstract:-- **The environmental change and ecological preservation are the principle issues of this century. India ranks as the second biggest in the populace, the fourth biggest in energy utilization and third biggest greenhouse maker and blazes ten folds fuel wood when contrasted with the United States. With a specific end goal to control the greenhouse outflows and for empowering countries for taking applicable measures the UN has concocted the matter of carbon exchanging on the premise of discharge moderation accomplished by the government and corporate firms by employing environmentally friendly technology for their production activity. The coal fired power generation in India is the greatest polluter and in the meantime gives the greatest chance to outflow lessening and procuring of carbon credits. In no time, India is creating the second most astounding number of carbon credits on the planet and is next just to China. In contrast with the developed countries the carbon emission level in India is substantially less. This gives enough opportunities to its industry to convey carbon units and seat points of interest out of its exchanging. With this vast potential to acquire carbon credits, India has a enormous degree for carbon consultancy organizations to flourish and is going to add another extent to the environmental and wealth related organizations zone. This paper presents an estimation of emission mitigation and carbon credit for a biogas electricity plant located in Maharashtra.**

Index Terms:— **Renewable energy, bio-energy, emission mitigation, certified emission reduction**

I. INTRODUCTION

Energy is the essential driver of the world's economies. Increasing populaces and wishes of upgraded lifestyles are enlivening the enthusiasm for energy. The present general energy supply is remarkably subjected to fossil sources (unrefined petroleum, lignite, hard coal, normal gas). These are fossilized stays of dead plants and creatures, which have been displayed to warmth and weight in the Earth's outside over an immense number of years. The multifold increment in the fossil fuel based force era in the course of the most recent couple of decades has undoubtedly gone about as a driver for financial development of countries, yet in the meantime it has accompanied its own particular weight of carbon impressions. Scholars have perceived the positive or direct relationship between money related advancement and greenhouse gas (GHG) outflows.

One of the key variables influencing this positive relationship builds energy demand as a result of economic well-being. Additionally, the world's fossil fuel stores are not boundless and they will undoubtedly be totally exhausted in the near future. The world's economies are dependent today on crude oil. There is some disagreement among researchers on to what extent this fossil asset will last however, as indicated by scientists, the "peak oil production" has already occurred or it is expected to occur within the next period of time. The peak oil production is defined as the point in time at which the maximum rate of global production of crude oil is reached, after which the rate of production enters its terminal decline [1].

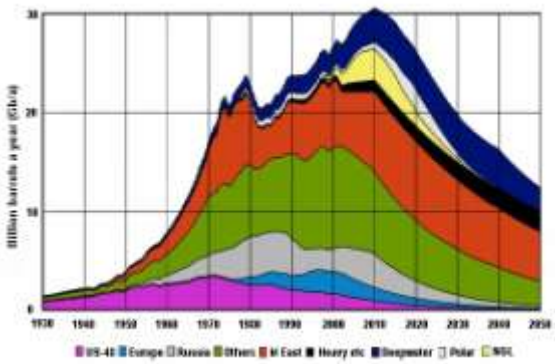

Fig 1. Plot of world oil production and "peak oil" (ASPO 2008) [1]

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II. CARBON EMISSIONS

a. *Global Warming*

It is an unnatural weather change issue realized by a great deal of improvement of greenhouse gas emissions that transforms into the blazing point. Hence, the atmospheric concentrations of greenhouse gases must be kept steadily at a legitimate level and forestall sensational climate change causing harm to human. Carbon dioxide and other gases warm the surface of the planet. Actually by trapping the solar heat, keeping the Earth livable; however when we blaze fossil energizes, for example, coal, gas and oil and clear woods, we drastically expand the measure of CO_2 in the air and temperature rises rapidly [2]. The relative commitment of the major GHG i.e. CO_2, CH_4 and N_2O to a worldwide temperature alteration is 80%, 9.5% and 5.8% separately [2].

b. *Carbon Footprint*

Carbon impression (CF) is a total discharge of greenhouse gases, which created straightforwardly or in a roundabout way through the whole life cycle of the items and/or administrations, communicating in carbon dioxide equals CO_2. The essential greenhouse gas Carbon dioxide (CO_2) is for the most part transmitted through human exercises. It is actually present in the air as a feature of the Earth's carbon cycle (the normal flow of carbon among the air, seas, soil, plants, and creatures). Human exercises are changing the carbon cycle both by adding more CO_2 to the environment and by affecting the capacity of common sinks, similar to woodlands, to expel CO_2 from the air [2].

III. EMISSION MITIGATION

The three most essential methods for reducing the extent of carbon dioxide in the atmosphere are as follows:

1) Efficiency and Conservation: There are numerous energy proficiency and protection methods that lessen the utilization of carbon-based powers (for e.g., regular gas, oil, coal, or gas), diminishing carbon dioxide outflows. Energy protection is the act of diminishing the amount of energy utilized. It might be accomplished through productive energy use, in which case energy use is reduced while accomplishing a comparative result, or by lessened utilization of energy services [4].

2) Carbon-Free and Reduced-Carbon Energy Sources: The other approach to decrease carbon dioxide discharges is to utilize sans carbon or lessened carbon roots of energy. Carbon-free sources of energy have their own related effects, however when all is said in done, these advancements create energy without delivering and discharging carbon dioxide to the climate. Without carbon energy sources incorporates solar power, wind power, geothermal energy, low-head hydro power, hydro kinetics (e.g. wave and tidal power), and also the nuclear power. On the other hand, changing from high-carbon powers like coal and oil, to condensed carbon fills, for instance, regular gas will bring about diminished carbon dioxide releases. The extent to which biomass energy is thought to be without carbon or a decreased carbon fuel depends on upon the sort of biomass used and the methods by which it is changed over to vitality. [4].

3) Carbon Capture and Sequestration: A third option to minimize carbon dioxide in the atmosphere is carbon sequestration. It involves the capture and storage of carbon dioxide that would otherwise be present in the atmosphere, contributing to the greenhouse effect. Carbon dioxide can be removed and held inside plants and soil supporting the plants. On the other hand, carbon dioxide can be caught (either before or after fossil fuel is burnt) and afterwards stored (sequestered) inside the earth [4]

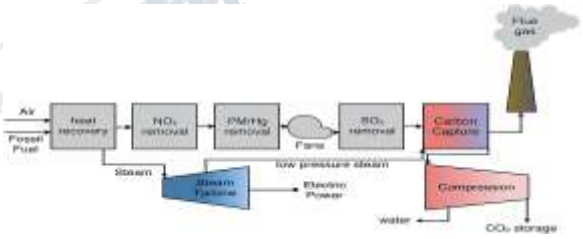

Fig 2: Carbon Capture and Sequestration (Source: Energy & Environ. Sci., 2014, 7, 4132-4146)

IV. INDIA'S POTENTIAL FOR RENEWABLE ENERGY

India has a substantial future for the adoption of renewable energy technologies that goes beyond addressing environmental concerns. The underlying principle is to gain from the current worldwide interest in renewable energy for three reasons [3]:

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1. To take care of the developing demand for energy inside the nation, particularly in provincial territories
2. To diminish GHG outflows and add to environmental change mitigation.
3. To gain by the extending market for renewable energy and secure an early market advantage

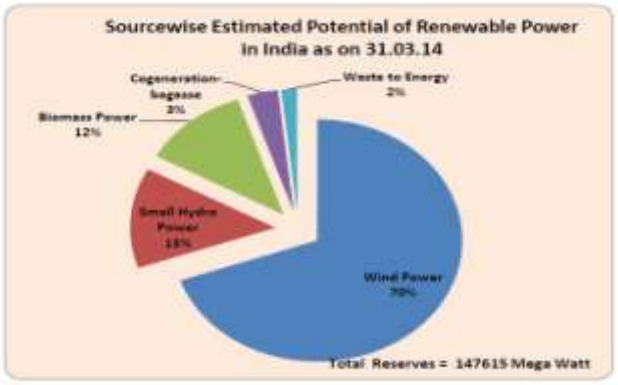

Fig 3. Sourcewise Assessed Potential of Sustainable Power in India as on March 31, 2014 (Source: Energy Statistics 2015)

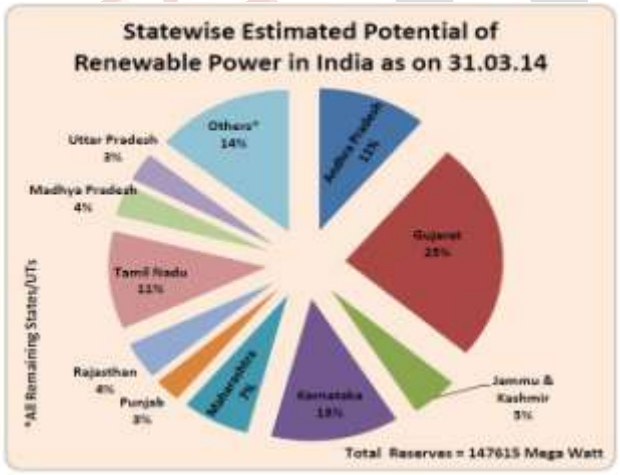

Fig 4. Statewise Assessed Potential of Sustainable Power in India As on March 31, 2014 (Source: Energy Statistics 2015)

The different sources of renewable energy comprising of Solar, Wind, Biomass, Small Hydro and Co-generation Bagasse provides a high potential for generation of renewable energy. The aggregate potential for nonconventional power generation in the country as on March 31, 2014 is evaluated at 147615 MW. This incorporates wind power capability of 102772 MW (69.6%), SHP (little hydro power) capability of 19749 MW (13.38%), Biomass power capability of 17,538 MW (11.88%) and 5000 MW (3.39%) from bagasse-based cogeneration in sugar factories. The geographic circulation of the evaluated capability of renewable power as on 31.03.2014 uncovers that Gujarat has the most astounding offer of around 25.04% (36,956 MW), trailed by Karnataka with 13.08% offer (19,315 MW) and Tamil Nadu with 11.17% offer (16,483 MW), primarily by virtue of wind power potential [3].

V. CLEAN DEVELOPMENT MECHANSISM

The Clean Development Mechanism (CDM) under the Kyoto Protocol has accepted a significant part in supporting Greenhouse Gas (GHG) discharge decrease ventures in India [5]. Till December 2012, the CDM and other business sector components have bolstered the progress and execution of around 3,000 projects from India, out of which around 40% have been selected with UNFCCC [6]. These enlisted ventures represents an investment of over INR 1.6 trillion and have generated more than 170 million Certified Emission Reductions (CERs) that can be utilized by the developed nations to meet their consistence prerequisites under the Kyoto Protocol [6].

The Kyoto Protocol contrived three innovative mechanisms [7], [8]:

- Joint Implementation (JI)
- International Emission Trading (IET)
- Clean Development Mechanism (CDM)

VI. INDIA'S CDM PERFORMANCE

In 1997, the administrations taking an interest in the United Nations Framework Convention on Climate Change (UNFCCC) concurred in the Kyoto Protocol. Amongst the developed and developing nations The Protocol chips away at the rule of regular however separated obligations. [6].

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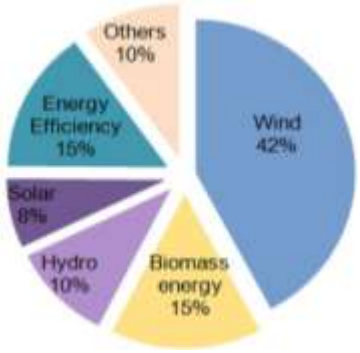

Fig 4: CDM projects in India by type as on March 1, 2015 ***(Source: UNEP DTUCDM/JI Pipeline Analysis and Database.)***

38 Number of nations that settled to honestly required focuses for their outflows of a pack of six greenhouse gases in the affirmation stage 2008-2012 [6]. India has the second rank to hold number of enlisted CDM ventures under the Kyoto Protocol. The campaign of India's CDM is nothing less than remarkable. The majority of the CDM ventures in India are moved in a couple of divisions, specifically, those identified with the renewable energy segment (Fig 4).

VII. CARBON CREDIT THROUGH BIOGAS ENERGY: The Indian Context

Biogas Energy

Biogas is a fuel gas, a mix containing 65% methane (CH4) and of 35% carbon di-oxide (CO2) and is formed from the anaerobic bacterial deterioration of natural mixes of common blends, i.e. without oxygen, creating a renewable energy resulting from biomass. The gases formed are the waste products of the breath of these decomposer microorganisms and the content of the gases relies on upon the substance that is being disintegrated [5].

Composition of Biogas

Biogas is mainly a mixture of methane (CH_4) and inert carbonic gas (CO_2). However the name "biogas" assembles an expansive assortment of gases resulting because of particular treatment forms, beginning from different natural wastes - commercial enterprises, animal or residential source wastes and so forth. The table below shows a typical composition of biogas:

Table I: Typical Composition of Biogas [5]

Compound	Molecular Formula	Percentage (%)
Methane	CH_4	50-75
Carbon Dioxide	CO_2	25-50
Nitrogen	N_2	0-10
Hydrogen	H_2	0-1
Hydrogen Sulphide	H_2S	0-3
Oxygen	O_2	0-0

Significance of Biogas Energy for India

Biogas innovation is being advanced in India primarily overwhelmingly under the segment of vitality. The emphasis on this gets from the critical energy supply circumstance for the people in the Country. India is the distinct nation where the improvement of uncomplicated biogas plants for the Tropics which are easy to work began, after China. Biogas covers an assortment of business sectors, which includes the electricity power, heat and transportation fills. Despite the fact that using the gas for direct burning in family unit stoves and gas lights is normal in a few nations, delivering power from biogas is still moderately uncommon in most developing nations. Power generation is the principle motivation behind biogas plants; change of biogas to power has turned into a standard imaginative innovation in the industrialized nations,. To enhance general productivity of biogas use, consolidated heat and power plants are regularly utilized [5].

VIII. GLOBAL WARMING POTENTIAL, GLOBAL WARMING MITIGATION POTENTIAL AND CARBON CREDIT

A. The Global Warming Potential (GWP):

Global Warming attributes to the general increment in the world's normal temperature, which causes changes in climate patterns across the globe. GWPs are utilized to assess the environmental change effects of different GHG outflows and express them in a solitary unit – carbon dioxide reciprocals (CO2e) – and are essential part to report associations to mull over[10].

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Table II: GWP of Various Green House Gases on 100 Years' Time Horizon [9]

Sr No.	Greenhouse Gases	Global Warming Potential (GWP)
1	Carbon dioxide	1
2	Methane	21
3	Nitrous Oxide	310
4	Hydroflouro-carbons	140-1170
5	Perfluoro carbons	6500-9200
6	Sulphur	23900

Each GHG has a substitute breaking point for catching and re-transmitting active infrared radiation in the air, in this way adding to radiative constraining [9]. The net effect of the shorter lifetime and higher energy absorption is reflected in the GWP. It's obvious that the Global Warming Potential (GWP) of the first three greenhouse gases in the above table taken together will be given by the following equation [9]:

$$GWP = CH_4 \times 21 + N_2O \times 310 + CO_2 \times 1 \ldots\ldots\ldots \text{(i)}$$

B. *The Global Warming Mitigation Potential (GMP):*

The term Global Warming Mitigation Potential is used in context of a renewable energy generation project which is designed as an alternative to a conventional fossil fuel based source of energy. The GMP of such a project is the total amount of greenhouse gases that would have been emitted by the conventional source converted to the equivalent amount of carbon dioxide (CO_2) that will have the same global warming potential. This can be the total GMP of a mixture of greenhouse gases emitted from a project will be equal to the sum of their individual Global Warming Potentials [9]. This can be expressed in terms of the following equation:

$$\left\{\begin{array}{l}\text{GMP of a renewable}\\ \text{Energy Project}\end{array}\right\} = \left\{\begin{array}{l}\text{GWP of } CO_2 \text{ equivalent}\\ \text{of total emission reduction}\end{array}\right\}$$

$$= \left\{\begin{array}{l}\text{GWP of } CO_2\\ \text{Emission reduction}\end{array}\right\} + \left\{\begin{array}{l}\text{GWP of } CO_2 \text{ equivalent}\\ \text{of } CH_4 \text{ Emission reduction}\end{array}\right\}$$

$$+ \left\{\begin{array}{l}\text{GWP of } CO_2 \text{ equivalent}\\ \text{of } N_2O \text{ Emission reduction}\end{array}\right\} \ldots\ldots\text{(ii)}$$

C. *Carbon Credit*

It's also known as certified emission reduction (CER). It's a type of reward to the savers of emanation of carbon dioxide. One carbon credit is equal to one ton of carbon dioxide or its proportionate greenhouse gases (GHG). "privileged certificates" in the form of carbon credits are issued by the united nations framework convention on climate change (UNFCCC) to the implementers of the endorsed clean development mechanism (CDM) ventures. The considered carbon credits is set up in the KYOTO protocol, which licenses industrialized countries that agree to carbon tops to meet their sums in part by bank moving emission reducing endeavors at areas where the undertaking will be less unreasonable [9].

IX. THE CASE STUDY

A case study had been carried out at a Bio-Methanation Plant in the state of Maharashtra. The objective was to assess the global warming mitigation potential (GMP) of the plant and the resulting carbon credits.

A. *About the Plant*

The plant under study was 1.5 tons per day (TPD) limit decentralized biomethanation-cum power generation plant sustained by metropolitan waste. The essential objective of setting up this plant was to treat the wet disconnected regular metropolitan solid waste decentralized at source point itself in a most circumstance neighborly way. Consequently, the city municipal corporation of Pune is aided straightforwardly as far as saving money on transportation of such wastes to the landfill site which is just about 22 km from the site [10].

B. *The Biomethanation Process*

The genuine segment of Municipal Solid Waste (MSW) is the common division (40-60%) which can be easily treated by anaerobic assimilation. the solid wastes conveyed in urban zones from vegetable markets, lodgings, motels, kitchen waste and so on are most appropriate for this approach, in view of the proximity of high moistness and common parts (up to 90%).The aggregate solids in the natural waste break down quickly and subsequently these wastes can be dealt with by Biomethanation process (all

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the more usually called Anaerobic Digestion, AD) in more successful way [10].

Fig 7: The biomethanation-cum power generation plant [10]

C. Data Collection

Table III. Plant Operation Details [10]

Particulars	Product
Plant capacity	5 TPD per day segregated organic biodegradable municipal solid waste
Type of Process	Bio-methanation through two stage process
Biogas Generation	300 Cum/day
Electricity Generation	375 kWh/day
Manure Generation	500 kg/day (50% moisture basis)

Table IV: Major Component and specifications of the Plant [10]

Component Name	Quantity	Remarks
Waste Reception and Fine Segregation Section	1	-
Mechanical Crushers	2	5 HP Motor
Two Stage Anaerobic Reactors	200 m^3	With Aeration, Biogas and Leachate Recirculation facility
Manure Handling Section	35 m^2	In BBM
Biogas Collection Section	2 Nos. 75 m^3 each	Neoprene Rubber with enclosure
Biogas Cleaning System	1	CO_2 and H_2S Scrubbers, Pressure Vessel and Vacuum Pump.
Power Generation	40kVA	100% Biogas based Indian Engine
Leachate Recirculation System	1	-
Solar Water Heating System	500 Litres/day	-

2. Calculation of GMP and Carbon Credits

The bio-energy project under study effects emission mitigation in the following three ways:

Through renewable energy generation: This is the direct mitigation achieved through avoidance of equivalent energy generated through fossil fuels. In the plant under consideration, assuming a power factor of 1, power generation can be taken as 375kW.

***Through the replacement of chemical fertilizers with organic fertilizers*:** This is indirect mitigation achieved through composting of biogas slurry and its use as organic fertilizer. One ton of manure from the biogas plant is equal to 5.4 kg of Urea (MNRE, 2010). The carbon dioxide emissions from Nitrogen, Phosphorus and Potassium fertilizer production in the units kg kg^{-1} have been sourced from [8]. The following table shows the complete

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calculation for the total emission in terms of CO_2 equivalent per kg of fertilizer production of each type:

Table V: Calculation of Emission due to production of different fertilizers

Fertilizer Type	Emission in kg kg^{-1}			
	CO_2	N_2O	N_2O in terms of CO_2 i.e. N_2O x 310	Total in terms of CO_2 Equivalent
Nitrogen	1.30	0.07	21.70	23.00
Phosphorus	0.20	-	-	0.20
Potassium	0.20	-	-	0.20

***Through a solar water heating system*:** The bio-methanation plant has a 500 litre capacity solar water heating system for heating water to a temperature of 50ºC. The hot water is used for accelerating the bio-methanation process. The amount of emission reduction due to this solar heating system has been computed on the basis of heat imparted to the water that is

$$Q = m \times Cp \times \Delta T \text{……. (iii)}$$

With yearly average temperature of the city as 22ºC, the value of ΔT is 33ºC and the amount of heat transferred to 500 litre of water is 69085.5 kJ/day of energy. With this is equivalent to an annual electrical energy saving of 7004.5MWH approximately. This is equivalent to 5806.316 tons of emission mitigation per annum [11].

Estimations:

1. 100% CO2 is produced from exhaust of the engine.
2. Biogas formed after scrubbing is 70-75 % pure
3. Methane and CO2 as 25 %.
4. Methane produced = 225 m^3 and Carbon dioxide =75m^3.

According to Equation (i),
The calculation of Global Warming Potential is for the Bio-Methanation Plant is calculated as

GWP = $CH_4 \times 21 + N_2O \times 310 + CO_2 \times 1$
= 225 x 21 + 0 x 310 +75 x1
= 4800 m^3.

Thus, Global Warming Potential for the Plant is 4800m^3.

According to Equation (ii),
The calculation of Global Warming Mitigating Potential is calculated as

GMP = 1.3* 250 + 0.2* 250 + 0.2 * 250 + 0.07 * 250
= 325 + 50 + 50 +17.5
= 442.5kg CO_2 per day

Therefore the GMP for this renewable Energy project turns out to be 442.5kg CO_2 per day.

V. CALCULATION OF CARBON CREDIT FOR THE PUNE BIO-METHANATION PLANT:

One carbon credit is equivalent to one tonne of carbon dioxide or its equivalent greenhouse gas (GHG)[12].

In India, €24 i.e. 26$ is equal to one carbon credit i.e. `1765 = `1765 x 0.4425 = ` 781per day [12]
The table below comprises the Carbon credits can be earned:-

Table VII: Carbon Credits Earned By Pune Bio-Methanation Plant

SR NO.	CO_2 PRODUCED IN TONNES		CREDITS EARNED IN `
1	DAILY	0.4425	` 781
2	MONTHLY	13.275	` 23430
3	ANNUALLY	161.5	` 285065

Therefore, it is observed that, the annual carbon credits earned will give the maintenance cost, and other expenses involved such as transportation etc. of the plant very efficiently.

VI. CONCLUSION

1. Biogas innovation gives a superb chance to alleviation of GHG and decreasing an Earth-wide temperature boost i.e. global warming. Biogas plant is a valuable innovation for the asset poor agriculturists in developing nations. By a wide margin it has been seen as another vitality source yet now it assumes a noteworthy part in relieving in global warming by substituting cooking fuel and chemical compost.

2. Carbon credit may be the cost reducer or cost gainer. It should be considered as intangible assets as it is invisible and can be sold.
3. The GWP, GMP and Carbon Credits for the Bio-Methanation Plant have been finished dynamically and it offers rise to become such diverse plants in various parts of India. India has a broad potential to obtain carbon credits and in this setting the carbon consultancy organization connection the carbon consultancy administration has a larger part to play and is going to add another measurement to the Environmental consultancies and financial related administrations enclosure.

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