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Techno-economic feasibility report to reduce carbon footprint of JSPM campus

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ABSTRACT

The basic idea of becoming Carbon Neutral or Carbon Negative is to reduce greenhouse emissions from direct and indirect sources such as electricity, transportation, solid waste, sewage waste, etc. These are potential sources of CO_2 emissions which release a large amount of CO_2 into the atmosphere. The accumulation of CO_2 causes a serious impact on health and the environment. Also, there is a high cost for the generation of electricity which is uneconomical to our college. Following are the tasks which need to be accomplished to become Carbon Neutral: To identify various potential direct or indirect sources of carbon emission in JSPM campus which can be processed on the alternate energy source. To find out the CO_2 equivalent of each identified sources. Working out on an alternate solution for the identified source within the existing conditions. To determine the techno-economic feasibility of suggested techniques. This paper discusses the various economical steps to reduce the Greenhouse Gases and they are implemented around the campus. These plans include: (a) Electricity: Analyze various electrical equipment and find their overall CO2 emissions per year and suggest feasible solutions to reduce the content of CO_2 by the installation of solar panels and photovoltaic cells. (b) Vehicular Emission: Reduce the vehicular pollution using solutions like carpooling systems within the campus and replacing petrol and diesel by CNG's. (c) Sewage Waste: The CO_2emissions can be reduced by various techniques like reducing the BOD of the sewage treatment water.

Keywords— *Carbon emission, Greenhouse gas, Sustainable energy, Carbon neutrality*

1. INTRODUCTION

Energy is a very important aspect in all sectors for any country's economy. The economic development of any country is closely linked with the consumption of energy. Coal and gas are conventional sources of energy and available in limited forms. Both these sources are important for electricity generation. It is very necessary to optimize the use of natural resources and it is necessary to avoid energy crisis. Energy demand has increased as its consumption is increased so proper energy conservation methodology need to be adopted. Wasteful use of energy can be avoided by energy conservation. Energy saving achieved through energy efficiency and conservation avoids capital investment in mining, fuel, water, transport and land required for power plant, thereby mitigating environmental pollution.

1.1 Need of Carbon Neutrality

Carbon Neutrality is defined as the action of various organizations, universities and individuals taking action to achieve zero carbon footprint and remove as much as CO_2 from the atmosphere**.** It can be achieved by various methods like installation of solar panels, setting up of wind turbines, using carpooling techniques, recycling of solid waste, etc.

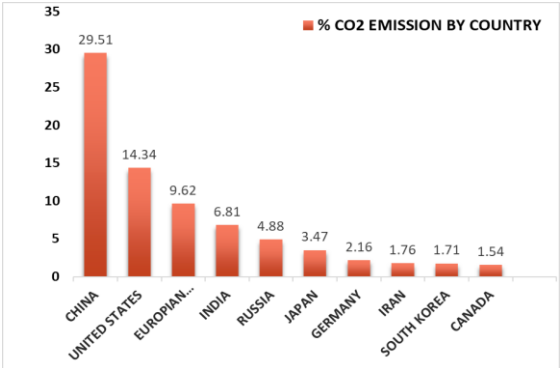

Fig. 1: Top 10 CO_2 emitting countries

Climate change is one of the most serious challenges the world is facing. Various problems or difficulties arise such as an

increase in temperature, increase in water level in ocean, health problems in humans, etc. Hence, to solve these problems related to climate change, Carbon Neutrality should be achieved. However, it is impossible to get zero carbon emission but we try going Carbon Neutral. We can become carbon neutral by purchasing carbon offsets which are practical, affordable and easily available to neutralize the emissions.

1.2 Carbon Auditing

The following steps need to be followed for Carbon Auditing:

- The carbon footprints of various elements present in the campus are determined.
- Emissions of various gases in terms of their carbon equivalent is measured.
- Reviewing the use of energy, i.e. Air conditioner, fans and lightings and various electrical appliances.
- Finding an alternate solution of energy that can reduce carbon emissions.

2. LITERATURE REVIEW

Warners and Heun (2007) have worked on carbon neutrality project of Calvin College, Michigan. They have created an inventory of GHG emission and sequestration potential. They came up with a detailed solution to achieve carbon neutrality. They divided the work into five groups as an approach to the project and investigated the following areas:

- Energy use and Purchasing
- Land use and Wastewater management
- Recycling and Solid waste management
- Construction and Renovation
- Transportation

Kevin P Crosby (2010) has studied the environmental sustainability of Taylor University, Indiana. The assessment is divided into main sections of finance, administration, operation and people. Most of the emphasis is on operations which consisted of various categories like carbon emission, energy, transportation, waste, etc. The main aim of his project was to provide data for benchmarking and to improve the sustainability of the university.

Aroonsrimorakot, Yuwaree (2013) have studied the carbon footprint of Mahidol University, Salaya Campus, Thailand. Their study focused on the importance of measuring the amount of GHG or carbon footprint by calculating the GHG emissions in units of CO_2 equivalent from the activities of the university with the data collected from various sources such as electricity, water supply consumption, and quality of wastewater, garbage and amount of fuels used. Then these data are multiplied by the emission factor to get the carbon emission of the university.

P. B. Londhe, s. M. Bhosale (2015) have studied that vermicomposting is the process of conversion of organic wastes by earthworm to valuable humus-like material which is used as a natural soil conditioner. Vermicomposting is environment-friendly and cost-effective technique for solid waste management. It helps mainly in two purposes, i.e. Degradation of solid waste and cast produced during this process is used as a natural fertilizer. This technique is better than using chemical fertilizer. It consists of methods like pre-composting, collection of material, collection of earthworm species (EISENIA FETIDA) and substrates used for vermicomposting.

S. V. Khirade, S. S. Shastri (2016) have developed a strategy to make SCOE campus carbon neutral. The ultimate aim of their project is to study the carbon emission occurring on campus and develop a strategy to reduce the carbon footprint. This project is an attempt to reduce carbon emissions by suggesting various techniques based on techno-economic feasibility.

The objective of their project work was:

- Creating an inventory of GHG emission.
- Coming up with detailed solutions to achieve carbon neutrality.
- Working out a practical schedule to implement those solutions.
- Developing a realistic plan to finance the process to achieve carbon neutrality.

3. METHODOLOGY

The following steps need to be implemented to achieve Carbon Neutrality:

- Counting and Analysing
- Action
- Reduction
- Evaluation

3.1 Counting and Analysing

The analysis of various natural and man-made activities and emission coming from it is calculated. The activities which can be reduced are first identified without affecting the existing environment. Carbon calculators are easily available online which significantly vary in their uses and parameters they analyse.

3.2 Action

To reduce carbon footprint or emissions, various administrations and universities are undergoing strict actions such as cutting their energy resources, using more renewable resources, etc.

3.3 Reduction

This is the most important step to reduce the carbon footprint. In this step, various alternative method or solutions such as the installation of solar panels or erection of wind turbines, carpooling techniques, etc. are used which will restrict the use of energy and reduce the emissions.

3.4 Evaluation

This step includes a collection of all the above data and it is evaluated for upgrading and to achieve Carbon Neutrality.

After the evaluation is completed, the cycle is restarted again and experiences of previous lessons are learnt. From this, technology is upgraded, demand in the standard of living is uplifted and the overall improvement of a building is carried out.

4. CALCULATIONS

4.1 Emission from Electricity

Estimation of carbon emission from electricity is done on the basis of the consumption of electricity per kW. It consists of power generated from Fans (60W), T12 Tube lights (40W), T8 Tube lights (32W), Wall fan (20W), Bulb (15W), Concealed lights (10W).

The emission factor of electricity is 0.81.

The total CO_2 emission from the campus is calculated by using the equation:

$$CO2\ emission\ per\ day = Emission\ factor \times Use\ of\ electricity\ (kW)$$

Total use of electricity in JSPM Campus is 322.212 kW.

Therefore,

$$Total\ CO2\ emission\ from\ JSPM\ Campus = Emission\ factor \times Use\ of\ electricity$$

$$= 0.81\ x\ 322.212$$
$$= \mathbf{260.99\ KgCO2e/day}$$

4.2 Emission from Vehicle Pollution

Emission from vehicular pollution is done on the basis of a number of vehicles and distance travelled in the entire campus by the vehicles. Emission factor for vehicles ***(www.epagov.in).***

Vehicle	Emission factor
Bike	0.343
Car	0.189
Bus	0.056

Total CO_2 emission from the campus is calculated by using the equation:

$$CO2\ emission\ per\ day = Emission\ factor \times No.of\ vehicles \times Distance\ travelled$$

Therefore,

$$Total\ CO2\ emission\ from\ JSPM\ Campus = 88.866\ KgCO2e/day$$

4.3 Emission from Sewage Treatment Plant

$$\boldsymbol{CO2\ emission\ per\ day\ from\ sewage\ plant = 10-6 \times QWW \times OD \times \eta \times CFCO2 \times [(1-MCFWW \times BGCH4)\ (1-\lambda)]}$$

Where,

Q_{WW} = Wastewater influent flow rate (m^3/hr)

OD =BOD_5 or COD (mg/l),

η = Oxygen demand removal efficiency of the biological treatment plant,

CF_{CO2} = Conversion factor for maximum CO_2 generation per unit of oxygen demand,

MCF_{WW} =Methane correction factor for wastewater treatment plant (Taken as 0.3),

BG_{CH4} =Fraction of carbon as CH_4 in generated biogas (Generally taken as 0.65),

λ =Biomass yield (Generally taken as 0.45),

Therefore,

$$Total\ CO2\ emission\ from\ JSPM\ Campus = 10-6 \times QWW \times OD \times \eta \times CFCO2 \times [(1-MCFWW \times BGCH4)\ (1-\lambda)]$$
$$= 10-6 \times 53.33 \times 73.97 \times 0.9313 \times [(1-0.3 \times 0.65)\ (1-0.45)]$$
$$= 8.13 \times 10-4\ MgCO2e/day$$
$$= \mathbf{0.813 KgCO2e/day}$$

Hence,

$$Total\ CO2\ emission\ from\ JSPM\ Campus\ from\ various\ sources = 260.99 + 88.866 + 0.813$$
$$= \mathbf{350.669 KgCO2e/day}$$

5. REDUCTION TECHNIQUES

5.1 Emission from Electricity

- Replacing fans and tube lights by solar panels instead of operating them on the conventional electric source.
- Replacing filament bulbs by LED bulbs.
- Use of power-grid system instead of an open or closed system.
- In windy areas, running electric source by using wind turbines.

5.2 Emission for Vehicle Pollution

- Replacing petrol and diesel by natural gas like CNG.
- Vehicle inspection programs like PUC and regular check-up of cars and plants.
- Catalytic converters are fitted between the engine and exhaust pipe.
- Oxidation catalyst can be fitted to petrol and diesel vehicles.
- Use of electric cars as well as hybrid cars as well as carpooling techniques.
- Existing greenery near parking and around college campus can reduce up to 50% of CO_2 emission.

6. CONCLUSION

- Direct and indirect sources of carbon dioxide in the campus were identified.
- The carbon equivalent of each of the given sources was determined.
- Reduction techniques like solar panels for electricity, carpooling techniques for vehicular pollution and reduction of BOD for sewage treatment plant was implemented.
- The total CO_2 emission from the identified sources of electricity, vehicular pollution and sewage treatment plant is 350.669KgCO_2e/day.

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