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Greenhouse Gas (CO_2, CH_4 & N_2O) Emissions from Electricity Consumption in Private Sectors Universities of Karachi.

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ABSTRACT

Increasing greenhouse gas (GHG) emissions is worsening the climate change and its impacts all over the world. Currently there are number of techniques to estimate the GHG emissions and their concentration in the atmosphere. This study estimates the GHG (carbon dioxide, methane and nitrous oxide) footprint based on the one-year average fossil fuel consumption in selected Private Sector Universities of Karachi. The annual average GHG emissions from all of the universities were calculated to be 2,183.84 Tons of carbon dioxide (CO_2), 41.3544 kg of methane (CH_4) and 7.2612 kg of nitrous oxide (N_2O). The CO_2 emission from individual universities were in the range of 800 to 5,000 tons per year. Similarly, the CH_4 was emitted in the range of 15-90 kg per year. N_2O emission from all the selected universities was found very low in the range 2-16 kg per annum. The study found that the overall rate of GHG emissions is rapidly increasing with an increase in fuel consumption resulted from high number of enrollments in selected universities. Study recommends the energy saving measures and the transition from fossil energy to renewable energy.

Keywords: Photovoltaic, Carbon dioxide, Renewable Energy, Energy Conservation, Sustainable Energy, Solar Power, Greenhouse gas emission.

1. INTRODUCTION

Since the beginning of time the humans require energy in various forms (Kreith, 1990). We get most of this energy from burning fossil fuels and even after the creation of electricity, majority of this electricity is generated using/burning fossil fuels (Munez,2019). Similar to many other countries, Pakistan's energy mix for power generation mostly consist of the fossil fuels (Alasai et al. 2017). Electric power in Pakistan comes from an extensive spread of sources. These all-combined make Pakistan's energies mix a rich blend of numerous Energy Generation Sector. However, Thermal Sector dominates this Energy Mix (Memon, 2006).

The main sources of energy in Pakistan include coal, nuclear, CNG, LPG, and natural gas. Main energy is the energy that is found in unprocessed fuels and other types of energy that are introduced into a system as input. Renewable or nonrenewable sources of energy can be used for primary energy. The converted form of energy in usable form, such electricity, is referred to as subordinate energy. Hydropower, solar, wind, and biomass energy are examples of renewable energy sources in Pakistan (Malik et al. 2019).

Successive discoveries of large natural gas reserves have shaped Pakistan's energy history since the 1950s [6]. These flashed, in the 1960s, the growth of the domestic fertilizer industry and large public-sector gas distribution services (Mulvaney et al. 2019). All the major power plants built by the government between the mid-1970s and the 1990s were dual fuel, with natural gas as the primary fuel. In 2005, gas accounted for roughly half of Pakistan's major energy mix (Ministry of Energy, 2018). Gas output has plateaued since then, in the absence of substantial gas field additions, and imported oil has begun to cover an increasing share of the energy requirement. Higher coal and LNG imports have recently helped to compensate for the declining share of local gas supply. In 2017–18, Pakistan's indigenous gas supply accounted for 35% of total primary energy supplies, while oil contributed for 31% of total supplies (International Energy Agency, 2011).

Global climate change is widely acknowledged to be primarily caused by rising greenhouse gas (GHG) emissions as a result of growing fossil fuel use (Wuebbles & Jain, 2001). Over 30 gigatons (Gt) of emissions were thought to have been produced globally in 2010 (Pratt, 2010). About 12 Gt (or 40%) of the emissions from the electricity production sector come from the combustion of fossil fuels like coal, oil, and natural gas to produce the heat required to power steam-driven turbines. Burning these fuels releases carbon dioxide, the main "greenhouse gas" that traps heat and contributes to global warming, as well as other nitrogen and Sulphur oxides that have a variety of adverse effects on the environment (Ministry of Energy, 2018). The electricity industry was blamed for the global GHG emissions in 2014. According to the

IEA (2017), CO2 accounts for 90% of all greenhouse gas emissions, followed by N_2O at 1%, CH_4 at 9%, and miscellaneous gases at 14%. Climate change has an impact on all of these things: weather variations, household income, poverty, agricultural and forestry products, local livelihoods, household revenue, and field growth income. Water supply, harvest patterns, livestock, forests, biodiversity, coastal zones, and other aspects of Pakistan's economy are only a few of the sectors that are directly impacted by the environmental change weights (Baig & Baig 2014). This is one of the most complex and dangerous environmental problems as a result. The global society has decided to limit the global desired temperature to 20C till the current century in order to lessen the effects of claims of atmosphere change. All in all, these assurances are referred to as the Intended Nationally.

Although wind and solar energy are "free," the amount of construction materials consumed per unit of electricity or hydrogen produced for a "renewable" plant is frequently substantially more than for traditional natural gas-based electricity and hydrogen production (Granovskii et al. 2006). Renewable energy technology gets power from natural sources such as the wind, sun, and biomass, and it is a feasible choice for meeting energy demands while also being environmentally friendly (De Vries, 2007). One of the key advantages of renewable energy is that it produces substantially less greenhouse gas than fossil fuels. Because renewable energy technology emits less GHG it can assist to prevent global warming. Solar panels are one method that renewable technology is currently being implemented in universities; a typical solar system may meet the energy needs of an entire university (Pearce, 2002). To limit the consequences of Green House Gas, it is necessary to provide a clear overview of Greenhouse Gas emissions from conventional fuels (Energy, 2018). This study will look into Pakistan's power sector's CO2, N2O, and CH4 emissions. The creation of short- and long-term emission reduction plans (using solar and thermal power, respectively) for environmental protection has as its consecutive goals the balance of payments (BoP), economic growth (EG), energy security (ES), and environmental sustainability. Load shedding has escalated to five hours in Pakistan as a result of the current 6000–7000 MW electrical shortage (The Nation Pakistan 2018).

About 136,532.70 GWH of electricity are produced nationwide in Pakistan. Approximately 82,195 GWH, or 60% of the nation's total electricity production, is generated from fossil fuels (Eggleston et al. 2006). The total annual amount of greenhouse gases caused by human activity (CO_2) released has been rising significantly over the past ten years. The longer the mitigation measures are delayed, the harder it will be to achieve low long-term emissions, and the more limited the mitigation alternatives will be. Now that the 21C objective has gained widespread acceptance, it is necessary to limit the temperature increase caused by human activities in accordance with this fundamental limit (Generation KE, 2019). Therefore, it is imperative to drastically cut CO_2 emissions, particularly those from the electricity generation system. The sooner this is accomplished, the better it is (NEPRA, 2020). A zero CO_2 emitting economy must be realized.

The objectives of this research are to determine the amount of GHG emissions from electricity consumption in selected universities. GHG emission in this research accounts for the electricity supplied by the K-electric and the backup generators in the respective universities. Study estimates the average greenhouse emission from the burning of fossil fuels. This research also helps to estimate the alternate and renewable energy sources to replace with fossil fuels. Such estimations may be useful in other parts of the country as well.

2. MATERIAL AND METHODS

2.1 Emission Factor Data

It is noted from Table 1 that as per intergovernmental panel on climate change the emissions of coal, petroleum and natural gas for Pakistan are standardized as per given emission factors and therefore can be utilized as per the requirement of analysis (IEA, 2017).

Table 1: Standard Emission Factors of Fossil Fuel

Fuel Type	Emission Factor	Unit
Coal	0.094	Tons CO_2e/ GJ
Petroleum	0.072	Tons CO_2e/ GJ
Natural Gas	0.0503	Tons CO_2e/ GJ

While electricity consumption is defined, electricity generation is the volume of power produced during a certain time by a generator (IEA, 2017). as a source of electricity used for its own purposes. Different sources are used by each nation to produce power. However, a significant portion of GHG emissions is caused by thermal fuels and electricity produced using coal. Pakistan's Table 2 country-specific emissions are lower since it relies mostly on the production of oil, natural gas, and hydroelectric electricity. Power-related emissions are categorized as indirect emissions, which

indicates that when we use electricity, we are also indirectly contributing to emissions created during the electricity producing process. The transmission and distribution (T&D) losses of power in Pakistan were from 20% to 25%, which increased the consumption rate (IEA, 2017).

Table 2: Emission data of CH_4 and N_2O per KWH energy generated & Consumed

Consumption Category	kg CH_4/kWh	kgN_2O/kWh
Electricity (generated)	0.00001383671	0.00000243096
Electricity (consumed)	0.00001798722	0.00000316016
Total	0.00003182	0.00000559112

Energy consumptions details used in this study for GHG emissions analysis of Private sector universities in Karachi are taken through Market research survey of 05 different universities in Karachi Jurisdiction. These universities were visited and energy consumption detail were taken by means of in-person meeting with university's utility department personnel. Five different universities were visited and average of their data was taken to eliminate the error.

The estimation of GHG footprint involves certain key steps (IPCC, 2007). The first step is to set up a boundary or reference point for which Greenhouse gas emissions in Pakistan are calculated. For calculations, guidelines provided by IPCC in 2006 are used. The formula provided by IPCC 2006 guidelines is mentioned in Equation 1.

$$E_{(GHG,\ fuel\ type)} = FC_{(fuel\ type)} \times EF_{(GHG),\ fuel\ type} \quad \text{----------(1)}$$

Here,

$E_{(GHG,\ fuel\ type)}$ = Green House Gas emissions, tons CO_2e

$FC_{(fuel\ type)}$ = Fuel Consumption, TJ

$EF_{(GHG,\ fuel\ type)}$ = Country specific emission factor of selected fuel, tons CO_2e/GJ

2.2 Calculation of CO_2 Emission

Using the fuel consumption data from each university collected and equation (1), CO_2 emissions of respective fuel type are calculated.

Coal

$$41.868\ \text{tj} = 1\ \text{KTOE}$$

$$0.094\text{X}41.868\text{X}7.6\text{X}10\text{^}6 = 29{,}910{,}499$$

Petroleum

$$0.072\text{X}41.868\text{X}20.75\text{X}10\text{^}6 = 62{,}550{,}792$$

Natural Gas

$$0.0503\text{X}8.9\text{X}10\text{^}8 = 44{,}767{,}000$$

The CO_2 emissions for coal, petroleum and natural gas were found to be 29.91, 62.6 and 44.9 million tons of CO_2e respectively. The sum of these emissions will be 137 million tons of CO_2e against 82,195 GWH which is equal to 1.66 KG of CO_2e in per KWH as per below calculation:

$$82{,}195 = 137\ X\ 10\text{^}6$$

$$1GWH = 137\ X10\text{^}6 / 82195$$

$$1GWH = 1{,}666.768\ million\ tonnes\ of\ CO2e$$

$$1GWH = 10\text{^}6\ KWH$$

$$10\text{^}6\ KWH = 1{,}666.768$$

$$1KWH = 1{,}666.768/10\text{^}6$$

$$1KWH = 0.000166\ million\ tonnes\ of\ CO2e$$

$$1KWH = 1.66\ KG\ of\ CO2e$$

3. RESULTS AND DISCUSSIONS

It is noted from Table 3 that the survey results of Private sector universities in Karachi Jurisdiction reveal that 100% of the universities utilize both K-Electric Supply and supply from their dedicated Generator sets. As per survey findings, university 01 have 03, 02 & 01 units of 500KVA, 450 KVA & 100 KVA generators, respectively. University 02 have 03 Units of 500 KVA generators, respectively. University 03 have 02 & 01 unit of 500 KVA and 100 KVA generators, respectively. University 4 has 02 Units for both 500 KVA and 450 KVA, respectively. University 5 have 01 unit of both 500 KVA and 450 KVA generator respectively a total of Furthermore, a range of universities were surveyed as energy consumption of university is directly proportional to its size. Hence, a comprehensive data is gathered by sampling large, medium, small i.e., all private sector universities.

Table 3: Energy Consumption data of Private Sector Universities in Karachi

University NO.	K-Electric (KWh)	Generator (KWh)	Total (KWh)
01	1,917,024	948,924	2,865,948
02	520,956	662,040	1,182,996
03	36,396	485,496	521,892
04	297,036	639,972	937,008
05	374,964	419,292	794,256

3.1 Greenhous Gas Emissions

Table 4 provides the GHG emissions from University # 1 both from K-electric and generators. It is noted from Table 4 that GHG emissions from generators combined are lesser than the emissions if K-Electric supply as it uses the total of 5-10% of the total energy in a year. Therefore, we can say that if K-Electric supply is switched with alternate energy source such as PV Panels than a drastic decrease in GHGs will occur.

Table 4: GHG Emission from University 01

GHG	K-Electric	Generator			Total Emissions
		500 - KVA	450 - KVA	100 – KVA	
		03 Nos.	01 No.	02 Nos.	
CO2	3,182.20 tons	1,098.98 tons	659.39 tons	176.54 tons	5,117.11 tons
CH_4	60.99 kg	21.066 kg	6.31 kg	2.80 kg	91.166 kg
N_2O	10.718 kg	3.70 kg	1.11 kg	0.49 kg	16.018 kg

Table 5 provides the GHG emissions from University # 2 both from K-electric and generators. It is also noted from Table 5 that GHG emissions from generators combined are greater than the emissions if K-Electric supply although it uses the total of 5-10% of the total energy in a year. The reason behind that the university No. 02 is using big capacity of generator for each block. Therefore, we can say that if K-Electric supply is switched with alternate energy source such as PV Panels than a drastic decrease in GHGs will occur.

Table 5: GHG Emission from University 02

GHG	K-Electric	Generator	Total Emissions
		500 – KVA	
		03 Nos.	
CO_2	864.786 tons	1098.98 tons	1963.74 tons
CH_4	16.57 kg	21.066 kg	37.636 kg
N_2O	2.912 kg	3.70 kg	6.612 kg

GHG emissions from University # 3 both from K-electric and generators have been provided in table 6 below. It is also noted from Table 6 that GHG emissions from generators combined are greater than the emissions if K-Electric supply although it uses the total of 5-10% of the total energy in a year. The reason behind that the university No. 03 is using big capacity of generator for each block. Therefore, we can say that if K-Electric supply is switched with alternate energy source such as PV Panels than a drastic decrease in GHGs will occur.

Table 6: GHG Emission from University 03

GHG	K-Electric	Generator		Total Emissions
		500 – KVA	100 – KVA	
		02 Nos.	01 Nos.	
CO_2	60.41 tons	732.657 tons	73.265 tons	866.719 tons
CH_4	1.15 kg	14.04 kg	1.40 kg	16.59 kg
N_2O	0.20 kg	2.46 kg	0.246 kg	2.906 kg

Table 7 provides the GHG emissions from University # 4 both from K-electric and generators. It is also noted from Table 7 that GHG emissions from generators combined are greater than the emissions if K-Electric supply although it uses the total of 5-10% of the total energy in a year. The reason behind that the university No. 04 is using big capacity of generator for each block. Therefore, we can say that if K-Electric supply is switched with alternate energy source such as PV Panels than a drastic decrease in GHGs will occur.

Table 7: GHG Emission from University 04

GHG	K-Electric	Generator		Total Emissions
		500 - KVA	450 - KVA	
		02 Nos.	02 No.	
CO_2	475.257 tons	732.657 tons	659.391 tons	1867.305 tons
CH_4	9.45 kg	14.04 kg	12.63 kg	36.32 kg
N_2O	1.66 kg	2.46 kg	2.22 kg	6.34 kg

GHG emissions from University # 5 both from K-electric and generators have been provided in table 8 below. It can be noted from Table 8 that GHG emissions from generators combined are lesser than the emissions if K-Electric supply as it uses the total of 5-10% of the total energy in a year. Therefore, we can say that if K-Electric supply is switched with alternate energy source such as PV Panels than a drastic decrease in GHGs will occur.

Table 8: GHG Emission from University 05

GHG	K-Electric	Generator		Total Emissions
		500 - KVA	450 - KVA	
		01 Nos.	01 No.	
CO_2	622.44 tons	366.32 tons	317.77 tons	1306.53 tons
CH_4	11.93 kg	7.02 kg	6.31 kg	23.26 kg
N_2O	2.09 kg	1.23 kg	1.11 kg	4.43 kg

Figure 4 shows that university 01 has significantly higher CO_2 emissions than the remaining universities. The reason for the higher emissions is the large scale of the university and hence it has highest consumption of electricity comparative to other universities. From Figure 4 we can observe that the average CO_2 emissions are greater than the individual emission of university 02, 03, 04 & 05 and if alternate energy source is adopted than these average emissions will be reduced.

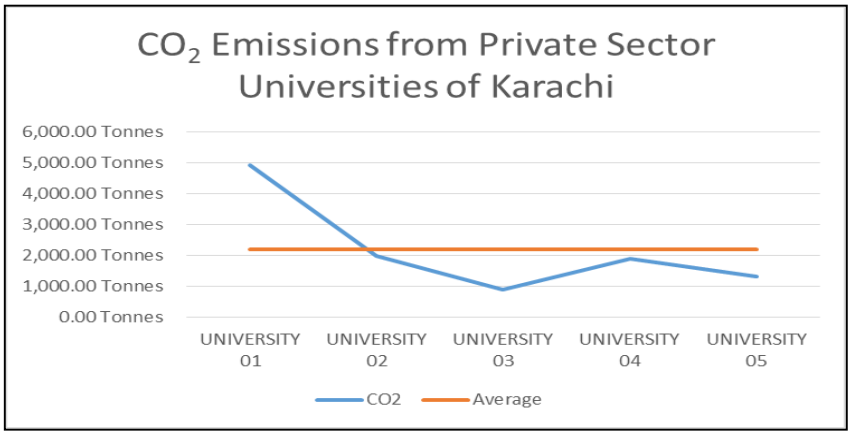

Figure 4: CO2 Emissions from Private Sector Universities of Karachi

Figure 5 shows that university 01 has significantly higher CH_4 emissions than the remaining universities. The reason for the higher emissions is the large scale of the university and hence it has highest consumption of electricity comparative to other universities. From Figure 5 we can observe that the average CH_4 emissions are greater than the individual emission of university 02, 03, 04 & 05 and if alternate energy source is adopted than these average emissions will be reduced.

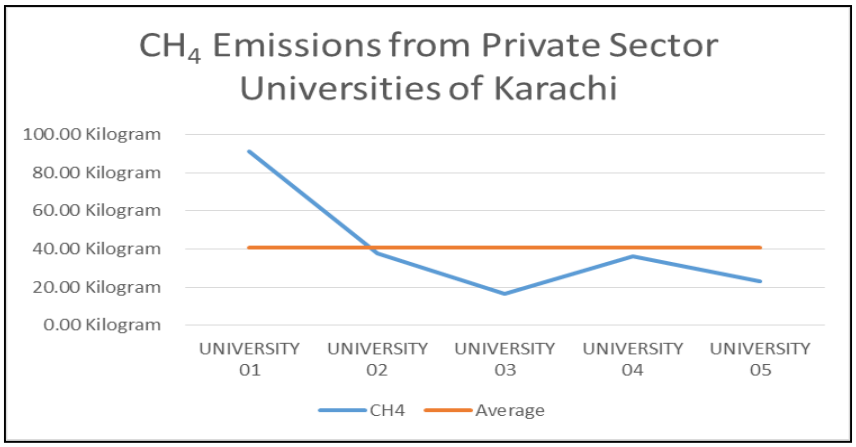

Figure 5: CH_4 Emissions from Private Sector Universities of Karachi

Figure 6 shows that university 01 has significantly higher N_2O emissions than the remaining universities. The reason for the higher emissions is the large scale of the university and hence it has highest consumption of electricity comparative to other universities. From Figure 6 we can observe that the average N_2O emissions are greater than the individual emission of university 02, 03, 04 & 05 and if alternate energy source is adopted than these average emissions will be reduced.

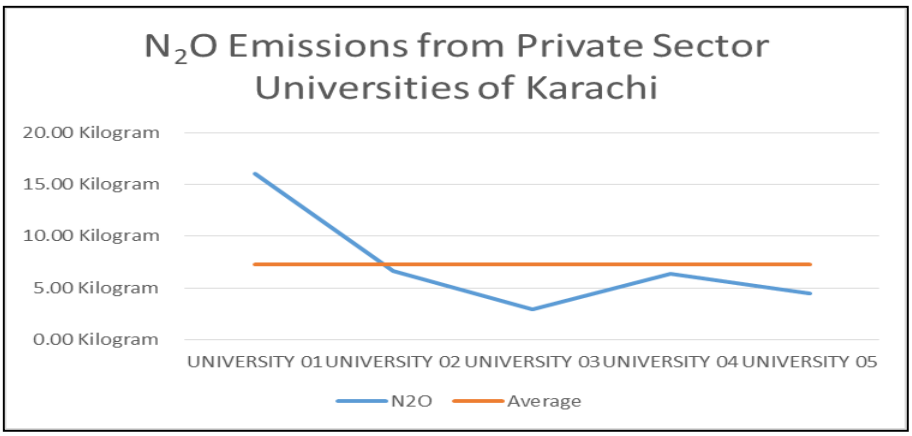

Figure 6: N_2O Emissions from Private Sector Universities of Karachi

3.2 Reduction of GHG Emission

If photovoltaic cell be installed in private sector universities of Karachi, as we already know that it generates power in daytime from 8Am to 6PM at an average, that is mean it able to produce electricity for 10 hours out of total hours of 14 which is operational time of Private sector Universities of Karachi, and rest of the time from 6PM to 10PM Private sector Universities of Karachi power runs on K-Electric. Below is the differentiate of working hours in percentage for how long does photovoltaic K-Electric be operational

$$\boldsymbol{For\ Photovoltaic\ Cell}: Percentage = 10/15 * 100 = 71.42\%$$

$$\boldsymbol{For\ K-Electric}: Percentage = 4/15 * 100 = 28.57\%$$

4. CONCLUSIONS

Carbon footprint analysis is used to measure total greenhouse gas emissions directly or indirectly related to our related systems. The average GHG emissions were calculated to be 2,224.28 tons of CO_2e 41.3544 kg of CH_4 and 7.2612 kg of N_2O in 2021. Therefore, proper care is needed to deal with these emissions to avoid harmful effects on the environment. Burning fossil fuels increases carbon dioxide, Nitrous Oxide, and methane concentration of carbon dioxide in the environment, leading to global warming through a mechanism commonly known as the greenhouse effect. The importance of switching to renewable resources (photovoltaic cells) reduces global warming as it reduces our atmosphere. Similarly, the use of photovoltaic cells to power the Private sector universities of Karachi is also of immense importance, as it can reduce GHG emissions and thus plays a role in reducing global warming. Therefore, the management of the Private Sector University of Karachi needs to take some serious measures to deal with this rapidly increasing emission. The management should invest in research and development related to climate change research. Air quality must be monitored regularly, and severe measures must be taken against those who do not meet environmental standards. Another solution is to use renewable energy to meet the energy needs of Private Sector Universities of Karachi.

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