2.0 Methodology

Estimation of emissions (emission inventory) of air pollutants from operating and proposed thermal power plants in Nigeria was done using emission factors of stationary gas turbines for electricity generation in AP-42 of the United States environmental protection agency (EPA, 1995) (Table 3). Other inputs were the thermal plants capacity (Tables 1), potential natural gas consumption rates of about 0.39 MMScf for 1 MW (Sonibare and Akeredolu, 2006), and the number of days the plants will be available for operation per annum which was taken to be about 300 days. The worst case scenario assuming 100% of the thermal power plant capacity on generation was used.

Table 3 Emission factors used in emission computation

Parameter	Emission Factor Ibs/MMScf
CO	*180*
NO_X	*301*
PM	*6.78*
SO_2	*3.45*
VOC	*2.09*

Source : Extracted from Table 3. 4-1 of EPA (1995).

Emission inventories are the foundation of air quality management. They are developed using emission factors (*EF*s) and associated activity (*A*) information. Emission factors are the mass of pollutant emissions released per unit of the associated process variable. Activities are the related process variable,such as mass of fuel consumed or output produced (Miller, 2006). The emissions (*E*) are then calculated as:

$Emission_{pollutant} = Activity * Emission\ Factor_{pollutant}$

Or

$$E = A \times EF \qquad \text{equation 1}$$

Where

E = emissions, in units of pollutant per unit of time,

A = activity rate, in units of weight, volume, distance or duration per unit of time,

EF = emission factor, in of pollutant per unit of weight, volume distance or duration.

3.0 Results and Discussion

Annual emission generated from thermal power plants using the emission factors approach were reported in Table 4. Uncontrolled calculated emissions ranged between 47.76 – 26747.41, 80.28 – 44727.62, 1.80 – 1004.51, 0.92 – 512.66, 0.55 – 310.57 ton/ annum for carbon monoxide (CO), oxides of nitrogen (NO_x), particulate matter (PM), sulphur dioxide (SO_2), and volatile organic compounds (VOCs), respectively. From the results, overall emission increases as generation capacity increases, since emissions are directly proportional to the volume of a gas required for combustion. The gaseous inventory results showed the significant contribution from thermal power plants among other factors. Power plant with the lowest electricity generation was estimated to generate the lowest emission rate while, those with highest production capacity were predicted to generate the highest emission rate. From the emission inventory of the thermal power plants, NO_x has the highest emission rate while VOCs has the least emission rate. Also, Lagos State has the highest number of thermal power plants, hence will experience the highest level of pollution. The higher the production capacity, the higher the emissions generated.

Table 4: Calculated levels of criteria air pollutants from thermal power plants in Nigeria

Power Plant/ State	**Installed Capacity(MW)**	**Status**	**Fuel type**	**parameters**	**Emissions**	
					$\frac{ton}{annum}$	$\frac{g}{sec}$
Sapele/ Delta	1020.00	Existing	Natural gas	CO	9743.70	375.91
				NO_x	16293	628.61
				PM_{total}	365.99	14.12
				SO_2	186.88	7.21
				VOC	113.14	4.365
Egbin/ Lagos	1320.00	Existing	Natural gas	CO	12609.50	485.48
				NO_x	21085.00	813.50
				PM_{total}	473.56	18.27
				SO_2	241.68	9.33
				VOC	146.41	5.65
Afam/Rivers	969.60	Existing	Natural gas	CO	9262.13	357.34
				NO_x	15448.50	597.55
				PM_{total}	347.85	13.42
				SO_2	177.55	6.85
				VOC	107.57	4.15
Delta- ughelli /Delta	912.00	Existing	Natural gas	CO	8711.97	336.11
				NO_x	14568.34	562.05
				PM_{total}	327.11	12.62
				SO_2	166.93	6.44
				VOC	101.08	3.90
Ijora / Lagos	40.00	Existing	Natural gas	CO	382.06	14.70
				NO_x	638.93	24.65
				PM_{total}	14.36	0.55
				SO_2	7.34	0.28
				VOC	4.41	0.17
Calabar	561.00	Planning	Natural gas	CO	5358.96	206.75
				NO_x	8961.58	345.74
				PM_{total}	201.14	7.76
				SO_2	102.64	3.96
				VOC	62.21	2.40
Ibom power	188.00	Existing	Natural gas	CO	1796.00	69.29
				NO_x	3003.09	115.86
				PM_{total}	67.39	2.60
				SO_2	34.21	1.32
				VOC	20.74	0.80
Papalanto	335.00	Existing	Natural gas	CO	3200	123.46
				NO_x	5351.44	206.46
				PM_{total}	120.27	4.64
				SO_2	61.43	2.37
				VOC	37.07	1.43
Ewekoro	12.50	Existing	Natural gas	CO	119.41	4.61
				NO_x	199.68	7.70
				PM_{total}	4.48	0.17
				SO_2	2.29	0.09
				VOC	1.39	0.05
Omotoso	335.00	Existing	Natural gas	CO	3200	123.46
				NO_x	5351.44	206.46
				PM_{total}	120.27	4.64
				SO_2	61.43	2.37
				VOC	37.07	1.43
Geregu	424.00	Existing	Natural gas	CO	4050.26	156.26
				NO_x	6773.16	261.31
				PM_{total}	152.15	5.87
				SO_2	77.65	3.00
				VOC	46.92	1.81

Akute thermal plant	12.00	Operating	Natural gas	CO	114.63	4.42
				NO_x	191.69	7.40
				PM_{total}	4.31	0.17
				SO_2	2.18	0.84
				VOC	1.33	0.05
Dangote obajana	350.00	Existing	Natural gas	CO	3343.44	128.99
				NO_x	5590.95	215.70
				PM_{total}	125.56	4.84
				SO_2	64.08	2.47
				VOC	38.82	1.50
Omoku power	150.00	Existing	Natural gas	CO	1432.90	55.28
				NO_x	23.96	92.44
				PM_{total}	53.81	2.08
				SO_2	27.46	1.06
				VOC	16.64	0.63
NNPC/Agip	480.00	Existing	Natural gas	CO	4585.25	176.90
				NO_x	7667.65	295.82
				PM_{total}	172.11	6.64
				SO_2	87.87	3.39
				VOC	53.14	2.05
NNPC/Shell	642.00	Existing	Natural gas	CO	6132.67	236.60
				NO_x	10255.51	395.66
				PM_{total}	233.28	9.00
				SO_2	117.42	4.53
				VOC	71.28	2.75

From the results of the emission inventory, it can be seen that the thermal power plants are the major sources of gaseous emissions. Among these gaseous emissions, the largest emission is from NO_x and CO. The NO_x and CO emitted from natural gas combustion is very higher than expected. This is not surprising since the carbon content of natural gas is higher compared to unit of heat input. Emission from thermal power plant are generally high while using natural gas as a fuel. The factor was significant information for the decision of policy makers. They can use the factor for planning to control the emissions from power generation by using appropriate proportions of fuel type. Finally, the policy will be covered for all point of view both environment, economic and reliable of grid system as well.

4.0 Conclusion

The study focussed on emission inventory from thermal power plants in Nigeria. Annual emissions of CO, NO_x, PM, SO_2 and VOCs were calculated. Then emission factors of stationary gas turbines for electricity generation in AP-42 of the United States environmental

protection agency (EPA, 1995), were used, emission inventories of the electricity generating from thermal power plant was conducted at each thermal power plant. From the results, it can be concluded that annual gaseous emissions increased due to increasing electricity generation, hence increased fuel consumption. In terms of contribution of emission to the atmosphere, thermal power plants releases larger quantity of emission.

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