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Development of Evaluation Models for Estimation of Economic Values of Natural Gas Fractionation in the Niger Delta

Udie, A. C.[1], Nwakaudu, S. M[2].
[1](Department of Petroleum Engineering, Federal University of Technology Owerri (FUTO), Nigeria
[2](Department of Chemical Engineering, Federal University of Technology Owerri (FUTO), Nigeria)

Abstract: *Natural gas fractionation components and economic values models have been developed in the Niger Delta. The importance is to enhance diversifying utilization, reduce gas flaring, creates fast development, impacts on building the Nation's economy, industrialization and jobs creation in the country. This was possible calculated average Natural gas values, weight, heating value, specific gravity and ratio of the gas components (LNG, LPG and condensate). The resulted fractionation ratio is 85.76% of LNG, 11.61% of LPG and 2.28% of condensate (liquid) with a revenue generation of LNG USD**1.85**/SCF, LPG ₦ **0.41**/SCF and ₦ **0.38**/SCF. The revenue per give time depends on demand and supply.*

Keywords: *Economic values of natural gas fractionation ratio, liquefied natural gas, liquefied petroleum gas and condensate components*

I. Introduction

Natural gas is a compound of carbon and hydrogen as the major elements and some impurities such as: H_2S, CO_2, N_2 and water vapour ($H_2O_{(g)}$) as manor components. The compound CH-bond is called hydrocarbon and combusts in oxygen to produce carbon dioxide (CO_2), water vapour and appreciable energy released that can be used in generating heat, electricity cooking and condensate for gas based power plant for electricity generation as well. Natural gas is found in porous rocks (Reservoirs) either associated with crude oil (called associated gas), in gas reservoir with no crude oil (called non-associated gas) or Coal Beds (called coal bed Methane, CBM). The challenge in this work is to find out the natural gas useful fractions ratios for diversifying utilization and Successful fractionation enhances proper ratios estimations and modelling which results in economic evaluations. Natural gas fractionation is done to multiply its utilization.

i. Liquefied Natural Gas (LNG)

This is natural gas component which contains methane (C_1H_4) and ethane (C_2H_6) only. This component can be liquefied or solidified (chips) for easy transportation management with reduced boil-off value. The major use of LNG is heat energy generation for industrial manufacturing plants (fertilizer manufacturing plant, petrochemicals, soap, and may others) and gas base power plant for electric energy generation.

ii. Liquefied Petroleum Gas (LPG)

This is natural gas component which contains propane (C_3H_8) and butane (C_4H_{10}) only. The major uses of LPG are as cooking gas and industrial tarnishes.

iii. Condensate

This component is the hydrocarbons mixture of pentane (C_5H_{12}), hexane (C_6H_{14}) and heptanes plus (C_7+) used mainly for crude oil stabilization and gas base power plant fuel for generating electric energy for sustainability of life in a country or community.

Many authors worked on gas recovery, processing and sales. Udie and Nwankaudu, (2015)[1] worked on natural gas fractionation in Nigeria for diversifying utilization showed that it contains three useful components or ratios (LNG, LPG and Condensate). Rankine',, (Mid-19th century)[2], a British Physicist and Engineer, 1820-1872 designed an absolute temperature scale in which each degree equals one degree on the Fahrenheit scale, with the freezing point of water being 491.67° and its boiling point 671.67°. Baryon Cycly' (Mid-20th Century)[3] discovered the Subatomic particle that undergoes strong interactions", with a mass greater than or equal to that of the proton, and consists of three quarks. Here It is a gas turbine using compression skid, combustion skid and exhaust unit, releasing heat for electrical generation. National Petroleum Council, NPC, (1984)[4], studied the economics of enhanced oil recovery and developed models for oil marketing. The models were accepted worldwide and they were adopted by OPEC for Oil. Mathematically: $\boldsymbol{Rev = X_s(S - 0.02(40 - API))}$. Zanker, (1973)[5], **p**rovided methods for estimation of NGL recovery fractionator trays efficiencies. He stated that there was no good prior method of estimating tray efficiencies for unsteady or different separations. The reason was that many factors affect tray efficiency: relative vapour and liquid holding `of the tray, physical characteristics of liquid (foaming Viscosity and surface tension), trays characteristics, mechanical design as well as installation. Another factor was the thermodynamic properties used to determine the number of theoretical trays. They recommended O-"Connel correlation model. Tray efficiency of 75 – 85%, $\mu = 0.088cp$, $\propto = \boldsymbol{1.695\ and\ \propto \mu = 0.15}$: $\boldsymbol{T_{NT} = \frac{32-1bioler}{0.8}}$. Williams, (1996)[6] work showed that Liquids recovery in gas-condensate reservoirs is classified under low hydrocarbons fluids reservoirs (marginal oil field), because the techniques, quantity and expenses for liquid (oil) recovery in gas condensate reservoir are off the conventional recovery methods. The quantity of oil to be recovered using gas-injection depends on the quantity of the injected gas invasion and by volumetric depletion depends on the reservoir pressure. The gas invasion value depends on the void spaces in a reservoir to be replaced as a displacing agent. Gas injection gears towards an overall recovery factor of 0.46 to 0.48. The control or dependant parameters are rock permeability uniformity, displacement and injected-gas invasion/swept efficiencies. The recovery value is due to pressure maintenance, sweep efficiency and displacement by the injected gas vapour. If pressure is not enhanced (maintained), low recovery would establish itself through retrograde condensation in the gas-condensate reservoir. Gas re-cycling is only fairly good in a gas condensate with gas-cap, which is overlying by an oil-zone that is also overlain by an active water-drive. In this case the pressure is supported by the aquifer. In the absence of active water-drive, oil-zone can be depleted first, allowing the gas-cap to expand and sweep through the oil-zone, maximizing the recovery. This is because in the absence of active water-drive, the application of gas re-cycling would cause oil to zone into shrink gas-cap and/or the original oil-zone initially displaced by gas, resulting in low recovery. Johnson and Morgan, (1985)[7] worked on gas fractionation control and found out that it operates by using a controlled temperature gradient from top to bottom. The composition of the distillate product is fixed by its bubble point The Bottom is controlled by bubble pint and top by dew point. *Izuwa, et al (2014)*[8] studied optimum recovery of condensate in gas-condensate reservoirs and found out that the highest injection rate was not the optimum recovery factor. They concluded that optimum recovery was by a combination of many factors. *Izuwa and Obah, (2014)*[9] developed a model by integration of exponent design fluid characteristic and reservoir compositional simulation. These predictive models were used to assess the effects of the reservoir production parameters on condensate recovery. They concluded that recycling was best above dew-point pressure. *Maddox and Morgan, (1998)*[10] worked on gas treatment and sulfour recovery and stated that fractionation is a sluggish device, so liquid hold up is fairly large since flow rates are relatively low compared to its flow inventory. They recommended that fractionation should be operated so that the material and energy balances around it are satisfied on a steady state basis. This is because any momentary upsets cause internal unstable operation. Hauseh, (1986)[11], developed a General Pressure Drop Correlation (GPDC) model which is widely used today to size packed Tower for water content adjustment in gas processing and conditioning. The flood point is a function of liquid rate, packing characteristics, Gas and Liquid densities and liquid viscosity. Mathematically: $\boldsymbol{y = \frac{A\,F\,G^2 v^{0.1}}{\rho_g(\rho_L - \rho_g)}\ and\ x = \frac{L}{G}\left(\frac{\rho_v}{\rho_L}\right)^{0.5}}$. Hubard, (1997)[12], studied an independent appraisal of gas dehydration using reflux and fractionation type stabilizers in crude oil and condensate stabilization process. He recommended stabilizer in place of stage separator. The reasons were that stabilizers are more economical and have higher efficiency than stage separators. Brown, (1990)[13] Compared sizes of hydrocarbons separator and explained that large capacity separators have more foam Problems and recommended sizeable ones or fractionation type stabilizer units. Udie, et al, (2014***)***[14], did a comparative study of techniques for condensate recovery and found out that the highest recovery technique was water injection at dew-point pressure. Their result showed that 62% of gas, 25% condensate (liquid) and 13% residual saturation.

II. Materials and Methods

2.1 Materials

The material used in this work were mainly sample data obtained from the inlets and outlets of stages-separators and West African Gas Pipeline feed-up (node) in the Niger Delta. Table 2.1 shows details sample data.

Table 2.1: Gas Sample Analysis Record from Separators *and* WAGP Gas Sample *in Niger Delta*

Gas Sample Component	Stage Separators Gas Sample				WAGP Gas Sample Composition				
	Well-1 % Mole	Well - 2 % Mole	Well - 3 % Mole	Well - 4 % Mole	Well - 5 % Mole	Well - 6 % Mole	Well - 7 % Mole	Well - 8 % Mole	Wee-9 % Mole
CO_2	4.39	4.02	4.11	1.85	2.852	3.220	0.51	1.22	1.65
N_2	4.61	4.53	405	0.04	0.130	0.058	0.13	0.13	0.08
H_2S	-	-	-	-	-	-	-	-	-
C_1	76.41	78.22	80.79	86.85	80.28	83.87	85.37	88.96	89.77
C_2	8.35	8.12	7.66	5.33	8.68	6.89	6.70	5.26	3.95
C_3	4.08	3.57	2.62	3.54	4.90	3.42	4.09	2.70	2.64
iC_4	0.64	0.05	0.28	0.62	-	-	-	-	-
nC_4	0.93	0.68	\0.34	1.05	2.23	1.60	2.21	1.14	1.20
iC_5	0.22	0.14	0.06	0.30	-	-	-	-	-
nC_5	0.16	0.10	0.04	0.28	0.68	0.52	0.99	0.31	0.35
C_6	0.07	0.06	0.02	0.14	0.25	0.423	0.00	0.28	0.36
C_7+	0.14	0.06	0.03	-	-	-	-	-	-
H_2O	-	-	-	-	-	-	-	-	-
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1/00

2.2: Natural Gas Fractionation Ratios Estimation Procedure

2.2.1: Calculation of the Values using Stage Separator Samples

The Weight (M_{gi}), Gross Heating Value (GHV_i) and Specific Gravity (γ_{gi}) of the Natural Gas were estimated using samples collected from stages-separators. These samples data were each collated or grouped into three components liquefied natural gas (LNP), liquefied petroleum gas (LPG) and condensate (Liquid). The ratio of each component was calculated using well-1 to well-9. Table 2.2 shows the estimation procedure of Weel-1 to Well-4. The averages of these values, $\boldsymbol{M_{gi}}$, $\boldsymbol{GHV_i}$ and $\boldsymbol{\gamma_{gi}}$ were also calculated using eqn2,5 and eqn2.6 on each separator values.

Table 2.2a Well-1 Weight, Heating Value and Specific Gravity Estimation

Natural Gas Components	*% Mole yi*	*Mass, g Mi*	*Weight yi Mi*	*(GHV)i Btu/scf*	*Net Heat yi (GHV)i*
CO2	0.0439	44.01	1.9320	-	-
H2S	-	34.08	-	-	-
N2	0.0461	28.01	1.2913	-	-
C1	0.7641	16.04	12.2562	1007.7	769. 9836
C2	0.0835	30.07	2.5108	1768.8	147.6948
C3	0.0408	44.10	1.7993	2517.4	102.7099
iC4	0.0064	55.14	0.3520	3257.4	20.8474
nC4	0.0093	55.14	0.5128	3257.4	30.2938
iC5	0.0022	72.20	0.0588	4071.8	8.9580
nC5	0.0016	72.20	0.1165	4071.8	6.5149
C6	0.0007	86.12	0.0603	4886.2	3.4203
C7+	0.0014	101.00	0.1414	5435.2	7.6993
H2O	-	18.08	-	-	-
Total	1.0000	-	21.1313	-	1098.0320

Table 2.2b Well-2 Weight, Heating Value and Specific Gravity Estimation

Natural Gas Components	*% Mole yi*	*Mass, g Mi*	*Weight yi Mi*	*(GHV)i Btu/scf*	*Net Heat yi (GHV)i*
CO2	0.0402	44.01	1.7692	-	-
H2S	-	34.08	-	-	-
N2	0.0453	28.01	1.2689	-	-
C1	0.7822	16.04	12.5465	1007.7	788. 2220
C2	0.0812	30.07	2.4417	1768.8	143.6266
C3	0.0357	44.10	1.5540	2517.4	89.8722
iC4	0.0005	55.14	0.0276	3257.4	1.6287
nC4	0.0068	55.14	0.3750	3257.4	22.1502
iC5	0.0014	72.20	0.1011	4071.8	5.7005
nC5	0.0010	72.20	0.0722	4071.8	4.0718
C6	0.0006	86.12	0.0517	4886.2	2.9317
C7+	0.0006	101.00	0.0606	5435.2	3.2611
H2O	-	18.08	-	-	-
Total	1.0000	-	20.2588	-	1061.4647

Table 2.2c Well-3 Weight, Heating Value and Specific Gravity Estimation

Natural Gas Components	*% Mole yi*	*Mass, g Mi*	*Weight yi Mi*	*(GHV)i Btu/scf*	*Net Heat yi (GHV)i*
CO_2	0.0411	44.01	1.8088	-	-
H_2S	-	34.08	-	-	-
N_2	0.0405	28.01	1.1344	-	-
C1	0.8079	16.04	12.9587	1007.7	814.1208
C2	0.0866	30.07	2.3034	1768.8	135.4901
C3	0.0363	44.10	1.1554	2517.4	65.9559
iC4	0.0028	55.14	0.1544	3257.4	9.1207
nC4	0.0034	55.14	0.1875	3257.4	11.0752
iC5	0.0006	72.20	0.0433	4071.8	2.4431
nC5	0.0004	72.20	0.0289	4071.8	1.6287
C6	0.0002	86.12	0.0172	4886.2	0.9772
C7+	0.0003	101.00	0.0303	5435.2	1.6306
H_2O	-	18.08	-	-	-
	1.0000	-	19.8223	-	1042.4418

Table 2.2d: Well-4 Weight, Heating Value and Specific Gravity Estimation

Natural Gas Components	*% Mole yi*	*Mass, g Mi*	*Weight yi Mi*	*(GHV)i Btu/scf*	*Net Heat yi (GHV)i*
CO_2	0.0185	44.01	0.8142	-	-
H_2S	-	34.08	-	-	-
N_2	0.0004	28.01	0.0112	-	-
C1	0.8635	16.04	13.8505	1007.7	814.1208
C2	0.0533	30.07	1.6027	1768.8	135.4901
C3	0.0354	44.10	1.5560	2517.4	65.9559
iC4	0.0062	55.14	0.3419	3257.4	9.1207
nC4	0.0105	55.14	0.5790	3257.4	11.0752
iC5	0.0030	72.20	0.2166	4071.8	2.4431
nC5	0.0028	72.20	0.2022	4071.8	1.6287
C6	0.0014	86.12	0.1206	4886.2	0.9772
C7+	-	101.00	-	5435.2	-
H_2O	-	18.08	-	-	-
	1.0000	-	19.2949	-	1138.3877

$$Gas\ Weight,\ M_{gi} = \sum(y_i M_i)\ g \qquad [2.1]$$

$$Gross\ Heating\ Value, GHV = \sum y_i (GHV)_i\ \ MBtu/scf \qquad [2.2]$$

$$\gamma_{gi} = \frac{\sum(y_i M_i)}{M_{air}} = \frac{\sum_i^n (y_i M_i)}{29} = 0.69 \qquad [2.3]$$

$$Gas\ Density,\ \gamma_g = \frac{\sum(y_i M_i)}{M_{air}} = \frac{\sum(y_i M_i)}{29} \qquad [2.4]$$

Stages Separators Average Gas Values

$$M_{gs} = \frac{\sum_i^n (y_i M_i)}{n_w} \qquad [2.5]$$

$$= \frac{21.1313+20.2588+19.8223+19.2949}{4} = 20.13g$$

$$(GHV)_{sg} = \frac{\sum_1^n y_i (GHV)_i}{n_w} \qquad [2.6]$$

$$= \frac{1098.0320+1061.4647+1042.4418+1138.3877}{4} = 1085.0736\ MBtu/scf$$

2.2.2: *Calculation of the Values using West African Gas Pipeline (WAGPS)*

Weight (M_{gi}), Gross Heating Value (GHV_i) and Specific Gravity **(γ_{gi}) of** Natural gas were also estimated using samples collected from the West African Gas Pipeline (WAGPS) feed-up (node). Table 2.3 shows the estimation procedure of Well-5 to Well-9. The averages of these values, M_{gi}, GHV_i and γ_{gi} were also calculated using eqn2,9 and eqn2.10 on each separator values.

Table 2.3a: Well-5 Weight, Heating Value and Specific Gravity Estimation

Natural Gas Components	*% Mole yi*	*Mass, g Mi*	*Weight yi Mi*	*(GHV)i Btu/scf*	*Net Heat yi (GHV)i*
CO2	0.0285	44.01	1.4171	-	-
H2S	-	34.08	-	-	-
N2	0.0058	28.01	0.1625	-	-
C1	0.8387	16.04	13.4527	1007.7	808.9816
C2	0.0689	30.07	2.0718	1768.8	153.5318
C3	0.0342	44.10	1.5051	2517.4	123.3526
C4	0.0160	55.14	0.8822	3257.4	72.6400
C5	0.0052	72.20	0.3754	4071.8	11.4010
C6+	0.0042	86.12	0.3617	4886.2	12.2155
H2O	-	18.08	-	-	-
	1.0000	-	20.8301	-	1182.1225

Table 2.3b: Well-6 Weight, Heating Value and Specific Gravity Estimation

Natural Gas Components	*% Mole yi*	*Mass, g Mi*	*Weight yi Mi*	*(GHV)i Btu/scf*	*Net Heat yi (GHV)i*
CO2	0.0322	44.01	1.2543	-	-
H2S	-	34.08	-	-	-
N2	0.0013	28.01	0.0364	-	-
C1	0.8028	16.04	12.8769	1007.7	845.1580
C2	0.0868	30.07	2.6101	1768.8	121.8703
C3	0.0490	44.10	2.1565	2517.4	86.0951
C4	0.0223	55.14	1.2296	3257.4	52.1184
C5	0.0068	72.20	0.4910	4071.8	21.1734
C6+	0.0025	86.12	0.2153	4886.2	20.5220
H2O	-	18.08	-	-	-
	1.0000	-	20.2285	-	1146.9372

Table 2.3c: Well-7 Weight, Heating Value and Specific Gravity Estimation

Natural Gas Components	*% Mole yi*	*Mass, g Mi*	*Weight yi Mi*	*(GHV)i Btu/scf*	*Net Heat yi (GHV)i*
CO2	0.0051	44.01	0.2245	-	-
H2S	-	34.08	-	-	-
N2	0.0013	28.01	0.0364	-	-
C1	0.8537	16.04	13.6933	1007.7	860.2735
C2	0.0670	30.07	2.0147	1768.8	118.5096
C3	0.0409	44.10	1.8037	2517.4	102.9517
C4	0.0221	55.14	1.2186	3257.4	71.9885
C5	0.0099	72.20	0.7148	4071.8	40.3108
C6+	-	86.12	-	4886.2	-
H2O	-	18.08	-	-	-
	1.0000	-	19.7060	-	1194.0441

Table 2.3d: Well-8 Weight, Heating Value and Specific Gravity Estimation

Natural Gas Components	*% Mole yi*	*Mass, g Mi*	*Weight yi Mi*	*(GHV)i Btu/scf*	*Net Heat yi (GHV)i*
CO2	**0.0122**	**44.01**	**0.5369**	**-**	**-**
H2S	**-**	**34.08**	**-**	**-**	**-**
N2	**0.0013**	**28.01**	**0.0364**	**-**	**-**
C1	**0.8896**	**16.04**	**14.2692**	**1007.7**	**896.4499**
C2	**0.0526**	**30.07**	**1.5817**	**1768.8**	**93.0389**
C3	**0.0270**	**44.10**	**1.1907**	**2517.4**	**67.9698**
C4	**0.0114**	**55.14**	**0.6286**	**3257.4**	**37.1344**
C5	**0.0031**	**72.20**	**0.2238**	**4071.8**	**12.6226**
C6+	**0.0028**	**86.12**	**0.2411**	**4886.2**	**13.6814**
H2O	**-**	**18.08**	**-**	**-**	**-**
	1.0000	**-**	**18.7084**	**-**	**1117.8970**

Table 2.3e: Well-9 Weight, Heating Value and Specific Gravity Estimation

Natural Gas Components	*% Mole yi*	*Mass, g Mi*	*Weight yi Mi*	*(GHV)i Btu/scf*	*Net Heat yi (GHV)i*
CO2	**0.0165**	**44.01**	**0.7262**	**-**	**-**
H2S	**-**	**34.08**	**-**	**-**	**-**
N2	**0.0008**	**28.01**	**0.0224**	**-**	**-**
C1	**0.8977**	**16.04**	**14.3991**	**1007.7**	**904.6023**
C2	**0.0395**	**30.07**	**1.1878**	**1768.8**	**69.8676**
C3	**0.0264**	**44.10**	**1.1642**	**2517.4**	**66.4594**
C4	**0.0120**	**55.14**	**0.6617**	**3257.4**	**39.0888**
C5	**0.0035**	**72.20**	**0.2527**	**4071.8**	**14.2513**
C6+	**0.0036**	**86.12**	**0.3100**	**4886.2**	**17.5903**
H2O	**-**	**18.08**	**-**	**-**	**-**
	1.0000	**-**	**18.7241**	**-**	**1111.8697**

$$\boldsymbol{Gas\ Weight,\ M_{pgi} = \sum(y_i M_i)\ g} \quad [2.5]$$

$$\boldsymbol{Gross\ Heating\ Value, (GHV)_{pg} = \sum y_i (GHV)_i\ \ MBtu/scf} \quad [2.6]$$

$$\boldsymbol{\gamma_{pgi} = \frac{\sum(y_i M_i)}{M_{air}} = \frac{\sum_1^n (y_i M_i)}{29} = 0.69} \quad [2.7]$$

$$\boldsymbol{Gas\ Density,\ \gamma_{pg} = \frac{\sum(y_i M_i)}{M_{air}} = \frac{\sum(y_i M_i)}{29}} \quad [2.8]$$

West African Gas Pipeline Average Gas Values

$$\boldsymbol{M_{gp} = \frac{\sum_i^n (y_i M_i)}{n_w}} \quad [2.9]$$

$$= \frac{20.8301 + 20.2285 + 19.7060 + 18.7084 + 18.7241}{5} = 20.13$$

$$\boldsymbol{(GHV)_{gp} = \frac{\sum_1^n y_i (GHV)_i}{n_w}} \quad [2.10]$$

$$= \frac{1182.1225 + 1146.9372 + 1194.0441 + 1117.8970 + 1111.8697}{5} = 1150.5741\ MBtu/scf$$

2.2.3 Calculation of the Niger Delta Gas Average Values

Average values of Weight (M_{gi}), Gross Heating Value (GHV_i) and Specific Gravity (γ_{gi}) were calculated using the mean values from stages-separators and West African Gas Pipeline (WAGPS) system.

$$\boldsymbol{M_g = \frac{1}{n}\sum_1^n (y_i M_i) = \frac{1}{2}\left[(y_i M_i)_s + (y_i M_i)_p\right] = 19.883\ g = 0.02 Kg/scf}$$

$$\boldsymbol{\gamma_g = \frac{\sum_1^n (y_i M_i)}{M_{air}} = \frac{\frac{1}{2}[(y_i M_i)_s + (y_i M_i)_p]}{29} = 0.69}$$

$$(GHV)_g = \frac{\sum_1^n y_i(GHV)_i}{n_w} = \frac{1}{n_w}\left[y_i(GHV)_s + y_i(GHV)_p\right] = 1117.8Btu/scf$$
$$= 1.12\,MBtu/scf$$

2.3 Development of the Natural Gas Fractions Evaluation Models

Using separators weight values (Well-1 to Well-4), the percentage weight of LPG and gross heating values of LNP and condensate were obtained. Similarly using the *WAGPS* weight values (Wel-5 to Well-9), the percentage weight of LPG, gross heating values of LNP and condensate were also obtained. Conventionally the means of the gas lines were calculated.

Separator Gas Lines (Well-1 to Well-4)

LPG: $\% M_g = \frac{\sum_1^n \% M_{gi}}{n} = \frac{\% M_{g1} + \% M_{g2} + \% M_{g3} + \ldots\ldots + \% M_{gn}}{n} = 10.75\%$ [2.11]

LNG: $\%(GHV)_g = \frac{\sum_1^n \%(GHV)_{gi}}{n} = 86.75\%$ [2.12]

CONDENSATE: $\%(GHV)_c = \frac{\sum_1^n \%(GHV)_{ci}}{n} = 1.71\%$ [2.13]

WAGPS (Well-5 to Well-9)

LPG: $\% M_g = \frac{\sum_1^n \% M_{gi}}{n} = \frac{\% M_{g1} + \% M_{g2} + \% M_{g3} + \ldots\ldots + \% M_{gn}}{n} = 12.47\%$

LNG: $\%(GHV)_g = \frac{\sum_1^n \%(GHV)_{gi}}{n} = 84.77\%$

CONDENSATE: $\%(GHV)_c = \frac{\sum_1^n \%(GHV)_{ci}}{n} = 2.28\%$

Niger Delta Natural Fractionation Ratio (G_{fn})

LPG: $\mathbf{G_{fn}} = \frac{1}{n}\sum_1^n M_{gi} = \frac{1}{2}\left[M_{gs} + M_{gw}\right] = 11.61\ \%\ \mathbf{M_g}$ [2.14]

LNG: $G_{fn} = \frac{1}{n}\sum_1^n \%(GHV)_i = \frac{1}{2}\left[\%(GHV)_{gs} + \%(GHV)_{gw}\right]u$ [2.15]

COND : $\mathbf{G_{fn}} = \frac{1}{n}\sum_1^n \%(GHV)_i = \frac{1}{2}\left[\%(GHV)_{cs} + \%(GHV)_{cw}\right] = 2.28\ \%\text{MBtu}$ [2.16]

$= 85.76\ \%\text{MBt}u$

2.4 Revenue from the Proceeds of Natural Gas Fractionation

Procedure

- Daily Natural Gas Volume, V_g, MMscf, Market Sale Price, S_G and Inflection, $F_{in} = 8\%$
- Market Modifying Factor, $\mathbf{X_G = 1.0}$ ***for sweet Gas and* 0.9 *for Sour Gas***
- Average or conventional modifier, $\mathbf{X_G = 0.95}$ ***since Nigeria gas is sweet***
- Natural Gas Fraction Ratio, $G_{fn} = 85.76\%V_g$ **for LNG**, $G_{fn} = 11.61\%V_g$ **for LPG and** $G_{fn} = 2.28\%V_g$ **for Condensate**
- Nigerian Gas Heating Value, $H_V = 1.12$ MBtu and Weight of Gas, $M_g = 0.02$ Kg

- ***General Revenue generating Evaluation Models for Condensate (liquid) in the Niger Delta***

$$\begin{bmatrix}Revenue\\unit\ time\end{bmatrix} = \begin{bmatrix}Market\\Modifier\end{bmatrix}\begin{bmatrix}Inflection\\\%\ Value,\end{bmatrix}\begin{bmatrix}Gas\\Ratio\end{bmatrix}\begin{bmatrix}Volume\\of\ Gas\end{bmatrix}\begin{bmatrix}Gas\\Price\end{bmatrix}\begin{bmatrix}Heating\\Value\end{bmatrix}$$

$\text{Rev} = [X_G] * [F_{in}]S_G * [G_{fn}]V_g * [H_V]$ [2.17]

$= [0.95] * [1 - 0.08]S_G * [0.0228]V_g * [1.12]$

$\text{Rev} = 0.023\ V_g\ S_G$ [2.18]

- ***General Revenue generating Evaluation Models for LNG in the Niger Delta***

$$\begin{bmatrix}Revenue\\unit\ time\end{bmatrix} = \begin{bmatrix}Market\\Modifier\end{bmatrix}\begin{bmatrix}Inflection\\\%\ Value,\end{bmatrix}\begin{bmatrix}Gas\\Ratio\end{bmatrix}\begin{bmatrix}Volume\\of\ Gas\end{bmatrix}\begin{bmatrix}Gas\\Price\end{bmatrix}\begin{bmatrix}Heating\\Value\end{bmatrix}$$

$\text{Rev} = [X_G] * [F_{in}]S_G * [G_{fn}]V_g * [H_V]$ [2.19]

$= [0.95] * [1 - 0.08]S_G * [0.8576]V_g * [1.12]$

$\text{Rev} = 0.8395\ V_g\ S_G$ [2.20]

- ***Revenue generating Evaluation Models for Cooking Gas) in the Niger Delta***

$$\begin{bmatrix}Revenue\\unit\ time\end{bmatrix} = \begin{bmatrix}Market\\Modifier\end{bmatrix}\begin{bmatrix}Inflection\\\%\ Value,\end{bmatrix}\begin{bmatrix}Gas\\Ratio\end{bmatrix}\begin{bmatrix}Volume\\of\ Gas\end{bmatrix}\begin{bmatrix}Gas\\Price\end{bmatrix}\begin{bmatrix}Wieght\\of\ Gas\end{bmatrix}$$

$$\text{Rev} = [X_G] * [F_{in}]S_G * [\boldsymbol{G_{fn}}]V_g * [M_g] \quad [2.21]$$
$$= [0.95] * [1-0.08]S_G * [0.1161]V_g * [0.02]$$
$$\text{Rev} = 0.00203\ V_g\ S_G \quad [2.22]$$

2.5 Models Applications using Daily Gas Volume

Assumptions

- Daily Gas Supply and Demand is between 1 to 250MMscf/d
- The revenue inflection is only 8%
- Taxation: Income tax is 10% of the Revenue and State tax is 8% of the Revenue
- Capital Expenses (CAPEX) and Operation Expenses (OPEX) must be calculated
- Overhead is 10% of the OPEX and amortization must be calculated with a Bank
- CAPEX value is the loan obtained from a bank to set up the business, so it is the amortization value.

Economic Values from the Proceeds of Natural Gas Fractionation

The estimation of revenue generation from the proceeds accounts for the business income before taxation. Raw LNG is mainly for export selling at USD2.5/SCF or as heating value, $H_v = USD11/MBtu$. In domestic utilization heating value is for electricity generation using LNG or condensate in power base plants selling at N16.44/MBtu. LPG is used as cooking gas selling at N200/Kg. These are the current prices of natural gas proceeds from the fractionation components.

Table 2.5: ***Models Applications using Daily Gas Volume***

Daily Gas Volume V_g, MMscf	**Fraction**	**Evaluation Model**	**Unit Price S_G,**	**Revenue**	
				Internal ₦ $* 10^6$	**Export USD $* 10^6$**
50	LNG LPG Condt	$\textbf{Rev} = \mathbf{0.8395}\ V_g\ S_G$ $\textbf{Rev} = \mathbf{0.00203}\ V_g\ S_G$ $\textbf{Rev} = \mathbf{0.0230}\ V_g\ S_G$	USD2.5/SCF N200/Kg N16.44/MBtu	- 20.30 18.91	104.94 - -
Total				**40.21**	**104.94**
100	LNG LPG Condt	$\textbf{Rev} = \mathbf{0.8395}\ V_g\ S_G$ $\textbf{Rev} = \mathbf{0.00203}\ V_g\ S_G$ $\textbf{Rev} = \mathbf{0.0230}\ V_g\ S_G$	USD2.5/SCF N200/Kg N16.44/MBtu	- 40.60 37.81	209.88 - -
Total				**78.41**	**209.88**
150	LNG LPG Condt	$\textbf{Rev} = \mathbf{0.8395}\ V_g\ S_G$ $\textbf{Rev} = \mathbf{0.00203}\ V_g\ S_G$ $\textbf{Rev} = \mathbf{0.0230}\ V_g\ S_G$	USD2.5/SCF N200/Kg N16.44/MBtu	- 60.90 56.72	314.81 - -
Total				**117.62**	**314.81**
200	LNG LPG Condt	$\textbf{Rev} = \mathbf{0.8395}\ V_g\ S_G$ $\textbf{Rev} = \mathbf{0.00203}\ V_g\ S_G$ $\textbf{Rev} = \mathbf{0.0230}\ V_g\ S_G$	USD2.5/SCF N200/Kg N16.44/MBtu	- 81.20 75.62	419.75 - -
Total				**156.82**	**419.75**
250	LNG LPG Condt	$\textbf{Rev} = \mathbf{0.8395}\ V_g\ S_G$ $\textbf{Rev} = \mathbf{0.00203}\ V_g\ S_G$ $\textbf{Rev} = \mathbf{0.0230}\ V_g\ S_G$	USD2.5/SCF N200/Kg N16.44/MBtu	- 101.50 94.53	524.69 - -
Total				**196.03**	**524.69**

III. Results and Discussion

Results

Table 3.1 shows the Niger Delta average gas Weight (M_{gi}), Gross Heating Value (GHV_i) and Specific Gravity (γ_{gi}). Table 3.2 shows the Niger Delta fractionation components ratios in percentages. Table 3.3 shows the developed models for estimation of revenue generation from the proceeds of the Niger Delta natural gas system. Table 3.4 shows the application of the models on daily gas demand and supply results estimated before tax. Figure 3.1 shows the graphical representation of daily gas (export, USD/day and domestic utilization, ₦/day) revenue generation from the proceeds.

Table 3.1: Niger Delta Natural gas average Values

	Gas Weight (M_{gi}), Kg/SCF	Gross Heating Value (GHV_i), MBtu/SCF	Specific Gravity (γ_{gi})
Value	0.02	1.12	0.69

Table 3.2: Ratios of the Niger Delta Natural Gas Fractionation Components

components	Liquefied Natural Gas (LNG)	Liquefied Petroleum Gas (LPG)	Condensate (Liquid)
Ratio	85.76%	11.61%	2.28%

Table 3.3: Revenue Estimation Models from the proceeds of the Niger Delta natural gas

Equation	Component	Evaluation Model
2.18	Condensate (Liquid)	$\mathbf{Rev} = \mathbf{0.0230\ V_g\ S_G}$
2.20	Liquefied Natural Gas (LNG)	$\mathbf{Rev} = \mathbf{0.8395\ V_g\ S_G}$
2.22	Liquefied Petroleum Gas (LPG)	$\mathbf{Rev} = \mathbf{0.00203\ V_g\ S_G}$

Table 3.4: Results of Revenue from Proceeds Using the Gas Fractionation Models

Daily Gas Volume V_g, MMscf/d	Domestic Utilization Revenue, ₦ $* 10^6/d$	Gas for Export Revenue, USD $* 10^6$
0	0	0
5	4.02	10.49
10	7.84	20.99
15	11.76	31.48
20	15.58	41.98
25	19.60	53.47
30	23.52	62.96
35	27.44	73.46
40	31.36	83.95
45	35.29	94.44
50	40.21	104.94
100	78.41	209.88
150	117.62	314.81
200	156.82	419.75
250	196.03	524.69

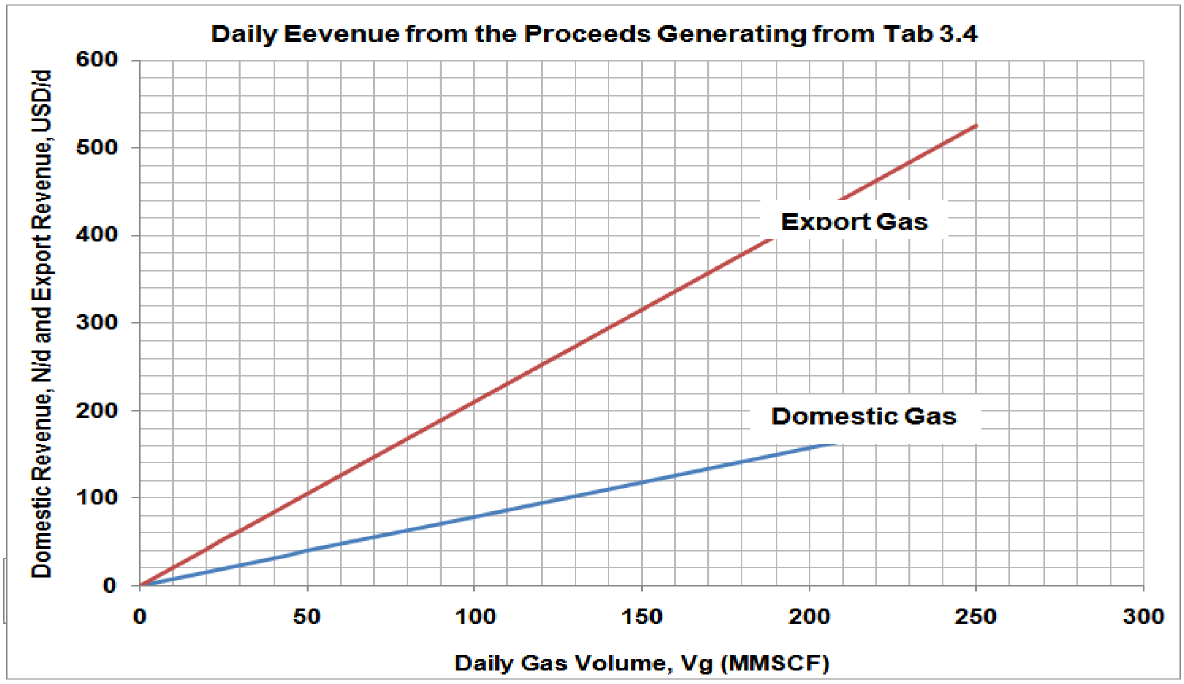

Fig 3.1: Daily Revenue from Proceeds Using the Gas Fractionation Models

Discussion

The average values calculated on Table 3.1 show that Niger Delta natural gas weight is 0.02Kg/scf, heating value is 1.12MBtu/scf and the specific gravity is 0.69. The resulted ratio of the Niger Delta natural gas fractionation components on Table 3.2 shows that LNG is 85.76%, LPG is 11.61% and condensate (liquid) is 2.28%. Revenue estimation evaluation models on Table 3.4 are fractionation components for triple utilization of natural gas of a Nation. This enhances industrialization system. Figure 3.1 shows that economic values of both domestic gas utilization and export gas could be estimated base on daily natural gas volume supplied. Using table 3.1 and table 3.2 the average weight is 0.02Kg and 11.61& of this is the cooking gas (LPG), Average heating value is 1.12MBtu, 85.76% of this is LNG and 2.28 of this is condensate (liquid)

IV. Conclusion and Recommendations

Conclusion

Models for estimation of revenue from the proceeds of natural gas fractionation components in the Niger Delta were developed. This was possible using the natural gas average values gas weight, heating value, specific gravity and the ratio of the gas fractions components were first calculated. Natural gas fractionation components models in the Niger Delta enhance economic values estimation from the proceeds of natural gas of the nation. The yearly revenue depends on the demand and supply and the economic value depends on the CAPEX, OPEX and government taxation policy. The importance of this work is to enhance estimation of revenue of the proceeds from natural gas fractionation in the Niger Delta. The revenue value is the business income.

Recommendations

This research did not work on yearly revalue, capital expenses (CAPEX) or operation expenses (OPEX) for business formation, so I recommend that economic models be developed for estimating yearly revenue of the proceeds from gas fractionation components in the Niger Delta. This will encourage many investors into gas business in Nigeria.

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