

Predictive Models on Viable Options for Liquefied Petroleum Gas (LPG) Distribution: A Case for Small and Medium Scale Enterprise (SME) Commodity in Nigeria.

By

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ABSTRACT

Liquefied Petroleum Gas (LPG), as a product of natural gas processing that is a mixture of hydrocarbon gases mainly propane, butane, butylene and impurities such as Sulphur compound. LPG production and distribution in Nigeria appeared to have had limited growth over the last three decades before 2016. In this study, a stochastic model is applied to secondary historical data from 1994 to 2020, on the production, consumption and streamline distribution pattern for the country. Certain assumptions were made including changes in the various stages in the production value chains (production, storage, distribution, pipeline infrastructure, and supply chains) in-country. Linear regression and correlation approaches were adopted, using the models which agreed with the plots from the Department of Petroleum Resources. It indicated that LPG consumption increased rapidly from 2016 upward following increases in infrastructural surplus, investment and awareness enlightenment initiatives. The results obtained have a strong correlation between demand-supply bond driven by market forces in the urban and suburban cities in-country. These indicators can be considered reliable parameters for sustainable strategic planning, policy development and implementation for rapid economic recovery.

Key Words: Predictive Models, LPG Distribution, SME Commodity, Natural Gas, HydroFlouroCarbon, SulphurHexaFloride, PerFlouroCarbon and Economic Growth.

INTRODUCTION

Petroleum Gas is a mixture of hydrocarbon gases of propane, butane, propylene and butylene with certain impurities from Sulphur compounds etc. A natural Liquefied Petroleum Gas (LPG) is odourless, and formal injection of Sulphur-based agents assists in its sensitivity for leak detection in the value chain. LPG is a useful trade commodity either at the domestic level or on industrial scale as feedstock for economic growth¹. At the domestic levels, LPG serves the useful purposes for cooking (it is common to hear people call it cooking gas), water heating, and space heating etc. It can also be used for automotive vehicular transportation. At the industrial levels, LPG is used for electricity and power generation, feedstock for factories and chemical plants, Petrochemical and Refinery operations etc. Therefore, the essential ingredients for developing stochastic models on LPG distribution in an emerging economy is predicated on available historical data from 1984 to 2020 (WJAR)². The aim of the forecast is to examine the viability options in LPG market in Nigeria for rapid national development. LPG consumption provide alternatives to deforestation, and desert encroachment bane of climate change and coastal degradation in the sub-Saharan Africa.

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¹ Energy Worldwide Resources Market Limited (2010): An assessment of LPG and PNG Demand and Supply trend in Nigeria. Federal Ministry of Petroleum Resources, Abuja. Pp 12 – 46.

² World Liquefied Natural Gas Association Report, April 2015.

The first model captured natural gas production trend and pipeline network infrastructure while the second model highlights an attempt to simulate the behaviour of the market forces subject to the constraints. These constraints together, describe the physical infrastructure together with commercial indices such as existing gas supply chains. Planning and strategic policy constraints are assumed to play key roles in the socio-political decisions on final investment decisions, location and distribution channels, where cost is at minimum and funding is adequately provided³. Fundamentally, the consumption pattern of any commodity determines the size of the market. LPG economy with both industrial and domestic application in Nigeria and its uses in commercial transportation, which is growing acceptable momentum among motorists in recent times could be veritable in small and medium scale enterprise business for economic development. Therefore, the application of statistical tools in the analysis of well-established data from a government regulator in the oil and gas industry provides better insight into the expected trend in LPG market in-country. The predictive models further confirm the trend and offer solutions, which this paper advocates for the growth of the economy. Simplifying LPG distribution would certainly leverage as SME commodity and foster economic transformation⁴. The recoverable LPG product as a function of the produced natural gas over ten years is shown in table 1 below, indicating further the prospects of LPG from available natural gas resources.

GLOBAL HISTORICAL ANALYSIS ON LPG MARKETS.

The global LPG market can be considered in two areas namely; East Suez's covering the Middle East (excluding Turkey) and Far East; West Suez's covering Europe, Americas, former Soviet Union and Africa⁵. The Commonwealth of Independent States (CIS) countries are rapidly utilizing LPG and equally expanding the market trend in the global sphere. For instance, the African market had experienced over 76.2% increase in LPG production and utilization between 2000 and 2012. Analysis have shown that between 2000 to 2008, the production rose from 15million tones to 18million tones. Moreover, between 2008 to 2012, the upsurge in production rises 22million tones mainly products from Algeria and Nigeria. The increase is about 28.5 million tons in 2017 because of the refinery operation in Ghana and Namibia. 5% of LPG demand is concentrated in the Northern Coast and 95% of LPG consumed by the residential and commercial segment against 5% utilization in the industrial sector essentially needed to boast economic recovery. National economic growth is dependent on available resources of the Nation. Table 2 highlights progress in natural gas production, which in turn increased the LPG output within ten years.

Major consumers of LPG in the African markets include Algeria, Egypt. Morocco and the expanding market in Ghana. Nigeria is trailing behind even with the vast population and ever lucrative market for rapid economic growth. On a percentage scale, LPG production has increased from 56% in 2012 to about 68.7% in 2016 with over 66% of global production from Oil and Gas fields. This can vary significantly on a regional basis, depending on the concentration of regional refining capacity relative to regional Oil and Gas production. Niger Republic and Chad are expected to boast the production in the West African sub-region, while the Dangote Refinery is equally estimated to increase the Nigeria's production level by 5% in year 2020. Brazil is the

³ Goodhead, B.E and Iyagba, E.T (2012): Economic Analysis of a Refinery; Proceedings of the 1st International Conference on Petroleum Refining and Petrochemicals. Port Harcourt. Pp 113-121.

⁴ Tony Ogbuigwe (2018): Refining in the age of electric cars: Petroleum technology Development Fund 4th Quarterly Lecture Series; PTDF Building Abuja Nigeria. Pp 7-8.

⁵ Energy Market International Limited, United Kingdom (2010): Natural Gas Distribution and Renewable Energy Reports; Pp 98 – 101.

largest consumer in South America, accounting for 40% of the regional demand with huge supply from Argentina because Brazilian natural gas network is not fully developed for LPG production.

OUTLOOK OF THE NIGERIAN LPG PRODUCTION.

Nigeria is ranked the 7th largest World gas reserve province with about 188.7TCF and high potential for more discoveries especially with the intense exploration activities in the hinterland across the country. More gas discoveries and reserves documentation would imply availability of gas for domestic, commercial and export-oriented utilization. These would have multiplier effects in creating windows for small and medium enterprise businesses across the value chain. Although the domestic gas market is characterized by poor supply agreement, it is estimated that LPG production and utilization will be better in the future with the gas masterplan and Domestic Gas Supply Obligation currently in operation. Historically, Nigerian LPG domestic demand has been relatively low compare to the volume of this resource available, size of the population and estimated size of its market⁶. Accordingly, LPG production in Nigeria is a function of the large gas reserve base of the country. Production has been tied to the operational capacity of the refineries, the LNG plants, gas processing plants and importation activities. While the target of one million tons of LPG utilization per annum is defined by the NNPC, the production rate from the refineries are grossly low. Existing refinery facilities, maintenance point and turnaround work must be upgraded in the four refineries and other gas processing plants across the country.

LPG PRODUCTION FROM THE REFINERIES.

The current outlook of LPG production from the four refineries are grossly below design plate capacity when the operations are at maximum. Recovery in upward production would require greater investment in crude oil processing, equipment maintenance, staff training, building of more infrastructure that would support safety standards. Regular repairs of LPG production facilities and LPG handling or storage equipment to bring the products to the domestic market. Regular turnaround maintenance operation is essentially needed to sustain maximum operations and ensure effective product utilizations.

LPG PRODUCTION FROM GAS PROCESSING PLANT.

The existing Exxon Mobile Oso Bonny River terminal facility for Natural Gas Liquid (NGL) and similar facilities could be modified for LPG production. Coastal and inland terminals are crucial designated supply routes where small and medium enterprise businesses can be located for economic growth. The gas masterplan implementation and Domestic Gas Supply Obligation are fundamental in increasing the in-country gas processing activities. It is estimated that LPG production from natural gas processing plant for the domestic market could hit one million tonnes per annum in 2020. Distribution channels and terminals could be increased especially around coastal areas.

LPG IMPORTATION.

Considerable attention is given to LPG importation in-country along with other petroleum finished products, such as Premium Motor Spirit (PMS) Automobile Gas Oil (AGO), Dual Purpose Kerosene (DPK) etc., essentially from the low refinery and the petrochemical operations. Importation and transportation of LPG are risk bound because of inflammability of the product. Transportation of the product requires safe design pipeline infrastructure with standard real time safety indicators along the designated right of way within the coastal cities and in land Basins.

⁶ Department of Petroleum Resources 2014 Annual Report on Nigerian Oil and Gas Industry; pp 28-31.

Barges for in-between depot transportation and trucking for short to medium distances on the inland ports are effective for domestic small-scale product utilization. These are opportunities for the growth and expansion of SME businesses in-country. Importation of cylinder bottles also poses tremendous risk for the LPG market. Ownership and maintenance of cylinder bottles must be regulated, and designated distributors appointed with requisite facilities to reduce the risk element in the transportation and distribution of LPG products for domestic and commercial utilization.

STRUCTURE OF THE SME MARKET IN NIGERIA.

Small and Medium Enterprise market in a developing economy has great potential to contribute significantly to the economic growth of the country. SME in Nigeria is a developing market with robust business linkages that is strengthened by advisory and advocacy from an established government agency: Small and Medium Enterprises Development Agency of Nigeria (SMEDAN) in collaboration with other relevant organization in-country. SME structure is derived from business development framework, investment promotion strategy, product- services enhancement, supply chain development, promoting out-sourcing activities, promoting parks and garden clusters, developing linkages and sustainable market and environmental concerns. Therefore, needed market stimulant in small scale businesses are obvious in LPG commodity distributions and the prospect for economic recovery. It is essentially strategic for closer collaboration and partnership engagement to be driven by SMEDAN, NNPC, DPR, PTDF and other relevant stakeholders for the actualization of the distribution model options advocated⁷. If the size of pipe networks, compressibility factor and flow dynamics are determined and standardized, and concentration of LPG products remain constant for all the streams of products outlined hereunder, then the models can be developed thus:

DEVELOPING THE MODEL EQUATIONS.

Deriving the sources of LPG from refineries (l_r), Petrochemical plants (l_p), Gas processing plants (l_g) and importation (l_i) respectively.

The equation of states for gas properties in pipelines is represented as:

$$PV = ZnRT \dots\dots\dots 1.$$

Where P is Pressure, V is Volume, Z is the Compressibility factor, n is Number of Moles, R is Rate and T is Temperature. The Bernoulli's theorem for a one-dimensional steady state flow through a pipeline, using the concept of energy conservation for an incompressible fluid gives;

$$f(x) = (a_0(x) + a_1(x_1) + a_2(x_2) \dots\dots a_n(x_n) \dots\dots\dots 2.$$

Where $f(x)$ = the quantity of LPG, (a_0 = Temperature over time (x), a_1 = Vol. over time(x_1), a_2 = Pressure over time(x_2) $a_n(x_n)$ to infinity.

$$\text{LPG from the Refinery over time} = l_r(x) = a_0(x) + a_1(x_1) + a_2(x_2) + \dots\dots\dots a_n(x_n) \dots\dots\dots 3.$$

⁷ Neeka, J.B, Abubakar M and Agboola O (2018): An integration of Small and Medium Enterprises Options into Waste Management and Climate Change in Nigeria: A Simplified Economic Model. Proceedings of the 48th Conference of the Nigerian Association of Chemical Engineers (NSChE) Abeokuta Ogun State.

If the product concentration is kept constant for all the streams of LPG sources outlined above.

Substituting equation 2 into 3 and expressing same for all the sources of LPG stated above, with the further assumption that all $f(x)$ starts from point zero with the right conditions; then the simplex model in linear programming would yield:

$$l_q(x) = a_{11}x_1 + a_{12}x_2 + a_{13}x_3 \dots a_{1n}x_n \dots 4.$$

$$l_g(x) = a_{21}x_1 + a_{22}x_2 + a_{23}x_3 \dots a_{2n}x_n \dots 5.$$

$$l_i(x) = a_{31}x_1 + a_{32}x_2 + a_{33}x_3 \dots a_{3n}x_n \dots 6.$$

$$l_n(x) = a_{n1}x_1 + a_{n2}x_2 + a_{n3}x_3 \dots a_{nn}x_n \dots 7.$$

Introducing sets of sign restrictions of the non-negative components of the LPG products, yield:

$$X_1 \geq 0, X_2 \geq 0 \dots x_n \dots 8,$$

Indicating that no two streams of LPG products can have the same product cost per quantity without some fundamental assumptions of palliatives to storage and distribution stability.

For which the linear function; $f = c_1x_1 + c_2x_2 + c_3x_3 \dots c_nx_n \dots 9,$

Where the available quantity of LPG over cost per time could be determined.

Equation 8 has a maximum solution to the set of problem flow of LPG gas in pipes when the facilities are commissioned, not undermining the issue of compressibility of flow dynamics and leakages from damage spots etc. The production and distribution of LPG to the end users is also tied to the prevailing market price. The dynamics of market forces as a function of demand-supply interplay is important for the determination of the viability options in simulating LPG as an economic recovery commodity in the small and medium scale enterprise business model. This is because time value of money, recovery factor on investment capital, risk and the future market trend are fundamental for reasonable investment decisions on LPG consumption. Accordingly, the economic consideration of these factors is modelled in the underlying equations thus: Carbon commodity predominance in LPG product and other impurities are fundamental assumptions in this model. The United Nation Framework Convention on Climate Change (UNFCCC) stipulates that carbon molecules, though considered as waste can also generate sustainable income from the carbon credit schemes. This is essential in the Green House Gas revolution determination and carbon molecular estimate in the universal equation thus:

$$g = (\text{Carbon dioxide}) CO_2 + (21 * a) + (310 * b^2) + (1300 * c^3) + (23900 * d^4) + (6500 * e^5) \dots 10.$$

Where g is the Green House Gas, a = (methane) CH_4 , b = (Nitrogen Oxide) N_2O , c = (HydroFlouroCarbon) HFC, d = (SulphurHexaFloride) SF_6 , e = (PerFlouroCarbon) PFC.

Where negligible yields of HFC and PFC are recorded, Equation 9 is rearranged to yield:

$$g = CO_2 + (21 * a) + (310 * b^2) + (23900 * c^3) \dots 11.$$

Equating g to l_r and rearranging from 11, yield:

$$l_r = CO_2 + 21 * a + 310 * b^2 + 23900 * d^3 \dots\dots\dots 12.$$

For the number of LPG sources estimated; $l_n = CO_2 + 21 * a + 310 * b^2 + 23900 * d^3 \dots\dots\dots 13.$

Taking the LPG from refineries, for instance to simulate the number of carbon commodity and the monetary value in the future market gives:

$$l_r = f(T) \Sigma FV_i \dots\dots\dots 14.$$

Where T is the future worth of LPG in the market. Further alignment with the prevailing market forces yield;

$l_r = K' T \Sigma FV_i$, where K' is the market value index factor F is the sum of the constants and V_i is the sum of the independent variables respectively. But time is a strong factor in the actual determination of the value of LPG demand – supply relationship, either in the industry or for domestic use. The concept of time introduced reduce equation 14 thus:

$$T = f(T) \dots\dots\dots 15$$

But the constant factors such as infrastructures, personnel etc. in the model is represented thus:

$$T = K'' T \dots\dots\dots 16$$

For every changing variable introduced by market dynamics, we assume that the cost of LPG in the market is fixed for every initial investment decision made, and been conscious of the market forces that influence interest rates or return on investment over time, equation 16 yield;

$$T = K'' T \left(\frac{1}{1+r} \right) \dots\dots\dots 17.$$

Equating K' to K'' as K and rearranging 17 yield;

$$K = T \frac{l_r \left(\frac{1}{1+r} \right)}{KT \Sigma FV_i} \dots\dots\dots 18.$$

Where $\left(\frac{1}{1+r} \right)$ is the compound interest index factor over a specified period T . Equation 18 is the fundamental equation for the economic model needed for the actual market valuation of LPG as a product of trade for the SME's businesses. However, it is important to see the investment and return on investment as a function of cashflow and Net Present Value (NPV) in respect to market determinants of the LPG product.

So that the Net Cash Flow is integrated into the estimated income over the quantity of LPG sold (consumption); $l_r = NPV = K' T \Sigma FV_i \dots\dots\dots 19.$

But the Net Present Value is given as:

$$NPV = \sum_{t=1}^n \frac{NCF}{(1+i)^t} \dots\dots\dots 20.$$

Therefore LPG, l_r is profitable in terms of the Net Cash Flow for businesses at designated locations where demand is high, and supply is sustainable.

$$\text{So that } I_r = \frac{NCF}{(1+i)^t} \dots\dots\dots 21.$$

Equation 21 is the determinant for simulating LPG sales as an option for the SME businesses in a recession economy. The profitability index as a function of time and number of years of investment is almost at infinity. It is absolute to factor into the economic recovery plans, the production and utilization of LPG in growing the small and medium enterprise businesses in-country. The estimate is quite promising for any investor, all things being equal under favourable investment climate.

RESULTS AND DISCUSSIONS.

For economic commodity to serve the demand purposes of end-users and meet the supply needs of society such commodity must have sustainable productivity and available distribution network. Table 1. Indicates a serious fluctuation in the production and distribution of LPG commodity from 1998 – 2008. This is attributed to declining production of natural gas within the period under review (Fig.1). The price determinant and percentage profitability were equally not attractive compared to the investment profile expected to increase income generation. Table 2 represent a stable and sustainable production and distribution of LPG commodity between 2009 and 2020. This is a combination of actual and predictive value for the LPG commodity market as shown in Fig.2 below.

Table 3 further shows good market trend and favourable investment climate for future incremental utilization of the product in Nigeria (see equations 14 – 17). It should be noted that the fundamental assumption is that SME businesses do not attract large scale investment to start. Profitability depends on volume of sales and rate of return (frequency) of sales. The rate of returns increases and help to soar profitability which, in turn deepened the reliability variables of the off-takers. Furthermore, profitability as explained in equations 19 -20 is simulated by policy and programmes including incentivization, tax holidays and infrastructural surplus in place. Table 4 is the ratio of LPG annual consumption per capita and the income profiles of some selected African Countries. The North African Sates appeared to have increased the consumption of LPG both at the domestic and industrial levels. Interestingly, it is market forces that determine the cost of LPG when complete deregulation of the downstream sector is achieved⁸. Fig.3 shows the reality between the actual and predictive values in LPG consumption with an increase in demand – supply relationship from 2016 upward. It corresponds with a period of increased natural gas production, enlightenment, rapid investment in the sector with the establishment of LPG off-takers points in the country, tax and fiscal policy stability etc. This also proportional to profitability and income generation of the investors (equation 18); with increase utility value of product – to – market of LPG and stable buy-in from end-users and less risk of hazardous incidences. The indices depend largely on the cost of LPG and its per capita income when compared with the strength of the workforce in-country. Fig 4 provides the consumption trend as a determinant from price regimes within selected African Countries. Nigeria has the least per capita income from LPG, notwithstanding its huge gas reserves and production history in the Oil and Gas sector. It will be profitable to explore the utilization of LPG and its good economic value towards growing the economy; using the small and medium enterprise businesses platform for economic recovery (see

⁸ Olamigoke, o and Davies A, A (2018): Quantitative hazard Analysis of Liquefied Petroleum Gas (LPG) Bottling Plants: A case study. Proceedings of the 48th Annual Conference of the Nigerian Society of Chemical Engineers (NSChE), Abeokuta Ogun State.

equation 21)⁹. Fig 5 shows the LPG analysis of other World powers in the East and West of the Commonwealth of Independent States¹⁰. The level of LPG utilization at both domestic and industrial scale cannot be compared with the African Countries. It is therefore expedient to harness the huge potential in LPG for industrial and economic development through the SME platforms.

CONCLUSIONS AND RECOMMENDATIONS.

Liquefied Petroleum Gas (LPG) commodity domestic utilization in Nigeria ranked below acceptable annual projections from other seemingly developed African countries like Morocco and Egypt where natural gas resources contribute significantly to their annual income and gross domestic products (GDP)¹¹. Nigeria is the second largest producer of LPG in Africa after Algeria. However, adoption of LPG in the Nigerian market ranked the lowest compared to other African Countries. From available statistics in terms of domestic energy consumption in Nigeria, 5% of households uses LPG, 5% uses charcoal, 60% uses firewood and 30% uses kerosene for cooking¹². The National health impact of such energy mix could be devastating¹³ on the citizens of any country. It is imperative to recommend an advance LPG scheme for both domestic and industrial development using the Moroccan model for the rapid transformation of the economy.

Nigeria has LPG commodity from the refinery and liquefied natural gas plants, mostly export oriented because of low domestic utilization. Inadequate infrastructure such as loading and unloading terminals, access road and pipeline networks, funding constraints, citizens education and conscientization programmes, maintenance centers for LPG accessories are some of the challenges that needed to be overcome in-country for the swift embrace of the commodity locally. As a revenue earner, government policies and programmes should promote LPG domestic utilization through:

- 1) Ministries, Departments and Agencies (MDAs) involvement in capacity building (man power training) in gas engineering and technology;
- 2) regulation of the fiscal policy on gas;
- 3) regulation of investors and key players in the sector through tax incentivization;
- 4) provision of gas cylinders and other basic accessories to the citizenry as a stimulant alternative to deforestation and desert encroachment; and
- 5) regular and effective citizens education and awareness programmes in all the geo-political zones in the country among others.

To further increase LPG domestic utilization, other sectors of the economy should be integrated into the LPG revolution programme. For instance,

- 1) in the Agricultural sector, LPG can be used in powering farm tractors, transportation as auto gas, cooking and storage etc.
- 2) Industrial welding and food processing techniques are expansive areas of utilization.
- 3) The power sector could power street lights and mega stadia with LPG,

⁹ Neeka Jacob, Agboola Olayinka and Jide Adebulehin (2018): Recession to Recovery: Essentials of Education and the Role of Petroleum Technology Development Fund (PTDF) in the Development of the Petroleum Industry in Nigeria. PTDJ Vol 2(1) 2018; Pp 120-121.

¹⁰ Available online; www.googleng.com CIS Countries on LPG/ Access November 21, 2018.

¹¹ Neeka, J.B, Abubakar, M and Agboola, O (2018): cited in the 48th Proceedings of the Nigerian Association of Chemical Engineers (NSChE), Abeokuta, Ogun State.

¹² The Health implication of desertification in Nigeria, UNIDO Newsletter No: 14, 2000.

¹³ World Bank President, Jim Yong Kim, April 2015.

4) Real estate developers should begin to design homes that will use LPG for domestic heating and cooling¹⁴ as the weather conditions permit.
LPG market in Nigeria, if properly harness, have ever increasing prospects for the growth of the economy and as huge revenue earner for sustainable development.

Table 1: Fluctuating Natural Gas and LPG production profile over ten (10) Years.

Year	Net Natural Gas Production (bcfa)	Net Natural Gas Production (bcma)	% Increase pa	000 tonnes LPG equivalent	000 tonnes LPG recoverable at 10%
1998	181	5.1		4,105	410
1999	213	6.0	18%	4,836	484
2000	441	12.5	107%	10,028	1,003
2001	526	14.9	19%	11,920	1,192
2002	501	14.2	-5%	11,360	1,136
2003	678	19.2	35%	15,360	1,536
2004	803	22.8	18%	18,240	1,824
2005	791	22.4	-1%	17,920	1,792
2006	1004	28.4	27%	22,744	2,274
2007	1237	35.0	23%	28,011	2,801
2008	1234	35.0	0%	28,021	2,802

¹⁴ Domestication and Utilization of LPG in Nigeria, PTDF Quarterly Lecture Series, 2019

Table 2: Improved Natural Gas and LPG production Profile over Twelve (12) Years.

Year	Net Natural Gas Production (bcfa)	Net Natural Gas Production (bcma)	% Increase pa	000 tonnes LPG equivalent	000 tonnes LPG recoverable at 10%
2009	1,480	42	20%	33,626	3,363
2010	1,776	50	20%	40,351	4,035
2011	2,132	61	20%	48,421	4,842
2012	2,558	73	20%	58,105	5,810
2013	3,070	87	20%	69,726	6,973
2014	3,683	105	20%	83,671	8,367
2015	4,420	126	20%	100,405	10,041
2016	4,641	132	5%	105,426	10,543
2017	4,873	138	5%	110,697	11,070
2018	5,117	145	5%	116,232	11,623
2019	5,373	153	5%	122,043	12,204
2020	5,641	160	5%	128,145	12,815

Table 3 Nigerian Gas and LPG Production – Historic and Forecast

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2019	5,373	153	5%	122,043	12,204
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Table 4: Per Capita LPG Consumption in Selected African Countries.

Country	Total National Annual Consumption (Tonnes	Per Capita Annual Consumption (Kilograms).
Morocco	1,465,000	44.4
Egypt	3,370,000	43.1
South Africa	220,000	5.5
Ghana	71,000	3.0
Nigeria	58,567	0.40
Niger	32,540	1.65

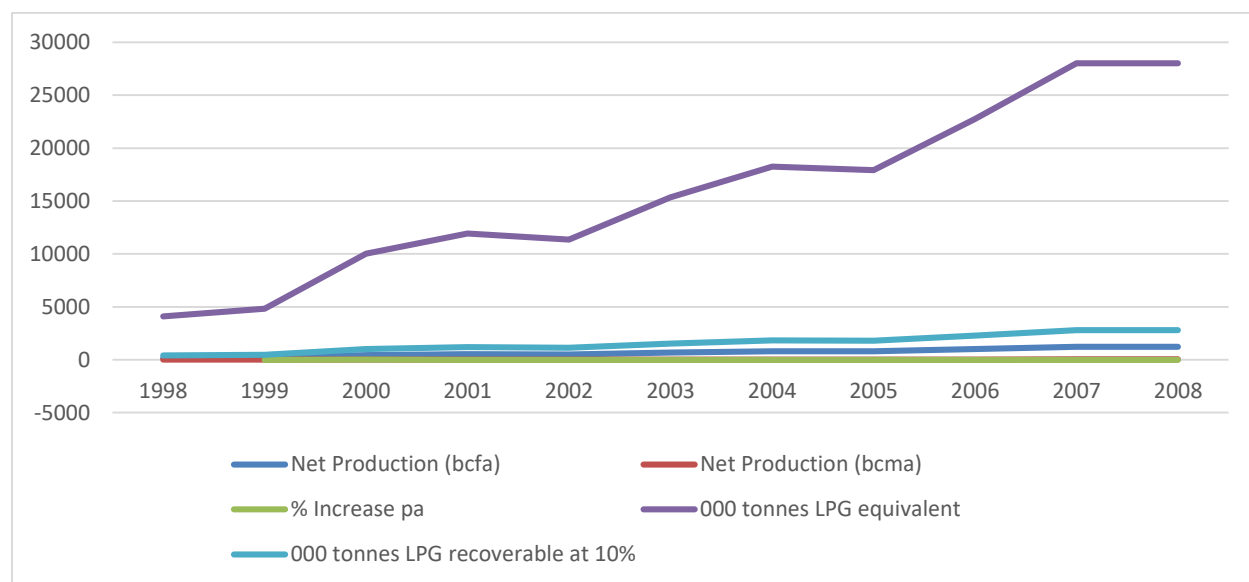


Fig 1: Plot of Natural Gas and LPG Production (1998 – 2008).

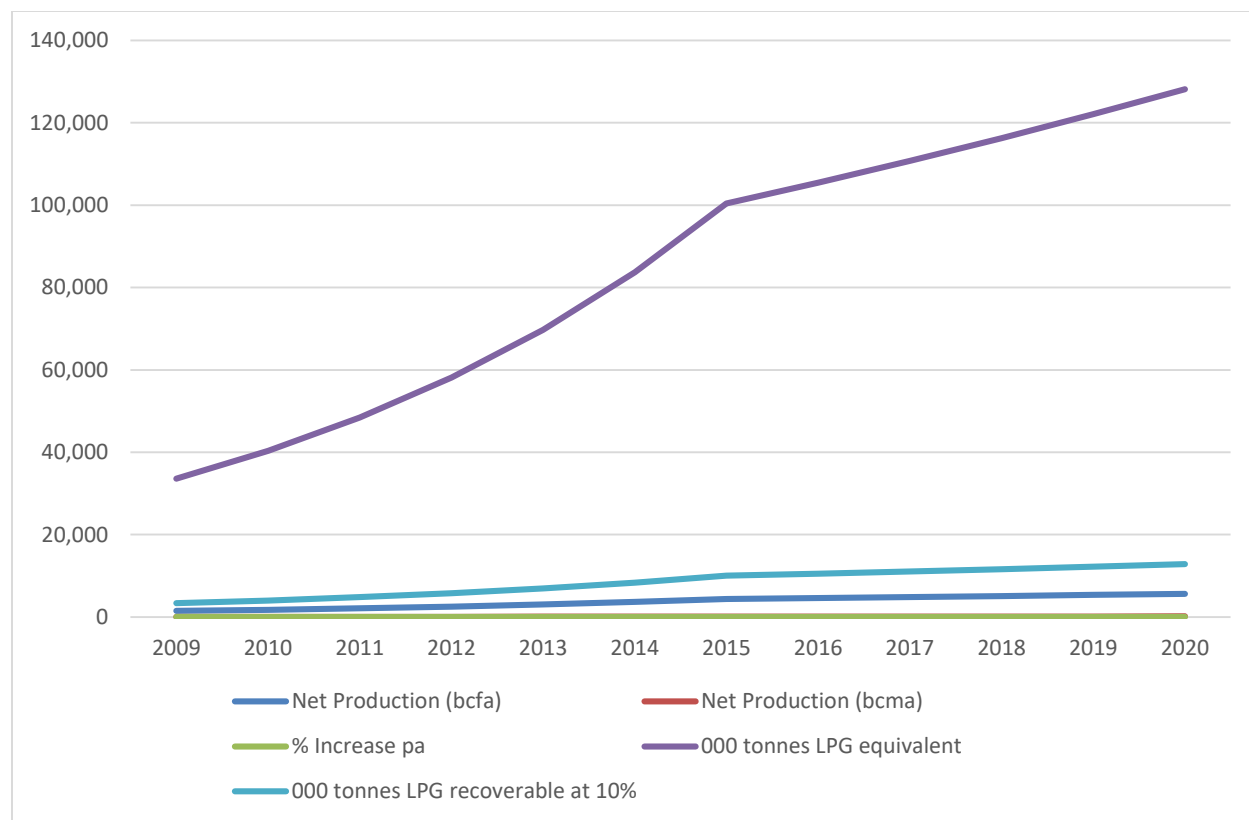


Fig 2: Trends in Actual and Predictive Plot of Natural Gas and LPG production (2009 – 2020)

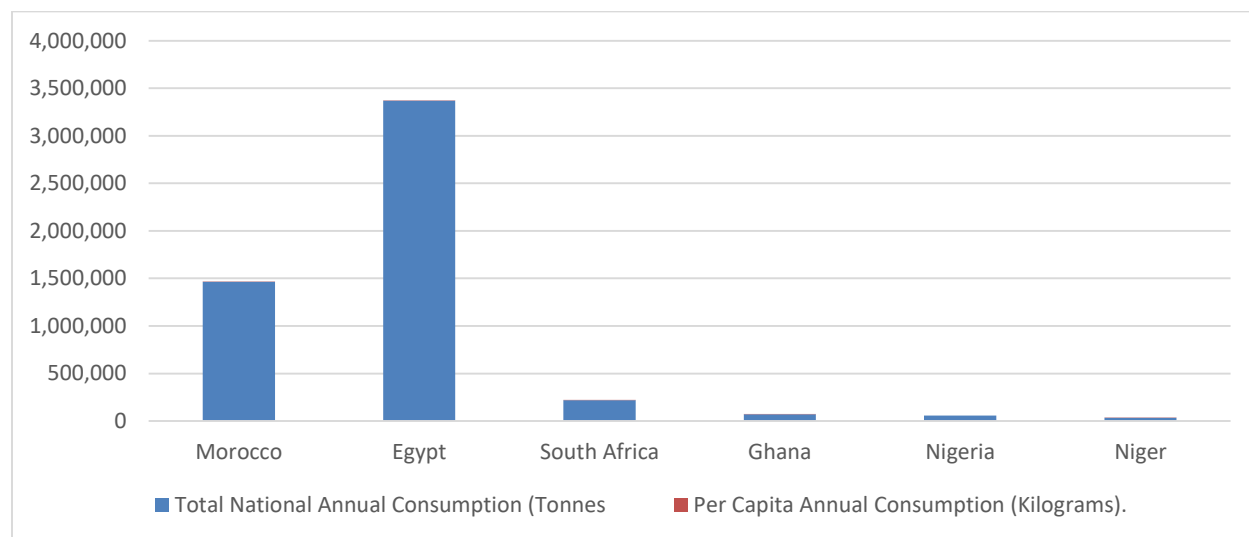


Fig 3: Ratio of LPG Annual Consumption and Per Capita Income in Africa.

Liquefied Petroleum Gas

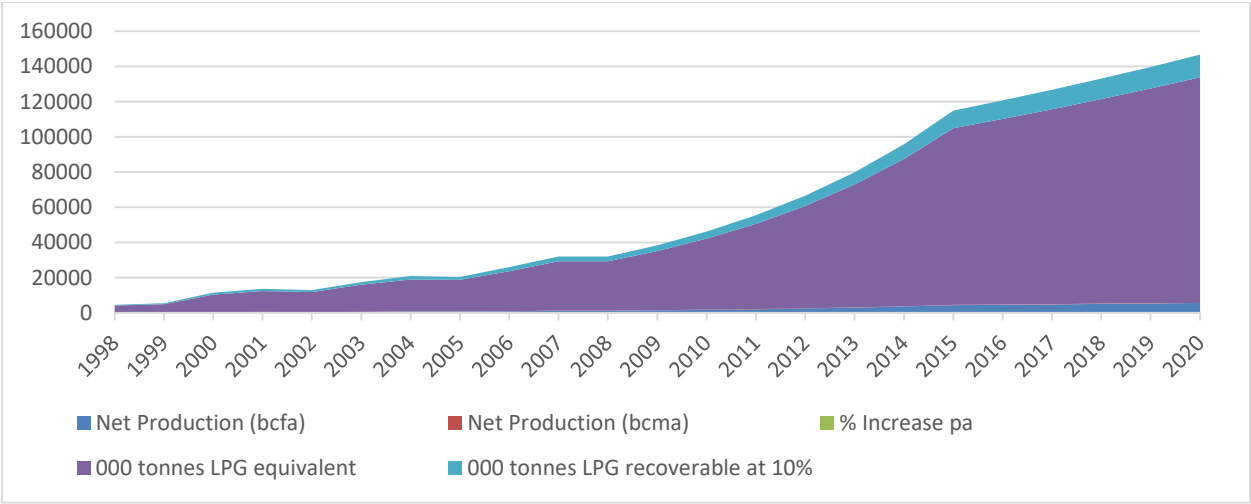


Fig 4: Plot of Natural Gas and LPG Capacity Utilization (1998 – 2020).

- LPG supply should expand rapidly in the East of Suez region.
- The most significant LPG supply expansion should occur in the Middle East where rising production of crude oil and natural gas is the key driver.
- This rapid development of LPG production in the East of Suez region should **increase East-to-West LPG trade.**

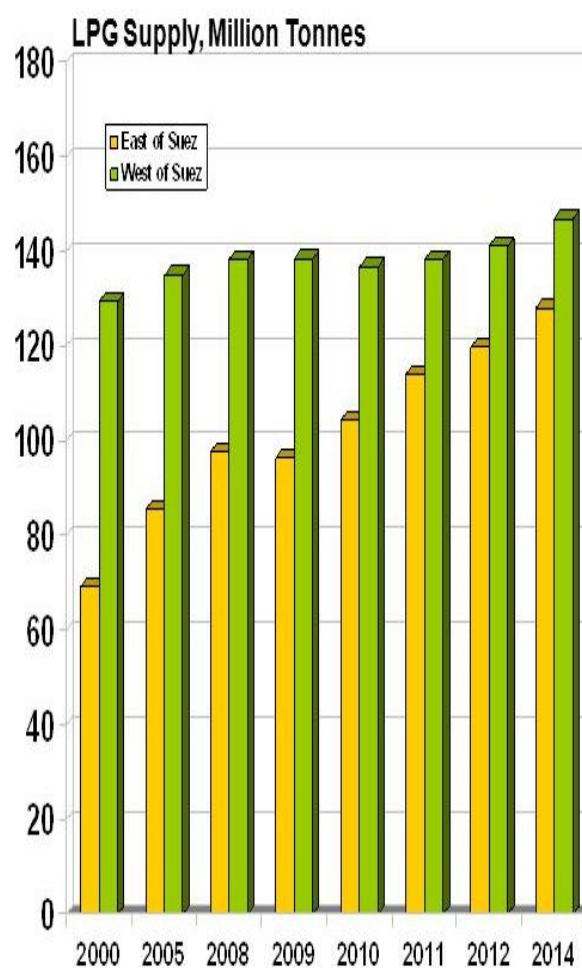


Fig 5: LPG Analysis on Common Wealth of Independent States: Source CIS online.