

Domestic Natural Gas Pricing: Issues and Policy Options for Nigeria.

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ABSTRACT

Energy industry reform has become a global phenomenon. Though the framework varies widely across countries and regions, the international experience has shown that the fundamental objectives of these reforms have been generally similar. Due to its comparative advantage in terms of environmental consideration, natural gas development, especially in the developing countries, has attracted international attention. One of the major critical challenges of natural gas market development centers on developing a policy framework which encourages an appropriate market determined gas pricing as against the long history of regulated pricing. Despite the intrinsic peculiarities in terms of the international experiences and practices, valuable policy lessons can still be drawn with the intention of understanding the process, challenges and different policy options with respect to natural gas pricing in developing countries.

It is against this background that this paper discusses and gives a thorough appraisal of the Nigerian natural gas pricing framework, its peculiarity, challenges and viable policy options with respect to current international experience. While highlighting basic economic theoretical framework underlying natural gas resource pricing, more specifically, the study the paper reviews the proposed natural gas pricing framework in Nigeria and offers a plausible policy options with respect to different pricing models. The methodological approach employed in this study is basically descriptive and analytical. As evidenced from this study, given the complexity of appropriate gas pricing, the paper proffers

valuable policy lessons with respect to the ongoing proposed natural gas pricing in Nigeria.

(Keywords: natural gas pricing, gas pricing regime, natural gas market, domestic gas deregulation)

INTRODUCTION

The growing consensus among policy makers, oil and gas industry analysts as well as energy economists is that government intervention in the energy industry distorts the market functioning and results in lower economic efficiency and misallocation of resources (Kupolokun, 2006; Mathias and Szklo, 2007). As a result of inherent problems of the state-controlled energy industry and coupled with the global trend of energy industry reform, the oil and gas endowed countries continue to witness the unbundling of government controlled energy monopolies among other reforms. Over the past decades, different countries have embarked on reforming their energy industries. The international experience has shown that the fundamental objectives of these reforms have been generally similar for the most part that is, aiming at introducing competition in the potentially competitive segments. However, the contexts in which they have been carried out differ (Heren, 1999; Radetzki, 1999).¹ Hence, the core of the energy industry reform program, just like any other economic reforms, centers on redefining the role of government and business in the economic

¹. Of course, the divergent approaches may be due to the past regulatory experience in each country, the maturity of the industry and/or the number of agents when the reform process started.

activities in the sector (Vickers, 1995 and Baldwin and Cave, 1999).

Natural gas is one of the most important sources of energy today because it is environmentally friendly and has economic and technical advantages. The development of a natural gas domestic market in Nigeria is still in the early stages. While the potential of natural gas to reduce the heavy dependency on oil in Nigeria's energy mix is quite great, the infrastructures for delivering natural gas in its domestic market are very limited. Meanwhile, one of the critical challenges of developing domestic gas market in Nigeria, apart from the challenges of gas reserves availability² and infrastructural development, concerns the appropriate gas pricing structure. Appropriate pricing is fundamental to achieving efficient production and use of natural gas in Nigeria.

Meanwhile, the international experience has also shown that low domestic price of gas creates a very serious disincentive for investment in the gas sector, particularly where such investments are expected to be made by private sector. This has consequently induced an emerging policy debate in the sector with respect to the wisdom of allocating gas resources to export projects versus holding these resources for current and future internal consumption. Over time, the price charged for domestic gas has been very low resulting in inefficient use of gas, a disincentive for private investment in the domestic gas market, and a bias in favor of gas exports. Given the fact that an essential element of pricing policy is the determination of the economic price of the commodity in question, it therefore holds that the economic price of natural gas forms the basis for evaluating the development of gas projects, a guide for policies concerning flaring or depletion, and for many other types of decisions relating to gas development and use (Julius and Mashayekhi, 1990).

Despite intrinsic peculiarities in terms of the international experience, valuable policy lessons can still be drawn with the intention of understanding the process, challenges and different policy options with respect to natural gas pricing in developing countries. It is against this background that this paper discusses and gives a

². There is limited proven gas reserves availability in the medium term (see Table 2 for detailed breakdown of the Nigerian gas reserves availability).

thorough appraisal of the Nigerian and Indian natural gas pricing frameworks, their peculiarity, challenges and viable policy options with respect to current international experiences.

ECONOMICS OF NATURAL GAS PRICING: A THEORETICAL PERSPECTIVE

The economic price of natural gas, as is the case with other commodities, is determined by the intersection of aggregate demand and supply. However, the monopolistic production and distribution of natural gas, political and economic factors have generally led to price regulation in the domestic markets. To determine natural gas price, governments in developing countries are confronted with determining which pricing framework is to be adopted. Meanwhile, the theoretical pricing framework adopted in this study is based on the theory of exhaustible resource pricing by Hotelling (1931) and as further extended by Dasgupta and Heal (1980); Halvorsen and Smith (1991).

Hotelling's basic model predicted that the shadow price of the resource stock, which is an economic measure of the scarcity of the resource, should grow at the rate of interest. Hence, the proposition that the unit price of an exhaustible resource, less the marginal cost of extracting it, would tend to rise over time at a rate equal to the return on comparable capital assets has come to be called the Hotelling Pricing Principle (Hotelling 1931). This principle emphasizes the upward trend in net prices propelling the current generation of resource owners to extract just the right amount of the resource for themselves and then conserve the rest for future generations. This fundamental insight has remained the starting point for virtually all subsequent economic explanation and analyses of national policies on the exhaustible natural resource reform especially as it relates to pricing.

Core to the theoretical paradigm of exhaustible resource pricing as conjectured by Hotelling is the concept of '*resource finiteness*.' According to Hotelling (1931), while the depletion of proven natural gas reserves can be replenished by transforming additional resources into reserves through additional investment into exploration or improvement of existing production, the fact remains that natural gas is a finite resource.

To start with, let us denote by $x(t)$ the cumulated output of the exhaustible resource producing firm from time 0 until t . Thus if we denote current output by $q(t)$ then $q(t) = dx(t)/dt$. The basic assumption is that $x(t) \leq a$, for all t . That is, the total cumulated output is constrained by the total availability of the ore or mineral in the ground (a). Also, let $R(q)$ be the revenue obtained from the sale of current output and let $C(q)$ be the cost associated with this output; therefore, $\pi(q) = R(q) - C(q)$ is the profit function at time t . The assumption is that the firm is interested in maximizing the present value of the stream of profits. Thus, we specify the following maximization problem:

$$\text{Max } \int_0^T e^{-rt} \pi(q) dt, \quad (1)$$

subject to $q \geq 0$ and $x(t) \leq a$.

The condition for the optimal extraction of the mineral is therefore:

$$e^{-rt} \frac{\partial \pi}{\partial q} = \lambda, \quad (2)$$

where λ represents the 'Lagrange multiplier.' Thus the marginal profit discounted to time zero should remain the same in all periods. To satisfy this condition the marginal profit, is expected to rise at an exponential rate equal to the rate of interest r (the r per cent rule). From (2):

$$\frac{\partial q}{\partial t} = \lambda r e^{rt} / \pi''(q) < 0 \text{ (using } \pi''(q) < 0 \text{)}. \quad (3)$$

Equation (3) represents output which is set as a decreasing function of time. Recall that at the terminal point, $q(T)$ either equals zero or is set so as to maximize average profit ($\pi(q)/q$) (see Gordon, 1967). In either case, the resource is necessarily exhausted, i.e. $x(T) = a$.

While extending the basic assumption of Hotelling as regards the exhaustible resource complete depletion, we take account of the fact that the cost of extraction depends on the volume of resource remaining yet untapped. The more resource extracted, the more it costs to extract another unit of resource. Denoting by $C(q, x)$, a cost function which depends on current and cumulated output, we assume, therefore, that $C_x(q, x) \geq 0$. The present value of profit at time t is:

$$e^{-rt} \pi(q, x) = e^{-rt} [R(q) - C(q, x)]. \quad (4)$$

Therefore, the maximization objective becomes:

$$\int_0^T e^{-rt} \pi(q, x) dt, \quad (5)$$

Subject to $q \geq 0$ and $x(T) \leq a$.

The condition of maximization is obtained by Euler's equation:

$$\frac{d}{dt} \left[\frac{\partial e^{-rt} \pi(q, x)}{\partial q} \right] = e^{-rt} \left[\frac{\partial \pi(q, x)}{\partial x} \right]. \quad (6)$$

To obtain our new formulation of 'full marginal cost' we integrate (5):

$$\int_t^T \frac{d}{ds} \left[\frac{\partial e^{-rs} \pi(q, x)}{\partial q} \right] ds = \int_0^T e^{-rs} \left[\frac{\partial \pi(q, x)}{\partial x} \right] ds. \quad (7)$$

While the equation should hold for all t , using the definition of $\pi(q, x)$ we obtain:

$$R'(q) = \frac{\partial C(q, x)}{\partial q} + e^{-r(T-t)} \left[R'[q(T)] - \frac{\partial C[q(T), x(T)]}{\partial q(T)} \right] - \int_t^T e^{-r(s-t)} \left[\frac{\partial e^{-rs} \pi(q, x)}{\partial x} \right] ds \quad (8)$$

Now, if we denote by MR_t the marginal revenue at time t and by MC_t the marginal cost at time t , (7) can be re-written as:

$$MR_t = MC_t + e^{-r(T-t)} [MR_T = MC_T] + \int_t^T e^{-r(s-t)} \left[\frac{\partial C(q, x)}{\partial x} \right] ds = MC_t^*. \quad (9)$$

Equation (9) asserts that the marginal revenue at t equals 'full marginal cost MC_t^* ' which consists of a sum of three components of extra costs associated with the last unit of output. The first component is the direct current marginal cost; the second component reflects the alternative cost of producing now rather than at the end of period T . This represents the present value of the marginal profit at T . The third component is the present value of all future additional costs of production engendered by the decision to produce the last unit at t . Now, given a situation of many firms in a competitive market then the full marginal cost would be equal in all firms, being equated to the price of the resource.

Now, it should be recalled that the fundamental question is: How is the natural gas price efficiently determined? More practically, the natural gas price-setting process is mainly influenced by

government's economic, social and political objectives. Broadly speaking, these objectives center on concerns for industrial growth/regional development (efficiency) and social costs and benefits/income distribution (social equity).³ Standard economic theory proposes that the gas price level must be equal to the economic price of gas. One of the major contributory factors to the complexity of efficient natural gas pricing directly concerns the fact that natural gas is not a widely traded commodity. Moreover, apart from the fact that natural gas is a depletable resource, and its depletion premium cannot be easily calculated, the market structure of natural gas industry, which is fundamentally monopolistic both in production and distribution, has generally led to price regulation in the domestic markets. Consequently, the international experience in natural gas pricing, especially among the gas resource-rich developing countries, suggests that the price of the gas must essentially reflect, among other things, the long-term marginal costs and its foregone current or potential future net value (depletion premium).

Taking into account that a gas-supply system is divided into interrelated phases (exploration, development and production, transmission, and distribution), the price of gas must send a coherent signal to actors involved in the chain: producers, pipeline operators, distributors and consumers. It is, therefore, essential that for every recommended price level for one phase, a corresponding price analysis be made for other parts of the network. To determine such a set of prices, governments in developing countries are confronted with determining which framework is to be adopted: a bottom-up or top-down framework. The bottom-up framework is linked to a cost-plus methodology, which relates the price of gas to costs incurred by the producing company plus an amount added to provide the company with a return on capital invested. The top-down framework, on the other hand, is associated with the netback value methodology or market price, which is a netback to the wellhead of the border price of a substitute fuel.

In conclusion, several factors indeed influence the method of gas pricing used in any particular market. These include reserves availability, number of producers, production costs,

³ Conflicts often arise within the above set of objectives, since they are not mutually consistent.

distribution infrastructure, market size, structure and maturity and end use, cost of competing fuels.

A GLANCE AT THE NATURAL GAS INDUSTRY SITUATIONS IN NIGERIA

As depicted in Figure 1, Nigeria is ranked 8th in the world in terms of proven reserves. With growing reserves and production, associated gas production also increased. Currently, the proven gas reserve stands at about 184 trillion cubic feet with a significant growth potential of about 600 trillion cubic feet level given appropriate fiscal incentives and funding. Meanwhile, of the over 1.2 trillion cubic feet of associated gas produced annually, less than 10% is actually utilized in power generation, artificial lift and gas reinjection programs. While the gas utilization level over time has improved to about 30% with the completion of the Bonny NLNG plant, the Bonny NLNG plant has contributed immensely in term of revenue generation to the country's coffers and more importantly the development of regional export markets. It becomes apparent that Nigeria's gas resource endowment represents a key competitive advantage waiting to be explored.

In the African region, Algeria ranked 10th in the world in terms of proven gas reserves. This makes Algeria the only major competitor to Nigeria. Algeria, Nigeria, Libya and Egypt combined hold over 90% of Africa's proven gas reserves. However, while Algeria and Egypt have reserves with limited production lives, Nigeria's reserve to production ratio exceeds 100 years, a significant competitive advantage (see Table 1).

Given this rich profile of the Nigerian gas reserves, about 53% of the total reserve is associated gas and over 50% of this is gas cap gas available showing that gas cap gas is closely tied with oil production the long term. A closer look at Table 2 shows that only about 99 tcf is available in both the short and medium term out of which the non-associated gas reserves present the most opportunities for gas supply.

Accelerating global LNG business represents more opportunities to grow Nigerian domestic gas market. For instance, Figure 2 depicts natural gas production, utilization and export in Nigeria from 1980 to 2008.

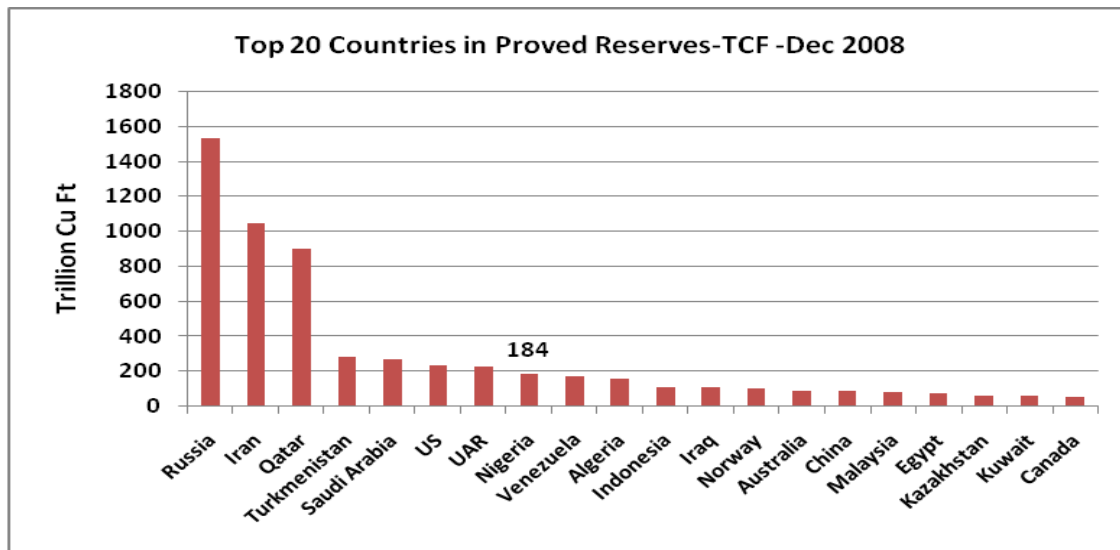


Figure 1: Nigerian Position among Gas Reserve Countries.

Table 1: Gas Proved Reserves for African Region-2008.

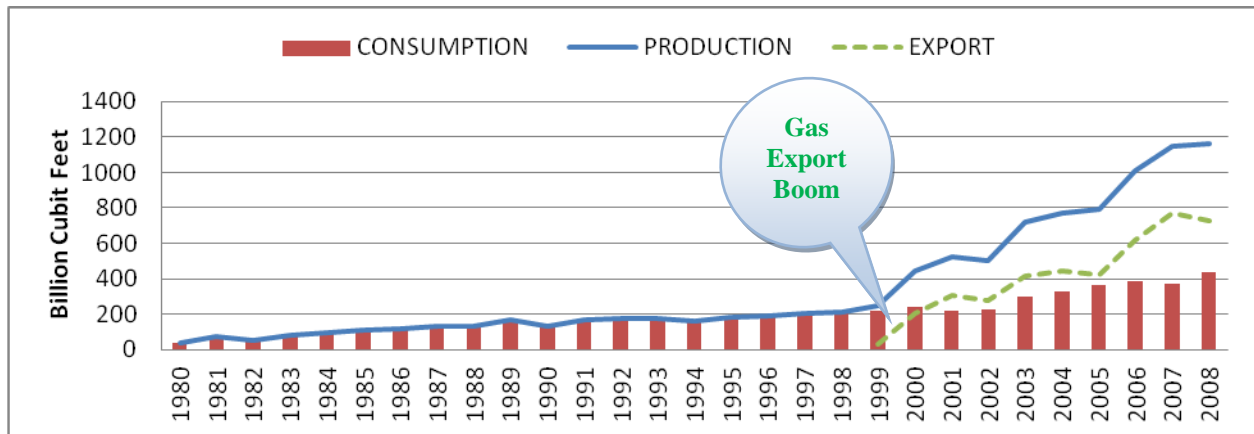
Country	Reserves (tcf)	Percentage (%)	R/P ratio
Algeria	159.1	30.7	52.1
Egypt	76.6	14.8	36.9
Libya	54.4	10.5	96.9
Nigeria	184.2	35.6	>100*
Other Africa Countries	43.3	8.4%	66.2
Total Africa	517.5		68.2

Source: Nigerian Gas Master Plan (GMP) Review, 2009

Table 2: Nigerian Gas Reserves Availability Breakdown.

Availability	Reserves Description	Size (tcf)	Cumm. Reserves	(%) of Total
Short Term	Solution Gas (JVC+PSCs)	19.8	19.8	11
	Non Associated Gas in Big Fields	66.3	86.1	47
	PSCs Non Associated Gas Reserves	7.7	93.9	51
Medium Term	Non Associated Gas in Small Fields	6.1	100	55
	Stranded Gas in Ogoni	9.8	109.8	60
	Stranded Gas Unresolved in Utilization Issues	0.7	110.5	61
	Stranded Gas due to Infrastructure Issues	2.7	113.2	62
Long Term	Gas Cap Gas	56.6	168.8	93
	Remaining Solution Gas	14.6	180.5	100

Source: Nigerian Gas Master Plan (GMP) Review, 2009



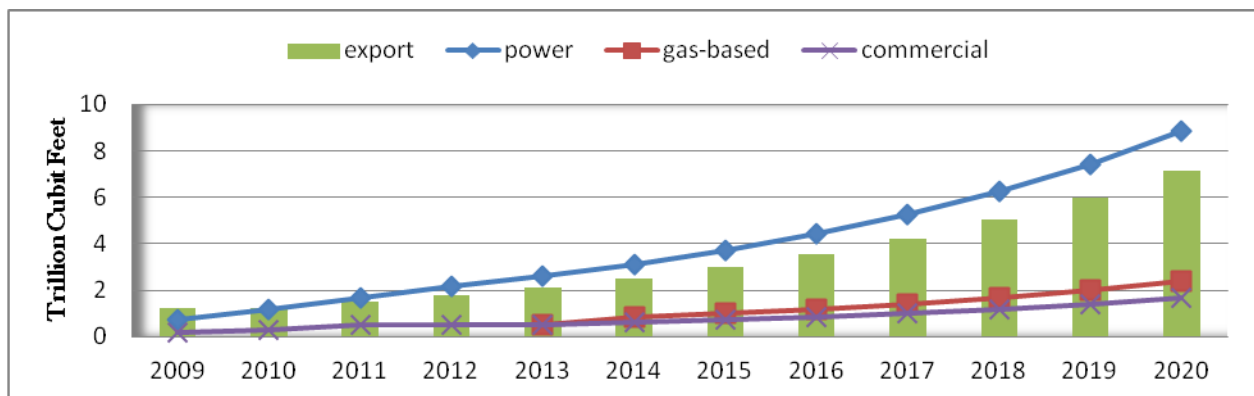
Source: Computed by Author from EIA, 2009

Figure 2: Nigerian Natural Gas Production, Consumption and Export, 1980-2008.

Gas production is seen to have picked up substantially around 1999 and increased rapidly mainly due the successful completion of Bonny NLNG project. This remarkably represents the gas export boom. The total gas demand profile is depicted in Figure 3. Natural gas demand is projected to reach 10 trillion cubic feet by 2016 and exceed 20 trillion cu feet by 2020 based on the envisaged double digit growth in these sectors. The gas demand profile shows the significance of the domestic power sector and the export/regional markets in the overall pace of gas market development. These two sectors contribute about 80% of total projected natural gas demand.

NATURAL GAS PRICING FRAMEWORKS IN NIGERIA

As earlier noted, natural gas pricing forms one of the factors upon which the realization of the Nigerian dream of developing both domestic and export/regional markets is based. The challenge is primarily determining an appropriate gas pricing framework that encourages efficiency in production and consumption. The complexity of this challenge is exacerbated by the widely divergent interests of major players in the industry.



Source: Computed by Author from Nigeria Nigerian Gas Master Plan (GMP) Review, 2009

Figure 3: Projected Natural Gas Demand by Sectors in Nigeria.

While the growth of the economy through new gas based industries and consequent employment generation would be attractive to government, other industrial players particularly the IOCs are driven mostly by profit maximization. The scope and space of domestic gas market development in Nigeria depend significantly on the signals the underlying pricing mechanism sends to both prospective suppliers and consumers. Hence, the core of gas pricing in Nigeria revolves around achieving economic pricing such that it provides sufficient incentive for the efficient producer to remain in business.

The need for a pricing strategy that recognizes the diversity in the ability of the various industrial sub-sectors to bear gas price cannot be overstated. Apart from enabling and sustain diversity of the demand sectors, thereby enabling Nigeria to benefit from the industrialization potential that is inherent in natural gas, the pricing strategy is also aimed at enabling the selective maximization of net revenues for Nigerian gas from sectors that are most able to deliver that direct economic benefit. From a gas pricing strategy perspective, government has grouped the entire domestic demand into three broad groupings. This grouping is in recognition of the fact that the different demand sectors have different strategic benefits to the country and different pricing considerations. The sectors are as follows:

- (i) **Strategic Domestic Sector:** *This refers to a limited set of sectors that have a significant direct multiplier effect on the economy namely the Power Sector. The strategic intent in gas pricing is to facilitate and ensure low cost gas access to these sectors in order to stimulate rapid economic growth and development.*
- (ii) **Strategic Industrial Sector:** *This refers to industries that utilize gas as feedstock in the production of value added products which are either meant for export or domestic consumption. Strategically, these sectors ensure that value is added to Nigerian gas before it is exported. Projects in this group are Methanol, GTL and Fertilizer. For this sector, the strategic intent in pricing is to ensure that feed gas price is affordable and predictable in order to ensure competitiveness of the products in international markets in the face of competition from other gas producing*

countries that provide gas at very low prices to buyers.

- (iii) **Strategic Commercial Sectors:** *This refers to sectors that use gas as fuel as opposed to feedstock. Unlike the two previous classifications, projects in this category are a potential major direct revenue earner for Nigerian gas in view of their capacity to bear high gas prices as the competing alternative fuel is LPFO. Typical sectors in this category include cement and domestic manufacturing industries, industrial power etc.*

Three distinct price regimes are evident in the framework, corresponding to three different approaches for determining the floor price.⁴ The three approaches include:

1. *Cost of supply basis (regulated pricing regime)*
2. *Product netback price basis and (pseudo-regulated pricing regime)*
3. *Alternative fuels basis (market led regime).*

The Regulated Pricing Regime (cost of supply basis): This pricing approach applies specifically to the strategic domestic sectors of power. As discussed in section C, the floor price for this category is determined primarily by establishing the lowest cost of supply that allows a 15% rate of return to the supplier. This has been established as \$0.1/mmbtu for a limited volume of gas reserves. These reserves will therefore be assumed dedicated to the strategic domestic sector.

The Pseudo-Regulated Pricing Regime (Product Netback basis): The second floor price determination approach applies strictly to strategic industrial sectors (i.e., sectors that use the gas as feedstock). For this group, the floor price is not based on the cost of supply of the gas, but on the netback of the product price. The product price used in determining the floor price is the assumed long run price of the product. With this approach, the pricing of gas will better reflect

⁴ The gas pricing framework proposed in this policy is a transitional pricing arrangement.

the ability of the sector to pay given the price of its product. However, since the intention of this policy is not to support sectors that are unviable i.e. sectors whose netback price translates to a gas floor price lower than the cost of supply of gas, the consideration of affordability will not be at the expense of sustainability of gas supply.

The Market Led Regime (Alternative Fuels Basis): The third floor price determination approach applies to all other sectors that use gas as fuel or wholesale buyers buying gas for subsequent resale. For this category, the price of gas is indexed to the price of alternative fuel such as LPFO. The indexation will be established during negotiation.

It is assumed that pricing for each demand sector will transit to the next higher pricing band once a saturation level has been attained. For example, for the strategic domestic sector, once the domestic requirement has been met (domestic saturation point) and power is now being exported, the framework proposes that export power benefits from a relatively higher price, determined by the netbacking philosophy applied to strategic industrial sectors such as methanol.

NATURAL GAS PRICE POOLING SYSTEM AND INSTITUTIONAL MECHANISM

The large variation in prices of a largely similar commodity supplied from various sources results in significant distortions in the end use markets. While a certain degree of differences in prices of supplies to consumers is inevitable, the wide variations have significant ramifications for customers. The impact is manifested in several ways. Producers of price controlled gas have little incentive to optimize production profile and costs. At the consumer end, wide divergence in prices make certain producers uncompetitive *vis-à-vis* others within the same industry. Artificially controlled and uneven price signals also distort price benchmarks for introducing new supplies, thus making sourcing and investment decisions more difficult and contentious. All of these have very significant impact for the economy, which is severely hampered on account of the constrained access to energy sources.

Hence, from an economic standpoint it is important to avoid a wide range of prices for the same commodity as this leads to inefficient

consumption and seriously impairs inter-sectoral competitiveness of the players in the same consuming industry. The one to one attribution of sources various buyers (as opposed to supply at a common price based on standard contracts) results in contractual inflexibilities both for buyers and suppliers, further raising risks and inequities. It can well be construed that the prevalence of a large number of diverse pricing and contractual arrangements is seriously affecting market development and overall consumer interest. *Price pooling options assume significance in this context.*⁵

Pooling Options

Generally, the pooling options can be broadly divided into two major categories: *Cost-Based and Bid-Based pool*. Cost based pool has been further divided into *general and sectoral pool*. The following section defines the various pools considered for this study.

Cost-Based Pool

General Pool: In this type of pooling arrangement all the gas producers or traders participate in the pool. Gas is supplied to all the customers through the pool administrators. This could feature two basic options as variants: *Mandatory and facilitated pools*. In mandatory pool, all the gas producers or traders have to participate in the pool and subsequently all the sale of gas will happen through the pool. Similarly, all demand would be required to contract through the pool for supplies. Meanwhile, the facilitated pool does not make it compulsory for the gas producers or gas suppliers to participate in the pool. The gas producers or traders can participate in the pool and exit from the pool as per the defined rules of the pool. The same would apply for buyers from the pool.

Sectoral Pool: Sectoral pool is specifically for pre-identified sectors. As regards this study, this has been considered for Power and Fertilizer segments, although variants could extend to other

⁵ Price pooling arrangements can help address several of these issues. However such pools need to be designed considering the specific objectives of the market, the stage of market development, economic policies, legal frameworks, and the costs of implementation.

sectors as well. Two basic forms of sectoral pools have been considered. They are: *Combined and Individual Pools*. In combined pooling arrangement, there is a single pool for, say, Power and Fertilizer. The gas at pooled price is supplied to customers from both the sectors through an identified mechanism. In the Individual pooling arrangement, there will be two different pools for Power and Fertilizer separately. The pool operator may or may not be same. The gas at pooled price is supplied to the respective customers through an identified mechanism. The pooled price may or may not be same for both the pools.⁶

POLICY RECOMMENDATION AND CONCLUSION

One of the major critical challenges of natural gas market development centers on developing a policy framework which encourages an appropriate market determined gas pricing as against the long history of regulated pricing. This paper discusses and gives a thorough appraisal of the Nigerian and Indian natural gas pricing frameworks, their peculiarity, challenges and viable policy options with respect to current international experience. The paper reviews the proposed natural gas pricing frameworks and offers a comparative analysis of natural gas pricing methodologies in Nigeria with the aim of underscoring plausible policy options with respect to different pricing models.

It is important to note that natural gas market needs a rational gas pricing mechanism to encourage efficient consumption and development of natural gas infrastructure, while preserving the incentives to gas suppliers. Gas

⁶ It should be noted that in all options presented herein, the existing cost structures of the gas supply from producers (or importers) remain unchanged, and the revenues to be generated would correspond to these costs, plus the transportation costs, taxes and duties as at present. Hence there is no impact on subsidies as a whole, although the cost of gas to individual consumer costs would be rationalized as a result of the pooling arrangements. In subsequent years, with expansion of supplies in the pool, this would be altered based on the cost and quantum of additional gas supplies. Hence, irrespective of the option selected, specific pool rules would need to be agreed on the cost and quantity limits and implemented by the pool operator accordingly.

price pooling (either based on cost pooling or bid based pooling) is desirable for all the sectors consuming gas in order to bring in price stability at the individual consumer level. The decision about the treatment of natural gas pricing should be based on an analytic foundation that correctly describes the economic advantages and disadvantages of alternative pricing policies. Significant changes in gas pricing policies would have a sizable impact on the economy. Hence, there is need to find the balance between ensuring that prices are sufficiently high to provide returns that will attract investment and prices that are sufficient low to be affordable to the end-user.

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