ESTIMATING HOUSEHOL DEMAND FOR PRIVATE GENERATORS IN NIGERIA AS A BYE-PRODUCT OF CONSUMPTION DISUTILITY AND SYSTEM DYSFUNTION

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The electricity market is two-tier, the grid and non-grid. The latter represents the transactions involving the backup generators that kick-in for some households. Using the MAN calibrations for the System Annual Interruptions Duration Index (SAIDI) that capture consumption disutility from table 1 in the appendix, the expected value of this blackout period per day over which the non-grid market is functional would be 2.7 hours. Based on the 1998 survey reported in Adenikinju (2003), the average would be 3.6 hours, though the duration for residential usage interruptions might differ from the manufacturing customers represented in both cases .

Generator Submarket and Consumer Welfare.

The second-tier generator submarket, which has served as an equilibrating force in the overall power market, poses some real challenges to consumer well-being as they adjust to a stabilizing and maturing power market. As we noted earlier, the submarket exists to mitigate the unsatisfied demand for grid-based electricity. There are various indications of the market size and cost of generators from NERC's estimate of N796.7 billion in fuelling costs annually,[i] to N2 billion allocation for generator procurement, maintenance and fuelling in the 2009 Federal budget.[ii] Another anecdotal estimate puts the aggregate fuelling cost at N16.408 trillion.[iii] The analysis of a 1998 survey(Adenikinju, 2003) put the operating cost at N15.70 per kWh for both the electricity and the cost of producing it.

The size of the generator market stems from three principal factors:

- Unsatisfied Demand (U). Generators are desired to coax the demand unmet by the grid market. We noted various demand estimates earlier under the discussion of the spatial profile of electricity market. U is the difference between current output (Q_s) and demand (Q_d) levels. i.e.

  $U = Q_d - Q_s$

  Current output is between 2500 and 3000 MW. Demand estimate range from a lower bound of 5100 MW[iv] to an upper bound of 10,000 -12,000 MW as noted earlier. Hence, a rough estimate of the unsatisfied demand is a range between 2,00 MW and 9,000 MW.

  $2,000 \text{ MW} < U < 9,000 \text{ MW}$

Coverage for power interruptions due to demand shortfall will call for 5000 MW additional generation (or 3000MW excess capacity) to attain equilibrium (100%) reliability, assuming uniform distribution of consumption over time. The strength of consumer preference for reliability as indicated by the coverage function above will determine how much of this theoretical excess capacity will be absorbed. This can be estimated with the coverage equation above. This also tells us that under the current production level constrained by existing technological and managerial state of the country's power system, market equilibrium calls for 5000 MW to 24,500 MW additional generation to eliminate the demand for generators.

- Back-Up Demand (B). Beyond factors U and C , this reflects the sensitivity of the consumer's activities to power interruptions. Hence this component is highly driven by the tolerance for interruptions as dictated by the scope of the urgency of power for its activity. Different customer categories will exhibit differential responses to this factor. Hospitals and other healthcare firms, as well as retailers of perishable foods will have high back-up requirements. Industrial firms will have greater sensitivity than households. Some Utilities promote back-up generator demand as a tool for managing peak-load demand. Eskom of South Africa made this decision in 2007 as a result of which the value of the country's importation of diesel generators increased from a mere $23.8 million in 2006 to $265.4 million in 2008. Growth and export-oriented firms will also have a high back-up demand to minimize output losses. Hence, back-up demand is a function of income(Y) and an autonomous influence of preference borne out of industrial policy (G). While this variable would be highly correlated with C, the Reliability Coverage Effect, it is yet distinct, reflecting the independent influence of operational functionality (factor of necessity). C reflects taste or status effect. In the absence of any reliability problem, B will assume a greater weight as demonstrated by South African example noted here. We have no a-priori estimate for B under the Nigerian experience due to an overwhelming influence of both U and C.

- low reliability or "Reliability Coverage Effect" (C). This provision is a risk index reflecting the probability that power will not flow in consistency with expectations. In an excess demand environment, there is a tacit acceptance by the consumer of interruption occasioned by unsatisfied demand (U). Beyond this is a behavioral pattern that spells discontinuities in power provision in the face of supply constraints. This a function of reliability versus resource adequacy. Reliability in power supply will come at a price, which could be considerable spare capacity or operating reserve. We can capture this effect from such salient variables as the age of the plant (A), state of technology (T), efficiency of management / organization of production (E). In addition, this depends on income (Y) and taste (X). The magnitude of the cover by consumers depends upon their financial capacity to pay for the convenience of overcoming the interruption (Y) and the preference for procuring non-grid electricity at a higher price rather than substituting other, cheaper fuel sources for generating light (X). Thus

$$C = f(A, T, E, Y, X)$$

Both A and 'T' reflect system depreciation with A being a measure of the wear and tear and 'T' capturing system functionality and innovation. We may invoke ASAI, the Average Service Availability Index (or the ratio: (Consumer hours service available) / (Consumer hours service demanded) estimated in table 1 as a proxy for C. Hence,

$$C \approx 1 - 0.4 \approx 0.6$$

This implies that consumers will desire to buy the generator to supply additional 60% additional electricity above their demand level. However, their income and preference will determine the extent to which they will go.

The implications of the analysis above are far reaching. First, one of the secondary effects of service inadequacies and poor system performance in the power sector is an accentuated pent-up demand arising from consumers' defensive response to those inadequacies. This calls for a more careful demand analysis. Failure to recognize these influences would produce estimation errors. Furthermore, consumer response to the system shortfall precipitate negative welfare effects both in the environmental and health arena. This is documented in Fasoranti (2008) who noted that "The products of diesel fuel and its combustion represent one of the most common toxins……diesel exhaust is 100 times more toxic than gasoline exhaust………California Air Resources Board attributed about 2400 deaths directly to the deleterious effect of toxic fumes from diesel combustion." This problem appears to be receiving a close attention of the government as it was recently reported that the government is considering banning the importation of generators that do not come with 'optimizers' that limit emission of pollutants.[v]

Appendices 2 and 3 indicate that over 20,000MW are in the pipeline to boost current anemic production capacity. Our cursory analysis here indicates that this is only sufficient to coax current, estimated level of excess demand under the depicted market conditions. This will not accommodate economic growth at recent levels if this is sustained and more injection of capital is greatly needed. Government efforts at crafting standard Purchasing Power Agreements (PPA) to induce more merchant producers into the sector are timely but this has the potential of increasing prices in the short run as experience from Russia and other emerging markets have shown, thus negatively impacting consumer welfare.

Observations

Nigeria's early engagement with the restructuring of its electric power sector using the standard approach of breaking up its vertically integrated framework has provided some perspectives on the promises and pains of privatization. We see the beginning of the welding of the expectations of the major parties to the typical power sector privatization—these being the government, private sector, particularly IPPs, and the consumers of electricity, both residential and industrial . In many ways, the government's motivation is typical, its approach conventional and outcomes or prospects reflect some common early experience as well as its idiosyncrasies.

Its common early experience includes the growing pain of market adjustment. The power market remains in a state of distortion with the production bottlenecks not abating or worsening at times; and the glaring inefficiencies that make it stand out at the low end of reliability as we depicted in table 1 persist. Unsatisfied demand remains high and the cost of operating in the second-tier market of private, back-up generators remain high. However, the market is very dynamic with over 20,000 megawatts of electricity, which will more than quadruple current capacity, in the pipeline. This is a strong commitment to implementation of the privatization objectives. The institution of the subsidies will provide room for some benefits of the exercise to come on before consumers find themselves dealing with the market consequences of the improved amenities and services. The government, by its pronouncements, is also sending signals to the public that it intends to let private contracts between parties in the private market rule the day rather than hang on to vestiges of protectionism. It let it be known that standard Power Purchase Agreements are being fashioned as the bases for attracting merchant producers. It made a declaration to let market forces take hold upon the expiration of subsidy program.

APPENDIX

Table 1

Comparative Measures of System Reliability

Country	SAIDI* (Minutes)	SAIFI** # per year	CAIDI*** Hours	ASAI****
USA	88	1.5	0	1
Singapore	1.5	n/a	n/a	1
France	52	n/a	0	1

Nigeria (NEPA)	900	5	9	n/a
Manufacturer's Association of Nigeria	60,000	600	15 hours	0.4
% Electricity Requirement Generated by MAN………..72%				

Source: Manufacturer Association of Nigeria (MAN President's paper at EPSRA Conference)

(Table compiled from the president's presentation)

NOTE:

*SAIDI….System Average Interruption Duration Index (Annual average total duration of power interruptions to a consumer)

**SAIFI…. System Average Interruption Frequency Index (average number of interruptions of supply that a consumer experiences annually)

***CAIDI…. (Consumer Average Interruption Duration Index (average duration of an interruption of supply for a consumer who experiences the interruption of supply on an annual basis)

****ASAI…. Average Service Availability Index (Consumer hours service available/ Consumer hours service demanded)

[i] Reported by Usigbe, Leon, Aziken, Emma, Akinboade, Laide. Nigeria: N-Assembly passes Budget 2008. www.nairaland.com , February 12, 2008.

[ii] As reported in Oham, Otei, Owete, Festus, andFolasade-Koyi. Nigeria:2009 Budget – Presidency, NAS, MDAs to Spend N2 billion on Generators. www.nairaland.com, January 6, 2009.

[iii] See Amoda (2008).

[iv] This number was stated by the minister of Power , Dr Rilwan Olanrewaju Babalola in an interview with Africa Oil and Gas Report (www.africaoilandgasreport.com) reported in the July edition in which he stated, "We have just concluded a National Demand Study. It is the first focused, comprehensive study, not modeling, looking at growth rates of people, etc. We found out that the demand, including repressed demand is 5100 MW."

[v] "Banning Generators in Nigeria." Nigerian Curiosity, October 7, 2009. www.nigeriancuriosity.com