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The Benefits of Alternative Power Tariffs for Nigeria and Indonesia

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When the public sector's capacity to produce power is limited and private manufacturing firms are producing their own electricity, alternative power tariffs can result in aggregate cost savings and improve reliability.

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Summary findings

Anas and Lee present simulation results on the benefits of alternative power tariffs for Nigeria and Indonesia, based on several closely related models of the firm.

Nigeria is representative of developing countries where the public sector is inefficient and manufacturers provide their own electricity to compensate for that inefficiency. The use of private generators by Nigerian manufacturers is virtually ubiquitous, even though the government, to protect its monopoly, did not encourage that use in the 1980s. About 89 percent of a sample of Nigerian firms produced some of their power needs internally. But many large firms underused their power plants because of the substantial quantity discounts public power offered to large manufacturers.

By contrast, in Indonesia, manufacturers were offered only slight quantity discounts for public power. Indonesia has encouraged manufacturers to produce their own power. About 61 percent of Indonesian manufacturers produced some power internally.

Generally, in both countries firms purchase some power from the public sector at a quantity discount (slight in Indonesia, considerable in Nigeria) and also produce power internally at a declining marginal cost. The reliability of public power declines as the total quantity purchased increases, because transmission gets congested.

Simulations confirm that an increasing block tariff is optimal in each country and produces savings in the cost of producing public power and in firms' operating costs (including the firm's cost of producing power internally). Under increasing block tariffs, firms that purchase more public power would be charged higher marginal prices than firms that purchase less.

Large firms respond to the increasing block tariff by expanding their generating capacity and reducing their reliance on public power, while smaller firms contract their capacities and buy more from the public sector. When congestion in transmission persists, cost savings are higher as the increasing block tariff reduces total use of public power which in turn improves reliability.

In Nigeria, where strong quantity discounts are offered, total costs savings (for NEPA and manufacturers) under 1989 conditions are about 4 percent without congestion and increase to 9 percent when there is some congestion.

In Indonesia, where quantity discounts are mild, increasing the block tariff produces only slight cost savings.

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PREFACE

This report is part of a series of project reports (see the list below) produced within the research project, "Infrastructure Bottlenecks, Private Provisions, and Industrial Productivity: A Study of Indonesian and Thai Cities," which was jointly funded by the World Bank Research Committee (RPO 676-71) and USAID, Jakarta. Under the overall direction of Kyu Sik Lee, the study was jointly conducted with a research team headed by Chalongphob Sussangkarn at Thailand Development Research Institute, Bangkok, and a team headed by B.S. Kusbiantoro at Institute of Technology Bandung.

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SIMULATING ALTERNATIVE INFRASTRUCTURE PRICING POLICIES IN THE PRESENCE OF PRIVATE PROVISIONS: NIGERIAN AND INDONESIAN MANUFACTURING

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I. INTRODUCTION

Our purpose in this report is to explore the welfare implications of alternative pricing schemes for publicly supplied electricity when public supply is unreliable and competes with private provision. This will be done by calibrating models based on simple alternative assumptions about the firm's production technology and then simulating the responses of the individual firms in our sample to hypothetical changes in NEPA's pricing policy in Nigeria and PLN's pricing policy in Indonesia.

Nigeria is representative of those developing countries where the public sector is inefficient and private provision of electricity by manufacturers compensates for public sector inefficiency. The use of private generators among Nigerian manufacturers is virtually ubiquitous even though the Nigerian government did not encourage the use of generators in order to protect NEPA's monopoly. In our Nigerian sample collected in 1988, 89% of the firms produced some of their power needs internally. We also observed, however, that many firms underutilized their plant and also their generators. This is because of the recessionary conditions which prevailed in the 1980's.

In Indonesia, PLN is fairly efficient but its ability to supply power in a reliable manner is strained by the bottlenecks created due to the rapid growth of the Indonesian economy. In this situation and unlike Nigeria, the Indonesian government has encouraged the production of power by manufacturers and in 1991 has reduced the import tax on generators. In our Indonesian sample, collected in 1992, 61% of the manufacturers produced some of their power needs internally.

Another difference between the two countries is that NEPA offers substantial quantity discounts to manufacturers and in 1988 was operating far below cost recovery levels. By mid-1989, NEPA was reported to have raised its tariff and achieved full recovery of its operating costs. By contrast, in Indonesia any quantity discount offered to manufacturers is very slight. Also, PLN in 1992 was projected to be recovering 139% of its operating cost, probably in order to finance capital expansion.

As explained in Report No. 2, econometric analysis revealed that in Nigeria public electricity supplies are more limited for small firms, and small firms face higher marginal costs in self provision. As a result, small firms value improvements in the quantity and quality of publicly supplied power more than large firms do. This higher valuation was reflected in the higher shadow prices of electricity for small firms. In Nigeria, a one percent increase in the quantity of electric power bought resulted in a 0.65 percent decrease in the shadow price (Report No. 2).

A similar situation existed in Indonesia in 1992. Larger firms in Indonesia may value public power less than smaller firms do but the difference in the valuations of large and small firms is not as large as it is in Nigeria. A one percent increase in the quantity of electric power bought resulted in a 0.44 percent decrease in the shadow price (Report No.2). However, because of the rapid expansion in the Indonesian manufacturing sector, there are many large firms which attach high valuations to public power.

We will measure firm size by the quantity of electricity a firm buys from the public sector (NEPA or PLN). Current pricing policy, in both countries, is to offer quantity discounts (though these are slight in Indonesia, they are but considerable in Nigeria). Hence, firms which purchase less public power are charged higher marginal prices than are firms which purchase more. This pricing scheme, which would be efficient if public supplies were reliable, favors more intensive power consumption by the larger users and less by the smaller ones. In contrast, an increasing block tariff, if offered by NEPA or PLN, would induce the opposite consumption pattern by reducing the demands for public power by the large users and increasing it by the smaller ones. This would have the benefit of reallocating power to the smaller users who value it more and away from the larger users who value it less. The larger users would incur higher marginal costs than they do at present as they responded to the new tariff by switching a part of their supply from NEPA or PLN to their own generators.

Further cost-savings from an increasing block tariff would be realized if the new tariff were such that the reduction in the power bought by large users was more than the increase in the power bought by small users. If this were true, total power quantity purchased from the public sector would fall and the degree of congestion on the transmission network would be lower with the result that there would be fewer interruptions in public power supplies. As a result, all firms small and large, would have less need to utilize their own generators which are a more expensive source of power.[1]

While the above scenario makes intuitive sense, our immediate purpose in this chapter is to substantiate it at a quantitative level by utilizing simple models of the firm. In this spirit, the chapter is organized into six sections.

In section II, we present a simple version of the theoretical model which is similar to that developed in Section II of Report 2. In so doing we depart from the translog cost function estimated in Report 2. This departure is forced on us because of a well known technical limitation of the translog cost function. While these limitations are not critical in econometric estimation they do pose a difficulty in performing simulations.

The chief limitation is that translog is an approximate cost function which only locally satisfies the concavity and monotonicity properties of the cost function and does not do so for every sample point. Because of this, simulations with the estimated translog coefficients can produce inconsistent economic behavior. To circumvent this problem in this chapter, we use the Cobb-Douglas production function for the firm. The production technology is separately calibrated for each firm so that the observed behavior of the firm is predicted perfectly using the calibrated coefficients.

Two alternative Cobb-Douglas specifications are used. The first one assumes that the two types of electricity (publicly supplied and internally generated or embedded) enter the production function as two <u>essential substitutes</u>. The second specification, introduced in this report, assumes that the two types of electricity are <u>strict complements</u> to each other but that electricity is an

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[1] The presence of congestion in electricity transmission is well documented and strongly supported by anecdotal evidence. Unfortunately, there is little data that can be used to relate the aggregate demand for power to the degree of power breakdowns experienced by customers.

essential substitute with the other inputs.

Clearly, these two specifications have different economic interpretations. In the essential substitutes case the two electricities are assumed to have different qualities and production cannot take place unless both are used in positive quantities. However, the firm has flexibility in substituting one for the other. In the strict complements case, there are technological constraints related to the unreliability of the publicly supplied power. In this case, the firm must use its own power source to complement or boost the unreliable power bought from the public sector. Firms are assumed to use the two power sources at a ratio which is fixed and determined by the unreliability of the public sector. If publicly supplied power becomes less reliable, firms increase the ratio of privately generated to publicly supplied power and operate at a new fixed ratio.

In section II we investigate the economic behavior of the firm, under the assumption that the two types of power are essential substitutes. In section III we examine the case of strict complements. In section III we also present a further extension of the strict complements case by assuming that the degree of unreliability in the public sector's power supply is endogenously determined. This is based on the view that use of public power in Nigeria creates an externality : if a firm buys more power from the public sector it congests the transmission network and raises the rate of power disruptions for all the firms buying from the public sector. A switch by a firm to its own generators confers a positive externality on all firms by reducing the rate of public power unreliability experienced by all firms. While each firm can to some extent directly influence the rate of power unreliability which it experiences, by investing in voltage stabilizers, that rate is made endogenous largely by the level of aggregate purchases from NEPA or PLN and is therefore influenced by the tariff.

Section IV presents a set of simulations for Nigeria based on the essential substitutes and strict complements models. We show that an increasing block tariff produces cost savings for NEPA as well as for the smaller firms. Larger firms reduce their reliance on NEPA power increasing their use of their generators and other inputs. Smaller firms respond in the opposite manner by increasing consumption of NEPA power and relying less on their generators and on the other inputs. The higher costs of production experienced by the largest dozen or so firms are more than offset by the cost savings which accrue to all the smaller ones. NEPA's behavior is constrained and assumed to remain inefficient. We calibrate the level of NEPA's offered tariff by assuming that it seeks to recover a given fraction of its costs.

Lack of data did not allow us to measure the degree to which public power unreliability is sensitive to the level of congestion. To compensate for this weakness, we have performed simulations, also reported in Section IV using alternative assumptions about the degree of this sensitivity. Once congestion is taken into account, then increases in NEPAs tariff have higher benefits, especially for smaller firms, because, in the presence of improved reliability, these firms reduce their dependence on their own generators and substitute more of the cheaper NEPA power for their own.

In Section V, the results of pricing simulations for Indonesia are reported. The simulations follow the example of those reported for Nigeria. However, in the Indonesia simulations, we confined our attention to the strict complements model only since the results of the two models were similar. Also, we excluded those firms which did not have any generators installed in 1992. While this sample selection makes the universe of studied firms superficially comparable to those in Nigeria, the findings are quantitatively quite different.

An increasing block tariff produces positive benefits in the case of Indonesia as well. However, the benefits are smaller in Indonesia than they are in Nigeria because the Indonesian tariff does not offer much of a quantity discount as does the tariff in Nigeria. Also, our sample of manufacturers in Nigeria included several very large firms which used substantial quantities of NEPA power. When these firms switch away from NEPA, large reductions in congestion are realized. In the case of Indonesia, the largest firms do not account for as big a degree of usage. Hence, inducing them to use their own generators produces lower benefits.

II. THE ESSENTIAL SUBSTITUTES MODEL

The firm's cost minimization problem is stated in general terms as :

(1) $$\underset{L,M,e,e_N}{\text{Minimize}} \; C_i = p_{Li}\, L + p_{Mi}\, M + c_i(w_i,e) + t_i(e_N)$$

subject to :

(2) $$Q_i(L,M,e,e_N) = Q_i.$$

Each firm i produces the target output level Q_i at the lowest possible cost. The inputs of labor (L) and raw materials (M) are bought at the constant prices p_{Li} and p_{Mi}. Power from the public sector (e_N) is purchased at a quantity discount. Therefore, the marginal price declines with the quantity purchased. The public sector's tariff is estimated by the concave function,

(3a) $$t_i(e_N) = B\, \delta_i\, e_N^{\beta}.$$

δ_i is a scale effect capturing variations in pricing which are specific to the firm.[2] The marginal price calculated from (3a) is:

(3b) $$t_i'(e_N) = \beta\, B\, \delta_i\, e_N^{\beta-1}.$$

The cost of endogenously generated power is measured by the cost function $c_i(w_i,e)$. The inputs used in endogenous power generation are labor, materials and generators. These are assumed purchased at constant prices given by the vector w_i. Hence, the embedded cost function has the form :

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[2] In Nigeria, B = 0.56678 and β = 0.67714. In Indonesia, B = 249.38 and β = 0.90972. The value of B is, of course, a reflection of different monetary units (nairas in Nigeria and rupiyahs in Indonesia). β, however, reflects the degree of quantity discount offered. The closer β is to one the lower the discount. These tariff equations given by (3a) were estimated as simple regressions of ln $t_i(e_{Ni})$ against ln e_{Ni} , with ln B the regression constant and β the slope coefficient. The value of R^2 was 59% in Nigeria and 84% in Indonesia. This reflects the considerably higher variation in tariffs in Nigeria. The variation is due to regional and industry specific differences in pricing.

(4a) $$c_i(w_i,e) = G_i e^{\alpha},$$

where α measures the degree of scale economies in embedded electricity production and G_i is a firm-specific constant which measures the effects of the input prices.[3] The marginal cost calculated from (4a) is :

(4b) $$c_i'(w_i,e) = \alpha\, G_i e^{\alpha-1}.$$

Now consider the specification of the firm's primary production function. We will use the Cobb-Douglas form with the two types of electricity entering as essential substitutes.

(5a) $$Q_i(L,M,e,e_N) = A_i\, L^{a_{Li}} \quad M^{a_{Mi}} \cdot e^{a_{\alpha i}} \quad e_N^{a_{Ni}} \quad .$$

We will assume that there is diminishing returns with respect to each input which requires that the exponent be greater than zero but less than one.[4] Isoquants will be convex to the origin. (5a) implies that the two kinds of power have different qualities, acting as two different inputs. Production cannot occur unless each input is used in positive quantities. The isoquant between e and e_N keeping L and M fixed is convex to the origin and does not cut the axes.

The shape of the isocost curve, keeping L and M fixed, depends on whether NEPA offers a decreasing or increasing block tariff. In both cases, the slope of the isocost line is,

(6a) $$\frac{de}{de_N} = - \frac{\partial t/\partial e_N}{\partial c/\partial e} = - \frac{\beta\, B\, \delta_i\, e_N^{\beta-1}}{\alpha\, G_i e^{\alpha-1}} < 0.$$

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[3] This functional form corresponds, for example, to an underlying embedded technology which is Cobb-Douglas. In that case, G_i would be a Cobb-Douglas function of the embedded input prices with the exponents of the input prices being the cost-shares of the embedded inputs in total embedded cost. Cobb-Douglas estimates of such cost functions gave $\alpha = 0.55407$ for Nigeria and $\alpha = 0.3240$ for Indonesia.

[4] This condition was satisfied in calibration.

(6b)
$$\frac{d^2e}{de_N^2} = -\beta \frac{t'(e_N)}{c'(w,e)} \left[\frac{\beta-1}{\beta} - \frac{1-\alpha}{\alpha} \frac{t(e_N)}{c(w,e)} \right] e_N^{-1}.$$

The sign of (6b) is positive when a decreasing block tariff is offered (quantity discount, $\beta < 1$) insuring that the isocost is convex to the origin and tangent to both axes with the cost minimizing solution occurring as shown in Figure 1a. When $\beta = 1$,a constant block tariff is offered and the isocost is still convex to the origin, is tangent to the e_N-axis and cuts the e-axis. Finally, when an increasing block tariff is offered, the isocost obtains a skewed sigmoid shape as shown in Figure 1b. In each case, we will assume that there is a single cost minimizing point, ruling out the possibility that the isocost and isoquant "hug" each other.

Solving the cost minimization problem, we obtain the familiar first order conditions, (7a)-(7c) below, which state that the rates of technical substitution between each pair of inputs equal the ratio of the relevant inputs prices. The only modification in the present case is that marginal rather than constant prices are used for e and e_N :

(7a) $(p_{Mi}/p_{Li}) - (a_{Mi}/a_{Li})\,(L/M) = 0,$

(7b) $(\partial c_i/\partial e)p_{Li}^{-1} - (a_{oi}/a_{Li})\,(L/e) = 0,$

(7c) $(\partial t_i/\partial e_N)p_{Li}^{-1} - (a_{Ni}/a_{Li})\,(L/e_N) = 0.$

To these conditions we add the output constraint :

(7d) $$Q_i = A_i\, L^{a_{Li}}\, M^{a_{Mi}}\, e^{a_{oi}}\, e_N^{a_{Ni}}\ .$$

For each firm i, the above four equations (7a)-(7d) are solved simultaneously to find the firm's choice of inputs L_i, M_i, e_i, e_{Ni}, <u>given</u> the constant prices p_{Li}, p_{Mi}, the embedded cost and tariff parameters B, δ_i, β, G_i, α, the production function coefficients A_i, a_{Li}, a_{Mi}, a_{oi}, a_{Ni} and the output level Q_i.

Suppose that the price of one input falls, then the firm will use more of that input and less of each of the other inputs. The substitution effect is even stronger when, because of quantity discounts, marginal prices fall with the quantity used. Hence, suppose that the marginal price of public power falls (due to a shift in the tariff), then the firm will buy more public power, will produce less from its own generators and will buy less labor and materials at constant prices. As the firm buys more public power, the marginal price of it will fall further due to the decreasing block tariff and as the firm produces less of its own power, the marginal cost of its own power will rise due to the scale economy in embedded production.

III. THE STRICT COMPLEMENTS MODEL

Our field observations in both countries strongly suggested the presence of technological constraints with respect to power use. In Nigeria, as well as in Indonesia, some firms are forced to use their own generators when public power fails while others use their own generators to stabilize voltage fluctuations in public power. These observations suggested the possibility that the two kinds of power are complementary rather than substitutable. Hence, our interest in developing a model which treats this view.

In the strict complements case, we specify the production function as,

$$Q_i(L,M,e,e_N) = A_i\, L^{a_{Li}}\ M^{a_{Mi}}\ (e + e_N)^{a_{Ei}}, \tag{8a}$$

with the requirement that $e = b_i\, e_N$, which says that the two electricities must be used at a fixed ratio, b_i. The ratio is related to the reliability of the public power source. If the public source gets less reliable for firm i, then b_i increases forcing the firm to use more e per unit of e_N. Alternatively, let E be the total quantity of power used by the firm. Then, $e = \pi_i E$ is the quantity internally generated and $e_N = (1-\pi_i)E$ is the quantity bought from the public sector, where π_i is the fraction of total power, E, which is internally generated. Then clearly $b_i = \pi_i/(1-\pi_i)$. Making the appropriate substitutions into (8a) we can now rewrite it as :

$$Q_i(L,M,b,e_N) = (1+b_i)^{a_{Ei}}\ A_i\, L^{a_{Li}}\ M^{a_{Mi}}\ e_N^{a_{Ei}}\ . \tag{8b}$$

This formulation expresses output as a function of public power, labor and materials and shows clearly that the output of the firm also depends on the rate b_i at which the firm boosts public power with its endogenously generated power : firms which operate at higher rates of boosting will be more productive. (8b) also shows that a higher rate of boosting can be substituted for public power. This is shown in Figure 2. Rays through the origin represent discrete alternative technologies for combining public power with endogenous power. The higher the slope of a ray, the higher the degree to which endogenous power is used to boost (or complement) public power. Points A and A', which correspond to the same level of output, represent two different quantities of public power and two different rates of boosting. As we shall see below, the rate of boosting given by b_i is determined by two factors. One of these is the degree of congestion in the delivery of the public sector's power and the other is a firm-specific effect representing the firm's investment in equipment aimed to regulate voltage fluctuations and other exogenous characteristics of the firm such as its location.

The cost minimization problem of the firm can now be written as follows :

(9a) $$\underset{L,M,E}{\text{Minimize}} \quad C_i = p_{Li} L + p_{Mi} M + c_i(w_l, \pi_i E) + t_i([1-\pi_i]E)$$

subject to :

(9b) $$Q_i(L,M,E) = Q_i,$$

The Marshallian optimization conditions for this problem are :

(10a) $$(p_{Mi}/p_{Li}) - (a_{Mi}/a_{Li})\,(L/M) = 0,$$

(10b) $$[(\partial c_i/\partial e)\pi_i + (\partial t_i/\partial e_N)(1-\pi_i)]p_{Li}^{-1} - (a_{ei}/a_{Li})(L/E) = 0,$$

and the output constraint given by (9b).

(10a) and (10b) state that the rates of technical substitution between labor and materials and labor and electricity equal the ratio of input prices. In the case of electricity the relevant marginal price is the weighted average of the marginal embedded cost and the marginal tariff price. Assuming that the latter is smaller than the former, a higher rate of public sector unreliability given by π_i increases the weighted marginal price of E and, hence, the labor to electricity ratio in production.

For each firm i, (10a), (10b) and (9b) are solved simultaneously to find the firm's choice of inputs L_i, M_i, and E_i, given the constant prices p_{Li}, p_{Mi}, the parameters B, δ_i, β, G_i, α and the production function coefficients A_i, a_{Li}, a_{Mi}, a_{ei}, the output level Q_i and the exogenous rate of unreliability, π_i.

As a next step we extend the above model further by endogenizing the effect of congestion on the rate of unreliability. Although each firm faces an exogenous rate, the aggregate demand for NEPA power determines the rates of unreliability faced by each firm. Note first that the aggregate demand for public sector power is :

(11) $$D = \Sigma_j (1-\pi_j)E_j,$$

where the summation is over all the firms. Now suppose that the following function determines the rate of unreliability faced by the ith firm :

(12) $$\pi_i = \frac{\Omega_i D^{\phi}}{1 + \Omega_i D^{\phi}} = \frac{\Omega_i[\Sigma_j(1-\pi_j)E_j]^{\phi}}{1+\Omega_i[\Sigma_j(1-\pi_j)E_j]^{\phi}} \; ; i=1,\ldots,n.$$

Two influences contribute to this process. One, the aggregate demand for public sector power, D, affects all firms by raising the value of π_i. If $\phi = 0$, then aggregate demand has no effect and there is no congestion. The higher the value of $\phi > 0$, the higher the congestion effect. The second influence is a firm-specific idiosyncratic effect measured by the parameter Ω_i. This reflects such things as the firm's region or location within a region, the quality of the firm's cable connections to the public power network, the quality of the firm's voltage stabilizing equipment etc. The lower the value of Ω_i, the lower the rate of unreliability which is implied.

This suggests that the firm can partially control its vulnerability to the public sector's unreliability by making investments in equipment and in logistical procedures which reduce the value of Ω_i or even by changing its location. In our simulations, we will assume that Ω_i are exogenous to the firm and remain fixed.

Equation (12) shows that the interruption rates faced by various firms are interdependent through the congestion externality: given the firm-specific Ω_i's and the n firm-specific demands, the E_i's, equilibrium requires that all n equations must be simultaneously solved by a set of π_i's.

Consider the following comparative statics argument. Suppose that a firm's Ω_i is reduced exogenously. Ceteris paribus, this causes the rate of unreliability to fall. In Figure 2 this corresponds to the firm switching from point A to point A' as it reduces its Ω_i, requiring less boosting of public sector power by its own. But higher reliability makes the effective marginal price of E lower [see (10b)] and raises the amount of E consumed. This means that to produce the same output the firm moves to a higher isoquant between e and e_N because the non-power inputs L and M are lowered. Hence, E_i is raised and so is $(1-\pi_i)E_i$ as π_i is lowered. In Figure 2, this is shown by the movement from A to B'. So when firm-specific factors which contribute to the unreliability experienced by a firm are reduced, that firm buys more public sector power and, through congestion, contributes to higher unreliability for other firms. An unambiguous reduction in unreliability takes place for all firms when the aggregate demand for public sector power is reduced either by a change in the tariff or by an indirect means such as subsidizing the cost of private power generation.

IV. SIMULATING TARIFF POLICY FOR NIGERIA

In order to perform simulations with the above models of the firms' behavior, we have to first do two preparatory tasks. One is to calibrate the firm's production function using data from the survey of Nigerian manufacturers. The second task is to decide on an appropriate price setting behavior on the part of NEPA.

A. Calibration Procedure

As explained in the earlier section, the degree of scale economies in producing endogenous power were assumed to be the same for each firm and the coefficient $\alpha = 0.55407$ was estimated from a Cobb-Douglas specification of the embedded cost function. Then, the scale factor G_i was set for each firm in such a way that the firm's reported cost of endogenous electricity generation was replicated.

Following this, the essential substitutes model was calibrated as follows. a_{Li}, the exponent of labor in the ith firm's production function, was set as $a_{Li} = s_{Li}/s_Y$, where s_{Li} is labor's share in the firm's total production cost and $s_Y = 0.88172$ is the degree of scale economies in primary production estimated from a Cobb-Douglas specification of the cost function. Once a_{Li} was thus calibrated, equations (7a)-(7c) were used with the observed prices and input levels to calculate a_{Mi}, a_{oi} and a_{Ni}, the remaining exponents in the firm's production function. Then, using the observed output and input levels and the calibrated exponents, the scale parameter of the production function A_i was calculated. Similarly, the production function of the strict complements model was also calibrated using an analogous procedure, in this case working with (9b) and (10a), (10b) and obtaining a_{Li}, a_{Mi} and a_{Ei} and the scale parameter A_i.

B. NEPA's Behavior

NEPA offers quantity discounts which are a form of price discrimination. The prices charged to specific firms vary around the estimated tariff. Some such variation is obviously due to measurement errors, but a part of the variation is due to the fact that prices charged by NEPA vary considerably by industry and location within Nigeria.

In 1988, when our data was collected, NEPA was believed to be covering only about 21.9% of its operating cost. This is surmised from World Bank studies of NEPA [Report No. 11672-UNI, July 1993].[5] In 1988 the average tariff charged by NEPA was 0.07 naira/KWh which was much below average operating cost. By mid-1989 the average tariff was raised to 0.32 naira/KWh which covered NEPA's operating cost. Hence, assuming that conditions were roughly unchanged between 1988 and mid-1989, only 21.9% of NEPA's operating cost was covered in 1989. Further scrutiny of the data shows that the cost recovery ratio was much higher from power sold to residential users than it was from power sold to manufacturers. Estimates by NEPA management in 1990 indicate that 73.33% of the power sale revenues were from non-manufacturers (residential and commercial users) with the remaining 26.67% from

[5] See page 5 of World Bank Report No. 11672-UNI.

manufacturers.[6]

Assuming that the sources of the revenues were not changed in the 1988-1990 period, the following equation relates the cost-recovery ratios applied to the two sectors in 1988 :

(13a) $$x_1 (0.267) + x_2 (0.733) = 0.219,$$

where x_1 and x_2 are the cost recovery ratios of manufacturing and non-manufacturing respectively. If one of these ratios can be estimated, then the other can be calculated from the above equation. We estimate x_1 from our sampled manufacturers and then use the above equation to calculate x_2.

The 160 firms in our sample bought 837,148,000 KWh of power from NEPA in 1987 and collectively paid 15,845,000 naira to NEPA. At an average cost of 0.32 naira per KWh, the power delivered to these firms cost 267,887,360 naira to produce. Dividing payments to NEPA by the cost we get $x_1 = 0.059$. Hence, only 5.9% of the cost of serving these manufacturers was recovered by NEPA. From the above equation, $x_2 = 0.277$, which means that NEPA recovered 27.7% of the cost of serving the nonmanufacturing users. Together, the two sectors recovered 21.9% of NEPA's operating cost. Hence, the nonmanufacturing sector's cost recovery rate in 1988 was 4.695 times that of the manufacturing sector.

In performing simulations, we will experiment with alternative tariffs while keeping the relative cost recovery ratios (or the rates of cross-subsidization) at 1988 conditions. We will also simulate mid-1989 conditions when NEPA achieved full cost recovery, with the average tariff raised to 0.32 naira/KWh, by assuming that the relative cost recovery ratios remained at 1988 levels. For mid-1989, the above equation will be written by setting the right side equal to one

[6] See page 85 of World Bank Report No. 11672-UNI.

(full cost recovery) and setting $x_2/x_1 = 4.695$. Then, letting y be the cost recovery ratio for manufacturing, we solve y from :

$$(13b) \qquad y\,(0.267) + (x_2/x_1)\,y\,(0.733) = 1.00,$$

and find y = 0.269. Hence, as NEPA moved towards operating cost recovery in mid-1989, the cost recovered from the manufacturing sector would have risen from 5.9% to 26.9% while that recovered from the nonmanufacturing sector would have risen from 27.7% to 130% assuming no change in the relative rate of cross-subsidization of the manufacturing sector by the nonmanufacturing sector.

Our purpose is to test the effects of alternative tariffs on the manufacturing sector by simulating the factor choices of each of the firms in our sample, while keeping constant NEPA's cost recovery ratio for manufacturing. Alternative tariffs will be simulated by changing the value of β which determines the rate of quantity discount in Equation 3a and by calculating the constant B for each value of β, such that the cost recovery ratio is at the given level. Thus, denoting the cost-recovery ratio by ρ, the value of B (given β) must satisfy the following equation :

$$(14) \qquad \Sigma_i\, B\, \delta_i\, e_{Ni}^{\beta} = k\,(\Sigma_i\, e_{Ni})\,\rho,$$

where the left side is total NEPA revenue by summation of the total tariffs charged to the n firms (from Equation 3a) and the right side is the cost-recovery ratio times total NEPA cost, calculated as average cost per KWh (k) times the total number of KWh of power sold by NEPA to the n firms.[7] Of course, the values of e_{Ni} are found by solving each firm's cost minimizing response in light of the new tariff characterized by a given value of β and the calculated value of B. When $\beta < 1$ the NEPA tariff embodies a quantity discount and when $\beta > 1$ it embodies

[7] The average tariff per KWh, k, was 0.32 naira (32 kobos) in the period 1988, 1989.

a an increasing block structure. For 1988 conditions, we will set the cost recovery ratio ρ = 0.059 and for mid-1989 we will set it at $\rho = 0.269$.

In Figure 3, two tariffs, one decreasing-block and the other increasing-block are juxtaposed. The decreasing-block tariff is the curve OA (with $\beta < 1$) and the increasing-block tariff the curve OB (with $\beta > 1$). Suppose that the tariff is changed from OA to OB. Now consider the point N which is a quantity purchased from NEPA such that the marginal tariff before and after the change is the same. All firms which initially purchased power less than N will now be facing lower marginal costs and will increase their use of NEPA power, while the firms originally purchasing more than N units are now facing higher marginal costs and will decrease their use of NEPA power. It is easily seen from this that the increasing block tariff encourages small users to buy more NEPA power while inducing larger users to buy less. If the reduced purchases of the latter more than offset the increased purchases of the former, NEPA's operating costs will be reduced. Moreover, total payments to NEPA will also be reduced for many firms. For example, the firm originally buying OC units will face lower total NEPA payments as long as the changed tariff does not induce it to consume more than OC' units. We will return to Figure 3 when we interpret the results of our simulations.

C. Measurement of Benefits

Now let us consider how the economic benefits of a given tariff should be calculated in the present context. First note that firms are minimizing costs. Hence, output levels and output prices are considered unchanged for each firm. This is clearly somewhat unsatisfactory, but there is no way around it since we do not have any knowledge of the market demand functions for the goods in question and, therefore, we cannot simulate how output prices would change in response to changes in marginal costs generated by the changed tariffs. Because of this, we are forced to pose our welfare calculations in a cost minimizing context. Benefits to firms will be measured by the reduction in their total payments to the factors of production needed to produce the given amount of output. Hence, the benefit level will be measured by the sum of their labor, materials, embedded electricity and NEPA costs. Benefits to NEPA will be measured by the decrease in NEPA's losses (NEPA's production cost less NEPA's revenues). Total economic benefits are the sum of the benefits to the firms less losses by NEPA. Note that payments to NEPA appear as costs borne by the firms, on the one hand, and as payments received by NEPA on the other, cancelling from the total benefit calculation. Because of this, the total benefit measure is written as the sum of all costs of production including the cost of producing the power supplied by NEPA :

$$TC = \Sigma_i \, [p_{Li} \, L_i + p_{Mi} \, M_i + c(w_i,e_i) + k \, e_{Ni}].$$

Improvements in benefits are equivalent to reductions in TC.

Consider also, how a tariff change for manufacturing will affect the non-manufacturing sector. Suppose that the effect of the tariff is to decrease total NEPA production. Since the cost recovery ratio of the manufacturing sector is being kept constant and since the non-manufacturing sector is subsidizing the manufacturing sector, the tariff charged to non-manufacturing users can be decreased. Such a decrease is a cost saving and a benefit to non-manufacturing users but this is exactly offset by the lower payments NEPA collects from these users. Non-manufacturing users could increase their demands for NEPA electricity following the lowering in NEPA's tariff to them. However, it is reasonable to assume that non-manufacturing demands for NEPA electricity are inelastic. With all these assumptions, total costs in the non-manufacturing sector, as defined above, will be the appropriate measure of welfare, but those costs will remain unchanged.

Using the values observed in 1988, the 160 firms in our sample accounted for a total cost level (TC) of 1,693,515,650 naira of which 79.4% (or 1,344,588,875 naira) comprised expenditures on labor and materials inputs, another 15.8% (or 267,887,360 naira) was the cost of public electricity produced by NEPA and the remaining 4.8% (81,039,415 naira) was the cost of privately produced electricity. Payments to NEPA were 15,845,000 naira or about 20% of the aggregate cost of internally generated power.

D. Simulations with the Essential-Substitutes Model

Table 1 shows the results of the search for the optimal tariff under 1988 conditions, with the cost-recovery ratio for manufacturing at 5.9% (ρ=0.059). Each row of the table calculates the value of the tariff "level" parameter B given the tariff "rate" parameter β. Changes and benefits are calculated relative to the observed tariff with B = 0.5667823 and β = 0.67714. As the tariff exponent β is increased toward one, quantity discounts get weaker and as it passes one increasing block tariffs are offered.

At first, total benefits increase sharply as the value of β deviates from the observed value. For example, increasing β from 0.8 to 1.8 raises the percentage increase in total benefits from 2.83% to 10.00%. Subsequently, the rate of increase becomes more gradual. The biggest percentage decrease in the firms' operating costs is about 0.94% and is observed for β between 1.2 and 1.4. Embedded costs decrease by as much as 0.62% when β=1.2 and then increase gradually thereafter. Between β = 13.8 and β = 18.8, the benefits are virtually unchanged. The optimum is approximately at β = 15.2. The overwhelming part of the gain in benefits comes from a reduction in NEPA's costs. Because of the increasing block nature of the tariff, firms reduce their NEPA purchases by 95% on the average. At the optimal β value, embedded costs increase by 1.49% and firms' total operating costs by 0.87% but the decrease in NEPA costs more than offsets the increase in private costs resulting in a 13.43% increase in total benefits.

Table 2 presents the responses of a subsample of selected individual firms from the full sample of 160 manufacturers when β is at its optimal value of 15.2. The table includes the responses of the five smallest and five largest NEPA users (by annual 1000 KWhs) and every tenth firm from the fifth smallest to the fifth largest user of NEPA. Referring to Figure 3, the quantity N is at about 250,000 KWh per year. There are 78 firms which initially consumed more than N units of power and these firms reduce their power consumption because they face a higher marginal price after the tariff change.[8] Reductions of NEPA power increase gradually from 1.2% for the smallest of these 78 largest firms to 99.9% for the very largest. The 82 smallest firms, on the other hand, face lowered marginal prices and increase their NEPA purchases by 4097% for the smallest firm to 0.7% for the largest such firm. The total operating cost of firms consuming more than a million KWhs of NEPA power increases while all smaller firms experience some reduction in their operating costs (Table 3). However, savings in operating cost are relatively small percentages because the firms have to compensate for the large changes in NEPA power by making adjustments in their other inputs. Because of the Cobb-Douglas nature of the technology, labor, material and embedded electricity expenditures are changed by the same percentage amount for each firm. As explained earlier, the bulk of the total benefits are due to less power production and, hence, lower costs by NEPA.

A second simulation was done to evaluate the effects of the actual tariff change which occurred in mid-1989. As explained earlier the tariff change was such that NEPA's average tariff per KWh was raised from 7 kobos in 1988 to 32 kobos in mid-1989 to roughly cover NEPA's

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[8] Twelve of these seventy eight firms appear in Table 2.

operating cost. As we saw earlier, this change implied an increase in the cost-recovery ratio of manufacturing from 5.9% to 27%. Keeping the value β at its observed level, we simulated the effects of imposing the higher cost-recovery ratio and calculated B accordingly. The marginal price of NEPA power increased by about 340% for each firm in our sample. To this the firms reacted as expected by substituting embedded power and other inputs for NEPA power. Each firm reduced its purchases from NEPA by about 76%-78% and increased its embedded power by various percentages ranging up to 30%. Total internally generated power increased by 0.69% and total expenditures on labor and materials increased by about 1.4%. The total cost of internal electricity generation increased by 1.08% and total operating cost increased by 1.13%. NEPA revenue from manufacturing and NEPA's cost of serving manufacturers increased by 3.95%.

The next step is to use the above simulation as the new base on which to find the optimal tariff under mid-1989 conditions. These results are shown in Table 3, which again varies the value of β finding B in each case so that the cost-recovery ratio is now 27%. The optimal tariff is around $\beta = 2.6$. Total benefits increase by 1.65%. Although an increasing block tariff does result in improvement under the mid-1989 conditions, the percentage improvement is about an eighth of that which occurs under the 1988 conditions. However, the optimal tariff still requires raising the marginal costs of the larger NEPA users and lowering the costs of the smaller users. NEPA saves 44,793,960 naira in production cost, NEPA revenues are reduced by 11,489,850 naira and the firms' operating costs are increased by 8,119,000 naira. Under the optimal tariff, the largest thirteen NEPA users experience higher marginal costs and reduce their NEPA purchases from 9% to 98.5%. The responses of the five largest users is included in Table 4.

E. Simulations with the Strict-Complements Model

In the strict complements case we report the results of three simulations which parallel those discussed above. Under each alternative tariff, the degree of unreliability, π, is assumed to remain fixed at its observed value for each firm. This means that firms will respond to a higher marginal NEPA price by reducing both NEPA and internally generated power by the same percentage amount and increasing all other inputs by the some other percentage amount. This is easily seen from Figure 2 where the firm is constrained to operate on the same rate of boosting, i.e. on a fixed ray through the origin with given slope b_i.

As shown in Table 5, improvements over the 1988 actual tariff are maximized by offering a steeply rising tariff. The optimal values of β is 7.8. With this tariff, total benefits are increased by 12.96%. Embedded production costs are 4.56% lower and operating costs are 0.29% higher. NEPA's production costs are 88.7% lower. From Table 6, we can see that the largest firms decrease their use of power. There are actually 13 such firms, which face a higher marginal price than they did before the tariff change. These firms reduce their power usages by various percentages ranging from 3.4% for the smallest to 99.4% for the largest. The responses of the largest five are included in Table 6. The smallest firms, on the other hand, increase their consumption of power because NEPA tariffs for small users are drastically reduced. Tariffs fall virtually to zero for firms using up to about 750,000 KWh of power annually.

The next simulation imposes the cost recovering tariff which took place in mid-1989. The general rise in tariffs results in a 53% reduction in NEPA's cost of production and a 22% reduction in embedded power production costs. Operating costs of production increase by 2.63%. Table 7 shows the search for the optimal tariff in the mid-1989 conditions. The value of β is 2.4. The benefit level increases by 4.05%. NEPA's costs are 79.6% lower, embedded costs 9.88% lower and operating costs 0.77% higher. The responses of the subsample of firms is shown in Table 8.

The next set of simulations with the strict complements model treats congestion endogenously. Therefore, the equilibrium degrees of reliability, π_i, facing each firm satisfy the equation system given by (12). One unknown piece of information is the degree to which π_i will respond to changes in the aggregate demand for NEPA power, D. We assumed that a one percent decrease in aggregate demand for NEPA power will result in a one percent reduction in π_i. The value of ϕ in (12) was calibrated so that the weighted average elasticity of π_i with respect to D was 0.01.

The simulations for this case also parallel the previous ones. From Table 9, the optimal 1988 tariff has $\beta = 17.5$. The benefit level is improved by 14.49%, NEPA's costs fall by 86.34%, embedded costs fall by 61.32% and operating costs by 1.93%. From Table 10 we can see that all firms which increase their total power use, increase their purchases from NEPA by a bigger percentage than they increase their own production. Many firms even decrease their own production. As shown in Figure 4, both patterns are consistent with an improvement in reliability. In Figure 4a, the substitution effect of the reliability improvement dominates over the output effect. In Figure 4b, the output effect dominates. However, because in our simulations the output level is fixed, a reduction in the use of the other inputs (labor and materials) in favor of electricity is required to produce the constant level of output under higher reliability in public electricity supply.

Because reliability is improving, there are firms which increase their use of NEPA power even as the marginal price of NEPA power offered to them increases. As we saw earlier, keeping reliability constant, a firm which faces a higher marginal price would want to reduce its use of both kinds of power. However, because reliability is improved, the firm will want to use more NEPA power. This substitution effect of the reliability improvement can more than offset the substitution effect of the price increase.

The largest firms decrease their consumption of both kinds of power, but decrease their internally generated power by a larger percentage.

In the second simulation, the actual mid-1989 tariff improves reliability because the increase in the tariff results in a 42.27% reduction in the aggregate demand for NEPA power. Firms' own electricity generation drops by 67.2% and their embedded cost by 36%. Operating cost increases by 2.33%. Under mid-1989 conditions, the optimal $\beta = 3.5$. As seen from Table 11, this results in a 7.32% improvement in the level of benefits. Operating costs drop by almost 2%, embedded cost by almost 60% and NEPA cost by 75.5%. The firms' responses are shown in Table 12.

A final set of simulations with endogenous reliability was also performed by assuming that the elasticity of the degree of unreliability with respect to the aggregate NEPA use was 2% or twice as high as in the set of simulations discussed above. Detailed results for this last set of simulations are not presented. But Table 13 which summarizes the aggregate results of all the simulations includes this last case as well. It is seen from that table that the benefits of an optimized tariff are higher when the degree of congestion in the supply of public electricity is higher.

V. SIMULATING TARIFF POLICY FOR INDONESIA

Our survey sample in Indonesia was conducted in 1992, five years later than in Nigeria. A total of 279 firms remained after routine data cleaning and of these only 171 reported using both power sources. Virtually all of the remaining firms relied entirely on PLN. This is an important difference from Nigeria where, as mentioned earlier, 87% of the firms used both power sources. In addition, the Indonesian sample includes a broader representation of the smallest firms whereas the Nigerian sample is strongly biased towards larger firms. In the Indonesian sample many firms which used both sources of power used small quantities of their own power. This is in part a reflection of the fact that the public power source is more reliable in Indonesia than it is Nigeria and that some of the sampled firms had, perhaps, virtually abandoned use of their generators by 1992, but it may also be due to the bias that smaller users appeared more frequently in the Indonesian sample.

Since we are simulating tariff policy we ought to consider, in principle, the potential response of exclusive PLN users when PLN's tariff is changed. More specifically, if some firms are charged a sufficiently higher marginal price for PLN power they might consider installing their own generators and using their own power at least part of the time. At the other extreme, firms for which PLN power is made sufficiently cheaper could greatly increase purchases from PLN. These two types of responses are important components of how the entire Indonesian population of firms would respond to PLN tariff changes. It is difficult to include in the simulations the behavior of the exclusive PLN users. The main reason for this is that we do not know what kind of embedded power technology such firms might install (if at all) and we also do not know at what "boosting rate" they are likely to operate.[9] Also, in the simulations reported here we did not consider the responses of those firms which did not have any generators in place and those which either purchased less than 5,000 KWh from PLN or produced less than 1,000 KWh from their own generators. There were 35 such firms in the sample. Removing them reduced the Indonesian simulation sample to 136 firms. This makes our simulation sample more comparable to the Nigerian one.

The Indonesian data on energy sales by PLN show a rapidly increasing trend in the late eighties (of about 16% per annum) with slightly lower projections into the 1990s of about (13-15% per annum) [World Bank Report, February 1989]. Because of the rapid growth of the Indonesian economy, it was deemed important to use figures which would be accurate for the survey year 1992. However, in the absence of actual figures for that year, we had to rely on the projections made in the late eighties. Based on these projections, PLN produced and sold 38,850 GWh of power in 1992/93. This would have cost 3,851 billion rupiyah giving a unit cost (or average tariff) of 99.12 rupiyah/Kwh. Projected PLN revenues would have been 5,386 billion rupiyah, giving a cost recovery rate of 1.398 times the operating cost.[10]

The 136 firms in our sample bought 78,404,000 KWh of power from PLN in 1992 and collectively paid 11,373,340 rupiyah to PLN. At an average cost of 99.12 rupiyah per KWh, the power delivered to these firms cost 7,771,404 rupiyah to produce. Dividing payments to PLN by the cost we get x_1 = 1.456. Hence, 145.6%% of the cost of serving these manufacturers was recovered by PLN. According to projections, manufacturing in 1992/93

[9] Similarly, the essential substitutes model can only be estimated with a sample of firms each of which is using both power sources.

[10] While in Nigeria, NEPA barely covered operating cost in mid-1989, in Indonesia PLN more than covered operating cost because of the need to pay for capital expansion in a rapidly growing economy. By contrast, in Nigeria there was comparatively little capital expansion or the central government subsidized such expansion rather than requiring NEPA to pay for it.

would have accounted for 50.6% of power use. Hence, equation (13a) can be used to calculate that the implied cost recovery rate for nonmanufacturing customers would have been 133.8%. Hence, the nonmanufacturing and manufacturing sectors' cost recovery rates in 1992 were close with relatively little cross-subsidization, while in Nigeria nonmanufacturing cross-subsidized the manufacturing sector.

Table 14 compares the cost shares of inputs in the Indonesian sample with those in the Nigerian sample. Both social cost shares and operating cost shares are compared. It is noteworthy that in the Indonesian sample, the share of electricity in social cost is only 3.65% whereas in Nigerian sample it is 20.6%. In Indonesia the cost share of electricity in private operating cost is very close to its share in social cost, but in Nigeria the private cost share of electricity is about a third of the social cost share of electricity. Total payments for public power in Nigeria are about 20% of the total cost of privately generated power. In Indonesia, the equivalent percentage is 65%. In terms of private operating cost, the Nigerian firms spend five times more on private power than on public power, but Indonesian firms spend only 1.5 times more. The differences between the two countries are driven in part by the absence of very large electricity users in the Indonesian sample.

The Indonesian simulations parallel those for Nigeria based on the strict complements model. First, in Table 15, the optimal tariff is found when the degree of unreliability (or the boosting rate, π) is insensitive to the aggregate demand for PLN power. In this case, as the table shows, the optimal value of β is 0.95 which is slightly higher than the actual value of 0.909. Hence, it may be said that the actual tariff is nearly optimal. Furthermore, Table 15 also shows that the total benefit changes by a mere 0.01 percent when the tariff is adjusted from the actual

0.909 to the optimal 0.95. Table 16 displays the responses of selected individual firms.[11] Marginal price changes induced by optimizing the tariff are small compared to Nigeria : the smallest firms experience a decrease in their marginal tariffs of around 15% and the largest users of about 11%. Since unreliability is exogenous and fixed, both kinds of power are increased or decreased by the same percentage : the smallest firms increase their power use while the biggest ones decrease it. Total power use is decreased by 3.91%.

Next, as was done in the case of Nigeria, we resimulated the firms' responses and recalculated the optimal tariff under the assumption that the degree of unreliability (π) was endogenous and that the elasticity of π to aggregate demand for PLN power was 1%. As shown in Table 17, the optimal tariff has a $\beta = 1.05$ (a very slightly increasing block structure and very close to the actual tariff of 0.909) and total cost saving is merely 0.03%. Aggregate purchases from PLN decline by 10.71% and internal production of electricity by 5.93%. The aggregate cost of embedded production drops by 3.72% and total operating cost drops by 0.085%. Table 18 shows the responses of the selected firms. Smaller firms increase purchases from PLN and produce more power internally, but because reliability is improved, the percent increase in PLN power purchased is bigger as firms operate on lower rates of boosting. As firm size gets larger some firms begin to even decrease their own power production, and for the largest firms both power sources are used less but there is a bigger percentage cutback in the private power source. Of course, this pattern is induced by the big percentage decrease (as much as 45%) in the marginal PLN tariff offered to smaller firms and the big percentage increase (as much as 51%) offered to larger firms. Although, the change in tariff from the actual tariff with $\beta = 0.909$ to the optimal one with $\beta = 1.05$ appears rather slight, firms respond, as in the case

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[11] As in the Nigeria tables, we selected the five smallest users of PLN, the five biggest users and every other tenth firm after the fifth smallest user.

of Nigeria, with substantial individual changes and in a similar way although the degree of response is not as strong as those for Nigeria which were documented in Table 10. It is noteworthy that although there are big drops in individual boosting rates for many firms, on the average the degree of unreliability (see Equation 12) falls by only 4.12% from 25.51% to 24.46%, not as big an improvement as that observed in Nigeria. Tables 19 and 20 document the optimal tariff and firms' responses when the elasticity of unreliability to the aggregate PLN demand is 2%. As expected and as we also saw in the Nigerian case, the response is qualitatively similar to the pattern of Table 18 but more pronounced. The average degree of unreliability falls by 9.4% to 23.11 percent.

VI. CONCLUSIONS AND CAVEATS ON SIMULATION RESULTS

At the qualitative level our results for Nigeria demonstrate that in the presence of unreliable power supply by the public utility and partial cost recovery, the constrained-optimal tariff is one which penalizes power use by large customers in favor of subsidizing power use by small ones. This finding was borne out regardless of the assumptions used to model the firm's production technology and regardless of whether the degree of unreliability faced by the firms was exogenously or endogenously determined. In all cases examined, the optimal tariff is a major departure from the quantity discounts actually offered by NEPA.

It should be kept in mind, of course, that the tariffs calculated in this study are optimal only in a short run sense. It was assumed that the unreliability of delivered power cannot be directly improved by the public sector. The costs of such improvement in Nigeria are assumed to be very high for the short run. It was also assumed, in the case of 1988 conditions, that full cost-recovery was not possible for NEPA.

In most cases, as is readily seen from the even-numbered tables for Nigeria, the optimal tariff has a steeply rising increasing block nature : marginal quantities of power are offered at virtually no cost per KWh to the smallest customers and at a very high cost per KWh to the largest customers. Therefore, it may be concluded that the optimal pricing policy in Nigeria can be approximated by a rationing scheme which disconnects the largest industrial customers and offers power a very low price to the smallest customers. Such a policy would be consistent with the large investment of private generators available to the largest customers and with the social need to stimulate investment and job formation in the small manufacturers sector.

At a more detailed level, our chief findings for Nigeria which need highlighting are as follows. First, the improvement in total cost experienced by the firms in our sample was quite robust under the 1988 conditions. Regardless of the technology and congestion assumptions, benefits ranged from 12.96% to 15.36% reductions in cost. Second, under the mid-1989 conditions which recovered NEPA costs, benefits were lower in every case but varied more ranging from 1.65% to 9.04% savings in cost. Third, significant reductions in operating cost were observed when the degree of unreliability was made endogenous. In this case, the private sector's aggregate operating costs of production fell by almost 2% to almost 3.5% depending on the elasticity of unreliability with respect to aggregate NEPA purchases. This may not appear as a large percentage decrease if it is not placed in perspective. Firms in our sample spent just over twenty percent of their operating cost on the internal generation of electricity and on purchases from NEPA. So a reduction in operating costs of 2-4% is actually a considerable saving as a proportion of the firms' aggregate energy bill. More significantly, individual firms in our sample were affected differentially.

Consider, for example, Tables 10 and 12 which show that when unreliability is endogenous some individual firms reduced their operating costs by as much as 37%. Cost savings in the order of 10%-15% were not uncommon. In most cases, these savings were realized by those firms which were sold NEPA power more cheaply after the tariff change. The largest firms, on the other hand experienced increases as high as 20% in their operating costs. It is efficient that such cost increases be borne by the largest firms in order to induce them to use their private generators more efficiently and to get them to contribute to a lower level of congestion. In this sense, the higher cost serves as a proxy for a "congestion toll". An analogy may be made with the optimal use of congestion tolls in road-pricing. Trucks (analogous to large firms in our case) contribute much more significantly to road wear and tear and to traffic congestion than do cars (analogous to small firms in our case). Efficient road pricing would require a higher congestion toll per axle-weight on trucks than on cars, because diverting one truckload to an alternate mode, say railroads (analogous to private provision in our case), would save society more than diverting one car trip.

Our results also indicate that one effect of the optimized tariff structure is to induce firms to use other inputs in place of their own and NEPA's power. This is perhaps more readily seen from the results of the essential substitutes model as summarized in Table 13. In this case the aggregate operating cost of firms increases by less than one percent and embedded cost increases by more than one percent. Therefore, it is NEPA's cost reduction and any cost-savings from the use of other inputs which are chiefly responsible for the total cost savings which exceeded 10%. In fact, this pattern is seen to hold for the small firms as seen from Table 2. They are induced, by the lower marginal tariff charged to them, to greatly increase their consumption of NEPA power and cut back on the cost of other inputs, achieving a lower overall operating cost. The pattern is similar to that seen in Table 10 when unreliability is endogenous. In this case, as well, the lower marginal tariff induces small firms to reduce their own power use in favor of purchases from NEPA and to substitute away from other inputs.

Several caveats are in order for the further interpretation of our quantitative results for Nigeria. Perhaps the most important of these concerns the use of a Cobb-Douglas functional form to represent the firms' technologies. Although this form was selected for its convenience in calibration and computation, it is not a sufficiently flexible functional form. Our calibration approach assures that each firm has its own Cobb-Douglas technology, but flexible substitution patterns are ruled out for each firm.

A second caveat concerns the fact that our sample of firms in Nigeria may not be representative. While this limitation does not affect our analysis of how individual firms respond to tariff changes, it would affect the accuracy of our aggregate calculations and our ability to project the aggregate results to the national industrial sector in Nigeria. The report in the references states (World Bank, 1993, page 92) that a total of 2,121 GWh of electricity was sold to manufacturers in 1988. This amounted to 29% of NEPA's total sales in that year and the percentage has remained roughly constant over time. NEPA purchases by the firms in our sample amounted to 837 GWh or 39.5% of the total sold to industries in 1988. Our firms are 160 in number or 12.4% % of the total number of 1,294 manufacturers in the five Nigerian cities included in the study. The largest firm in our sample was responsible for the purchase of 662.72 GWh of power from NEPA. This is 79% of the total power use by the 160 firms in our sample. Clearly, this largest firm is an unusually power intensive unit. However, even exclusion of this firm from our sample leaves a total consumption of 175 GWh of NEPA power by the remaining 159 firms which is still 8.2% of the total sold by NEPA in 1988. Nevertheless, a few rough calculations can be made to provide an upper bound for aggregate savings.

Consider, for example, that under 1988 conditions the optimal tariff with endogenous reliability (Table 9) would have resulted in a total cost saving of 245.4 million naira by the firms included in our sample. As a crude guess, if aggregate gains are ten times this number (based on 12.4% sample), then the aggregate benefit for the five cities is about 2.5 billion naira annually. However, we cannot overemphasize the fact that this is a very rough projection. A more meaningful way to evaluate the significance of the estimated cost saving is to consider it as an annual return on the present value of investments in privately owned generators. As reported in Lee and Anas (1992a), the manufacturers in our sample had investments in generators worth 169.1 million naira and spent 26.4 million naira annually on the maintenance and operation of these generators. At a 10% rate of discount, the present value of investment and annual operating outlays was 393.7 million naira. Under 1988 conditions, the 245.4 million naira in savings is a 62% annual return on this private investment in generating capacity. Under mid-1989 conditions the annual cost saving induced by the optimal tariff was 113.7 million naira (see Table 11) which amounts to 29% annual return on private investments in power generation.

Our conclusions for Indonesia are qualitatively similar, but the benefits produced by tariff optimization are much smaller than in Nigeria. The reason for this is that there are relatively fewer very large users public power in the Indonesian sample. If this is the result of sampling error, then the inclusion of even larger PLN customers would bring the Indonesian results closer in line with those for Nigeria. We conducted a reverse test of this by rerunning some of the Nigerian simulations after removing the one largest user of power (firm number 32) from the sample. After doing this, the quantitative Nigerian results gravitated considerably towards the Indonesian results. The intuition is straightforward and is best seen by considering the highway analogy : if there are very few large trucks on the road, then it is obvious that there would be fewer benefits from using tolls to divert truck shipments to the rail mode.

Despite the above caveats and data limitations, we believe that our results have demonstrated a basic fallacy of using quantity discounts to price unreliable public infrastructure services in developing countries in the presence of competing private infrastructure provision by firms. In this situation, public sector pricing policy should consider the full social cost of infrastructure provision. This requires taking into account the productive capacity installed in the private sector and the fact that strained public supply networks are unreliable. Therefore, an optimal pricing policy should in part aim to reduce demands for the public source and shift such demands to the private sector. As a result, the private self provision capacity will be more fully utilized, while also the degree of unreliability on the public supply network will be reduced.

VII. INCREASING SUPPLY CAPACITY BY PRIVATE SECTOR PARTICIPATION: FUTURE POLICY DIRECTION

The quality of infrastructure services delivered by the public sector in Nigeria are inadequate for the needs of most manufacturers. Deficiencies are observed in the delivery of electricity, water, telephone service, transportation of goods and people and waste disposal. All of these deficiencies impose significant costs on manufacturers which affects the quality and quantity of their production. The highest costs are incurred in relation to electric power because this input is essential in virtually all manufacturing operations and because it is costly for manufacturers to compensate for the nonperformance of the public power sector.

The nonperformance of the public sector is not due to the lack of adequate generating capacity. To the contrary, the country is not fully utilizing its installed public power generating capacity. Rather bottlenecks occur in the transmission and delivery of power. Recurring failures take the form of voltage fluctuations and power interruptions. These problems are due to operational difficulties in the management of the transmission and distribution of electricity. The personnel and officials who are responsible for these operations are poorly paid and poorly trained. As well, there are problems with the availability and delivery of spare parts. In the presence of these operational problems, the transmission bottlenecks cause power failures because of the high loads placed on the system.

To compensate for the nonperformance of the public sector in the transmission and distribution of electricity, manufacturers have installed their own private in-plant power generation systems. These are used in a variety of ways to offset as much as possible the costs of interruptions and voltage fluctuations in the electricity supplied by NEPA. In 1988, 89 % of the firms had some degree of reliance on their own power generators despite the much higher cost (for most firms) of generating power internally.

We have identified essentially four broad ways in which firms make use of the power delivered by NEPA. Self sufficient firms have enough scale and power is sufficiently important to their operations that they can afford to provide their own power virtually all of the time. Such firms are essentially immune to the nonperformance in the public sector. Most firms, however, cannot afford to be self sufficient. Some firms prefer to use their own power consistently during those periods in the day when NEPA power is most likely to be unreliable and to use NEPA power at other times. The vast majority of firms, however, are in the mode of using the cheaper NEPA power as their main source and switching to their own power sources when NEPA power fails or the voltage becomes unstable. Still other firms, those that cannot afford to install their own generators, are captive to NEPA and reduce or shut down operations when NEPA power fails.

The incidence of public sector nonperformance varies widely among firms according to the firm's location within the country or within the Greater Lagos area. It varies also according to the sensitivity of the firm's operations to a steady power supply. Larger firms are better able to cope with public sector non-performance than are smaller firms because the latter cannot as easily afford the higher fixed cost of installing power generators. In addition to the failures associated with the delivery of public power, there is also a pricing failure on the part of NEPA. NEPA's tariff for electricity incorporates a quantity discount : larger users of public power pay less per quantity used than do smaller users. In 1988, the level of the tariff was quite low relative to marginal cost. This created a major inefficiency. A general rise in the level of the tariff structure would price electricity more accurately and would reduce the demand for NEPA power, thus somewhat relieving the degree of congestion on the transmission network. This would reduce the frequency of power failures.

The tariff structure reflects two other forms of inefficiency because NEPA ignores the marginal social costs of power generation in pricing public power in a congested situation.

First, the present tariff does not take into account the network externality which arises because large users of power impose a bigger cost on the transmission network by causing more congestion. When a large manufacturer begins operations, it draws more power than does a small manufacturer and ties up more network capacity. Hence, the probability of a power failure is heightened when large manufacturers draw power from the NEPA network. We observed, for example, that large power surges occur when large manufacturers draw NEPA power and that this creates voltage fluctuations for smaller manufacturers located nearby. This suggests that hook up costs should be much higher for large manufacturers than for small ones to discourage them from imposing added congestion on other users.

Second, most large manufacturers have installed adequate private power generating capacity but the low costs of NEPA power induce many of these manufacturers to treat their private capacity as stand-by (or back-up) power and to use it only when NEPA power fails. Instead, NEPA pricing policy would be more efficient if it encouraged more intensive use of private power generating capacity. This would occur in large part by raising tariffs to more fully reflect the marginal costs of production. But further tilting of the tariff structure in favor of smaller users is needed. This can be done by disconnecting those larger manufacturers who have installed adequate power capacity or by raising the slope of the tariff so that these manufacturers would find it in their best interest to fully utilize their private generating capacities. Such a pricing structure would free up public transmission network capacity. In turn, this would reduce power failures and would improve the quality of power delivered to the smaller firms with less adequate privately installed capacities.

Because of these inefficiencies, the optimal tariff for NEPA power would be a modification of the current NEPA tariff so that the marginal price charged to large users is much higher relative to the marginal price charged to small users. Indeed, it might be possible to lower the marginal price paid by small users and to raise the marginal price paid by large users in such a way that NEPA revenues would remain the same. A combination of differential hook-up costs (i.e., access fees) and unit charges should be used to do this while raising the overall level of the tariff for larger firms and, perhaps reducing it for smaller firms.

The proposed tariff would satisfy two objectives ; 1) reduction of the total power purchased from the public sector in order to reduce congestion and the occurrence of power failures; 2) fuller utilization of the privately installed power generating capacity.

"Markets for Power": Private Sector Participation

While pricing is a powerful tool which can be used to partially compensate for the non-performance of the public sector, bigger gains are likely by restructuring the Nigerian market for electricity. This market currently consists of NEPA which controls all generation and distribution and of private manufacturers with their own generators.

A major restructuring of the current situation would have two components. First, NEPA operations can be restructured to improve public operations. Second, current regulations can be relaxed to allow new forms of electricity generation and trading in the private sector.

NEPA operates as a centralized protected public monopoly. A restructuring of NEPA should be based on the theory of contestable markets. According to this theory, related functions such as transmission, distribution and generation can be unbundled according to the degree of sunk cost in each of these operations.

Activities with low sunk costs can easily be performed in the private sector and under competitive conditions. So there is little economic reason for such activities to be performed by NEPA. Power generation is characterized with relatively low sunk costs which assures a relative ease of entry and exit. As long as access to a public transmission/distribution network is guaranteed, many small and large competitive private power generation firms would emerge in Nigeria. Such firms can compete with NEPA in the provision of power in the various regions of Nigeria. In addition, NEPA can be broken up into several different power generating units serving the different parts of the country, since there is little economic reason to centralize power generation.

Currently, regulations do not allow the generation of power by units other than NEPA. There are only two non-NEPA providers of power in the country and these have been in existence since Nigeria was a British colony.

Unlike power generation, the transmission and distribution of electricity is characterized with high sunk costs and is a natural monopoly. Duplication of transmission and distribution networks by more than one independent suppliers leads to ruinous competition. The appropriate policy is to maintain central control over the transmission/distribution network and to allow access to all providers of electricity such as NEPA, and other public providers and private power generation companies that would emerge.

The continuation of transmission/distribution operations as a monopoly does not mean that this monopoly should be in the public sector. It can be privatized and regulated. A privatization of NEPA might be the only sure way of alleviating the many operational difficulties which currently characterize transmission and distribution.

In addition to these structural reforms, arcane laws and regulations prohibiting firms from selling power to one another or from cooperating in power generation should be removed. Our observations in Nigeria revealed that many smaller firms are motivated to purchase power from nearby larger firms which have idle generating capacity in place. Such an arrangement is mutually beneficial because it reduces the average cost of electricity for both firms. The large firm can operate bigger generators this reducing average cost and selling its excess power to its neighbors. The smaller firms avoid the cost of installing their own generators and buy power from the larger neighbor who can afford to produce power more cheaply because they are producing larger quantities.

Another arrangement that will emerge from liberalizing current restrictions are utility pools. Under such an arrangement manufacturers located in the same industrial area might pool resources to build a shared power plant. Utility pools and large firms which choose to produce excess power in order to achieve higher scale economies should be allowed to sell any excess to the transmission network. If the transmission/distribution monopoly acts as a central broker between all power producers and demanders, then each type of supplier will be inclined to seek the optimal scale of power production and thus each type of power will be supplied at the cheapest possible cost.

Chart 1 illustrated the proposed market organization. The transmission/distribution network continues to operate as a natural monopoly. It is either operated by the public sector or, preferably, it is privatized. On the right side of the vertical line, currently existing arrangements are shown. All power is supplied by NEPA. The chief users of power are households, and manufacturers, large and small. Some firms are self sufficient and provide all their own power needs, but most firms of all sizes rely in varying degree on their own generators as well.

On the left side of the vertical line in Figure 1, we have indicated the new arrangements that we expect will emerge in the new market organization. First, additional power companies would be created by the private sector or by the public sector in the event that NEPA is broken up. Second, some large firms would be allowed to sell their excess power to smaller firms nearby or to sell it to the centralized network. Third, utility pools would emerge as an arrangement of firms with a shared power plant producing their own power.

In Indonesia and Thailand, much of the potential benefits of private sector participation have been initiated as the government policy whereas in Nigeria the same benefits remain unrealized because the government treats NEPA as a protected monopoly. In Indonesia and Thailand, markets for electric power supply and other infrastructure services have been opened up and the government encourages private production of power. Private utility companies have been licensed and there are some cases of large firms producing excess power and selling it to smaller firms. Industrial estates are common in Indonesia and Thailand and in some cases provide their own power to the establishments in the estate. As these emerging markets for power expand, the potential benefits from private sector participation will be realized.

CHART 1

The Market for Power in Nigeria

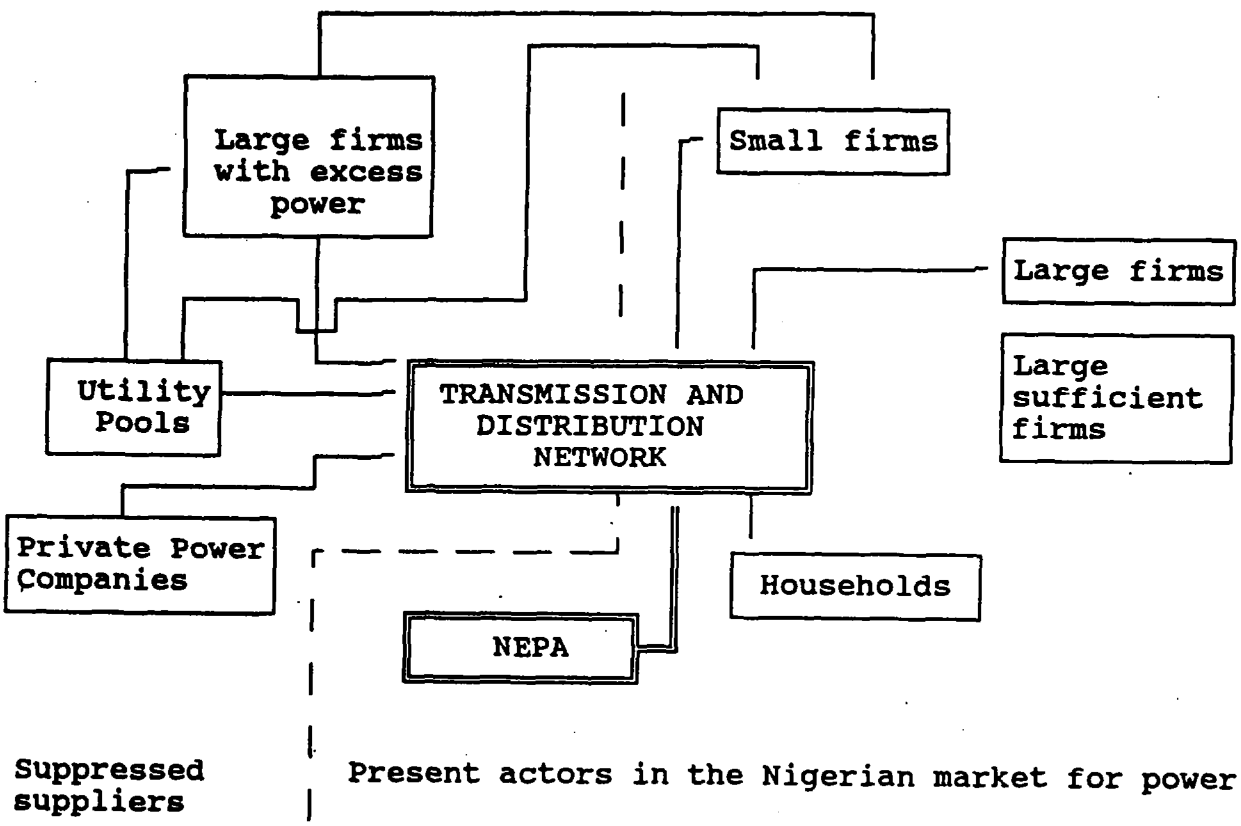

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TABLE 1 : Effects of alternative NEPA tariffs under 1988 conditions.
(Essential substitutes model.)

β	B X 1000	OPERATING COST ESTD	OPERATING COST % CHNG	EMBEDDED COST ESTD	EMBEDDED COST % CHNG	NEPA's COSTS ESTD	NEPA's COSTS %CHNG	TOTAL BENEFIT ESTD	TOTAL BENEFIT % CHNG
0.6	1569.754	1448438.6	0.48	81344.9	0.38	305625.0	14.09	-42470.8	-2.51
0.8	125.984	1434460.0	-0.49	80742.1	-0.37	224475.0	-16.21	47857.9	2.83
1.0	14.530	1429321.1	-0.84	80552.5	-0.60	178667.0	-33.31	96095.3	5.67
1.2	2.189	1427902.0	-0.94	80535.0	-0.62	149096.8	-44.34	125335.6	7.40
1.4	0.391	1427968.9	-0.94	80581.7	-0.56	128262.9	-52.12	144870.3	8.55
1.6	0.078	1428617.9	-0.89	80649.8	-0.48	112704.7	-57.93	158859.4	9.38
1.8	0.0168	1429485.2	-0.83	80722.8	-0.39	100603.6	-62.45	169377.3	10.00
2.8	0.0000147	1433957.6	-0.52	81042.0	0.00	65792.5	-75.44	197657.0	11.67
3.8	0.237E-07	1437495.5	-0.28	81271.8	0.29	49056.2	-81.69	209865.6	12.39
4.8	0.554E-10	1440268.0	-0.08	81444.9	0.50	39178.4	-85.38	216386.6	12.78
5.8	0.168E-12	1442524.6	0.07	81582.4	0.67	32648.2	-87.81	220273.9	13.01
6.8	0.626E-15	1444421.0	0.20	81696.2	0.81	28005.5	-89.55	222745.6	13.15
7.8	0.277E-17	1446054.2	0.32	81792.9	0.93	24532.7	-90.84	224379.8	13.25
8.8	0.141E-19	1447487.4	0.42	81877.0	1.03	21835.7	-91.85	225484.1	13.31
9.8	0.818E-22	1448764.0	0.51	81951.4	1.13	19679.7	-92.65	226236.0	13.36
10.8	0.529E-24	1449914.7	0.59	82018.0	1.21	17916.3	-93.31	226744.4	13.39
11.8	0.378E-26	1450962.1	0.66	82078.2	1.28	16446.7	-93.86	227079.7	13.41
12.8	0.296E-28	1451923.2	0.72	82133.3	1.35	15202.9	-94.32	227288.8	13.42
13.8	0.251E-30	1452811.1	0.79	82184.0	1.41	14136.4	-94.72	227404.2	13.43
14.8	0.230E-32	1453636.4	0.84	82230.9	1.47	13211.7	-95.07	227449.0	13.43
15.2	0.359E-33	1453950.9	0.87	82248.8	1.49	12875.3	-95.19	227451.0	13.43
15.8	0.226E-34	1454407.3	0.90	82274.7	1.52	12402.1	-95.37	227439.9	13.43
16.8	0.237E-36	1455130.5	0.95	82315.6	1.57	11687.3	-95.64	227389.2	13.43
17.8	0.266E-38	1455811.7	0.99	82354.0	1.62	11051.5	-95.87	227306.2	13.42
18.8	0.314E-40	1456455.5	1.04	82390.2	1.67	10482.2	-96.09	227197.9	13.42

Notes : a) Cost-recovery ratio for manufacturing is 5.9%. Benefits are calculated as the saving in total cost relative to that under the observed tariff with B=0.5667823 and β=0.67714.

b) Numbers are in thousand naira.

TABLE 2 : Responses of selected firms to the optimal tariff in 1988
(Essential substitutes model.)

FIRM	NEPA POWER (1000 KWh)	% CHNG	OWN POWER (1000 KWh)	% CHNG	% CHANGE IN MARGINAL PRICES AND OTHER COSTS				
					NEPA PRICE	EMBEDDED PRICE	OTHER INPUTS	NEPA COST	OPERATING COST
130	5.0	4097.9	58.0	-10.0	-97.8	4.8	-5.7	-95.8	-7.7
21	7.0	2952.5	55.0	-2.6	-96.8	1.2	-1.4	-95.6	-2.0
154	12.0	1725.3	20.0	-0.5	-94.5	0.2	-0.3	-95.6	-0.4
29	14.0	1470.4	9.0	-8.7	-93.9	4.1	-4.9	-95.8	-7.3
74	16.0	1285.0	26.0	-3.6	-92.9	1.7	-2.0	-95.6	-3.1
84	30.0	659.5	21.0	-4.3	-87.1	2.0	-2.4	-95.7	-4.0
103	50.0	366.7	10.0	-1.1	-78.7	0.5	-0.6	-95.6	-1.2
156	65.0	263.3	20.0	-0.9	-72.6	0.4	-0.5	-95.6	-1.1
25	83.0	187.7	65.0	-0.2	-65.3	0.1	-0.1	-95.6	-0.3
45	110.0	119.7	150.0	-1.5	-54.9	0.7	-0.8	-95.6	-2.3
158	150.0	63.4	40.0	-0.2	-38.9	0.1	-0.1	-95.6	-0.5
42	213.0	16.9	2000.0	-0.1	-14.5	0.0	-0.1	-95.5	-0.6
28	259.0	-3.0	65.0	0.1	3.1	0.0	0.0	-95.5	-1.6
148	322.0	-21.2	322.0	0.1	27.0	0.0	0.1	-95.5	-0.3
91	427.0	-39.8	400.0	0.2	66.4	-0.1	0.1	-95.5	-0.2
48	583.0	-55.3	146.0	2.2	126.4	-1.0	1.2	-95.5	-0.9
88	765.0	-65.5	510.0	1.3	192.1	-0.6	0.7	-95.5	-0.2
71	1000.0	-73.3	538.0	5.2	284.8	-2.2	2.8	-95.4	-0.1
30	1561.0	-82.6	820.0	2.0	479.6	-0.9	1.1	-95.5	0.2
105	16000.0	-98.1	23.0	14.1	5575.3	-5.7	7.6	-95.2	4.9
20	16275.0	-98.1	958.0	37.8	6258.9	-13.3	19.4	-94.7	12.4
49	21000.0	-98.5	2183.0	12.3	7198.8	-5.0	6.6	-95.2	4.4
106	37769.0	-99.2	9760.0	19.4	13098.6	-7.6	10.3	-95.1	7.2
32	662720.0	-99.9	198816.0	0.9	186781.6	-0.4	0.5	-95.5	0.4

Note : The optimal tariff is B= 0.356E-36 and β = 15.2.

TABLE 3 : Effects of alternative NEPA tariffs under mid-1989 conditions.
(Essential substitutes model.)

β	B X 1000	OPERATING COST ESTD	OPERATING COST % CHNG	EMBEDDED COST ESTD	EMBEDDED COST % CHNG	NEPA's COSTS ESTD	NEPA's COSTS %CHNG	TOTAL BENEFIT ESTD	TOTAL BENEFIT % CHNG
0.6	3835.209	1464902.6	1.63	82219.7	1.46	69480.7	14.10	-29692.8	-2.00
0.8	415.938	1450627.0	0.64	81612.3	0.71	51025.9	-16.21	-1954.3	-0.13
1.0	64.728	1445418.0	0.27	81424.4	0.48	40622.4	-33.29	10844.1	0.73
1.2	13.130	1444011.8	0.18	81410.3	0.46	33910.9	-44.31	17146.5	1.15
1.4	3.154	1444121.8	0.18	81461.0	0.52	29183.0	-52.08	20485.5	1.38
1.6	0.844	1444824.0	0.23	81532.9	0.61	25652.0	-57.87	22359.2	1.50
1.8	0.244	1445746.7	0.30	81609.5	0.70	22905.1	-62.39	23440.5	1.58
2.0	0.745E-01	1446734.7	0.36	81684.5	0.80	20702.7	-66.00	24059.1	1.62
2.2	0.238E-01	1447721.2	0.43	81755.7	0.88	18895.3	-68.97	24391.2	1.64
2.4	0.786E-02	1448677.4	0.50	81822.4	0.97	17384.1	-71.45	24537.4	1.65
2.6	0.268E-02	1449591.9	0.56	81884.6	1.04	16101.0	-73.56	24558.9	1.65
2.8	0.936E-03	1450460.9	0.62	81942.6	1.11	14997.6	-75.37	24494.8	1.65
3.0	0.335E-03	1451284.8	0.68	81996.7	1.18	14038.2	-76.95	24370.8	1.64
3.2	0.122E-03	1452065.6	0.73	82047.3	1.24	13196.3	-78.33	24204.2	1.63
3.4	0.455E-04	1452805.9	0.79	82094.8	1.30	12451.2	-79.55	24007.5	1.62
3.6	0.172E-04	1453508.6	0.83	82139.5	1.36	11787.2	-80.64	23789.2	1.60
3.8	0.661E-05	1454176.7	0.88	82181.6	1.41	11191.4	-81.62	23555.7	1.59
4.0	0.258E-05	1454812.8	0.93	82221.4	1.46	10654.0	-82.50	23311.6	1.57
4.2	0.102E-05	1455419.5	0.97	82259.1	1.51	10166.6	-83.30	23060.5	1.55
4.4	0.407E-06	1455999.1	1.01	82294.9	1.55	9722.6	-84.03	22804.8	1.53

Notes : a) Cost-recovery ratio for manufacturing is 27%. Benefits are calculated as the saving in total costs relative to the costs under the tariff with B=1.55527 and β=0.67714.

b) Numbers are in thousand naira.

TABLE 4 : Responses of selected firms to the optimal tariff in mid-1989
(Essential substitutes model.)

FIRM	NEPA POWER (1000 KWh)	% CHNG	OWN POWER (1000 KWh)	% CHNG	% CHANGE IN MARGINAL PRICES AND OTHER COSTS				
					NEPA PRICE	EMBEDDED PRICE	OTHER INPUT COSTS	NEPA COST	OPERATING COST
130	1.2	8445.7	60.4	-11.8	-98.9	5.7	-6.7	-75.1	-8.2
21	1.6	6818.9	55.6	-3.2	-98.6	1.5	-1.8	-74.3	-2.2
154	2.7	4593.5	20.1	-0.7	-97.9	0.3	-0.4	-74.0	-0.5
29	3.3	3876.7	9.4	-11.5	-97.6	5.6	-6.5	-75.0	-8.3
74	3.7	3617.9	26.5	-5.0	-97.4	2.3	-2.8	-74.4	-3.6
84	6.9	2212.4	21.7	-6.5	-95.8	3.1	-3.7	-74.5	-4.9
103	11.4	1521.3	10.1	-2.0	-93.9	0.9	-1.1	-74.1	-1.5
156	14.8	1235.9	20.2	-1.8	-92.6	0.8	-1.0	-74.1	-1.4
25	18.7	1023.0	65.2	-0.5	-91.1	0.2	-0.3	-74.0	-0.4
45	25.4	791.0	154.3	-4.2	-89.0	1.9	-2.3	-74.2	-3.5
158	34.0	622.8	40.3	-0.9	-86.2	0.4	-0.5	-74.0	-0.8
42	48.4	456.1	2021.1	-1.2	-82.1	0.5	-0.7	-74.0	-1.1
28	59.9	372.9	67.1	-3.3	-79.2	1.5	-1.8	-74.0	-3.1
148	72.9	311.3	323.9	-0.6	-75.8	0.3	-0.3	-74.0	-0.6
91	96.7	233.9	402.5	-0.5	-70.1	0.2	-0.3	-73.9	-0.5
48	135.6	158.8	151.8	-2.5	-61.9	1.1	-1.4	-73.8	-3.0
88	174.8	115.2	519.1	-0.9	-53.8	0.4	-0.5	-73.8	-1.2
71	235.7	72.1	568.7	-2.1	-42.6	0.9	-1.1	-73.5	-3.4
30	356.5	27.2	834.1	-0.3	-21.5	0.1	-0.2	-73.7	-0.8
105	3748.6	-77.4	24.1	5.1	355.2	-2.2	2.8	-72.5	0.8
20	4019.3	-78.2	1072.3	13.1	391.4	-5.3	7.0	-70.3	2.1
49	4887.0	-81.5	2272.2	4.7	453.2	-2.0	2.6	-72.7	0.9
106	8887.0	-88.0	10297.1	8.2	770.5	-3.4	4.4	-72.0	2.2
32	149475.4	-98.5	199182.4	0.5	6746.5	-0.2	0.3	-73.9	0.2

Note : The optimal tariff is B= 0.268E-05 and β = 2.60

TABLE 5 : Effects of alternative NEPA tariffs under 1988 conditions.
(Strict complements model with exogenous reliability.)

β	B X 1000	OPERATING COST ESTD	OPERATING COST % CHNG	EMBEDDED COST ESTD	EMBEDDED COST % CHNG	NEPA's COSTS ESTD	NEPA's COSTS %CHNG	TOTAL BENEFIT ESTD	TOTAL BENEFIT % CHNG
0.6	1110.834	1442364.2	0.06	81367.7	0.41	295829.4	10.43	-27180.3	-1.60
0.8	181.508	1439551.6	-0.13	81261.8	0.27	224203.7	-16.31	43021.5	2.54
1.0	25.320	1436368.1	-0.35	82434.1	1.72	166908.5	-37.69	100111.4	5.91
1.2	3.412	1434152.0	-0.51	83477.3	3.01	129761.8	-51.56	137277.0	8.11
1.4	0.473	1432858.6	-0.60	84115.7	3.80	106375.2	-60.29	160573.7	9.48
1.6	0.688E-01	1432188.9	-0.64	84428.4	4.18	91076.4	-66.00	175637.3	10.37
1.8	0.105E-01	1431920.0	-0.66	84522.5	4.30	80528.5	-69.94	185830.2	10.97
2.8	0.174E-05	1433166.3	-0.58	83676.1	3.25	55750.6	-79.19	207896.2	12.28
3.8	0.655E-09	1435768.0	-0.40	82324.4	1.59	45604.5	-82.98	214840.6	12.69
4.8	0.421E-12	1438531.8	-0.20	80972.7	-0.08	39682.6	-85.19	217648.4	12.85
5.8	0.380E-15	1441125.9	-0.02	79680.5	-1.68	35649.1	-86.69	218849.2	12.92
6.8	0.433E-18	1443482.9	0.14	78468.8	-3.17	32637.9	-87.82	219325.3	12.95
7.8	0.592E-21	1445637.8	0.29	77347.6	-4.56	30250.0	-88.71	219417.0	12.96
8.8	0.948E-24	1447635.7	0.43	76316.1	-5.83	28280.1	-89.44	219272.5	12.95

Notes : a) Cost-recovery ratio for manufacturing is 5.9%. Benefits are calculated as the saving in total cost relative to that under the observed tariff with B=0.5667823 and β=0.67714.

b) Numbers are in thousand naira.

TABLE 6 : Responses of selected firms to the optimal tariff in 1988
(Strict complements model with exogenous reliability.)

FIRM	NEPA POWER (1000 KWh)	%CHNG	OWN POWER (1000 KWh)	%CHNG	% CHANGE IN MARGINAL PRICES AND OTHER COSTS: NEPA PRICE	EMBEDDED PRICE	OTHER INPUT COSTS	EMBEDDED COST	NEPA COST	OPERATING COST
130	5,0	49.2	58.0	49.2	-100.0	-16.3	-3.0	24.8	-100.0	-2.6
21	7.0	41.9	55.0	41.9	-100.0	-14.5	-0.8	21.4	-100.0	-0.7
154	12.0	7.0	20.0	7.0	-100.0	-3.0	-0.2	3.8	-100.0	-0.2
29	14.0	95.5	9.0	95.5	-100.0	-25.8	-3.8	45.0	-100.0	-3.3
74	16.0	50.4	26.0	50.4	-100.0	-16.6	-1.6	25.4	-100.0	-1.3
84	30.0	35.5	21.0	35.5	-100.0	-12.7	-2.3	18.3	-100.0	-1.9
103	50.0	13.8	10.0	13.8	-100.0	-5.6	-0.7	7.4	-100.0	-0.6
156	65.0	16.2	20.0	16.2	-100.0	-6.5	-0.7	8.7	-100.0	-0.6
25	83.0	22.1	65.0	22.1	-100.0	-8.5	-0.2	11.7	-100.0	-0.2
45	110.0	4.1	150.0	4.1	-100.0	-1.8	-1.9	2.3	-100.0	-1.6
158	150.0	13.6	40.0	13.6	-100.0	-5.5	-0.5	7.3	-100.0	-0.4
42	213.0	0.7	2000.0	0.7	-100.0	-0.3	-0.7	0.4	-100.0	-0.6
28	259.0	71.8	65.0	71.8	-100.0	-21.4	-2.4	35.0	-100.0	-2.1
148	322.0	6.4	322.0	6.4	-100.0	-2.7	-0.4	3.5	-100.0	-0.3
91	427.0	37.9	400.0	37.9	-99.9	-13.3	-0.5	19.5	-100.0	-0.4
48	583.0	5.4	146.0	5.4	-99.9	-2.3	-2.6	3.0	-100.0	-2.2
88	765.0	42.9	510.0	42.9	-95.8	-14.7	-1.2	21.9	-99.5	-1.1
125	903.0	7.5	387.0	7.5	-98.0	-3.2	-0.7	4.1	-99.8	-0.5
71	1000.0	26.5	538.0	26.5	-88.0	-10.0	-3.4	13.9	-98.6	-3.3
30	1561.0	5.2	820.0	5.2	-22.4	-2.2	-0.2	2.9	-92.7	-0.9
105	16000.0	-85.6	23.0	-85.6	1404.4	137.6	9.5	-65.9	-80.8	3.6
20	16275.0	-85.5	958.0	-85.5	1732.3	136.3	27.6	-65.7	-76.3	10.7
49	21000.0	-88.2	2183.0	-88.2	2650.6	159.1	13.3	-69.4	-71.0	5.7
106	37769.0	-93.8	9760.0	-93.8	2221.3	244.8	8.5	-78.5	-87.1	4.4
32	662720.0	-99.4	198816.0	-99.4	125888.1	905.5	2.6	-94.3	-36.6	1.8

Note : The optimal tariff is B= 0.592E-21 and β = 7.6.

TABLE 7 : Effects of alternative NEPA tariffs under mid-1989 conditions. (Strict complements model with exogenous reliability.)

β	B X 1000	OPERATING COST ESTD	OPERATING COST %CHNG	EMBEDDED COST ESTD	EMBEDDED COST % CHNG	NEPA's COSTS ESTD	NEPA's COSTS %CHNG	TOTAL BENEFIT ESTD	TOTAL BENEFIT % CHNG
0.6	5762.005	1489051.9	3.30	60692.3	-25.11	152158.1	20.64	-66568.4	-4.34
0.8	806.591	1468140.1	1.85	66387.2	-18.08	95881.2	-23.98	-4602.0	-0.30
1.0	118.455	1457490.3	1.11	70422.7	-13.10	66697.7	-47.12	27337.4	1.78
1.2	19.441	1452489.6	0.76	72680.4	-10.31	51059.8	-59.52	43746.1	2.85
1.4	3.576	1450361.1	0.62	73763.0	-8.98	42006.1	-66.70	52479.4	3.42
1.6	0.727	1449740.8	0.57	74146.1	-8.51	36309.1	-71.21	57255.7	3.73
1.8	0.160	1449941.1	0.59	74124.3	-8.53	32438.1	-74.28	59879.3	3.90
2.0	0.379E-01	1450595.2	0.63	73870.5	-8.85	29628.5	-76.51	61274.9	4.00
2.2	0.943E-02	1451498.2	0.70	73485.6	-9.32	27475.8	-78.22	61942.3	4.04
2.4	0.245E-02	1452532.3	0.77	73029.2	-9.88	25753.5	-79.58	62164.7	4.05
2.6	0.660E-03	1453629.2	0.84	72536.8	-10.49	24328.1	-80.71	62107.6	4.05
2.8	0.182E-03	1454749.6	0.92	72029.7	-11.12	23117.1	-81.67	61870.6	4.03
3.0	0.519E-04	1455871.1	1.00	71520.6	-11.75	22067.1	-82.50	61515.0	4.01
3.2	0.151E-04	1456981.3	1.08	71017.1	-12.37	21142.3	-83.24	61079.5	3.98
3.4	0.446E-05	1458073.0	1.15	70523.5	-12.98	20317.5	-83.89	60589.5	3.95
3.6	0.134E-05	1459142.4	1.23	70042.1	-13.57	19574.6	-84.48	60062.1	3.92
3.8	0.411E-06	1460187.6	1.30	69574.1	-14.15	18899.9	-85.02	59509.1	3.88
4.0	0.127E-06	1461207.4	1.37	69119.8	-14.71	18283.1	-85.50	58939.3	3.84

Notes : a) Cost-recovery ratio for manufacturing is 27%. Benefits are calculated as the saving in total costs relative to the costs under the tariff with B=1.55527 and β=0.67714.

b) Numbers are in thousand naira.

TABLE 8 : Responses of selected firms to the optimal tariff in mid-1989
(Strict complements model with exogenous reliability.)

FIRM	NEPA POWER (1000 KWh)	%CHNG	OWN POWER (1000 KWh)	%CHNG	% CHANGE IN MARGINAL PRICES AND OTHER COSTS: NEPA PRICE	EMBEDDED PRICE	OTHER INPUT COSTS	EMBEDDED COST	NEPA COST	OPERATING COST
130	2.1	257.2	24.2	257.2	-100.0	-43.3	-9.4	102.5	-100.0	-8.2
21	3.1	222.9	24.2	222.9	-100.0	-40.7	-2.8	91.5	-100.0	-2.4
154	9.6	34.2	15.9	34.2	-100.0	-12.3	-0.8	17.7	-100.0	-0.7
29	4.3	531.7	2.8	531.7	-99.9	-56.0	-10.2	177.7	-99.9	-9.1
74	6.5	269.4	10.6	269.4	-99.9	-44.2	-4.9	106.3	-99.9	-4.3
84	14.4	181.1	10.1	181.1	-99.9	-36.9	-7.6	77.3	-99.9	-6.6
103	33.8	67.7	6.8	67.7	-99.7	-20.6	-2.9	33.2	-99.9	-2.5
156	41.8	79.8	12.9	79.8	-99.5	-23.0	-2.9	38.4	-99.8	-2.4
25	47.6	111.0	37.3	111.0	-99.3	-28.3	-0.9	51.3	-99.6	-0.8
45	95.9	19.2	130.8	19.2	-98.9	-7.5	-8.0	10.2	-99.6	-6.8
158	101.7	65.2	27.1	65.2	-98.1	-20.1	-1.9	32.1	-99.1	-1.6
42	207.4	3.3	1947.7	3.3	-96.7	-1.4	-3.1	1.8	-99.0	-2.7
28	89.9	292.3	22.6	292.3	-94.9	-45.6	-6.1	113.3	-94.4	-6.0
148	261.5	28.2	261.5	28.2	-93.4	-10.5	-1.6	14.8	-97.6	-1.5
91	195.6	143.6	183.2	143.6	-90.1	-32.8	-1.2	63.8	-93.2	-1.3
48	491.2	19.3	123.0	19.3	-82.2	-7.6	-8.6	10.3	-94.0	-8.6
88	324.2	118.3	216.1	118.3	-79.7	-29.4	-2.7	54.1	-87.5	-3.2
71	513.0	66.0	276.0	66.0	-69.6	-20.2	-7.2	32.4	-85.7	-9.5
30	797.7	38.6	419.0	38.6	-49.4	-13.5	-1.5	19.8	-80.2	-2.7
105	4112.0	-47.6	5.9	-47.6	118.7	33.4	3.1	-30.1	-67.7	-1.0
20	4918.6	-52.2	289.5	-52.2	162.0	38.9	9.8	-33.5	-64.6	-0.9
49	7373.8	-63.0	766.5	-63.0	266.7	55.9	6.0	-42.4	-61.8	0.9
106	5817.7	-60.2	1503.4	-60.2	170.1	50.9	2.8	-40.0	-69.7	-0.2
32	334281.9	-97.0	100284.6	-97.0	7557.3	380.2	1.8	-85.8	-36.0	1.2

Note : The optimal tariff is B= 0.245E-05 and β = 2.4.

TABLE 9 : Effects of alternative NEPA tariffs under 1988 conditions.
(Strict complements model with endogenous reliability. Elasticity =1%)

β	B X 1000	OPERATING COST ESTD	OPERATING COST % CHNG	EMBEDDED COST ESTD	EMBEDDED COST % CHNG	NEPA's COSTS ESTD	NEPA's COSTS %CHNG	TOTAL BENEFIT ESTD	TOTAL BENEFIT % CHNG
0.5	2333.693	1445011.1	0.25	84642.7	4.45	298708.7	11.51	-32536.2	-1.92
1.0	26.344	1338476.6	-7.15	30219.7	-62.71	496318.0	85.27	-111922.8	-6.61
1.5	0.172	1338904.0	-7.12	40560.4	-49.95	275092.3	2.69	95790.5	5.66
2.0	0.189E-02	1399990.3	-2.88	71474.3	-11.80	109145.6	-59.26	190835.5	11.27
2.5	0.303E-04	1397582.6	-3.04	68627.2	-15.32	96737.6	-63.89	204917.3	12.10
3.5	0.143E-07	1397013.3	-3.08	63593.5	-21.53	82464.3	-69.22	218915.6	12.93
4.5	0.105E-10	1397871.8	-3.02	59378.3	-26.73	73265.5	-72.65	226711.8	13.39
5.5	0.100E-13	1399079.8	-2.94	55764.2	-31.19	66493.2	-75.18	231875.6	13.69
6.5	0.114E-16	1400368.6	-2.85	52578.6	-35.12	61241.2	-77.14	235528.1	13.91
7.5	0.149E-19	1401664.8	-2.76	49715.2	-38.65	57027.0	-78.71	238196.9	14.07
8.5	0.212E-22	1402942.2	-2.67	47103.2	-41.88	53567.6	-80.00	240174.2	14.18
9.5	0.327E-25	1404186.4	-2.59	44699.3	-44.84	50675.3	-81.08	241651.3	14.27
10.5	0.538E-28	1405400.9	-2.50	42486.6	-47.57	48200.2	-82.01	242765.5	14.34
11.5	0.947E-31	1406598.9	-2.42	40455.9	-50.08	46028.7	-82.82	243610.5	14.38
12.5	0.177E-33	1407790.6	-2.34	38595.6	-52.37	44085.3	-83.54	244247.4	14.42
13.5	0.356E-36	1408979.3	-2.25	36891.4	-54.48	42322.4	-84.20	244717.3	14.45
14.5	0.761E-39	1410166.2	-2.17	35328.4	-56.41	40709.5	-84.80	245047.8	14.47
15.5	0.172E-41	1411351.4	-2.09	33892.4	-58.18	39225.6	-85.36	245258.8	14.48
16.5	0.412E-44	1412531.1	-2.01	32570.2	-59.81	37855.1	-85.87	245368.5	14.49
17.5	0.103E-46	1413697.8	-1.93	31349.9	-61.32	36586.2	-86.34	245395.7	14.49
18.5	0.271E-49	1414842.9	-1.85	30220.9	-62.71	35409.7	-86.78	245357.5	14.49
19.5	0.739E-52	1415963.2	-1.77	29173.7	-64.00	34316.9	-87.19	245265.4	14.48

Notes : a) Cost-recovery ratio for manufacturing is 5.9%. Benefits are calculated as the saving in total cost relative to that under the observed tariff with B=0.5667823 and β=0.67714.

b) Numbers are in thousand naira.

TABLE 10 : Responses of selected firms to the optimal tariff in 1988
(Strict complements model with endogenous reliability. Elasticity = 1%)

FIRM	NEPA POWER (1000 KWh)	%CHNG	OWN POWER (1000 KWh)	%CHNG	% CHANGE IN MARGINAL PRICES AND OTHER COSTS: NEPA PRICE	EMBEDDED PRICE	OTHER INPUT COSTS	EMBEDDED COST	NEPA COST	OPERATING COST
130	5.0	1662.0	58.0	37.6	-100.0	-13.3	-7.3	-7.3	-100.0	-6.8
21	7.0	1654.7	55.0	37.0	-100.0	-13.1	-2.7	19.1	-100.0	-2.6
154	12.0	1162.1	20.0	-1.4	-100.0	0.6	-4.6	-0.8	-100.0	-4.6
29	14.0	1949.7	9.0	60.1	-100.0	-18.9	-13.9	29.8	-100.0	-13.4
74	16.0	1624.5	26.0	34.7	-100.0	-12.4	-7.4	17.9	-100.0	-7.2
84	30.0	1250.3	21.0	5.5	-100.0	-2.3	-15.0	3.0	-100.0	-14.6
103	50.0	1052.5	10.0	-10.0	-99.4	4.8	-12.3	-5.7	-99.7	-12.2
156	65.0	943.6	20.0	-18.5	-90.5	9.5	-9.8	-10.7	-96.2	-10.4
25	83.0	768.5	65.0	-32.2	-71.9	18.9	-1.9	-19.4	-90.6	-2.4
45	110.0	474.5	150.0	-55.1	-96.5	43.0	-37.7	-35.9	-99.2	-37.8
158	150.0	414.2	40.0	-59.8	3.9	50.2	-5.2	-39.7	-79.3	-7.6
42	213.0	327.7	2000.0	-66.6	1712.1	63.1	39.2	-45.5	199.9	-13.5
28	259.0	190.0	65.0	-77.3	-19.9	93.9	-3.9	-56.1	-91.0	-8.3
148	322.0	162.0	322.0	-79.5	485.0	102.9	-2.3	-58.5	-40.7	-8.2
91	427.0	85.7	400.0	-85.5	130.2	136.5	0.0	-65.7	-83.5	-1.7
48	583.0	45.8	146.0	-88.6	696.4	163.5	-8.5	-70.0	-55.1	-37.5
138	793.0	0.2	1780.0	-92.2	190.6	211.5	0.9	-75.6	-88.7	-0.3
71	1000.0	-17.1	538.0	-93.5	524.4	239.0	8.9	-78.1	-80.0	-9.0
30	1561.0	-45.5	820.0	-95.7	1028.3	308.5	4.8	-82.6	-76.2	-1.8
105	16000.0	-94.4	23.0	-99.6	4748.9	1031.5	14.5	-95.1	-89.6	6.7
20	16275.0	-94.5	958.0	-99.6	6269.3	1031.9	45.0	-95.1	-86.3	21.1
49	21000.0	-95.6	2183.0	-99.7	9460.8	1157.1	20.7	-95.7	-83.8	10.4
106	37769.0	-97.6	9760.0	-99.8	6582.8	1557.5	12.4	-96.9	-93.9	7.6
32	662720.0	-99.8	198816.0	-100.0	456009.4	5339.7	3.4	-99.3	-71.0	2.5

Note : The optimal tariff is B= 0.104E-49 and β = 17.5.

TABLE 11 : Effects of alternative NEPA tariffs under mid-1989 conditions.
(Strict complements model with endogenous reliability. Elasticity=1%)

β	B X 1000	OPERATING COST ESTD	% CHNG	EMBEDDED COST ESTD	% CHNG	NEPA's COSTS ESTD	%CHNG	TOTAL BENEFIT ESTD	% CHNG
0.5	17104.120	1509412.3	4.71	52690.6	-34.98	218250.2	41.14	-114344.1	-7.36
1.0	118.832	1375775.2	-4.56	7134.1	-91.20	162894.9	5.34	59675.2	3.84
1.5	1.610	1411133.1	-2.10	48393.1	-40.28	64397.1	-58.36	96172.6	6.19
2.0	0.412E-01	1408239.1	-2.31	43747.4	-46.02	52976.3	-65.74	107398.1	6.91
2.5	0.137E-02	1409023.8	-2.25	39553.8	-51.19	46215.2	-70.11	111545.7	7.18
3.0	0.523E-04	1410814.5	-2.13	35931.6	-55.66	41463.9	-73.19	113221.2	7.28
3.5	0.220E-05	1412945.1	-1.98	32831.3	-59.49	37827.4	-75.54	113743.4	7.32
4.5	0.483E-08	1417511.0	-1.66	27907.7	-65.56	32462.0	-79.01	113091.6	7.28
5.5	0.132E-10	1422083.1	-1.35	24238.2	-70.09	28605.9	-81.50	111332.5	7.16
6.5	0.429E-13	1426483.9	-1.04	21422.0	-73.57	25671.1	-83.40	109072.7	7.02
7.5	0.159E-15	1430655.6	-0.75	19195.9	-76.31	23355.8	-84.90	106590.1	6.86
8.5	0.659E-18	1434573.7	-0.48	17385.0	-78.55	21484.8	-86.11	104036.9	6.69
9.5	0.298E-20	1438241.3	-0.22	15876.3	-80.41	19942.1	-87.10	101494.7	6.53
10.5	0.146E-22	1441688.0	0.01	14600.4	-81.98	18644.7	-87.94	98994.5	6.37
11.5	0.763E-25	1444947.4	0.24	13510.6	-83.33	17534.4	-88.66	96545.0	6.21
12.5	0.426E-27	1448046.2	0.46	12571.6	-84.49	16571.1	-89.28	94148.9	6.06
13.5	0.252E-29	1451004.0	0.66	11755.9	-85.49	15726.0	-89.83	91807.7	5.91
14.5	0.158E-31	1453835.7	0.86	11041.7	-86.37	14977.7	-90.31	89521.8	5.76
15.5	0.104E-33	1456553.4	1.05	10411.9	-87.15	14310.1	-90.75	87291.2	5.62
16.5	0.721E-36	1459166.9	1.23	9852.7	-87.84	13710.3	-91.13	85115.2	5.48
17.5	0.521E-38	1461684.6	1.40	9353.1	-88.46	13168.3	-91.48	82992.9	5.34
18.5	0.392E-40	1464113.9	1.57	8904.2	-89.01	12675.8	-91.80	80922.9	5.21
19.5	0.307E-42	1466461.1	1.73	8498.8	-89.51	12226.2	-92.09	78903.7	5.08

Notes : a) Cost-recovery ratio for manufacturing is 27%. Benefits are calculated as the saving in total costs relative to the costs under the tariff with B=1.55527 and β=0.67714.

b) Numbers are in thousand naira.

TABLE 12 : Responses of selected firms to the optimal tariff in mid-1989
(Strict complements model with endogenous reliability. Elasticity=1%)

FIRM	NEPA POWER (1000 KWh)	%CHNG	OWN POWER (1000 KWh)	%CHNG	% CHANGE IN MARGINAL PRICES AND OTHER COSTS: NEPA PRICE	EMBEDDED PRICE	OTHER INPUT COSTS	EMBEDDED COST	NEPA COST	OPERATING COST
130	2.4	3347.4	13.9	467.9	-100.0	-53.9	-16.3	161.8	-99.8	-15.1
21	3.6	3081.2	14.0	424.1	-99.9	-52.2	-5.5	150.4	-99.5	-5.1
154	15.5	831.6	12.7	53.5	-99.8	-17.4	-4.8	26.8	-99.6	-4.7
29	4.4	4627.2	1.4	678.8	-99.6	-60.0	-19.0	211.8	-96.7	-19.0
74	7.3	2887.1	5.9	392.1	-99.5	-50.9	-10.7	141.8	-97.2	-10.5
84	16.9	1619.1	5.9	183.2	-98.7	-37.1	-18.0	78.0	-95.7	-18.3
103	47.0	775.7	4.7	44.3	-95.7	-15.1	-11.4	22.5	-92.7	-12.0
156	56.9	729.3	8.7	36.6	-93.5	-13.0	-9.4	18.9	-89.6	-10.4
25	62.5	744.0	24.2	39.0	-91.2	-13.7	-2.2	20.0	-85.6	-2.6
45	145.2	260.8	98.0	-40.6	-88.7	26.1	-34.1	-25.0	-92.1	-36.9
158	144.0	376.6	19.0	-21.5	-77.8	11.4	-5.4	-12.5	-79.5	-7.2
42	384.3	218.3	1785.1	-47.6	29.4	33.4	0.5	-30.1	-20.3	-18.5
28	93.9	539.0	11.7	5.3	-86.2	-2.3	-7.7	2.9	-82.9	-11.0
148	417.7	143.8	206.7	-59.8	-16.0	50.2	-3.7	-39.7	-60.4	-7.9
91	231.1	234.3	107.1	-44.9	-65.2	30.5	-1.3	-28.1	-77.5	-2.5
48	646.4	58.8	80.1	-73.8	-1.2	81.8	-17.1	-52.4	-69.6	-35.8
88	367.4	131.5	121.2	-61.9	-48.6	53.7	-2.1	-41.4	-77.0	-5.3
71	600.1	58.3	159.7	-73.9	-20.5	82.1	-3.9	-52.5	-75.7	-15.7
30	970.6	12.2	252.2	-81.5	30.6	112.3	0.3	-60.8	-71.6	-4.4
105	3915.3	-65.4	2.8	-94.3	253.7	258.7	5.1	-79.5	-76.3	-0.4
20	4745.3	-69.4	138.2	-95.0	347.7	278.9	16.5	-80.9	-73.5	1.6
49	7652.1	-78.9	393.5	-96.5	579.2	347.4	9.8	-84.5	-72.3	2.6
106	5017.0	-72.5	641.4	-95.5	299.6	297.6	4.2	-82.0	-78.8	0.7
32	413403.4	-99.1	61357.4	-99.9	20145.4	1720.2	2.5	-97.3	-64.5	1.8

Note : The optimal tariff is B= 0.220E-08 and β = 3.5.

TABLE 13 : Summary of the aggregate effects of the optimal NEPA tariffs

	Essential Substitutes Model		Strict Complements Model					
			Exogenous Reliability		Endogenous Reliability (1%)[3]		Endogenous Reliability (2%)[3]	
	1988[1]	mid-1989[2]	1988[1]	mid-1989[2]	1988[1]	mid-1989[2]	1988[1]	mid-1989[2]
β	15.2	2.60	7.60	2.4	17.5	3.5	19.5	4.0
NEPA output	-95.2%	-73.56%	-88.54%	-79.58%	-86.34%	-75.54%	-84.16%	-74.71%
Embedded output	+ 1.86%	+ 1.36%	-78.62%	-81.67%	-95.98%	-95.48%	-99.41%	-99.39%
Operating cost (a)	+ 0.86%	+ 0.56%	+ 0.26%	+ 0.77%	-1.93%	-1.98%	-3.32%	-3.35%
NEPA revenue (b)	-95.2%	-73.56%	-88.54%	-79.58%	-86.34%	-75.54%	-84.16%	-74.71%
Embedded cost	+1.49%	+1.04%	-4.29%	-9.88%	-61.32%	-59.48%	-86.56%	-85.76%
NEPA cost (c)	-95.2%	-73.56%	-88.54%	-79.58%	-86.34%	-75.54%	-84.16%	-74.71%
Total benefit [4]	-13.43%	-1.65%	-12.96%	-4.05%	-14.49%	-7.32%	-15.36%	-9.04%
Unreliability (π)	N/A	N/A	fixed	fixed	-80.78%	-71.24%	-97.18%	-94.40%

[1] Changes computed relative to the actual 1988 tariff (β = 0.67714, B = 0.56678).

[2] Changes computed relative to the actual mid-1989 tariff (β = 0.67714, B = 1.55528).

[3] Number in parentheses is the elasticity of unreliability with respect to aggregate purchases from NEPA.

[4] Benefits are measured as savings in total social cost which is a - b + c.

TABLE 14 : Aggregate cost shares of inputs in social cost and in private operating cost. (Nigeria sample, 1988 and Indonesia sample, 1992)

	Shares in social cost		Shares in operating cost	
	Nigeria	Indonesia	Nigeria	Indonesia
Labor and materials a/	79.4 %	96.4 %	93.3%	95.8 %
Embedded electricity b/	4.8 %	2.3 %	5.6 %	2.5 %
NEPA or PLN electricityc/	15.8 %	1.3 %	--	--
Payments to NEPA or PLN	--	--	1.1 %	1.7 %
Total	100.0 %	100.0 %	100.0 %	100.0 %
Payments to NEPA or PLN as % of the cost of embedded electricity	20.0 %	65 %		

a/ Used by manufacturing firms in primary production.

b/ Costs of all inputs in embedded production of electric power.

c/ Costs of all inputs used by NEPA and PLN.

TABLE 15 : Effect of alternative PLN tariffs under 1992 conditions.
(Strict complements model with exogenous reliability.)

β	B X 1000	OPERATING COST ESTD	OPERATING COST % CHNG	EMBEDED COST ESTD	EMBEDED COST % CHNG	PLN's COST ESTD	PLN's COST % CHNG	TOTAL BENEFIT ESTD	TOTAL BENEFIT % CHNG
0.60	2589615.147	696018504.6	0.71	17268485.3	-0.38	11797875.8	51.81	-3043616.6	-0.44
0.65	1690904.717	694535609.8	0.50	17350726.1	0.10	10829286.8	39.35	-2009649.0	-0.29
0.70	1118490.827	693419692.7	0.33	17395325.2	0.36	10027914.5	29.04	-1265156.6	-0.18
0.75	748361.268	692580358.4	0.21	17410861.8	0.45	9353946.4	20.36	-738196.9	-0.11
0.80	505847.969	691953286.4	0.12	17403959.2	0.41	8779066.8	12.97	-377573.5	-0.05
0.85	345077.622	691491578.3	0.06	17379757.1	0.27	8282648.8	6.58	-145948.1	-0.02
0.90	237372.327	691160300.3	0.01	17342263.8	0.05	7849348.6	1.00	-15498.6	0.00
0.95	164528.802	690932945.2	-0.03	17294618.3	-0.23	7467539.3	-3.91	34893.4	0.01
1.00	114835.570	690789077.6	-0.05	17239286.1	-0.54	7128265.3	-8.28	21512.3	0.00
1.05	80666.182	690712728.2	-0.06	17178208.2	-0.90	6824526.8	-12.18	-42916.8	-0.01
1.10	56999.749	690691272.2	-0.06	17112914.7	-1.27	6550780.6	-15.71	-148338.2	-0.02
1.60	2264.686	691988100.3	0.13	16400730.6	-5.38	4788457.7	-38.38	-2261978.0	-0.33
2.10	121.186	694088264.5	0.43	15762878.4	-9.06	3863333.1	-50.29	-4790924.3	-0.70
2.60	7.774	696162142.7	0.73	15234762.2	-12.11	3280889.9	-57.78	-7134756.6	-1.04
3.10	0.565	698064854.3	1.01	14796092.6	-14.64	2876812.1	-62.98	-9224752.5	-1.34
3.60	0.449E-01	699787406.2	1.26	14426720.3	-16.77	2578836.9	-66.82	-11085411.7	-1.61
4.10	0.384E-02	701349537.4	1.48	14111401.7	-18.59	2349584.5	-69.77	-12753798.1	-1.86
4.60	0.347E-03	702774600.8	1.69	13838903.4	-20.16	2167560.8	-72.11	-14263226.9	-2.07
5.10	0.328E-04	704083530.4	1.88	13600855.0	-21.54	2019446.2	-74.01	-15640805.6	-2.28
5.60	0.324E-05	705293804.9	2.05	13390909.5	-22.75	1896514.4	-75.60	-16908057.1	-2.46
6.10	0.329E-06	706419724.7	2.22	13204172.3	-23.82	1792796.4	-76.93	-18082048.8	-2.63
6.60	0.346E-07	707472960.3	2.37	13036810.2	-24.79	1704066.6	-78.07	-19176409.4	-2.79
7.10	0.372E-08	708463076.7	2.51	12885780.3	-25.66	1627248.3	-79.06	-20202129.9	-2.94

Note : a) Cost-recovery ratio for manufacturing is 145.6%. Benefits are calculated as the saving in total cost relative to that under the observed tariff with B=220.920 and β= 0.90972.

b) Numbers are in thousand rupiyah.

TABLE 16 : Responses of selected firms to the optimal PLN tariff in 1992
(Strict complements model with exogenous reliability.)

FIRM	NEPA POWER (1000 Kwh)	%CHNG	OWN POWER (1000 KWh)	%CHNG	% CHANGE IN MARGINAL PRICES AND OTHER COSTS: PLN PRICE	EMBEDDED PRICE	OTHER INPUT COSTS	EMBEDDED COST	PLN COST	OPERATING COST
174	6.0	14.4	5.0	14.4	-17.0	-8.7	-0.3	4.5	-9.0	-0.2
81	6.0	2.7	11.0	2.7	-16.5	-1.8	0.0	0.9	-17.9	0.0
598	6.0	1.9	564.0	1.9	-16.5	-1.3	0.0	0.6	-18.5	0.0
399	7.0	13.8	40.0	13.8	-16.4	-8.4	-0.1	4.3	-8.9	-0.1
565	7.0	0.4	150.0	0.4	-15.9	-0.3	0.0	0.1	-19.1	0.0
472	14.0	7.3	2.0	7.3	-13.8	-4.7	-0.4	2.3	-11.4	-0.3
430	22.0	2.7	21.0	2.7	-12.0	-1.8	-0.1	0.9	-13.5	-0.1
613	59.0	8.6	2.0	8.6	-8.7	-5.4	-0.4	2.7	-5.1	-0.6
353	105.0	6.1	59.0	6.1	-6.5	-4.0	-0.5	2.0	-4.9	-0.9
609	150.0	4.7	10.0	4.7	-5.1	-3.1	-0.1	1.5	-4.8	-0.2
438	211.0	3.3	11.0	3.3	-3.7	-2.2	0.0	1.1	-4.7	0.0
262	238.0	2.4	5.0	2.4	-3.2	-1.6	-0.2	0.8	-5.1	-0.3
344	292.0	2.1	11.0	2.1	-2.4	-1.4	-0.1	0.7	-4.5	-0.3
282	325.0	1.2	250.0	1.2	-1.9	-0.8	0.0	0.4	-4.9	0.0
219	446.0	0.5	24.0	0.5	-0.6	-0.3	0.0	0.2	-4.3	-0.1
703	935.0	-2.2	690.0	-2.2	2.6	1.5	0.0	-0.7	-3.9	0.0
3	1667.0	-4.6	15.0	-4.6	5.1	3.2	0.2	-1.5	-3.9	0.0
289	3129.0	-6.2	17.0	-6.2	7.9	4.4	0.6	-2.0	-3.1	0.2
260	3164.0	-6.7	167.0	-6.7	8.0	4.8	0.3	-2.2	-3.6	0.1
88	6200.0	-7.0	5500.0	-7.0	11.0	5.0	0.1	-2.3	-1.2	0.0
65	7596.0	-8.1	4000.0	-8.1	11.9	5.9	1.0	-2.7	-1.5	0.4
98	10186.0	-10.3	1420.0	-10.3	13.4	7.6	1.7	-3.5	-2.6	1.1

Note : The optimal tariff is B = 164.53 and β = 0.95.

TABLE 17 : Effects of alternative PLN tariffs under 1992 conditions
(Strict complements model with endogenous reliability. Elasticity =1%)

β	B	PRIMARY COST ESTD	PRIMARY COST %CHNG	EMBEDED COST ESTD	EMBEDED COST %CHNG	PLN's COST ESTD	PLN's COST %CHNG	TOTAL BENEFIT ESTD	TOTAL BENEFIT %CHNG
0.60	2539.427	696175763.4	0.73	18800349.9	8.46	11152745.9	43.51	-3499766.1	-0.51
0.65	1667.908	694742197.4	0.53	18581806.2	7.20	10354532.1	33.24	-2436039.7	-0.35
0.70	1108.503	693630386.5	0.36	18348508.1	5.85	9688851.2	24.67	-1632862.5	-0.24
0.75	744.351	692764594.1	0.24	18107479.2	4.46	9123860.8	17.40	-1028993.9	-0.15
0.80	504.435	692091058.1	0.14	17863642.7	3.06	8637269.5	11.14	-581020.7	-0.08
0.85	344.699	691570530.5	0.07	17620370.9	1.65	8212973.6	5.68	-257168.7	-0.04
0.90	237.344	691173535.0	0.01	17379957.3	0.27	7839050.3	0.87	-33493.4	0.00
0.95	164.575	690877379.3	-0.03	17143940.9	-1.09	7506479.6	-3.41	108513.6	0.02
1.00	114.861	690664229.8	-0.06	16913329.7	-2.43	7208307.9	-7.25	183460.7	0.03
1.05	80.650	690519837.5	-0.09	16688755.9	-3.72	6939085.5	-10.71	203069.8	0.03
1.1	56.949	690432677.3	-0.10	16470595.5	-4.98	6694475.0	-13.86	176858.4	0.03
1.6	2.231	691249625.7	0.02	14636950.2	-15.56	5068013.5	-34.79	-1393892.7	-0.20
2.1	0.117	693110542.9	0.29	13308406.6	-23.22	4172985.6	-46.30	-3669657.3	-0.53
2.6	0.007	695073079.5	0.57	12313662.7	-28.96	3594414.4	-53.75	-5900360.3	-0.86
3.1	0.515	696941342.3	0.84	11543208.2	-33.41	3187614.4	-58.98	-7957173.8	-1.16
3.6	0.0395E-01	698679493.4	1.10	10929280.3	-36.95	2886202.7	-62.86	-9835028.2	-1.43
4.1	0.0032E-02	700289444.0	1.33	10428032.7	-39.84	2654497.1	-65.84	-11552373.2	-1.68
4.6	0.000279E-03	701782134.9	1.54	10009883.5	-42.25	2471286.5	-68.20	-13129981.0	-1.91
5.1	0.000251E-04	703170285.5	1.75	9654511.8	-44.30	2323059.4	-70.11	-14586833.7	-2.12
5.6	0.000232E-05	704466462.3	1.93	9347937.0	-46.07	2200777.1	-71.68	-15939687.3	-2.32
6.1	0.000221E-06	705682347.7	2.11	9080393.1	-47.61	2098179.8	-73.00	-17203125.7	-2.50
6.6	0.000215E-07	706828324.6	2.27	8844770.2	-48.97	2010817.6	-74.13	-18389594.3	-2.67
7.1	0.000213E-08	707913330.9	2.43	8635638.5	-50.18	1935456.8	-75.10	-19509529.7	-2.84

Note : a) Cost-recovery ratio for manufacturing is 145.6%. Benefits are calculated as the saving in total cost relative to that under the observed tariff with B=220.920 and β= 0.90972.

b) Numbers are in thousand rupiyah.

TABLE 18 : Responses of selected firms to the optimal PLN tariff in 1992
(Strict complements model with endogenous reliability. Elasticity=1%.)

FIRM	NEPA POWER (1000 Kwh)	%CHNG	OWN POWER (1000 KWh)	%CHNG	% CHANGE IN MARGINAL PRICES AND OTHER COSTS					
					PLN PRICE	EMBEDDED PRICE	OTHER INPUT COSTS	EMBEDDED COST	PLN COST	OPERATING COST
174	6.0	57.7	5.0	37.6	-44.6	-19.4	-0.9	10.9	-24.3	-0.7
81	6.0	21.8	11.0	6.3	-45.3	-4.0	-0.1	2.0	-42.3	-0.1
598	6.0	19.8	564.0	4.5	-45.3	-2.9	-0.1	1.4	-43.3	0.0
399	7.0	55.7	40.0	35.9	-43.4	-18.7	-0.2	10.4	-23.6	-0.1
565	7.0	15.6	150.0	0.9	-44.2	-0.6	-0.1	0.3	-44.2	-0.1
472	14.0	32.6	2.0	15.7	-38.1	-9.4	-1.5	4.8	-28.9	-1.2
430	22.0	20.1	21.0	4.8	-34.4	-3.1	-0.7	1.5	-31.7	-0.5
613	59.0	29.4	2.0	12.9	-24.4	-7.9	-1.3	4.0	-15.2	-1.9
353	105.0	20.6	59.0	5.2	-18.3	-3.4	-1.3	1.7	-14.6	-2.3
609	150.0	15.9	10.0	1.1	-14.3	-0.7	-0.4	0.4	-13.9	-0.8
438	211.0	11.8	11.0	-2.5	-10.2	1.7	0.0	-0.8	-13.1	-0.1
262	238.0	9.5	5.0	-4.5	-8.8	3.1	-0.7	-1.5	-13.5	-1.3
344	292.0	6.7	11.0	-6.9	-6.3	5.0	-0.4	-2.3	-13.4	-1.1
282	325.0	8.3	250.0	-5.5	-4.8	3.9	0.0	-1.8	-10.6	0.0
219	446.0	2.4	24.0	-10.7	-0.7	7.9	-0.1	-3.6	-11.9	-0.6
703	935.0	-6.4	690.0	-18.3	9.6	14.7	0.2	-6.3	-11.1	0.0
3	1667.0	-14.4	15.0	-25.3	18.4	21.8	0.5	-9.0	-12.2	0.0
289	3129.0	-18.6	17.0	-29.0	29.0	26.1	1.9	-10.5	-9.1	0.5
260	3164.0	-20.3	167.0	-30.5	29.0	27.8	1.2	-11.1	-10.9	0.4
88	6200.0	-19.2	5500.0	-29.5	41.9	26.7	0.3	-10.7	-0.7	0.1
65	7596.0	-23.2	4000.0	-33.0	45.6	31.0	3.6	-12.2	-3.1	1.6
98	10186.0	-29.9	1420.0	-38.8	51.1	39.4	5.9	-14.7	-8.2	3.8

Note : The optimal tariff is B = 80.675 and β = 1.05

TABLE 19 : Effects of alternative PLN tariffs under 1992 conditions
(Strict complements model with endogenous reliability. Elasticity =2%)

		PRIMARY COST		EMBEDED COST		PLN's COST		TOTAL BENEFIT	
β	B	ESTD	%CHNG	ESTD	%CHNG	ESTD	%CHNG	ESTD	%CHNG
0.60	250.408	696189862.2	0.74	19960244.5	15.15	10651899.5	37.07	-3745933.3	-0.54
0.65	1651.345	694831517.8	0.54	19516925.4	12.60	9986618.4	28.50	-2695945.3	-0.39
0.70	1101.198	693750390.7	0.38	19074697.2	10.04	9426443.8	21.30	-1874537.9	-0.27
0.75	741.387	692883677.3	0.26	18639598.8	7.53	8946062.7	15.12	-1230519.0	-0.18
0.80	503.382	692187099.7	0.16	18215546.7	5.09	8527890.7	9.73	-727781.1	-0.11
0.85	344.414	691628484.3	0.08	17804892.5	2.72	8159338.4	4.99	-339996.1	-0.05
0.90	237.322	691183622.2	0.01	17408917.4	0.43	7831144.1	0.77	-47253.1	-0.01
0.95	164.612	690833679.2	-0.04	17028086.9	-1.76	7536330.4	-3.02	166071.8	0.02
1.00	114.886	690563607.8	-0.08	16662699.9	-3.87	7269498.3	-6.46	312451.7	0.05
1.05	80.648	690361118.4	-0.11	16312392.1	-5.89	7026419.8	-9.59	402268.4	0.06
1.1	56.924	690216067.6	-0.13	15976840.6	-7.83	6803687.2	-12.45	444092.4	0.06
1.6	2.213	690552217.3	-0.08	13295581.8	-23.30	5273604.7	-32.14	-601233.6	-0.09
2.1	0.115	692108385.8	0.14	11475738.4	-33.80	4392140.0	-43.48	-2565911.7	-0.37
2.6	0.007	693883780.1	0.40	10167322.3	-41.34	3808556.0	-50.99	-4611803.3	-0.67
3.1	0.000496	695639816.5	0.66	9175914.1	-47.06	3393309.0	-56.34	-6560307.1	-0.95
3.6	0.037729	697309674.7	0.90	8395178.8	-51.57	3083432.7	-60.32	-8373791.7	-1.22
4.1	0.003051	698878690.3	1.12	7765645.3	-55.20	2843725.0	-63.41	-10053910.4	-1.46
4.6	0.000259	700348580.5	1.34	7249208.5	-58.18	2652978.4	-65.86	-11612209.9	-1.69
5.1	0.228146E-07	701725513.4	1.54	6818912.0	-60.66	2497647.5	-67.86	-13061136.5	-1.90
5.6	0.207184E-08	703017320.5	1.72	6455244.0	-62.76	2368665.3	-69.52	-14412724.7	-2.10
6.1	0.192837E-09	704232663.1	1.90	6143967.0	-64.55	2259752.4	-70.92	-15678546.7	-2.28
6.6	0.183253E-10	705380248.3	2.07	5874551.1	-66.11	2166442.3	-72.12	-16869379.9	-2.45
7.1	0.177322E-11	706468207.9	2.22	5639074.4	-67.47	2085484.4	-73.16	-17994862.8	-2.62

Note : a) Cost-recovery ratio for manufacturing is 145.6%. Benefits are calculated as the saving in total cost relative to that under the observed tariff with B=220.920 and β= 0.90972.

b) Numbers are in thousand rupiyah.

TABLE 20 : Responses of selected firms to the optimal PLN tariff in 1992
(Strict complements model with endogenous reliability. Elasticity=2%.)

FIRM	NEPA POWER (1000 Kwh)	%CHNG	OWN POWER (1000 KWh)	%CHNG	% CHANGE IN MARGINAL PRICES AND OTHER COSTS: PLN PRICE	EMBEDDED PRICE	OTHER INPUT COSTS	EMBEDDED COST	PLN COST	OPERATING COST
174	6.0	87.4	5.0	36.1	-53.3	-18.8	-1.1	10.5	-27.7	-1.0
81	6.0	46.0	11.0	6.0	-54.5	-3.9	-0.2	1.9	-45.1	-0.2
598	6.0	43.9	564.0	4.5	-54.6	-2.9	-0.1	1.4	-45.9	0.0
399	7.0	84.7	40.0	34.1	-52.0	-18.0	-0.2	10.0	-26.7	-0.2
565	7.0	38.6	150.0	0.7	-53.4	-0.4	-0.2	0.2	-46.6	-0.1
472	14.0	53.8	2.0	11.7	-46.3	-7.2	-2.2	3.6	-31.6	-2.0
430	22.0	40.8	21.0	2.2	-41.9	-1.5	-1.1	0.7	-32.4	-1.0
613	59.0	39.9	2.0	1.6	-30.0	-1.1	-1.7	0.5	-19.0	-2.5
353	105.0	27.7	59.0	-7.3	-22.6	5.2	-1.3	-2.4	-18.3	-2.7
609	150.0	21.7	10.0	-11.6	-17.6	8.7	-0.6	-3.9	-17.0	-1.1
438	211.0	16.8	11.0	-15.2	-12.4	11.8	0.0	-5.2	-15.4	-0.1
262	238.0	14.5	5.0	-16.9	-10.5	13.3	-1.0	-5.8	-15.3	-2.1
344	292.0	8.9	11.0	-20.9	-7.5	17.2	-0.4	-7.3	-16.7	-1.5
282	325.0	15.5	250.0	-16.2	-5.0	12.7	0.0	-5.5	-9.3	0.0
219	446.0	4.2	24.0	-24.4	-0.1	20.8	-0.1	-8.6	-14.0	-0.9
703	935.0	-7.6	690.0	-32.9	13.6	31.0	0.4	-12.1	-13.2	0.0
3	1667.0	-18.4	15.0	-40.8	25.2	42.5	0.7	-15.6	-15.5	0.0
289	3129.0	-23.5	17.0	-44.4	40.3	48.8	2.4	-17.3	-11.2	0.5
260	3164.0	-25.6	167.0	-46.0	40.2	51.7	1.5	-18.1	-13.8	0.5
88	6200.0	-22.9	5500.0	-44.0	59.9	48.0	0.4	-17.1	2.0	0.1
65	7596.0	-28.5	4000.0	-48.1	65.0	55.8	5.1	-19.1	-2.5	2.1
98	10186.0	-37.2	1420.0	-54.4	72.2	70.0	8.0	-22.5	-10.6	5.2

Note : The optimal tariff is B = 56.925 and β = 1.10

TABLE 21: Summary of the Aggregate Effects of the Optimal PLN Tariffs
Strict Complements Model (1992)[1/]

	Exogenous Reliability	Endogenous Reliability[2/] (1%)	Endogenous Reliability[2/] (2%)
β	0.95	1.05	1.10
PLN Output	-3.91%	-10.71%	-12.45%
Embedded output	-2.96%	-5.93%	-7.16%
Operating Cost (a)	-0.03%	-0.09%	-0.13%
PLN Revenue (b)	-3.91%	-10.71%	-12.45%
Embedded Cost	-0.23%	-3.72%	-7.83%
PLN Cost (c)	-3.91%	-10.71%	-12.45%
Total benefit[3/]	-0.01%	-0.03%	-0.06%
Unreliability (Π)	fixed	-4.12%	-9.40%

1/ Changes computed relative to the actual 1992 tariff
(β = 0.90972, B = 220.920)

2/ Number in parentheses is the elasticity of unreliability with respect to aggregate purchases from PLN.

3/ Benefits are measured as savings in total social cost which is a-b+c.

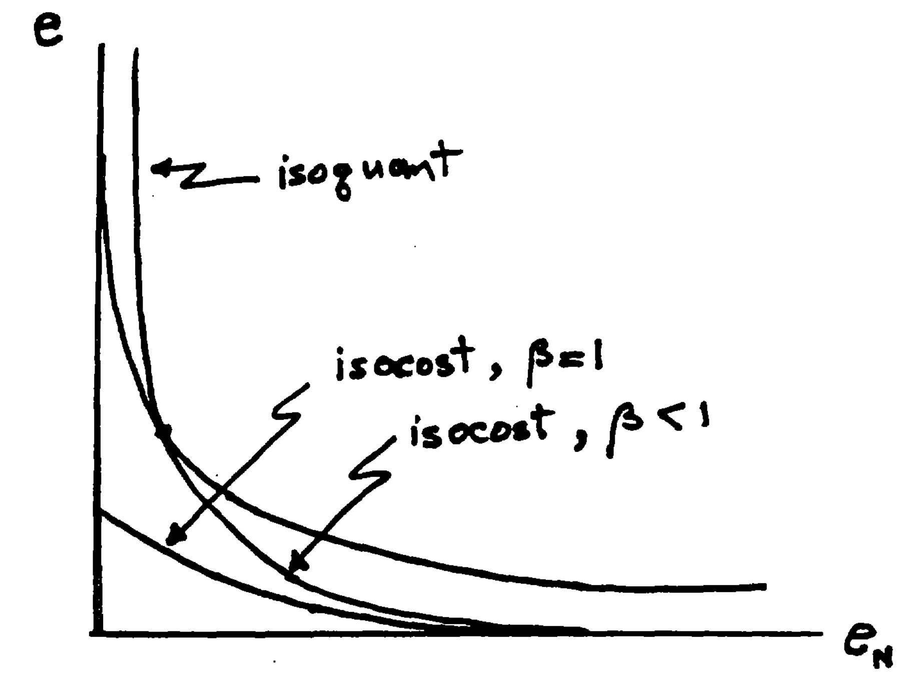

Figure 1a

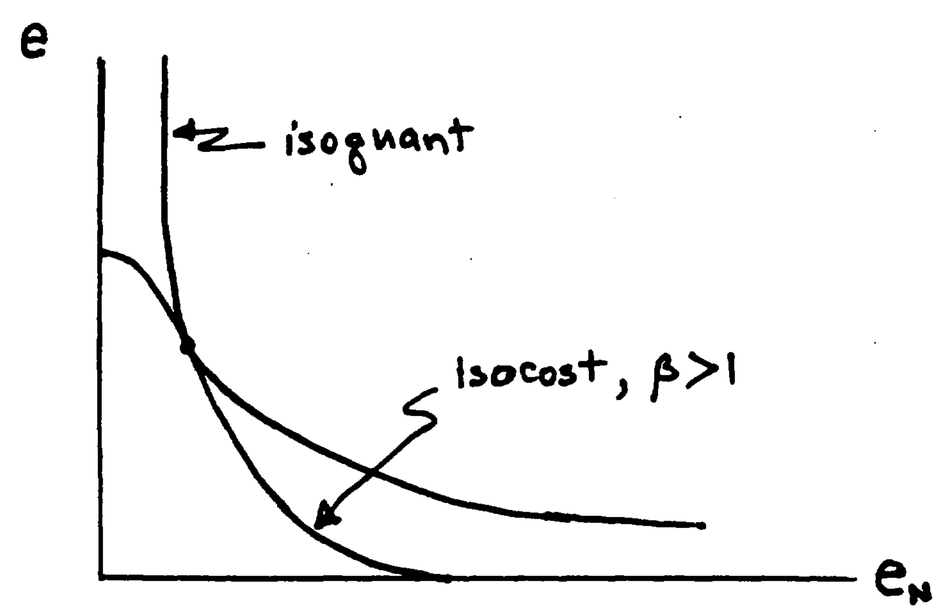

Figure 1b

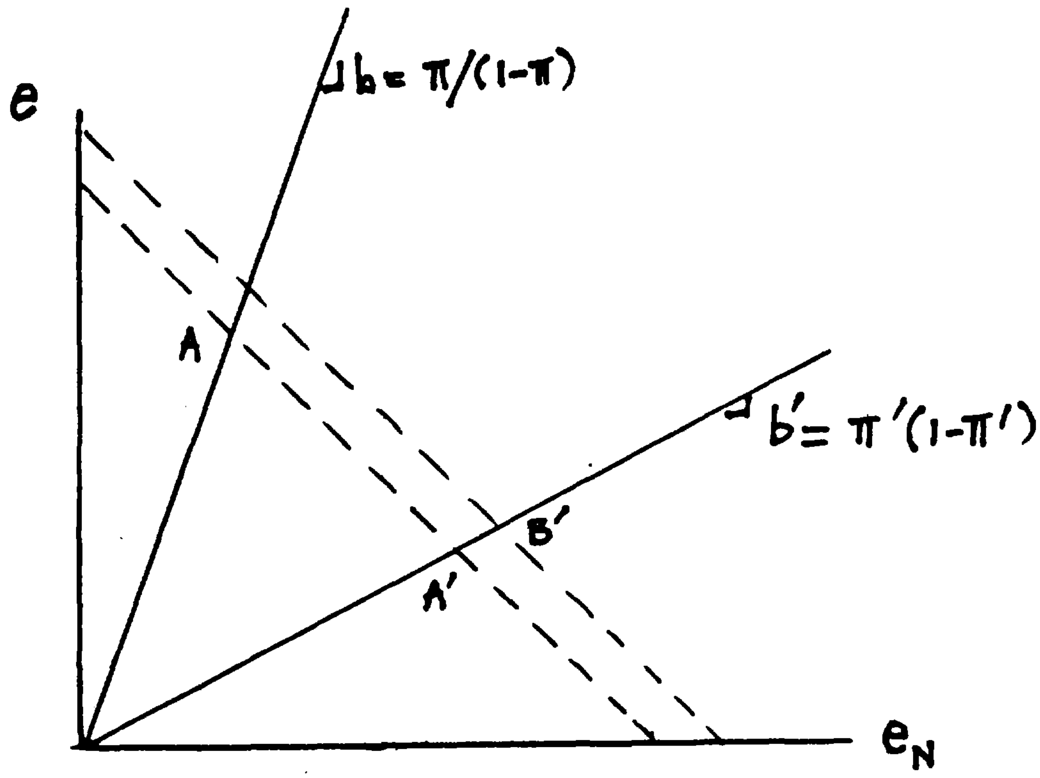

Figure 2

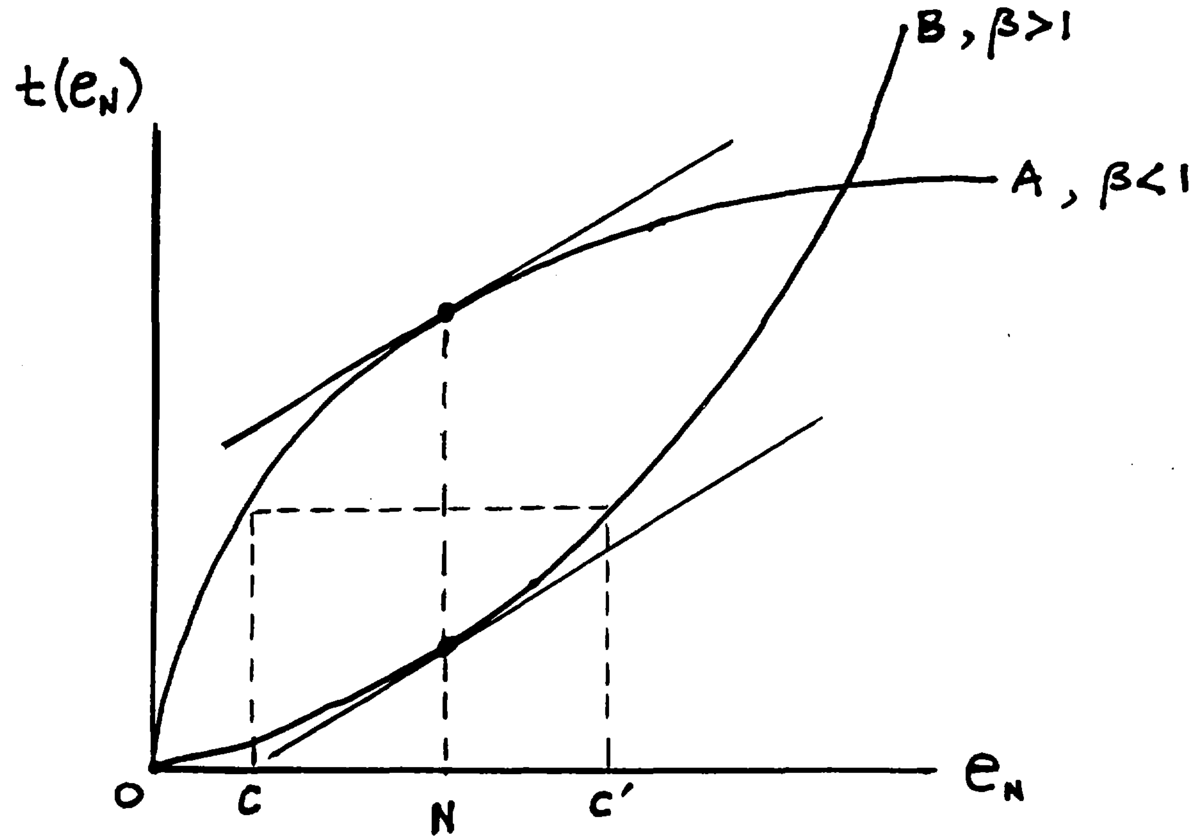

Figure 3

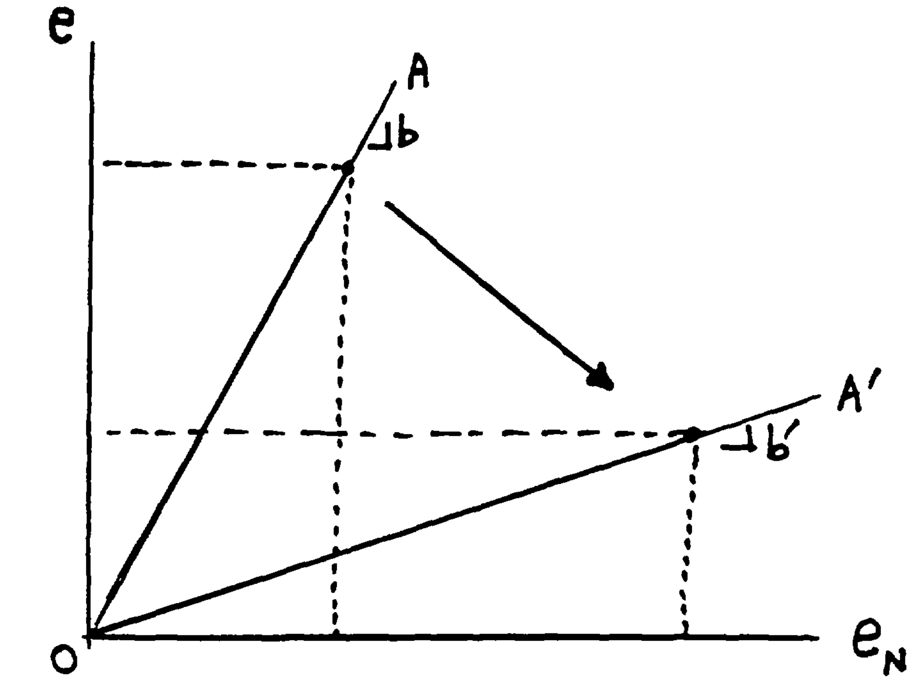

Figure 4a

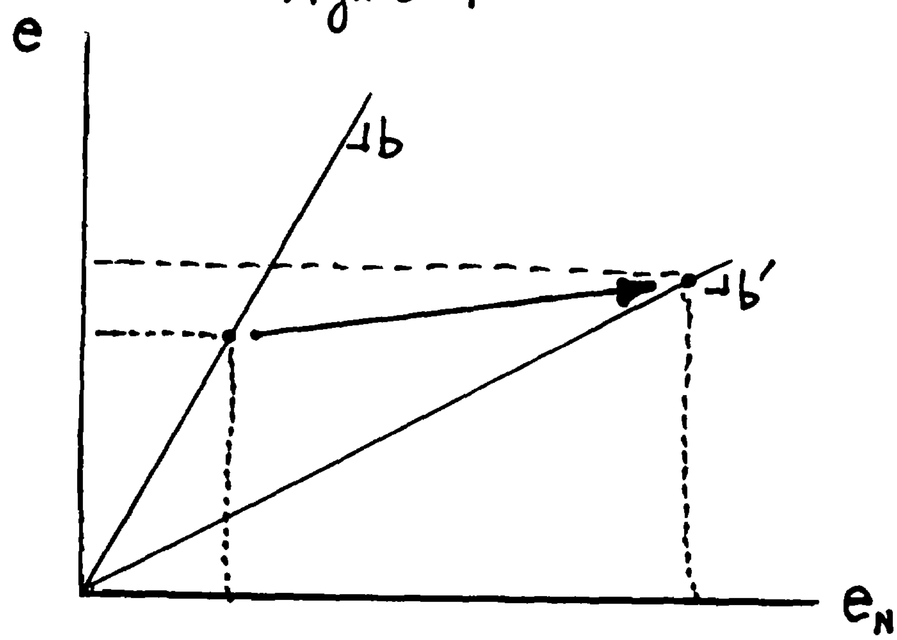

Figure 4b

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