Beyond BEST:
An Alternative for Pro-Poor Energy Pricing

Draft December 13, 2004

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The Basic Electricity Support Tariff (BEST) was designed to advance the welfare of poor households (UCT 2002). Specifically the South African government chose to supply 50kWh Free Basic Electricity (FBE) per month per household. We illustrate an alternative that would cost less, with larger benefits for the poor. By offering electricity for free, FBE distorts the energy choices of poor households—encouraging them, for example, to cook with electricity when alternatives such as LPG can deliver a similar cooking service at a much lower cost to society.

For a decade, the South African government has steadfastly supported energy policies that advance the welfare of the poor. These have included the world's most effective *policy* for electrifying low-income areas in urban and rural regions alike (Gaunt 2004). In this tradition, the government has introduced a "Free Basic Electricity (FBE)" scheme that will offer 50 kilowatt hours per month for free to most households that have access to electricity.

We suggest some caution and offer an alternative strategy that would cost government no more yet deliver larger—possibly much larger—benefits for the poorest households while also lightening the stress on the South Africa's increasingly strained power grid.

The offer of 50 kWh for free is likely to have a substantial effect on the energy choices of poor households. Detailed surveys of energy budgets in extremely poor electrified households—such as impoverished shacks in townships—show that when the household must purchase its electricity usage varies, but is typically about 20 kWh. Electricity is more expensive than traditional alternatives such as coal or firewood for cooking and heating (Williams et. al. 1996); the rational household devotes electricity sparingly. Typically, purchased electricity is used for television, lighting, electric irons, and a few other applications for which fuel substitutes are inferior or absent. For the most energy-hungry applications, however, traditional fuels continue to dominate (Afrane-Okese 1998). Free electricity may change this.

In a trial run in 2002, government offered 50 kWh of free electricity to households for a one year period. The response, documented in detail through Eskom's Load Research Programme, was a rapid rise in average monthly consumption of tens of kWh per household. And there is reason to expect that the surge in demand will be even higher when households have confidence that free electricity is here to stay. As free electricity was offered in Khayelitsha township, a survey by the University of Cape Town in January (Cowan & Mohlankoana 2004) revealed that households are responding as expected. In ever-larger numbers, households are purchasing and using electric cookers, and there is some evidence that households are also using electricity for bulk heating of water.

There is little doubt that free electricity has improved the livelihoods of poor households. FBE has reduced household expenditures and also expanded the use of a clean fuel at the expense of mainly dirty alternatives. Our question is whether it is possible to do better at the same cost.

We focus on the most striking and possibly costly shift to free electricity—the use of electricity for cooking. This shift is worrisome because there are rivals for clean cooking—notably LPG stoves—that will find it difficult to survive in the marketplace when electricity is free. Moreover, most cooking (with electricity) occurs during periods when electricity is already in peak demand. At the margin, this electricity is particularly costly for society since electricity is difficult to store and thus the entire electric power system must be sized for adequate supply during peak periods. We illustrate our point quantitatively by comparing electric cookers with LPG stoves, and we focus on the incidence of cooking during peak electric periods.

The South African electric power system is already close to peak capacity during winter months. New demand will require the construction of new power plants. Plants (and transmission and distribution lines) are needed not only to supply the quantity of power consumed, but also to preserve the buffer of about 15% (NER 2004) extra capacity—known as the "reserve margin," which sits on call ready for dispatch should another generator or power line in the system fail. (Even without FBE, South Africa will require new power plants; the extra power consumed under FBE accelerates that need.) The details of the calculations rely mainly on the same assumptions and models deployed in the National Electricity Regulator's most recent National Integrated Resource Plan (NER 2004).

We assume that the hot plates introduced in response to FBE will operate 45 minutes (Cowan 2004) per day, with a 70% chance that this takes place during peak periods. Further we assume that on average they are operating at 50% of their power level. Consider boiling food in water. When heating water, hot plates will be consuming close to maximum power. However, once brought to a boil the power will be reduced, and the average power consumed will be less than maximum power. During operation, these plates use electricity from, amongst others, baseload coal plants, which is extremely inexpensive: about 0.08 R/kWh (NER 2004), including the cost of maintenance, fuel, and losses (including theft) that are typical of electric service in low-income areas (We consider the cost of connection to the grid as largely "sunk" and do not include the costs of transmission and distribution. These simplifications will act to underestimate the cost savings that would accrue from switching fuel use away from electricity).

For electricity supply, we assume that this new demand (often termed the "marginal demand" by economists) for electricity will be served by an average blend of two types of plants: large coal-fired power plants typical of South Africa's present power system (which are "on the margin" 80% of the time) and pumped storage facilities such as the Braamhoek scheme (which are "on the margin" 20% of the time). These assumptions are extremely conservative, as most cooking will take place when the system is near peak (eg. late afternoon) and maybe the role for pumped storage (which is costly) may be even larger than we assume. With our conservative assumption the average marginal price of electricity generation is about 0,09 R/kWh consumed.

Using a more realistic blend of plant (including OCGT plant) and marginal operating time, we would derive a marginal generation cost of about 0.17R/kWh consumed. The table shows the operating and maintenance costs and fuel costs for these options.

Plant type	Pumped storage	Open cycle gas turbine	Coal fired
Units	R/kWh	R/kWh	R/kWh
Operating & maintenance	0.05	0.14	0.02
Fuel costs	0.06	0.81	0.04
Losses (T&D)	0.03	0.24	0.02
Total	**0.13**	**1.18**	**0.08**

Table 1: **Operating and Maintenance (O&M) and Fuel Costs for the three main options for generating peak power.** (NER 2004)

The results are particularly sensitive to the assumptions about the relative roles for pumped storage and OCGT. As a general rule, pumped storage schemes are costly to build and require long lead times, but have low operating costs compared to OCGT. Thus South Africa has built a few—and has begun the process to build one more—and once these facilities exist there are strong incentives to use them. OCGT, by contrast, is relatively inexpensive to build but extremely expensive to operate. (If the plant burns oil-based fuels then during periods of high oil prices, such as today, power generation is especially costly). These units are much smaller in size and require less lead time for construction; thus OCGT investments are easier to scale to the exact demand. In most of the world—where demand for peak power is rising sharply—these properties help to explain why such gas turbines are occupying an increasing role in the power system.

To illustrate what is at stake, we assume that power is dispatched on South Africa's power system at minimum cost. Thus coal plants are constantly in operation; during non-peak periods extra electricity from these plants is used to pump water in pumped storage facilities. During peak periods the pumped storage is used to the maximum extent possible, and any residual need for power supply is satisfied with OCGT. Using such a method, and looking over the next decade, we expect that OCGT plants will be needed to supply only a very small fraction of the extra demand for cooking power that FBE creates. However, during most peak periods the OCGT plants are still essential—they maintain the reserve margin, which means that they incur the cost of construction and maintenance but not the actual cost of operation. All told, for every kilowatt of capacity required by low income consumers at peak time there is a once-off cost of R5949 required. (This is the per kilowatt cost of an OCGT plant inflated by the losses associated with transmitting and distributing it to the customers concerned. Again, we neglect the cost having to increase the capacity of the transmission and distribution system. This again reflects a very conservative assumption.)

To summarize, using our simplified and conservative assumptions, we may approximate the minimum cost of supplying electricity. We distinguish between the cost of supplying electrical energy and the cost of maintaining the reserve margin. The cost of supplying electrical energy is a function of what plant are running "on the margin"[1]. The cost of the reserve margin is the cost required to install the cheapest capacity on the grid, namely OCGT plant[2].

Suppose that electricity were not free. What alternative sources of heat energy might households select? We focus on LPG because it offers service that is comparable to electricity: quick heating with essentially zero indoor air pollution (Williams 1994). Already many low income households select LPG for cooking where it is available. From those markets—which are served mainly by private enterprise—we derive estimates of the actual costs for LPG services. Compared with electric stoves, LPG systems (stove, valve and tank) are about 50 R more costly and have twice the life time: 10 years, rather than 5. The valve systems have a short lifetime of 3 about years. The retail price of a six kilogram LPG cylinder is 36 R (Tatham 2004). We expect that these costs would decline with experience as the LPG business is still struggling to secure a foothold in these new markets and probably incurs higher costs than would prevail at larger scale; for this analysis, however, we use these values.

The LPG option is less costly than electricity. Let us consider the cost of maintaining 1.5 kW of electric cooking capacity and the cost of 1.3kW LPG hotplates over a twenty year period, which is the economic life time of the new OCGT plant. According to our assumptions, 1.5kW of electric hotplate on average will consume 0.75kW, and only 70% of these hotplates will be consuming electricity during peak periods. This implies that 0.525kW, or R3123, of reserve margin will not be needed for the LPG option. Over the period the household would have invested in four electric hotplates, and these would have consumed on average 205kWh per year, not all at peak times. The total cost of the hotplates, reserve margin requirements and electricity (with our conservative assumptions and a 10% discount rate) is R3514. The total cost of supplying the same cooking requirement using LPG systems, with two LPG stove/cylinder systems, seven valve systems, and similar quantities of fuel consumed the total cost is R1774. This means there is a (net present value) difference of R1740 over the twenty year period. This represents an average annual levelized (taking into account that money could be earned were it left in the bank) saving of 187R per year if households were to use LPG instead of electric hotplates. (Again we emphasize that this figure relies on conservative assumptions; higher savings are likely.)

That amount (187 R/year) is about 4% of annual income for a typical poor household (<poorest 10%). In other words, the distortion created by offering free electricity—which results in households cooking with electricity rather than gas—is a waste that could otherwise be used

[1] In order to be conservative, we do not consider the capital cost component of new plants required to produce electricity.

[2] In the NIRP analysis carried out by the national regulator OCGT plant are build at various intervals during the twenty year planning horizon considered, and OCGT plant built during times of capacity requirement are not decommissioned. It is therefore reasonable, according to the NIRP activity, to assume that the minimum cost incurred to maintain the reserve margin is the capital cost of OCGT's.

for other pressing needs. The amount is equivalent to removing the total cost of the LPG stoves and giving every household 2.3 free kilograms of LPG per month. This is more than sufficient to the very basic cooking requirements considered in this experiment. Such resources are substantial for the very poor; they also indicate the savings that government could capture with a better designed energy policy for the poor.

Of course, the savings (of 187R/year/household) we describe would accrue to society as a whole. Thus the benefits to the target households will not change, but the cost of supply will be reduced.

Before turning to implementation, we note that these calculations are very sensitive to several assumptions. It depends on the peak coincidence factor—that is, the assumption that 70% of cooking occurs during peak periods. Our sense is that that assumption is robust, and without real time pricing of electricity it will be difficult to shift cooking behavior away from peak periods. The crucial assumptions concern the technologies that will be used to supply peak power and maintain reserve margin. As South Africa has already committed to build new pumped storage, we have assumed that actual power generated by OCGT plant(s) is 0% of the total marginal power consumed by these hot plates. OCGT is used *only* to preserve the peak reserve margin. But there are three reasons to be skeptical of that assumption, and all three underscore that our calculations may be extremely conservative. One is that as households gain confidence that FBE is, indeed, a permanent policy they will optimize their investment in electric appliances (including stoves) to make fullest use of the free power. A second reason is that 50 kWh is not set in stone, and already there are agitations to raise the number—additional load would require additional operation of OCGT unless a substantial commitment were made to pumped storage facilities. Third, with time the rest of the economy is likely to shift, as well, to a more peaky load profile; as that happens, the marginal kWh consumed through FBE increasingly require dispatch of OCGT.

Peak co-incidence factor	Annualized saving	Operational load factor	Annualized saving
100%	330	80%	300
90%	282	70%	262
80%	235	60%	225
70%	187	50%	187
60%	140	40%	150
50%	92	30%	112

Table 2: Key assumptions and their effect on the annualized saving to society.

Implementation

These calculations illustrate the potential for substantial savings. They also suggest urgency for reform since expectations (and capital investments, such as electric stoves) are solidifying around the promise of free electricity. Once those promises are cemented in place it may be politically difficult to change course.

We focus on two options. For both, we assume that government will keep the social cost of pro-poor energy policy fixed. Our aim is to illustrate how deployment of the same level of public resources could yield much larger benefits for poor households.

The first option reflects what many governments in other countries have done. Namely, government could simply extend the policy of free (or cheap) energy services to a wider array of fuels, so as to re-level to playing field. It could cut prices on LPG, for example, so as to encourage its use. But such policies have two severe—and, in our view, fatal—problems. First, it is politically very difficult to contain costs through a policy that multiplies price distortions in an already distorted market. Government will find it very difficult to roll back the 50 kWh of free electricity already on offer; instead, it will probably find the need to add new cut price services on top of the existing subsidies. Second, managing behavior and technological choices through distorted markets is extremely difficult and prone to failure. For example, although LPG appears to be superior for cooking, should government also offer subsidies for solar hot water heaters that, like LPG, are more cost effective than electricity for supplying the service of water heating in some settings? How will government anticipate the rise of new technologies—will it offer to subsidize all newcomers, and will innovators of new technologies believe that such a promise is credible? (Already LPG is at a disadvantage relative to paraffin as the latter enjoys special tax treatment.) With time, such an approach to pro-poor energy policy is likely to become both expensive and highly market distorting.

A second option would make use of the market. We envision a simple but profoundly important change to the free electricity policy: offer free energy *equivalent* to 50 kWh per month. Allow households to choose the clean energy source that best meets their needs, rather than specifying (through an electricity-only subsidy) that the choice must be electric. The best way to implement such an approach will probably vary by region and type of household. For households that use pre-paid codes on their electric meters, the subsidy can be delivered by household, allowing the user to choose a mix of energy options adding up to a total consistent with the subsidy. Such a system could be administered by means of distributing to consumers, vouchers or an "energy card" akin to a bank card. Approved vendors—whether LPG sellers or installers of solar hot water heaters—could debit the cost of their services directly from the cards or use the vouchers as a cash equivalent. This option[3] offers the opportunity to rectify a distortion that is already arising in electric services, with negative consequences for innovation and fairness in the provision of electric services: rural homes served by solar power have limited electricity supply. The approach proposed here, which would make free basic energy fungible for non-grid electric services as well as non-electric services, would level the playing field.

For households that have traditional meters (rather than pre-paid cards), implementation may prove more difficult. Such households presently receive FBE directly on their electric bills; for non-electric services to have easy access to the same subsidy it may be necessary to create a scheme that would allow households to transfer some (or all) of their subsidy from the electric distributors to non-electric vendors. Such an approach may be cumbersome and could allow incumbent electric distributors to frustrate the policy by raising barriers and complications; those

[3] It should be noted that this option requires further study to determine the practicality of such an administration.

problems, however, are not appreciably different from those that arise with many types of regulation of electric distributors worldwide and can be overcome with relative ease and the focused attention of NER.

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We offer these calculations and thoughts on FBE reform in the spirit of directing a powerful locomotive before it travels too far down a track that could prove costly and much less effective than plausible alternatives. We accept the importance of pro-poor energy policies and propose reforms that could be surprisingly simple to implement yet profoundly important in multiplying the benefits to the poorest households from the offer of free energy. We also suggest that this reform will make it politically easier for government to contain the cost of these programs, and that a focus on performance will encourage innovators to devise a wider array of pro-poor energy services than would occur through an electricity-only approach. Indeed, this approach may alleviate pending power shortages on the national power grid due to current peak reserve limits and help serve at least two urgent national imperatives.

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