IWMI-TATA WATER POLICY RESEARCH PROGRAM

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Can Pre-Paid Cards Help Management of Farm Power Supply?

Lessons for India from a South African Experience

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An Assessment of South Africa's Prepaid Electricity Experiment and Policy Implications for Developing Countries

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1.0 Introduction and Objectives

The usual way for paying for electricity is that it is metered and billed to the electricity consumer. The costs of metering, billing and collecting dues become huge when electricity is to be supplied to large numbers of tiny and dispersed consumers. High electricity costs to consumers make them insensitive to the system and coerce them into pilfering electricity or to fudge meter readings, and so on. In some countries, for example in India, it is alleged that a large part of 30-35% transmission and distribution loss is due to pilferage alone. To counter this problem, many State electricity Boards (SEBs) in India switched from metered to flat tariff regime in the 1970s. However, this rendered the SEBs hopelessly less viable.

The re-introduction of metering has invited much opposition, with a host of other problems related to it. One solution to it is to go for prepaid electricity. In this context, the South African experiment with promoting the use of prepaid electricity cards is notable and may offer solutions to many developing countries like India which face similar problems. The experiment is now roughly 12 years old and its assessment can provide useful insights to policy makers in power sector in many developing countries.

The major objective of this study is to understand the economics, logistics, and technology underlying the South African Experiment of pre-paid electricity card system. The study makes an assessment of the experiment in resolving the problems of viable power supply to small, dispersed consumers and discuss its relevance for the developing countries. More specifically, the study is aimed at assessing the following questions in particular:

(1) What factors motivated Eskom's experiment with pre-paid electricity card system?
(2) How does the technology work in the field condition?
(3) What is the economics of the prepaid technology and what are other possible advantages and disadvantages of the prepaid electricity system?
(4) How good or poor has been the acceptance of technology and whether it has done well in particular market segments and not in others? If so, why?
(5) What has been the consumers' assessment in different market segments and how do they view this technology?
(6) What has been the Eskom's assessment of the impact so far and has it been beneficial to both Eskom and Consumers?
(7) Is there any indication of a stoppage of the pilferage of power, expanding the reach of electricity to far off areas, reducing the metering and collection cost, among others?
(8) Has there been a need for an aggressive marketing of pre-paid electricity, initially through subsidies to get consumers to switch over to it?

(9) What lessons from the South African experience should be kept in mind while planning introduction of such technology in the developing countries?
(10) What might be the prospects, problems and advantages of introducing pre-paid electricity technology in power distribution in the rural areas of developing economies?

The motivation for prepaid electricity system and a brief history of development of prepayment system in South Africa, are discussed in Section 2. The principles and functions of prepayment technology are detailed in Section 3. The economics of prepaid electricity and other cost-related considerations are discussed in section 4. Various advantages and disadvantages to Eskom and to consumers are delineated in section 5. Factors affecting the success of the expansion of prepaid electricity are assessed in section 6. The lessons learned from this experiment are summarized in section 7. Prospects for promoting prepaid electricity in developing countries are discussed in section 7.

2.0 Eskom's Prepaid Electricity Experiment

Prior to 1988 Eskom supplied electricity mainly to large customers like mines and municipalities. At that time, although Eskom was one of the largest generators of electricity in the world, had only 120,000 customers all of whom were on billed accounts. In 1988, Eskom had a change of strategy to supply electricity directly to the large masses of domestic customers who did not have access to electricity then. Most of these customers were in rural areas. Then came the revolutionary change: "Electricity for All." The vision of Eskom was broadened and positioned in the context of African Renaissance. Its major objective was redefined as to vigorously promote economic growth in Southern Africa and, at the same time, support social and economic objectives in energy and selected markets.

This visionary change in 1988 brought several problems to the forefront, which can be basically divided in to three categories.

1. Many small areas had to be supported with a small number of Eskom personnel. The standard billed accounts system required much day-to-day management to process accounts and to maintain connections and disconnections. This implied operating with a low level of management and maintenance.
2. Many of the areas, where potential customers lived, had neither the infrastructure nor the economy that was merely sustainable. That is, people did not have permanent jobs or bank accounts, therefore, there were no fixed addresses to which billed accounts could be posted; there was no postal service in these areas. All these features are the basic requisites for a billing to operate effectively. Many customers were illiterate and did not understand the bills that arrived only after the electricity had been consumed. Many did not have the budget to pay for the fixed charges--a component of the billed account.
3. Many consumers resented the idea of paying a fixed charge--an expense that they believed they did not incur.

To address these and other related problems, Eskom initiated development of a basic pre-paid system that is still in use and has grown over the years.

2.1 A Brief Review of Development of Prepayment System

The first inquiry for electricity dispensers (EDs) or prepayment meters in Eskom was issued in 1989. This inquiry was based on a short specification produced by Eskom. Contracts were issued to two manufacturers (AEG, then Schlumberger, and Conlog) based on this specification for 10,000 meters. An earth leakage protection device was included with the meter and dispensers were only required to perform Amp-hour measurement instead of KWh (KiloWatt hours).

The specification document was upgraded and made more comprehensive in 1990 (it included NRS009, Parts 1, 2, and 3). This time the earth leakage protection device was removed from the ED. The specification based on NRS009 was contracted out to three manufacturers: AEG, Conlog, and EML, then Spescom; some 30,000 meters were ordered at the rate of 10,000 meters per manufacturer. The project was renamed as the "Eskom Electrification Project". Lightening related failures were also becoming apparent during this time. An exhaustive investigation established that the international requirements as specified in NRS009 document were not stringent enough for the South African conditions. A lightning arrestor was developed in conjunction with the Council of Scientific and Industrial Research (CSIR) and was installed in the EDs; this effectively addressed the lightning problems.

In 1990, The South African Bureau of Standards (SABs) provided a completely new specification of prepayment meters and replaced the old one. However, it did take into account the NRS009 while creating the new specification. And, the total number of prepayment meters to be manufactured was increased to 200,000 per annum in 1993. It was further planned to be increased to 300,000 meters per annum by the year 2000.

Having standardized the specification of prepayment meters by the SAB, Eskom identified the need for standardizing the vending system to be able to sell electricity from one meter to the rest, manufactured by different manufacturers. Eskom initiated a program to standardize the EDs and the vending process in 1993. An inquiry was issued for the vending system based on a draft specification and for EDs to accompany it. Later, the development of the new common vending system (CVS) was started jointly by Eskom in conjunction with Conlog, a meter manufacturing company.

The development of CVS was followed by the development of "Standard Transfer Specification" (STS). Both Conlog and Eskom developed the STS to enable the new vending system to transfer credit to all types of meters. This warranted developing a standard transfer medium and protocol to the meters. All EDs produced from the beginning of 1994 implemented the STS and allowed the CVS to produce tokens for any manufacturer's EDs. The first functional specification (MC 171 rev 2.10) was released at the same time and has been implemented in all the STS based EDs since 1994. In 1994, the modified specification for lightning arrestors (TRMSCAAP2 rev 2) that could withstand 400 volt was also released.

In 1996, to achieve a further reduction in the cost of electrification, a 2.5 Amp Circuit Breaker Unit (CBU) was designed (MC 196 rev 1.01); a CBU is a device equipped with earth leakage and overload protection, designed to supply up to 2.5 Amp and to be managed on a flat rate tariff. Operational cost studies were done in late 1997 and Eskom came to the conclusion that prepayment is still cost effective or cheaper than the CBU flat rate system. The decision was then made to implement a prepayment 2.5 Amp prepayment system with ECUs instead CBU.

Common Vending System (CVS) and the STS meters formed the basis of the existing prepayment system of Eskom. The CVS and STS have been further improved and are adopted as standard by other electricity utilities, such as Durban Metro, in South Africa. South Africa is now seen as world leader in prepayment technology and many other countries have adopted the South African Standards.

3.0 The Prepayment Technology

How the prepayment technology works has been illustrated briefly in this section. The technology is rather simple but requires an understanding of functioning of various components that produce the final delivery of service. The basic principles of the prepayment system are discussed, followed by description of the functioning of the prepayment technology. Two important technologies—STS and CVS—which are very essential for functioning of prepayment technology, have also been discussed in this section.

3.1 Principles of Operation of Prepayment

Two important elements of operation of prepayment system are token technology and systems approach to management. The prepayment meters or Electricity Dispensers (EDs) are installed at the customer's residence or at any other point of sale of electricity. A prepayment meter is designed to supply electricity up to 60 Amp. EDs plug into a standard passive base or socket and the output is connected to a distribution board. The customer then has to buy tokens from Eskom. These tokens are then inserted into the EDs. If the token is valid, the ED accepts it and adds the credit, i.e. the amount of units of electricity encrypted on the token in KWh, to the current credit in the ED. The customer, then, can use electricity until the entire credit is exhausted. Then the ED interrupts the electric supply. A token can only be entered once and is issued for use in a unique ED, that is, the customer buys a token for his/her specific ED. However, the token can be entered at any time to prevent interruption.

Eskom uses two types of token technologies for EDs. Both the types are of use-once-and-dispose nature. The customers cannot reuse the tokens once they have been entered into the ED for the credits are recorded. Two types of tokens are used: (1) disposable paper cards with a magnetic stripe (Conforming to 1S0780 and 7811size and strip location), and (2) numeric tokens which are strips of paper with a 16 or 20 digit number to be entered into the ED, via a keypad on the face of ED, by the customer.

The choice of the token depends upon the types of meters--magnetic card and numeric keypad. The magnetic card meters accept the magnetic token while the numeric tokens are acceptable to numeric or keypad meters. The numeric token is unique to South African EDs in that it need not be transported physically and thus making them ideal for sale over the telephone. Tokens for prepayment can be categorized as being "one-way" or "two- way." The one-way tokens transfer credit and control information from the sale point to the meter; the tokens are usually discarded after use. The major drawback with one-way tokens is that the Eskom cannot determine how much electricity has been disbursed through the prepayment Electrical Dispensers. The Eskom personnel have to visit the customer's premises to determine the authenticity of consumption. The two-way tokens require the customer to return the token to the point of sale for the next purchase. This allows the Eskom personnel the reading of the data stored by the meter from the returned token. The statistical processing is carried out by the data management system.

In case of the conventional meter (rotating disk Ferraris meters), the functions of technical support, maintenance and revenue collection and management can to a large extent be operated autonomously. In contrast, the prepayment metering requires an integrated system approach. It requires (1) an effective and available token (electricity) sales points, and (2) proper sales management systems (which is made up of both manual person-based as well as information technology equipment based). For example, producing bills two days later does not deprive customers of electricity, whereas inoperative prepayment sales point for two days will cause significant customer inconvenience. It is therefore emphasized that when prepayment electricity is to be introduced, we must give consideration to the whole system in its entirety, not merely to the prepayment meters.

3.2 Functioning of Prepayment Technology

As discussed above, prepayment electricity is based on systems approach and its revenue and maintenance management is inextricably linked with the operation of the entire system. Eskom started the development of basic prepayment system in 1993. This system consisted of the following components: (1) Prepayment meters, also called Electricity Dispensers or EDs; (2) Vending machines where the customers can purchase electricity credit, known as Credit Dispensing Units or CDUs; (3) Data Concentrators (DCs) that manage the CDUs and collect the transaction data from the CDUs, also called the System Master Station or SMSs (Figure 1).

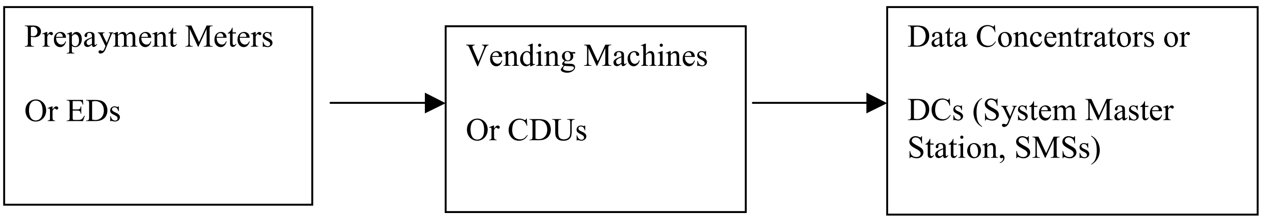

Figure 1: Basic Components of the Prepayment System: A Schematic Diagram

The EDs can be of two types: proprietary meter and STS meter. Proprietary meters are the old meters supplied to Eskom by companies like AEG, Ash, Conlog, Plessey, and Spescom. The STS meters are the new meters specified by the Eskom which accept tokens conforming the STS specification (to be discussed later in Chapter 3). Originally the EDs were not built with protection devices to arrest lightning; later these changes were incorporated and such an ED is called Electricity Control Unit (ECU)[i].

The CDUs are nothing but a prepaid token vending machine; these are of two types, proprietary and common vending. The proprietary CDU vends only proprietary tokens; on the other hand, the common vending system CDU vends both STS and proprietary tokens. Typically a vending machine is currently installed for every 800 to 1000 customers[ii]. The DCs or data concentrators collect information from CDUs and transfer it to mainframe computer.

In order to manage the prepaid electricity, the Eskom has divided the entire geographical area of electricity supply in to **Supply Group Codes** (SGCs). Eskom buys meters from suppliers pre-coded for a specific SGC or on a default SGC and then codes the meter for the specific SGC. This personalizes a meter for a specific area and also adds a few additional items like specific tariff index, etc. All this information is combined to form a key for the meter and every token is encrypted under such a key. If the key is wrong, the meter will not accept the token. The whole encryption process is defined by the STS standard which will be discussed later in this chapter. Every meter is also shipped with a meter card with this same information. The only use of the card is to make it easy to identify the customer, otherwise the entire information will have to be typed in to the vending machine (CDU) when customer buys electricity, but now the customer can just swipe the card to identify his meter details.

The vending machine or CDU, which is nothing but a PC that is close to customers, stores the hidden SGC keys enabling the machine to identify the exact location of the customer. A customer, who wants to buy electricity presents his meter card to the vendor, pays the sum of money that he/she wants to spend. The vending machine then produces a magnetic or keypad token for the customer. The customer can take it home and enter into his meter. The transaction data are then uploaded from the vending machine to the SMS and mainframe computer for statistical and data management purposes.

Each meter card contains the following information: (1) supply group code, (2) key revision number, (3) tariff index, (4) meter number. The moment the customer swipes his/her meter card in the vending machine or CDUs, it reads the information and then generates a meter key taking into account the: (1) key revision number, (2) associated invisible vending key, and (3) tariff index (Figure 2). This meter key is also stored inside the ED. Thus meter keys--one in CDU and other in ED-- can exchange tokens. Once the customer pays the amount and gives his/her meter card to the vendor, the vending machine generates a token, keeping into account the meter key and tariff rate. The credit token is thus generated and fed to the ED.

3.3 The Development of CVS and STS

The development of the Common Vending System (CVS) and the Standard Transfer Specification (STS) are the two pillars of prepayment technology and need to be understood well. The CVS consists of various groups of Credit Dispensing Units or CDUs which are distributed at various points of sale (POS) locations, with each CDU group concentrated by a System Master Station (STS). The SMSs are in turn concentrated by a Transaction Manager (TM) on Eskom's Mainframe Information System (MIS), as depicted in Figure 2.

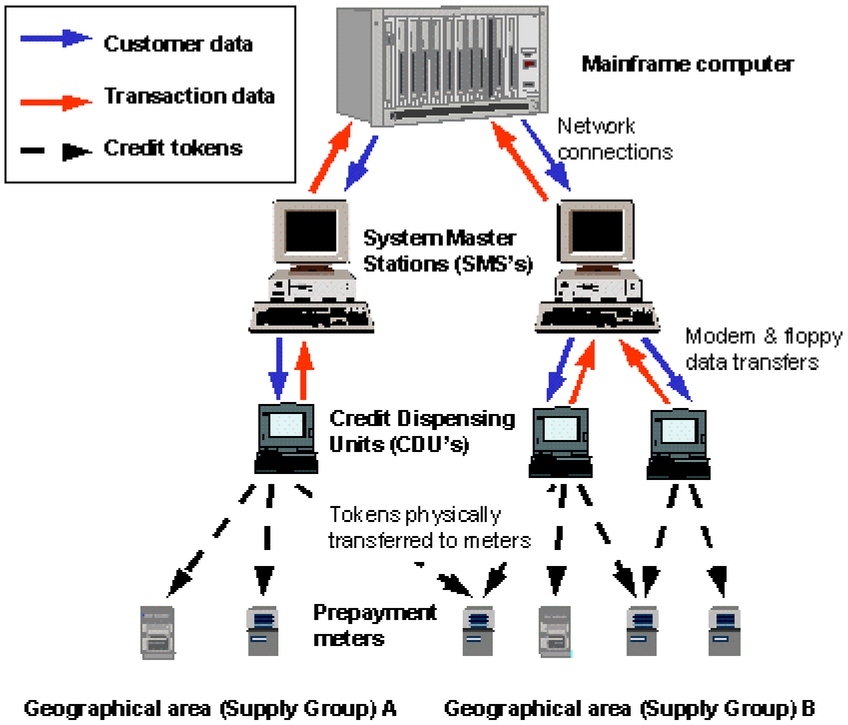

Figure 2: A Schematic Diagram Showing Functioning of Eskom Prepayment System

In other words, CVS incorporates the network of CDUs, SMSs, and the TM, all interfacing to the MIS. The MIS consists of several subsystems which include: (1) Customer Information System Data Base (CIS DB); (2) Customer Management System (CMS); (3) General Ledger (GL); (4) Nedisys-ED Tracking System (NED); (5) Power Billing System (IPS). The hardware and software that support the interface between CDU, SMSs, and TM are shown in Figure 3. In brief, the CVS provides for the vending of a STS token, which enables the individual customer to use electricity. This enables CDUs to vend STS tokens, which are compatible to EDs that support the standard transfer algorithm (STA). The CDU also has the capability to interface to standard token translator (STT) to support a proprietary token, using a proprietary algorithm. This ensures the backward compatibility for proprietary EDs that are already installed.

The implementation task of CDU and ED becomes easier if the STS is understood well. During the early years of prepayment electrification, the focus of specification and standardization was on the ED, not on the vending system and other infrastructure. This produced a variety of vending systems which were usually incompatible with each other. This incompatibility led to the inability of the vending system of one manufacturer to vend to the ED of another. As a result, a distributor had to purchase different vending systems to support the sale of prepayment electricity. This proved expensive and operationally inconvenient. To overcome the problem, Eskom, being a major buyer of EDs, initiated the process of standardization so that prepayment token from a CDU, developed by one manufacturer, could be used into an ED developed by another manufacturer. This required development of standards which could ensure compatibility. It should be noted that the STS is a standard for the electricity dispensing industry, whereas the CVS is a system implemented according to a set of standards, which is STS.

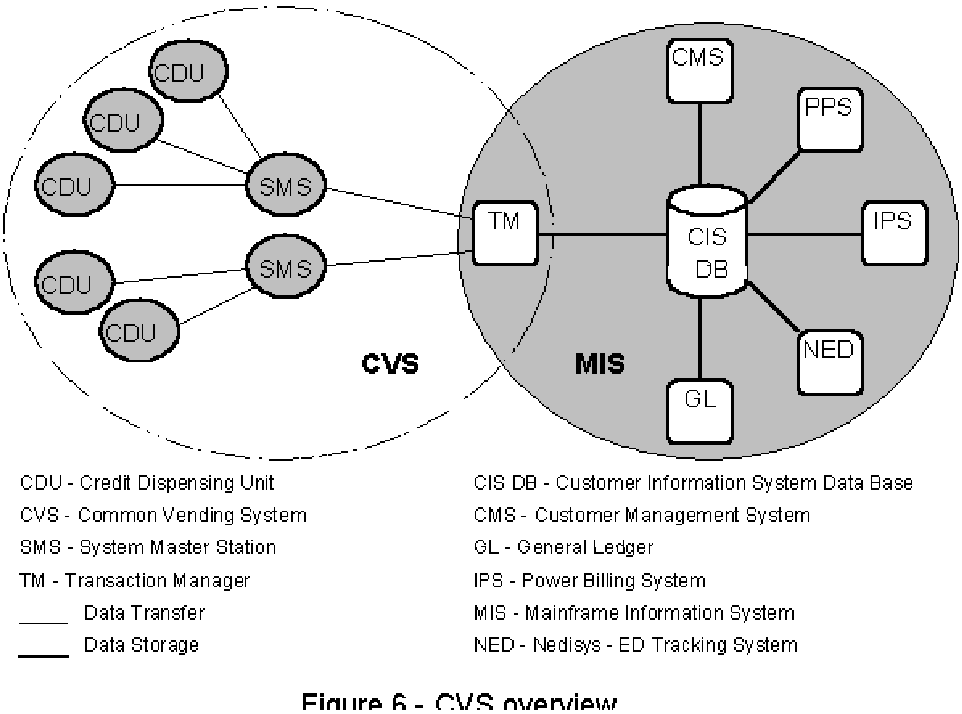

Figure 3: A Schematic Overview of CVS

STS is thus a standard for the electricity dispensing industry which allows STS compatible dispensing and vending equipment from different manufactures to operate with one another. This benefits consumer, distributor and agent, thereby promoting competition, cost-efficiency, and convenience in the industry. The STS is based upon a number of concepts. Most of these concepts are directly addressed in the STS, nevertheless, some being the subject of other specifications/standards applicable to other areas such as the CVS, are addressed else where as well. To ensure compatibility, the STS defines the following: (1) A set of management and credit functions to be supported by an ED. (2) The various data elements required by the CDU to support the implementation of these management and credit function. (3) The format of management and credit token data corresponding to the management and credit functions. (4) The cryptographic methods of encrypting and decrypting the formatted token data so as to ensure its authenticity and/or secrecy during transfer between CDU and ED. (5) The cryptographic method of key management in support of the encryption and decryption of token data. (6) The type of token technology that can be input by EDs and output by CDUs; and (7) The method of encoding token data for each type of token technology.

4.0 Economics of Prepaid Electricity

The cost of electricity can affect the price that is to be charged to the electricity consumers. The price to the final consumer is thus made of several types of costs. Eskom's cost of electric supply can be explained by way of the supply chain. This includes five types of costs: (1) generation (2) transmission (3) distribution (4) reticulation (5) Service. Generation involves the cost of raw material and other input used in the production of electricity in power station. Eskom has some 25 power stations which generate approximately 97% of South African electricity supply. From the power station electricity is sent to all parts of the country. The transmission network carries a very high voltage current and only very large customers can be supplied directly from the transmission network. Only 2% customers are directly sold electricity from the transmission network. The electricity is then further distributed through the distribution network. The electrical power is transformed to a lower voltage at distribution substations. Some larger customers such as towns or factories are supplied directly from the distribution network. From the distribution network the electricity is then distributed to the customer's property by means of reticulation network, generally located in the immediate area at a lower voltage. Most of Eskom's customers are supplied from reticulation network. At the end of supply chain is the customer's service connection. This includes any line, cable or metering to connect the customer's installation to Eskom's network. It can therefore be concluded that cost of electricity to customers depends upon where one is in the supply chain. The higher up the supply chain, the less network Eskom has to build to supply a customer.

Various types of costs that Eskom incurs can be classified into three categories: (1) fixed costs which primarily cover the materials and erection cost of establishing all of Eskom's equipment; this is generally referred to as the **capital cost,** (2) operation, maintenance, and administration costs which refer to the costs incurred in ensuring that electricity supply is maintained, and (3) raw material or variable cost which includes the cost of coal or water. In general, the pricing of electricity by Eskom must cover all of the above costs so as to remain an economically viable enterprise in the economy. The price set by Eskom is designed as far as possible to meet the following objectives: (1) Pricing must provide the means to recover adequate revenue. (2) It should promote overall economic efficiency. (3) The price changed should be fair, equitable, and transparent to all customers and (4) Cost-effective tariffs should be established.

The price of electricity is implemented through a tariff package. A tariff package is made up of a tariff and various other charges and conditions applicable to electricity use. Different tariff packages are designed and made available to customers with different conditions and needs. For example, specific packages for residential sector, both rural and urban customers, are used by Eskom. In addition to tariff, Eskom also levies various charges depending upon individual circumstances such as connection fee, conversion fee, capital charges, service charges, and so on. For example, a connection fee is payable by the customer towards the cost of a new connection. A conversion fee is payable when a customer converts supply or is applied when there are changes such as meter changes, changes in installation or when a supply point is shifted.

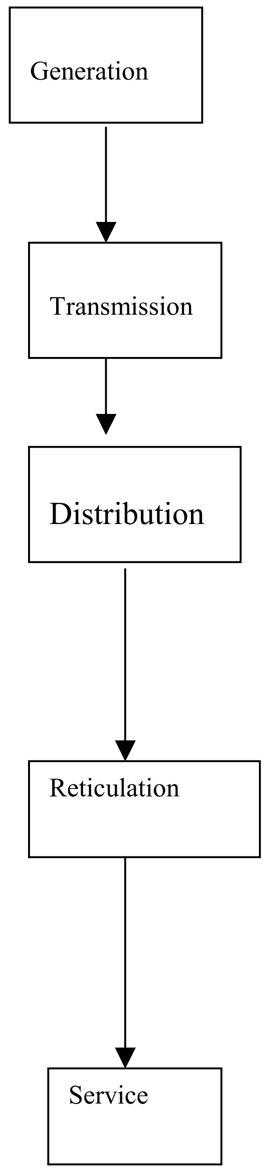

Figure 4: A General Overview of Costing of Electricity in South Africa

The network capital costs are not recovered through tariff but through additional capital charges over and above tariff. Generally speaking, the capital charges are of a fixed nature and paid as a **monthly rental**. This is paid irrespective of usage of electricity. It is a contribution towards Eskom's fixed costs and escalates annually with Eskom's price hike. Sometimes this is also known as the **basic charge**. A part of the capital charges is repaid towards the long-term use of capital. In Eskom, this is a non-escalating monthly capital repayment rate. It is a percentage per month of the total capital cost which needs to be repaid. In the year 2000, this was set at 15.5% annual discount rate and a repayment period of 25 years or less. The capital rate can change from one year to the other. In addition to these charges, Eskom also levies service charges such as transfer fee, payable by a new customer when ownership of a conventionally metered point of supply changes hands, call out fee, payable when Eskom is called out due to a supply interruption and fault is found to be within the customer's installation, special meter reading fee, payable when a special meter reading is done at the customer's request, meter test fee, payable when a meter test is requested by the customer, and so on.

In brief, the two types of charges make up the tariff: (1) basic charge, (2) energy charge. The basic charge is a fixed charge payable every month, irrespective of electric usage and contributes towards the fixed cost of supplying electricity. The energy charge covers the cost of electricity and is levied per kilo watt-hour of energy consumed; for example, 16.98 c/KWh. This is also called "rate" in colloquial language. The price equation can thus be written as follows:

$P = \alpha + \beta Q$

Where,

P = total price of electricity

α = Basic charge

β = Rate or energy charge rate

Q = amount of electricity consumed

Eskom has a number of tariffs available to consumers. These tariffs are usually set according to the size of the supply, the type of supply, and whether the supply is urban or rural.

4.1 Costs of Prepaid Electricity

Eskom tariffs are linked to all types of meters installed. Irrespective of tariff, a consumer can opt for prepayment or the conventional meter. Eskom follows three basic principles in this regard. Firstly, Eskom does not encourage prepayment meters in an area where vending sites are not situated close to the location of customer demanding prepayment meters. Even the conventional meters are not installed in the no-go areas which are very remote and costly. Secondly, the current prepayment meters cannot handle a supply size of more than 65 KVA[iii]. Thirdly, the prepayment vending system cannot handle fixed/basic charges and variable energy (high block vs. low block) rates. The fixed or basic charge has to be paid through the normal billing system.

In general, prepayment meters are available for home light, home power, business-rate, and land-rate. The standard supply size available for prepayment supplies are:

- Single-phase: 16 KVA (2.5 Amp, 20 Amp, 60 Amp)
- Two-phase: 32 KVA or 64 KVA
- Three- phase: 25 KVA or 50 KVA (60 Amp or more).

Eskom requires a deposit prior to connection of prepayment meters. Generally the deposit is equivalent to the electricity bill for three consecutive months estimated by the authorities. However, deposits are not required if prepayment meter is for home light supplies.

Monthly rentals or basic charges towards repayments of capital expenditures are required to be paid by all prepayment-meter-owners, with the exception of the home-light and business rate 4. It is important to note that the meters of the prepayments system cannot accommodate a tariff with both basic charge and energy rate, hence a monthly account is received by the consumer for the basic charge/monthly rental towards repayment of net work cost. Eskom supplies various levels of current under single, dual, and three-phase systems. Currently it provides four types of electricity supplies.

This is provided for customers with minimum electricity requirements and comprises electricity control unit (ECU) and double electricity plug outlet. This supply is only intended for very low usage customers that normally have only lights, radio, and television. It is not sufficient for cooking purposes. The meter charge depends upon the size of current. For 2.5 Amp supply, Eskom provides a free meter. However, this is done only in pilot projects areas. This is a much commonly used electricity supply. It consists of an ECU and a double plug outlet but with a current limit of 20 Amp. It is intended to supply for lights, radio, television, basic cooking, refrigeration and ironing needs of domestic customers. Customers are required to pay an upgrade or installation fee to receive 20 Amp supply. For 20 Amp supply (both prepayment or conventional meters) the meter fee is R (Rands) 150.

The 60 Amp supply is provided with an Electricity Dispenser (ED) and the consumer is required to provide his own internal wiring or distribution. The customer has to pay the full installation cost. This supply is typically used for consumers with hot water heaters or other small business. For 60 Amp supply, the meter (prepayment or conventional) charge is R1000; this is the minimum cash amount payable and additional charges based on actual costs may be raised as per current policy. There is a Three Phase Supply at 60 Amp or more which is provided with three phase ED and intended for business that require large supplies and are situated in areas that have prepaid electricity. This is not frequently used electricity as businesses are generally supplied with billing meters on a non- prepayment account. Eskom has set different tariff rates for different categories of uses. At present, there are four categories of consumers: (1) low usage residential consumers, (2) medium-to high usage residential consumers; (3) small business in urban areas; and (4) farmers and rural businesses. The details of current size and tariff structure are given in Table 1.

Table 1: Basic and Energy Charges for Different Types of Prepaid Electricity Usage, South Africa

Tariff	**Electricity Supply Size**	**Basic Charge**	**Energy Charge**
Business Rate 1	Less than 25 KVA	R 120.80 + VATt = R 137.71	19.34c + Vat = 22.05 c/KWh
Business Rate 2	Between 25 and 50 KVA	R 151.75 + VAT = R 173.00	19.34c + Vat = 22.05c/KWh
Business Rate 3	Between 50 and 100 KVA	R 209.78 + VAT = R 239.15	19.34c + Vat = 22.05c/KWh
Business Rate 4	Less than 25KVA	N/A	43.50c + Vat = 49.59c/KWh
Land Rate 1	16KVA-80A(1phase) 32KVA-80A(2phase) 25KVA-40A(3phase)	R 226.13 + VAT = R 257.79	First 500 KWh @38.12c/KWh34c (incl.VAT) .>500KWh @ 22.05c/KWh (incl. VAT)
Land Rate 2	64KVA-160A(2phase) 50KVA-80A (3phase)	R 257.05 + VAT = R 293.04	First 500 KWh @38.12c/KWh34c (incl.VAT) .>500KWh @ 22.05c/KWh (incl. VAT)
Land Rate 3	96KVA- 225A(2phase) 100KVA-160A (3phase)	R315.07 + VAT = R 359.18	First 500 KWh @38.12c/KWh34c (incl. VAT) .>500KWh @ 22.05c/KWh
Land Rate 4	16 KVA-80A(1phase)	R85.13 + VAT = R 97.05	33.43c + Vat = 38.12c/KWh
Home Power		R 41.53 + Vat = 47.34	22.58c + Vat = 25.74c/KWh
Homelight 1	(2.5 and 20 Amp)	N/A	33.12c + Vat = 37.76c/KWh
Homelight 1	(60 Amp)	N/A	37.25c + Vat = 42.47c/KWh
Homelight 2 (20 Amp)	(60 Amp)	N/A	28.76c + Vat = 32.79c/KWh
Homelight 2	(60 Amp)	N/A	32.89c + Vat = 37.49c/KWh

4.1.1 Tariff for Low Usage Residential Customers

For low usage residential customers, Eskom supplies the single phase (2.5, 20, 60 Amp current) electricity. Most of these consumers are from low income and need only homelight. The electricity meter is supplied free, although normally a deposit equivalent to electricity bill for 3 consecutive months is payable. For 2.5 Amp current supply, Eskom has offered prepayment meters without any charge but R150 and R1000 are levied towards meter charge for 20 and 60 Amp current supply. There are no basic charges to the consumers and a single energy charge is levied, depending upon the category of light (home-light 1 and 2) as shown in Table 1.

4.1.2 Tariff for Medium to High-Usage Residential Customers

This is called homepower supply. It is suitable for medium to high usage residential customers, churches, schools, etc. Eskom requires a deposit equivalent to electricity bills for 3 consecutive months. The connection fees are levied and vary with the type of current subscribed. For a single phase supply, the meter charge, whether conventional or prepayment, is R 1000, whereas for a three phase supply, it is R 2500 for prepayment meter and R 2100 for conventional meter. These are minimum cost amounts payable and additional charges based on actual costs may be raised as per Eskom's policy. This category of customers are required to pay a monthly charge of R47.34 per month for each point of delivery whether electricity is consumed or not. A single energy charge is of 25.74c/KWh is charged (Table 4.1).

The breakeven point for homelight1 (60Amp) and homepower is 283 KWh/month, respectively. If electricity consumption is less than 283 KWh/month, then Homelight1 (60 Amp) is cheaper than Homepower. If more than 283KWh/month is used then Homepower is cheaper than Homelight.

4.1.3 Tariff for Small Businesses in Urban Areas

This is intended for small businesses in urban areas. A supply of greater than 100KVA is not permitted. Four business rates are available. Normally a deposit equivalent to electricity bill for 3 consecutive months is required. The connection fees or meter charge depend upon the type of current. The meter charge for a single-phase supply, (prepayment and conventional) levied is R 1000, for a three-phase supply R 2500 and for the conventional meter R 2100. These are minimum cost estimates and extra charge can be laid depending upon the actual costs. Baring business rate 4, all other electricity supplies are required to pay a basic charge, as shown in Table 1. And, a single energy charge of 22.05c/KWh for business rates 1, 2, 3 and 49.59c/KWh for business rate 4 is levied (Table 1). Business rate 1, 2, 3 are suitable for supplies where consistently more than 500KWh is used. The basic charge is payable each month. The business rate 4 is suitable where consumption is consistently less than 500KWh per month. Thus business rate 4 is cheaper if the consumption is less than 500 KWh and others are cheaper when consumption is more than 500 KWh/month.

4.1.4 Tariff for Farmers and Rural Businesses

Under this tariff structure, five types of tariff rates are applicable: Land Rate 1, 2, 3, 4 and Land Rate Dx. Land rate 1, 2, 3 are suitable for supplies where consistently more than 1000 KWh per month being consumed. The basic charge is payable per month. Land rate 4 is suitable where electricity consumption is less than 1000KWh/month and here the supply size cannot exceed 16KVA. Land rate 4 is for domestic or small supplies on farms. The basic charge is levied per month. The Land Rate Dx is applicable to very low usage single–phase supplies where the supply capacity is limited to 10A. This is typically suited for small telecommunication installations where electricity charge is low enough not to warrant metering for billing purposes. In this case, only a fixed charge of R 279.78 per month is payable.

In each case, a deposit equivalent to electricity bill for 3 consecutive months, is demanded. The charges for meters vary. For single-phase supply (conventional or prepayment meters), the meter charge is R 1300. The charge for conventional meter for three phase supply is R 2600 and for prepayment meter, R 2950. The prepayment meter is thus a bit more costly. In many rural areas, Eskom has to construct lines to provide electricity to customers, this entails extra cost burden on consumers in terms of extra monthly rentals. The cost estimates for laying the line are : three phase line R 54545 /kilometer and single-phase line R 30000/kilometer.

4.2 Cost Estimates and Scale Economies

Two sets of population were surveyed to estimate the cost of prepaid electricity to individual household: (1) Some 30 households in Kwandengezi and Shongweni areas, an area outside Durban city in Kwazulu Natal ; (2) some 20 households in Witbank in Mpumalanga province. The average estimates are given in Table 3. The average connection fee varies significantly from one area to another. For example, the average cost of meter in Kwadengzi area was R 150 per household while R 500 per household in witbank area. The average fee for South Africa is about US $15. This is a subsidized price. The full cost price can be up to R500 or more as discussed in the previous section. In Witbank area, we found that some households were not charged at all because they were fully subsidized. The average prepaid electricity consumption is R80 to R150 per household in Kwadengzi-Shongweni and Witbank areas. The electricity charge comes to about 36c/KWh.

In the surveyed samples in Witbank area, some 10% households were using prepaid electricity for small businesses and pump irrigation. The monthly expenditure on electricity in these households ranged from R 1000 to R 2000 per month. For business use, in the Witbank area, the users accepted that economies of scale are realized. As the consumption of electricity increases, the cost per unit of electricity declines. Inquiries with managers revealed that it all depends upon the tariff structure. Mostly for small-scale consumption, scale economies are a rare thing.

Cost studies in Eskom show a wide range of variation in the cost of service per month to customers. This needs to be reduced while maintaining an acceptable level of service. Due to sharing of labor and infrastructure costs, the appointment of agents for Eskom has been found to reduce the cost of service. This method of cost reduction has proved successful where implemented. In future, costs could be reduced by introducing automation on-line metering. The costs of vending infrastructure can be reduced through the sharing of electronic infrastructures with other bodies such as banks and retail chains that needed electronic fund infrastructures.

5.0 Advantages and Disadvantages of Prepaid Electricity to Different Stakeholders

Prepaid electricity has benefited both the supplier (Eskom) and the consumers/customers. These advantages accrue in various forms and contribute to efficient functioning of electricity production, distribution, and revenue generation. Some of the numerous advantages to Eskom from prepaid cards are as under: (1) Improving customer service as it eliminates billing delay and no account posting or additional billing system is required. (2) Prepayment is up-front that improves the cash flow of the business. (3) Cost of meter reading is cut as no meter readers are required. (4) It can also be used to recover debts. In Eastern Cape, every time a customer buys a prepaid card, s/he pays 15% towards redemption of old debt. (5) It eliminates the disconnection and reconnection fees and administrative hassles associated with these problems. (6) It is easy to install prepayment meters than the conventional ones. It costs less both to Eskom and customer, as well. (7) It is easy to control fraud with the help of prepayment meters. (8) There is no need to hold customer's keys as is required under the conventional metering. (9) Eskom does not need to access the customer's property, thus risk to its employees' lives is reduced. This is particularly important in South Africa, which is a crime-ridden society and where wide divide of income between the Black and the White communities exists. (10) Further, it eliminates the danger of inaccurate meter reading, thereby eliminating scope for such complaints. (11) The prepayment electricity system finally improves the revenue management system of Eskom.

The prepaid system also has advantages to consumers : (1) With the prepaid system enabling controlled use of energy, the customer learns to economize on its use. (2) Controlled use of energy and budget management go hand in hand. By learning to economise on energy use, customer learn to manage his/her budget, too. (3) The consumer can buy tokens at the time and place that suits him/her. (4) There is no cost for disconnection/reconnection and no waiting for reconnection. (5) The consumer is not required to deposit any amount. (6) It also enables the consumer to pay back his/her debt, thereby empowering him/her.

However, there are disadvantages to Eskom associated with the use of prepaid cards. Some of these are as follows: (1) Based on interviews of senior mangers, it is now being felt that the cost of maintenance of prepayment meters is not going down, rather it has escalated due to some unanticipated problems that have cropped up now. (2)The prepayment system cannot handle large size currents at this stage; therefore, it is not always the best solution. (3) The prepayment technology has reduced, but not necessarily solved the problem of pilferage; revenue losses from pilferage are still high and estimated to the tune of R 51 million per annum (Business Day, 23 March 2001).

Disadvantages experienced by consumers of electricity through the pre-paid system are as follows: (1) Consumers perceived the prepayment system as an instrument to control the communities. However, this view was prevalent only in highly politicized communities such as SOWETO in Johannesburg. (2) Many users considered it a big hassle to buy electricity frequently, which consumed their time and heightened their worries of not having power in the house.

6.0 Factors Affecting the Success of Prepaid Electricity and Impediments to Expansion of the system

Success of prepaid electricity depends upon a number of factors, which finally produce a viable system. This requires proper planning and management of resources, and a careful marketing campaign to increase the market size, among others. Several impediments that exist in the expansion of the prepaid electricity are highlighted here.

6.1 Factors Affecting Success of Prepaid Electricity

Success of the prepaid electricity experiment in South Africa can be attributed to better planning and management of resources by Eskom and a careful media campaign, among other factors. Two important factors affecting the success are (1) better planning and (2) a good marketing campaign.

6.1.1 Better Planning and Management

Careful planning is a must to set up a successful prepaid electricity system. Some of the actions that need planning are: tender specification, selecting a prepayment system, staff training, marketing campaign, selection of vending sites, contracting vendors, revenue management, installation of equipment, maintenance, and daily administration.

Selection of compatible components of a system is necessary to ensure the efficient revenue management. This means that the meter, the payment system, and management tools should be aligned well. It also demands that a smooth flow of information between meter, vending machine, and the databases, is ensured. Only a complete system ensures efficient revenue management.

Similarly selection of prepayment system demands the specification of the following; procedures for revenue collection, data required for management, reports and maintenance, as well as emergency credit, friendly credit, required tariffs and taxes, compatibility to systems, hardware requirement, vendor selection, and number of customers to be served.

Sophistication of the prepayment system requires staff training at different levels such as management, system administration, installation teams, maintenance teams, customer service staff, vendors, and vending operators. All employees need to understand different aspects of the prepayment system in order to complete the task.

A successful marketing campaign should be planned. More about this will be discussed in the second section. Selection of vending sites and contracting out to reliable vendors has to be done carefully so as to increase demand for prepaid electricity. Contracts need to be set up with vendors prior to commencing the operation. Eskom's research had revealed the following with respect to the prepaid electricity service: (1) The point-of–sale image and the personnel operating the equipment must be trustworthy in the eyes of customers. (2) The system must be secure so that others do not use tokens. (3) The point of sale should be available for vending during the time periods convenient to the customers. (4) The activity of buying electricity (getting to the vending sites, buying and getting back) should not take more than 30 minutes. (5) It should be easy to purchase electricity and customers of any reasonable age should be able to identify their meter and specify purchase. Children are the main purchasers and purchase is often for convenience, not specifically planned for buying electricity and is similar to making an errand of buying cigarettes at the local super market.

The other important task is to streamline the revenue management system. This requires selecting a system manager, appointing supervisors, training system operators, configuring the SMS to the needs, verifying its compatibility with other information technology system, ensuring implementation of security measures, and finally, arriving at policies and procedures with respect to housekeeping of database, running of reports, communication with vending station.

Installation of equipment is yet another task that needs careful planning. This requires setting up the installation teams and preparation of an appropriate tool kit. It is very important to determine the time for each installation and to answer queries by customers. The staff should be trained in faultfinding and product testing. Performance measurement of staff, modification of their plans feedback to customer base are some other exercises that must be undertaken regularly.

Ongoing maintenance is one important key to the success of prepaid electricity management. This can be ensured by setting up a meter maintenance center with required tools such as a credit reader, an ED verifier, and an engineering workstation. Simultaneously, one needs to define the procedures on how to handle inquiries and meter change-outs.

Daily administration of prepayment electricity is needed to ensure smooth functioning. This subsumes ensuring sufficient provisions for emergencies such as hardware failure, power etc., defining procedures for emergencies, archiving of data, backing up data, and running of exception reports. Regular training sessions for the staff is yet another significant feature of streamlining the system..

6.1.2 A Good Marketing Campaign

The prepayment system is a relatively new innovation in the electricity industry and not well received yet. This requires a good marketing campaign. Eskom has taken to a good marketing campaign to reach out to its customers both in urban and rural areas. The major purpose of a marketing campaign is to engender consumer acceptance and appreciation. A multi-pronged approach has been followed by Eskom through:

- Advertisement of themes
- Media (TV, radio, mail shots, brochures, posters, etc)
- Public meetings
- Encouraging participation of local community leaders
- Encouraging the demand by developing an effective supply of prepaid electricity
- Emphasizing the benefits to the consumer.

Various advertising themes have been used by Eskom to popularize the consumption of prepaid electricity:

"Making your life easier"
"Electricity at your convenience"
" No more shocking bills/accounts"
"Putting you in control of your electricity costs"
"Pay as you go"

These themes have been communicated to the targeted public by means of various media such as television, radio, mail shots, brochures, posters, and public meetings. Local opinion leaders have been involved in the program to increase participation of general public in the expansion of prepaid electricity.

Marketing the benefits of prepaid electricity requires that consumers develop an appreciation of this facility. Thus, they need to be made aware of advantages of prepaid electricity. Being in control of one's budget is the prime advantage of this system. Consumers decide how often and in what value do they wish to buy electricity. Should they forget or not be able to pay for their electricity, they will not be physically cut off by Eskom, or will they have to wait to be reconnected nor pay reconnection fee. They do not have to understand and pay accounts or bills, any longer.

Marketing campaign is aimed not only at convincing the customers about the advantages of the prepaid system but also educating consumers about the prepaid electricity. This entails educating customers about the use of the product, i.e., how and when to purchase credit, how to read the ED and decide when to repurchase credit, how to clean the ED, what to do or who to contact if they experience problems, and finally to know how much credit they can avail of at any time, and so on. Consumer education has been, therefore, made a part of the marketing campaign.

The other part of media campaign is to encourage demand for electricity. To encourage demand for electricity, we should know that most of the prepaid electrification falls in deep rural areas; and, this requires promotion of electricity uses. These customers do not always have the appliances to use electricity. There is thus a need to develop cost-effective appliances and promote their use. One way to do so could be in terms of Eskom developing partnership with appliance manufacturers or distributors: the connection fee or deposit can be used to purchase a hot plate stove; the discount coupon be provided by the appliance manufacturer with every ED to be exchanged for electricity; the customers be shown demonstrations on the use of appliances and given donations or prizes in the form of appliances. As such, in many places, the vendor acts as an agent for the appliance manufacturer.

6.2 Impediments to the Expansion of Prepaid Electricity

Prepaid electricity was initially launched to meet the homelight needs of the rural areas that were sparsely populated. Early research by Eskom indicated significant cost savings by switching to prepaid electricity by abating the cost of billing, meter reading, and meter repairing. Besides it added to convenience by reducing the risk of security to Eskom employees who had to visit customers' houses at odd hours. Savings were also expected to be realized in the form of a decreased level of pilferage through meter tampering. The introduction of prepaid electricity solved these problems to a great extent. However, new maintenance problems, not visualized at the time of initiation of the project, have cropped up. The new maintenance problems are related to meter failures/replacement, vendor fraud and meter tampering, in that order in terms of severity.

The prepaid program was started about 10-12 years ago. The new meters were installed with an expectation that they will last long. Eskom is now expecting a high rate of meter failures, leading to extra cost of replacement. Interviews with senior managers indicated that to be the most important and costly problem presently faced by Eskom. Since the cost of replacement of meters is to be borne by Eskom, it has become a costly operation.

The second important concern is fraud by vendors. Eskom has to depend on various vendors to sell electricity to its consumers. Normally there are a number of agents in an area who buy electricity from Eskom and sell it to consumers. Over the past years, Eskom management has realized that many vendors have been providing fraudulent reports of electricity sales. Thus revenues collected from consumers are not channeled back to Eskom. In fact, this is being considered as the biggest impediment in the expansion of prepayment technology. To thwart the problem, Eskom is now trying to develop a national level organization which can deal with the demand for vending from Eskom.

The third most pressing problem is that of meter tampering. The tampering of meters can be done by a pin or a magnet. An office pin or safety pin is inserted under the plug of the circuit breaker. The pin is inserted in the gap between the circuit breaker and the bottom of the shunt. The method works well in all circuit breakers making it possible to customers to steal electricity. The usage of this method is evident by the marks left under the circuit breaker when the pin is removed. To circumvent the problem, Eskom contrived the circuit breaker tamper covers on all makes and models. On the other hand, the magnetic tampering method entails a process where magnet is fixed under the plugger circuit breaker while it is on. The magnet produces a magnetic field, which is stronger than that of the circuit breaker trip coil. This prevents the trip breaker mechanism from operating by not allowing the trip coil to pull the mechanism with its own field of strength. The tamper covers were also used to prevent the magnet tampering. The tamper covers have helped reduce the electricity pilferage to a great extent[iv].

However, simple technological improvements such as tamper covers cannot be attributed to the trend of declining meter tampering alone. Eskom has introduced infrastructure audits of meters from time to time, adding to the cost, of course. Improvement in technology, such as the tamper cover, and audits from time to time have certainly produced better results. During the last 4-5 years, only 3 to 4% of meters have been tampered and estimated loss of electricity varies between R 51 and R 100 million annually (Based on interviews of mangers and Business Day, 2nd March, 2001).

6.3 A Brief Assessment of Expansion of Prepaid Electricity

A cursory examination of the expansion of the prepaid electricity system reveals that it has grown very rapidly. The prepaid program was started sometime in 1992, since then Eskom and other agencies have carried out the task of installation of millions of EDs in South Africa; the targets are given in Table 2. Almost all of these targets have been achieved. It is estimated that some 3 million more homes would be electrified by the year 2000 and beyond, thus enhancing the standard of living of half the population of South Africa. The customers whose homes have been electrified are predominantly economically poor Initially Eskom had problems in carrying out the task as many who subscribed to prepaid electricity thought that it was of inferior quality compared to that supplied to the White.[v] This resulted in slow takeoff but the campaign through advertising and education by Eskom changed the perceptions and prepaid electrification grew very rapidly. The process of electrification has slowed down since 2000 as a majority of domestic consumers have received electricity. It would be prohibitively expensive to provide electricity to the remaining population as they are located in the interior rural locations.

Table 2: Number of Prepaid Meters (in thousands) Installed by Eskom and Other Agencies, 1992-2001

Year	Eskom	National Target
1992	146	NA
1993	205	250
1994	271	350
1995	328	400
1996	316	450
1997	285	450
1998	301	450
1999	299	450
2000	256	NA
2001	200	**NA**
Total	2607	2800

7.0 Lessons Learned

Lessons learned from the South African experience are many. They have been grouped under 6 categories.

7.1 Lesson 1: Benefits to Large Masses of Small and Dispersed , Consumers

Some 50% population of South Africa lives in rural areas; and, until recently, most of these areas did not have electricity--the basic amenity for the 21st century standard of living. The new democratic government aimed at producing electricity for all so as to right the mistakes of apartheid. Installation of prepaid meters took place with an amazing speed. Between 1994 and 1999, Eskom installed some 300,000 new prepayment meters every year, totaling to about 1.8 million meters. In addition, local supply authorities also installed in their own distribution areas. By 2000, some 3.2 million prepaid meters were installed in South Africa by Eskom and local supply authorities/municipalities. This comes to roughly installing about 1000-1500 meters per working day (this trend was on until 2000). Majority of these meters went to new customers, i.e., previously non- electrified houses in South Africa. Nevertheless, about 2.1 million rural households remain without electricity in South Africa, even today. Approximately 46% of rural areas have been grid electrified as opposed to 80% of urban areas. Prepayment electrification has slowed down since 2000 as further expansion of grid electrification is too costly for Eskom and other local authorities. A number of factors contributing to this include: (1) high cost of grid electrification in rural areas, (2) low electricity consumption with very little ability to pay off consumers, (3) no big anchor consumers. To supply electricity to deep rural areas, therefore, the government has initiated a project for non-grid electrification through regulation.

7.2 Lesson 2: Empowering Consumers

Prepaid electricity has in a way empowered small and dispersed consumers in South Africa in various ways. The traditional billing system required a good infrastructure and a good ability to pay for electricity. This meant that only the consumers with fixed addresses, bank accounts, postal addresses, could receive the benefit of electricity. Prepayment omitted the problems of billing to customers and connection/ disconnection of supplies in the event consumer failed to pay his/her bills in time. Hence, consumer got a better understanding of the amount of energy being used. This enabled them to cut the unnecessary use and economize on its use by turning off lights, geyser, fans, and other electricity based instruments. Control of energy and budget management go hand in hand. By learning to economize on energy use and manage their budget effectively, the customers have been empowered.

7.3 Lesson 3: Empowering Eskom

Prepaid electricity has not only empowered consumers, it has also strengthened the position of Eskom in many ways. For example, the day-to-day management and maintenance of conventional meters in rural and semi-urban areas had become an impossible task for Eskom, mainly because of socio-economic-attitudinal problems. Eskom had a difficult time managing the conventional meters. Eskom used to hire workers whose main task was to read meters and disconnect electricity of those whose payments were overdue. This entailed ensuring the transportation from house to house and the protection of its employees in the event of conflict with customers. This added to the cost of management of conventional meters. Further, consumers tampered with meters to use electricity illegally, adding repairment cost to Eskom. As Eskom was not able to repair the breakdowns efficiently, this made the day-to-day management cost prohibitively high. The conventional metering, in the absence of proper social attitudes to electricity, became a system demanding very high maintenance. Prepaid metering reduced this cost tremendously. It however has not solved the problem of pilferage and unauthorized use completely. This innovation cut down the cost of hiring meter readers, their transportation, and above all the risk to life and resultant cost to Eskom. Besides solving the day-to-day maintenance problem, the prepaid electricity improved the cash flow and eliminated the problems of disconnection and reconnection all together. Thus the revenue system was beefed up. The new system thus empowered Eskom by reducing its transaction cost significantly. In brief, the transaction cost related to billing, deposit management, postage management, incomplete or non-existent addresses, large up-front connection fees, etc., were altogether done away with. Life-cycle costing studies have shown that prepayment is now proving to be a more cost effective option of system operation for Eskom than the then billed system .

7.4 Lesson 4: Role of Advertising and Initial Subsidy in Popularizing Prepaid Electricity

When Eskom had initiated the prepaid electricity program in 1992, it had encountered several social and economic-resistance to the spread of the technology. Many early consumers of prepaid electricity, who were primarily black Africans in rural or semi urban areas, considered the technology unfair and of poor quality as compared to electricity supplied to the White community, which resulted in slow take-off. To fine-tune attitudes towards prepaid electricity, Eskom initiated a massive advertisement and media campaign to sensitize people about the importance of using prepaid electricity. This was achieved by using multi-media approach and various advertising themes. Various media such as television, radio, mail shots, brochures, posters, public meetings, discussions with public groups with the involvement of local leaders were tried out. The major idea was to develop an appreciation of prepaid electricity in consumer's mind.

The marketing campaign was not just directed at convincing consumers but also educating consumers about prepaid electricity. This meant that consumers were taught how and when to purchase credit or tokens, how to read the ED and to know when to repurchase credit tokens, how to clean ED, what to do and who to contact if they experience problems and finally to know how much credit is available at any time. Consumer education was therefore made a part of marketing campaign.

7.5 Lesson 5: Prepayment not necessarily a well-Received Innovation in all Segments of Society

Discussions with various Eskom managers reflected that prepayment is not necessarily well received in all parts of the country. In some highly politicized areas, prepayment is viewed by the people as a means of control by Eskom or government. For example, the highly politicized areas of Soweto near Johannesburg, the prepayment technology has not been accepted well and residents have insisted on conventional metering system. One major limitation of prepaid electricity is that current prepaid meters can handle electric supply of 65KV. This means it cannot handle high loads. However, as consumers start enjoying the convenience produced by electric supply, they tend to increase their consumption by switching to various types of new electric appliances. This can be considered a negative point with respect to technology. However, social unwillingness to use prepaid electricity primarily stems from the political power a society enjoys which gets translated in to rent-earning activity.

7.6 Lesson 6: Cost of Prepaid Electricity

Prepaid electricity was initially launched to meet the homelight needs of the rural areas that were sparsely populated. Early research by Eskom indicated significant cost savings by switching over to prepaid electricity by abating the cost of billing, meter reading, and meter repairing. Besides it added to convenience by abating the risk of security to Eskom employees. Savings were also expected to be realized in the form of decreased level of pilferage through meter tampering. The introduction of prepaid electricity solved these problems to a great extent.

However, new maintenance problems not visualized at the time of initiation of the project, have cropped up. They were related to meter tampering, vendor fraud, and meter failures. In terms of severity of the problem, the meter failure comes the first, the vendor fraud is the second most pressing problem, and the last and least severe is meter tampering.

The prepaid program was started about 10 years ago. The new meters were installed with an expectation that they will last long. Eskom is now expecting a high rate of failure, leading to extra cost of replacement the second most important concern is the vending fraud. Eskom has to depend on various vendors to sell electricity to its consumers. Normally there are a number of agents in an area who buy electricity from Eskom and sell to consumers. Over the past years, Eskom management has realized that many vendors are entering into fraudulent reporting of electricity sales. Thus revenues collected from consumers are not channeled back to Eskom. In point of fact, this is being considered as the biggest impediment in the expansion of prepayment technology. The third most pressing problem is that of meter tampering. The tampering of meters can be done by a pin or a magnet. The tamper covers were used to prevent the tampering in conjunction with infrastructure audits.

However, simple technological improvements such as tamper covers cannot be attributed to the trend of declining meter tampering. The statistical meters are installed as well, which measure the energy flowing into an area. This is then balanced with the energy sold. This then helps Eskom to prioritize areas for auditing. Eskom has introduced infrastructure audits of meters from time to time. This has been added to the cost. As a result of the improvements in technology (tamper covers) and audits from time to time, electricity thefts have gone down significantly. During the last 4-5 year period, only 3 to 4% of meters are tampered. The estimated loss of electricity through illegal means is placed around R 51 million per annum. In brief, pre-paid system may not necessarily be the cost-effective system in the long run because of increased costs and due to auditing and technological improvements.

8.0 Prospects for Prepaid Electricity in Developing Countries

The prospects of prepaid electricity, especially in rural areas, in the contexts of developing countries are expected to be good. Several advantages would accrue to the developing society and power sector in general. Lessons from South Africa can be used to estimate the prospects for prepaid electricity in the developing countries. One important developing region where prepaid electricity has been adopted is India where advantages can be seen in terms of improved cash-flow for the Indian State Electricity Boards (SEBs). This would help abate the financial crisis that many SEBs are presently facing. Further, maintenance costs to the SEBs and the problem of rent extraction by meter readers can also be eliminated altogether. With prepayment system in place, and taking South African experience into account, it is probable that electricity pilferage would be reduced to a minimum. Simultaneously, this will enable the SEBs to eschew the flat tariffs that had been in place for a very long time, and would permit increasing tariff rates. On the whole, this should enhance the revenue.

The problem that can possibly arise in transplanting this technology in the developing world context is the possibility of increasing frauds, especially, in the vending sector if preventive steps are not taken from the very beginning. Vending frauds have been a severe problem in the South African context. Developing countries can use this South African experience to their advantage by designing a credible management system from the outset. One way to circumvent this problem is to assign this task to reputed and large organizations that can stand by their credible commitments.

The important task for developing countries adopting this system would be to develop strong and durable prepaid meters that would suit to their particular environments. In the South African context, the replacement of meter after 10 years has cropped up as a major problem. Since this cost is not shared by the consumers, prepaid electricity becomes a costly venture. The developing world can stave off these problems from the very beginning by choosing and investing in the development of better prepaid technology, especially the vending and metering ones.

The concept of new technology —the remote metering or online metering—is in the offing. This is like the cell phone. Remote or online metering is essentially a communication to the meter from a remotely located point of sale. The principle of operation is like that used in the smart card banking. A person wishing to buy electricity would go to a vending station. A vending station can be a vending terminal similar to current banking machine. Transactions (tokens) for meters would be generated by the vending equipment/authorities. These tokens (which exist electronically) are routed to the transmission controller for the cell to which they belong. The transmission modules handle all tokens according to priority and additional transmission information, appended to the tokens. Service commands, for example, would receive higher priority and are queued for transmission immediately. The transmission control module handles all encryption of tokens and will be a secured system. The transmission control module broadcasts the tokens to the cell.

This has numerous advantages. One, consumer is not required to be physically present at his/her meter in order to effect the transaction, nor there is any need to buy a token. Two, credit purchases cannot get lost as they do not exist physically. Three, this enables the distributor to apply the time of day tariff or emergency control measures. Four, the problem of nonpayment can be eliminated altogether.

The prepaid electricity system can be promoted by using a differential charge if it were used for ground water abstraction. This could enhance the adoption of prepaid electricity by farmers for pumping the ground water to their fields.

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Endnotes

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[i] An ECU is a prepayment meter designed to supply up to 20 Amp current. An ECU is an ED with earth leakage and over-current protection built-in.

[ii] For some 3 million prepaid customers in South Africa, a minimum of 3000 to 4000 vending machines are installed.

[iii] A charge per unit of KWh is called active energy charge. This may be fixed rate or vary with the amount of electricity used, e.g., block rate tariffs (different rates for peak, off-peak period usage).

[iv] Eskom went through a number of schemes to curtail tampering. For example, in the early phase the magnetic card were replaced by numerical keypads; photocells were placed inside the meters to detect the opening of meters; electronic circuit was designed to detect all kinds of tampering. Split meters were used. To prevent cable tamper, Eskom used a stiff concentric cable with the armor shielding acting as the neutral conductor. However, no solution is completely tamperproof.

[v] Some more than 90 percent people who subscribed to prepaid electricity were living in rural areas and have very little income and almost illiterate.

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