

## **SLUM ELECTRIFICATION PROGRAMMES: AN OVERVIEW OF GLOBAL VERSUS AFRICAN EXPERIENCE**



*Background paper by Connie Smyser for the workshop "Promoting Energy Access for the Urban Poor in Africa: Approaches and challenges in slum electrification"*

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## 1. ABSTRACT

Significant challenges in electrifying formerly excluded poor urban and peri-urban households are being taken up and solved worldwide by electricity regulators, electricity distribution companies, international organizations, and municipalities and governments supporting slum upgrading.<sup>1</sup> Successful approaches to solving the problems associated with “slum electrification” are yielding a body of regionally differentiated information on what works and what does not and what problems still remain to be solved. Recent African efforts, such as those in South Africa, Kenya, Morocco and Mozambique, have shown that many of the problems and their solutions are shared with other regions and also that several additional challenges can be present in Africa that need to be solved in order to reach sustainability. One area needing more work in Africa is developing the political will of governments and regulators to supply services to informal or slum areas. This requires providing support for distribution companies motivated to reduce losses associated with serving such areas. Government electricity regulators that oversee the operation of the electricity sector and ensure that safe, fair and reliable service is provided to electricity customers and the electricity distribution companies that deliver power to those customers can be bolstered by better information about successes on the ground in a number of countries worldwide. The regulators can use their authority to make changes in 1) the regulatory treatment of return on the investment allowed to the distribution company so that it can turn a loss-making urban low income customer segment into one that is viable and not a drain on other customers or taxpayers and 2) how tariffs and connection costs and payment options should be modified to meet the needs and payment abilities of very low income urban customers. Support for adequate anti-theft actions and technologies needs to be provided so that re- or newly electrified areas do not invite immediate recidivism to former ways. In this, African electricity distributors can draw on lessons from other African efforts as well as from those in other regions, but with adaptation to the situation on the ground in the large conurbations that many African cities have become. This paper provides examples and cases from around the world and in Africa and then makes suggestions for areas that need more attention in order to turn African efforts into tailored and successful approaches to providing electricity access to the urban poor.

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<sup>1</sup> The term “slum” is used here as a way to refer to a range of informal urban and peri-urban situations, e.g., parcels that are legally and privately owned but illegally subdivided and “sold” or illegally occupied private or public property. Occupants may or may not “own” the structures that they live in and in many cases pay rent to a landlord who is illegally collecting rents from the occupants.

## **2. INTRODUCTION AND BACKGROUND: REASONS FOR REFOCUSING ON URBAN ELECTRIFICATION WORLDWIDE<sup>2</sup>**

Globally, slums are growing. The number of slum dwellers is expected to rise to 2 billion by 2022. In some countries, such as Brazil, Pakistan, and Kenya, there are already more children growing up in slums than non-slums. Slums grow where there are perceived economic opportunities but no place to live legally. Slums worldwide share a number of common problems: they are usually located in areas that are not authorized for habitation (i.e., they are either informal or illegally parcelled), and they are unsafe and “lawless” (although possibly having an informal governance structure established since residents often have little or no access to government services). Residents have very low incomes and generally do not have title to the land on which their house is situated and/or do not own the structure in which they live. Governments have generally failed to deal with the growth of slums until the development became entrenched and as a consequence roads and other infrastructure have not been planned. As a result slum growth tends to be haphazard, leaving a disorderly maze of alleys and passageways (sometimes even tunnels) and crowded and unsanitary conditions.

Households living in slums devote about 7% of their expenditures on energy, with this share increasing as incomes diminish. In Africa, Eastern Europe, and Latin America, energy ranks third in expenditures for households in this socio-economic stratum, following food and housing. In Asia, energy ranks second, surpassing housing. Distribution companies without theft control operations, routinely report growth rates in their unremunerated electricity consumption in the order of 4 to 5% per year. In sum, this is a large and growing problem that, if unattended, can threaten the viability of the distribution company and the reliability and quality of its service to its legal customers and/or put the burden on taxpayers or ratepayers or both.

Historically, because of the situation that they encounter in the slums in their service territories, electric utilities have experienced or expected low or negative returns from expanding service to low income customers, given their relatively low consumption levels and the added problems and costs of electrifying these mostly informal areas. However, as slums have grown, utilities have had to reduce the growing associated

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<sup>2</sup> Statistics cited in this section are derived mostly from: World Resources Institute (2007) *The Next 4 Billion: Market Size and Business Strategy at the Base of the Pyramid*. Base-of-the-Pyramid households are defined as households earning less than US\$3000/ year in local purchasing parity.

commercial and technical losses when many in slum communities resort to theft as a means to have access to electricity. The companies strive to increase net revenues to improve their financial viability as well as fulfill universal service policies that are increasingly being imposed by regulators. With such requirements regulators are recognizing the importance of access to electricity for improving the socio-economic well-being of a marginalized portion of society. They also recognize the need to reduce the technical and commercial losses associated with electricity theft in slums in order to reduce the financial burden that other electricity customers and/or society must pay for their own access to reliable electricity service. Nevertheless, the means necessary to establish and sustain electricity service may not always be recognized or allowed.

Often, because of the conditions in which they live and budgetary limitations, slum consumers have very poor internal wiring, no ground fault protection or circuit breakers, and/or very long and often undersized wires or cables connecting them to the electricity grid or to a neighbour who is connected or self-generates.<sup>3</sup> In these cases risks are high for electrocution and/or fires, further dragging families and communities down the economic ladder. Utilities may also risk costly damage to their facilities and/or outcries from the public about their poor and risky service as the source of blame – a nightmare for public opinion about the company's reputation which can bring political ramifications.

A special, but not uncommon case in Africa, is re-electrification<sup>4</sup> of war-torn areas where it is not uncommon that the entire electricity distribution system has been left in a shambles and grid-based electricity is no longer available to large portions of the population. The urban poor trying to get back on their feet as peace returns generally lack the resources to purchase the only alternatives to grid based power such as small generators or power sold to them by others who can afford larger generators (usually commercial establishments). In these cases families are left with the much poorer alternatives of candles, kerosene, or even firelight while paying far more on a per lumen basis than better off urban residents. Efforts to re-establish electricity service will tend to target first essential institutions such as hospitals and government buildings and next on commercial operations while leaving urban poor as the least likely to have power re-established.

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<sup>3</sup> Self-generation would be supplying a structure or local area via a diesel or gasoline powered generator.

<sup>4</sup> That is, re-establishment of generation, transmission, and distribution systems including re-metering and re-establishing billing and collections operations.

With increasing experience, utilities and governments and/or utility regulators are acquiring knowledge on effective ways to improve relations with communities, reduce theft, and dramatically increase collections, thus realizing the market potential of informal slums instead of losses. Thus, slum electrification can be an opportunity to increase revenues, albeit a risky one, that requires careful planning and execution and a sustained presence in the community for success. The following section highlights the commonalities in successful approaches and the subsequent sections provide more in-depth information on those approaches with the most relevance to the special situations that exist in many African countries.

### 3. COMMONALITIES IN APPROACH TO SLUM ELECTRIFICATION

While there are many differences in the socio-economic conditions and physical layout of slum communities as well as the structure of the electricity sector in different countries, there are nevertheless some commonalities in approach to slum electrification that emerge from studying attempts to develop sustainable electricity service. **Box 1** provides a listing of relevant literature where such approaches are described and discussed in some detail. This section briefly summarizes the common elements.

#### **Box1: Background Information on Slum Electrification**

United States Agency for International Development, "Innovative Approaches to Slum Electrification" 2004 [[http://pdf.usaid.gov/pdf\\_docs/PNADB219.pdf](http://pdf.usaid.gov/pdf_docs/PNADB219.pdf)]

Proceedings from September 2005 workshop in Salvador, Brazil called "Meeting the Energy Needs of the Urban Poor: The Case of Electrification." The report is available at [<http://esmap.org/filez/pubs/1252007111830ESMAPMeetingTheEnergyNeeds.pdf>]

Proceedings of the December 2007 Workshop, "Improving Electricity Service for the Urban Poor" held in São Paulo, Brazil [[http://pdf.usaid.gov/pdf\\_docs/PNADB219.pdf](http://pdf.usaid.gov/pdf_docs/PNADB219.pdf) or [http://www.usaid.gov/our\\_work/economic\\_growth\\_and\\_trade/energy/publications/EGAT0001.PDF](http://www.usaid.gov/our_work/economic_growth_and_trade/energy/publications/EGAT0001.PDF)]

United States Agency for International Development, "Transforming Electricity Consumers into Customers: Case Study of a Slum Electrification and Loss Reduction Project in São Paulo, Brazil," Washington, DC, February, 2009 [<http://www.leonardo-energy.org/transforming-electricity-consumers-customers-case-study-slum-electrification-and-loss-reduction>]

Patricia Márquez and Carlos Rufín (eds.), *Utilities at the Base of the Pyramid* (Cheltenham, England, and Northampton, Massachusetts: Edward Elgar Publishing, forthcoming 2010). See Chapter 10: "Challenges and Opportunities in Electricity Service Provision for Urban BOP Communities," Lawaetz, Simone and Connie Smyser.

United States Agency for International Development, "Optimal Feeder Level Connection Training and Field Support Toolkit," November 2009 [[www.energytoolbox.org](http://www.energytoolbox.org)]

UN Habitat, GENUS, October, 2009 Expert Group Meeting, Nairobi, Kenya, "Workshop report and presentations" [To be posted on Genus website]

In virtually all cases, solutions involve the same key stakeholders. These are: electricity distribution utilities; federal and local government authorities and regulators; slum communities and their leaders; residents and their usually informal income generating activities; and NGOs and community based organizations (CBOs) operating in the community. A "shadow" stakeholder is the illegal service provider who often steals electricity from the distribution grid to sell to those in the community who can afford it. Any approach to electrification of a city's slums must involve all of these stakeholders in order to achieve success; while failure to address their concerns, needs, and demands may derail the effort or greatly increase the cost and timeframe of success. However, the three stakeholder groups that are most likely to be in the forefront of making a

change in how an area is electrified are the electricity distribution company, the community (and prospective customers), and the utility regulator.

Most slum electrification efforts start with a concept to be tested at pilot scale before the launch of a larger effort. From there, the process of successful slum electrification generally involves the following programmatic elements<sup>5</sup> undertaken in the order indicated:

- First, there is community engagement and building of trust and the development of a social compact between the company and the community. This entails first contacting the community leadership and other stakeholders such as NGOs and CBOs operating in the community to gain support for the project. The benefits to each stakeholder group are discussed along with the process that will be followed to involve them in the next steps of service design and implementation. The social compact should be as explicit as possible: that is, the company will establish safe and reliable service in the area in return for a conscientious effort by the new customers to pay for their consumption and to eliminate power theft;
- Second, service planning and design will involve mapping an area and identifying potential customers (and those needing tougher anti-theft treatment), conducting pre-project baseline surveys including determining the likely load that will need to be served (and likely potential for reduction in usage from energy saving efforts), structure mapping and customer registration;
- Third, preparation for electrification comprises community-wide campaigns to prepare the population for the upcoming physical and operational changes, with particular attention paid to timing, sequencing, and the roles and responsibilities of each stakeholder involved in the social compact;
- Fourth, community education and problem solving parallels system installation. The focus is on helping customers to adapt to paying their electricity bills regularly and reducing their consumption through more efficient electricity use. Depending on the original condition of the distribution system and the modifications deemed necessary to reduce the likelihood of theft, upgrades to the distribution system and installation of new service drops and meters for the

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<sup>5</sup> See Lawaetz and Smyser for examples of the better practices in each of these common elements.



new or returning customers will take place and billing and collections will begin (or the prepayment system will be initiated).

- Fifth, post installation follow-up involves trouble shooting, customer and community satisfaction, ongoing engagement and vigilance. Evaluation entails post-project financial analyses and any post-project surveys to assess customers' satisfaction (or problems) with the implementation. These can inform future utility actions to improve program results or its replication or scaling up elsewhere in the utility's service territory.
- Finally, scale up is the most important and desired outcome and the true measure of the success of the regularization initiative when management agrees to invest substantial sums for replication throughout similar areas in its service territories and the regulator approve the necessary investments.

Virtually all distribution companies will measure their success foremost in terms of the return on investment required to serve the new customer base sustainably. Return on investment will in turn depend heavily on stemming the technical and non-technical losses associated with a slum area and/or avoiding losses where access to electricity is just being established, ensuring that accurate and efficient billing and collection systems are in place so that revenues continue to flow to the company. Slum consumers will measure success in terms of the improvement in their lives brought about by electrification. The things that are most important to them are not only quality and reliability of the power that they receive but also the ancillary benefits of taking the first step toward "citizenship" by establishing proof of an address and a payment history, improved safety in the home and security in the streets, and even the better ambiance that accrues when the tangle of wires is replaced by orderly distribution lines.<sup>6</sup> These benefits must balance the additional budgetary drain of connecting to and paying for electricity.

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<sup>6</sup> See the proceedings from the 2005 and 2007 workshops for references to these ancillary benefits.

## 4. CONSIDERATIONS IN SLUM ELECTRIFICATION SERVICE DESIGN IN THE AFRICAN CONTEXT

### 4.1 Design to incorporate starting conditions

Despite these commonalities in approach described above, each slum electrification program will differ in numerous details because the conditions encountered, the regulatory framework, and the social programs of the various levels of government will differ greatly from country to country and possibly even from state to state within a country. The main decisions that affect the design and cost of the improvements to be made will be 1) limiting external factors, such as restrictions on providing service to informal areas, 2) the original condition of the electricity infrastructure, 3) the type of service to be provided, 4) the type and amount of anti-theft technology that must be deployed to stop theft, and 5) the amount of customer assistance needed in affordability and budget control.

The main determinants of achieving sustained revenues and return on investment involve 1) conditions established for the distribution company in the concession contract or by government requirements regarding treatment of investments and losses and provision of subsidies, e.g., through low income tariff “make-up” payments by the government and 2) the customer’s ability to afford their consumption and to control the amount used for electricity within the confines of the level and periodicity of the income a household has at its disposal, and external factors such as the tariff structure (especially whether there is a low income tariff available).

Significant deterrents to slum electrification are posed by situations where the distribution company is not achieving full cost recovery in its tariffs which tends to dampen the enthusiasm of investors to support additional electrification (every kWh sold legally increases the losses) and where there is inadequate supply to serve new load. In these cases, careful analysis of the losses incurred by theft may reveal that regularization of slum areas will reduce losses enough to warrant action and should precede any proposal to regulators and/or company management for electrifying slums. Unfortunately inadequate cost recovery and supply are endemic in many areas of Africa.

Likewise, the existence of subsidies to the poor for electricity connection or consumption will need to be taken into account as to how they affect participation and affordability on the part of the new customer as well as how they affect the company's return on investment (e.g., in some cases, the difference between the low income tariff and the regular residential tariff is "refunded" to the company, but only if the former illegal consumer becomes a registered customer).<sup>7</sup>

In Africa, the present barriers that connection fees pose to electricity access are significant. Such barriers are beginning to be addressed, e.g., in World Bank GPOBA projects, some of which target slum electricity consumers. A project underway in Ethiopia is in its initial stages and targets connection fees by setting up a loan fund at concessional rates that can be used to lend new customers 80% of the funds needed for the connection.<sup>8</sup> Development officials are planning additional trials of output based aid aimed at electrification in Africa. Results of the planned evaluations of their practicality and sustainability will be very useful.

#### **4.2 Keeping investment and implementation costs low while maintaining effectiveness**

As a result of the differences in the conditions encountered in slums and in government policies in different regions, a wide range of service designs can be found throughout the world, ranging from very simple, low cost approaches to ones that involve highly sophisticated anti-theft technology.

The simplest programs generally attempt to keep service costs low (and in line with expected revenues from legal consumption) by eliminating the need for individual electricity meters. Since actual individual household consumption cannot be precisely known in these cases, a "fixed invoice" (set periodic payment) is usually adopted in place of billing based on actual consumption. The fixed invoice is usually based on an estimate of likely consumption and/or the average bill for a customer with similar number and type of appliances paying the applicable residential tariff. The use of

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<sup>7</sup> The Sao Paulo Case study describes how these subsidies improve the company's return on investment and at the same time provide a "double benefit" to the customer for electricity savings that bring consumption in line with the cap for the low income tariff.

<sup>8</sup> See OBA Approaches, June 2009, Note Number 27: Output Based Aid in Ethiopia (Dealing with the "Last Mile" Paradox in Rural Electrification," the Global Partnership on Output-Based Aid, based at the World Bank. [www.gpoba.org](http://www.gpoba.org)

limitations on current supplied is often justified by suppliers citing illegal commercial activities that have moved into an area to take advantage of free power. Simple approaches have been prevalent as a first step, largely due to the very low incomes and related potential usage of slum populations and inadequate capital funds for investment.

However, very few incidences of sustained successful slum electrification have been found using such simple approaches, and they tend to be unpopular for the very reason that they keep households from establishing micro-businesses in their homes. For example, the three main distribution companies in the Dominican Republic,<sup>9</sup> inter alia, have tried fixed-invoice payment and collection systems but found quite soon that theft became rampant again (despite sweeps to detect theft and efforts to disconnect miscreants and prosecute theft) while payments fell to virtually nothing.<sup>10</sup> The distribution companies are redesigning and adopting more rigorous service designs as a result. Likewise, in Africa Kenya Power and Light Company provides an example of heroic attempts to electrify parts of the Kibera slum in Nairobi that is at present being replaced with a pre-payment model because of continued theft and non-payment.

#### First Step: Visible, Enclosed Meters



Essential: Meters must be visible and "clean" (i.e., easy to spot irregular situations)

Other low cost first steps involve providing individual meters to each structure after cleaning up the distribution system so that illegal tapping is easily identified. It is essential that meters are situated so that they are visible from the street and preferably are enclosed in some sort of tamper proof enclosure, as shown to the left.

Where slum structures are too fragile to hang a meter, hollow square metal posts can be set in concrete with wiring running into it from the service drop and to the meter hung on the post as shown in the picture from Brazil to the right. Another technique in laying out new distribution networks is to minimize the amount of low

#### Free standing metal post



Source: COELBA, Brazil

<sup>9</sup> See the discussion of these cases in the Proceedings of the 2005 workshop referenced in the Box.

<sup>10</sup> Customers complain that the invoices keep coming even when the power does not – a clear sign that the social compact has been broken.

voltage lines (with new configurations, such as the so-called “maypole” design used in South Africa). By minimizing the low voltage portion, there is less opportunity to tap into cables that are the least risky in terms of electrocution.

MERALCO has had an evolving approach in Manila of serving slum communities. After first trying master metering of an area and forming community coops to collect from each unmetered customer that failed due to corruption, the company then moved to individual meters placed at the perimeter of the slum in 1998. After significant refinements in the technological side of their approach (using elevated individual meter banks placed on the perimeter of the slum with shielded and bundled service drop cables as shown to the right), it is finally proving to be effective.<sup>11</sup> Losses have been dramatically reduced but opportunities for theft still exist (i.e., from other customers). Another advantage of the placing the meters at the perimeter of the slum limits the liability of the company and avoids right of way problems due to the constricted and haphazard layout of the alleys inside.

#### Elevated Perimeter Individual Service



Source: Meralco, Philippines

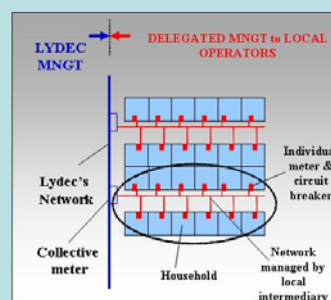
#### LYDEC's “Temporary” Electrification

Adapted service delivery model to government restrictions

Uses master meters, mini-grids and sub-meters with community agents doing collections, decreasing infrastructure investment cost

93% of the communities were electrified with payment performance around 96% of billing

Source: LYDEC Morocco



**Project payback: 1 year**

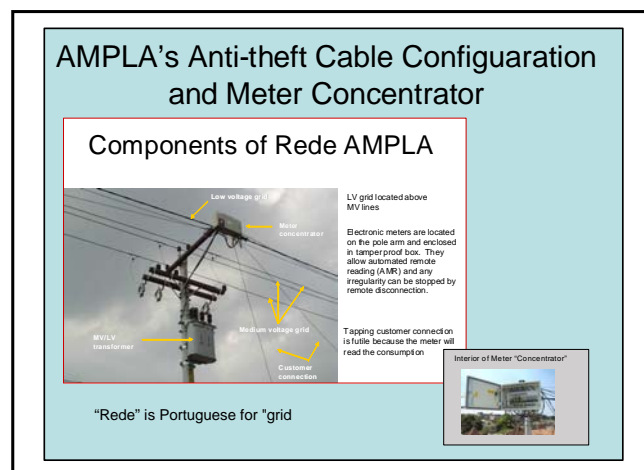
In Africa, some qualified examples of successes using relatively low technology approaches also exist, such as the perimeter electrification of slums using a community based collection agent assigned to a mini-grid that LYDEC pioneered in Casablanca (see Box to right and LYDEC Case Study in Appendix 1).

Sometimes the social compact is very difficult to establish, particularly in hard core areas, such as the situation encountered by LIGHT and AMPLA in Rio de Janeiro, Brazil

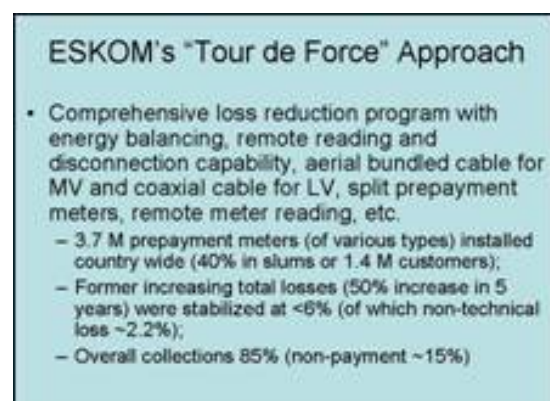
<sup>11</sup> The evolution of the Meralco approach can be seen by looking at presentations by the company in the 2005 and 2007 workshops on slum electrification referenced in the Sources Box.

or by ESKOM in South African slums. In these cases, the social compact invariably has to be backed up by anti-theft technology that goes beyond removing temptation (e.g., with plastic enclosures on visibly placed individual meters) to blocking most theft with specialized equipment.

Where theft is rampant and the stakes are high (e.g., rapid increase in losses sustained or consumption is especially high), sophisticated technology and community preparation as described above is usually warranted. Latin American distribution companies and regulators have pioneered some



of the most elaborate service approaches with combinations of anti-theft technology, sustained and real time monitoring to identify consumption anomalies to be investigated and disconnected if theft is confirmed, community social compacts, and high levels of assistance in affordability (mainly elimination of connection fees and energy efficiency assistance). A very high-technology approach is exhibited by the AMPLA example shown to the right.



In Africa tailored approaches will also have to be the norm, but best practices information can help to inform their design. The "tour de force" approach of South Africa's ESKOM most resembles the Latin American approach with the added feature of extensive use of prepayment. ESKOM focuses its investments in anti-theft technology to those areas and clients

with the highest losses (a large proportion of which are not low income customers. Its energy balancing/check metering system allows it to do this focusing and to monitor whether the effort continues to be effective. ESKOM is by far the largest user of prepayment technology as well. (See ESKOM Box to right and the ESKOM Case Study in the Appendix 3.)

### 4.3 Improving affordability and collections

"The new system (pre-paid) helps us in recovering money. It also gives a chance to customers to consume what they can afford and manage consumption...At least 95 percent of meters around Kigali City are now pre-paid. We are no longer connecting conventional meters to new customers."

Lucien Ruterana, the acting Commercial Director at Electrogaz, Rwanda  
[Installation of prepayment meters began in 1997] Source: AllAfrica.com, The New Times, by Berna Namata, 27 July 2009

**Prepayment:** Prepayment electricity meters operate in the same manner as prepaid cellular telephones which have revolutionized access to telephony by poor consumers unable to afford landlines and monthly service. As consumers purchase in advance only what they can afford at the moment, there is no risk to the distribution company of them falling into arrears and likewise no need to maintain service crews ready to disconnect customers for non-payment.

Africa leads the world in adoption of prepayment systems as they seem well suited to conditions there. Many distribution companies have moved to electricity prepayment systems to reduce their costs for billing and collections and disconnections associated with non-payment, particularly in remote areas and areas with structures that are difficult to locate or where postal systems are lacking. Such prepayment systems also eliminate potential graft in collections. They also benefit the customer, particularly those who are low income, to stay within their means while enjoying the benefits of electricity service. Note that, depending on the company's particular reasons for employing them, such systems may be used in urban or rural areas or middle or low income or all customers).

Prepayment systems are technologically somewhat different from conventional systems in that there is normally an intermediary vendor who sells electricity units as needed. The vending system can be relatively simple (with a vending machine or a merchant set up to sell the units to the consumer) or it can be set up to vend kWh via cell phones or even the internet. Prepayment systems for low income consumers tend to be on the simpler side, but they are evolving, particularly where cell phone service is practically universal, such as is found in most urban areas. The systems are set up to be relatively failsafe with identification numbers linking the prepayment meters with the customer. The company is then able to track all purchases (usually prepaid by the vendor) and match them to sales in order to identify irregularities that might indicate theft or malfunctions that need to be inspected. Surveys indicate that customers in general like

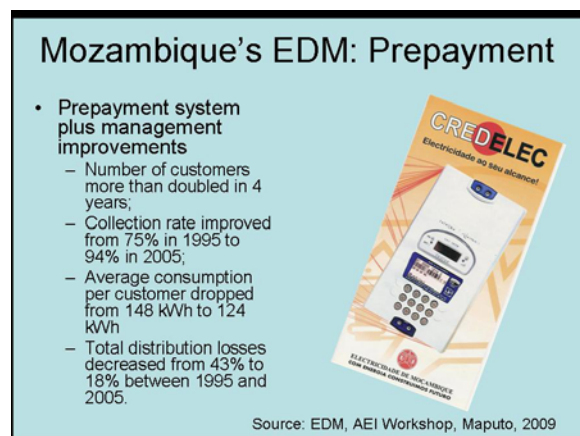
prepayment, and most companies report significant reductions of non-technical losses as a result of implementing the system.

Drawbacks include:

- Some older systems lack the best features of prepayment (e.g., split meter technology for greatly reducing theft, providing instant read-out on usage for customer control purposes, and communication systems to allow company easy tally of kWh sold vs. delivered.) Obtaining these features may mean costly replacement of the management system and possibly the meters too.
- Failure rates and life of the equipment are also a problem, particularly for older systems.
- Once a particular system is adopted, despite standardization of meter technology, the rest of the data management system may be proprietary and therefore difficult to change without changing out the whole data management system. There may also be integration issues of prepayment systems with basic utility management systems already in use, such as Supervisory Control and Data Acquisition (SCADA) systems.

Upwards of 30 African countries are known to have electricity prepayment systems. South Africa, Sudan, Rwanda and Mozambique were early adopters and are good sources of information and experience with how the systems work, the costs and benefits associated with them, and their acceptability to customers. The Case Study on

Mozambique in Appendix 2 provides details of how a prepayment scheme fits into the overall effort to add customers, improve business practices and reduce losses. The Box to the right supplies some results from their long term efforts.



**Improving energy efficiency:** In general, in areas where slum inhabitants have large illegal consumption (say, on the order of 250 to 350 kWh per month or more), higher investments in energy efficiency and “high-tech” anti-theft technology are more likely to be warranted (and necessary). Data on average consumption and household appliances



in slums targeted for electrification helps to determine the likely benefit from energy efficiency efforts and the likely urgency that will motivate slum consumers to try to steal electricity after regularization. Discussion of the costs and benefits of energy efficiency campaigns including replacement of inefficient lighting and appliances with much more efficient ones, such as is widely practiced in Brazil, can be found in the Case Study on AES Eletropaulo cited in the Sources Box. In Africa, and indeed in much of Asia, slum consumers use much less electricity, often less than 100 kWh per month, because their generally lower incomes limit the electricity using appliances that they can purchase and hence the usage that they have or could potentially have is much lower. Their proportion of the company's overall supply may, however, be as great as or greater than other regions because of the substantially lower rates of electrification in Africa. These factors need to be taken into account in deciding whether to incorporate energy efficiency measures in service design in Africa.

#### **4.4 Other important considerations: safety, security and community benefits**

**Unsafe household wiring or lack of wiring:** An important feature of many slum electrification service designs is an upgrade of household rewiring primarily for safety purposes.<sup>12</sup> Distribution companies in many countries include internal wiring upgrades in order to limit their liability when providing service to structures with very poor or degraded wiring. Examples are provided in the 2005 and 2007 workshop proceedings referenced earlier. The AES Eletropaulo case study provides more information on costs and lessons learned when electrical wiring was upgraded in the slum area where they tested the effectiveness of a variety of actions to improve slum electrification results. Because of the difficulty that many potential customers have in paying the connection costs to become a customer, Africa has a prevalence of “on-selling,” either sanctioned by the distribution company or not. In these cases, jurisdiction stops at the legally connected customers’ meters. Any unsafe conditions occurring after the meter are technically not the responsibility of the company. Nevertheless, electrocutions and fires resulting from such unsafe conditions are often blamed on the company. This problem has yet to be solved satisfactorily (partly because the company is still receiving the compensation for all of the electricity consumed “after the meter.”) The government of Senegal is investigating options for reducing such unsafe conditions which are quite

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<sup>12</sup> See AES Eletropaulo Case Study for discussion of additional energy efficiency benefits accruing from upgrading internal electrical wiring.

numerous there (with the anticipated help of donors), but it is too soon to tell whether proposed solutions will work out.

In the case where a structure has not had electricity in the past or where electricity usage is primarily for a few lights and a fan, the provision of a relatively low cost consolidated unit with a circuit breaker, a light bulb, and outlets for plugging in several electrical items can be supplied. These units are sometimes referred to as “ready boards.” Ready boards are widely used in Africa, particularly by ESKOM, as a rapid and uniform way of ensuring that internal wiring is adequate and safe no matter what condition the structure is in.

**Improving community acceptance:** In order to improve community acceptance of slum electrification, particularly where theft has been rampant and the newly regularized customers must start paying a regular bill for their electricity, some companies “sweeten” their side of the social contract by providing services that are important to the community to build overall support for the changes. These include improved public lighting for better community security and the implementation of social programs to improve socio-economic conditions within the slums as discussed in the Proceedings for the 2005 and 2007 workshops also cited in the Sources Box. While such efforts would seem to stretch already limited resources for slum electrification in Africa, it should be noted that analyses of the factors that increase acceptance are heavily weighted toward improved security and economic opportunities. Partners, such as municipalities and slum upgrading departments and NGOs, should be enlisted to bring available resources for such purposes into areas to be electrified.

## **5. OVERALL KEY SUCCESS FACTORS IN INCREASING URBAN ENERGY ACCESS AND ISSUES FOR AFRICA**

Numerous concerted and long-term efforts to electrify slums have yielded good results worldwide. Others have failed or fallen short or required going back to the drawing board, providing lessons and cautions for new electrification efforts. Recent case studies have been particularly useful for illustrating how each of the cases was approached. However, the case study approach often fails to identify the key factors that led to success or failure. Looking across these cases helps to focus on the factors that seem to be the most important for success.

Much of their success – or failure for that matter – depended on 1) the physical and socio-economic starting conditions within the targeted communities and prospective customers' eligibility for connections and ability to afford first the connection and subsequent consumption, 2) the regulatory framework under which the electrification took place and the incentives that the company had to undertake the effort, 3) technological decisions, and 3) the costs, benefits, and return on investment of the entire package. The key sources of losses associated with newly regularized slum customers are theft of electricity and poor payment performance (e.g., non-payment, late payment, and running up debts with the company.) The following bullets summarize some of the key issues that must be considered to improve the likelihood of a successful slum electrification effort.

Important physical and socio-economic starting conditions include:

- Cases where the slum communities were well established and cohesive may have improved the ability to communicate and work with the leadership but “hard core” criminal elements or gangs can completely undermine an effort.
- The condition of the distribution infrastructure within the slum or the proximity to such infrastructure.
- Consumers in the targeted area may already owe money to the company and/or will be hard pressed to come up with the funds to pay normal connection costs. These two situations must be dealt with early on as otherwise connections may not occur. Possible assistance to jump start connections could include: exoneration from past debts, elimination or reduction of the connection fee or

offering credit for the connection fees. To improve payment performance tailored payment schedules, and assistance with affordability and controllability of consumption should be considered. The latter could include caps on level of consumption billed while new customers are getting used to paying an electricity bill<sup>13</sup>, prepayment systems and/or and energy efficiency (EE) assistance.

- The efficacy of EE assistance depends on the level of usage upon connection and likely new appliances and business activities that might be added as customers realize the benefits of good quality, reliable electricity service. EE assistance aims to achieve two goals: reduce consumption that is above the low income tariff level and thereby reduce the number of kWh to be purchased as well as the price paid for them. In such cases where EE assistance is a component of slum electrification, the proportion of the budget that must be dedicated to electricity purchase can fall by as much as 40% as a result (that is, as an example, from 25% of the budget to 15%. This may still be too high for many slum residents, in which case, the case for prepayment is made. Assistance with getting social safety net assistance is another service that the company might try.
- Low income urban communities usually lack many essential services and have reduced economic opportunities; yet there is a fundamental drive to improve one's lot. Schemes that inadvertently block the expansion of small enterprises (such as with the application of load limiters) will be seen as a negative feature. Those that actually create such opportunities will be highly appreciated and add to the attractiveness of electrification. Adding or improving public lighting will also be highly appreciated, perhaps even above individual electrification.

Financial considerations for the distribution company will include:

- A plan to minimize non-technical losses and improve payment performance. An essential element of any loss reduction program is having the capability to identify where the losses are occurring and to track those losses over time. Non-technical losses undoubtedly are not only incurred in low income urban communities. Losses associated with the other customers may in fact be far greater than those associated with the slums. Investments that can be justified by their application to customers creating greater losses for the company may help to spread costs over a larger base with more revenue potential.

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<sup>13</sup> See the Sao Paulo case study for an example.

- Doing as much as possible to improve affordability of consumption when an illegal consumer gets converted into a customer or a non-paying customer is prevented from stealing electricity is equally important. A range of actions might be considered and would be selected based on their applicability to the consumers targeted. Helping new customers qualify for any benefits that are due to them is a good first step. These benefits could be helping them qualify for a low income tariff or social welfare assistance that would help to compensate for the increased expenditures.
- The larger the proportion of illegal consumers to the overall customer base or sales of the company, the greater the potential impact on other ratepayers or society in general.
- Given the added cost of anti-theft actions that are deemed needed, targeting the worst cases first will help spread the costs over the group where the most loss reduction could be expected.
- Where graft within the company is endemic, solutions must include eliminating the sources and means of graft. These issues go beyond questions of expanding access to low income customers and must be solved before attempting to do so. Solving graft requires identifying where the losses are occurring, devising new business systems, and rigorously monitoring collections to ensure that it is indeed rooted out and stays out.
- Regulatory and other measures should be incorporated in cases where distribution companies lack incentives to begin tackling the problem.

Government legislation, regulatory framework, policies and incentives can make or break the development of a successful electrification project. They include:

- Cases where there are low electrification rates and/or insufficient supply of electricity even for higher income areas make it hard to justify serving low income when higher income/consuming households and businesses cannot gain access.
- In cases where there is poor cost recovery, conditions might be improved by reducing losses and improving payment performance. However, if the company is insolvent and has no ready source of funds for infrastructure investments, it may be hard to raise the funds necessary for technological upgrades. Likewise if the major source of losses is via graft within the company.

- The single most important driver of a company to electrify new areas will be its drive to improve revenues and reduce losses and the degree to which its compensation is linked to this. In general, privatized or corporatized companies tend to show more motivation and vigor in reducing losses and increasing revenues.
- Concessions can include provisions for reducing losses. Placing caps on non-technical losses that can earn a return on investment will motivate the company to reduce losses to below those caps and take action to regularize the communities and customers that are contributing to those losses. A gradual lowering of the cap keeps the company working to tighten its management of losses.

Technological considerations include:

- Technological upgrades are almost inevitable given the likely tendency for theft if conditions are too tempting or too easy. Technology alone will not solve a theft problem, however, because of the basic nature of humanity. For this reason physical vigilance supported by consumption data monitoring and balancing against electricity supplied will aid in identifying where breaches are occurring.
- Because of the cost of additional anti-theft technology, its application should be targeted to the worst cases or areas. Low cost fixes may work for the bulk of the low income consumers, but the more “hard core” consumers may require more sophisticated technology.
- Customer preferences should be taken into account in making technology decisions. Customers prefer individual meters to master meters (basically sharing a meter with others that generally leads to inequities or graft). Customers greatly value being able to control their expenditures on electricity such as is possible with prepayment systems. Where advance payment has been required, however, without the vending and prepayment meter technology, customers feel that they are “double paying,” and the company finds it hard to keep up with the myriad accounts that have not made their payments and disconnect them.

Other considerations can also be important to success. These include that municipalities and other government entities having jurisdiction over the targeted areas

may have objections to their electrification. Numerous creative ways to get approval to electrify have been devised and should be considered in these cases.

Above all, companies and regulators need to plan for the long haul. Numerous cases from around the world show that achieving success may take 10 years or more of sustained effort.

## **6. SUSTAINABILITY PROSPECTS FOR AFRICAN SLUM ELECTRIFICATION**

Each solution to slum electrification in Africa will have to be tailored to the starting conditions, financial and regulatory situation, etc. as discussed above. African distribution companies are, on the one hand, starting from behind on overall rates of electrification and the condition of the infrastructure. Very low incomes and the extreme subsistence conditions in slum communities pose a great challenge. On the other hand, since infrastructure investment is recognized as essential by development organizations, there is an opportunity to design such infrastructure to be as safe and secure from theft as is practicable and to incorporate the management systems that should be the basis of any electrification project involving the urban poor. Likewise, African distribution companies are somewhat ahead of other regions in their adoption of the prepayment systems that make electricity consumption by the poor affordable because it is controllable. The African examples provided here in the form of case studies on three very different approaches to urban electrification show that, where there is a motivation on the part of the distribution company and regulatory support for making investments, innovative and sustainable service designs can be implemented.



## **APPENDIX 1: Case study – LYDEC/Morocco (Temporary Lower-cost Mini-grid Electrification)**

When it took over the Casablanca electricity distribution system serving all of greater Casablanca area in 1997, the distribution concessionaire Lyonnaise des Eaux Casablanca (LYDEC) tried to eliminate theft amounting to 1.4 M Euros per year through the traditional method of disconnections. When this failed, the company devised and introduced its “temporary electrification” scheme targeting approximately 130 “bidonvilles” (slum in French) containing 159,000 illegal slum households in 2004.

LYDEC convinced the municipality to let it operate in informal areas that by government policy would be either upgraded or eliminated. The system comprised mini-networks maintained and managed by local community representatives. It did so by locating transformers and master meters at the perimeter of the slums or in easily accessible areas within the slums so that they could be quickly removed on short notice if the city decided to eliminate the slum. The slum residents built and owned the mini-grid network from the master meter to the household structures. Restrictions at the transformer on the load served were also applied as the municipality did not want significant growth in these areas. The community representatives worked as trusted intermediaries between the utility and the slum community.

Under this scheme LYDEC worked with the representatives designated by the community, each of whom is responsible for a “secondary network” which supplied around twenty households. In exchange for payment by community members, the representative managed the installation and maintenance of the network and was responsible for collecting from the households their share of the bill (as measured by the collective meter for the network) based on their individual household sub-meter reading. If the amount owed for the entire mini-grid was not paid in full, the service was disconnected for all families on the circuit.

The electrification program’s results were impressive: approximately 93% of the communities were legally electrified; the number of businesses increased by 17% after electrification, and 3,500 jobs were created (including 1,250 community representatives). Payments were on the order of 96% of billing, and the project

payback was around one year. The cost to LYDEC for the representative was offset by their reduced costs of billing and collections.

There were some lessons learned that should be taken into account if such a scheme would be replicated elsewhere. Some representatives complained about difficulties with collections and about insufficient remuneration for the effort involved. Some residents and businesses wanted to have their own meters, bypassing the collective aspect of the scheme. Also, since the "distribution system" after the LYDEC master meter was the responsibility of the customers and their representative, there were problems with safety caused by poor maintenance or inadequate wiring or both, and the representative was sometimes "unreliable." LYDEC's relatively simple and low cost approach may have been successful in part because of the rather orderly layout of the slum households and the social cohesiveness of the slum communities in Morocco which might not be the case in other regions of the world or in sub-Saharan Africa.<sup>14</sup>

While the results were indeed impressive, policy changes by the Government of Morocco required a complete redesign of the approach to slum electrification. In 2005, a requirement that water and sewer also be added as services to slums that would not be relocated (approximately half of the households living in slums) caused LYDEC to rethink the prior scheme given the much greater cost and disruption that providing individual water, sewer and electricity service to each household would create. At present LYDEC is converting them to conventional customer service at the same time as they bring in water and sewer services but only where the city now has formerly designated that the particular area will be in the "onsite upgrade" category.<sup>15</sup>

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<sup>14</sup> See 2005 workshop presentations by Djerrari and Jobert for more detail.

<sup>15</sup> See 2009 UN Habitat, GENUS workshop presentation by Cluzeau.

## **APPENDIX 2: Case Study Mozambique – Prepayment**

Eletricidade de Mozambique (EDM) provides an example of how a prepayment system has been integrated into a distribution company's operations and the advantages that this brought to the company and its customers. In 1995 EDM began to take action to improve its operations and performance. At that time total distribution losses were about 43% due to fraud, a bad collection ratio, poor distribution grid quality, some customers without meters or having obsolete/old meters, and error-prone manual billing and collection.

The company's first steps were to develop a commercialization strategy comprising creation of a Commercial Department, implementation of loss reduction projects such as improved meter reading and bill delivery, inspections for fraud house by house, increased diligence in disconnections and reconnections, changing out (bad/old) meters, and paying special attention to the High and Medium Voltage Customers while increasing its involvement in low income communities to improve its acceptance in such areas.

After this restructuring and modernization of the commercial activities, the company began to implement a prepayment system. This required a sizeable initial investment in distribution upgrade, and management system and meters, in particular: sales and management system software, the System Master Station (SMS Hardware) necessary to operate the system, vendor points of sale, and a GIS/GPS system. Of necessity it had to adopt a progressive financing approach, starting with "turn-key" projects financed by the prepayment system vendor itself, moving on to projects financed by EDM itself, and finally obtaining finance via commercial credits and grid expansion credits.

The combined result of these actions was substantially improved financial performance of the company while reducing losses and improving collections. The number of customers more than doubled in 4 years; the collection rate improved from 75% in 1995 to 94% in 2005, average consumption per customer dropped from 148 kWh to 124 kWh while total distribution losses decreased from 43% in 1995 to 18% in 2005.

### **APPENDIX 3: Case Study South Africa – Tour de Force (Anti-theft Technology, Comprehensive Management Systems plus Prepayment)<sup>16</sup>**

ESKOM Distribution is the “retail” arm of ESKOM which also owns and operates generation and transmission infrastructure throughout South Africa and in several neighboring countries. Its retail operation began in the early 1990s when it started taking over electricity distribution systems of bankrupt municipal systems.<sup>17</sup> It now has more than 4 million retail customers. These customers consume less than 10% of Eskom’s energy, the rest being consumed by commercial and industrial customers.

From the inception of its retail service, ESKOM moved fast to begin to electrify households, installing pre-payment meters (sometimes referred to in ESKOM literature as electricity dispensers) to ensure that households could pay for all the electricity that they consumed. For slum structures with little or no existing or highly inadequate wiring they also provided “ready boards” (i.e., modular plug, circuit breaker and light socket) to ensure that people could use electricity safely despite the poor condition of their houses. About 7/8ths of the retail customers now have prepayment meters in South Africa and the resulting distribution of is approximately 35% rural, 25% formal urban, 40% informal urban (townships or slums). In other words, around 1.4 M prepayment meters are now installed in slum areas.

ESKOM selected prepaid metering systems because of the following reasons:

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<sup>16</sup> Source of information was the Optimal Feeder Technology Toolkit Case Study on ESKOM which in turn used a variety of ESKOM sources.

<sup>17</sup> One of its first such retail initiatives was PN Energy. In Cape Town, the Phambali Nombane Energy (PN Energy) – meaning Forward with Electricity – was started in 1994 as a pilot project by a joint venture between ESKOM, Electricité de France (EDF) and East Midlands Electricity of the UK and continues to operate today. This company was established to test a new scheme for providing electricity to the Khayelitsha Township (slum) on the outskirts of Cape Town. The township had a track record of non-payment and theft of power from the municipality, which had provided poor quality service. In addition to using technical innovations, such as a pre-payment metering system, the company fostered stronger links with the community through the establishment of community-based customer service centers of the distribution company, which were built and staffed by locals, as well as locating vendors of prepaid electricity at convenient locations within the community. From 1994-2003, 60,000 connections were made and reductions in non-payment from 70% in 1994 to 5% in 1998 were achieved. PN Energy continues to exist today and its approach to electrification has been replicated elsewhere in South Africa not only by ESKOM but by municipalities (although not necessarily establishing a separate entity). There is a presentation in the 2005 workshop on PN Energy and a case study in the 2004 overview of slum electrification programs listed in Box 1).

- difficult or very remote access to meters for meter reading,
- deposit management problems,
- customers that do not understand, trust or cannot always afford the fixed monthly portion of a conventional account,
- bad or non-existent postage systems in many rural areas, and
- no formal addresses for rural and some informal urban (townships) or urban customers.

ESKOM issues a prepayment meter to any customer that requests it, and many municipalities only install prepayment for all domestic customers. However, even with prepayment meters, losses (via tampering, illegal connections) were running to about 10%-15% of power supply. The majority of the theft was from customers in informal townships. This was primarily due to the prevalence of integral (rather than split) prepayment meters that were purchased in bulk by ESKOM early in its electrification campaign.<sup>18</sup> ESKOM has more recently decided to install only split meters to reduce this source of theft.

Furthermore, most of ESKOM's electrification starting from 1999 is done with aerial bundled cables on the Medium Voltage lines and coaxial cables (a stiff concentric cable with armor shielding acting as the neutral conductor) on Low Voltage lines.<sup>19</sup> This makes it very difficult to connect to the less risky low voltage cable because the very act of penetrating the cable with a metal object makes it short circuit and cut off the supply.

Nevertheless from 2002 to 2007, evaluation of losses showed a steadily increasing loss curve due mainly to non-technical losses. As a result ESKOM instituted what they call a "Mid-Block Electrification/Feeder Level Check Meter Principle." This is an approach that combines split prepaid metering systems with power balancing and service drop in maypole configurations in areas with high levels of theft.<sup>20</sup> This feeder level check meter system is implemented company wide. Residential meters are installed on high

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<sup>18</sup> So-called split meters consist of a meter that can be located high on a pole and therefore much harder to tamper or bypass and a customer interface unit (CIU) that is situated within the structure so that the customer can input the prepayment credits and monitor consumption and remaining credit. The meter is in most cases a compact and simplified unit that acts as a counter and can be communicated with from the ground or from the office. It's small size lends itself to the grouping of several such meters in a locked and tamper indicating "concentrator" box high on a pole and thus serving a dozen or more individual premises.

<sup>19</sup> The Optimal Feeder Technology Toolkit referenced in Box 1 provides a description and how these are used in the ESKOM case study.

<sup>20</sup> Check meter power balancing compares energy purchased with energy consumed. If energy consumed rises to unacceptable levels over energy purchased, targeted audits are conducted at the premises.

distribution poles either in meter concentrators rising up to 6-8 meter.<sup>21</sup> or in a steel enclosure outside. The steel enclosures are equipped with real time RF or cell communication to detect tampering or vandalism. This is only suitable for urban environments with relatively high consumption since manpower costs to quickly address tampering are high. The check meter is installed before a transformer and read on a quarterly basis. The total consumption of electricity, as registered by the control unit (or credit meter) must equal consumption registered by the sum of the prepayment meters in the area covered by the check meter over the same period. New software was developed to produce thorough checks and balances between all the relevant data captured from the reports to identify “tamper” properties.

Network expansion is the largest component of the capital cost of electrifying townships and has varied from \$180 to \$570 per customer. The split meter alone is about \$36 to \$60 (without the installation, vending infrastructure or any remote communication which would be spread across tens of thousands of customers). As of October 2008, over \$1.2 million in consumption was charged and \$1.02 million recouped.