# CUSTOMER TARIFFS: DISCUSSION PAPER

## Supporting the Policy Environment for Economic Development (SPEED+)

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# ACKNOWLEDGEMENTS

# ACRONYMS

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| ARENE | *Autoridade Reguladora de Energia,* Mozambique's Energy Regulatory Authority. ARENE is an independent regulator established by Law 11/2017 of 8 September 2017. |
| EdM | Electricidade de Moçambique, E.P. is the principal electrical utility in Mozambique. EdM is a parastatal company, and also the National Transmission Grid Operator and systems operator. |
| IPP | Independent power producer, a non-state entity that generates electric power for sale to either utilities or off-takers |
| MIREME | *Ministério dos Recursos Minerais e Energia*/Ministry of Energy and Mineral Resources |

# KEY CONCEPTS FOR TARIFF SETTING

### CONCEPTS ABOUT COSTS AND FEES

**Electricity tariffs:** The price for electricity that is charged to customers. Electricity tariffs should be calculated based on the costs to produce and deliver electricity to customers plus a reasonable level of profit. Government regulation usually establishes a tariff structure or tariff structure with different rates (i.e. prices) for different categories of customers.

**Costs:** Refer to the costs incurred by the electricity provider to generate, transmit, and distribute electricity, and to provide supporting services to customers through the administration and management of the public utility or independent provider's business. Descriptions of various types of costs are included below.

**Fees:** Charges to customers by the electricity provider to recover their costs. Descriptions of various types of fees are included below.

**Capacity costs**: The fixed costs to maintain capacity in the electrical system to generate enough electricity to meet peak demand. Peak demand is the highest amount of electricity that the system has to generate and transmit at any one time – see concepts about production and consumption below. Capacity costs include all costs for investment and operation of all the electricity generators and transmission infrastructure required to meet peak demand. To meet peak demand, the provider must charge all of its costs for maintaining this level of electricity availability at all times. These costs are recovered through the **demand fee** also known as the **capacity fee.**

> **Demand fee/capacity fee:** A fee to all customers to recover the provider's **capacity costs** (see above). The demand fee is typically a fixed fee rather than charged a kWh basis. In Mozambique it is charged to commercial and industrial users, not residential users.

**Service costs:** The costs to deliver electricity to the customer, such as installation and maintenance of transmission and distribution lines, meters, and customer interaction expenses.

> **Service fee:** A fee to all customers to recover the provider's **service costs** (see above). The service fee is a fixed fee, not per kWh used. Service charges can be flat, inclining (with higher rates for usage over a base level), or declining (with lower rates for usage equal to or under a base level).

**Marginal costs**: Short-term costs that shift with changes in demand, given a fixed amount of production capacity and distribution infrastructure. For example, an increase in demand from a fossil fuel plant increases the fossil fuel consumed.

**Operating costs:** Costs from operating generation plants and maintaining transmission and distribution lines, including labor, fuel, taxes, and other recurring costs. These costs are recovered through the **consumption fee/usage fee**.

> **Consumption fee or usage fee:** A fee to the customer to cover the provider's operating costs. The consumption fee varies depending on the amount of electricity used.

**Social tariff or lifeline tariff:** A subsidized tariff rate for a low level of electricity consumption, intended to allow the poor to afford basic access to electricity. The cut-off point for the lower rate is known as the “lifeline block”. In Mozambique this is currently set at 125kWh. The social tariff is not **cost-reflective**.

**Cost-reflective fees:** Capacity or consumption fees are cost-reflective when the fee equals the real costs incurred by the provider for serving that specific customer. If every customer was charged precise cost-reflective fees, the electricity provider would achieve full **cost-recovery** (see definition). However, in most tariff structures the regulator must make choices and trade-offs to balance the importance of cost-reflective fees with the difficulty and cost of administering the tariff structure, and with other social/political/environmental goals (such as incentivizing energy efficiency). Therefore, full cost-recovery is generally achieved through the revenue collected from the entire tariff structure, in which some fees are cost-reflective and others are either higher or lower than actual costs. A more in-depth discussion is provided at the end of this Key Concepts section under “Boiteaux Principle of Cost-Reflectivity”.

**Cost-recovery**: Electricity providers (public utility or private sector providers) must recover the full costs of prudent investment, operation and maintenance, and earn a reasonable profit, in order to continue providing electricity. Cost recovery includes the costs of generation, transmission and distribution of electricity, the interest payments on debt and a “reasonable” rate of return on investment The definition of “prudent” costs and “reasonable” profit are determined through regulation, as is the method for the providers to recover costs and receive profits.

Full cost recovery through fees to customers is needed so that the public utility can be sustainable without subsidies from the government budget. Full cost recovery is also necessary for investors (whether they are lenders to the public utility or private sector investors) to be confident that the return on their investments is predictable and secure. Full cost recovery is critical to attract new investment in electricity generation, transmission, and distribution by both the public utility and the private sector.

Cost-recovery through fees to customers does not require fully **cost-reflective** (see definition) fees to each customer, but it does require that all customer fees together provide sufficient revenue to cover the costs of prudent expenditures plus reasonable profit.

**Decapitalization**: The ongoing loss of assets caused when a utility is not able to achieve full cost recovery (i.e. has higher costs than revenue) for an extended time.

**Prudent costs**: In regulated utilities, including electricity utilities, regulators typically try to reimburse and reward utilities for reasonable investments but not for unwise ones. If costs are high because a utility failed to take reasonable actions to reduce those costs, the regulator often refuses to allow customers to be forced to pay those costs. For example, if a utility has high line losses, a regulator would not allow the utility to be compensated for line losses but would allow for the reimbursement of measures to reduce the line losses. If a utility invested in generation capacity or other technology that was unreasonably expensive or was not, in the regulators’ minds needed, they would not allow the utility to be compensated for it. The regulator would only allow reimbursement for “prudent” investments.

**Rate base:** The electricity provider’s investment in facilities and related capital costs, including interest on debt and a return on equity. It includes such items as buildings, power plants, fleet vehicles, office furniture, poles, wires, transformers, pipes, computers, and computer software. The rate base is fixed and does not fluctuate with the amount of electricity generated.

**Progressive tariffs**: Fees or tariff structures that charge larger, wealthier customers a higher rate on the basis of larger consumption than poorer or smaller customers.

**Regressive tariffs:** Fees or tariff structures that charge poorer customers a higher rate than wealthier customers. Regressive tariffs are typically implemented by charging more per unit for lower levels of consumption.

**Market Willingness to Pay (MWTP):** The maximum price at which a customer will buy a unit of a product (such as electricity).

**Time of use fee**: Tariff structure with different prices for usage during periods with different demand. Simple time of use fees have peak and off-peak prices. Higher prices are charged during peak times, such as weekdays in the summer months, with lower prices the rest of the time, plus a daily service fee. Customers that can respond by reducing their usage in peak times or shifting their use to off-peak times benefit. This requires time of use meters, data collection networks, and meter data management software. If enough customers shift consumption patterns and reduce the peak, less installed capacity is needed to meet peak demand, thus reducing total capacity costs (see definition above) and costs to customers. Furthermore, as the most expensive sources are only used during peak times, reducing the peak reduces the average cost of electricity. In addition, remaining assets are more fully utilized during the rest of the day. If there is a large difference between the electricity consumed during off-peak times and peak times then some generating assets will be left partially used or unused during off-peak times. Enough generation must be available to meet high peak demand, but because some of those assets are only used part of the time, their per kWh cost is high. If they were used more fully, throughout the day and throughout the year, the fixed costs would be distributed across more kWhs and the per KWh cost would be lower. In this way, reducing peak demand and shifting it reduces the overall amount of generating capacity needed and reduces the cost of electricity.

Time-of-use fees usually specify standard hours considered “peak” and “off-peak” and charge associated higher and lower tariffs. A more complex form of time-of-use tariff structure is called dynamic pricing and reflects actual, real-time system load. In terms of economic theory this should work the same but in practice it is too complex for most customers and rarely results in significant load shifting. Some utilities install equipment that allows them to reduce electricity consumption without household intervention, such as by shutting off air conditioning systems briefly, so that customers automatically benefit from lower time-of-use fees. Typically simpler tariff structures have greater support.

## CONCEPTS ABOUT ELECTRICITY PRODUCTION, CONSUMPTION AND MEASUREMENT

### PRODUCTION

**Peak demand:** The highest anticipated simultaneous usage (“demand”) for electricity within an electrical system. To avoid brown-outs, overall system capacity must be sufficient to meet peak demand. Load shifting and electricity storage can help. Also known as “peak load”.

The system must be able to meet that peak demand or have a brown-out or black-out.[1] In order to meet that peak demand at that peak time, the utility must maintain that level of capacity all the time. In other words, to provide this power at this time only, the generator must charge all of its costs for maintaining this level of power at all times. Peak power demands are extremely expensive to the system overall.

**Baseload power plants**: Provide reliable electricity and are run at a high capacity factor, amortizing their expenses over a larger number of kWh. Unlike wind or solar they are not intermittent. Baseload plants tend to be geothermal, hydropower, biomass, or fossil fuel based.

**Peaking power plants**: *Also* known as peaker *plants*, and occasionally just "peakers", *power plants* that generally run only when there is a high demand, known as *peak* demand (see definition above), for electricity. Peaking power plants are for several reasons often more costly to operate.

**Off-taker:** A purchaser of electricity from a generator. Examples include a public utility buying from a private generator, or a cement factory buying from a private generator. A potential electricity generator must have a financially viable off-taker to have a business plan that will be credible to investors and lenders.

### CONSUMPTION

**Energy conservation:** Reducing total energy consumed by reducing the use of electrical equipment, such as turning off lights or appliances when not in use. Conservation is often confused with efficiency (see efficiency definition below).

**Energy efficiency:** Reducing total energy consumed by using electrical equipment that produces the same result with less electricity, such as replacing incandescent bulbs with LED bulbs that produce the same amount of light with less electricity. Efficiency is often confused with conservation (see conservation definition above).

**Energy intensity:** This term reflects how much energy is consumed in order to produce all the goods and services in an economy (i.e. the gross domestic product). High energy intensity results from an industrial and manufacturing based economy, while low energy intensity indicates a labor intensive economy. High energy intensive economies are more seriously impacted by changes in the costs of electricity, known as **supply shocks**.

**Supply shocks:** The impact to an economy or a business of changes in the price of an input. In reference to electricity markets, supply shocks most often occur when the cost of fuel for generating

[1] During brown-outs, voltage is reduced, causing lights to dim, televisions to flicker, and electrical appliances to malfunction. Computers and other sensitive equipment can be damaged by these fluctuations.

electricity increases on the global market. This creates a significant problem if the electricity provider does not have a mechanism for adjusting tariffs quickly to ensure cost recovery.

### MEASUREMENT

**Watt:** A unit of measurement of the rate of energy transfer, or power. The International System of Units definition of a watt is "a derived unit of 1 joule per second".

**Kilowatt (kW) and Megawatt (MW):** Units of measurement of the flow of electricity at any one time. A kilowatt equals 1000 watts and a megawatt equals 1000 kilowatts (or one million watts). For example, a light bulb may use 25 watts of power when it is turned on, while an air conditioner may use 1000 watts.

**Kilowatt hour (kWh) and Megawatt hour (MWh):** Units of measurement of electrical consumption, or the amount of energy used over a period of time. A kilowatt hour is equal to one thousand watts used continuously for one hour. A megawatt hour is equal to 1000 kilowatt hours. For example, since an air conditioner may use 1000 watts each moment that it is turned on, if an air conditioner is turned on for one hour it will consume one kWh of electricity.

**Voltage:** Potential difference in charge between two points in an electrical field. Voltage can be described as similar to water pressure - high voltage allows more electricity to be transmitted through the same size electrical line in a similar way to how high water pressure allows larger amounts of water to flow through the same size pipe.

**Kilovolt (kV):** Unit of measurement of the rate at which electricity is transferred through electrical lines and equipment. High voltage allows more electricity to be transmitted through the same size electrical line. Domestic and light industrial or commercial users commonly use low voltage lines and appliances. Industrial customers more commonly use high voltage lines and equipment.

**Power and Energy:** Although they are sometimes mistakenly used to mean the same thing, energy and power are actually different. Power is the ability to do work – it is the amount of electricity needed to make a motor turn, to make a lightbulb shine, and or to make a refrigerator cold. The watt (kilowatt, megawatt or gigawatt) is a measure of power. Energy is the amount of power per unit of time – how many watts are used during one hour. The watt-hour (kWh, MWh or GWh) is a measure of energy.

## GOALS SPECIFIED BY THE GOVERNMENT OF MOZAMBIQUE FOR ENERGY REGULATION

The government of Mozambique has adopted the Sustainable Development Goal of universal access to electricity by 2030. Law 11/2017 of 8 September, which established ARENE, specified the following goals for energy regulation:

- Fair competition between public and private operators
- An energy market that is more competitive, efficient, economical, and environmentally sustainable
- Satisfaction of the public interest and defense of the rights of consumers
- Stronger control of the impacts of energy use on the environment
- Improved national energy security

The current Electricity Law (Law 21/97) provides that "Fair and Reasonable Tariffs" for the use, consumption and transit of electrical energy are considered to be fair and reasonable when fixed in accordance with the following criteria:

a) ensure the minimum possible cost to consumers which is consistent with the quality of the service provided;
b) amortise over time the capital and operating costs, and provide an adequate return on the capital invested in the installation.

**PRINCIPLES OF ELECTRICITY PRICING**

Principles of Modern Electricity Pricing, published by the World Bank in 1981, argues that a tariff schedule should also aim for

- Fair allocation of costs among consumers according to the burdens the consumers impose on the system
- Price stability and the avoidance of large fluctuations in price
- A minimum level of basic service provided to those who cannot afford it
- Sufficient revenue for the utility to be financially sustainable
- Administrative efficiency

These principles are in line with the regulatory goals set out in Law 11/2017 as set out above.

**BOITEAUX PRINCIPLE OF COST REFLECTIVITY**

In economic terms, the ideal is a situation where nothing can be improved without something else being hurt, including social and environmental elements. This status is called "economic efficiency." Encouraging customers to manage their usage in response to price signals promotes energy efficiency and conservation and reduces waste, allowing more people to benefit from the same amount of installed capacity.

Prices should reflect all of the costs of production, including environmental. Since the 1949 publication of Marcel Boiteux's "La Tarification des demandes en pointe," classic economic theory calls for those who cause a cost to be incurred to be the ones paying for it – in other words, for tariffs to be cost-reflective. This has become known as the "Boiteux principle". For example, while the expense could be financed over time, customers would still be required to pay the full cost for connection to their home or business.

Cost-reflective pricing is necessary for cost recovery and energy efficiency. Cost recovery and energy efficiency are essential to developing a viable and sustainable electricity supply market that enables the achievement of Mozambique's regulatory goals. Regulation that fails to provide cost recovery discourages investment in new generation and distribution capacity and has left Electricidade de Moçambique, E.P. (EdM) as a weakened state utility that cannot maintain its equipment, provide current customers with satisfactory service, or extend the grid to additional customers. Such a utility cannot be a credible off-taker, which further impedes efforts to attract private investment to expand generation capacity or access. Without well-implemented, cost-reflective tariff policies that promote an economically healthy electricity sector and increase energy efficiency, Mozambique is more vulnerable to energy shocks and unable to offer its citizenry and business sector access to an essential economic development tool. Paying full price, including the environmental cost, of electricity incentivizes customers to conserve and use energy efficiently. Subsidies distort the market and encourage economically irrational behavior, such as the use of domestic and industrial appliances, motors, or irrigation pumps that are not energy efficient, that may be initially cheaper, but longer term energy consumption makes the overall cost more expensive. A 5 watt LED bulb may be more expensive, but it uses and costs 20 times less to use than a 100 watt incandescent light bulb for example.

Given the Boiteux principle of cost-reflectivity, the rate for off-grid electricity will differ from that for on-grid electricity as it is significantly more expensive per kWh to provide electricity to a smaller number of people with a lower rate of consumption than to a larger number of people with a higher rate of consumption. Charging the same rates for on and off-grid electricity is not financially sustainable, and will either destroy the system or require substantial cross-subsidies from another source such as urban users. Experience has shown that tariff subsidies are generally not sustainable and can damage the sustainability of the market, even though there might be a short term benefit. Given the current circumstances of the Mozambican market, unless the off-grid electricity is being provided by EdM, the process of cross-subsidization will be administratively more difficult. Investors and lenders would need confidence in the administrative and financial sustainability of a cross-subsidization process.

# INTRODUCTION

A customer tariff structure is a mechanism for users to pay either a public utility or a private sector provider for the costs of generating and delivering electricity to them. Although this sounds simple, setting customer tariffs for the power sector is a complex issue with broad social, economic, and environmental implications. It is also a highly technical issue that can require significant and potentially costly data collection and analysis for establishing tariffs, and administrative costs for implementation. This discussion paper provides a concise summary of the key considerations and decisions facing any country establishing a customer electricity tariff structure. It describes the trade-offs among the different financial, social, economic, and environmental objectives that are inherent in all tariff structures. It can help Mozambique to determine how to create a tariff structure that will balance objectives of universal access, enable Electricidade de Mocambique (EdM) to restore financial health, facilitate economic growth, and protect the environment.

The Key Concepts section presented above is critical to understanding the discussion presented in the body of this paper. In order to present a streamlined and concise summary of issues, the fundamental Key Concepts are explained fully in the preliminary section and then used in context within the paper. The first usage of a Key Concept in the paper will be highlighted to assist readers in referring back to the full explanation as needed. All readers are encouraged to read the Key Concepts section thoroughly.

Classic economic theory (as described in the Boiteaux Principle of Cost-Reflectivity) calls for a tariff structure to be cost-reflective to ensure cost recovery.  Cost recovery allows utilities to be sustainable without subsidies from the government budget, and investors to be confident that the return on their investments is predictable and secure. Cost recovery includes the costs of generation, transmission, and distribution of electricity, the interest payments on debt, and a "reasonable" rate of return on investment  Full cost recovery is critical to attract new investment in electricity generation, transmission, and distribution by both the public utility and the private sector.

If the public utility is not able to recover the costs of providing electricity, and the government is not able to give permanent subsidies, the public utility will decapitalize and eventually become insolvent. If cost recovery is not assured, the private sector will not make the very large investments necessary to expand access to electricity and provide good, reliable service to all customers.

The provision of electricity is inextricably linked with many other public policy goals including economic growth and development; improving health, education and communication; lowering crime and improving citizens' sense of safety; and protecting the environment. Without access to reliable electricity all development progress is impaired. Businesses struggle to compete. Schools go without modern technology. Streets are unlit, contributing to a perception of danger. Citizens lose respect for their government because it is unable to provide basic services. Drinking water and irrigation pumps cannot be operated. Health clinics cannot be properly lit and vaccines and other medication cannot be refrigerated. Thus, a tariff structure that ensures cost recovery and thus promotes electricity access is required to to achieve ARENE's goals of satisfying the public interest and improving national energy security.

The achievement of these broader policy objectives is9 impacted by choices and trade-offs made when establishing a customer tariff structure. While the tariff structure must ensure overall cost recovery, it can distribute costs among different classes of customers, and provide incentives or disincentives for various investments in the sector and for different consumption patterns.

The choices for how to ensure cost recovery will require trade-offs between multiple goals and objectives including rapidly expanding access, keeping prices low, maintaining administrative efficiency, encouraging energy conservation and efficiency, increasing business competitiveness and stimulating economic growth. A few examples of the types of choices and trade-offs include:

*How are costs categorized as fixed versus variable?*

| | |
|---|---|
| • Fixed (typically based on capacity costs for generation, transmission, and distribution)<br>• Variable (typically based on fuel and O&M) | • Fixed costs cover the basic cost of providing service such as transmission and distribution lines and the cost of the electric meter. Service fees can be staggered by level of service. For example, in Mozambique residences are not charged service fees. Commercial and industrial consumers are charged sevices fees based on levels of maximum consumption.<br>• The benefit of correctly classifying fixed fees is that charging consumers based on their highest capacity needs incentivizes them to reduce their peak demand to get to a lower level of maximum consumption and the reduces the overall system's need for high peak capacity.<br>• The disadvantage of classifying more costs as fixed is that it results in a more regressive tariff structure. Poor consumers cannot reduce fixed fees by reducing consumption. As Mozamibique does not currently charge residences fixed fees this is less relevant. |

*How precise and detailed is tariff structure and thus the data required to calculate costs?*

| | |
|---|---|
| • Simplicity<br>○ Precision | • The simpler a system is to administer the cheaper the administration costs and the easier it is for employees and consumers to understand. Excessive complexity frustrates consumers and increases the probability of billing errors, reducing trust in the sytem.<br>• The more sophisticated the cost calculations, the more precisely incentives and disincentives can be directed. For example, limiting a lifeline tariff to 125kWh a month is simple to administer, but could lead a household to attempt to install many meters in order to take advantage of the low tariff. If multiple households are connected to one tariff, the households may be poor but consume over the monthly lifeline limit and lose the benefit of the lifeline tariff. However, an accurate census to determine economic well-being for all consumers would be prohibitively difficult, time-consuming, and complicated, and would thus violate the principle of administrative efficiency. |

*How often are costs updated?*

| | |
|---|---|
| ○ More frequently<br>○ Less frequently | • Frequent updating of costs allows the system to respond to price fluctuations more quickly, which could be important to the financial health of generators<br>• Frequent price changes increase administrative costs and reduce budget certainty for household and commercial consumers, violating the principles of price stability and administrative efficiency |

*Should the tariff structure contribute to other social, economic or environmental policy objectives?*

| | |
|---|---|
| • Cheaper electricity | • Artificially cheap electricity discourages energy efficiency, encourages waste, and requires more capacity be built and paid for to serve the same needs<br>• By discouraging energy efficiency, artificially cheap electricity increases the environmental costs of meeting the same energy needs<br>• Lifeline tariffs allow the poor to receive benefit from basic electrification but the subsidy must be paid for by other consumers to have cost recovery<br>• Low costs to industrial consumers could increase international competitiveness but would discourage investments in energy efficiency and the subsidy would have to be paid for by other consumers<br>• If tariffs paid by one class of consumers to subsidize another class of consumers rise too high, they can opt out with self-generation, causing the overall system to collapse<br>• Cross-subsidization puts the principle of providing a minimum level of basic service to those who cannot afford it in conflict with the principle of those responsible for incurring a cost paying for it |
| • More expensive electricity | • Attracts more investors and financiers and potentially increases the availability of electricity to rural areas; increases the financial viability of the electricity providers so that they can provide electricity more reliably<br>• Prices electricity out of reach of more people |

| | |
|---|---|
| | • Can result in political dissatisfaction |

*Should off-grid consumers pay the same rate as on-grid consumers?*

| | |
|---|---|
| • Universal rate system<br>• Cost-reflective rates | • Rural consumers are typically poorer making the cost of electricity a greater burden for them, violating the Boiteux principle<br>• A uniform tariff structure is perceived as equitable<br>• Extending the lifeline tariff to the rural areas is in keeping with the World Bank's Principles of Modern Electricity Pricing goal of a minimum level of basic service to those who cannot afford it<br>• Rural consumers cost more to serve so a universal tariff structure requires cross-subsidization from other consumers<br>• The amount of cross-subsidy needed to provide a lifeline tariff to all who qualify may be unsustainable<br>• Cross-subsidization from other consumers increases administrative burden and is considered unreliable by developers and financiers, resulting in an increase in the cost of finance and an increase in the cost of electricity<br>• Artificially low prices without reliable subsidization will dissuade developers and financiers. The goal of providing rural areas with low cost electricity could thus result in them getting no electricity at all |

By reviewing the current tariff structure, presenting a concise overview of additional issues that need to be addressed, and exploring how the issues and trade-offs differ for on-grid and off-grid providers, this paper will enable policy makers to make more informed decisions.

## CURRENT TARIFF STRUCTURE

### TARIFF POLICY

Tariff structures are in place to ensure reliable electricity supply while balancing the interests of stakeholders. Electricity differs from other consumer or business goods in that it is both a natural monopoly and inextricably linked with broader policy goals including economic development, health, education, communication, crime and perceptions of physical safety, and the environment. Regulators are constantly told to "get prices right" but given competing goals this is impossible to do perfectly – there will always be trade-offs. Mozambique will need to engage in a well-informed discussion about tariff policy that recognizes and resolves these trade-offs as the new tariff structure is established.

Full cost-recovery for on-grid and off-grid systems is one of the essential components of creating an investment climate that will draw the private sector and lenders to invest in electricity in Mozambique. It is therefore critical to ensuring the vulnerable and the rural have access.

Since investors are free to invest their capital anywhere in the world, the returns in the Mozambique electricity sector must be high enough to attract capital, but the cost of electricity must not so high that it impedes household access and disadvantages local businesses. The establishment of ARENE with the legal authority to set tariffs and the mandate to protect customers and make the energy market more competitive, efficient, economical, and environmentally sustainable is an important mechanism for balancing returns to investors with benefits to citizens.

The "Fair and Reasonable Tariffs" provision of the current Electricity Law (Law 21/97) states that tariffs for the use, consumption, and transit of electrical energy are considered to be fair and reasonable when fixed in accordance with the following principles:

b) ensure the minimum possible cost to customers which is consistent with the quality of the service provided;
c) amortise over time the capital and operating costs, and provide an adequate return on

In terms of regional or international level policy, the government of Mozambique has adopted the UN Sustainable Development Goals (SDG) for achievement by 2030. This includes SDG 7: Ensure access to affordable, reliable, sustainable, and modern energy for all. In addition, the achievement of cost reflective electricity prices by 2019 has been adopted as an objective of the Southern African Development Community (SADC), of which Mozambique is a member.

## SETTING TARIFFS

To set rates at a level allowing cost recovery for prudent expenses and a reasonable rate of return, electricity regulators generally use the following process:

1. calculate the amount of revenue required for cost-recovery
    a. determine overall level of expenses and investment to be recovered,
    b. determine the appropriate rate of return (profit and interest),
2. establish a categorization of customers based on factors such as consumption amounts and/or voltage requirements
3. develop rates for each category of customers that, given estimated consumption, will in total be sufficient to recover that revenue.

In Mozambique, the World Bank is planning to study the rate base and determine the current cost of EdM providing electricity. This type of study of the rate base and marginal costs will need to be repeated by ARENE at regular intervals to review and revise tariffs to maintain their cost reflectivity.

Before the creation of ARENE, EdM served the role of tariff regulator, having the authority (subject to Government approval) to set tariffs for grid-based customers in accordance with the Electricity Tariff Regulations approved by Decree 29/2003[2]. These regulations classify customers into three

[2] EdM also has the discretionary authority to negotiate power purchase agréments with IPPs – independent power projects.

categories according to voltage demands:  voltage levels below 1 KV, between 1 KV and 66 KV, and over 66 KV.

Within the lowest voltage level there are different rates for different customers. The regulation provides a social tariff for consumption under 125 kWh.  For customers using over 125kWh, the rates are divided again for domestic users, agricultural users, and general users (the highest rates). The rates also increase in increments with one rate for less than 200 kWh monthly, a higher rate for consumption between 201 and 500 kWh, and a third, higher rate for consumption over 500 kWh. EdM has the authority to negotiate specific tariffs with large scale industrial and commercial customers.

Small low voltage customers include residences, market stalls, small shops, and small offices. Medium voltage customers include factories, manufacturing and hotels. Large, high voltage customers would include larger factories, foundries or mining facilities. Large high voltage customers, which are cheaper to serve on a per kWh basis, could avoid paying for EdM supplied electricity by investing in their own facilities, especially as costs for solar equipment drop. It has been standard practice to charge large customers a tariff based on actual costs plus a capacity fee for firm energy supply.

The currently approved tariff structure also provides a rate for prepayment that is less than the highest rate for residential, agricultural, and general customers. Prepayment for electricity is standard and has widespread acceptance in Mozambique. It is increasingly used in residential consumption in other countries in Sub-Saharan Africa. In Mozambique it is perceived as universal as new connections automatically receive a pre-payment meter. With mobile phone and ATM technology, pre-payment meters allow customers to purchase electricity without queuing. The meters also allow the utility to secure payment for electricity consumed with fewer administrative costs and interactions regarding billing and disconnection. Finally, it allows the customer to budget and avoid debt and results in greater awareness of electricity consumption.

In 2014 there were 3,596 customers on the lifeline tariff and 1,259,638 on the residential tariff.[3] Given the small number of users on the lifeline tariff and their low consumption, the lifeline tariff is not currently placing a large financial burden on EdM. However, it does work as a disincentive to expanding grid coverage to the rural and peri-urban poor, as the high cost of grid connection fees will never be recovered with the low lifelien tariff. If the lifeline tariff is used for providing access for the 75% of the population overall and the approximate 90% of rural residents currently without access, universal access will result in the lifeline tariff becoming an unsustainable burden and in itself a disincentive to universal access.

The key issue with the current tariff structure is that it does not accomplish cost recovery. EdM is financially not a credible off-taker, severely limiting the attractiveness of private, commercial investment in the electricity sector in Mozambique. Most new investment involving EdM has relied on grant and concessionary finance. Decapitalization (caused by persistent expenditures greater than revenues) weakens EdM's ability to perform necessary operation and maintenance (O&M) and thereby reduce technical losses. Without cost recovery EdM loses money on every kWh sold and every connection made, making it impossible to achieve the goals of full electrification. At the same time, current technical and commercial line losses are estimated at 26% in 2016 (up from 24% in 2014). [4] By contrast, line losses of 8-15% are reasonable in a typical transmission and distribution network.

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[3] EdM, Proposta de Ajustamento Tarifário para 2015, June 2015

[4] Losses were estimated at 24% in 2014. See: http://documents.worldbank.org/curated/en/135711468180536987/ACS17091-REVISED-PUBLIC-Mozambique-Energy-Sector-Policy-Note.pdf

# KEY CONSIDERATIONS FOR A NEW TARIFF STRUCTURE

## FINANCIAL AND ECONOMIC CONSIDERATIONS

### IMPORTANCE OF COST RECOVERY

Many countries have historically subsidized the cost of electricity, leaving their utilities financially weakened, losing money on every connection and every kWh offered. The utilities had to be propped up with subsidies from the government budget, but when the governments had financial difficulties or other priorities, the utilities were left unable to invest in proper operation and maintenance, let alone in the expansion of capacity and coverage.

This led to outdated, failing systems with frequent outages and low electrification rates. These countries typically also had high theft rates. This situation was worsened when political will was insufficient to allow disconnection for non-payment. With no competition, customer service was ignored. Citizens rationalized not paying their electricity bills with an argument that they shouldn't pay for such bad service. The benefit of the subsidies went to the wealthier citizens as they could afford to pay for greater electricity consumption for appliances, while the poorer citizens could not even get access to electricity. In desperation countries began turning to the private sector. Unfortunately, the private sector learned through multiple business failures throughout the world that taking over electrical systems was extremely risky if the country had not reached the point where customers paid their bills at rates that allowed for full cost recovery.

It is essential that the overall tariffs achieve cost-recovery. The electricity system does not operate properly unless expenses are recuperated. Without cost-recovery, the utility cannot be financially strong enough to perform its role properly or to be a viable off-taker for private sector companies interested in generating electricity and selling it to the grid. In addition to facilitating cost-recovery, cost-reflective tariffs can result in incentives and disincentives as explained in the following.

### INCENTIVES

Cost-reflective tariffs can provide incentives that change customer behavior to be more economically rational, resulting in the achievement of other policy goals, as discussed below.

#### INCENTIVIZING ENERGY EFFICIENCY AND CONSERVATION

Having customers pay the full cost of their consumption incentivizes energy efficiency and energy conservation. Customers will be more likely to invest in energy efficient lighting and appliances and to turn these off when they are not needed. Energy efficiency and conservation, which reduce each customer's usage, allow more customers to be served with the same amount of power produced by the existing generation capacity. This approach expands access to electricity to more people, with only limited increases in financial and environmental costs required to expand transmission and distribution.

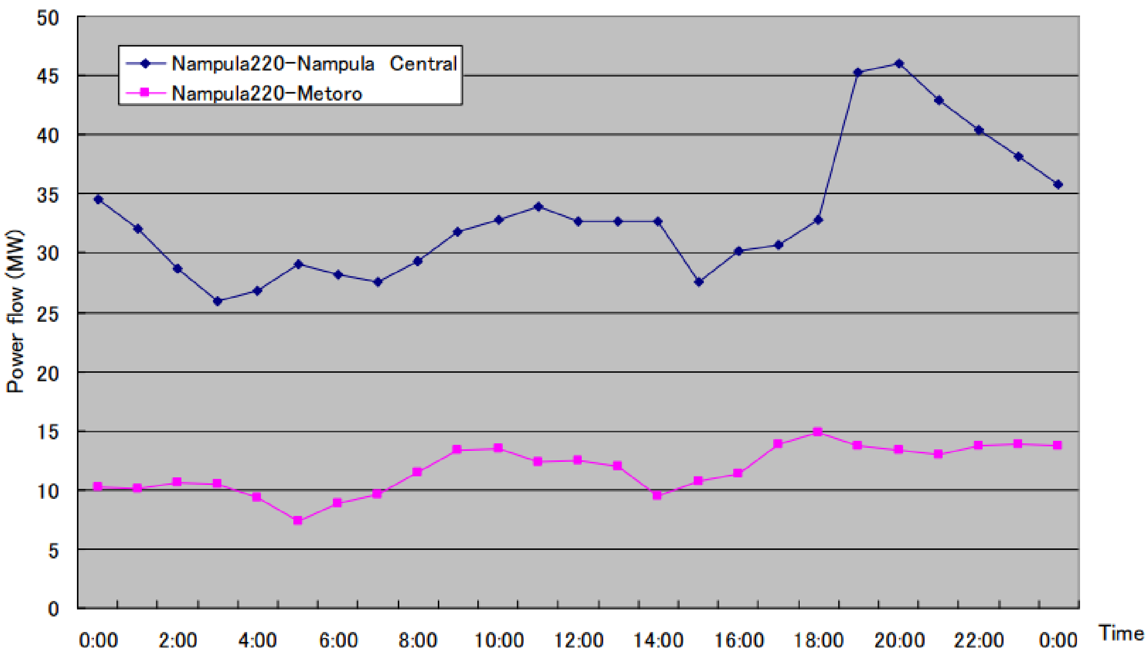
Energy intensity is the amount of energy required by the country per unit of gross domestic product. Greater energy intensity leaves an economy more vulnerable to electricity supply shocks. Cost reflective tariffs discourage wasteful energy use and encourages investment in energy efficiency and conservation. Businesses with high energy requirements will be more likely to purchase energy efficient machinery. Lowering the energy intensity reduces the country's economic risk from internal or external supply shocks. In addition, the more efficient an economy is, the better it can weather fuel price fluctuations or energy supply shocks.

## INCENTIVING A REDUCTION IN PEAK DEMAND

Having customers pay a demand fee incentivizes them to keep their peak demand low, which in turn reduces the amount of capacity and the capacity costs required to meet those periodic peak demands.

Figure 1 shows the change in demand over the course of a day. Demand peaks at 9 pm. The system must be able to meet that peak demand or have a brown-out or black-out.[5] In order to meet that peak demand at that peak time, the utility must maintain that level of capacity all the time. In other words, to provide this power at this time only, the generator must charge all of its costs for maintaining this level of power at all times. Peak power demands are extremely expensive to the system overall.

If the demand could be shifted in time, generators could amortize their costs over more electricity produced over a broader period of time. Rather than recovering all of their costs for a small amount of energy, they can spread their costs out over a greater amount of kWhs, resulting in a lower per kWh cost. It is therefore more efficient for the system as a whole to have demand shifted to eliminate large variations during the day.




(Source: Load Record at Nampula 220 Substation)

**Figure 1 Hourly change in power flow of the Nampula 220 - Nampula Central Line (May 23, 2012) http://open_jicareport.jica.go.jp/pdf/12088548.pdf p. 3-13**

Sophisticated meters can allow changes in the rate charged to customers based on the time of day. This is allowed under the existing regulations for medium and high voltage customers. A higher tariff during peak hours incentivizes a shift in electrical consumption from peak hours to off-peak hours and allows the entire sytem to operate more efficiently with the same economic output. EdM has

[5] During brown-outs, voltage is reduced, causing lights to dim, televisions to flicker, and electrical appliances to malfunction. Computers and other sensitive equipment can be damaged by these fluctuations.

been investigating the use of peak/non-peak tariffs, which would, however, require both regulatory adaptations and improved technology in order to implement

Time-of-use pricing is administratively more difficult than simple usage pricing, requiring more sophisticated billing systems and meters that are able to determine time of use. Experience has shown that while time-of-use should work in shifting demand, only a small number of customers are able to shift demand in practice.

### DISINCENTIVES

Subsidies that reduce the cost of electricity can have unintended consequences despite positive intentions. For example, subsidies for poor consumers to permit a greater number of connections increase consumption and financially burden the system. Government expenditures spent on the subsidy are not available for other social purposes and if the government is no longer able to maintain the subsidy the rapid price increase can result in a massive shock to the consumer market. If the utility is not reimbursed for the cost of providing the artificially cheap electricity, it acts as a disincentive to connect more poor consumers or makes it impossible for them to perform proper O&M to maintain system reliability.

Artificially low electricity prices disincentivize investment in energy efficiency, resulting in higher financial and environmental costs to provide the same service, as well as leaving the country more vulnerable to price fluctuations. They also distort the market. If solar home systems are not similarly subsidized, it encourages more consumers to insist on grid-based electricity even if that is, overall, more expensive.

## CONSIDERATIONS FOR CALCULATING COSTS AND ALLOCATING TARIFF RATES

Simplified, there are two steps to setting tariffs.

1) Calculation of allowed costs to be recovered
2) Allocation of allowed costs through the tariff structure as capacity, service, or usage

The methods chosen to identify and calculate costs vary in precision, complexity and timeliness. Methods chosen to allocate these costs to customers through various types of fees also vary in ease of billing, understanding by the customer, and perceptions of fairness. The choices made in calculating and allocating costs through the tariff structure have impacts on how difficult and expensive the system is to administer.

The World Bank is currently engaged in a study of the EdM cost of generating electricity in Mozambique which should contribute significantly to the first step. ARENE is charged with defining the tariff structure for the second step. ARENE is currently engaged in the drafting of regulations.

### CALCULATING COSTS

Two approaches to allocating costs are the "the accounting approach" and the "long run marginal cost approach." The accounting approach relies upon actual costs, is easier to understand, is administratively easier to implement, politically simpler to explain, and is more appropriate for the electricity sector in general.

#### ACCOUNTING APPROACH

The accounting approach divides allowed revenue into different functional segments and then into cost components. These are based on actual costs. While every regulator uses a different methodology for the aspects described below, the accounting approach is still administratively and conceptually simpler than the long run marginal cost approach. The accounting approach can be applied equally to on-grid and off-grid operations.

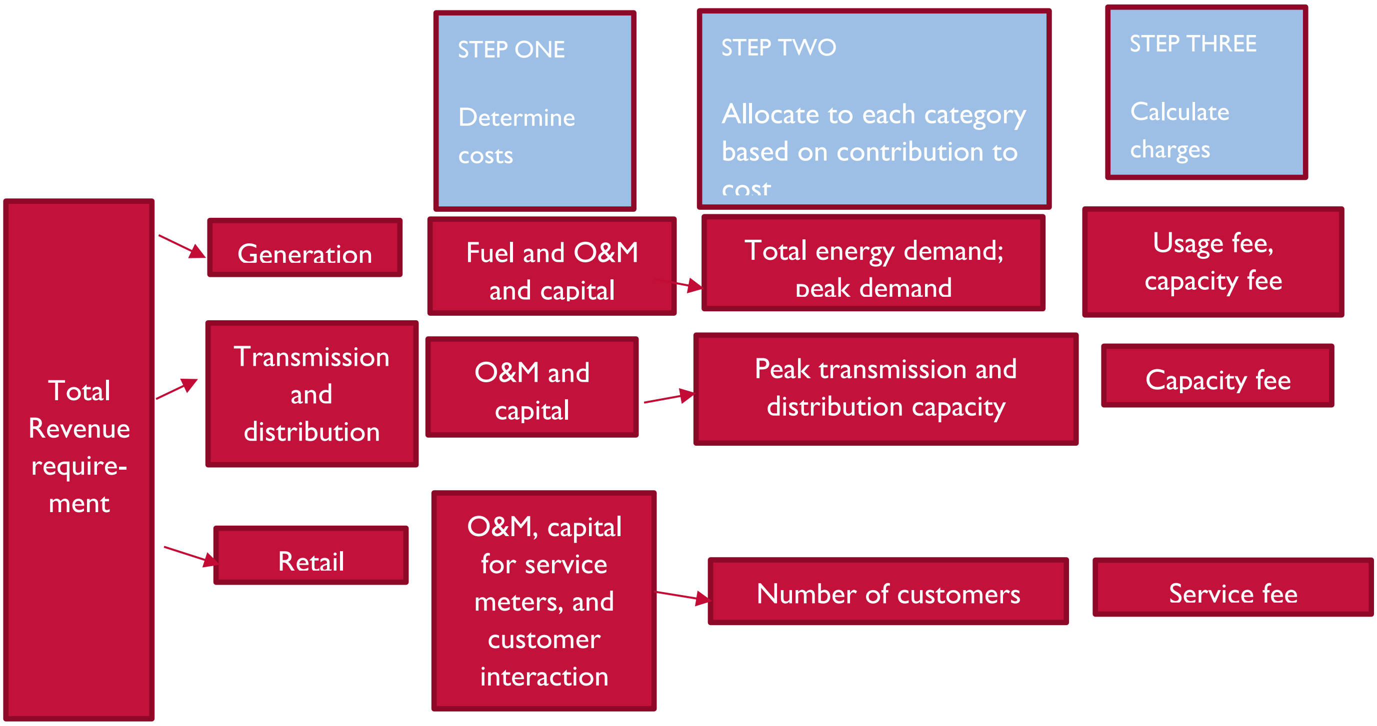
Cost components include costs from peak demand, or capacity costs; costs from generation; and costs from the number of users. Costs can then be passed on to customers as capacity fees, usage fees, and service fees per connection. Chart 1 outlines, in simple terms, the steps involved in calculating fees. The total revenue that must be recovered is calculated from the costs for generation, transmission and distribution, and retail (serving customers at the individual level). The total fees to customers for each of these functions must equal the total costs.

*Generation costs* are comprised of fuel, O&M, and the embedded capital costs. These costs are to serve total energy demand and peak demand. They are typically recovered through a usage fee, or per kWh fee, and in the case of commercial and industrial customers, an additional demand fee, or a fee based on the maximum capacity a customer uses over an established time frame.

*Transmission and distribution* infrastructure costs include capital for installation and O&M. This infrastructure is sized to meet peak transmission and distribution capacity, plus a reserve capacity for resilence during unusual spikes in consumption. A way to recover this cost is to average it into usage fees. Another method is to use demand fees. Usage fees vary with consumption and can be reduced with efficiency and conservation. Demand fees are based on maximum consumption and can be reduced by reducing peak load.

*Retail costs* include the costs of metering, billing and collecting from individual customers. On a per kWh basis large customers are cheaper to serve because they use more kWh for the same cost of metering, billing, and collecting. The retail cost increases with the number of customers, even where pre-paid equipment is used. This cost can be recovered through a service fee.

CHART 1: STEPS TO CALCULATING COSTS AND ALLOCATING FEES



### LONG RUN MARGINAL COST APPROACH

The long-run marginal cost approach estimates the economic value of future resources required to meet incremental changes in consumption over the next five to ten years for each category. Marginal cost theory states that rational choices on whether to buy more or less of a given product require a price equal to the cost of supplying more or less of that product, or the marginal cost of the product. Ideally, long run marginal cost pricing provides customers with up-to-date changes in price signals and helps electric utilities attain economic efficiency. If it is expected that relevant fuel prices will increase, the long run marginal cost increases. Prices are set according to expected future costs not current costs. If it is expected that the cost of generation will decrease, then the long run marginal cost will decrease. In jurisdictions where this approach has been used, the amount of revenue needed rarely equals the amount of revenue collected. Any surplus can be taxed or used to subsidize some aspect of the sytem. If the amount collected is less than current expenses then fees must be increased, the government must cover the shortfall (which is not an option in Mozambique's situation), or the utility will decapitalize and service and reliability will suffer.

The long run marginal cost approach is significantly more complicated to enact and for customers to understand. Other issues that often militate against the practical application of the marginal cost theory for electricity pricing and in favor of the accounting approach include:

- Electricity investment is "lumpy" not continuous, meaning it occurs in large amounts, not in incremental, marginal amounts
- Demand, input prices, and technology change over time
- System reliability standards and optimal reserve margins vary when demand and supply are uncertain
- Calculating the extra cost of an additional kWh is more complicated than calculating many other marginal costs. Costs depend on generation source, timing, and transmission distance.
- Marginal costs ignore embedded costs, or costs that remain a financial obligation of the utility.

## ALLOCATING FEES

In most countries the tariff structure has a variety of *types of fees*, *categories of customers*, and *tariff rates*. The main *types of fees* are service fees, demand fees, and usage fees. The primary *categories of customers* are residential, commercial, and industrial. The *tariff rates* may be set according to criteria such as category of customer, amount of consumption, poverty or vulnerability of the customer (social tariff rate), and peak and non-peak time of day (time-of-use rate).

Any discount in the rate for one customer must be compensated for by higher fees for other customers. While larger customers typically can better bear the load of higher prices, they also have alternatives. Should the cost of electricity be too high they can opt out of the system and generate their own electricity. This would effectively increase the cost for remaining customers as they must pay for the fixed costs without allocating a portion to the larger customers. It can also be argued that charging industrial customers too high a rate will disadvantage them relative to international competitors and thereby hurt the overall economy. Charging them too low a rate forces smaller customers to pay higher prices.

The cost of providing electricity varies as well. The administrative costs of serving smaller customers is greater per kWh than of serving larger customers. A meter for a household consuming very little electricity costs the same as a meter for a household using much more electricity, resulting in a higher per kWh expense. Rural customers require longer transmission infrastructure and thus are more expensive to serve per kWh. Finally, because electricity is typically bought from the lowest cost producers first and more expensive producers as demand increases, the cost of electricity varies throughout the day. In many countries with time-of-use metering systems customers are charged more for electricity use during high demand periods and less for use during low demand periods to encourage customers to shift the time of use.

The variations in costs are frequently dealt with by separating the fees charged to customers into different categories. Fixed costs are recovered through fixed fees that the customer is charged regardless of the amount of electricity they use. Variable costs are recovered through usage fees that vary depending on the amount of electricity the customer uses. Electricity bills typically consist of two fixed fees (the service fee and the demand fee) plus a usage fee based on consumption.

The classification of costs as fixed or variable determines the overall progressive or regressive nature of the tariff structure. The lower the fixed costs, the higher the usage costs, the more progressive the tariff structure. If more costs are classified as fixed, then even though usgage costs are lower, a basic level of service costs more, resulting in a more regressive tariff structure.

There is a great deal of flexibility in determining the classification of costs and thus the relative burden different rate categories bear. Rate setting, and especially allocation decisions, can be partly judgmental and partly political, not just technical. For example, regulators may seek to encourage economic development by offering lower rates to industrial customers. Regulators may seek to protect residential customers by allocating more expenses to commercial and industrial users.

**SERVICE FEE**

A service fee is a fee charged to each customer regardless of the amount of electricity used. It covers charges that do not vary depending on customeractual energy use. This includes maintaining transmission poles and wires and customer administration. The service fee may be a flat rate (the same for all levels of consumption) or inclining (with higher rates for consumption over a base level). An inclining rate benefits those who consume less, and tend to be poorer, by shifting more of the fixed costs to those who consume more. However, this attempt to benefit the poor will fail if there is high consumption for the connection because many family members share the same meter, increasing the consumption measured by that meter. In addition, in some countries wealthier customers will get many separate connections for the same house in order to keep the consumption for each meter below the established base line and take advantage of lower rates. A flat rate is regressive in that it is a larger percentage of a smaller customer's bill than a larger customer's bill.

The more expenses regulators classify as fixed costs, the higher the service fee. The more expenses are defined as usage costs that vary with the amount of electricity consumed, the lower the service fee and thus less regressive the fee.

**DEMAND FEE**

Demand fees are based on the maximum amount a customer uses at any one time and reflects the utility need to be able to supply that amount at a moment's notice. Some utilities charge residences demand fees, other utilities reserve this for commercial and industrial customers.

This is a progressive fee in that larger customers are usually charged more than smaller customers. Service fees and demand fees are "fixed" in that they are charged irrespective of the amount of electricity consumed. A household or enterprise consuming no electricity for a month, but still having the electricity turned on, would still be charged this fixed tariff.

### USAGE FEE

A consumption or usage fee is based on the amount of electricity actually consumed. This is only regressive or progressive if the usage fees for different level customers vary. It should be based on the cost of generating the electricity and thus be neutral. Costs based on usage are neither regressive nor progressive but fall on all customers equally.

### TIME-OF-USE PRICING

This paper has discussed cost-reflective tariffs and provided details about how they work in practice. Cost-reflective tariffs result in more financially sustainable and thus stronger, more resilient electrical systems and send price signals that incentivize economically rational behavior such as energy efficiency, conservation, and shifting load to off-peak periods.

Time-of-use pricing, or charging more when the cost of generating electricity is greater, is administratively more difficult than simple usage pricing, requiring more sophisticated billing systems and meters that are able to determine time of use. Experience has shown that while time-of-use should work in shifting demand, only a small number of customers are able to shift demand in practice. Population-wide demand response is minimal. When time-of-use pricing works, it reduces the cost of installed infrastructure and lowers average market prices. When it does not work, it is because there are too few customers taking advantage of it, and their demand response is insufficient.

Time-of-use pricing is also more complex for the customer. Simpler pricing structures are easier to understand and more likely to have broad acceptance. Households where all adults have formal employment may not have the ability to shift load significantly because they are outside the house for the majority of the day.

### SUBSIDIZED TARIFF

A weakness of cost-reflective tariffs is that they may be a hardship for poorer customers. Electricity is important for participation in a modern society. Without electricity radios and mobile phones do not work, severely limiting communication. This has dire impacts in times of emergency but even in regular times it is difficult for citizens to feel a part of their country and invested in its success when they are effectively cut off from the broader world. Electricity allows better quality light than candles or keresene, without the health consequences and risk of fire. Possibly the most important and yet most difficult to measure is the intangible benefit of electric light demonstrating that change is possible.

Rationales for subsidizing tariffs have included protecting the poor and vulnerable and stimulating industry with low energy costs. Tariffs are typically subsidized initially to curry political favor or to achieve social welfare goals. Even when well-intended, these subsidies have led to financially weak, unreliable electricity systems. If electricity prices were reduced or kept low to foster industry, the goal is subverted when new businesses cannot get access or have to invest in backup generators and fuel. If electricity prices were kept low or reduced out of concern for the poor, the actual result was fewer poor households with connections, fewer rural communities with access, and unreliable power due to frequent blackouts because the system is poorly maintained. In most countries the wealthy take advantage of the subsidies, reaping most of the benefit.

Furthermore, subsidies distort the market. Artificially low electricity prices result in energy waste. Cost-reflective tariffs incentivize investment in energy efficiency and greater efforts to conserve.

### SOCIAL OR LIFELINE TARIFF

To prevent the problem of the rich reaping most of the benefit of subsidies, some countries provide a social or "lifeline" tariff. This is a subsidized rate for only the most basic consumption. As long as there is sufficient cross-subsidization by wealthier, larger customers, this does not inherently result in a weakened electricity system. A small amount of electricity results in tremendous improvements in quality of life, reducing damage to eyes and lungs and increasing access to communication through radios and mobile phones.

An essential criteria for a lifeline tariff to work is that other users be able to provide the cross-subsidy. If the subsidy is provided outside the electricity system, such as directly by government coffers or by donors, it is inherently unreliable. The larger the proportion of the customer base receiving the subsidy, the higher the cost of electricity for those providing the subsidy. If that cost increase is too high it will dissuade job-creating investment that will move to a more conducive country and encourage wealthier residents to invest in their own supply, resulting in the collapse of the system.

### CONSIDERATIONS FOR OFF-GRID TARIFFS

Regulation is needed for off-grid electricity for the same reasons it is needed for on-grid electricity: to provide the certainty needed to attract private investment and to protect customers. Businesses will not invest if they cannot make an adequate return, including compensation for risk. With mini-grid systems there are two primary sources of risk: (1) that companies will not receive agreed upon payment for the electricity they provide, and (2) that they will not be compensated if the grid comes to the community. Regulation that reduces risk should, in a competitive market, reduce the cost of capital and the rate of return needed to compensate for that risk, in turn reducing the per kWh cost of the electricity. To reduce risk, regulation must ensure companies can recover their costs and make a reasonable level of profit and specify, in a fair and transparent manner, the outcome if and when the main electric grid comes to town. Likewise, customers need regulation because if developers and investors don't feel safe investing in mini-grids they will not receive access. Furthermore, customers become dependent on electricity and can be hurt if the electricity supply and costs are not reliable.

Section 7.3. Tariff Schedules, of Mozambique's Energy Sector Strategy[6], states that tariffs should reflect the cost of supply including reasonable profit margins. This wording does not require all customers, off-grid and on-grid, to pay the same price. If off-grid prices are kept artificially low, the only way to provide full capital recovery, operating cost, and reasonable profit margins, is either with subsidized capital investment or a subsidized tariff being provided by Government or another party. To attract private capital at reasonable rates developers and financiers must be assured of reasonable profit margins. Subsidies are considered riskier than full cost recovery. Unless there is confidence in the subsidy system, it will result in increased perceived risk and increased cost to compensate for that risk.

There is no economic reason why the on-grid and off-grid regulatory regimes must be the same as their circumstances are extremely different. Contrary to general belief that rural customers may not be willing or able to pay for electricity services (as opposed to kerosene, candles, batteries, etc), studies[7] (and other anecdotal experience) have found that they are willing to pay for better quality

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[6] Resolution 10/2009, of 4 June

[7] http://sun-connect-news.org/fileadmin/DATEIEN/Dateien/New/Are_the_off-grid_customers_ready_to_pay__1_.pdf

energy. As described above, different categories of customers typically do and should pay different rates for electricity. Charging a uniform rate for electricity has the benefit of simplicity and a perception of fairness, but different customers cost different amounts to serve. Therefore a uniform rate results in a cross-subsidy that may introduce economic distortions or unfairly burden some customers to the benefit of others. It may also be administratively difficult if one entity is not responsible for all pertinent aspects of the system. Unless investors and lenders are confident that the cross-subsidization payment will take place, they will not invest in mini-grid systems that do not involve full cost recovery and reasonable profitability. The subsidies would have to be funded from a financial source that is perceived as reliable for the life of the mini-grid. Investors are dubious of subsidy systems as they are less likely to be maintained than a full cost-recovery system.

Lack of electricity imposes developmental and economic costs. Streets are perceived to be less secure. Small shops cannot refrigerate items for sale or use fans to keep customers cool. Equipment that improves productivity and quality, such as sewing machines, require electricity. Communication devices such as radios and cell phones require electricity. Electric light bulbs provide superior lighting and are safer than candles and kerosene. Therefore, trying to spare poorer, rural communities the cost of electricity, if it delays or impedes electrification, both ignores existing incurred costs for substandard alternatives and imposes other costs.

Regulators can take a light-handed approach on the premise of a willing buyer and willing seller. This approach allows a community full flexibility in negotiating with a developer and involves the government only if agreed-upon terms are not met. Tanzania's Mini-Grid Regulations and Kenya's proposed Mini-Grid Regulations take this approach as relevant regional examples. Regulators can take the opposite approach and require a consistent, national utility tariff, necessitating cross-subsidies and the accompanying administrative burden and risk. This can be accompanied by requirements that the off-grid provider meet the same service standards as mandated for the national utility.

A middle approach would allow system operators to charge a cost reflective tariff, explicitly approved by the regulatory agency or pertinent ministry, and meet agreed-upon service standards. It may be that communities can save significantly if they agree to lower levels of service or reliability, and as marginal willingness to pay (MWTP) can vary widely, this flexibility may increase the ability to provide some form of electricity to every Mozambican household by 2030. An example of a lower level of service may be to restrict the hours when electricity is available to some customers to reduce peak demand in order to lower the overall costs. Another approach may be to provide only low amperage lines to customers paying a lower rate and thereby restricting total electrical current that can be consumed at any specific moment, reducing total peak use.

**REGIONAL EXPERIENCE**

Southern Africa has a low level of access to electricity. Access and reliability are hampered by electricity sectors weakened by prolonged periods of artificially low tariffs. Most countries have chosen between affordability and cost recovery. Affordability has led to lack of access and unreliable power for those who do have access. Recognizing that increasing access and reliability requires a financially healthy electricity sytem, most countries in the region have stated a commitment to move toward cost-reflective tariffs. Essentially it is a decision between having more expensive but reliable electricity, not having electricity at all, or having erratic electricity and investing in expensive back-up power.

Figure 1 shows the residential electricity tariff by country for many African and OECD countries. South Africa is shown as having multiple rates because some of its electricity is delivered by municipalities at highly divergent costs to the end-users. For comparison, Mozambique's current pre-paid residential rate is 6.95 metical/11 cents per kWh, fitting in between Zambia and Botswana.

In the absence of electricity, energy needs are either unmet or are met with candles, kerosene, and batteries. Thus, while there is a cost to electricity, there is a cost resulting from the lack of electricity as well. Those without access to reliable grid-based electricity who are able to will often pay several times more for electricity from their own generators. Smaller enterprises will pay for a lack of reliable electricity with foregone income – they produce and sell less than they otherwise would.

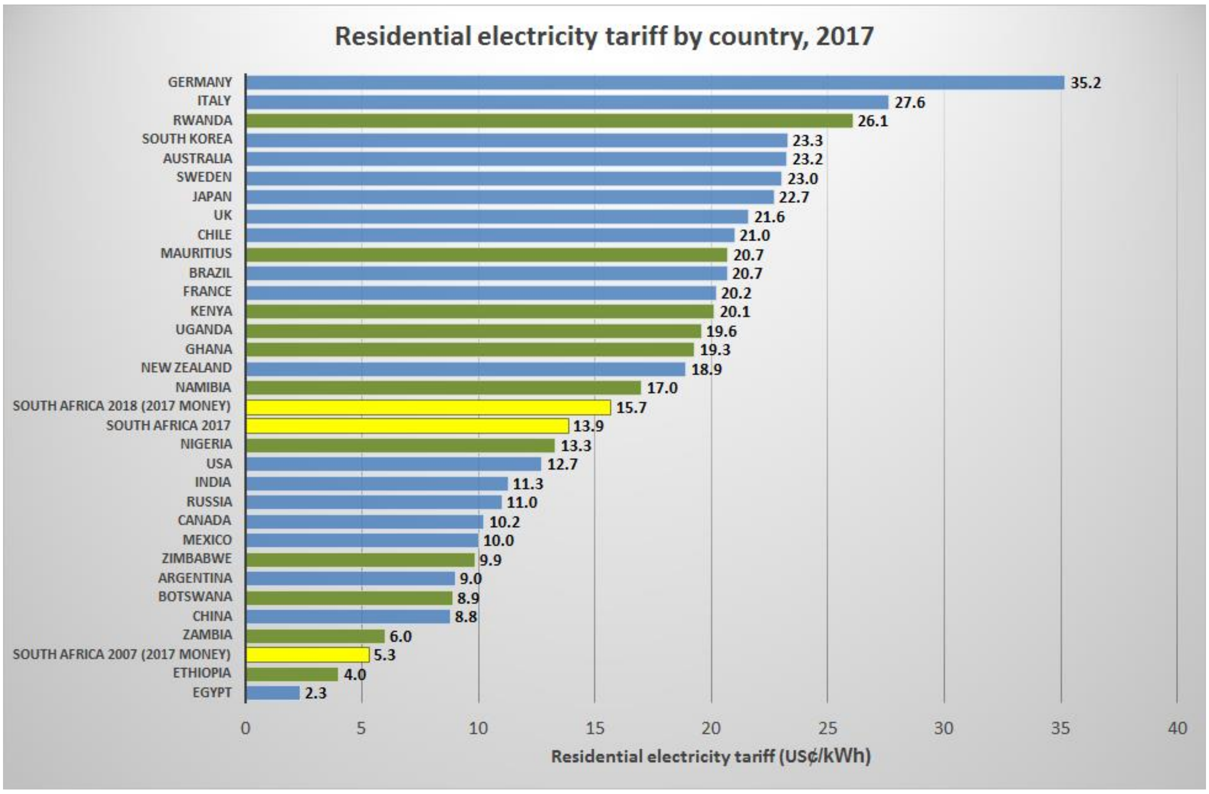


**Figure 2 Residential electricity tariff by country, 2017, www.poweroptimal.com**

TANZANIA

36% of households have access to electricity (World Bank 2016) (http://www.worldbank.org/en/results/2016/12/06/increasing-electricity-access-in-tanzania-to-reduce-poverty), a dramatic increase over the past five years

8.9 power outages in firms in a typical month (World Bank 2013 https://data.worldbank.org/indicator/IC.ELC.OUTG?locations=TZ)

86% of firms experiencing electrical outages during the previous fiscal year. 2013 (https://data.worldbank.org/indicator/IC.ELC.OUTG.ZS?locations=TZ)

Partial blackouts occur regularly, forcing many businesses to use power generators as backups, increasing their operating costs. Investors have long complained that the lack of reliable power hurts business.

## On grid

The World Economic Forum's Global Competitiveness Report 2015/6 ranked Tanzania as 122 out of 140 countries for reliability of electricity supply – above Burundi but otherwise below neighbours Kenya, Rwanda and Uganda. (https://www.insideafricalaw.com/publications/tanzania-investing-in-the-african-electricity-sector-ten-things-to-know)

TANESCO, the state-owned power utility, is in poor financial health. Its current liabilities are greater than its current assets, increasing the likelihood of default in payment to creditors. In 2012 and 2013 TANESCO's cost of purchased electricity and its own generation rose. Tanzania is heavily dependent on large hydropower. During droughts TANESCO purchases expensive emergency power and uses relatively more expensive thermal generation. The utility is now deeply in debt to independent generators and requests to increase tariffs have been denied or only partially met. An argument against the tariff increase was that it would increase prices without improving quality or addressing operational inefficiencies.

TANESCO provides all electricity transmission and most distribution. All independent power production plants must sign power purchase agreements (PPAs) with TANESCO. TANESCO's financial health is therefore essential to power investment in Tanzania. Prior to 1990 electricity pricing was viewed as a mechanism for income redistribution. Tanzania now hopes to attract private investment and redirect government spending to other uses.

In Tanzania five different price levels exist:

- Domestic Low Usage Tariff (DI): applies to customers and includes a service fee. There is a subsidized rate for the first 75 kWh.
- General Usage Tariff (T1): applies to consumption above 283 kWh per year, voltage is 230V in monophase and 400V in triphase
- Low Voltage Usage Tariff (T2): applies to customers with a consumption of 400V and a more than 7.500 kWh, but less than 500 KVA
- High Voltage Usage Tariff (T3): applies to customers using 11KV and above

Table 1: Current tariff rates in Tanzania (TANESCO 2017)

| Type of Customer | Type of fee | Unit | Cost | MTZ | $ |
|---|---|---|---|---|---|
| Domestic Low Usage Tariff (DI) | Service | TZS monthly | - | | |
| | Usage (0-75 kWh) | TZS/kWh | 100 | 2.70 | .04 |
| | Usage (>75 kWh) | TZS/kWh | 350 | 9.46 | .15 |
| General Usage Tariff (T1) Residential, Commercial and Public Lighting, Small Industries, Bill Boards, and Communication Towers | Service | TZS monthly | 5,520 | 149.24 | 2.45 |
| | Usage | TZS/kWh | 298 | 8.06 | .13 |
| | Capacity | TZS/kVA/monthly | _ | _ | _ |
| General Usage Tariff (T2) Low Voltage | Service | TZS monthly | 14,233 | 384.80 | 6.32 |
| | Usage | TZS/kWh | 200 | 5.41 | .09 |
| | Capacity | TZS/kVA/monthly | 15,004 | 405.64 | 6.66 |
| T3MV -- Medium Voltage | Service | TZS monthly | 16,769 | 453.36 | 7.44 |
| | Usage | TZS/kWh | 159 | 4.30 | .07 |
| | Capacity | TZS/kVA/monthly | 13,200 | 356.87 | 5.86 |
| T3HV – High Voltage | Service | TZS monthly | - | - | - |
| | Usage | TZS/kWh | 156 | 4.22 | .07 |
| | Capacity | TZS/kVA/monthly | 16550 | 447.44 | 7.35 |

(Exchange rate as of 13 and 14 February 2018)

Like Mozambique, Tanzania offers a social tariff but limits it to the first 75 kWh per month. Residences are charged for consumption only, not a fixed service fee or a capacity fee. Mozambique categorizes customers according to voltage capacity and, with the exception of residences and smaller general uses, Tanzania does as well. Larger customers are charged less for usage, but their fixed service fees and capacity fees increase.

## Off grid

The Rural Energy Agency (REA) is responsible for improved access to modern energy in rural areas. Tanzania's REA has a world class reputation for small power producer (SPP) regulation. The regulatory framework for small power producers, defined as power plants that use renewable energy and have an export capacity of between 100kW and 10 MW, was designed to streamline the process by removing the need for negotiation and regulatory review of tariffs in order to reduce transaction and administrative costs.

"In contrast with Tanzania's experience with IPPs and (*emergency power producers*) EPPs, mainly taking place before the establishment of the independent regulator in 2006, the development of the SPP investment regulatory framework is driven by EWURA, whose work has been cited as an example for other countries developing SPP projects (Tenenbaum, Greacen, Siyambalapitiya, & Knuckles, 2014). A framework consisting of standardized PPA, tariff methodology, process guidelines with standardized forms, process rules, and interconnection guidelines have been developed. The regulatory framework was developed consciously to streamline the process of developing SPPs by removing the need for negotiation and regulatory review of tariff, to reduce transaction and administrative costs. Under the EWURA regulations, an SPP is defined as a power plant that uses a renewable energy source with an export capacity of between 100 kW and 10 MW (Mtepa, 2014). Due to their proximity to electricity customers, and sometimes their position as the sole electricity source in a particular community, SPPs in Tanzania can bypass the monopoly of TANESCO in transmission and distribution and sell power directly to end-users." (Poudineh 2016) p. 35

When TANESCO is the off-taker, the tariff is based on avoided cost. When end-users are the off-taker, the developer submits an application to EWURA for a cost-based tariff.[8] If or when small power producers are connected the to national grid they can convert to power purchase agreements. There are 150 MW of capacity in the pipeline. (Poudineh 2016) p. 35

[8] SPPs are allowed to propose their own tariffs but are subject to EWURA approval. The tariffs may be higher than TANESCO's national tariff if the cash flow data indicates it reflects prudent costs, including operating costs, capital depreciation, debt payments, reserves for emergency repairs, and a reasonable return on investment. No EWURA tariff approval is necessary if the electricity is sold to "eligible customers," a category that was once defined as customers with a peak load of 250 kVa or higher but currently is undefined. Tanzania Solar Power Purchas Agreements (PPA) with private off-takers in Tanzania – an analysis of the regulatory and legal framework for Special Purpose Companies (SPC), Federal Ministry for Economic Affairs and Energy, GIZ, November 2015, P. 16 (https://www.giz.de/fachexpertise/downloads/2016-en-pep-ssa-tz-solar-ppa-private-offtaker.pdf)

28% of households are estimated to have access to electricity (Africa-EU Renewable Energy Cooperation Program (https://www.africa-eu-renewables.org/market-information/zambia/energy-sector/)

5.2 power outages in firms in a typical month (World Bank 2013 https://data.worldbank.org/indicator/IC.ELC.OUTG?locations=TZ)

85.6% of firms experienced electrical outages during the previous fiscal year. 2013 (https://data.worldbank.org/indicator/IC.ELC.OUTG.ZS?locations=TZ)

The regular blackouts force many business to invest in backup power generation, increasing their capital and investment costs and decreasing their competitiveness. College students rioted in 2016 over load shedding.

## ZAMBIA

Zambia has low access to electricity. Its tariffs are among the lowest in Africa but high connection fees are a barrier to access. Zambia is dependent on hydropower and is forced to shed load during droughts. Zambia has an official target of 51 percent rural electricity access by 2030. Industries, rather than households, currently reap most of the benefit from electricity subsidies.

ZESCO is migrating to cost-reflective tariffs with the intention to eliminate government subsidies. This will allow the government to redirect money currently spent on subsidies to other purposes and is intended to attract private sector investment in electricity. In 2017 ZESCO applied to the Energy Regulation Board for a 75 percent tariff increase, to begin with a 50 percent increase in May and the remaining 25 percent in September 2017. It was approved.

Table 2: Current ZESCO Tariffs (ZESCO n.d.)

Note: Does not include 3% excise duty or 16% VAT

| Type of Customer | Type of fee | Unit | Cost | MTZ | $ |
|---|---|---|---|---|---|
| Residential Prepaid up to 200 kWh | Service | ZMK@ monthly | - | - | - |
| | Usage | ZMK /kWh | .15 | 0.93 | .015 |
| | Capacity | ZMK /kVA/monthly | - | - | - |
| Residential Prepaid above 200 kWh | Service | ZMK @ monthly | 18.23 | 113.5 | 1.85 |
| | Usage | ZMK/kWh | .15 | 0.93 | .015 |
| | Capacity | | - | - | - |
| Commercial (Capacity 15 kVA) | Service | ZK monthly | 96.41 | 600.62 | 9.81 |
| | Usage | ZK /kWh | .54 | 3.36 | .05 |
| | Capacity | ZMK /kVA/monthly | - | - | - |
| Social Services Tariffs | Service | ZMK monthly | 83.84 | 522.31 | 8.53 |
| | Usage | ZMK /kWh | .49 | 3.05 | .05 |

| | | | | | |
|---|---|---|---|---|---|
| (Schools, Hospitals, Orphanages, Churches, Water pumping, Street lighting) | Capacity | ZMK /kVA/monthly | - | - | - |
| Maximum Demand Tariffs | | | | | |
| Capacity between 16-300 kVA | Service | ZMK /monthly | 239.44 | 1,491.67 | 24.36 |
| | Usage | ZMK /kWh | .35 | 2.18 | .04 |
| | Off Peak Usage | ZMK /kWh | .26 | 1.62 | .03 |
| | Peak Usage | ZMK/kWh | .44 | 2.74 | .04 |
| | MD Fee | ZMK /kVA/Month | 24.45 | 152.32 | 2.49 |
| | Off Peak MD Fee | ZMK/kVA/Month | 12.22 | 76.51 | 1.24 |
| | Peak MD Fee | ZMK/kVA/Month | 30.56 | 191.34 | 3.11 |
| Capacity between 301-2,000 kVA | Service | ZMK/monthly | 478.84 | 2983.09 | 48.71 |
| | Usage | ZMK/kWh | .3 | 1.87 | .03 |
| | Off Peak Usage | ZMK/kWh | .23 | 1.43 | .03 |
| | Peak Usage | ZMK/kWh | .37 | 2.31 | .04 |
| | MD Fee | ZMK/kVA/Month | 45.73 | 284.89 | 4.65 |
| | Off Peak MD Fee | ZMK/kVA/Month | 22.87 | 142.48 | 2.33 |
| | Peak MD Fee | ZMK/kVA/Month | 57.17 | 356.16 | 5.82 |
| Capacity between 2,001-7,500 kVA | Service | ZMK/monthly | 1,014.55 | 6320.47 | 103.21 |
| | Usage | ZMK/kWh | .25 | 1.56 | .03 |

| | | | | | |
|---|---|---|---|---|---|
| | Off Peak Usage | ZMK/kWh | .18 | 1.12 | .02 |
| | Peak Usage | ZMK/kWh | .30 | 1.87 | .03 |
| | MD Fee | ZMK/kVA/Month | 2,029.13 | 12641.12 | 206.42 |
| | Off Peak MD Fee | ZMK/kVA/Month | 36.52 | 227.51 | 3.72 |
| | Peak MD Fee | ZMK/kVA/Month | 91.33 | 568.97 | 9.29 |
| Capacity above 7,501-10,000 kVA | Service | ZMK/monthly | 2,029.13 | 12,641.12 | 206.42 |
| | Usage | ZMK/kWh | .21 | 1.31 | .02 |
| | Off Peak Usage | ZMK/kWh | .16 | 1 | .02 |
| | Peak Usage | ZMK/kWh | .25 | 1.56 | .03 |
| | MD Fee | ZMK/kVA/Month | 73.47 | 457.71 | 7.47 |
| | Off Peak MD Fee | ZMK/kVA/Month | 36.73 | 228.82 | 3.74 |
| | Peak MD Fee | ZMK/kVA/Month | 91.84 | 572.15 | 9.34 |

Exchange rate ZMK to MTZ14 February 2018, ZMK to USD 15 February 2018

(ZMK = Zambian kwacha, MZN = Mozambican metical)

Other customers are divided according to capacity needs, with declining energy costs as energy consumption increases. It is cheaper to serve larger customers, on a per kWh basis, than smaller customers. However, as usage increases, the fixed monthly fee increases. Given that larger users necessitate more infrastructure investment in total than smaller customers, this is in keeping with the Boiteux principle. As capacity needs increase, the demand fee, in Zambia called "maximum demand" or MD, increases. For each MD customer there is a division between a single price for usage and capacity and off-peak and on-peak rates. Enterprises with time-of-use meters can avail themselves of the differential pricing, providing an incentive to shift the timing of loads.

## SOUTH AFRICA

In 2006 Eskom offered the second lowest residential taiff of the 33 countries surveyed by the International Energy Agency. (Deloitte 2017) p 61. Comparison with other countries generating sources and tariffs indicates subsidization, despite sharp increases in electricity prices. While South Africa has the highest electrification rate in Africa, the electricity supply is unreliable. The recession in 2009 resulted in decreased demand and Eskom used peaking stations even during off-peak times. By 2015 these measures were insufficient and South Africa had regular power outages that threatened the country's economy. Eskom required a massive government bailout. As of 2017 the country had a surplus and is planning to close some plants.

> 86% of households had access to electricity in 2014 (https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZA
>
> Eskom has enough supply that load shedding is no longer needed. Outages are due to faults on local distribution grids. Due to poor municipal maintenance, many communities in South Africa have electricity but it is unreliable.

Some electricity is distributed directly by Eskom. Some is distributed by municipalities. Lack of institutional capacity and lack of spending on operation and maintenance have resulted in a decline of reliability in the municipal distribution infrastructure. There are also numerous municipalities in default, at risk of Eskom cutting off electricity. The electricity regulator's authority to regulate tariffs charged by municipal distributors is unclear. Each municipality has a different tariff structure. Discrepencies in tariff rates cause some South Africans to enjoy low prices and others to face high rates for a developed country.

The tariffs for Mozambique, Tanzania, and Zambia fit into a one to two page table. The ESKOM schedule of standard prices are covered in a 46 page document that can be found at http://www.eskom.co.za/CustomerCare/TariffsAndCharges/Documents/Eskom%20schedule%20of%20standard%20prices%202017_18%2015_02_2017%20(00).pdf. Eskom has "free basic electricity," and service, usage, and demand fees, but goes much further. The South African system alters tariffs not only for time-of-use into peak or off-peak but into Nightsave Urban Large, Nightsave Urban Small, and Nightsave Rural, and includes rates for public holidays. Customers are categorized as urban (not residential), rural, residential, and municipalities or redistributors. The urban category has seven tariff plans. There are five rural tariff plans, and three residential-in-urban-areas plans. South Africa has elected precision over simplicity, a decision that increases administrative complexity and decreases the likelihood that customers can understand the basis for electricity rates.

## MAURITIUS

99.2% of households had access to electricity in 2014 (World Bank n.d.)

In 2014 Mauritius had only 6% line losses (World Bank n.d.). Current system losses are published online at http://ceb.intnet.mu/ and show only 6.27% system losses.

1.2 power outages in firms in a typical month in 2009 with an average duration of 3.2 hours (World Bank n.d.) Current reliability figures are published online at http://ceb.intnet.mu/ and show less than one outage a month.

Average losses as a percentage of annual sales due to electrical outages were 2.2% in 2009. (World Bank n.d.)

In 2017 the government established a Utility Regulatory Authority to regulate electricity, water, and waste water. An Energy Efficiency Act requires labeling for the import of energy efficiency equipment. The Central Electricity Board (CEB) is is responsible for transmission, distribution, and sale of electiricity. It produces 40% of the country's power and purchases 60% from IPPs. Most of these IPPs are in the sugarcane industry. To reduce the reliance on imported fuels the government is working to increase the use of renewable energy. In 2016 it created the Mauritius Renewable Energy Agency. Mauritius intends to use bagasse, hydro, wind, landfill gas, and solar.

CEB's sole source of revenue is the electricity tariff and there is full cost-recovery. There is cross-subsidization. CEB considers this a weakness but wishes to avoid tariff shocks from significant adjustments to the tariffs. Mauritius uses the accounting approach to setting tariffs, allocating all costs to each business unit and then allocating them to different voltage levels and then to different customer categories. The objectives are to

- ensure efficient allocation of resources
- price electricity for efficient usage
- keep CEB financially viable
- treat customers equitably
- achieve simplicity and stability in pricing (Central Electricity Board n.d.)

CEB does offer a social tariff for qualifying customers but otherwise works to eliminate subsidies and to price according to cost. The proportion of the poor in Mauritius is 8.7%[9] which makes a social tariff easier for the rest of the system to bear.

The tariffs are not simple enough to be placed in one table, but the tariffs for each category are comprehensible and explained on the CEB website at http://ceb.intnet.mu/tariffs/Overview.asp. Tariff categories are domestic, commercial, industrial, sugar factories, street lighting and traffic lights, irrigation, and temporary supply. There is a social tariff for customers

- receiving governement allowance,
- registered by the National Empowerment Foundation, or
- registered with the CEB and having a minimum of six consecutive months of consumptions less than 85 kWh on average and no month exceeding 120 kWh.

[9] https://www.ifad.org/

This criteria allows a lifeline tariff but is more administratively complicated, for the government and for the CEB, than simply offering a lifeline tariff for those using less than a specified amount. For other domestic customers the rates increase with use in a progressive manner.

There are five commercial tariff categories. Three of them have usage and demand fees. All have a minimum fee. There are nine industrial tariff categories. All but one category pays a usage and demand fee with a minimum fee. Some categories are able to take advantage of time-of-use pricing which is based on specific times of day and thus can be predicted and scheduled around. There are two categories for sugar factories. One category provides a usage fee for restricted hour supply. The other provides a lower usage fee but includes a demand fee based on the capacity needed. The irrigation tariff offers peak and off peak rates with the hours specified. This tariff schedule presents a balance of attempting to be cost-reflective and to keep the schedule simple. It also presents a balance of cost-reflective tariffs with social tariffs.

# CONCLUSION

Access to electricity is key to development and quality of life, influencing education, health services, and the ability for businesses to establish themselves, grow, and hire employees. Lack of reliable electricity impacts communication, governance, and people's attitudes towards their lives. Electricity allows businesses to produce more, at higher quality, at lower prices. Even very small amounts of electricity dramatically improve the quality of life in households by allowing electric lights, radios, fans, and the powering of mobile phones. Households that cannot afford even basic lighting benefit when the community provides street lighting and the schools and health clinics can offer better services at later hours.

Unreliable power results in lost production, rotten food, and spoiled vaccines. Businesses are shut down and wages are unpaid. Small firms lose annual output, larger firms have higher costs because they must invest in back-up generators that supply electricity at much higher prices.

The nearest example of a country with an extended history of cost-reflective tariffs is Mauiritius. Every other regional country has, at least until recently, subsidized electricity at some point in its value chain which led to insufficient investment in generation, transmission, and/or distribution. Either the lack of investment was in capacity or in operation and maintenance, but the end result is unreliable electricity. South Africa has a high electrification rate but even there the unreliability of the electricity supply has damaged the economy.

To electrify an entire population, and to have their access be reliable, requires a financially healthy electricity sector. Experience from around the world has shown that electricity systems are only financially secure if they have full cost-recovery. Subsidies from external sources are unreliable and therefore, if electricity is subsidized for one part of the population, it must be paid for by other electricity users. To attract private sector investment, this subsidization must be viewed as secure. If the subsidies come from outside the electricity system, such as from the government or from donors, they are viewed as less secure and will have a negative impact on private investment, either dissuading it entirely or raising the cost of capital and thus the end user cost of electricity.

Social tariffs are common. In fact, every country reviewed for this document has a subsidized tariff for the lowest level of consumption. The greater the total cost of the subsidy, the greater the burden on other rate-payers.

Principles of sound tariff setting include:

- Fair allocation among customers according to the burdents they impose on the system
- Price stability and the avoidance of large fluctuations in price
- A minimum level of basic service provided to those who cannot afford it
- Sufficient revenue for the utility to be financially sustainable
- Administrative efficiency

As some objectives contradict each other, tariff setting is always a balancing act. To help achieve the Boiteux principle of those who cause a cost to be incurred to be the ones paying for it, tariffs are based on usage, demand, and service fees. The allocation of costs to these fees can be done using the long run marginal cost approach or the accounting approach. The accounting approach is simpler and more appropriate for a sector such as electricity.

Given the vital role that electricity plays, it is appropriate to regulate off-grid electricity, but the regulation must not become so burdensome that it increases costs to the point that regulation to protect customers ensures they cannot get access. The tariff for on-grid electricity does not have to equal the tariff for off-grid electricity. The country that is viewed as having the most effective off-grid investment promotion is Tanzania. Tanzania worked to reduce transaction and administration costs with a standardized PPA, tariff methodology, process guidelines with standardized forms, process rules, and interconnection. These reduce transaction and administrative costs by removing the need for negotiation and regulatory review of tariffs.

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