Rwanda: Electricity Tariff Reform

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Internal political stability, policy reforms, and foreign aid have helped Rwanda stage a remarkable economic recovery over the decade since the genocide. Real GDP growth averaged more than 7 percent per annum over the period 1998–2002, slowed to 3 percent in 2003, and is estimated to be around 4 percent in 2004 and 6 percent over 2005–7. Despite the growth in GDP, however, poverty remains widespread (Government of Rwanda 2002; World Bank 2003), and infrastructure bottlenecks have emerged as a significant constraint to continuing economic growth and human capital development. This is the case for the energy sector, especially the provision of electricity, which is currently in a state of crisis. The objective of this chapter is to document this crisis, explain the need to increase electricity tariffs, and—most importantly—assess the impact of such an increase on the poor and also analyze the distributive properties of alternative tariff structures.

ELECTRICITY IN RWANDA: CURRENT CONTEXT

The modern energy sector in Rwanda is very small. Wood and charcoal remain the most significant—and often the only—fuels available to households and the productive sectors of the economy. Most of Rwanda's electricity has traditionally come from hydroelectric power produced domestically, along with imports from Sinelac (which is a utility owned jointly by Rwanda, Burundi, and the Democratic Republic of Congo) and SNEL (a utility company from the Democratic Republic of Congo). Electrogaz, Rwanda's main energy provider, provides service to fewer than 70,000 customers or about 7 percent of the households (nearly two-thirds of them in Kigali alone). Peak electricity demand—which is currently not being met—is about 50 to 55 megawatts. Grid extension beyond the urban areas has been extremely limited. At about 20 to 25 kilowatts per year, per capita consumption of electricity in Rwanda is among the lowest in the world. Electrogaz is in a difficult situation because strong demand growth is combined with unexpectedly low lake levels in both domestic and shared hydropower sources. The financial situation of Electrogaz is also problematic, and supply shortages and unreliability (there have been extensive and lengthy power cuts beginning in early 2004) have raised the cost of doing business for firms in Rwanda and weakened the prospects of attracting new investments.

Rwanda is facing a severe electricity crisis because of increased demand and production costs coupled with reduced revenues over time in real terms per kilowatt-hour distributed. The government's strategy has been to respond to the twin objectives of extracting the sector from its crisis situation and establishing a sound basis for future growth and development. Over the medium term, the government intends to establish policies and institutional frameworks that would create incentives for developing indigenous energy resources, ensuring the sustainable and efficient performance of sector entities, and increasing access to electricity and enhancing the flow of investments, both from development partners and from the private sector. In the near term, the government intends to use a transition strategy to address the power shortage by investing in thermal generation and by reviving the performance of Electrogaz. Finally, immediately, the government's focus has been on raising electricity tariffs to increase revenues for Electrogaz and avoid large deficits in the sector.

Objectives and Findings of this Analysis

A doubling of electricity tariffs was recently approved, from a flat rate of 42 Rwanda francs (RF) per kilowatt hour to a flat rate of RF 81.25 per kilowatt hour. The new tariff became effective in January of 2005. However, the new flat rate may not be appropriate for protecting some of the poorer residential customers of Electrogaz from the increase in the level of electricity tariffs. This chapter provides simulations for the distributional properties of alternative tariff designs, including an interesting Inverted-U Block Tariff Structure (IUBT) proposed by Electrogaz. In the next section of this chapter, which is based on material prepared for the Urgent Electricity Rehabilitation credit recently granted to Rwanda (World Bank 2004), we document the current state of crisis of the electricity sector and its origins, and explain the need for the upward revision of electricity tariffs. In the subsequent section, which closely follows a framework for the analysis of utility tariffs proposed by Angel-Urdinola and Wodon (2005), we assess the distributional characteristics of alternative potential tariff structures using recent household survey data.

It is important to note that this chapter was prepared as part of broader work at the World Bank on Rwanda's energy sector. This work includes the Urgent Electricity Rehabilitation credit, which has a detailed discussion of the difficulties encountered in the electricity sector (World Bank 2004), and a second Poverty Reduction Strategy Grant or PRSG II (World Bank 2005), which was approved by the Bank's board in November 2005 and includes further measures related to this sector. Specifically, one of the triggers for the PRSG III (that is, one of the measures that should be implemented by the authorities to benefit from a third PRSG) is the passage of electricity and gas legislation that includes tariff reform in order to improve energy sector performance.

Our findings in this chapter can be summarized as follows. Because few people have access to the electricity network, the share of the implicit subsidies that prevailed before the increase in tariff and that benefited the poor was very low. Today, consumption subsidies are still likely to be badly targeted to the poor, and the IUBT proposal would improve targeting performance slightly. Nevertheless, the IUBT tariff structure is less pro-poor than a volume-differentiated tariff (VDT) would be. Furthermore, if substantial subsidies (or cross-subsidies) were to be implemented in the future, it would probably be more effective from a poverty reduction point of view to give priority to subsidies for new connections to the network for the poor rather than providing subsidies for consumption for those households already connected. Yet there may still be some benefit to also providing some level of protection for households that are already connected and that consume small amounts of electricity, especially if such protection is not too expensive and if a careful analysis of the distributional properties of the proposal is carried out.

Rwanda's Electricity Sector: A Brief Review

In 2003 and in 2004, Rwanda's demand for energy was about 50 to 55 megawatts per year. However, domestic power generation facilities consist of only four hydroelectric plants that together can produce about

28.6 megawatts per year. The largest two of these plants (with a combined capacity of about 24 megawatts) are based on interconnected lakes, the levels of which have declined precipitously in recent years. As a result, energy demand is not being met and the country is critically dependent on imports of modern energy sources. Petroleum products are transported from Mombasa in Kenya via pipelines to Eldoret in Uganda, then by road to Kigali and elsewhere in the country (which introduces very high transportation costs and several duties and taxes).

In 2004, on average, about 20 percent of the peak demand and energy requirements were not met. The lack of energy was more severe during the dry period of August/September 2004, when as much as 50 percent of the energy requirements during peak hours were not met. The extent of hydroelectricity supply shortfall in the face of growing demand is expected to continue for several years.

Apart from weaknesses in production, the national transmission and distribution network is small and dilapidated. Some of the network was damaged during the civil war period (in 1994), but all of it suffers from inadequate maintenance, compounding the bulk supply problems. Technical and nontechnical physical losses—the difference between energy sent out and energy billed—were about 25 percent in 2003. These losses are attributable mainly to poor network conditions and metering equipment, though there may also be a small amount of illegal use. Although investment requirements in network rehabilitation are high, only a small amount of urgent patchwork repair and replacement has been done. Over the next three years, it will be urgent not only that sufficient resources be made available for expanding overall capacity to meet demand growth, but also that Electrogaz revenues be adequate for financing the sharp increases in variable (fuel and other operating) costs of using new capacity.

Electrogaz is Rwanda's largest company. It is a 100 percent publicly owned utility for grid electricity and urban water supplies. Although national in scope, most of its distribution network and sales are concentrated in Kigali. Although the government abolished its legal monopoly on power distribution in 2000, it remains the only operator in the sector. A five-year management contract to Lahmeyer International has been in place since November 1, 2003. The government of Rwanda has postponed a decision on privatization of Electrogaz until the end of this management contract. Transforming Electrogaz into a well-run, commercially oriented utility is a major challenge. The success of the management contract with Lahmeyer depends on the availability of funding for system rehabilitation and expansion, and there have been delays in mobilizing the necessary resources. In addition, considerable effort has had to be devoted to addressing the ongoing power shortages on a crisis basis, which has hindered the longer-term task of system planning and improving Electrogaz's commercial performance.

Electrogaz is in a difficult financial situation. Revenue collection has been poor until recently, but this has apparently improved since new management took over in late 2003. More than half of all Electrogaz's customers—these are customers in both residential and commercial or government sectors, most of them in Kigali—are on pre-paid meters, contributing to advance payment on some 25 percent of the company's total sales. As with the supply infrastructure, there has been little new investment on the customer service end: meters, billing, and accounting systems are old and their reliability low. Still, the number of low-voltage customers has grown about 60 percent since 1997, at an average of 4,000 new connections per year.

Electrogaz's electricity and water tariffs were last revised in 1997. Since then there has been nearly 50 percent real decline in electricity tariffs in U.S. dollar terms—from about US$0.150 per kilowatt hour in 1997 to about US$0.072 per kilowatt hour in 2004. During this period, imports from the jointly owned company Sinelac increased rapidly. Largely because of its high lending terms and capitalization of debt service, Sinelac tariffs have reached levels that cannot reasonably be passed through to the customers. Electrogaz had a flat tariff of RF 42 per kilowatt hour (before 18 percent value added tax [VAT]) charged to all customers, irrespective of type of activity, individual supply voltage or consumption volumes from mid- to late 1997 to end-2004, when it was revised to a flat tariff of RF 81.25 per kilowatt hour. The flat tariff structure limits the ability to target effective cross-subsidies to existing and prospective low-volume/poor household customers.

Background and Objective of this Analysis

In recent negotiations between the World Bank and the Government of Rwanda on a credit to the country for urgent electricity rehabilitation, financial cost recovery objectives were agreed upon. The terms of the agreement specify that during fiscal 2005 and 2006, cash revenues from sales should be sufficient to cover cash operating expenses. Thereafter, during fiscal 2007, cash revenues from sales should be sufficient to cover cash operating expenses and debt service. Finally, effective in fiscal 2008, Electrogaz should set tariffs such that cash revenues from sales should be sufficient to cover cash operating expense, debt service, and 25 percent of the investment program during that year.

In setting these targets, it was assumed that Electrogaz would be exempted from all taxes on generation fuels. Thus, the tariff adjustments have been designed to enable Electrogaz to meet its financial objectives in the respective years. In practice, as a temporary measure, a doubling of electricity tariffs was recently approved, as mentioned earlier. The rate rose from a flat rate of RF 42 per kilowatt hour to RF 81.25 per kilowatt hour.

More recently, the Bank and the authorities of Rwanda agreed that a trigger for the next Poverty Reduction Support Grant (PRSG III) would be the adoption by the authorities of electricity and gas legislation that would include tariff reform to improve energy sector performance. The question now is which new tariff structure would be appropriate, and whether the new proposals for an IUBT (discussed below) by Electrogaz make sense. In the next section of this chapter, we try to answer these questions by looking at the impact of the tariff structure on the poor using recent household survey data, and we also simulate the distributional characteristics of alternative tariff structures.

Before presenting our framework for analysis and key results, it is worth noting the limits of the exercise. Our objective was not to conduct a full Poverty and Social Impact Analysis (PSIA) as this analysis is traditionally understood. We did not have a request from the government to do such a full analysis, nor did we have funding for a large scale study. We aimed to provide a rapid appraisal of the main distributional features of alternative tariff structures, since this was the main issue to be acted upon by the authorities in order to complete the trigger for the PRSG III. We focused on a rapid benefit incidence analysis and, by extension, on a poverty impact analysis, without carrying out a social analysis of the potential impact of the reforms. For example, we did not conduct any stakeholder analysis, nor did we conduct qualitative work on the perceptions of key stakeholders, especially the poor, of the tariff reform. We also did not carry out institutional work on the capacity constraints for implementing specific policy proposals.

Most of the results provided here were presented at a workshop in Kigali in March 2005. The workshop was organized jointly by the World Bank and the Rwandese government unit in charge of the preparation, implementation, and revision of Rwanda's Poverty Reduction Strategy. One of the sessions of the full-day seminar was devoted to electricity tariffs, with representation from the management of Electrogaz. The work that had been prepared by the Bank team for that session focused on comparing the flat tariff structure existing in Rwanda at the time with traditional inverted block tariffs (IBTs) and volume-differentiated tariffs (VDTs). As discussed in Komives et al. (2005), IBTs are typically based on the assumption that poorer consumers have lower levels of consumption, so that reduced tariffs at low levels of consumption provide a higher degree of affordability for the poor, while supposedly targeting only the poor in so doing. Thus it is often believed that subsidies are not provided to other classes of customers who consume higher levels of electricity and presumably have the means to pay the full cost for it. But the problem with IBTs is that all customers benefit from the lower price for the first bracket(s) of consumption, and this leads to high leakage of the implicit or explicit subsidies to the non-poor.

VDTs, the alternative to the IBTs, provide the lower price at low levels of consumption to only those households that consume less than a given threshold. This threshold is often referred to as the *lifeline* level of consumption that should be affordable to all. In many countries, IBTs and/or VDTs have more than two levels of pricing for different blocks of consumers. It can then be shown that VDTs tend to be better targeted than IBTs, both of which have better distributional characteristics than flat tariff rates such as the flat fee that had prevailed in Rwanda for many years. This was also the case in Rwanda, and these were the results that were presented by the Bank team. Unfortunately, as pointed out by the seminar participants, VDTs have one weakness: they imply a discontinuity in the amount of the bill for the customer. For example, assume that the lifeline is set at 40 kilowatt hours per month per household, that a lower price per kilowatt hour applies to households with consumption levels below that lifeline, and a higher price applies to all households where the consumption level is above the lifeline. This means that a household consuming 40.5 kilowatt hours per month will have a much higher bill than the household consuming only 39.5 kilowatt hours, although both households may be equally poor. In addition, some households might move from one price to another depending on their monthly consumption and the billing system.

The idea of the IUBT came from the staff of Electrogaz. Their proposal was to provide a reduced price on all consumption below 20 kilowatt hours, along with a price that is higher than the cost-recovery level for all consumption between 20 and 100 kilowatt hours. The price for units consumed above 100 kilowatt hours were to be set at cost-recovery level. This was an interesting idea because it aimed to recoup some of the subsidy provided in the lower bracket by requesting above-cost contribution in the middle bracket. Under some circumstances, this type of tariff structure can achieve a better targeting performance than a simple IBT, while also avoiding the discontinuity in price under VDTs. After the seminar, the Bank team estimated the extent of the difference engendered by the IUBT idea. These results are provided below, and then compared among other tariff structures with the targeting performance of a VDT.

THE DISTRIBUTIONAL PROPERTIES OF ALTERNATIVE TARIFF STRUCTURES

Our aim in this section is to provide a rapid appraisal of the distributional characteristics of alternative tariff structures. For this we use data from a household survey and a basic analytical framework proposed by Angel-Urdinola and Wodon (2005).

Data and Basic Statistics

The analysis in this section is based on data from the Integrated Household Living Conditions Survey (*Enquête Intégrale sur les Conditions de Vie des Ménages au Rwanda*) conducted by the National Statistical Office between October 1999 and July 2001. Data were collected between October 1999 and December 2000 in urban areas, and from July 2000 to July 2001 in rural areas. The estimates of poverty presented in Rwanda's Poverty Reduction Strategy suggest that 62 percent of the population is poor (Government of Rwanda 2002), with the poverty line set at 64,000 Rwanda francs per adult equivalent per year (the use of the equivalence scale implies that not all household members are considered to have the same needs). Only 10 percent of the population is considered to be living in urban areas, which is where access to the electricity network is concentrated.

Table 7.1 provides data on access to electricity in Rwanda's population (at the national level and in urban areas), as well as average consumption and expenditure for electricity. At the national level, access to electricity is virtually nonexistent in the bottom seven deciles of the distribution of consumption per equivalent adult essentially because access is not available in rural areas, where close to 90 percent of the population lives. This means that almost no one among the poorest 70 percent of the population at the national level has access to electricity. The distribution is different in urban areas, where access rates start to pick up in the third decile. However, according to the official poverty estimates in the country, because only 14 percent of the urban population is considered poor, access among the poor remains very low (as shown by the data for the bottom two deciles of the distribution of consumption per equivalent adult in urban areas). Note that the share of households paying for electricity is close to the share of households declaring in the survey that they use electricity. This suggests that the amount of fraud or illicit

Table 7.1 Electricity Access, Consumption, and Expenditure in Rwanda, 1999/2001

Decile expenditure per equivalent adult	*Total expenditure equivalent adult per month*[a]	*Household size per equivalent adult*	*Expenditure in electricity per equivalent adult per month*[a]	*Average kWh consumed per month per household*	*Access to electricity (%)*	*Share paying for electricity (%)*	*Access to electricity at the PSU level (%)*	*Take up rate (%)*
				National level				
1	1,333.38	5.78	0.00	0.00	0.00	0.00	4.08	0.00
2	2,172.59	5.88	0.00	0.00	0.00	0.00	5.08	0.00
3	2,751.59	5.78	0.00	0.00	0.16	0.00	4.42	3.63
4	3,321.85	5.57	0.00	0.00	0.00	0.00	4.58	0.00
5	4,007.26	5.54	1.16	0.33	0.54	0.47	4.53	12.01
6	4,829.01	5.22	0.10	0.01	0.20	0.08	8.86	2.23
7	5,811.95	5.23	1.16	0.20	0.54	0.39	7.99	6.73
8	7,270.61	5.42	11.72	2.30	3.29	3.29	13.70	24.01
9	9,861.02	5.18	30.75	5.30	7.85	7.12	21.79	36.00
10	23,798.89	5.41	248.45	34.00	39.94	33.49	63.04	63.35
				Urban areas only				
1	3,431.03	6.44	10.81	3.10	5.07	4.36	71.16	7.12
2	5,486.05	5.97	12.02	2.00	7.01	4.53	82.78	8.47
3	7,714.26	6.81	59.45	13.00	22.16	21.92	88.51	25.04
4	9,778.16	6.46	188.28	33.00	42.25	37.78	89.24	47.34
5	12,349.32	6.25	139.25	22.00	44.20	36.77	94.19	46.92
6	15,094.02	6.08	130.24	21.00	40.41	29.00	92.31	43.78
7	18,788.44	5.87	266.60	46.00	56.70	49.83	93.98	60.33
8	23,440.77	5.49	334.94	48.00	54.77	45.28	94.53	57.94
9	30,665.18	6.22	427.62	68.00	70.29	64.99	98.73	71.19
10	57,860.51	5.06	1,030.07	115.00	92.90	79.32	99.34	93.51

Source: Authors' calculations, based on Rwanda's EICV 1999/2001.
a. In local currency (Rwanda francs).

connections in Rwanda is relatively low (higher levels of fraud have been observed in other countries).[1]

Table 7.1 also shows that consumption levels are very low. In urban areas, in the first six deciles of the population, the average consumption is below 40 kilowatt hours per month, which is often considered as a possible lifeline level. Consumption is above 60 kilowatt hours per month only in the top two deciles. Total expenditure for electricity is also very low both in absolute terms and as a percentage of the total expenditure per equivalent adult of the households. This implies that an increase in tariffs would have only a very minor impact on poverty among households connected to the network. Therefore, instead of looking at the impact of tariff hikes on the poor (this impact would be negligible, especially at the national level, because most of the poor simply do not consume any electricity), we will look at the distributional properties of the implicit subsidies that existed until recently in Rwanda for electricity consumption. These subsidies are implicit because, although no cash is distributed directly to the consumers of the electricity, the cost of its production is higher than the price charged. We will then assess how different tariff structures would affect these distributional properties.

A Framework for Assessing the Targeting Performance of Consumption Subsidies

In order to analyze the distributional characteristics of electricity subsidies, we use the very simple analytical framework proposed by Angel-Urdinola and Wodon (2005; see also Komives et al., 2005, for an application of this framework to a large set of countries).[2] Our key parameter of interest is Ω, which is the share of the subsidies, implicit in the tariff structure, received by poor households and divided by the share of the poor in the population. In mathematical terms, this is

$$\Omega = \frac{S_P}{S_H} \times \frac{H}{P}, \qquad (7.1)$$

where S denotes the nominal implicit subsidies, subscript P denotes the population of poor people, and subscript H denotes the population as a whole, P denotes the number of poor households or individuals, and H represents the total number of households or individuals.

If Ω takes a value of 1, this implies that the subsidy is roughly neutral from a distribution and poverty point of view, so that the share of benefits going to the poor is equal to their population share. A value above (below) 1 implies that the program is somewhat pro-poor (not pro-poor), since the poor benefit from a larger (smaller) share of the total benefits than their population share.

In practice, many poor households in the population do not receive subsidies, and thus the value of Ω is usually less than 1. There are several reasons for this. First, access to networks may not reach poorer areas. If we denote access to networks by A, this means that in many cases $A_P < A_H$. Also, poor households, although they may have access to the networks, may be less likely than the population on average to use the services because they cannot afford to. If we denote the share of all households that have access to the service in their neighborhood and actually use the service as $U_{H|A}$, this would mean that $U_{H|A} < U_{P|A}$ in most cases. While $U_{H|A}$ represents the take-up rate of connections among those with potential access, $A_H \times U_{H|A}$ represents the actual household connection rate, with the same relationships for the poor (denoted by the subscript P).

Now denote the share of eligible utility service users who are beneficiaries of a subsidy by $T_{H|U}$. In Rwanda, since the consumption of all households was subsidized under the flat rate (before this rate was increased), all users received the subsidy and therefore $T_{H|P} = T_{H|U} = 1$. The share of households receiving the subsidy was equal to the share of all connected household times the share of households eligible for subsidy (that is, $A_H \times U_{H|A} \times T_{H|U}$). Similarly, the share of poor households receiving the subsidy is $A_P \times U_{P|A} \times T_{P|U}$. We will use below the variable B to capture this beneficiary incidence, so that:

$$B_H = A_H \times U_{H|A} \times T_{H|U} \tag{7.2}$$

$$B_P = A_P \times U_{P|A} \times T_{P|U} \tag{7.3}$$

A second important variable for assessing the targeting performance of subsidies is the rate of subsidization or the difference between what households pay per kilowatt hour of electricity and what it actually costs to produce, transmit, and distribute that kilowatt hour. Denote the average unit cost of producing, transmitting, and distributing the good by C. Then the average rate of subsidization is $R_{H|T} = 1 - E_{H|T} / (Q_{H|T} \times C)$, with $Q_{H|T}$ being the average quantity consumed by *subsidy recipients* and $E_{H|T}$ being their average expenditure on electricity. Again, these parameters can be estimated for the poor as a group (by using the subscript P instead of H). The average subsidy benefit per household receiving (and per poor household) in the population as a whole (and among the poor) can then be written as

$$\frac{S_H}{H} = B_H \times R_{H|T} \times Q_{H|T} \times C \tag{7.4}$$

$$\frac{S_P}{P} = B_P \times R_{P|T} \times Q_{P|T} \times C \tag{7.5}$$

The benefit targeting performance indicator Ω, which again represents the share of the benefits of the subsidy obtained by the poor and divided by the share of the poor in the population is equal to

$$\Omega = \frac{A_P}{A_H} \times \frac{U_{P|A}}{U_{H|A}} \times \frac{T_{P|U}}{T_{H|U}} \times \frac{R_{P|T}}{R_{H|T}} \times \frac{Q_{P|T}}{Q_{H|T}} \tag{7.6}$$

Thus five ratios determine the value of the overall performance parameter Ω: access, uptake, targeting, rate of subsidization, and quantity consumed. The ratio of access rates (*A*) will in most cases be lower than 1 simply because the poor tend to live in areas without access to electricity. The usage or take-up ratio (*U*) will also be less than 1 if the cost of connecting to the network is high for the poor, or if they live farther away from the grid even when there is access in their neighborhood. This means that the product of the *R* and *Q* ratios must be greater than 1 for the subsidy to be progressive. As we will see, in Rwanda (and as has been observed elsewhere), this is rarely the case.

Analyzing Empirical Results for Consumption Subsidies in Rwanda

We analyze the targeting performance of three different types of subsidies or tariff structures: inverted block tariffs, volume-differentiated tariffs, and U-shape tariffs. Table 7.2 provides estimates of Ω at the national level and for urban areas using the official poverty line to define the poor. The benchmark case is the situation that existed before the doubling of tariffs at the end of 2004. At the national level for the benchmark case, Ω takes a value of 0.007, which is extremely low, suggesting that less than 1 percent of the subsidy (or lack of cost recovery) that existed before the increase in tariffs benefited the poor, even though the poor accounted for 62 percent of the population. When estimations are performed for urban areas only, the value of Ω increases to 0.035 but this is still very low, in part because of low official rates of poverty in urban areas (14 percent of the urban population).

The low values of Ω are driven by the comparatively low electricity connection rates among the poor compared with the connection rates of the population as a whole. There are lower access rates (A_P) in the neighborhoods where the poor live than the overall access rate (A_N), and lower take-up rates where there is potential access among the poor U_P than the overall take-up rate (U_N). Because all households that were connected to

Table 7.2 Distributional Characteristics of Alternative Tariff Structures

Parameter	Benchmark flat tariff (price = 42 Rwanda francs/kWh)	Inverted block tariff			Volume-differentiated tariff			Perfect Targeting
		L = 20 kWh	L = 40 kWh	L = 50 kWh	L = 20 kWh	L = 40 kWh	L = 50 kWh	
				National: Absolute poverty definition				
A_H	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
A_P	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
$U_{H\|A}$	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
$U_{P\|A}$	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
$T_{H\|U}$	1.00	1.00	1.00	1.00	0.06	0.30	0.45	0.01
$T_{P\|U}$	1.00	1.00	1.00	1.00	0.63	0.72	0.72	1.00
$R_{H\|T}$	0.48	0.11	0.20	0.23	0.48	0.48	0.48	0.48
$R_{P\|T}$	0.48	0.17	0.25	0.28	0.48	0.48	0.48	0.48
$Q_{H\|T}$	88.26	88.26	88.26	88.26	13.15	25.43	32.74	38.46
$Q_{P\|T}$	38.46	38.46	38.46	38.46	10.11	11.83	11.83	38.46
A	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
U	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
T	1.00	1.00	1.00	1.00	10.58	2.41	1.58	101.52
R	1.00	1.62	1.27	1.23	1.00	1.00	1.00	1.00
Q	0.44	0.44	0.44	0.44	0.77	0.47	0.36	1.00
Ω	0.007	0.012	0.009	0.009	0.138	0.019	0.010	1.726
				Urban areas: Absolute poverty definition				
A_H	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
A_P	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
$U_{H\|A}$	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
$U_{P\|A}$	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
$T_{H\|U}$	1.00	1.00	1.00	1.00	0.05	0.28	0.42	0.01
$T_{P\|U}$	1.00	1.00	1.00	1.00	0.63	0.72	0.72	1.00
$R_{H\|T}$	0.48	0.10	0.19	0.22	0.48	0.48	0.48	0.48
$R_{P\|T}$	0.48	0.17	0.25	0.28	0.48	0.48	0.48	0.48
$Q_{H\|T}$	92.49	92.49	92.49	92.49	12.73	25.11	32.54	38.46
$Q_{P\|T}$	38.46	38.46	38.46	38.46	10.11	11.83	11.83	38.46
A	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81
U	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
T	1.00	1.00	1.00	1.00	11.78	2.60	1.72	90.78
R	1.00	1.69	1.33	1.27	1.00	1.00	1.00	1.00
Q	0.42	0.42	0.42	0.42	0.79	0.47	0.36	1.00
Ω	0.035	0.060	0.047	0.045	0.794	0.104	0.053	7.699

Source: Authors' calculations, based on Rwanda's EICV 1999/2001.
Note: Simulation uses standard definition of the poor using the consumption aggregate and the official absolute poverty line. Absolute poverty line = 65,145 Rwanda francs per equivalent adult per year. Unit cost is 81.25 Rwanda francs per kilowatt hour. L = lifeline.

the network benefited from the low tariff rate before the increase in tariff, the targeting parameters T_P and T_N were both equal to 1. Finally, the low value of Ω was also a result of higher consumption levels among the connected population as a whole (who therefore benefited more from the below-cost flat rate) than the consumption levels among the poor.

Table 7.2 also provides results from various simulations. We first consider inverted block tariff structures with two brackets, so that consumption below and above the lifeline—the threshold for the lower consumption bracket, denoted by L in the table—have different costs per kilowatt hour. Lifelines of 20, 40, and 50 kilowatt hours are considered. In addition, we also simulate the value of Ω under volume-differentiated tariffs for small customers. With this structure, only those who consume less than the lifeline reap the benefit from the lower cost per kilowatt hour. When simulations are conducted at the national level, none of the scenarios generates a high value for Ω. In urban areas, Ω takes a significantly higher value only for the volume-differentiated tariff and a lifeline of 20 kilowatt hour. In this case, the value of Ω is 0.79, which is better, but implies that the poor still benefit less than the population as a whole from the implicit subsidy.

Additionally, table 7.2 provides simulations under which there is perfect targeting of the subsidy or special tariff to the poor. In practice, however, such perfect targeting cannot be achieved. These values should simply be considered as the best that could be achieved under perfect information and implementation given the current structure of connection rates. In fact, it is unclear whether a good proxy means-testing mechanism could and should be implemented in Rwanda's urban areas at this time, especially considering that poverty is much higher in rural areas.

In table 7.3, the simulations for the urban sample are reworked by considering that 40 percent of the urban population is poor. This is an arbitrary threshold, with poverty defined in relative terms and a much higher poverty headcount than occurs under the official measures of poverty. In a political economy setting, considering such alternative definitions of poverty in urban areas may be warranted by a desire to protect part of the connected population (which is located, for the most part, in urban areas) from the increase in tariffs. With this alternative definition of the poor, the value of Ω is 0.30 in the benchmark case. The value of Ω reaches 1.35 with the volume discount applied to the consumption below 20 kilowatt hours. Note that, with perfect targeting, increasing the population considered to be poor reduces the value of Ω.

Finally, we analyze results for the IUBT structure proposed by Electrogaz. This tariff structure assumes, as before, a cost of RF 81.25 per

Table 7.3 Distributional Characteristics of Alternative Tariff Structures in Urban Areas

Parameter	Benchmark flat tariff (price = 42 Rwanda francs/kWh)	Inverted block tariff L = 20 kWh	Inverted block tariff L = 40 kWh	Inverted block tariff L = 50 kWh	Volume-differentiated tariff L = 20 kWh	Volume-differentiated tariff L = 40 kWh	Volume-differentiated tariff L = 50 kWh	Perfect Targeting
	Urban areas: Relative poverty definition							
A_H	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
A_P	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
$U_{H\|A}$	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
$U_{P\|A}$	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
$T_{H\|U}$	1.00	1.00	1.00	1.00	0.05	0.28	0.42	0.18
$T_{P\|U}$	1.00	1.00	1.00	1.00	0.15	0.45	0.57	1.00
$R_{H\|T}$	0.48	0.10	0.19	0.22	0.48	0.48	0.48	0.48
$R_{P\|T}$	0.48	0.15	0.24	0.28	0.48	0.48	0.48	0.48
$Q_{H\|T}$	92.49	92.49	92.49	92.49	12.73	25.11	32.54	63.01
$Q_{P\|T}$	63.01	63.01	63.01	63.01	13.55	21.99	27.45	63.01
A	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
U	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
T	1.00	1.00	1.00	1.00	2.87	1.62	1.38	5.65
R	1.00	1.42	1.31	1.27	1.00	1.00	1.00	1.00
Q	0.68	0.68	0.68	0.68	1.06	0.88	0.84	1.00
Ω	0.30	0.43	0.39	0.38	1.35	0.63	0.51	2.50

Source: Authors' calculations, based on Rwanda's EICV 1999/2001.
Note: Simulation uses a relative poverty line that identifies 40 percent of the urban population as poor. Relative poverty line = 40 percent of households. Unit cost per kWh = RF 81.25/kWh. L = lifeline.

kilowatt hour. It also considers two thresholds: the lower price for fewer than 20 kilowatt hours and the baseline price for more than 100 kilowatt hours, with the middle consumption bracket priced at above-cost levels in order to recoup the subsidies provided in the lower bracket. As presented in table 7.4, this alternative structure increases the value of Ω over the value of the IBTs in table 7.3, but not by a lot (from 0.43 to 0.52, assuming a lifeline of 20 kilowatt hours). Additional results are provided in table 7.4 for alternative thresholds with the IUBT.

Apart from considering alternative tariff structures, there is another way to provide benefits to the poor: by providing connection subsidies instead of consumption subsidies. As seen above, consumption subsidies are often difficult to target well because of the role played by access and usage factors in attempting to channel subsidies to nonpoor households. With connection subsidies, access and usage factors

Table 7.4 Distributional Characteristics of the Proposed IUBT

Parameter	*Proposed block tariff structure*	*Simulation 1*	*Simulation 2*	*Simulation 3*	*Simulation 4*
	1.00	1.00	1.00	1.00	1.00
$T_{P\|U}$	1.00	1.00	1.00	1.00	1.00
$R_{H\|T}$	0.04	0.02	0.09	0.12	0.16
$R_{P\|T}$	0.07	0.04	0.12	0.17	0.21
$Q_{H\|T}$	92.49	92.49	92.49	92.49	92.49
$Q_{P\|T}$	63.01	63.01	63.01	63.01	63.01
T	1.00	1.00	1.00	1.00	1.00
R	1.72	2.22	1.46	1.35	1.30
Q	0.68	0.68	0.68	0.68	0.68
Ω	0.52	0.67	0.44	0.41	0.39

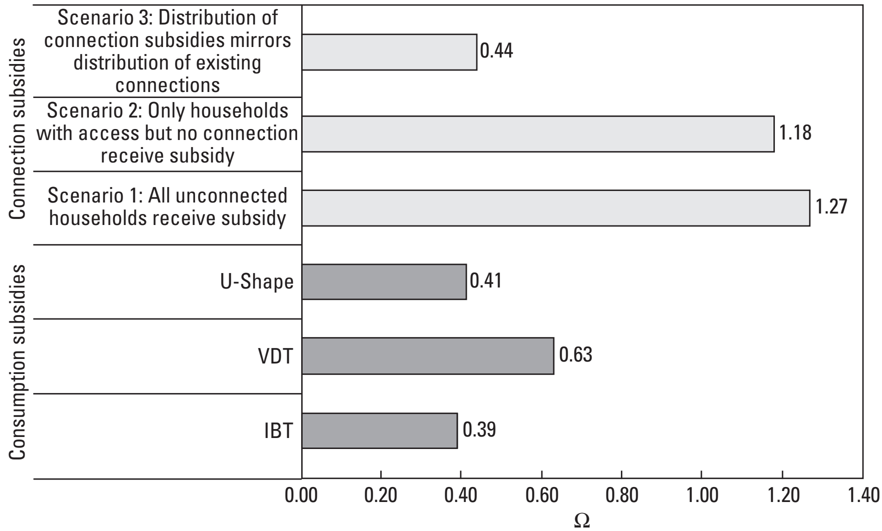
Source: Authors' calculations, based on Rwanda's EICV 1999/2001.
Note: Simulation uses the urban areas sample and the relative poverty measure. A and U parameters are equal to those in table 7.3. Relative poverty line = 40 percent of households. Unit cost per kWh = 81.25 RF/kWh.
Proposed block tariff structure: 0–20 kWh : P1 = 42; 20–100 kWh: P2 = 88; >100 kWh : P3 = 81. Simulation 1: 0–15 kWh : P1 = 42; 15–100 kWh: P2 = 88; >100 kWh : P3 = 81. Simulation 2: 0–30 kWh : P1 = 42; 30–100 kWh: P2 = 88; >100 kWh : P3 = 81. Simulation 3: 0–40 kWh : P1 = 42; 40–100 kWh: P2 = 88; >100 kWh : P3 = 81. Simulation 4: 0–50 kWh : P1 = 42; 50–100 kWh: P2 = 88; 100 kWh : P3 = 81.

can play in the other direction. Since the poor tend to not have access, they may benefit the most from connection subsidies. This is, however, not necessarily the case, because it depends on who exactly will receive the connection subsidy (this depends on how the extension of the network takes place).

The methodological details for considering different scenarios are explained in Angel-Urdinola and Wodon (2005). We present here the results from three scenarios:

- First, the households that receive connection subsidies are selected randomly from those households in population without a connection today, which—from a measurement point of view—would be the same as giving a connection subsidy to all the population not connected today (scenario 1 in figure 7.1).
- Second, the beneficiaries of the connection subsidy are selected from the population with access but without usage or take-up (scenario 2 in figure 7.1). This means that to benefit from access, households must not currently use the service but must live in an area where the service exists.

FIGURE 7.1 Connection versus Consumption Subsidies in Rwanda



Source: Authors, using Rwanda's EICV 1999/2001.

- Third, the beneficiaries of the connection subsidy have the same distributional characteristics as the households connected today because, for example, of a complete lack of targeting in the connection subsidy design and a low access rate. This lack or targeting and low access would essentially prevent the poor from participating in the benefits of the increase in connection rates that are made feasible by the connection subsidy.

The key results for the value of Ω in all three scenarios are presented in figure 7.1. They are compared with the values of Ω for consumption subsidies in the case where the lifeline is set at 40 kilowatt hours (the latest proposal of Electrogaz was to set the lifeline at 20 kilowatt hours, but the results are similar for alternative lifelines and can be found in tables 7.3 and 7.4). In all scenarios presented in figure 7.1, we have used the urban sample and the relative poverty line for the estimations.

Clearly, connection subsidies have the potential to be better targeted than consumption subsidies. This conclusion is similar to the one drawn by Estache, Foster, and Wodon (2002) in their review of the evidence for Latin America. But this may not be necessarily the case, however—it could depend on how the mechanism for providing eligibility for connection subsidies would be implemented in practice.

Indeed, although connection subsidies have promise, they need to be implemented well to ensure good targeting and limit costs. For example, in their study on social or subsidized water connections in Abidjan and Dakar, Lauria and Hopkins (2004) explain how social connections were financed through a water development fund paid for with a surcharge on water tariffs. Unfortunately, poor targeting resulted in 90 percent of residential connections in Abidjan being eligible for the subsidy. In fact, some of the connected households paying the surcharge were found to be poorer than many of the households receiving the new social connections. The program suffered from distorted incentives because the flat fees paid for each social connection to private operators were an incentive for those operators to maximize the number of subsidized connections while at the same time seeking for these social connections richer households that were likely to consume more water and were located closer to the pipes. In this way the utilities would reap higher revenues and minimize the cost of connecting in the first place. According to the authors, these distortions may in fact have led to reductions in connection rates or at least to an increase in the time needed to get connected among the poorest households located in informal settlements. The fact that the social connections required households to own the land on which their dwelling was located also probably undermined the targeting performance of the program. This example makes it clear that for connection subsidies as well as for consumption subsidies, a good design of the eligibility mechanism is required for the subsidy to actually reach the poor.

CONCLUSION

The electricity sector in Rwanda is currently in a state of crisis. The country is simultaneously experiencing a growing demand for electricity, rising costs resulting from the need to rely increasingly on thermal power generation in the near term, and, until recently, very low tariffs that had remained unchanged for seven years and did not permit the national operator Electrogaz to break even. The government has recently approved a near doubling of tariff rates; its present consideration of alternative tariff designs is part of an effort to protect the poor from this increase in tariffs.

The objective of this chapter has been to document the extent to which the poor did benefit from past subsidies (in the form of tariffs that were well below cost recovery rates), and to discover whether they would benefit from alternative implicit or explicit cross-subsidies. Because access rates to the network are very low among the poor, the share of the implicit subsidies that prevailed before the increase in tariff and that benefited the poor was also very low. In other words, previous subsidies were badly targeted. Today, because tariffs have been increased to cost-recovery level, there are no more implicit subsidies in Rwanda's tariff structure.

Still, the government is considering amending the tariff structure to protect poorer consumers, and Electrogaz has proposed an interesting IUBT structure to achieve this objective without compromising the objective of cost recovery. We have shown that, in Rwanda, the subsidies or cross-subsidies under the IUBT would be better targeted to the poor than those existing under the previous flat tariff structure. The IUBT performed only slightly better than a more traditional IBT, but less well than a VDT. It remains to be seen—by looking at other case studies for other countries—if, under other circumstances, the IUBT idea could be proven to have a stronger positive impact on the overall targeting performance of subsidies. Although the IUBT in Rwanda would have the advantage over the VDT of avoiding the discontinuities that exist in VDT systems between customers just below and just above the lifeline level, the targeting performance of the VDT was superior. Therefore the VDT is the structure that could probably be recommended for poverty reduction in Rwanda.

Another important result of our analysis was the finding that it would probably be better for poverty reduction to give priority to a subsidy mechanism for new connections to the network rather than a subsidy for consumption for those households that are already connected. Such a new-connection subsidy would enable more households to benefit from electricity (this has been proven to generate positive externalities for outcomes related to education and health, for example). It would target a population currently without access, which tends to be poorer than the population with access. In fact, recent trends in new connections show a strong demand from households and small commercial as well as institutional customers. Although in the near term Electrogaz bulk supplies and network and metering capacities are extremely constrained, once the Electrogaz capacities have been rehabilitated, there is a considerable potential for expanding the electricity market in the immediate proximity of its current distribution network.

Even if subsidies for higher rates of connection appear to be better targeted for poverty reduction (and perhaps for achieving other development objectives related to the Millenium Development Goals) than subsidies for consumption among users currently connected, it must be recognized that there would be benefits in providing at least some level of protection from higher tariffs for those households consuming small amounts of electricity. This level of protection would be important also for new and potentially poorer households that are newly connected to the network. If such consumption cross-subsidies were to be implemented, they could take place either in the form of VDTs or IUBTs as well as IBTs. A detailed evaluation of the different pricing alternatives would need to be considered, following the preliminary assessment provided here. It is relatively straightforward to use our framework to conduct such assessments with household surveys.

NOTES

1. Casual observations and discussions suggest that there is a considerable degree of "subsidiary connections," however, so that some agents (external to Electrogaz) extend lines to other households. These external agents extract higher unit prices for electricity than the prices they pay to Electrogaz.
2. For simplicity of exposition, we will assume throughout the rest of this chapter that households have a zero elasticity of demand to changes in prices. Given the very low levels of consumption recorded in the survey, and given the fact that households are unlikely to adjust their consumption downward significantly with an increase in prices, the elasticity is indeed likely to be low, so that the assumption is not likely to result in severe bias in the empirical results.

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