TRANSFORMING END-USE ENERGY EFFICIENCY IN BRAZIL

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EXECUTIVE SUMMARY

Total electricity consumption in Brazil grew from 38 terawatt-hours (TWh) in 1970 to 265 TWh in 1995, an average growth rate of about 8 percent per year. During 1995-98, electricity consumption rose 5 percent per year on average, leading to 307 TWh of total electricity use in 1998. Demand is growing most rapidly in the residential and commercial sectors. Electricity consumption per capita (2,242 kilowatt-hours [kWh] per year as of 1998) was about one-fifth of that in the United States.

The most recent Eletrobras decade plan estimates that electricity demand will continue to grow about 5 percent per year and will reach 494 TWh by 2007. If this forecast proves to be correct, around 35 gigawatts (GW) of additional installed capacity will be needed by 2007. Adding this amount of new capacity in less than a decade will be difficult and expensive. Also, it would result in substantial adverse environmental impacts from fossil fuel power plant emissions along with flooding caused by new hydro power plants. On the other hand, if demand continues to grow 5 percent per year and supply is not expanded by this amount, power shortages will occur. In fact the risk of black-outs and power shortages is increasing because the expansion of generating capacity has not kept up with demand growth in recent years. Improving the efficiency with which electricity is used in Brazil can help to ameliorate all of these problems.

This report describes the efforts undertaken to stimulate greater efficiency in the use of electricity, the results achieved, and strategies for achieving market transformation in Brazil. Market transformation means reducing barriers so that cost-effective energy efficiency measures are widely and routinely sold and used. Special attention is devoted to efforts to improve the efficiency of three end-uses—lighting, refrigerators, and motors.

NATIONAL ELECTRICITY CONSERVATION PROGRAM (PROCEL)

The government of Brazil established a national electricity conservation program known as PROCEL in December 1985. PROCEL is housed in Eletrobras, a national utility holding and coordinating company. Eletrobras/PROCEL works on both increasing end-use efficiency and reducing losses in electricity generation and T&D systems throughout Brazil. PROCEL operates by funding or co-funding energy efficiency projects carried out by state and local utilities, state agencies, private companies, universities, and research institutes. These projects pertain to:

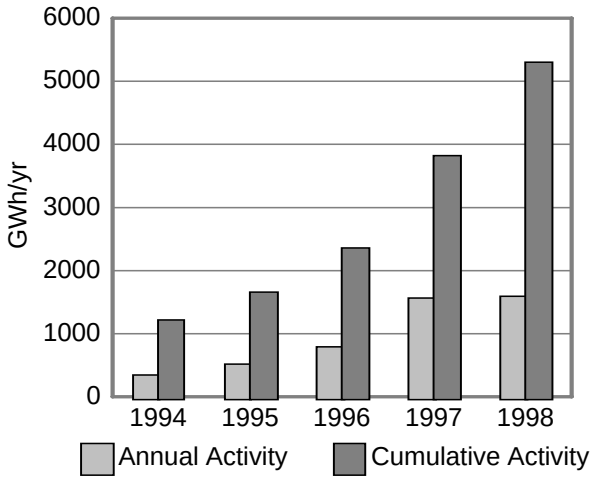
- research and development (R&D)
- demonstrations
- education and training
- testing, labeling, and standards
- marketing
- direct installation of conservation measures

- support for energy service companies (ESCOs) and other private sector actors
- legislation
- utility demand-side management programs.

Eletrobras/PROCEL also helps utilities obtain low-interest financing for major energy efficiency implementation projects from a loan fund known as the RGR.

PROCEL's expenditures, including low-interest loans and grants but excluding staff salaries and overhead, rose from less than $10 million in 1994 to around $50 million in 1998. PROCEL estimates that its overall efforts resulted in approximately 1.6 TWh per year of electricity savings in 1998 based on actions that year and 5.3 TWh per year of savings based on a cumulative activities (see Figure ES-1). The latter value is equivalent to 1.8 percent of total electricity consumption in Brazil. Approximately 33 percent of the savings came from improvements in refrigerator, freezers, and air conditioners; 31 percent from lighting efficiency improvements; 13 percent from installation of meters; 11 percent from motors projects; 8 percent from industrial programs; and 4 percent from other activities. In addition, Eletrobras/PROCEL took credit for approximately 1.4 TWh of additional power production in 1998 due to power plant improvements.

Figure ES-1: Trends in Electricity Savings in Brazil due to PROCEL's Activities



How significant are these savings and what do they mean for Brazil? The electricity savings and additional generation occurring in 1998 enabled utilities to avoid constructing approximately 1,560 megawatts (MW) of new capacity, meaning approximately US$3.1 billion of avoided investments in new power plants and T&D facilities. In contrast, Eletrobras/PROCEL and its utility partners spent approximately US$260 million on energy efficiency and power supply improvement projects during 1986-1998. Thus, from the utility sector perspective, PROCEL has achieved an overall benefit-cost ratio of approximately 12:1.

Recent Developments

Electric utility sector restructuring is occurring in Brazil, including privatization of many formerly government-owned utilities. At the same time, regulatory agencies are being established at both the federal and state levels. In July 1998, the new federal regulatory agency for the electrical sector (known as ANEEL) announced a key policy for stimulating further

electricity conservation. ANEEL is requiring distribution utilities in Brazil to invest at least 1 percent of their revenues (representing approximately US$200 million per year) in energy efficiency—both for T&D loss reduction and end-use efficiency projects. At least one-quarter of this 1 percent, representing approximately US$50 million per year, must be spent on end-use efficiency.

In order to increase its funding base and range of activities, Eletrobras/PROCEL submitted a US$43 million energy efficiency loan proposal to the World Bank and complementary US$15 million grant proposal to the Global Environmental Facility (GEF). These funds would be matched by an equal amount of Brazilian funding. The loan would support large-scale implementation of proven technologies and delivery mechanisms. The grant would support pilot projects featuring new technologies or delivery mechanisms as well as core activities and capacity building Bank approved the loan/grant package in October 1999 and implementation is expected to begin in 2000.

Eletrobras/PROCEL has set a goal a goal of saving approximately 11 TWh per year by 2000—mostly through increasing end-use efficiency but also through efficiency improvements on the supply side. This target is equivalent to approximately 3.5 percent of projected electricity use in Brazil that year. The longer-term goal is to save 77 TWh per year by 2010—equivalent to approximately 15 percent of projected electricity use in Brazil in 2010 without efficiency improvements. Achieving these targets will require steady growth in energy efficiency efforts, successful initiatives in all sectors, and active cooperation from consumers, manufacturers, and businesses.

Unfortunately, PROCEL's level of effort and activities significantly declined in 1999 following a change in the leadership of the program. Leadership changed again in early 2000, providing hope that the program will be reinvigorated.

PROGRAMS AND ACHIEVEMENTS IN KEY END USES

Refrigerators and Freezers

Refrigerators are now used in over 75 percent of Brazilian households. Most refrigerators sold in Brazil are so-called single door models with a small freezer compartment inside and total volume of 250-350 liters. Working closely with Brazilian appliance manufacturers, PROCEL has undertaken a number of initiatives to increase the efficiency of refrigerators and freezers including:

- adoption of a standard test procedure for measuring electricity use (mid-1980s)
- initiation of a testing and labeling program (1986)
- voluntary energy efficiency targets specifying the maximum electricity use of different types of products as a function of volume (1994)

- recognition and awards for the top-rated models (1995-1999)
- pilot rebate programs for the top-rated models (1996-1998)
- revisions of the test procedure and label, and a new voluntary agreement for efficiency improvements (1998).

According to Brazilian appliance manufacturers, the average savings per refrigerator and freezer model reached 90 kWh per year by 1993, approximately a 15 percent reduction from the baseline consumption for new models in 1985. PROCEL estimates that the average savings increased to 170 kWh per year by 1998, due mainly to the introduction and growing market share for high-efficiency models. Based on discussions with manufacturers and other experts, PROCEL is taking credit for 50 percent of this energy savings. With these assumptions, PROCEL is taking credit for about 1,700 gigawatt-hours (GWh) per year of electricity savings in 1998 as a result of efficiency improvements made in new refrigerators and freezers since 1986.

Lighting

As of 1998, lighting accounted for about 16 percent of electricity use in Brazil, or 48 TWh per year. Commercial and public buildings accounted for about 46 percent of total lighting electricity use, followed by the residential sector with around 28 percent, and street lighting with 20 percent. A wide range of energy-efficient lighting technologies are now available and sold in Brazil, including high-pressure sodium (HPS) lamps, compact and circular fluorescent lamps (CFLs), T8 triphosphor lamps, electronic ballasts, and specular reflectors. The sales of some of these products are rising rapidly. As of 1998, around 48 million efficient lighting products were in use in Brazil, leading to approximately 6.2 TWh per year of electricity savings. If these products had not been installed, lighting electricity use in Brazil in 1998 would have increased by approximately 12 percent.

PROCEL has undertaken many projects to promote more efficient lighting, including:

- co-funding replacement of over one million inefficient incandescent or "self-ballasted" type street lights with either HPS lamps or mercury vapor lamps;
- co-funding demonstrations, specific utility incentive programs, energy audits, labeling, and TV advertisements to promote use of CFLs;
- funding R&D and demonstration programs, audits, and educational activities to promote use of T8 lamps, electronic ballasts, and specular reflectors in fluorescent lighting; and
- negotiating and adopting minimum efficiency standards for electromagnetic ballasts.

Approximately 18 million CFLs, 11 million electronic ballasts, 8 million T8 lamps, and 3 million HPS lamps were in use in Brazil as of 1998. Overall, PROCEL estimates it saved approximately 1,630 GWh per year in 1998 by stimulating various types of lighting efficiency

improvements. Approximately 40 percent of this savings is due to use of CFLs, approximately 20 percent is due to use of HPS lamps, and the remaining 40 percent is due to the use of all other types of energy-efficient lighting technologies.

Motors and Motor Systems

Motors account for about half of industrial electricity use, about 40 percent of electricity use in commercial buildings (through air conditioning, refrigeration, and pumping systems), and about 40 percent of electricity consumption in homes (through refrigerators and other appliances). PROCEL has conducted a number of projects in collaboration with motor manufacturers to improve the energy efficiency of Brazilian motors including:

- sponsoring a project that resulted in greater thermal treatment of the carbon steel used in most motor cores, thereby increasing motor efficiency;
- developing a norm that set minimum efficiency levels for high-efficiency motors sold in Brazil;
- adopting an efficiency testing and labeling program for all three-phase induction motors and giving awards to the most efficient standard motors offered in the marketplace.

Taken together, these projects resulted in approximately 575 GWh per year of electricity savings as of 1998, according to PROCEL's estimates. In 1998, PROCEL and the Brazilian motor manufacturers reached a tentative agreement to phase out so-called standard efficiency motors within four years. However, this voluntary agreement never was finalized because one of the major manufacturers later changed its position and requested different efficiency standards. It is unclear what will happen to this potentially important policy.

The focus of PROCEL's efforts so far has been on increasing the efficiency of motors. PROCEL has done relatively little to improve the efficiency of motor systems. In fact, surveys in the late 1980s showed that many motors are oversized and consumed excess power because of poor operating conditions and maintenance practices. Better motor sizing, correcting voltage and other operating problems, and greater use of motor speed controls in applications with highly varying load could save a significant amount of electricity.

STRATEGIES FOR MARKET TRANSFORMATION

Many efficient technologies (such as high-efficiency refrigerators, air conditioners, motors, and CFLs and other efficient lighting products) are now being produced and/or marketed in Brazil. Although adoption of many of these technologies is rising, market penetration is still well below 5 percent in most cases. Energy efficiency improvements are inhibited by a series of market barriers and imperfections including decades of economic instability and high inflation leading to purchasing based on minimum first cost, lack of awareness of electricity conservation

measures and practices, an immature energy efficiency delivery infrastructure, electricity costs represent a relatively small portion of total costs for most businesses and households, and lack of available capital or attractive financing.

A number of these barriers have been reduced in recent years due to economic and political developments, as well as the efforts of PROCEL and other organizations in Brazil. Many consumers are paying relatively high electricity prices and are interested in learning about how they can cut their utility bills. The availability and awareness of efficiency measures is growing. However, much more could be done to stimulate more efficient electricity use on a large scale.

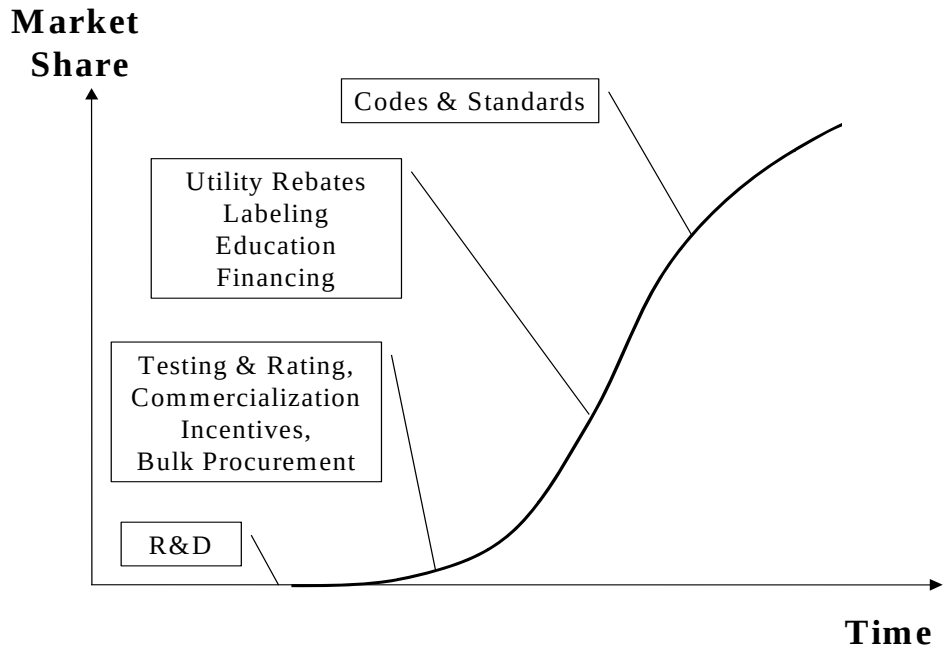
In order to achieve the ambitious electricity savings goals that have been established in Brazil, a **market transformation approach** could be adopted. This approach involves a coordinated set of initiatives to remove the barriers inhibiting widespread and routine adoption of energy efficiency measures in the marketplace. The initiatives that can and should be used include regulation, better use of utility resources, financing and infrastructure development, education and marketing, and public sector leadership (see Figure ES-2).

Regulations

In Brazil, adoption of efficiency standards has been through negotiations of voluntary targets with electrical equipment manufacturers. So far, this approach has given mixed results—it has been difficult to get the manufacturers to accept meaningful standards, and manufacturers have not fully complied with the voluntary targets that have been agreed to. In the future, it would be very helpful if the government could adopt mandatory standards, as has been done in North America. Legislation permitting this is pending in the Congress. This legislation is very important and should be strongly supported by energy planners, policymakers, and others concerned about increasing economic efficiency, reducing risk of power shortages in the future, and protecting the environment.

If the authorizing legislation is adopted, the Executive Branch should proceed rapidly with the development, discussion, and enactment of mandatory efficiency standards for refrigerators, freezers, air conditioners, motors, lamps, lighting fixtures, and lighting ballasts and possibly other products.

Figure ES-2: Accelerating the Market Transformation Process



Utility Energy Efficiency Programs

ANEEL, the federal regulatory agency for the electric sector, is requiring distribution utilities to invest at least 1 percent of their revenues in energy efficiency projects. A few utilities are already carrying out relatively well-designed and effective energy efficiency programs. But most are still developing plans and capacity to operate such programs. These utilities should move forward as quickly as possible, using support from PROCEL and other energy efficiency experts both within and outside Brazil if necessary. Moreover, given the enormous savings potential, utilities should consider spending the majority of their 1 percent requirement on promoting greater end-use efficiency, not just the minimum of one-quarter of 1 percent.

Private utilities complain about having to operate end-use energy efficiency programs and in some cases attempt to minimize expenditures and energy savings, if they are penalized financially when they help their consumers to use electricity more efficiently. Therefore, ANEEL should allow the utilities to recover energy efficiency expenditures that are "in the public interest," as well as the net lost revenues associated with these expenditures, through tariffs. ANEEL also should consider allowing utilities to receive a portion of the "net societal economic benefits" they create as a result of their efficiency programs, again through a small rate increase following independent analysis of these benefits.

There is a danger that distribution utilities in Brazil will design and implement a large array of uncoordinated energy efficiency programs in response to the ANEEL requirement. Market transformation will be enhanced if utilities coordinate their efforts; for example, by using the same efficiency thresholds and working together to stimulate introduction and wide dissemination of emerging or advanced technologies.

Education and Marketing

It is essential to educate consumers about efficiency options and convince them that improving energy efficiency is worth the effort, even if energy use represents a small fraction of the cost of operating a business or household. PROCEL has sponsored educational and information dissemination programs for all types of consumers. Also, PROCEL sponsored TV ad campaigns linked to the "selo PROCEL" in order to help reduce peak loads during the summers of 1997 and 1998. Greater research is needed on the effectiveness of past education and marketing efforts and the design of effective future programs and campaigns. And much more should be done to inform and educate consumers of all types about the practical steps that can be taken to save electricity and money.

Financing and Infrastructure Support

Lack of financing and high cost of capital are other barriers that need to be addressed. One way to do this would be to incorporate energy efficiency requirements into low-income housing projects, industry expansion, or urban development. These areas receive low-cost financing from the national development bank (BNDES) and housing finance bank (CEF). Another way is to use ESCOs, companies that plan, finance, and install energy efficiency projects in commercial and industrial facilities. A few local or national ESCOs are operating in Brazil, but they have little experience with performance contracting or third party financing of energy projects.

There is interest in setting up a Performance Investment Fund that would finance smaller-scale energy efficiency and renewable energy projects in Brazil. The Fund could receive equity capital from Brazilian banks, utilities, or other portions of the energy sector in Brazil, along with capital or guarantees from non-Brazilian sources. If the Fund is established, it should be actively promoted so that it does not meet the same fate as previous attempts at third party financing.

Public Sector Leadership

The public sector consumes about 9 percent of all electricity in Brazil for street lighting, water and sanitation services, and operating buildings. PROCEL, individual utilities, and municipalities have made significant progress in improving the energy efficiency of street lighting. But more should be done to cut energy waste in public facilities. The public sector could commit to purchasing energy-efficient products with the "selo PROCEL". Another useful

action would be to set energy savings targets, monitor results, and publicize government agencies that do the best (and the worst) in terms of cutting electricity use. And the public sector should make much greater use of ESCOs and performance contracting. On January 6, 2000, President Cardoso issued a decree requiring all federal agencies to reduce their electricity use for lighting, air conditioning, and refrigeration 20 percent by 2002.

CONCLUSION

Brazil has implemented one of the strongest national electricity conservation programs in the world. Through its cumulative efforts, PROCEL saved about 5.3 TWh as of 1998, equivalent to 1.8 percent of total electricity consumption in Brazil. The electricity savings enabled utilities to avoid constructing approximately 1,560 MW of new capacity. The estimated US$3.1 billion of avoided investments in new power plants and T&D facilities was approximately 12 times what Eletrobras/PROCEL and its utility partners spent on energy efficiency initiatives during 1986-1998.

Some recent developments including requirements for utility energy efficiency programs and the approval of an energy efficiency loan from the World Bank and complementary grant from the Global Environmental Facility should lead to even greater electricity savings in the future. But more needs to be done to achieve PROCEL's long-term goal of saving 77 TWh per year by 2010. A market transformation approach could help to overcome the barriers inhibiting more efficient electricity use. With this approach, the following policies could be especially valuable for increasing electricity savings:

- mandatory energy efficiency standards for appliances, lighting products, and motors sold in Brazil;
- regulations that allow utilities to recover energy efficiency expenditures that are "in the public interest," as well as the net lost revenues associated with these expenditures, through tariffs;
- coordination among utilities to influence equipment manufacturers and build sizable markets for new and emerging energy efficiency measures;
- expanded consumer education, training, and promotion efforts in all sectors;
- financing for energy efficiency projects that is easy for businesses to access and available at attractive terms; and
- public sector leadership in purchasing energy-efficient products and using ESCOs to implement energy efficiency projects.

INTRODUCTION

Total electricity consumption in Brazil grew from 38 terawatt-hours (TWh) in 1970 to 265 TWh in 1995, an average growth rate of 8.1 percent per year (Geller et al. 1998). This was more than twice as fast as the electricity consumption growth rate of 3.1 percent per year in the United States during 1970-1995. The share of electricity consumption in the overall energy mix, counting all electricity based on the energy required to generate power in thermal power plants, grew from 16 percent in 1970 to 39 percent in 1994 (MME 1997). Table 1 shows the evolution in electricity demand and electricity demand per capita during that period. Overall, the electricity intensity of the Brazilian economy increased 125 percent between 1970 and 1995, or some 3.3 percent per year on average.

Table 1: Trends In Electricity Supply and Demand in Brazil

	1970	**1975**	**1980**	**1985**	**1990**	**1995**	**1998**
electricity production (TWh)	45.7	78.9	139.5	195.6	249.3	307.4	361.0
electricity consumption (TWh)	38.2	69.9	122.8	173.6	217.7	264.8	307.0
installed capacity (GW)*	11.0	21.0	33.4	45.1	58.6	65.4	71.5
capacity factor (percent)	47	43	48	50	49	54	58
electricity consumption per capita	399	647	1,012	1,305	1,501	1,697	2,242
electricity consumption per unit GDP (1998 US$)	0.16	0.18	0.23	0.30	0.34	0.36	0.40

* Includes all of the capacity of the Itaipa binational hydro plant since nearly all of the electricity produced by Itaipu goes to Brazil.

Source: MME 1999.

During 1995-98, electricity consumption rose 5 percent per year on average, leading to 307 TWh of total electricity use in 1998 (MME 1999). Demand is growing most rapidly in the residential and commercial sectors due to increased disposable income and a surge of consumer spending on appliances and the like, as well as growing activity levels and equipment saturations in the services sector. Industrial electricity demand growth has been constrained by recession in a number of the key energy-intensive manufacturing industries. Real economic output rose only 2 percent per year on average during 1995-98, meaning electricity demand per unit of gross domestic product (GDP) is rising 3 percent per year. Electricity consumption per capita (2,242 kilowatt-hours [kWh] per year as of 1998) was about one-fifth of that in the United States.

The most recent Eletrobras decade plan estimates that electricity demand will continue to grow about 5 percent per year and will reach 494 TWh by 2007 (Eletrobras 1998). Furthermore, it is projected that fossil fuel (mostly coal and natural gas) will play an increasing role in power generation, accounting for over 12 percent of electricity supplied in 2007 compared to 5 percent of electricity supplied in 1998. And this estimate of the future contribution from fossil fuel-based power plants may be conservative given the high cost and difficulty of expanding hydro capacity under the new regulatory and ownership structure of the electric sector.

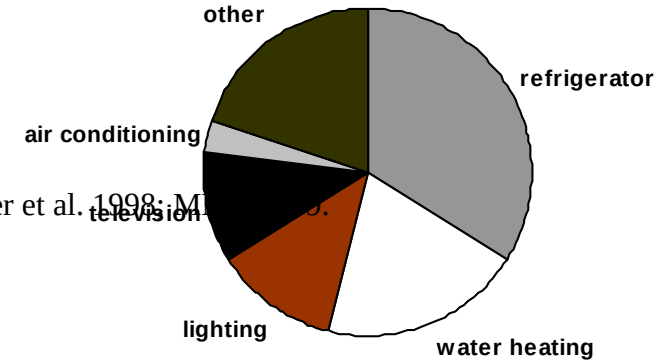
If this forecast proves to be correct, around 35 gigawatts (GW) of additional installed capacity will be needed by 2007. Adding this amount of new capacity, along with associated transmission and distribution (T&D) facilities, in less than a decade will be difficult and expensive. Also, it would result in substantial adverse environmental impacts from fossil fuel power plant emissions along with flooding caused by new hydro power plants. On the other hand, if demand continues to grow 5 percent per year and supply is not expanded by this amount, power shortages will occur. In fact the risk of black-outs and power shortages is increasing because the expansion of generating capacity has not kept up with demand growth in recent years. Improving the efficiency with which electricity is used in Brazil can help to ameliorate all of these problems.

Electricity use by most consumers in Brazil is no longer subsidized. The prevailing average electricity tariffs as of 1998 were about US$0.06/kWh for industrial customers and US$0.13/kWh for residential customers (MME 1999).[1] The devaluation of the “Real” in early 1999 reduced these prices somewhat in dollar terms but prices are high by Brazilian standards. Some very electricity intensive industries (e.g., aluminum smelters) and low consumption, low-income households still receive electricity at subsidized rates. But the subsidies are being reduced and tariffs on average are likely to stay high given the privatization of much of the electric sector and guaranteed rate increases built into the privatization contracts.

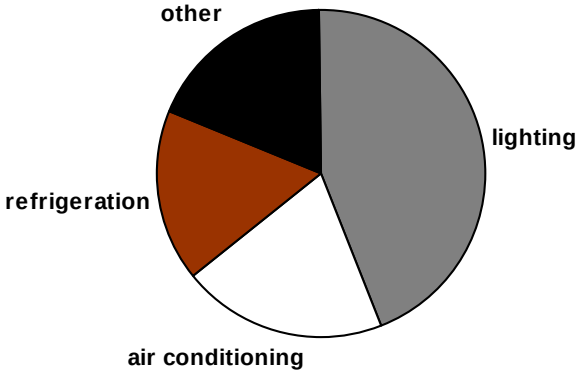
Figure 1: Estimates of Electricity Demand by Sector and End-Use in Brazil as of 1998 (total consumption = 307 TWh)

[1] The exchange rate was approximately R$1.85 per U.S. dollar in January 2000.

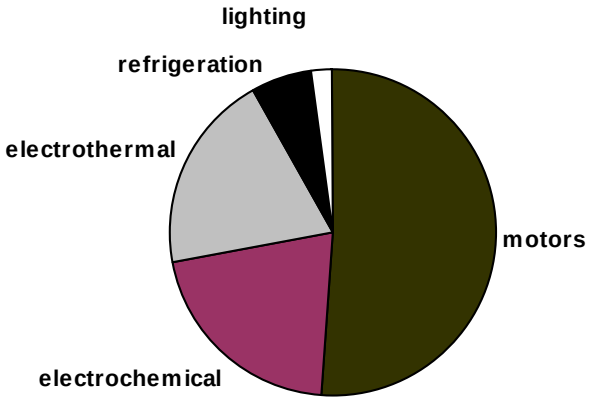
Residential Sector (79.4 TWh)



Sources: COPPE 1998; Geller et al. 1998; MI[illegible]



Commercial/ Public Services Sector (68.8 TWh)



Industrial Sector (136.4 TWh)

Before considering

electricity conservation opportunities and savings in Brazil, it is helpful to review how electricity is used in the country. Figure 1 presents estimates of electricity consumption by end-use for the major sectors of the economy in 1998. The industrial sector accounted for about 44 percent of total electricity consumption, the commercial and public services sector for 22 percent, the residential sector for 26 percent, and the remainder of the economy for 8 percent (MME, 1999). The public services sector in Brazil includes electricity
supplied for street lighting, water and sanitation services, and public buildings. In recent years, the residential and commercial/public services sectors shares increased and the industrial share fell.

The breakdowns by end-use shown in Figure 1 are estimates based on surveys where available, but in some cases these surveys are now outdated. Therefore, these breakdowns are somewhat uncertain and should be considered "guesstimates."

In the remainder of this report, I describe the efforts undertaken to stimulate greater efficiency and the results achieved with electricity conservation and demand-side management (DSM) programs in Brazil, including initiatives developed by the National Electricity Conservation Program. Special attention is devoted to efforts to improve the efficiency of three end-uses—lighting, refrigerators, and motors. Finally, I discuss opportunities and strategies for achieving market transformation. Market transformation means reducing barriers so that cost-effective energy efficiency measures are widely and routinely sold and used. Adopting a market transformation framework could be particularly valuable for advancing more efficient electricity use given the foundation built by PROCEL and its partners.

NATIONAL ELECTRICITY CONSERVATION PROGRAM (PROCEL)

Background

Policy makers started to be concerned about the efficiency of electricity use in Brazil in the mid-1980s even though there were plentiful supplies of hydropower at that time. A few leaders in the power sector promoted the concept of improving the efficiency of electricity use as one strategy for reducing the need for new investments in electricity supply. Since the power sector was beginning to experience financial difficulties, there was reasonable support for this concept.

The government of Brazil established a national electricity conservation program known as PROCEL in December 1985. Institutionally, PROCEL is housed in Eletrobras, a national utility holding and coordinating company. Eletrobras/PROCEL works on both increasing end-use efficiency and reducing losses in electricity generation and T&D systems throughout Brazil. PROCEL operates by funding or co-funding energy efficiency projects carried out by state and local utilities, state agencies, private companies, universities, and research institutes. These projects pertain to:

- research and development (R&D)
- demonstrations
- education and training
- testing, labeling, and standards
- marketing
- direct installation of conservation measures
- support for energy service companies (ESCOs) and other private sector actors
- legislation
- utility demand-side management programs.

Eletrobras/PROCEL also helps utilities obtain low-interest financing for major energy efficiency implementation projects from a loan fund (known as the RGR). The RGR was begun in 1993 and co-finances both supply- and demand-side investments within the electricity sector. Recently, states and municipalities in some parts of Brazil became eligible to receive low-interest loans for energy efficiency projects from this fund. The RGR has proven to be an important source of financing for energy efficiency improvements in Brazil.

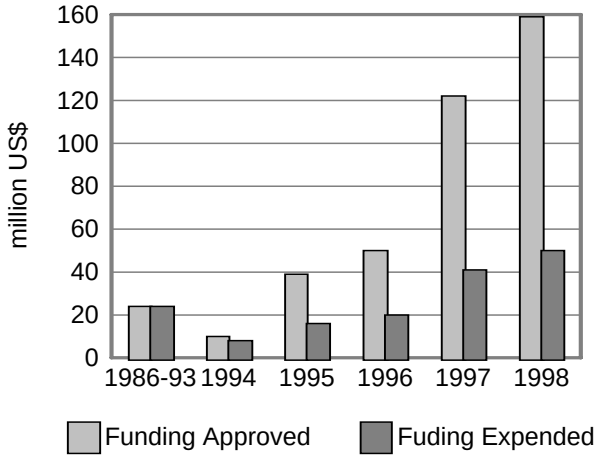
Expenditures and Results

During its initial eight years (1986-1993), PROCEL spent a total of approximately US$24 million on over 100 projects. PROCEL also received an equivalent amount of support for staff, overhead, and travel from Eletrobras. However, Brazil's electric sector experienced severe financial difficulties during the early 1990s because of low electricity prices and high debt (Geller et al. 1998). Consequently, PROCEL's budget was greatly reduced and influence relatively limited during 1990-1992.

PROCEL began a process of renewal in 1993 that continued through 1998. PROCEL's "core budget" for grants, consultants, and staff support increased to approximately US$20 million per year by 1997-1998. In addition, Eletrobras/ PROCEL arranged approximately US$40 million in project financing from the RGR fund in 1996, approximately US$90 million in 1997, and approximately US$140 million in 1998. However, actual expenditures lagged approved funding due to delays in starting and implementing some projects (see Figure 2).

PROCEL is funded by Eletrobras and managed and implemented by Brazilians. However, PROCEL has received some valuable assistance from non-Brazilian energy efficiency specialists over the years. As of early 1999, PROCEL was receiving assistance from and implementing cooperative projects with Canadian, European, and U.S. agencies and experts. For example, foreign experts were helping PROCEL to design and implement high-efficiency motors

Figure 2: Trends in Electricity Conservation Funding by PROCEL*



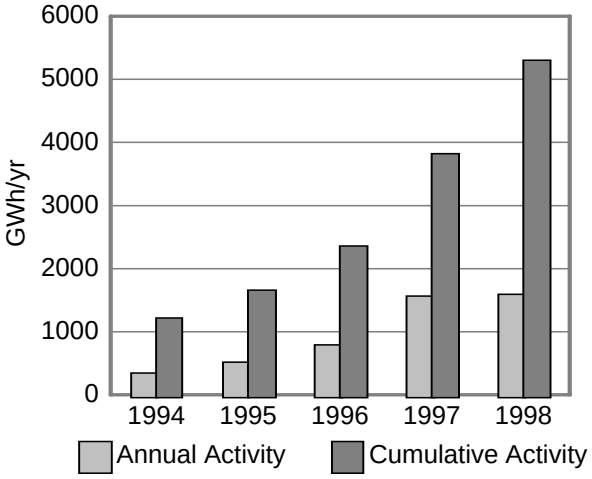
* Includes grants and low-interest loans from the RGR fund but excludes PROCEL staff salary and overhead.

incentive programs, a program to promote energy efficiency improvements by municipalities, a commercial and industrial sectors "Best Practices" program, and training for ESCOs.

As shown in Figure 3, Eletrobras/PROCEL estimates that its overall efforts resulted in approximately 1.6 TWh per year of electricity savings in 1998 based on actions that year and 5.3 TWh per year of savings based on a cumulative activities (PROCEL 1999a). The latter value is equivalent to 1.8 percent of total electricity consumption in Brazil. The electricity savings realized in 1998 was approximately three times that of 1995. This rapid rise in energy savings is attributed to the growth in PROCEL's budget, projects, and influence over the past five years, as well as to the cumulative impact of working in some areas (e.g., refrigerators and freezers) for more than a decade. In addition, Eletrobras/PROCEL took credit for approximately 1.4 TWh of additional power production in 1998 due to power plant improvements.

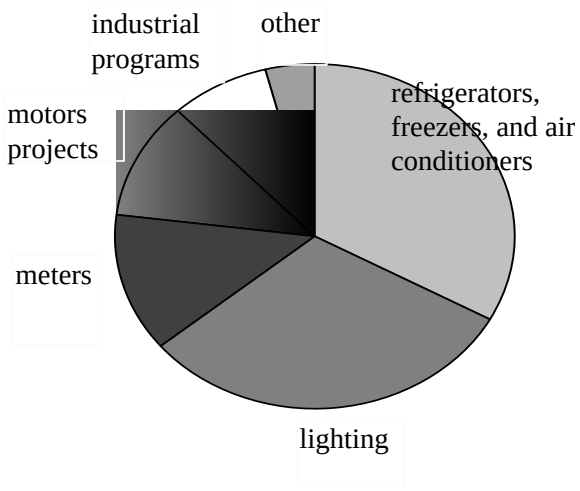
Figure 4 shows the break-down in energy savings by end-use and project area. Considering cumulative actions through 1998, approximately 33 percent of the savings came from refrigerator, freezers, and air conditioners; 31 percent from lighting efficiency improvements; 13 percent from installation of meters; 11 percent from motors projects; 8 percent from industrial programs; and 4 percent from other activities.

Figure 3: Trends in Electricity Savings in Brazil due to PROCEL's Activities



How significant are these savings and what do they mean for Brazil? The electricity savings and additional generation occurring in 1998 enabled utilities to avoid constructing approximately 1,560 megawatts (MW) of new capacity, meaning approximately US$3.1 billion of avoided investments in

Figure 4: Sources of Electricity Savings in 1998 due to PROCEL's Cumulative Activities



new power plants and T&D facilities.[2] In contrast, Eletrobras/PROCEL and its utility partners spent approximately US$260 million on energy efficiency and power supply improvement projects during 1986-1998. Thus, from the utility sector perspective, PROCEL has achieved an overall benefit-cost ratio of approximately 12:1.

PROCEL has had other positive impacts besides the direct economic savings. PROCEL has contributed to the development of a number of new technologies now manufactured in Brazil, including demand limiters, lighting controls, electronic ballasts for fluorescent lamps, and solar water heaters. PROCEL also has produced environmental benefits by reducing the need for new power plants. While 90-95 percent of total electricity generation in Brazil is hydroelectric, new power plants are increasingly based on fossil fuels. A number of new gas and coal-fired power plants are under development in Brazil. It is estimated that greenhouse gas emissions from the power sector in 1997 would have been 30 percent greater had the efficiency improvements stimulated by PROCEL not occurred (La Rovere and Americano 1999).

Recent Developments

Electric utility sector restructuring is occurring in Brazil, including privatization of many formerly government-owned utilities. At the same time, regulatory agencies are being established at both the federal and state levels. Fortunately, policy makers in Brazil are paying some attention to improving energy efficiency as privatization and sector restructuring takes place.

In July 1998, the new federal regulatory agency for the electrical sector in Brazil (known as ANEEL) announced a key policy for stimulating further electricity conservation. ANEEL is requiring distribution utilities in Brazil to invest at least 1 percent of their revenues (representing approximately US$200 million per year) in energy efficiency—both for T&D loss reduction and end-use efficiency projects. At least one-quarter of this 1 percent, representing approximately US$50 million per year, must be spent on end-use efficiency. This requirement was implemented

[2] These estimates are based on hydro plants that have an average capacity factor of 56 percent in Brazil as well as average T&D losses of 15 percent.

initially as part of privatization contracts for distribution utilities but was subsequently extended to other utilities throughout Brazil. Eletrobras/PROCEL was indicated by ANEEL as its "technical agent" to support implementation of this requirement. PROCEL is assisting utilities with preparation of energy efficiency plans, monitoring implementation, and certifying that utilities are carrying out adequate programs.

Eletrobras/PROCEL has had limited impact so far on the industrial sector, which is responsible for approximately 45 percent of electricity use in Brazil. In order to increase its impact in this important sector as well as the commercial sector, PROCEL is starting a "Best Practices" program with support from ETSU—the organization responsible for the successful Best Practices program in the United Kingdom. The key features of this program are demonstration projects, case studies, technical guides, and wide dissemination of information in collaboration with industry and commercial associations. The program is starting with particular sectors and states, such as the auto industry in Sao Paulo, the steel industry in Minas Gerais, and the food and beverage industry and hotels and supermarkets in Rio de Janeiro.

In order to increase its funding base and range of activities, Eletrobras/PROCEL submitted a US$43 million energy efficiency loan proposal to the World Bank and complementary US$15 million grant proposal to the Global Environmental Facility (GEF). These funds would be matched by an equal amount of Brazilian funding. The loan would support large-scale implementation of proven technologies and delivery mechanisms. The GEF grant would support pilot projects featuring new technologies or delivery mechanisms as well as core activities and capacity building (i.e., training, testing, labeling and standards, regulatory reform, marketing, and the Best Practices program). Some of these projects would be implemented directly by Eletrobras/PROCEL, others by state and utility partners. The World Bank approved the loan/grant package in October 1999 and implementation is expected to begin in 2000 (World Bank 1999). Besides its importance for Brazil, this project represents the first major end-use electricity conservation loan approved by the World Bank.

Eletrobras/PROCEL also has revived efforts to enact an energy efficiency law in Brazil. A draft law is under consideration in the Brazilian Congress. The draft law would authorize setting mandatory minimum efficiency standards for appliances, motors, and lighting products. The draft law also reinforces the ANEEL requirement that utilities spend at least 1 percent of their revenues on energy efficiency programs, and requires distribution utilities to prepare annual energy conservation plans. An initial version of the law was submitted to the Brazilian Congress in 1992 but was not approved. The law was revised and advanced in the Congress in 1997-1999, with good chances for final approval in 2000.

Eletrobras/PROCEL has set ambitious goals for energy savings in the future. Specifically, the goals are to save approximately 11 TWh per year by 2000—mostly through increasing end-use efficiency but also through efficiency improvements on the supply side. This target is equivalent to approximately 3.5 percent of projected electricity use in Brazil that year.

The longer-term goal is to save 77 TWh per year by 2010—equivalent to approximately 15 percent of projected electricity use in Brazil in 2010 without efficiency improvements. Achieving these goals is technically and economically feasible (Geller 1991; Geller et al. 1998). But achieving these targets will require steady growth in energy efficiency efforts, successful initiatives in all sectors, and active cooperation from consumers, manufacturers, and businesses. Unfortunately, PROCEL's overall level of effort and activities declined significantly in 1999 following a change in leadership of the program. Leadership changed again in early 2000, providing hope that the program will be reinvigorated.

PROGRAMS AND ACHIEVEMENTS IN KEY END USES

Refrigerators and Freezers

Refrigerators were used in approximately 63 percent of Brazilian households in 1988, according to a national appliance saturation survey (Geller et al. 1998). During 1990-1997, nearly 20 million new refrigerators were sold in Brazil (Appliance 1998), resulting in refrigerator saturation of greater than 75 percent by 1998. Most refrigerators sold in Brazil are so-called single door models with a small freezer compartment inside and total volume of 250-350 liters. However, two-door refrigerator-freezers of 300-425 liters are gaining in popularity. Statistical analysis of a national appliance saturation survey conducted in 1988 indicated that a typical one-door refrigerator in use at that time consumed 525 kWh per year and a typical two-door refrigerator consumed 800 kWh per year (Lins and Silva 1996).

Eletrobras/PROCEL has undertaken a number of initiatives to increase the efficiency of refrigerators and freezers including:.

- adoption of a standard test procedure for measuring electricity use (mid-1980s)
- initiation of a testing and labeling program (1986)
- voluntary energy efficiency targets specifying the maximum electricity use of different types of products as a function of volume (1994)
- recognition and awards for the top-rated models (1995-1999)
- pilot rebate programs for the top-rated models (1996-1998)
- revisions of the test procedure and label, and a new voluntary agreement for efficiency improvements (1998).

For the most part, these actions were implemented while working closely with Brazilian appliance manufacturers. The major appliance manufacturers in Brazil at the present time are subsidiaries of multinational corporations—Whirlpool, Electrolux, and Bosch-Siemens. In addition, General Electric Co. built an appliance factory in Brazil in 1999. The multinationals have purchased what were independent Brazilian appliance manufacturers or bought control of companies they previously had a minority interest in.

The standardized testing and labeling program begun in 1986 has had mixed results. Manufacturers claim that revealing how much electricity each model consumes prompted some efficiency improvements, but the labels themselves have been of little or no value in terms of influencing consumers since manufacturers do not attach them to all appliance models and very few models displayed in stores show the label. This is unfortunate since Brazil switched to the European (ISO) test procedure and label in 1997-98. The European-style label ranks all models between A through G based on energy efficiency. It also uses a colorful and attractive design that makes it easy for consumers to identify high-efficiency "Grade A" appliances, and lends itself to education and promotion efforts ("buy a Grade A appliance").

In 1995, Eletrobras/PROCEL developed a logo known as the 'selo PROCEL" that is used to label the top-rated refrigerators and freezers (as well as room air conditioners and motors) based on their energy efficiency. The development of this logo and related marketing efforts were based on consumer research in Brazil as well as the experience of similar programs in Canada and the United States. Since 1995, approximately US$20 million was spent on advertising and publicity campaigns. Research shows that the level of recall of the PROCEL logo among the public has reached approximately 30 percent in some major cities.

The "selo PROCEL" is similar in some respects to the U.S. ENERGY STAR® product labeling program but also has some key differences. Initially, the "selo" was given to the best (i.e., most efficient) product offered each year in each product category. The manufacturer is allowed to display the selo label on its products and benefits from both general advertising and participating in special marketing or rebate campaigns for models that have gained the selo. This has prompted manufacturers to introduce new high-efficiency models in part to compete to win the selo, leading to different models winning the selo from year to year. However, manufacturers complained about this discontinuity (i.e., one model winning one year, another model the next year). They suggested that the selo be given to the best two or three models in each category every year so that there would be more continuity. Consequently, PROCEL began giving the selo to the top two or three refrigerators and freezers in each category in 1999. The "selo PROCEL," unlike the energy efficiency label mentioned above that applies to all models, is widely found on qualifying models displayed in stores.

In 1994, Eletrobras/PROCEL, INMETRO (the national metering and normalization organization), and manufacturers signed a voluntary agreement concerning minimum efficiency targets for new refrigerators and freezers. The agreement included maximum energy consumption targets for different categories of refrigerators and freezers, similar in format to the U.S. appliance standards (i.e., maximum electricity use as a function of volume and product type). However, manufacturers only partially complied with these voluntary targets, replacing some inefficient models but maintaining production of others beyond the agreed-upon deadline. In 1998, Eletrobras/PROCEL, INMETRO, and the manufacturers signed a new voluntary agreement that calls for a 10 percent improvement in the average efficiency of new refrigerators, freezers, and room air conditioners sold in Brazil by 2000 and a 20 percent improvement in

average efficiency by 2002. This agreement includes changes in the labeling system such that efficiency improvements will be required in order to maintain high ratings in the future.

Individual utilities have done relatively little to promote high-efficiency refrigerators and freezers. One exception was a pilot rebate program carried out for six months in the city of Manaus in 1996-97. The objective of the rebate program was to promote the purchase of models that gained the "selo PROCEL." Consumers received a rebate of about US$30 for buying the top-rated single door model and about US$80 for buying the top-rated two-door model. The program stimulated additional sales of about 4,000 high-efficiency models, close to the goal of the program, although only about 1,600 rebate claims were registered. An evaluation of the pilot program indicated that future rebate programs should intensify advertising and also work on disposal of old models so that energy savings really occur, rather than increasing energy use which will occur if old models are kept running or resold.

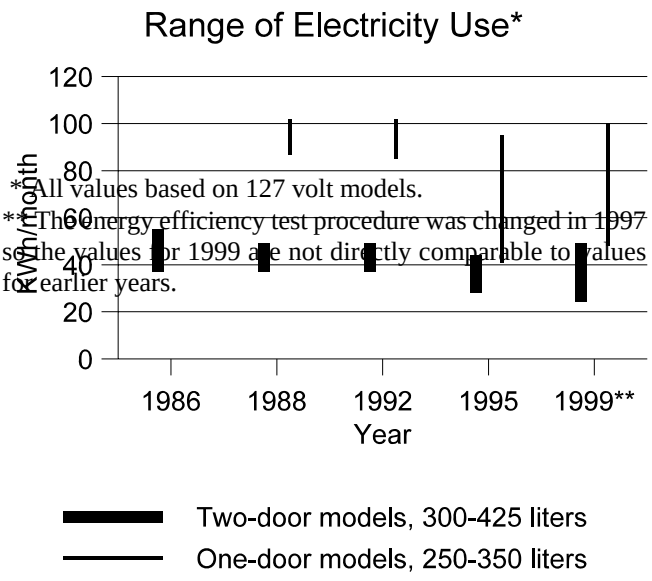
Another utility based in Rio de Janeiro ran a pilot program in 1998 offering low-interest financing to buyers of high-efficiency refrigerators. This program stimulated the sale of about 1,000 high-efficiency models in three months, only about 20 percent of the program target. Problems experienced included limited marketing, limited cooperation from appliance dealers in stocking and promoting the high-efficiency models, and confusion due to changes in mid-stream. The short duration of this pilot program may have contributed to these problems.

The actions described above, taken as a whole, helped to increase the energy efficiency of new refrigerators and freezers produced and sold in Brazil. Figure 5 shows the range of electricity use of models offered in the market from year to year. In the 1986-1988 period, some of the least efficient refrigerator models were replaced with models that used 10-20 percent less electricity. New high-efficiency refrigerators and freezer models were introduced in the marketplace in 1989, 1994, 1996, 1997, and 1998 (Geller et al. 1998).

According to Brazilian appliance manufacturers, the average savings per refrigerator and freezer model reached 90 kWh per year by 1993, approximately a 15 percent reduction from the baseline consumption for new models in 1985 (which was approximately 600 kWh per year, assuming 80 percent one-door models and 20 percent two-door models). PROCEL estimates that the average savings increased to 170 kWh per year by 1998, due mainly to the introduction and growing market share for high-efficiency models.[3] Based on discussions with manufacturers and other experts, PROCEL is taking credit for 50 percent of this energy savings. With these assumptions, Eletrobras/PROCEL is taking credit for about 1,700 gigawatt-hours (GWh) per year of electricity savings in 1998 as a result of efficiency improvements made in new refrigerators and freezers since 1986 (PROCEL 1999a).

[3] Unfortunately, appliance manufacturers in Brazil do not routinely calculate and report the average efficiency and energy use of new refrigerators and freezers sold in Brazil. Therefore, the energy savings figures are only estimates.

Figure 5: Energy Efficiency Improvements in Refrigerators



There is one other point worth making concerning the efficiency of refrigerators and freezers in Brazil. Embraco, one of the largest motor-compressor manufacturers in the world, is based in southern Brazil. Embraco, formerly a majority Brazilian company, is now owned by Whirlpool. Embraco produces around 12 million compressors per year in Brazil and about 20 million per year in its facilities worldwide (including plants in Italy and China). Most of the compressors made in Brazil are exported with a large number shipped to the United States where they are used in refrigerators and freezers made by Whirlpool and other U.S. appliance manufacturers.

Embraco had to significantly increase the efficiency of the compressors it was exporting starting in the mid-1980s due to efficiency standards adopted in California and other states, followed by the adoption of national standards in 1987 (effective in 1990) and the upgrading of these standards that took effect in 1993. Although Embraco's most efficient compressors are exported only, it improved the efficiency of the compressors used in Brazilian refrigerators at the same time it was improving its export lines. Embraco acknowledges that the U.S. standards were the main reason it greatly improved the efficiency of all its compressors over the past 15 years (Driessen 1997). Thus, the U.S. appliance efficiency standards are clearly having an impact and saving energy outside the United States.

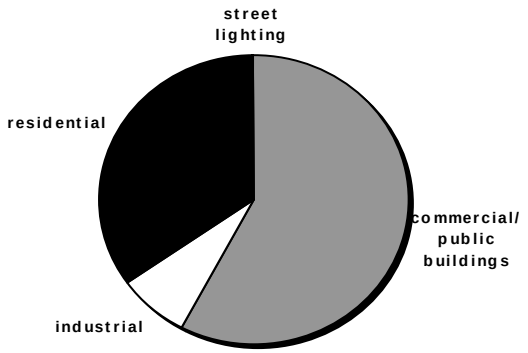
Lighting

As of 1998, lighting accounted for about 16 percent of electricity use in Brazil, or 48 TWh per year. Figure 6 shows that commercial and public buildings accounted for about 46 percent of total lighting electricity use, followed by the residential sector with around 28 percent and street lighting with 20 percent.

The national appliance saturation survey conducted in 1988 found a total of about nine lamps per household on average, with 26 percent of households using at least one fluorescent lamp (Geller 1991). Statistical analysis of this survey estimated that lighting consumes 390 kWh per year in an average household (Lins and Silva 1996). New surveys carried out in major cities in 1997-98 found a greater saturation of fluorescent lighting, with at least one fluorescent lamp per household in all cities and over two fluorescent lamps per household in a few cities (Leonelli 1998).

A wide range of energy-efficient lighting technologies are now available and sold in Brazil, including high-pressure sodium lamps, compact and circular fluorescent lamps, T8 triphosphor lamps, electronic ballasts, and specular reflectors (see Table 2). The sales of some of these products are rising rapidly (Geller et al. 1997). As of 1998, around 48 million efficient lighting products were in use in Brazil, leading to approximately 6.2 TWh per year of electricity savings. If these products had not been installed, lighting electricity use in Brazil in 1998 would have increased by approximately 12 percent.

Figure 6: Lighting Electricity Use in 1998 by Sector



Sources: Estimates by author.

Eletrobras/PROCEL has undertaken many projects to promote more efficient lighting, including:

- co-funding replacement of over one million inefficient incandescent or "self-ballasted" type street lights with either HPS lamps or mercury vapor lamps;
- co-funding demonstrations, specific utility incentive programs, energy audits, labeling, and TV advertisements to promote use of CFLs;
- funding R&D and demonstration programs, audits, and educational activities to promote use of T8 lamps, electronic ballasts, and specular reflectors in fluorescent lighting; and
- negotiating and adopting minimum efficiency standards for electromagnetic ballasts.

One priority area has been improving the efficiency of street lighting, which is responsible for approximately 3 percent of total electricity use in Brazil. Working with local utilities and municipalities, Eletrobras/PROCEL co-funds replacement of inefficient incandescent or "self-ballasted" type street lights with either high-pressure sodium (HPS) lamps

or mercury vapor lamps. For example, 17 projects involving about one million street lights were approved for co-financing from the RGR fund during 1996-1997. Approximately 1.3 million lamps were replaced by the end of 1998, leading to approximately 270 GWh per year of electricity savings (PROCEL 1999a).

Table 2: Sales Levels and Energy Savings from Six Energy-Efficient Lighting Technologies

Product	Sales in 1998 (10^6)	Stock in 1998 (10^6)	Average Savings (watts)	Average Usage (hours/yr)	Savings in 1998 (GWh/yr)	PROCEL portion (%)
HPS lamps*	0.2	0.3	85	4,500	115	100
HPS lamps**	1.0	3.0	150	4,500	1,755	10
CFLs	8.0	18.0	45	2,500	1,395	35
circular FLs	2.9	6.6	60	1,500	222	25
T8 lamps	2.8	7.8	10	3,000	207	10
electronic ballasts	4.0	11.4	28	3,000	596	10
specular reflectors	0.4	1.3	52	3,000	140	10
TOTAL	19.3	48.4	—	—	6,145	—

* High-pressure sodium lamps installed as part of PROCEL's street lighting program.
** High-pressure sodium lamps installed outside of PROCEL's street lighting program.

Source: PROCEL 1999a.

PROCEL also has encouraged use of HPS lighting in industries through its energy audits, seminars, and other promotional efforts. Sales of HPS lamps reached about 1.2 million units as of 1998, nearly double the level in 1995-96. But the market for mercury vapor and inefficient self-ballasted lamps is still about ten times the market for HPS lamps in Brazil.

Eletrobras/PROCEL has helped to increase the use of compact fluorescent lamps (CFLs) through co-funding demonstrations, specific utility incentive programs, energy audits, labeling, and general promotional activities including TV advertisements. Approximately 18 million CFLs were in use in Brazil as of 1998, with approximately 8 million sold that year alone. Eletrobras/PROCEL and its utility partners are taking credit for inducing 35 percent of CFL sales as of 1997-98 (PROCEL 1998; 1999a). Most CFLs are used in the commercial sector (hotels, restaurants, banks, etc.) where lights are typically left on for twelve hours per day and where low-voltage consumers pay around R$0.15/kWh. A high-quality CFL costing $R30 (about US$16) will have a 1.0-1.5 year payback under these usage conditions.

CFLs are sold in Brazil by GE, Osram, Philips and other lamp companies that are selling CFLs made in Japan, Korea, China, Europe, and the United States (specifically from Lights of America). There are a large variety of models available with a wide price and quality range—both high-quality European lamps with electronic ballasts and low-quality Asian imports. But so far no manufacturer is producing CFLs in Brazil. This could change soon as one manufacturer (Philips) has announced plans and received approval to build a CFL plant in the Manaus free trade zone. Philips will import key lamp components duty-free initially, increasing the "domestic content" over time. Producing high-quality CFLs in Brazil should lower the retail price by 25 percent or more.

Because both high- and low-quality CFLs are widely available and sold, PROCEL began a testing and labeling program in 1998 to help consumers identify high-quality lamps and to encourage manufacturers to improve product quality. A set of performance requirements pertaining to lumen efficacy, power factor, lumen depreciation, and durability were developed through negotiations with manufacturers (see Table 3). CFLs are submitted to an independent laboratory for testing. Lamps that qualify are allowed to display the PROCEL "selo" on the package and in advertising. PROCEL and individual utilities are promoting purchase of qualifying models through their incentive, promotion, and free distribution programs. This program is similar to (but pre-dates) the U.S. ENERGY STAR® labeling program for CFLs.

A few utilities have promoted use of CFLs in homes through free distribution or pilot rebate programs (Jannuzzi et al. 1997). In the early 1990s, one utility in Sao Paulo state (CPFL) tested different rebate programs to gauge consumer and supplier response to different incentive schemes. As expected, consumer participation increased as the amount of incentive (rebate) increased (Jannuzzi et al. 1997).

Table 3: Performance Specifications for PROCEL's CFL Labeling Program

Lumen Output		
Incandescent Lamp Replaced	**Minimum Lumen Output**	
	(127 volts)	(220 volts)
40 watt	495 lumens	415 lumens
60 watt	830 lumens	715 lumens
75 watt	1,075 lumens	890 lumens
100 watt	1,560 lumens	1,350 lumens
Durability: Maximum of 1 lamp in 10 burns out in 2,000 hours of operation.		
Lumen Depreciation: Maximum loss of 20% of initial lumens after 2,000 hours of operation.		
Power Factor: Minimum power factor = 0.50.		
Guaranty: Manufacturers must provide a performance guarantee of at least one year.		

In 1995-97, CEMIG (the utility in Minas Gerais) distributed about 90,000 CFLs to households in one region of the state, leading to about 900 megawatt-hours (MWh) per year of electricity savings and 1.8 MW of peak demand reduction (Jannuzzi et al. 1997). This effort was part of a successful DSM program to reduce peak demand and delay a transmission line upgrade in a rural region served by an overloaded transmission line. CFLS were purchased and distributed for around US$8 per lamp in this program and were well-received by consumers.

In 1999, CEMIG and COELBA (the utility in Bahia state) together were giving away about 75,000 CFLs to low-income households. This type of program costs the utility about US$12 per lamp (hardware and distribution). But free distribution of CFLs is very cost-effective since overhead costs are minimized and low-income households pay a subsidized tariff. The utility cuts the amount of subsidy it provides and cuts peak demand when it stimulates substitution of CFLs for incandescent lighting in low-income households. Also, COELBA is planning to carry out a large scale CFL rebate program for the 650,000 households in Salvador (the state capital) in 2000 (Mascarenhas 1999).

Besides CFLs, there is also experience with producing and promoting energy-efficient incandescent lamps in Brazil. Lamp manufacturers in Brazil were producing both standard and energy-saving type of incandescent lamps during the 1980s. The energy-saving lamps used a more efficient filament and consumed about 10 percent less power than regular lamps (e.g., a 54-watt energy-saving lamp providing about the same light output as a standard 60-watt lamp). About 21 percent of the 200 million incandescent lamps produced in Brazil in1989 were the

energy-saving type (Geller 1991). However, lamp manufacturers stopped making the energy-saving lamps in the early 1990s because of their slightly higher first cost.

In addition, lamp manufacturers changed the voltage of most incandescent lamps from 127 volts to 120 volts starting in 1996 through modification of a technical norm (Jannuzzi and Pagan 1998). This change increased the lumen output of incandescent lamps but increased electricity consumption and reduced average lamp lifetime, thereby increasing costs for both consumers and the power sector. It was estimated that the voltage change increased total electricity use in Brazil by about 1 TWh per year (Jannuzzi and Pagan 1998). After pressure from energy efficiency advocates (PROCEL and others) as well as some members of Congress, lamp manufacturers agreed in 1999 to change back to 127 Volts as well as shift all incandescent lamps to higher-efficiency filaments (Roizenblatt 1999). This will both cut electricity use and limit the reduction in light output that accompanies this change.

Fluorescent lighting is often inefficient and of poor quality, with fixtures that are poorly designed, dirty, lacking reflectors, etc. But the adoption of energy-efficient fluorescent fixtures is increasing, especially in new buildings. Approximately 8 million T8 lamps, 11 million electronic ballasts, and 1.3 million specular reflectors were used as of 1998. PROCEL and individual utilities have helped to stimulate the use of these products through R&D and demonstration programs, audits, and educational activities. There has not been major financing or incentive programs for efficient commercial lighting in large part because it is not cost-effective for utilities; i.e., utilities would bear costs and lose substantial revenue if they promoted efficient lighting in the commercial sector.

PROCEL has had an impact on the efficiency of fluorescent lighting ballasts made in Brazil. In 1994, PROCEL and ballast manufacturers signed a voluntary agreement to increase the efficiency of electromagnetic ballasts. This led to an average efficiency improvement of about 4 percent by 1996. And in 1996-97, PROCEL and the manufacturers agreed to adopt minimum efficiency standards through changes in the technical norm used in Brazil. In addition, PROCEL and manufacturers have been negotiating a technical norm to improve the quality of electronic ballasts sold in Brazil.

Overall, Eletrobras/PROCEL estimates it saved approximately 1,630 GWh per year in 1998 by stimulating various types of lighting efficiency improvements (PROCEL 1999a). Approximately 40 percent of this savings is due to use of CFLs, approximately 20 percent is due to use of HPS lamps, and the remaining 40 percent is due to the use of all other types of energy-efficient lighting technologies.

Motors and Motor Systems

Motors account for about half of industrial electricity use, about 40 percent of electricity use in commercial buildings (through air conditioning, refrigeration, and pumping systems), and

about 40 percent of electricity consumption in homes (through refrigerators and other appliances). PROCEL has conducted a number of projects in collaboration with motor manufacturers to improve the energy efficiency of induction motors produced in Brazil., including:

- sponsoring a project that resulted in greater thermal treatment of the carbon steel used in most motor cores, thereby increasing motor efficiency;
- developing a norm that set minimum efficiency levels for high-efficiency motors sold in Brazil;
- adopting an efficiency testing and labeling program for all three-phase induction motors and giving awards to the most efficient standard motors offered in the marketplace.

During 1991-1995, PROCEL sponsored a project that resulted in greater thermal treatment of the carbon steel used in most motor cores, thereby reducing core losses and increasing motor efficiency to some degree. PROCEL estimates that this project led to a 20 percent reduction in core losses in about 30 percent of motors manufactured in Brazil in recent years, resulting in about 190 GWh per year of electricity savings as of 1998 (PROCEL 1999a).

Brazilian manufacturers started producing high-efficiency motors containing silicon steel for export in the 1980s. These motors were first offered in the domestic market around 1990. In 1994, PROCEL sponsored development of a new norm that set minimum efficiency levels for high-efficiency motors sold in Brazil. This, along with U.S. and Canadian motor efficiency standards, led to efficiency improvements in these motors . But sales of high-efficiency motors still represented only approximately 1.5 percent of all three-phase induction motors sold in Brazil as of 1998. High-efficiency motors typically cost about 40 percent more than standard motors sold in Brazil, which limits their market penetration (Soares and Tabosa 1996).

In 1999, one utility (CEMIG) began a pilot rebate program with co-funding from PROCEL aimed at increasing the availability and sales of high-efficiency motors in the Belo Horizonte region. The goal is to stimulate the sale of about 2,500 high-efficiency motors within a year, thereby building supplier and end-user interest. CEMIG worked closely with motor manufacturers and vendors in the design of this program. Some manufacturers are reducing motor prices to complement the utility rebate, and incentives are paid to both purchasers and vendors.

In 1995, PROCEL, working together with motor manufacturers, adopted an efficiency testing and labeling program for all three-phase induction motors. At the same time, PROCEL began to recognize and give awards (the PROCEL “selo”) to the most efficient standard motors offered in the marketplace. In order to win the awards, the manufacturers increased the efficiency of most of their standard motors in the size range of 1-15 horsepower during 1996-1998. Table 4 compares the efficiency of typical standard efficiency motors made in Brazil in

1990, 1995, and 1999. There clearly were significant efficiency improvements throughout the decade. PROCEL estimates that the testing, labeling, and awards program resulted in about 350 GWh per year of electricity savings in Brazil as of 1998.

Table 4: Trends in the Energy Efficiency of "Standard Motors" Sold in Brazil*

Power (horsepower)	Typical Efficiency (%)		
	1990	1995	1999
1	68	70	78
2	72	76	80
5	76	83	85
10	84	85	89
15	86	88	89

* Four-pole motors operating at 1,800 RPM and tested according to the Brazilian efficiency testing standard.

Sources: Oliveira and Almeida 1995; Tabosa 1999.

Taken together, these projects resulted in approximately 575 GWh per year of electricity savings as of 1998, according to PROCEL's estimates (PROCEL 1999a). In 1998, PROCEL and the Brazilian motor manufacturers reached a tentative agreement to phase out so-called standard efficiency motors within four years (PROCEL 1999b). However, this voluntary agreement never was finalized because one of the major manufacturers later changed its position and requested different efficiency standards. It is unclear what will happen to this potentially important policy.

The focus of PROCEL's efforts so far has been on increasing the efficiency of motors. PROCEL has done relatively little to improve the efficiency of motor systems. In fact, surveys in the late 1980s showed that many motors are oversized and consumed excess power because of poor operating conditions and maintenance practices (Henriques 1995). Better motor sizing, correcting voltage and other operating problems, and use of motor speed controls in applications with highly varying load could save a significant amount of electricity in Brazil (Geller et al. 1998).

Adjustable speed drives (ASDs) are produced in Brazil and imported by a wide range of multinational companies such as ABB, Danfoss, GE, Rockwell, and Siemens. Sales of modern ASDs increased from around 9,000 units in 1993 to over 50,000 units in 1997 as import restrictions were lifted, the economy rebounded, and the quality and price of ASDs improved (David 1997). The chemicals, automotive, and food and beverage industries were the main buyers of ASDs up to 250 kilowatts (kW) in capacity during this period (David 1997).

The potential for energy savings through the use of ASDs remains large in spite of the recent growth in ASD sales (David 1997). PROCEL and its utility partners have done relatively little to promote ASDs so far. But PROCEL has initiated some projects related to developing software, manuals, and brochures to stimulate greater use of ASDs and other efficiency improvements in pumping and compressed air systems.

STRATEGIES FOR MARKET TRANSFORMATION

Many efficient technologies (such as high-efficiency refrigerators, air conditioners, motors, and CFLs and other efficient lighting products) are now being produced and/or marketed in Brazil. In addition, design and operational changes such as more careful equipment sizing, better use of natural lighting and ventilation, and load management can reduce electricity use and peak loads. Brazil has started to adopt these energy efficiency measures and practices on a large scale, as discussed above, but market penetration is still well below 5 percent in most cases.

Energy efficiency improvements are inhibited by a series of market barriers and imperfections including:

(1) decades of economic instability and high inflation—conditions that strongly discouraged life-cycle analysis and longer-term investing, and fostered a mentality of purchasing based on minimum first cost;

(2) lack of awareness of electricity conservation measures and practices on the part of many end users;

(3) an immature energy efficiency delivery infrastructure, related to the recent introduction and limited adoption of some of the efficiency measures;

(4) subsidized electricity prices still paid by large industries as well as low-income residential consumers;

(5) electricity costs represent a relatively small portion of total costs for most businesses and households;

(6) lack of available capital—many consumers and businesses are struggling economically and do not have spare cash for buying a more efficient product or undertaking an energy efficiency project; and

(7) lack of attractive financing—interests rates are generally very high and borrowing is discouraged by heavy bureaucracy, onerous guarantee requirements, and other barriers.

A number of these barriers have been reduced in recent years due to economic and political developments, as well as the efforts of PROCEL and other organizations in Brazil. Inflation has greatly decreased and overall economic conditions (standards of living, GDP, etc.) have improved since the adoption of the economic reform plan (the Plano Real) in 1994. Markets have been opened up, import duties reduced, and competition is growing. Many consumers are paying relatively high electricity prices and are interested in learning about how they can cut their utility bills. The availability and awareness of efficiency measures is growing, and manufacturers have made considerable progress in increasing the efficiency of mass-produced goods such as appliances and lighting products.

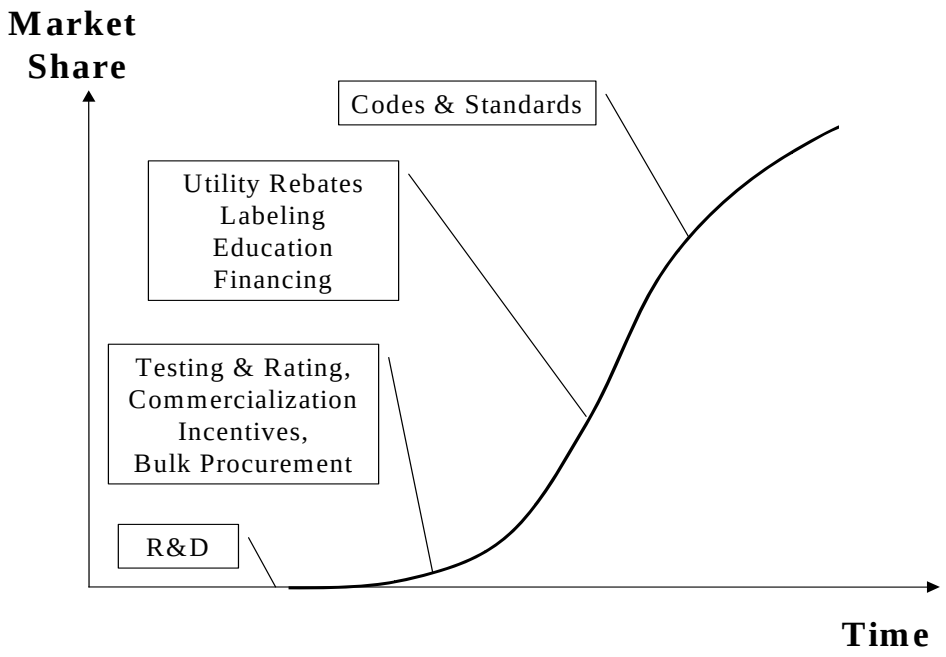
However, much more could be done to stimulate more efficient electricity use on a large scale and realize a greater portion of the enormous savings potential that still exists. In order to realize this potential and achieve the ambitious electricity savings goals that have been established in Brazil, I suggest that a **market transformation approach** be adopted. This approach involves a coordinated set of initiatives to remove the barriers inhibiting widespread and routine adoption of energy efficiency measures in the marketplace (Nadel and Latham 1998). The initiatives that can and should be used to achieve market transformation include regulations, better use of utility resources, financing and infrastructure development, education and marketing, and public sector leadership (see Figure 7).

Regulations

In Brazil, adoption of efficiency standards has been through negotiations of voluntary targets with electrical equipment manufacturers. So far, this approach has given mixed results—it has been difficult to get the manufacturers to accept meaningful standards, and manufacturers have not fully complied with the voluntary targets that have been agreed to. In the future, it would be very helpful if the government could adopt mandatory standards, as has been done in North America. Legislation permitting this is pending in the Congress. This legislation is very important and should be strongly supported by energy planners, policymakers, and others concerned about increasing economic efficiency, reducing risk of power shortages in the future, and protecting the environment.

If the authorizing legislation is adopted, the Executive Branch should proceed rapidly with the development, discussion, and enactment of mandatory efficiency standards for the

Figure 7: Accelerating the Market Transformation Process



products indicated in the draft law and others. The law specifies that standards be set for refrigerators, freezers, air conditioners, motors, lamps, lighting fixtures, and lighting ballasts. Without going into details, I suggest considering initial standards at the levels indicated in Table 5. In all cases, some products made and sold in Brazil already meet the suggested standards levels. In some cases, the levels are similar to efficiency standards already adopted in North America.

The draft law also gives the Executive Branch authority to adopt standards on other products. Electronic products (TVs, VCRs, audio equipment, etc.) and commercial air conditioning and refrigeration equipment are two other areas where standards may be technically and economically feasible (e.g., limiting the standby power consumption of electronic products). Standards should be developed in consultation with consumer representatives, manufacturers, and technical experts both inside and possibly outside of Brazil. U.S. standards experts no doubt could be of help if foreign assistance is desired.

Table 5: Recommended Minimum Efficiency Standards for Brazil

Product	Recommended Standard Level
refrigerators and freezers	Class A products under the Brazilian labeling scheme
room air conditioners	minimum EER = 9.0
Motors	high-efficiency motors as defined by Brazilian norm
incandescent and fluorescent lamps	North American minimum efficacy (lumen per watt) levels
fluorescent lamp ballasts	North American ballast standards

If it is not possible to pass the authorizing legislation, further efforts should be undertaken to raise product efficiency through technical norms, as has been done in the case of lighting ballasts. The technical norms are used to certify products and are used by many companies in purchasing goods such as motors or lighting products. However, the norms are adopted through a consensus process that makes it difficult to adopt provisions that manufacturers oppose.

In addition to equipment efficiency standards, there is a need to enact building energy codes in Brazil. Neither the federal government, states, or municipalities have adopted energy efficiency requirements for new buildings. A few municipalities (e.g., Salvador, Bahia) are interested in establishing such codes. PROCEL should encourage the development and implementation of building energy codes, as should utilities as part of their energy efficiency programs. Support is needed for training architects and construction firms, and enforcement activities, as well as building energy code design.

Utility Energy Efficiency Programs

The ANEEL 1 percent requirement (see page 7 for explanation) is an important step towards having utilities play a greater role in promoting more efficient electricity use in Brazil. A few distribution utilities are already carrying out relatively well-designed and effective energy efficiency programs. But most are still developing plans and capacity to operate such programs. These utilities should move forward as quickly as possible, using support from PROCEL and other energy efficiency experts both within and outside Brazil if necessary. If some utilities prove incapable of spending at least this amount in a sound manner, than ANEEL should consider requiring utilities to fund program implementation by a state or regional agency. Moreover, given the enormous savings potential, utilities should consider spending the majority of their 1 percent requirement on promoting greater end-use efficiency, not just the minimum of one-quarter of 1 percent. COELBA, the state utility in Bahia, is already doing this.

Private utilities complain about having to operate end-use energy efficiency programs and in some cases attempt to minimize expenditures and energy savings, if they are penalized financially when they help their consumers to use electricity more efficiently. Therefore, ANEEL should allow the utilities to recover energy efficiency expenditures that are "in the public interest," as well as the net lost revenues associated with these expenditures, through tariffs. ANEEL also should consider allowing utilities to receive a portion of the "net societal economic benefits" they create as a result of their efficiency programs, again through a small rate increase following independent analysis of these benefits. This strategy has been used to stimulate effective, large-scale utility energy efficiency programs in California and other parts of the United States (Nadel, Reid, and Wolcott 1992.).

There is a danger that distribution utilities in Brazil will design and implement a large array of uncoordinated energy efficiency programs in response to the ANEEL requirement. Market transformation will be enhanced if utilities coordinate their efforts; for example, by using the same efficiency thresholds and working together to stimulate introduction and wide dissemination of emerging or advanced technologies such as high-efficiency air conditioners, high-efficiency motors, newer lighting technologies including dimmable electronic ballasts and controls, high-efficiency distribution transformers, and low standby power electronic products. The coordinated utility approach has been relatively successful in the United States: e.g., the experience with the SuperEfficient Refrigerator Program (SERP), the various initiatives developed by the Consortium for Energy Efficiency, the ENERGY STAR® program, and the work of regional market transformation organizations (CEE 1998; Suozzo and Thorne 1999). Coordinated utility initiatives focused on increasing the sales and market share of new and/or underutilized energy-efficient technologies also should work in Brazil where products are manufactured for a national market. PROCEL is the logical organization to plan such coordinated efforts, consulting with utilities, manufacturers, and other affected parties. ANEEL also could serve in this capacity if PROCEL is unable or unwilling to.

There also is an opportunity for private utilities to finance, sell, and install energy efficiency products and services in Brazil, acting as an energy service company and making a profit on these transactions. Utilities could start their own ESCO subsidiaries, develop partnerships with some of the nascent ESCOs in Brazil (see discussion below), or form partnerships with international ESCOs. A few utilities in Brazil are starting or planning to do this. However, regulators should make sure that private utility ESCO subsidiaries do not have an unfair competitive advantage over non-utility ESCOs. For example, utilities should not be allowed to have their regulated business subsidize their unregulated ESCO activities, or use information collected on the regulated side to give an unfair advantage to their ESCO subsidiary.

Education and Marketing

Some energy efficiency measures like high-efficiency appliances and motors can be addressed through regulations and other "upstream" policies that are aimed at manufacturers and

suppliers. But other measures like CFLs, good lighting design, and motor system efficiency improvement are site- and application-specific and cannot be mandated. Thus, it is essential to educate consumers about efficiency options and convince them that improving energy efficiency is worth the effort, even if energy use represents a small fraction of the cost of operating a business or household.

There are a number of logical "hooks" for raising awareness of energy efficiency opportunities and increasing acceptance of energy efficiency measures and practices in Brazil (Pimentel et al. 1998). An obvious hook is cost savings potential. Many households in Brazil are struggling to make ends meet and are desperate for ways to save money. Surveys show that consumers are interested in learning more about how they can cut their utility bills (Pimentel et al. 1998). Likewise, many businesses are trying to cut their costs and improve their competitiveness. They need to be shown that energy efficiency measures often provide a very high rate of return at minimal risk. Another "hook" that can be used is the potential for power shortages in Brazil and the importance of energy efficiency for reducing the risk of power outages.

PROCEL has sponsored educational and information dissemination programs for all types of consumers. Also, PROCEL sponsored TV ad campaigns linked to the "selo PROCEL" in order to help reduce peak loads during the summers of 1997 and 1998. The ads ran during popular prime-time TV programs. There was some evidence that these campaigns helped to increase sales of energy efficiency measures (e.g., CFL lamps) and reduce overall peak load by about 1.5 percent (Pimentel et al. 1998; PROCEL 1998). But greater research is needed on the effectiveness of past education and marketing efforts and the design of effective future programs and campaigns. And given the high levels of energy waste and inefficiency that still exist in Brazil, much more needs to be done to inform and educate consumers of all types about the practical steps that can be taken to save electricity and money.

Eletrobras/PROCEL has made a good start at informing and educating consumers through the "selo PROCEL" effort. But further steps should be taken to raise awareness of this label and influence consumer behavior since Brazilian consumers do not identify the purchase of more efficient appliances or lamps as a way to reduce electricity waste (Pimentel et al. 1998). One option is to provide information to shoppers in appliance and lighting supply stores. Also, the label should be extended to a greater range of products including high-efficiency clothes washers, TVs, and other consumer electronic products. Another opportunity is to collaborate with the United States in promoting the production and sale of ENERGY STAR® personal computers and other types of energy-efficient office equipment. These products are designed, manufactured, and marketed globally. Japan and the European Union have already joined the United States in promoting ENERGY STAR® office equipment (Thigpen et al. 1998). It would be logical for Brazil to participate as well. If the ENERGY STAR® label is recognized and promoted in Brazil, PROCEL and local utilities could work on educating users on how to enable and properly use the ENERGY STAR® features.

The World Bank loan and GEF grant for Eletrobras/PROCEL and its partners includes co-funding for a number of major education and marketing initiatives. One is a "Best Practices" program for commercial and industrial consumers, involving demonstration projects, case studies, manuals, workshops, and other activities sector-by-sector. Another initiative involves information dissemination and marketing to improve the efficiency of lighting in the commercial and public services sector. And a third initiative involves training engineers and facility managers throughout Brazil on the practical steps that can be taken to improve energy efficiency and cut electricity waste. If policy makers in Brazil want to achieve the ambitious electricity savings goals that have been adopted over the next decade, it is critical that these initiatives be well-funded and well-implemented. In terms of achieving results, education and marketing are as important as technology development and commercialization.

Financing and Infrastructure Support

The lack of financing and high cost of capital are barriers that should be addressed as well. One way to do this would be to incorporate energy efficiency requirements as part of financing for other activities like low-income housing projects, industry expansion, or urban development. These areas receive low-cost financing from the national development bank (BNDES) and housing finance bank (CEF). Thus, financing would be provided for energy efficiency technologies incorporated into new housing or industrial projects. PROCEL should work on making such requirements practical—for example, by developing housing plans and demonstrating energy-efficient low-income housing, and developing energy specifications that could be incorporated into new factories. These activities are included to some degree under the GEF grant recently approved.

Another way to help address the financing and infrastructure barriers is through ESCOs, companies that plan, finance, and install energy efficiency projects in commercial and industrial facilities. A few local or national ESCOs are operating in Brazil (Poole and Geller 1997). However, there is little experience with performance contracting or third party financing of ESCO projects. Most ESCO projects are financed by the client on a fixed fee basis (Poole and Geller 1997). PROCEL has tried to facilitate the financing of ESCO-based energy efficiency projects by BNDES and a few projects have gone forward. But BNDES is difficult to work with, especially for projects less than US$1 million. Also, an attempt was made in 1997-99 to pass BNDES funds through a private bank in order to finance smaller-scale energy efficiency projects (specifically lighting projects). The lighting equipment manufacturers' association in Brazil (ABILUX) formed a partnership with Unibanco bank to develop and finance lighting retrofit products but this scheme did not function well because of lack of interest among end-users and a weak commitment on the part of some lighting companies.

A few utilities have begun to finance efficiency projects implemented by ESCOs as part of their energy efficiency programs. Also, part of the World Bank energy efficiency loan is targeted to public building retrofits that are supposed to be carried out by ESCOs. And a portion

of the GEF grant is designated for the design and initial operation of a new energy efficiency financing facility. The facility, in principal, will receive capital from other entities in Brazil (e.g., electric utilities and BNDES) and possibly financial agents outside of Brazil (both the multilateral financial institutions and private sources of capital). It will be important to make the facility relatively easy to access, with streamlined application procedures and limited credit guarantees for smaller-scale projects. PROCEL and the distribution utilities should promote the facility and help to develop a portfolio of worthy projects so that the facility will be a success.

The U.S. Agency for International Development (AID) also is attempting to set up a Performance Investment Fund that would finance smaller-scale energy efficiency and renewable energy projects in Brazil. This Fund hopefully will receive equity capital from Brazilian banks, utilities, or other portions of the energy sector in Brazil, along with capital or guarantees from non-Brazilian sources. The Fund as conceived would provide non-recourse financing with repayment based on utility bill savings. Project pooling would help to reduce risk and minimize overhead costs. Organizers of the Performance Investment Fund hope to raise on the order of US$50 million and select a Fund Manager in 2000 (Chazyn 2000). If the Fund is established, it should be actively promoted so that it does not meet the same fate as previous attempts at third-party financing.

Public Sector Leadership

The public sector consumes about 9 percent of all electricity in Brazil for street lighting, water and sanitation services, and operating buildings. As explained above, PROCEL, individual utilities, and municipalities have made significant progress in improving the energy efficiency of street lighting. But relatively little has been done to upgrade the energy efficiency of water supply and sanitation utilities or public buildings in spite of high levels of inefficiency and energy waste. Historically, this situation was linked to the fact that many water and sanitation utilities as well as municipalities and state agencies failed to pay their electricity bills. But now that electricity distribution is largely privatized, public sector entities are being forced to pay their bills. This in turn presents an excellent opportunity to pursue energy efficiency and waste reduction in the public sector.

There are some examples of energy efficiency projects in public buildings. For example, PROCEL and the utility in Brasilia sponsored lighting retrofits in 17 Ministry buildings that resulted in about 6.3 GWh per year of electricity savings and nearly 2 MW of reduced peak demand (PROCEL 1998). A number of utilities are funding audits and in some cases supporting implementation of energy efficiency projects in public buildings as part of their DSM programs. Also, many cities in Brazil have formed a network to share information on energy efficiency efforts and projects.

But PROCEL, utilities, and government officials at all levels (federal, state, and local) could do much more to cut energy waste in public facilities. One important action would be for

the public sector to commit to purchasing products with the "selo PROCEL" for products where the selo exists. Another useful action would be to set energy savings targets, monitor results, and publicize government agencies that do the best (and the worst) in terms of cutting electricity use. And a third action would be for the public sector to make much greater use of ESCOs and performance contracting for implementing energy efficiency projects. These actions would build markets for efficient products and services and set a good example for the private sector, as well as save the government money.

The World Bank loan and GEF grant should help to advance energy efficiency in the public sector. The loan includes co-financing for retrofits of forty state buildings and public hospitals in Bahia and the GEF grant includes co-funding of major demonstration projects in public buildings, schools, and hospitals in Sao Paulo and Brasilia (World Bank 1999). In mid-1999, Eletrobras/PROCEL proposed setting energy efficiency targets in federal buildings, creating mechanisms to facilitate use of ESCOs by public agencies, and requiring federal agencies to purchase products with the selo PROCEL (PROCEL 1999c). On January 6, 2000, President Cardoso issued a decree requiring all federal agencies to reduce their electricity use for lighting, air conditioning and refrigeration 20 percent by 2002. PROCEL is designated to assist agencies and monitor compliance, and federal agencies are authorized to use performance contracting with payment to ESCOs based on energy savings realized.

CONCLUSION

Brazil has implemented one of the strongest national electricity conservation programs in the world. Progress has been made in a wide range of areas including improving the efficiency of refrigerators and other household appliances, introducing and disseminating a variety of energy-efficient lighting technologies, and increasing the efficiency of motors made and sold in Brazil. PROCEL through its cumulative efforts saved about 5.3 TWh as of 1998, equivalent to 1.8 percent of total electricity consumption in Brazil. The electricity savings enabled utilities to avoid constructing approximately 1,560 MW of new capacity. The estimated US$3.1 billion of avoided investments in new power plants and T&D facilities was approximately 12 times what Eletrobras/PROCEL and its utility partners spent on energy efficiency initiatives during 1986-1998.

Some recent developments including requirements for utility energy efficiency programs and the approval of an energy efficiency loan from the World Bank and complementary grant from the Global Environmental Facility should lead to even greater electricity savings in the future. But more needs to be done to achieve PROCEL's long-term goal of saving 77 TWh per year by 2010—equivalent to approximately 15 percent of projected electricity use that year without efficiency improvements. The penetration of many energy efficiency measures is still quite low and consequently the cost-effective savings potential remains very large.

In order to realize a large fraction of this savings potential, a market transformation perspective is recommended. This perspective starts by identifying the barriers inhibiting more efficient electricity use and then develops policies and programs to remove or overcome these barriers. New or expanded policies that could be especially valuable for overcoming the barriers present in Brazil include:

- mandatory energy efficiency standards for appliances, lighting products, and motors sold in Brazil;
- regulations that allow utilities to recover energy efficiency expenditures that are "in the public interest," as well as the net lost revenues associated with these expenditures, through tariffs;
- coordination among utilities to influence equipment manufacturers and build sizable markets for new and emerging energy efficiency measures;
- expanded consumer education, training, and promotion efforts in all sectors (residential, commercial, and industrial);
- financing for energy efficiency projects that is easy for businesses to access and available at attractive terms; and
- public sector leadership in purchasing energy-efficient products and using ESCOs to implement energy efficiency projects.

Last but not least, better data on electricity use, efficiency levels, and the penetration of energy-efficient technologies in Brazil are needed. The last comprehensive national survey on appliance saturations and electricity use was completed in 1988; no national surveys on commercial or industrial electricity use were ever completed. Better data are needed on trends in the average efficiency and electricity use of key products such as refrigerators, motors, and lighting products. This information is essential for understanding the effectiveness of different policy and program initiatives and for better monitoring the overall progress in energy efficiency in Brazil.

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