Implementing Power Rationing in a Sensible Way:

Lessons Learned and International Best Practices

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PURPOSE

The Joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP) is a special global technical assistance partnership sponsored by the UNDP, the World Bank and bi-lateral official donors. Established with the support of UNDP and bilateral official donors in 1983, ESMAP is managed by the World Bank. ESMAP's mission is to promote the role of energy in poverty reduction and economic growth in an environmentally responsible manner. Its work applies to low-income, emerging, and transition economies and contributes to the achievement of internationally agreed development goals. ESMAP interventions are knowledge products including free technical assistance, specific studies, advisory services, pilot projects, knowledge generation and dissemination, trainings, workshops and seminars, conferences and roundtables, and publications. ESMAP work is focused on three priority areas: access to modern energy for the poorest, the development of sustainable energy markets, and the promotion of environmentally sustainable energy practices.

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Foreword

Dealing with energy shortages has become a reality in developed and developing countries. The balance between supply and demand can be threatened by a variety of reasons, from droughts that lower the water levels in reservoirs that hydro generators depend upon to financial disasters that curtail utilities from purchasing sufficient power to provide to their customers. The impact of curtailed services goes beyond the immediate inconvenience of a lack of electricity. Power crises affect the economic and social fabric of a community, region, or nation.

In this publication, Luiz Maurer, Mario Pereira, and José Rosenblatt examine energy crises that have occurred in a number of countries, particularly Brazil. They provide pragmatic suggestions to stakeholders—including governments, utilities, consumer advocates, and others—to help avoid power crises or at least mitigate their impact when they do occur.

The authors recognize that the use of rationing as a response to shortages reminds many of the implications of centrally planned economies. However, they make clear that power sector reform does not necessarily make a system more vulnerable to energy crises, nor is rationing incompatible with reform. In fact, they argue, rationing through price signals can allocate energy in a financially sustainable and socially equitable way, creating the environment for a more stable power system.

We hope that their analysis of countries' experiences with energy crises—both what has worked and what has not—will contribute to programs and policies that will, indeed, use energy in a rational way.

Dominique Lallement
Manager, ESMAP

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A special recognition should be made to Minister Pedro Pullen Parente of Brazil, the President's Chief of Staff when the energy crisis erupted in 2001. His role, vision, and commitment in conducting the entire rationing process in Brazil were vital to its success.

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Acronyms and Abbreviations

ABRACEEL	Brazilian Association of Marketers
ABRADEE	Brazilian Association of Discos
AES	Applied Energy Services (USA)
ANEEL	National Electric Energy Regulatory Agency (Brazil)
BNDES	National Bank of Development (Brazil)
BOT	Build Operate and Transfer
BYO	Build Your Own Baseline
CBL	Customer Base Load
CDE	Comisión Federal de Electricidad (Dominican Republic)
CGSE	Electric Sector Management Committee (Brazil)
CNPE	National Council of Energy Policy (Brazil)
CPP-F	Critical Peak Pricing - Fixed
CPP-V	Critical Peak Pricing - Variable
CPUC	California Public Utility Commission
Discos	Distribution Utilities
DWR	Department of Water Resources (California)
EBITDA	Earnings Before Interest, Taxes, Depreciation, Amortization
EDF	Electricité de France
ESKOM	State Owned Utility in South Africa
ESMAP	Energy Service Management Assistance Program
ESP	Estado de São Paulo (Newspaper)
FERC	Federal Regulatory Commission (USA)
FGV	Getúlio Vargas Foundation (Brazil)
FiVa	Fixed-Variable Tariff System
FSP	Folha de São Paulo (Newspaper)
GCE	Electric Energy Crisis Management Board (Brazil)
GCOI	Integrated Operation Coordination Group (Brazil)
GDP	Gross Domestic Product
Gencos	Generation companies
GM	Gazeta Mercantil (Newspaper)
GW	Gigawatts
IBGE	Brazilian Institute of Geography and Statistics
IBRD	International Bank for Reconstruction and Development
ICAP	Installed Capability
IEA	International Energy Agency
IPP	Independent Power Producer
ISO	Independent System Operator
JB	Jornal do Brasil (Newspaper)

kWh	Kilowatt-hour
LMP	Locational Marginal Pricing
LNG	Liquefied Natural Gas
LOLP	Loss of Load Probability
MAE	Wholesale Energy Market (Brazil)
MP	Provisional Measure (Brazil)
MRE	Energy Reallocation Mechanism (Brazil)
MW	Megawatt
MWh	Megawatt-hour
NEEPOL	New England Power Pool (USA)
NORDPOOL	Nordic Countries Power Pool
NOx	Nitrogen Oxide
NYPOOL	New York Power Pool (USA)
O&M	Operation and Maintenance
ONS	National System Operator (Brazil)
PJM	Pennsylvania-New Jersey-Maryland Power Pool (USA)
PPA	Power Purchase Agreement
PPIAF	Public Private Infrastructure Advisory Facility (IBRD)
PPP	Price Protection Products
PRA	Programa de Reducción de Apagones (Dominican Republic)
PROCEL	Energy Conservation Program (Brazil)
PT	Worker's Party (Brazil)
RE-SEB	Restructuring of the Power Sector in Brazil Assignment (1996-1998)
RTP	Real Time Pricing
SRMC	Short run marginal cost
TEMPO	Time of Use tariff system (France)
TEPCO	Tokyo Electric Power Company
TOU	Time of Use Tariffs
UF	Union Fenosa (Spain)
UNIFACS	Federal University of Salvador (Brazil)
VLL	Value of Lost Load

Executive Summary

1. Access to reliable power is an essential ingredient to foster economic growth and reduce poverty. However, mere access does not guarantee sustainable development. Problems with inadequate and insecure supply of electric power have increasingly affected both developed and developing countries. Unreliable power disrupts production, damages equipment, causes personal discomfort, increases the cost of doing business, deteriorates the investment climate, and, in the medium term, hurts job creation and economic development.

2. The objective of this report is to present practical measures that can be implemented to help countries minimize the economic and social consequences when confronted with power shortages. By examining best practices in handling power crises, it seems that a quota system in tandem with two-way price signals (bonuses and penalties) is a robust and technically sound methodology to deal with power shortages, particularly in energy-constrained systems. Contrary to the common wisdom, empirical evidence has shown that customers do respond to prices in a relatively short time frame, if they are instructed and motivated to do so.

3. Recent research and some innovative pilot studies have also suggested that variations of a quota-like system may also be used on a permanent basis, not only when energy rationing is imminent, but also when energy is abundant. The objective is to assure that the correct price signals are conveyed to the customers, who can respond accordingly by adjusting their consumption patterns. When price signals are put in place, it becomes imperative to implement appropriate safety nets to protect the poor. Those nets can also be designed in such a way to engage low-income customers, making them respond to rationing whenever necessary. Needless to say, these innovative approaches require a complete regulatory revamping how energy is regulated and priced.

4. By reviewing the causes of and responses to power shortages in Chile, China, California, the Dominican Republic, Japan, and particularly Brazil, this report analyzes ways in which governments, utilities, consumers, and other stakeholders can deal with the multifaceted aspects of power rationing. This report highlights the case of Brazil as one of the best international practices. Other countries can certainly benefit from using some of the Brazilian basic concepts to handle their power crisis.

Types of Shortages and Responses

5. Chapter 2 lays the groundwork for dealing with rationing in a sensible way. It distinguishes between three types of power shortages: energy-constrained, capacity-constrained, and those that encompass both types of constraints. Understanding the type of shortage in a given situation is critical to formulating effective solutions:

- An energy shortage is one in which the power system can supply the instantaneous demand at any given moment, but cannot supply energy on a continuous, long-term basis, as was the case in Brazil in 2001–2002, when lack of water in reservoirs led to a shortage in hydroelectric power;

- A capacity shortage is one in which the system is physically unable to supply part of the peak demand, but can still supply energy needs during off-peak hours, such as happened in California in 2000–2001;
- A combination energy-and-capacity shortage, as the name implies, involves both problems, as occurred in Chile during its worst period in 1998–1999.

6. Saving energy is absolutely necessary in dealing with shortages, whether market-driven power system reforms have taken place or whether a traditional, monopoly-based, state-owned utility is solely responsible for the power sector. When a power crisis is imminent, the power system's ability to promptly respond by building extra capacity is relatively limited. Unless the system has abundant cheap reserves, which is seldom the case, focusing on the demand side becomes imperative.

7. Unfortunately, very few, if any, countries plan how they would deal with rationing should it become necessary. "Planning" for a crisis is more often than not perceived as politically incorrect. As a consequence, when a shortage episode happens, there are no consistent procedures, regulations, incentives, and political consensus on how the crisis should be managed.

Case Studies

8. Chapters 3 and 4 examine case studies in which power shortages have led to different rationing responses. Chapter 3 focuses on Chile, China, California in the United States, the Dominican Republic, and Japan, while Chapter 4 deals more exhaustively with Brazil.

9. Those case studies provide diversity in terms of geographical scope, underlying causes of the crises, and how governments dealt with power shortages, as summarized in the following chart.

Country or Region	Period	Geographical Scope	Major Causes	How Government Dealt with Crisis
CHILE	1988-99	National Interconnected System	Drought and over-depletion of hydro reservoirs	Brown-outs and Black-outs
CHINA	2003 until today	Two thirds of the country	High demand growth, but capacity not growing at the same pace	Forced curtailment, black-outs and some DSM
CALIFORNIA	2001-2002	State and West Region	Shortage of capacity, drought in Northeastern US, and defective market rules	Interruptible contracts, some rolling black-outs, and demand response towards the end
DOMINICAN REPUBLIC	2002 until today	Country wide	Financially unsustainable sector and no resources to buy fuel - "financial black-outs," despite abundant capacity	Haphazard black-outs for several hours, more intense in poor neighborhoods
JAPAN	2003	Tokyo concession area	Forced stoppage of several nukes for security reasons	Strong campaign and massive DSM efforts - no black-outs
BRAZIL	2001-2002	Nationwide, except in the South Region	Drought and delays in the expansion of thermal generation	Quotas with price signals - no brown-outs or black-outs

10. Chile, one of the first countries in the world to privatize and deregulate its power sector, has experienced several power shortages in recent years. In 1998–1999, a crisis hit.

Although it was not devastating in absolute terms, it triggered a financial crisis among hydro generation companies. Several causes, including a drought, led to the shortage. One of the most important causes, however, was a regulation that essentially bailed out generator companies from purchasing in the expensive spot market when affected by a drought worse than one that occurred in 1968. Knowing that this waiver was in place led generators to operate their plants imprudently, over-depleting their reservoirs rather than purchasing power in the market. Some blackouts were implemented in order to deal with the crisis, but little other demand response took place.

11. China is currently facing a capacity shortage in about two-thirds of the country. Intensity varies depending upon seasonal and climatic conditions. Many factors play a role, but most significantly, industrial and residential energy consumption has greatly increased over the last decade. Rolling blackouts have been the predominant way of dealing with shortages. As China moves from a command-and-control economy to a more market-oriented one, it might find ways to reduce demand via price signals, which have been proposed but not implemented.

12. The California crisis received a large amount of media coverage, even though the amount and frequency of power curtailment were relatively small. It had two components: the power shortage per se, and a financial debacle that profoundly affected the financial solidity of distribution companies (discos), causing insolvency and even bankruptcy in the case of PG&E, the largest utility in California. The financial crisis also significantly increased the state's public debt. According to the prevailing regulatory arrangements, discos were forced to buy a large portion of their energy needs in the wholesale market at very high prices. As their financial situation worsened, the state felt that it had to step in as a buyer of last resort. It ended up spending billions of dollars in power purchase agreements, with long-term economical and political consequences. The crisis caused many to rethink the virtues and risks of power sector reform. Some experts say that if efforts were directed toward prompt implementation of demand response during the summer of 2000, much of the power crisis would have abated within a month, rather than persisting for a year.

13. In the Dominican Republic, power cuts have been a constant problem, with widespread blackouts considered "business as usual." Although supply was boosted in 2003 due to investments by the private sector, generators have not been collecting sufficient revenues from distribution companies who, in turn, have had problems collecting bills from consumers. Referred to as a "financial blackout," the result has been haphazard and chaotic service, with a predominant impact on the poor who cannot afford back-up generators. In response, the government designed the National Program to Reduce Blackouts (PRA), a two-year effort to target subsidies to the poor on a geographical basis and implement rolling blackouts in a more organized fashion. Yet, as Chapter 3 explains, PRA represents the antithesis of a sound demand management program, as it has led to resource waste and threatens the financial sustainability of the entire power sector.

14. Japan's 2003 power shortage occurred suddenly and without warning, when the Tokyo Electric Power Company (TEPCO) ceased operation of its 17 nuclear power plants for a safety analysis. TEPCO's actions on the demand side centered on an ambitious energy savings campaign conducted via multiple media channels. Because energy conservation was already ingrained in the culture of the average customer and standards to improve energy efficiency were

in place, customers reacted favorably to cutting back on their energy usage without resorting to blackouts or other measures.

15. Brazil experienced a major supply crisis that started in 2001, and led to an aggressive energy rationing plan from June 2001 through February 2002, as detailed in Chapter 4. The immediate cause of the crisis was a sequence of years drier than usual. However, the system would have been able to withstand low rainfall had more generation capacity been built. The government hoped to avoid rationing, but it became unavoidable. The debate focused on how to implement rationing: via rolling blackouts or a quota system with price signals. Most distribution companies' top executives claimed that a quota system would not work, challenging the assumption that customers would respond to economic signals, and strongly proposing the implementation of rolling black-outs instead. Had this advice been taken into account, the economic consequences for the country would have been devastating.

16. As in most power crises, there was initially a high degree of confusion and misinformation to carry out a solution. A two-way quota system was finally implemented in Brazil, which limited consumers to approximately 80 percent of their previous year's consumption, with bonuses given to those who consumed less and penalties to those who consumed more. Large customers had the flexibility to exchange quotas, which effectively allowed them to allocate energy savings among themselves in the most efficient way. In the end, the program achieved its targets. Despite customers' different price elasticities and therefore the intensity of their responses to the price signals, the rationing scheme proved to be extremely successful, in terms of engagement and results achieved. The two-way pricing system, in tandem with an honest perception of the crisis and a massive campaign on how to save energy, was critical in engaging the entire population in the overall energy conservation effort. Low-income customers, solely motivated on price signals, were the ones who contributed most.

Issues in Rationing

17. As discussed in Chapter 5, technological, financial, social, and other factors distinguish each rationing episode, yet some common features can provide guidance to decision makers when planning for and dealing with a power crisis. In some cases, the transition from a regulated to a market-driven system has created a vacuum in leadership and coordination among entities. Problems emerge when there is a shortage or a drought-induced event that stresses the power system. Gaps in responsibility and accountability certainly contributed to the power crises in California, Brazil, and China.

18. Another common feature in most of the cases analyzed in this document is the absence of a timely action plan capable of preventing or mitigating the impact of energy shortages. Governments tend to "wait and see" until the last possible moment. Power sector reforms do have checks and balances to deal with the government bias to withhold bad news, the most important of which is the creation of an independent system operator (ISO). The ISO possesses real-time knowledge about the system and is meant to be sufficiently neutral to make technical recommendations in a transparent and unbiased manner. In fact, however, as seen in Chile, California, and Brazil, the ISO cannot always operate independently. Its actions can be preempted or restricted by the government. The idea of centralizing all efforts under a single, high-level authority seems to be not only effective, but also essential when a major crisis breaks

out. In Brazil, the President appointed a decision-making committee coordinated by one of his closest advisors, who took on the position of “Minister of Rationing.” Although this centralization preempted the authority of the regulatory agencies of the power sector, it allowed for complex decisions to be closely coordinated. In contrast, in California, many players had a say in the process, including state and federal government agencies and consumer advocates. They had different views on the causes of the crisis and how to handle it. A convoluted decision-making process is one reason why California’s initially modest crisis, which (most probably) could have been mitigated with the introduction of effective demand response tools, grew to such colossal proportions.

19. In most of the cases analyzed, it becomes difficult to measure the overall social and economic impacts of energy crises, and how those could have been minimized, had a sensible rationing plan be put in place. In the short term, losses include a reduction in industrial production, costs to recover systems, and losses of revenues for utilities. In a crisis of longer duration, it is even more difficult to determine a reasonable baseline for comparison. External macroeconomic events certainly play a large role.

20. Power rationing often implies significant shifts in income among different stakeholders, with the end results hard to predict. Solving post-rationing crises has proven to be more difficult than the power crises themselves in Brazil, Chile, California, and other instances. In Brazil, where a price cap form of regulation prevails, the achieved reduction in consumption aggravated the already weak financial situation of distribution companies. [1] In other cases, when the government steps in by subsidizing fuel or providing it at no cost to the utilities, these subsidies end up benefiting only a minor fraction of the population and harming the poor: by artificially reducing the prices of energy, governments effectively invite clients to consume more, often leading to more wasteful use of energy. As the government must devote even more of its limited resources to the power sector, investments in other sectors, including health, education, and economic development, may be sacrificed.

Quotas Versus Rolling Blackouts

21. Once it is determined that a rationing system is necessary, governments must decide what form it should take. Chapter 6 compares quotas based on price signals with rolling blackouts. In most cases, rolling blackouts resulting from energy or capacity shortages have been decided on an ad-hoc and last-minute basis. Rolling blackouts, however, no matter how organized they are, represent the most inefficient way of rationing a scarce resource, since energy is rationed in a haphazard way, driven by the physical reality of the power grid and not by customers’ real needs.

22. Another form of rationing is a quota system incorporating two-way price signals, which gives the consumers the ability to decide how much they are willing to pay for electricity when the resource is scarce and the price is high. Some observers perceive the use of price signals with cynicism for several reasons. They may believe that price elasticity of energy is very

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[1] The form of regulation is a factor in the financial impacts of quotas for a disco. Financial results would have been less sensitive in a revenue cap form of regulation, which would have provided a better alignment between the utilities’ incentives and the policy objectives.

low, particularly in the short term and that, therefore, price signals will not reduce consumption. There are also concerns regarding income distribution, or the fairness of such a mechanism, since high prices are potentially more harmful to the poor. Yet, price signals can harness demand elasticity and have proven to be effective in a short time frame. Moreover, with appropriate design, the poor may be protected against high prices and even engage in the energy conservation efforts.

23. Quotas are less effective in handling capacity-constrained systems, because it is difficult in most countries to determine when a customer is saving (or using) energy. However, technological advances in metering are making quotas as effective in capacity-constrained as in energy-constrained systems. Also, countries can focus on large clients on a very expedited basis. With proper contractual arrangements, price incentives and protocols utilities can buy-back energy from large customers, with a significant impact on the quality and reliability of service for all customers.

24. Chapter 7 presents a simple rationing scheme based on energy quotas assigned to individual customers. It also considers the idea, proposed by some economists, of fixed energy assignments combined with price signals as a way to use energy in the most rational manner. In times of scarcity, when energy is expensive, customers should have incentives to save. Conversely, if energy is abundant, customers should have incentives to boost usage, increase production, and substitute fuels. Customers will still be financially hedged for a large part of their consumption, but will have incentives to react to the cost of scarcity. The chapter looks at cases where variations on demand response through tariffs are in place. Finally, interval metering, in which customers see their energy prices on a real-time basis and can act accordingly, have been introduced in the United States, Australia, and Canada. As the technology becomes more available, it may in effect allow customers to self-ration based on their willingness to pay.

Lessons Learned and Recommendations

25. By examining good and bad examples of countries' handling of their power crises, this publication extracts some lessons learned that may be applicable in a wide spectrum of circumstances. As detailed in Chapter 8, they include the following:

- Blackouts are the worst way to deal with electricity shortages and should be considered the last resort, when everything else has been [honestly] tried and failed;
- Price signals can entertain demand response and help bridge the supply gap. Even if price elasticity is modest, high price increases entertain sufficient demand response;
- A good rationing program should be tailored to the specifics of each power system. The case of Brazil, mentioned in this report as an international best practice, may be greatly simplified and adjusted to the specifics of smaller power systems. Sensible schemes may be simple, yet effective;
- Capacity and energy shortages affect power system reliability in different ways, but similar concepts may be applied, particularly if technology is available. Price signals should be given that consider the reality of each system, the available technology and the existence of reasonable commercial practices. The nature and intensity may vary,

but there will always be some way to entertain demand response via price and quantity rationing.

26. Based on these lessons, this publication makes seven recommendations as countries confront energy crises:

1. Plan in advance, long before rationing is necessary and also as a way to avoid it. Planning for a crisis is not politically incorrect. It merely acknowledges that systems fail, particularly if heavily dependent on hydro resources;
2. Have good early warning signals before the situation gets out of control. Starting and ending rationing is the most difficult decision to be made in the power sector; the political process and most governance mechanisms are ineffective to make the right decision at the right time. Some objective criteria should be put in place to help society before the situation gets out of control;
3. Foster the rational use of energy on a permanent basis to avoid crises. Expose customers to price signals, both in times of abundance and scarcity. Provide tariff hedges, but do not completely isolate the retail market from the reality of the wholesale market;
4. When an energy crisis does occur, put someone in control with across-the-board authority. Crises are multi-faceted and require fast decisions. They need expedited processes and someone to make the entire bureaucratic machine work;
5. Protect the poor from the consequences of rationing. Price increases may hurt the poor unless there are safety nets. Those nets should be designed in such a way to engage the poor in the overall conservation effort. The poor who save should be financially rewarded;
6. Do not socialize losses and gains. A market-based rationing scheme heavily relies on incentives and penalties. By definition, those who save should win and those who waste should lose. The political temptation to socialize gains and losses by virtue of a crisis defeats the purpose of price signals;
7. Finally, honor contracts—always. Crises should not be an excuse for not honoring contracts or for evoking *force majeure*. It is essential to preserve the contractual arrangements that encourage people to save and penalize those who do not.

1

Objectives of This Report

1.1 The main objective of this report is to present practical measures that can be implemented to help countries minimize the economic and social consequences when confronted with power shortages.

1.2 Rolling blackouts are the usual way of managing power crises. Most blackouts are carried out on a mandatory, oftentimes haphazard, last-minute basis. This report aims at drawing policymakers' attention to more efficient ways to deal with shortages. With self-rationing, customers themselves make voluntary consumption and conservation decisions. With proper implementation of price signals that convey the cost of scarcity, combined with safety nets to protect the poor, the negative impact of shortages on society and on the economy can be greatly minimized.

1.3 This report compares and contrasts rationing events in several countries, and extracts lessons and best practices that may be applied to other places currently facing or about to face power shortages. Specific challenges to deal with power crises are analyzed, and the best methods to minimize the social and economic consequences of power rationing are discussed. This report highlights six significant rationing episodes: Chile (1998–1999), California (2000–2001), Brazil (2001–2002), Dominican Republic (2001–present), Japan (2003), and China (2003–present). It also alludes to chronic power shortages experienced in other countries, particularly in Asia and in Sub-Saharan Africa. The way authorities have dealt with power crises is then discussed in great detail, addressing the issues involved and the efficiency of the measures adopted in each case.

1.4 This report is not meant to scrutinize, with the benefit of hindsight, how those shortage episodes could have been avoided and who should be held responsible for them. More often than not, a combination of factors triggered shortages. However, accepting that fact does not justify a passive, fait accompli approach to addressing the problem. Understanding the causes of a crisis is essential for planning and for avoiding future crises. However, it may come to a juncture when a crisis becomes unavoidable and handling it properly becomes imperative to minimize its social, financial, and economic hardships. Finger-pointing then becomes distracting and counter-productive. Proper management of a crisis is feasible if governments and regulators do not get distracted about whom to blame for the undesirable events.

1.5 By examining best practices in handling power shortages via the use of price signals, the report suggests that these mechanisms, or variations on them, are robust and technically sound enough to be used on a permanent basis, not only when energy rationing is imminent, but also when energy is abundant. New, non-conventional end-use tariff mechanisms have the potential to bolster demand response from customers long before a crisis takes place. By engaging customers in conservation efforts far in advance,[2] a crisis may be mitigated either in duration, intensity, or both. Depending on the effectiveness of the pricing mechanism used to foster customers to reduce consumption, and how far in advance it is applied, some crises could have been completely avoided.

1.6 Special attention is given in this report to the power crisis in Brazil in 2001 and 2002. The handling of this crisis per se has been considered a very successful case in the implementation of energy rationing using market mechanisms that resulted in remarkable demand response. Despite its important potential lessons, the Brazilian crisis has not received adequate coverage in the specialized literature. The experience in handling the crisis has not been disseminated to other countries that continue to suffer rolling blackouts in the absence of more creative ideas about how to handle the problem differently. This paper is an attempt to show other countries more creative, less painful ways to handle shortages.

1.7 Contrary to common wisdom, demand in Brazil was much more price elastic and faster to respond than industry players and regulators had imagined. No brownouts or blackouts were necessary, for an almost nationwide, nine-month, 20%+ across-the-board energy reduction program. The impact on the economy as a whole was significantly minimized. Some initial estimates indicated that rationing could represent a GDP reduction of about US$10 billion. At least half of this amount was saved due to the implementation of a "smart" scheme. Its long-term positive effects are also noticeable: the end-user learned how to use energy more effectively and some of the efficiency gains became irreversible.

1.8 However, not everything was rosy. The incentive scheme generated a large fiscal deficit that had to be absorbed by the National Treasury.[3] Industry players had significant revenue and margin losses, which was particularly hard for distribution companies that had been seriously hurt by earlier currency devaluation.[4] Contrary to what many utilities claimed, rationing was not the root cause of their financial distress, but certainly added to it. Furthermore, a crisis of this magnitude invariably strains institutions, particularly fledgling, newly created market and regulatory agencies. Rationing also entailed a major cost shift among generators (gencos), distribution companies (discos), and consumers in general. It became a challenge for the Brazilian government to put together all the necessary regulations, almost on a real-time

[2] Ideally, demand response should be an integral part of any power sector, but this is rarely the case. In the absence of this important mechanism, regulators should try to take advantage of an impending shortage crisis to entertain some demand response, by conveying the cost of scarcity and by providing incentives for customers to react to prices. In the case of Brazil, the crisis erupting in 2001 was anticipated with a reasonable degree of accuracy back in 1999, two years earlier, but all actions to avoid the crisis were only focused on the supply side.

[3] In part, due to the overwhelming response from customers who ended up receiving a volume of financial incentives higher than originally envisioned.

[4] Most of the utilities were privatized during the boom years of 1996–1998. In some cases, discos were sold at more than 100% premium. Assumptions to justify such high premiums were overly optimistic, even naive: market growth rates of 6–7 percent annually for 30 years, in tandem with tariff realignment. Many of the discos remained heavily choked off in un-hedged foreign debts. The currency devaluation in Brazil, which took place in early 1999 immediately after the privatization euphoria, was a watershed for many companies' financials. Therefore, several companies were already in a precarious financial situation when rationing started. To many utilities' surprise and dismay, the rationing crisis demonstrated that consumers do respond to prices.

basis, to deal with the multi-faceted aspects of the crisis. A real challenge as far as price signals are concerned is to provide the correct price incentives for customers to respond, but at the same time prevent massive shifts of income among different stakeholders.[5] It became clear that many contractual and regulatory aspects should have been dealt with far in advance.[6] More planning would certainly have been beneficial. More retail competition and other mechanisms, such as demand-side bidding, should have been implemented a long time before.

1.9 The Brazilian experiment has demonstrated that the use of market signals is preferable, if technically feasible. However, it should be noted that the Brazilian case was a textbook example of an energy-constrained system. Therefore, lessons learned and recommendations should be examined in this context. It may be more difficult to deal with capacity-constrained systems using the same techniques, where the key issue is to curtail demand only during certain critical periods of the day. In the absence of interval metering and real-time pricing, it becomes virtually impossible to know how much energy is being used and which prices to charge during those highly critical periods. This is not an issue for very large customers, but is certainly a handicap to implement price-effective measure in mass retail markets.

1.10 Recent advances in technology and the installation of selective metering in large clients have shown that some hurdles faced by capacity-constrained systems may be overcome and a significant demand response achieved, long before the deployment of real-time metering on a massive scale.[7] If consumption can be metered in shorter time intervals, the market-based approach adopted in Brazil, described in this paper, can have broader applicability, both for energy- and capacity-constrained systems.[8]

1.11 Despite the important findings about the role of demand response, not much has been done in post-crisis Brazil on the demand side of the equation. The new administration has thoroughly examined the nature and causes of the crisis, and has proposed several actions to avoid new crises in the future. However, most of those actions have focused on the supply side and almost none of them attempts to create the proper market mechanisms to bolster demand response.

1.12 Contrary to the case of Brazil, the power crisis in California was not an example of best practice. The complex political and regulatory environment did not enable decision makers to implement the necessary conservation measures on a timely basis. The state had to use rolling blackouts as a last resort.

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[5] This prompted a difficult situation for the government, which was forced to step in and bail out some of the losers, including state-owned generation companies.

[6] During the development of the RE-SEB project, which set the basis for the power sector model in Brazil from 1997 until late 2003, there was a specific recommendation from senior advisors to the Ministry of Mines and Energy not to address the issue of rationing, given a possible perception of failure of the new, proposed regime. This recommendation will be discussed further in this report.

[7] For example, when interval metering is available. Despite not being economic to have this kind of sophisticated metering on a wide-scale basis, it may be extremely advantageous to concentrate on large customers, who represent a critical mass and will have incentives to respond to price signals almost in real time.

[8] The installation of time-of-use metering is common in many countries. Despite being the first, important step towards good load management, one of its drawbacks is that energy prices are fixed for each of the pre-defined intervals and do not vary with system conditions. Real-time metering has become more useful with competitive markets and retail competition, where customers pay based on the prevailing spot price at any given moment in time.

1.13 However, a lot has been done in the post-crisis environment. California now has a much better understanding about how demand behaves and what kinds of tariff and regulatory arrangements are more conducive to an efficient demand response. Price and quantity rationing possibilities have been explored, in both large customer and mass market segments. Sophisticated technologies in metering and communication have been deployed, to allow real-time pricing in response to peak capacity shortages. There have been interesting findings and promising results on load responses to prices and other incentives. Some of those results are briefly addressed in this paper, as they may have broader application in other countries.

2

Background

2.1 Access to reliable power is an essential ingredient to foster economic growth and reduce poverty. However, mere access does not guarantee sustainable development. In order to be secure and meet future capacity requirements, electric systems need to be adequately designed and built. This chapter explains different causes of shortages and highlights ways to deal with them, which will be expanded upon in subsequent chapters.

Rationing: More Often and More Widespread

2.2 There is a growing amount of evidence that power systems have not been as reliable as customers expect. Power system failures and shortages have become more usual and widespread, both in countries that have restructured their power sectors and in countries that have preserved their traditional state-owned, vertically integrated utilities. Almost no power system has been immune to some form of shortage and/or service disruption. Table 2.1 illustrates situations where some form of power rationing, capacity curtailment, or shortages have taken place. Those incidents have happened under various types of institutional power sector arrangements, ranging from regulated (Argentina in 1988, Russia, India, China), to partially deregulated (Brazil), to completely deregulated (California, Norway).

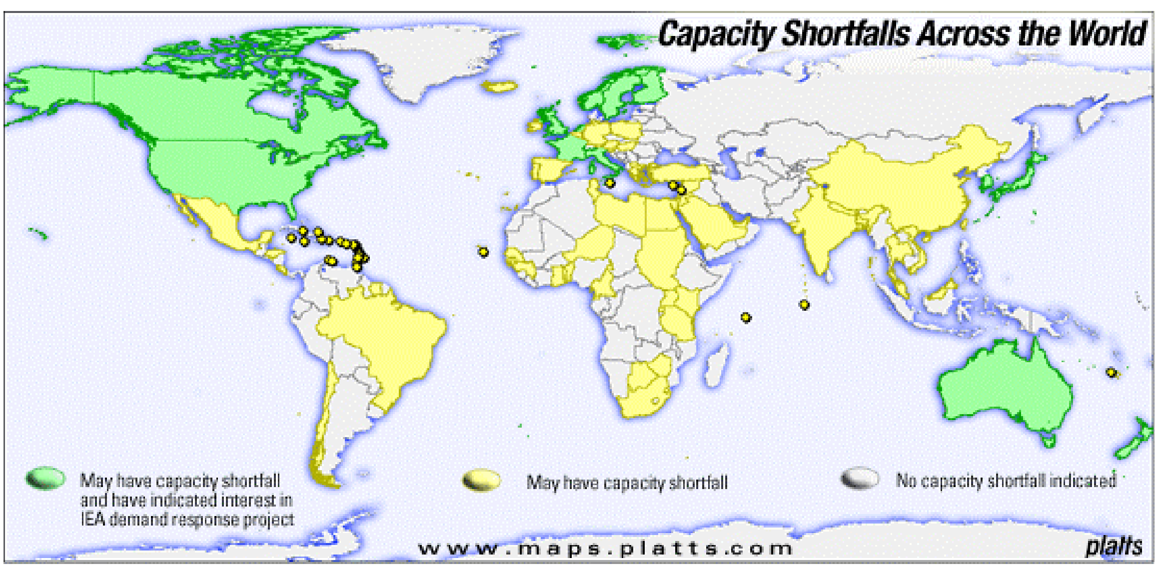
Table 2.1: Recent Scarcity and Power Shortage Episodes

System	Year
Argentina	1988
Indonesia	1991
Malaysia	1992
Colombia	1992
Ivory Coast, Ghana, Togo and Benin	1998
Chile	1998-1999
Philippines	1999
Tanzania, Kenya	2000
Yugoslavia	2000-2001
California	2000-2001
Russia	2001
New Zealand	2001
Brazil	2001-2002
Venezuela	2002
Marahashtra – India	2002
Norway	2001 and 2003
Dominican Republic	2002-present
China	2003- present

Source: Maurer (2003) and World Bank analysis

2.3 Figure 2.1 indicates areas of potential capacity (and energy) shortfall around the world, highlighting how widespread they may be. Shortages have threatened or will threaten some of the most populated and largest countries in the developing world, such as China, India, Brazil, Turkey, Thailand, and others, in part due to serious constraints in attracting capital for new investments. Surprisingly, risks of shortages also exist in large oil-producing and exporting countries, such as Saudi Arabia and Mexico, which may be experiencing capacity shortages in the short and medium term.

Figure 2.1: Capacity Shortfalls Across the World



Source: Platts

2.4 When systems are not reliable or not adequately designed, involuntary power curtailments take place, lasting from a few minutes up to several consecutive years. This problem is not limited to developing countries, and has happened in very rich areas of the United States. The most notable example is the State of California. In the late 1990s, and for almost two consecutive years, the existing, available generation capacity could not meet peak demand, leading to rolling blackouts in the summer months. As is well known, the power crisis had significant economic and political ramifications for California. Part of California's current debt may be attributed to additional costs incurred by the state in purchasing energy to resell to local utilities. The August 2004 serious and widespread blackouts in the eastern United States and, a few weeks later, in Italy also show the fragility of many power systems, as far as reliability is concerned.

2.5 In heavily hydro-dependent countries, energy-rationing measures are often necessary due to the systems' inadequacy in providing the necessary generation to meet the needs of growing economies. Reliability becomes subject to the vagaries of weather and rainfall. Extremely dry years may be rare, but they occur unpredictably and are only confirmed after the fact. A shocking example is the crisis in Brazil in late 2001 and early 2002. Up to the last minute, sufficient rainfall was still expected to fill the reservoirs. It was not expected that 2001 would be an extremely dry year, based on past statistical correlation patterns.[9] A combination of hydrology and other adverse aspects triggered one of Brazil's worst crises in recent history.

2.6 China started to face similar problems in 2003. Several provinces have had some form of rationing. In provinces such as Hunan, also very dependent on hydroelectricity, rolling blackouts have occurred on a constant basis, with adverse social and economic impacts.

2.7 In many developing countries, a lack of financial and technical resources contributes to poor security levels and inadequate capacity to meet the needs of a growing population starving for power services. Chronic curtailment, rolling blackouts, mounting unserved loads, and pent-up demand become the norm, limiting economic growth and the stability of the thin social fabric. For example, intense and haphazard blackouts have affected daily life in the Dominican Republic. In 2000, the magnitude of the situation was such that it led to social unrest and instability, claiming several lives.

2.8 Shortages of energy and capacity are not unique to California, Brazil, China, and the Dominican Republic. Asian and Sub-Saharan countries suffer shortages of power and energy almost on a chronic basis. In many cases, blackouts are so frequent that they have become part of the daily routine of customers. The power system in India, for example, was short 13 percent of peaking capacity and 7.8 percent of energy in 2001.[10] Lack of availability and system security has disrupted productive uses of electricity. For example, as a result of inadequate voltage levels and frequency, pumps used for water irrigation have been constantly damaged.

2.9 Lack of public and private funds to expand the power sector in developing countries, is likely to be a roadblock to increase system reliability. The supply-demand gap tends to widen, unless there are some creative forms to further attract private capital to the power

[9] 2001 was the driest year on record in the Northeast, and a very dry year in the Southeast.
[10] Conversation with Mr. Anil Kr. Sardana, CEO of North Delhi Power Limited.

sector, as happened in the 1990s. Even so, the amount of capital attracted was short of developing countries` real needs.[11]

2.10 Providing reliable electricity is also a key element of creating a good investment climate. The costs associated with unreliable electricity supply amount from more than 2 percent to almost 10 percent of sales in places where supply is least reliable, as shown in Table 2.2.

Table 2.2: Costs Associated with Unreliable Electricity Supply

Country	Electrical outages (days)	Value lost to electrical outages (% of sales)
Kyrgyz Republic (2003)	12.4	2.3
Brazil (2003)	4.6	2.4
Cambodia (2003)	5.7	2.9
Peru (2002)	8.8	3.2
Guatemala (2003)	13.7	3.3
Indonesia (2003)	4.4	4.2
Lithuania (2004)	1.1	4.2
Honduras (2003)	28.5	4.3
Zambia (2002)	37.2	4.5
Uzbekistan (2003)	7.7	4.7
Tajikistan (2003)	32.4	5.2
Algeria (2002)	14.0	5.3
Pakistan (2002)	14.5	5.4
Ecuador (2003)	11.8	5.7
Eritrea (2002)	93.9	5.9
Nicaragua (2003)	29.2	5.9
Uganda (2003)	70.8	6.2
Philippines (2003)	6.0	7.1
Kenya (2003)	83.6	9.3

Source: Several World Bank Country Investment Climate Reports

2.11 A power crisis is a very serious issue and deserves stronger attention from top government officials, policy makers, and industry representatives.

[11] Saghir (2004).

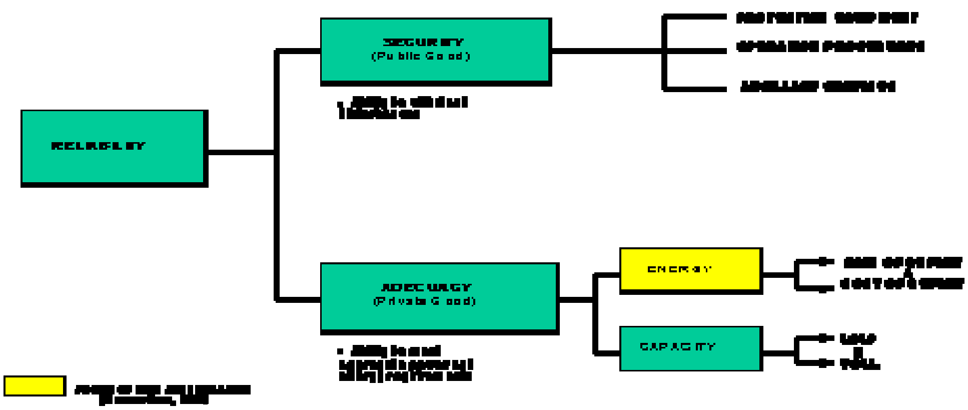
Basic Concepts of Power System Reliability

2.12 As stated earlier, a reliable power system needs to be both secure and adequate:

- A *secure system* should be able to withstand disturbances. The absolute level of security depends on the nature of protection equipment, operation procedures, availability of ancillary services, and adequate regulations.[12] The blackouts in the United States and Italy are the result of failures in one or more of those elements, jeopardizing the overall security level.[13]
- An *adequate system* has the necessary transmission and generation capacity to meet current and future demand growth, even under critical periods. Failures in adequacy result in energy- or capacity-constrained power systems.

2.13 Figure 2.2 illustrates the distinction between those two concepts.

Figure 2.2: Security and Adequacy as Components of Reliability[14]



2.14 It is argued that system security is a public good. It is intrinsic to the quality of a particular network and virtually impossible to establish different levels of security by different

[12] Such as reserve margin, back-up generation, black-start capability, and others.

[13] From a few hours to a week, depending on the time required to restore the system once the cause for a disturbance is resolved. Hydro systems can be restored relatively fast, while predominantly nuclear systems require a much longer time of a few days or even weeks to be fully restored.

[14] For the purpose of this publication, a distinction is established between LOLP (Loss of Load Probability) and the Cost of Deficit. Despite having many elements in common, LOLP is used more in terms of capacity- constrained systems and is difficult to be forecasted far in advance (a few days). Cost of deficit is the result of an energy-constrained system and may be forecasted long in advance. Because the effects of capacity-constrained systems can not be mitigated via intra-day load shifting, its impact (and therefore monetary value) on the load tends to be higher than the cost of deficit.

customer groups.[15] On the other hand, adequacy presents many of the characteristics of a private good. Customers could, in principle, determine the maximum amount of money they would be willing to pay before having their services curtailed or interrupted.[16] This maximum "willingness to pay" reflects the value that each individual customer assigns to electricity, and enables customers to choose their desired level of adequacy. The fact that customers have different "willingness to pay" levels is one of the basic pillars of sensible rationing schemes and other more sophisticated demand-response techniques described in this report.

Types of Power Shortages

2.15 There are three distinct types of power crises: energy shortages, capacity shortages, and a combination of both energy and capacity shortages:

- *Energy Shortage*: A situation in which the power system can supply the instantaneous demand at any given moment, but cannot supply energy on a continuous, long-term sustainable basis, such as in Brazil in 2001–2002. Such a system is energy-constrained because there is not sufficient "fuel" to keep the existing power plants running. (Lack of water in the reservoirs may be broadly construed as lack of "fuel.") A country lacking financial resources to acquire imported fuel may be analogous to an energy-constrained system, resulting in power rationing.
- *Capacity Shortage*: A situation in which the system is physically unable to supply part of the demand during peak hours, but can still supply energy needs in off-peak hours, such as in California in 2000–2001. The system is said to be "capacity constrained," since the total generation capacity (MW) available at any particular moment is not sufficient to meet peak demand needs. Therefore, some form of curtailment becomes necessary. Interruptible loads and rolling blackouts in the peak hours are the usual way to deal with capacity shortages.
- *Combination energy-and-capacity shortage:* This situation combines both problems, such as in Chile at its worst period in 1998–1999. This situation may happen, for example, when hydro reservoirs are over depleted and turbines are forced to operate at very low levels of efficiency, due to loss of head. If the reduction of hydro capacity cannot be offset by existing thermal generation reserves, the system becomes both energy and capacity constrained.

Rationing and Power Sector Reform

2.16 Energy rationing or capacity curtailment may be traumatic events. They limit economic development and disturb residents' lives.

2.17 Despite its recognized consequences, rationing has not received much attention either in traditional, vertically integrated state-owned companies, or in places where power sector

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[15] Some differentiation may be possible if dedicated feeders from substations are built to serve very special types of customers, where high levels of reliability are necessary. Even in those cases, security would still depend on the overall performance of the upstream generation system to where that particular substation is connected.

[16] The ability of a customer to express his/her willingness to pay depends on the existing regulations and on the nature of the energy contracts. Interruptible contracts would be one of many mechanisms to achieve this objective.

reform has taken place. "Planning" for a crisis is more often than not perceived as a politically incorrect oxymoron. Also, expressions such as "rationing" and "quotas" do not seem to dovetail with market-oriented power sectors, since they carry strong cultural baggage as a traditional way of allocating scarce goods in centrally planned economies.

2.18 Open discussions about how to ration energy, long before a crisis is anticipated, have seldom been part of the power sector reform agenda. In the eyes of many, resorting to rationing means that something has failed in the supply–demand balance. Policymakers tend to ignore the possibility of a crisis, as it seems to defeat the main objectives of the entire reform process.

2.19 This is probably one of the reasons why power rationing has usually been treated very superficially.[17] As a consequence, when it happens, there are not consistent procedures, regulations, incentives, and political consensus on how the crisis should be managed. To mitigate the damages caused by energy rationing and capacity curtailment, it is imperative to plan far in advance, in a realistic and objective manner.

Rolling Blackouts as the Last Resort

2.20 When a power crisis is imminent, the power sector's ability to promptly respond by building extra capacity is relatively limited. Unless the system has abundant cheap reserves, which is seldom the case, focusing on the demand side becomes imperative.[18]

2.21 As mentioned before, a lack of proper planning, insufficient regulations, or both means that energy rationing is usually carried out through rolling blackouts, decided upon ad hoc and at the last minute. The consequences for society and for the economy as a whole may be shattering. More organized rolling blackouts allow customers to know in advance when power will be curtailed and for how long, and to some extent they can plan for the event, as occurred in California. There, the system operator had some control and could reasonably anticipate the load based on weather forecasts. However, most blackouts happen in a very chaotic way.

2.22 One negative aspect about rolling blackouts is their compulsory nature. When power is curtailed, customers have no choice. No matter how they plan to save energy or how much they would be willing to pay, the customer loses power when the time comes. Rolling blackouts, no matter how "organized" they are, represent the most inefficient way of assigning a scarce resource, since energy is rationed in a haphazard way, driven by the physical reality of the power grid and not by customers' real needs. Clusters of customers of different types and with different uses for electricity are curtailed as a "block," on a mandatory basis. Unfortunately, the customers have no mechanisms to express how much they would be willing to pay not to have their services interrupted—that is, the relative value of electricity for each.

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[17] For the purpose of this publication, the expression "rationing" refers to either energy- or capacity-constrained systems.

[18] Sometimes reserves exist, but they are very expensive to run on a permanent basis, and it is still advisable to implement a rationing program.

Rationing Using Price Signals

2.23 The other form of rationing energy is through price signals, by giving people the ability to decide how much they are willing to pay for electricity when the resource is scarce and prices are high. Price signals give customers the option to self-ration. They may decide when and how much energy should be used or saved. By reacting to price signals, an "elastic," price-responsive demand curve is created, reflecting the customers' aggregate willingness to pay.[19] For the mechanism to be effective, energy should be priced as close as possible to the short-run marginal cost of energy both on a temporal and geographic basis.

2.24 A politically palatable and relatively efficient way of applying price signals is to define a baseline consumption for each customer, or a "quota." Customers should be charged regulated prices for the amount implicit in the quota and higher prices for any excess consumption.

2.25 The use of price signals has been perceived with a certain degree of cynicism in many circles. First, there is an ingrained belief in the power sector that price elasticity of energy is very low, particularly in the short term. Therefore, there is a concern that price signals will not be effective to reduce consumption. There are also concerns regarding income distribution, or the fairness of a mechanism, since high prices are potentially more harmful to the poor. Yet, as described in this report, some pricing mechanisms can harness demand elasticity and have proved to be effective in a relatively short time frame. Moreover, with appropriate design, the poor may be protected and in some cases even engage in the energy conservation efforts.

2.26 In sum, rationing via price signals, if properly designed, may be an extremely effective tool.

Saving Electricity "in a Hurry"

2.27 The International Energy Agency (IEA) coined the expression above. Due to their growing importance, electricity shortages were the focus of a seminal workshop held in Paris in 2003 by the IEA. Experiences from many, very diverse countries were discussed. Some of the major findings from the workshop are presented in Box 2.1.

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[19] The rolling blackout scheme assumes that people's willingness to pay is constant across a certain customer group and lower than the marginal cost of production for that particular period when the energy is curtailed. For essential loads, such as hospitals, police, fire stations, and others, the implicit assumption is that willingness to pay is extremely high, given the nature of the services provided.

Box 2.1: Saving Electricity "in a Hurry" [20]

Temporary shortfalls in electricity supplies happen somewhere in the world almost every year. Whatever the reason, there is a need to quickly reduce electricity demand while the supply side is repaired. Such shortfalls might occur as a result of reduced hydroelectric supplies caused by a drought, a breakdown in a power plant, a heat wave, or partial loss of transmission or distribution capabilities. Blackouts are likely to occur if no measures are taken to reduce demand. These blackouts can lead to deaths, injuries, and economic hardship. The goal is to quickly reduce electricity use until supplies are restored without causing lasting economic or environmental damage.

Even a temporary electricity shortfall can have a direct impact on demand for other fuels. Also, these crises can have important implications for deregulation and liberalization of electricity markets. If the markets cannot cope with a short-term crisis, governments may be tempted to re-assert regulatory controls.

In the last five years, there have been significant short-term electricity shortages in New Zealand (twice), California, Brazil, and Norway, plus emerging shortages in Italy, Japan, Ontario (Canada), and other parts of the United States besides California. Many smaller, less-publicized shortfalls have also occurred. Europe periodically undergoes electricity shortages when a cold wave freezes canals and prevents barges from delivering coal. Each crisis was unique, but all had complex political overtones and were often linked to deregulation.

Before developing a conservation strategy, it is crucial to understand the nature of the crisis. Is the shortfall in capacity or energy? How large? How long will the shortage last? What conservation measures are applicable and how much do they save? The portfolio of conservation options depends on the infrastructure already in place. The best prepared regions already had efficiency programs in place (to "save electricity slowly"), so it was possible to rapidly expand—sometimes more than ten-fold—the existing programs. Others developed portfolios of conservation options based on ease of reaching key customers and achieving quick results.

Electricity supply systems with inherently fluctuating supplies (hydro) should maintain an efficiency program to complement the uncertain supply situation. The "save electricity slowly" programs would serve as the foundation for rapid expansion when—not if—a supply shortfall occurs. On the other hand, the existing institutions may be so paralyzed by the crisis that entirely new institutions are needed to manage the campaign. This was the case in Brazil and California.

There is some evidence that energy shortfalls will increase in frequency and possibly in severity. Deregulation and market liberalization have caused many utilities to reduce generating reserves and transmission capacity. Operators of fuel supply networks, such as pipelines, oil storage facilities, and coal transport, have also sought to operate with smaller reserve margins. The result of these actions is an increased vulnerability to disruptions throughout the electricity supply system. Global climate change could have an impact, too. Climate change is likely to manifest itself first by greater and more frequent variation in weather patterns (even if mean values change only slightly). These fluctuations translate into more droughts, heat waves, cold waves, floods, and other triggers to short-term electricity crises. In regions with major air conditioning needs, the urban heat island phenomenon will amplify the electricity impacts of heat waves.

[20] Adapted from Meyer (2003).

3

Selected Case Studies

3.1 Many countries have dealt with energy crises in recent years. This chapter looks at five cases: Chile, China, California in the United States, the Dominican Republic, and Japan. As detailed, each instance was caused by different factors and was dealt with, more or less successfully, with different responses.

Chile

3.2 Chile was one of the first countries in the world to privatize and deregulate its power sector. Reforms took place in the early 1980s, even before the restructuring of the energy sector in the United Kingdom was on the radar screen.

3.3 Chile has been extremely dependent on hydro power over the last decades. Only recently, it has had access to Argentine gas, after the private sector built a pipeline crossing the Andes. As with any other predominantly hydro system, Chile is subject to the vagaries of rainfall or ice melting. That was the most important cause that triggered a rationing program in the late 1990s.

The Extent of the Power Shortage and Its Economic and Social Impact

3.4 Chile has experienced several power crises in recent years. The most important one took place from November 1998 until June 1999. In that eight-month period there was a restriction of about 450 GWh, for a total annual consumption of 25,000 GWh. In absolute terms, it was not a major crisis, but it contained important elements that are worth presenting.

3.5 The crisis was preceded by initial random outages in November 1998, followed by 66 days of deficit from April 1999 until the end of the shortage period. Additionally, there were brownouts caused by deliberate voltage reductions. The situation in Chile was fully normalized afterwards.

3.6 Despite not being a power shortage crisis of great proportions, it triggered a financial crisis among hydro generation companies, as most rationing usually does. Hydro generation companies, which became “short” in the market due to the lack of water, had to buy energy on a spot basis to honor their contracts with discos. In the absence of cheap, thermal generation alternatives, the spot price reflected the high marginal cost of the least-efficient plants. This caused a serious financial burden for hydro generators, with an immediate impact on their balance sheet. The financial results for Endesa, the largest generator, fell from over US$250 million in 1997 to less than US$100 million in 1998, mostly due to the additional energy purchases to fulfill its contracts in those critical months.

3.7 The aftermath of the power crisis basically centered on the regulatory and legal aspects caused by the financial imbalance of the crisis itself and the government's remediation actions.

The Causes of the Power Shortage

3.8 The main causes of the rationing were supply driven, something usually observed in hydro-dominated systems. The causes included one of the most serious droughts on record; delays in the operation of new thermal plants; excessive use of hydraulic energy in a dry year; and the absence of early preventive measures that could have mitigated the crisis, including some demand response. Perhaps the most important cause was the over depletion of hydro reservoirs, in part because of inadequate regulations and perverse incentives given to hydro generators to operate their plants imprudently. This was an important ingredient that precipitated the crisis.[21]

3.9 Under normal circumstances, generators in Chile, when short on their contracts, should buy energy from other generators at prevailing spot prices. Therefore, generators should have had some natural incentives to use their hydro resources rationally: a profit-maximizing generator would try to strike a proper balance between purchasing more expensive thermal energy now, or being penalized in case of non-deliverables due to a forced rationing program. The tradeoff for hydro generators was to exchange an uncertain cash flow necessary to compensate their customers for a very certain cash disbursement stream necessary to acquire energy on a spot basis.

3.10 However, there was an important exception to the regulatory obligation imposed on generators to compensate their customers. In the event of a drought worse than the one that happened in 1968, generators would be waived from their obligations and excused from compensating their customers. The possibility of facing a crisis worse than that of 1968 to some extent influenced how much to generate in hydro plants and how early to start buying from thermal plants. Generators would speculate and naturally take more risk given the chance of having their obligations waived.

3.11 This potential waiver to generators to fulfill their contract obligations unintentionally provided an implicit bail-out and therefore created a moral hazard. Generators preferred to recklessly over-deplete their reservoirs in the months preceding rationing than to crank up thermal plants and buy expensive energy from them.

Government Actions and Results to Deal with the Shortage

3.12 The situation of Chile's power system was already critical in July 1998, but the government took no real measures until the first unplanned blackout in November of the same year. It authorized hydro generators to use stored water more intensely, instead of acquiring the entire energy shortfall in the spot market, priced at the most expensive thermal generation plant to be dispatched. The government was cognizant of the financial difficulties that gencos would face if they had to acquire their entire contractual shortfall at spot prices, in the absence of cheap

[21] Fischer and Galetovic (2000).

alternatives to generate energy in the country.[22] In a more balanced hydro-thermal system, hedging mechanisms would exist against hydrological risks,[23] but this was not the case of Chile at that time. For a number of reasons, the government authorized gencos to use more water than recommended otherwise. The government did take a leading role to assure the integrity of the operating procedures and that the power system could be operated in such a way to guarantee a minimal level of reliability in the medium run.

3.13 As events progressed, the generators argued that the ongoing drought was worse than in 1968, so they should be exempted from compensating regulated consumers. The financial relief enabled by this exception could have saved generators several million dollars.

3.14 The law was changed in June 1999, lifting this exemption. There were disputes about whether or not compensations should be paid for the hydrologic year that began in April 1999 (which was a normal year, from a rainfall perspective). SEC (a supervisory agency reporting directly to the President) tried to enforce compensations to the customers, which resulted in court battles.[24]

3.15 Besides the mandatory and government-supported reduction in voltage,[25] there was almost no attempt to utilize demand response to manage the crisis. Rolling blackouts had to be implemented according to pre-specified rules, but the use of price signals to trigger demand reduction was virtually absent.

China

3.16 In recent years, China's energy usage, both industrial and residential, has increased greatly. The government has had to deal with shortages in most parts of the country.

The Extent of the Power Shortage and Its Economic and Social Impact

3.17 China faced a serious power crisis in 2003, which became more acute and widespread in 2004. The capacity shortage in 2004 was estimated to be from 20,000 to 30,000 MW. The real extent of the shortage varies depending upon seasonal and climatic conditions, such as temperature and rainfall.

3.18 Starting in June 2003, blackouts have been imposed in 19 provinces and municipalities, including the prosperous Yangtze River Delta, to lighten the pressure on overloaded power grids.[26] Twenty-one provincial areas, or two-thirds of China's total, had to limit the use of electricity due to power shortages.[27] China's central, eastern, southeastern, and southern areas had to switch off electricity frequently starting in November 2003, to prevent the grid from crashing. It is expected that the supply demand imbalance will persist for at least two

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[22] Natural gas was not available in Chile at that point in time. The construction of a natural gas pipeline connecting Argentine reserves to the markets in Chile was subsequent to the crisis – and partially motivated by it.

[23] Despite being one of the pioneers in privatizing and deregulating its power sector, some institutional arrangements, market rules, and financial hedging instruments did not evolve over time and issues such as monopoly power and independence of the operators were present when the rationing took place.

[24] Fischer and Galetovic (2000).

[25] A technique oftentimes used in many places. Energy consumed is proportional to the square of the voltage. A few percentage points in voltage reduction can provide a reasonable relief for energy- constrained systems.

[26] "China mulls over market Strategies in face of power shortage" (2003).

[27] "China strives to ease power shortage in 2004" (2004).

to three years in some provinces. In most parts of the country, the situation is expected to improve significantly in one year or so.

3.19 The impact on the economy is yet uncertain. In 2003 some contended that the "factory of the world" could be in jeopardy. More knowledgeable observers[28] acknowledged that some impact would be inevitable, but did not believe that the power shortage would derail China's sustained economic growth. At any rate, until the problem is resolved, millions have been coping with life without lights, at least part of the time,[29] and factories will experience some forms of mandatory restrictions on production.

The Causes of the Power Shortage

3.20 As in most power crises, the electric sector in China has faced both supply and demand shocks. On the supply side, several factors have contributed to a large reduction in the available energy capacity. Perhaps most important is the fact that energy planners underestimated electricity consumption in China, partly influenced by the slow electricity growth after the 1998–2000 Asian financial crisis. Planning authorities and utilities had deliberately revised their forecasts and reduced their expansion plans under the assumption that slower economic growth was a long-term trend across the entire region. It was even thought that supply would outstrip demand. This misperception led to the postponement and delay of some important power projects.

3.21 To make things worse, some hydro-dominated regions suffered an unprecedented drought, and production of hydro plants declined significantly. Provinces like Hunan, where 55 percent of the electricity usually comes from hydro power, Sichuan, and Chongqing were the most vulnerable. Dry years limit the production of hydropower plants, thus creating energy and potentially capacity shortages.

3.22 In other provinces, coal availability declined for several reasons. Environment and safety concerns in the mining industry were prompted by overproduction and an increased number of accidents. Coal reserves dropped below the warning level, and prices skyrocketed. The situation has improved with coal production increasing by 20 percent, but the total number of deaths continues to be high.

3.23 On the demand side, the surge of electricity consumption during the last two years caught most of the utilities off guard. The surge was due to fast urbanization, growing economy, and the increased elasticity of power to GDP growth. Ordinary people now have access to electric heaters and air conditioners. Also, more people can afford home appliances such as televisions and refrigerators. Coal for residential use has been displaced by electricity, spurring demand even further.

3.24 Demand growth was also induced by ill-advised measures taken by some local authorities, such as electricity price reductions and electricity promotion programs, following the short-term slow growth that resulted from the Asian financial crisis.

[28] Informal conversation with Mr. Jianping Zhao, from the World Bank in China.
[29] "Power shortages darken Southern China" (2003).

3.2.3 Government Actions to Deal with the Shortage and Results

3.25 China has a long history of allocating insufficient supply under central planning. The quota system is still practiced today when there is a shortage. The quota system is usually implemented in tandem with a priority list for emergency loads. Thus, in an emergency, the least important end users are cut off first.

3.26 Different regions and provinces have tried different approaches to deal with the crisis. Rolling blackouts have been the predominant way of limiting the consumption of energy. Cuts were visible in Changsa, the capital of Hunan. Under rolling blackouts, residents go one day in four without peak hour power between 8 a.m. and 6 p.m. Some cities considered the use of incentives to foster the installation of more efficient equipment and devices to reduce electricity demand. The idea was to trim electricity demand, especially through the use of energy-saving incentives and devices.

3.27 Energy-intensive factories were ordered to shut down during peaks. Key government offices, hospitals, schools, and military installations were not in principle subject to the scheduled blackouts. Nonessential loads connected to the same power lines ended up not being curtailed, while other non-priority loads were subject to blackouts that could last up to two days.

3.28 In some areas, power cuts were less predictable due to unexpected demand variations caused by changes in temperature, which in turn boosted demand for air conditioning and for agricultural land irrigation. Some cities tried to avoid rolling blackouts by darkening advertising signs, turning down heat in shopping centers, and encouraging factories to operate during off-peak hours. Factories in Shanghai were ordered to shut down a day a week in December 2003.[30] In 2004, some loads were instructed to shut down depending on the expected weather temperature for the following day or week.

3.29 Given the strong government mandate, the decision to "unplug" customers does not have major political implications in China, at least when compared to more democratic societies. This prerogative avoids the power system becoming excessively strained with the risk of blackouts of major proportions like those in Italy and the United States.[31]

3.30 There is a growing perception that energy conservation, load management, and changes in the tariff structure and levels are important tools to help China face and even avoid crises of this magnitude. Despite some government efforts, modest actions have been implemented along those lines. China is still subsidizing coal in large cities, and keeping the price of electricity artificially low, therefore fostering high consumption and wasteful behaviors.

3.31 Those distortions are, in part, due to the fact that China is in the middle of moving from a command-and-control to a market-oriented economy, including the establishment of a more competitive power sector. However, the success and sustainability of Demand Side Management (DSM) efforts depend on correct prices and tariffs. To some knowledgeable observers,[32] China is now serious about instituting such price signals.

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[30] "Power shortages darken Southern China" (2003).
[31] Conversation with Mr. Guy Chi Zhang, from the Program of Energy and Sustainable Development at Stanford University.
[32] Faruqui (2004).

3.32 Many alternatives to conserve energy and reduce consumption based on price signals have been proposed. Higher prices should restrain demand and encourage supply. Also, the government has tried to discourage customers from using electricity at peak times by increasing the cost during the busiest hours and cutting the overnight price. There is a perception that market prices should be used throughout the power system, fairly and evenly. Making prices realistic and making consumers responsible for paying their energy costs are the two fundamental reforms that any transition economy has to make.[33]

3.33 There is a lot of room for energy efficiency in China, when compared to the levels of efficiency achieved by Western countries. An example is that consumption of a kilowatt/hour of electricity in the United States can produce a profit of US$8 on average, but the figure in China is less than 8 yuan (US$0.96).[34] The power shortage has been a wake-up call and may have enduring effects. It has reminded China about the need to balance social and economic sustainable growth while promoting energy conservation and the most effective use of the existing resources.

California

3.34 As has been observed, "the California electricity crisis is not really a story about environmentalists gone bad, deregulatory details ignored, or unrestrained capitalists running amuck. It's a story about what happens when price controls are imposed on scarce goods." [35]

The Extent of the Power Shortage and Its Economic and Social Impact

3.35 The energy crisis in California lasted for about seven months, from November 2000 until May 2001. It has been widely publicized and documented. No other crisis in the power sector worldwide has received so much press coverage and political attention, even when compared to the Chernobyl and the Three Mile Island nuclear accidents combined.[36] Interestingly enough, the California crisis resulted in 6 days of power curtailment for firm customers, amounting to less than 4 percent of the state's peak demand, for a few hours during those critical periods. If curtailment of interruptible customers is included, the number of days of load-curtailed increases to 38.

3.36 This section of the report is not meant to add any breakthroughs to what has been extensively written and said. The objective is to frame this crisis in the context of shortages faced by developing countries described in this document.

3.37 What is usually referred as the "California crisis" had in fact two main components. The first was the power shortage per se, which led to rolling blackouts in some parts of the state. The second was the financial crisis that profoundly affected the incumbent distribution companies, some of which ended up filing for bankruptcy as a result. It also acutely affected the state's financial situation when it started buying expensive energy in the market and

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[33] Chandler (2003).
[34] "Power crunch not easy to solve" (2004).
[35] Taylor and Van Doren (2001).
[36] "California power crisis" had more than 1.4 million references in the Google.com search engine, while the "Three Mile Island nuclear accident" had about 200,000 and "Chernobyl nuclear accident" about 100,000. Those are indicative numbers only.

reselling at a cheaper price to non-creditworthy discos. The state incurred significant losses and built up a mounting fiscal deficit.

3.38 The first signs that a crisis was in the making were felt in the southern part of California in 2000, where retail prices, which had already been deregulated, started to grow exponentially.[37] No blackouts took place at that time, but the sudden tariff increase triggered a political outcry and an adversarial attitude against the local utility. A few months later, the crisis manifested itself again, this time in central and northern California. Lack of generation capacity resulted in rolling blackouts, which disrupted the lives of ordinary citizens.

3.39 The blackouts have been generally referred to as landmarks of the California crisis, and some of its harshest consequences. However, as mentioned, the real "blackouts" in California were relatively rare and short in duration, as shown in Table 3.1.

Table 3.1: Rolling Blackouts in California

Date (2001)	Curtailment Orders (MW)	% of Peak Load
January 17	500	1.6
January 18	1,000	3.2
March 19	500	1.7
March 20	500	1.7
May 7	300	0.9
May 8	400	1.1

Source: Sweeney (2002).

3.40 Blackouts were not the only factor that had a negative impact on the reliability of the power sector and the economy as a whole. In the period between June 2000 and July 2001, California faced a very tight demand–supply balance. As reserves declined, interruptible customers were curtailed for about 38 days, customers had to shed load voluntarily, expensive back-up generators were cranked up, and loads qualified as part of the demand relief program were also curtailed. The decision to reduce load or even to implement rolling blackouts was made by the system operator, depending on the expected reserves for the day ahead.[38]

[37] More particularly in the region of San Diego. Due to a regulatory arrangement spelled out as part of the reform process carried out in the early 1990s, retail rates would no longer be frozen once the utility had recovered all of its stranded assets. San Diego was the first area to have its assets recovered and therefore its retail rates deregulated.

[38] Under normal operation, operating reserves should be at least 7 percent of the generating capacity. If those reserves fell below 1.5 percent, a State 3 Emergency was declared, and utilities had to begin shedding load. States 1 and 2 triggered some form of demand response, but not rolling-blackouts.

3.41 The financial consequences of the California crisis were much deeper and more long-lasting. According to the prevailing regulatory arrangements, discos were forced to buy a large portion of their energy needs in the short-term wholesale market at very high prices. This energy had to be sold to end users at subsidized rates, frozen for almost 10 years. Therefore, real costs of energy purchased could not be passed through to the end users. In a matter of a few months, the largest utilities were immersed in an extremely intricate financial crisis. The "un-recovered" power costs' estimate was US$9 billion for Pacific Gas and Electric (PG&E), US$2.6 billion for Southern California Edison, and US$450 million for San Diego Gas and Electric (SDG&E).[39] PG&E, one of the most solid utilities in the United States, filed for protection under Chapter 11 of the U.S. Bankruptcy Code in April 2001.

3.42 The state felt that it had to step in as a buyer of last resort, therefore relieving the distribution companies from the obligation to buy energy in the wholesale market. The Department of Water Resources (DWR) was put in charge of purchasing energy on behalf of the discos, spending billions of dollars in power purchase agreements (PPAs). The economic and political consequences were significant and will remain for many years to come.

3.43 Perhaps the greatest impact of the California crisis was to encourage policymakers, regulators, and industry players to rethink what regulation was all about and the essential ingredients to create an effective power sector market. While the crisis was going on, several U.S. states and other countries decided to stop their ongoing processes of power sector reform. Several jurisdictions adopted a wait-and-see attitude, many of them postponing existing plans to introduce retail competition. This attitude was caused, in part, by a lack of understanding of what the crisis was all about and by a massive media campaign against power sector reform, which became the major culprit in the political arena. Governor Gray Davis, for example, often labeled electricity deregulation as the villain, and referred to FERC actions as a "reckless deregulation experiment" that would make "guinea pigs of California consumers" and described California's problems as the "ravages of a dysfunctional marketplace." [40]

3.44 The jury is still out. However, as the crisis is better understood, it becomes increasingly evident that it was not caused by the deregulation and power sector reform per se. This is an oversimplification of reality, to say the least. Many other power sector reforms in the United States and in other countries have succeeded, while in many places the status quo, represented by traditional state-owned vertically integrated companies, have failed or continue to fail. It is not intellectually honest to blame deregulation as the villain of the power crisis in California, which for many was considered a "botched deregulation."

3.45 A very important ramification of the California crisis was to show unequivocally to policymakers and regulators that creating a market must imply working on the demand and supply sides simultaneously. Thus far, most attention has been given to the latter, in California and elsewhere. Despite demand responding to prices not being something new, the California crisis contributed to build awareness about the necessity to institutionalize demand response as an essential ingredient of a functional and sustainable market. This increased awareness has started to change the way that power sectors are structured and markets are designed.

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[39] Energy Information Administration: Subsequent Events – in www.eia.doe.gov

[40] Sweeney (2002).

The Causes of the Power Shortage

3.46 It is difficult to pinpoint a single cause for the California crisis. Events of this nature are analogous to a "perfect storm," where several factors in tandem contribute to trigger a crisis of major proportions. To understand the crisis, it is important to analyze the process of deregulation and restructuring of the power sector in California. For some, deregulation per se was the culprit for the problems that emerged a few years later. For others, deregulation continues to be good, but the way California designed and implemented its power sector reform had many flaws, some of them detected even before the crisis emerged. Box 3.1 provides a background of California's power sector transformation.

3.47 In very simple terms, the California crisis was caused by lack of generation capacity. During some periods of the day, depending on the climatic conditions, the available generation capacity in the state, combined with energy imports from adjoining regions, was not sufficient to meet peak load. To maintain a minimum level of reserves, the system operator was forced to curtail load, causing rolling blackouts of a few hours per day, a few days per week. After those critical periods, the system was completely restored in a very short period of time, since generation capacity was no longer a limiting factor. As described earlier, this was a classical example of a "capacity-constrained" system.[41]

3.48 The lack of capacity, in turn, was caused by a combination of at least one demand and one supply shock. In the decade preceding the crisis, California had experienced a significant demand increase, spurred by sustained economic growth. The generation capacity did not grow at the same pace to meet demand needs. Several reasons explain this slow growth in capacity expansion. Perhaps the most important ones are serious environmental restrictions and a power sector reform process that inhibited new investments.

[41] It can be argued that the reduction of imports was, to a large extent, caused by a drought in the northwestern part of the United States, with a consequent reduction in hydro capacity. Therefore, on a regional basis, there were also constraints on energy production.

Box 3.1: Features of California's Reform

In the early 1990s, California's average electricity prices were about 50 percent higher than the U.S. average. The state's economy was in a recession, and major industries were threatening to move to other states. The governor and his advisors concluded that the state's power sector needed major reforms to lower electricity prices to levels comparable to those in neighboring states. Their solution was to restructure the state's power sector and introduce wholesale and retail competition. When the reform began in 1996, three privately owned utilities—Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E)—were the monopoly suppliers of about three-fourths of California's retail sales. These three utilities, known as investor-owned utilities, or IOUs, were vertically integrated monopolies. They generated, transmitted, and distributed electricity to retail customers who generally had no other supply options. The remaining 25 percent of the state's electricity consumers were served by municipal utilities, which were integrated to varying degrees. The California reform program involved restructuring and competition. It did not involve privatization because most of the power sector was already privately owned.

Its key elements were:

- Mandatory divestiture of 50 percent of the IOUs' fossil fuel generating plants, but without any contracts to buy back the output of the plants;
- Mandatory participation of the IOUs, both as buyers and as sellers, in centralized spot wholesale markets for day-ahead and day-of power sales run by a new organization called the Power Exchange (PX);
- Creation of the nonprofit Independent System Operator (ISO) to take operational control of the high-voltage transmission grid that continued to be owned by the IOUs;
- Introduction of retail competition or customer choice with retail customers served by the IOUs now being allowed to switch to other electricity suppliers;
- Recovery by the IOUs of "stranded costs" (costs that were anticipated to be above future market prices) through a "competitive transition charge" to be paid by all retail customers; and
- A mandated 10 percent reduction in, and freeze on, retail tariffs for four years or until the IOUs had recovered stranded costs, whichever came first. The 10 percent reduction was largely offset by the competitive transition charge. Although participation in the new market arrangements was mandatory for the IOUs, municipal utilities were given the option of not participating, and most of the municipal utilities chose not to participate.

California's reform program seemed to work reasonably well for the first two years, but it began to fall apart in the middle of 2000. Prices in the day-ahead wholesale market jumped by more than 500 percent between the second half of 1999 and the second half of 2000. In the first four months of 2001, wholesale prices continued to climb to an average of more than $300 per megawatt-hour, or roughly 10 times what they had been in 1998 and 1999. As a consequence, the total annual cost of wholesale electricity for California increased from $8 billion in 1999 to $28 billion in 2000 and could reach $30 to 50 billion. The principal beneficiaries of the higher revenues, according to California's then-governor, Gray Davis, were out-of-state generators he described as "pirates" and "marauders." But more recent evidence shows that some of the highest wholesale market prices were actually charged by government-owned utilities located both inside and outside California. A recent attempt to mediate the disputes over "overcharges" and "non payments" involved daily negotiations in Washington among more than 150 high-priced lawyers and lasted for more than two weeks. Ultimately, the negotiations failed.

Compounding the price shocks was the fact that California's two largest utilities, PG&E and SCE, were not allowed to pass the higher costs of power through to their retail customers. With unfunded liabilities of several billion dollars, PG&E was forced to declare bankruptcy. At the time of this writing, SCE is trying to avoid a similar fate by negotiating the sale of its high-voltage transmission grid to the California state government to raise cash. High prices have not been the only problem. California has also experienced major shortages of supply. Retail customers experienced their first blackouts in decades, with a cost to the California economy of several hundred million dollars. The federal and state governments have tried a number of "quick fixes" to deal with the crisis. More than 100 bills and resolutions have been introduced in the California legislature. When power suppliers refused to offer supplies to California buyers because they were afraid they would not be paid, the federal government and courts ordered generators to continue to supply the power. To reduce day-to-day supply shortfalls, a state agency began purchasing short-term power on behalf of California consumers and also entered into fixed-price, longer-term contracts. As in many developing countries that lack generation capacity, state government officials are now considering statewide reductions in voltage to get more supply out of existing generating capacity. Then-Governor Davis also proposed that the state purchase transmission facilities owned by PG&E and SCE and create a state government–owned power authority to build new power plants. That proposal never came to fruition.

Source: Adapted from Besant-Jones and Tenenbaum (2001).

3.49 Environmental restrictions delayed the construction of badly needed new transmission lines and substations. Given the complexities and uncertainties of the licensing processes, developers preferred to invest in less environmentally sensitive regions. Table 3.2 shows the average licensing times for the State of California, when compared to other U.S. states such as New York and Texas. The process to select a site and obtain the necessary approvals was extremely time-consuming and uncertain in California, thus discouraging potential investors.

Table 3.2: Power Plant Development Lead Times (in months)

	California	New York	Texas
Pre-application	6 to 48	6 to 24	6 to 12
Application Approval	12	14 to 20	6
Construction	6 to 24	6 to 24	6 to 24
Range	24 to 84	26 to 68	18 to 42
Average	54	47	30

Source: Beyond California's Power Crisis. CERA (2001).

3.50 The way the power sector was deregulated helped create, among other things, a financial imbalance between wholesale and retail rates, with serious financial consequences for the utilities. The imbalance was due to the fact that the retail rates were frozen, while the wholesale rates were allowed to fluctuate, reflecting the cost of shortage. Because utilities had limited ability to hedge themselves against spot price volatility by signing contracts with generators, they ended up absorbing the differences between the frozen sales price and the cost of energy purchased from third parties.

3.51 The decoupling between retail and wholesale rates isolated the customer from the realities of the power system. No economic signal was given to the customer to "see" the impending shortage and react accordingly. This artificial isolation of the retail customer ended up creating a very steep, almost price-inelastic demand curve. After all, customers were totally insensitive to a price signal that they could not see (or that, due to regulations, they did not have the opportunity to react to). In the absence of demand response, prices skyrocketed every time a shortage of capacity was imminent, making it increasingly difficult for utilities to bear the additional cost of energy in the wholesale market.[42]

3.52 It is often said that such high prices were the result of market power exercised by generators from other states. Studies developed by the California Independent System Operator (ISO) try to demonstrate that market power played an important role. However, high prices were not simply explained by market power from one or more generators acting collectively. The short-run marginal cost of energy in 2000[43] was extremely high and driven by legitimate costs factors. Table 3.3 presents an example of the production cost of a gas-fired power plant, considering the escalating price it had to pay for the fuel and the high costs of NO_x emission

[42] It is arguable to what extent the price increase was simply the result of supply and demand or there were elements of market power. However, regardless of the relevance of market power, it is widely accepted that a stronger demand response, even for part of the load, could have had a significant impact in avoiding prices to skyrocket.
[43] This served as a basis for pricing a very large part of the energy in California, acquired on a spot basis.

credits, necessary to run the plants in some areas of California. As it can be seen, even in the absence of market power, generation costs could be as high as US$520/MWh.

Table 3.3: Production Costs of Gas-Fired Generation

Year	Gas Price Range ($ per MMBtu)	Variable O&M ($ per MWh)	Emissions ($ per MWh)	Production Cost ($ per MWh)	Power Price ($ per MWh)
December 1999	2.64-2.97	1.68	2	35-39	19-35
December 2000	14.3-51.3	1.68	45	218-662	83-521

Source: Beyond California's Power Crisis. CERA. (2001)

Government Actions to Deal with the Shortage and Results

3.53 Several government agencies took part in dealing with the power shortage in California, but not always acting harmoniously. Gaps and overlaps of accountability happened more often than not. Agencies in state government, including the California Commission, and federal government, including the Federal Energy Regulatory Commission (FERC), were the major players in the attempt to fix the crisis.

3.54 The state government, from the very beginning, adopted an attitude that the best solution was to intervene in the wholesale market, given the perception that the crisis was driven, to a large extent, by the greedy misbehavior of existing players who were gouging the system. To fulfill political promises, the state hesitated to increase rates to final customers.

3.55 The state ignored the importance of the genuine supply-and-demand imbalance component of the crisis. As a consequence, regulators did not consider raising tariffs to the final customer or acting promptly to entertain demand response. The opposite occurred: in multiple opportunities, and with some degree of success, the state voiced its discontent about FERC's reluctance to set caps for energy prices in the wholesale market.

3.56 Some experts say that if efforts were directed towards prompt implementation of demand response during the summer of 2000, much of the power crisis that developed in May 2000 would have abated within a month, rather than persisting for a year. If only a small proportion of the total customers had bought power on Real Time Pricing, statewide peak demand would have dropped by 2.5 percent, or 1,250 MW. The federal government, on the other hand, acknowledged that many problems were due to a poor deregulation process carried out a few years earlier. Some of those problems, particularly regarding the functioning of the wholesale market, were well acknowledged several months before the crisis, but the institutional and governance arrangements were not capable of fixing those problems on time.[44] One of the first steps taken by FERC was to make a radical change in the governance of the Independent System Operator (ISO), under the allegation that its board was too slow to make decisions and

[44] An analysis of the dynamic of the market and the functioning (or lack thereof) of the market rules are beyond the scope of this paper.

that many of the problems that California was facing should have been confronted earlier, had the ISO had more discretion in changing some of the market rules.[45] FERC had no authority to interfere in retail rates or to mandate a more aggressive demand-response program. FERC preferred not to interfere in the wholesale market by setting caps, but had given some discretion to the state to do so.

3.57 As stated earlier, the State of California and FERC, the two major players in the government, did not act harmoniously. On the contrary, there was a lot of conflict, finger pointing, and lack of leadership throughout the process. Box 3.2 illustrates the position taken by the State and its conflicts with FERC's views on similar issues.

3.58 Politics played a major role throughout the entire crisis. Under the assumption that generators were gauging the system and hiding capacity, the state reacted, somehow emotionally, by dissolving the California PX (Power Exchange) and by taking full responsibility as the buyer of last resort. As a consequence, instead of having the utilities buying in the wholesale market and selling at frozen rates to their customers, the state itself signed long-term Power Purchase Agreements (PPAs) with power companies and started selling this energy to the distribution utilities at reduced prices. The state used its Department of Water Resources (DWR) to play this role. Despite the noble purpose, governments seldom have the commercial acumen to play such an important role at a critical juncture of the process. The state ended up purchasing energy at very high prices. DWR, the executing arm of the State of California, was harshly criticized for having signed power purchase agreements when the energy price was at its historical peak.

[45] The most important change was the transformation of a stakeholder board, with 26 members, into a professional board. Experiences in other places, such as Brazil, also reveal that stakeholder boards are slow to make decisions, in part due to the "zero sum game" nature of the players involved. A detailed discussion of the functioning of independent ISO boards can be found in Arizu et al (2001).

Box 3.2: State And Federal Policy Responses To The Crisis

The time of crisis was a time for strong, wise political leadership. Faced with the reality of the crisis at its peak, the California governor and the legislature made energy one of their highest priorities for communication and for policy development. Much of the policy action seemed primarily intent on casting blame outside of California, hiding the short-term problems, and shifting the consequences to the future, even at the cost of greatly increasing the overall difficulties for California.

The policies favored by the California political leadership emphasized direct government intervention in the marketplace, reliance on retail and wholesale price controls, and strong regulatory intervention. The California Public Utility Commission (CPUC), now with different leadership than when AB 1890 (legislation which set the basis for the power sector reform) had been passed, stopped trying to improve markets, strongly enforced retail price controls (which the state could control), and lobbied for wholesale price controls (which the state could not control).

The California governor intensified his public relations campaign of blaming California's electricity problems on the federal government, federal regulators, electricity generators, and "deregulation," without mentioning his own policy inaction. He continued his lead role in militating for strong price control regimes at both the retail level and the wholesale level. The legislature failed to modify the most damaging problems of the system but did take leadership in encouraging energy conservation and energy efficiency measures.

When the governor and legislature were forced to respond to the financial crisis, their response relied on direct governmental wholesale purchases of electricity and negotiations to acquire assets of the utilities, therefore moving the state toward public power and direct state participation in electricity markets. At the same time, federal action through the FERC, though slow, sometimes misdirected, and inconsistent over time, seemed designed to address the underlying flaws in the market design and implementation, to avoid simple ineffective palliatives, and to strengthen the role of markets. Like the CPUC of the early through mid-1990s, the FERC operated as a regulatory agency trying to move away from direct control of market transactions and market pricing. The FERC policy actions, overall, had the hope of providing longer-term solutions to California's energy crisis by attempting to identify, analyze, and correct fundamental problems. The ideological conflict was painful between state leadership, which continued to favor dominantly public sector roles, and the FERC, which continued to favor dominantly private sector roles. The state and the FERC each had jurisdiction over important parts of the restructured system, so neither could fully impose its views on the other, and each needed actions of the other to be fully effective. The fundamental ideological differences were never fully resolved and continue to this date.

Source: Sweeney (2002)

3.59 Energy prices ranged from US$128/MWh from Duke Energy up to US$425/MWh from Powerex Corporation, a difference greater than three to one. Of the four largest sellers, the DWR paid Mirant an average price of US$230/MWh, Dynegy an average price of US$187/MWh, Williams US$ 252/MWh, and Powerex, as mentioned, US$425/MWh.[46]

[46] Sweeney (2002), page 156.

3.60 It is usually accepted that DWR played a relevant role in curbing any attempt from players to manipulate the market. However, it was not able to recover the cost of the energy purchased, therefore contributing decisively to a mounting fiscal debt and the political consequences that ensued.

Dominican Republic [47]

3.61 Historically, power cuts have been a constant problem in the Dominican Republic, in recent years due to financial, rather than energy or capacity, constraints.

The Extent of the Power Shortage and Its Economic and Social Impact

3.62 Power cuts persisted for many years during the 1980s, due to insufficient generation capacity. The power system was chronically constrained and widespread blackouts, lasting up to 20 hours per day, were considered "business as usual." With the power sector reform in the 1990s, significant additional generation capacity was built by the private sector in a matter of a few years. In 2003, the Dominican Republic had an installed capacity of about 4,500 MW (1,500 MW as back-up generation), in good operating condition, for a peak demand of 1,900 MW. The boost in generation capacity provided temporary relief to the blackouts.

3.63 However, the country has been experiencing supply restrictions due to generators' financial difficulties to produce energy. Generators have not collected sufficient revenues for the energy sold to distribution companies. Sometimes distribution companies do not pay a sufficient amount to cover variable costs of production. Under those circumstances, some power plants have been forced to stop producing, potentially leading to involuntary power rationing.[48]

3.64 Lack of proper collections led the sector into a death spiral. Distribution companies needed tariff increases to survive, which in turn fed back into the process, increasing theft and non-collections.[49] The situation started to get out of control in late 2001, when oil prices skyrocketed, significantly increasing generation costs and, as a consequence, the monetary importance of technical and commercial losses for the financial health of the discos. Due to the poor quality of service, customers used to paying their bills became lost the incentive to continue. On the government side, a poorly designed and enforced property rights system made things worse, since people's stealing energy or not paying their bills were not compelled to change their behaviors.

3.65 All those things combined contributed to create, over the last few years, another kind of power shortage, the so-called "financial blackout." In many cases, power curtailment and loss of load has been happening in an unplanned, almost haphazard way. It has been difficult for customers to know where and for how long the next blackouts will take place. Therefore, customers have to deal with the cost of non served energy, as well as with a very high loss of load probability (LOLP). The power crisis became aggravated in late 2003, when a significant currency devaluation of the Dominican peso took place. Fuel costs, tied to the U.S. dollar, were

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[47] This section is largely based on the Project Appraisal Document on a proposed loan to the Dominican Republic for a Power Sector Technical Assistance Project. Report No 26186, The World Bank, January 7, 2004.

[48] According to the 12 August 2003 edition of "Listín Diario" of Santo Domingo, Dominican Republic, on the previous afternoon, generation was 1,279 MW, while non served demand was 527 MW.

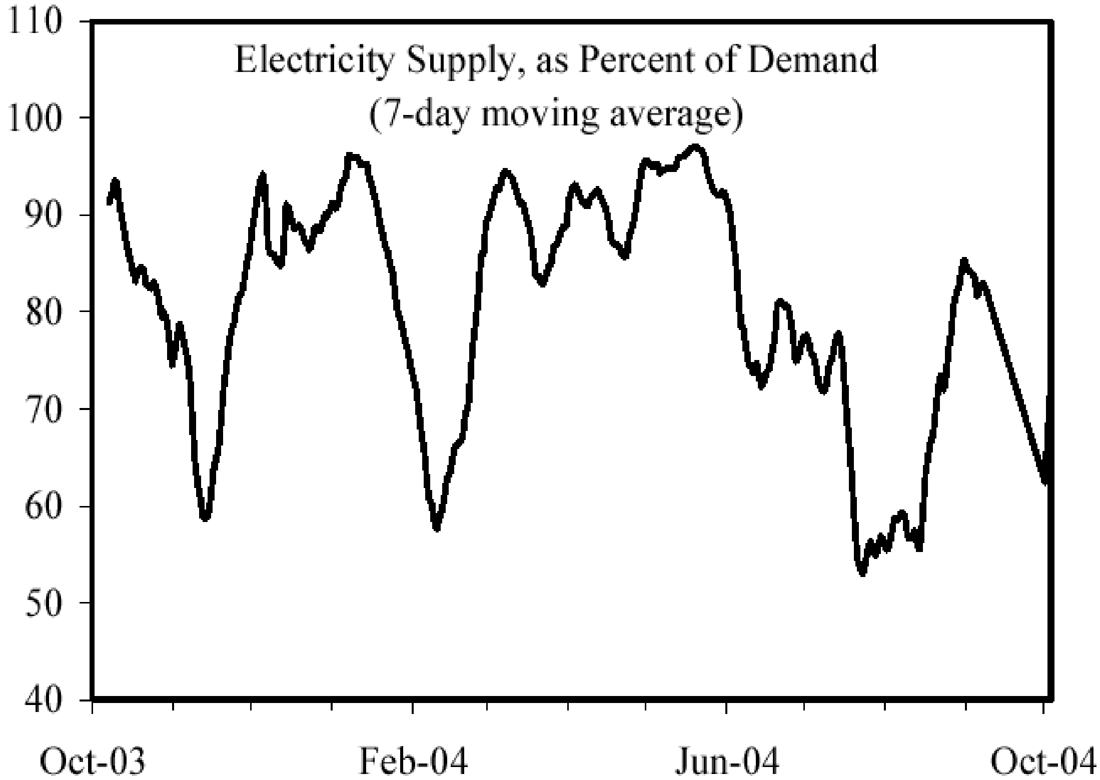
[49] The impact of technical and non technical losses is remarkable in countries with high costs of bulk power, such as the Dominican Republic, which basically imports hydrocarbons to meet most of its generation needs.

not fully passed through to customer tariffs. Subsidies were created for the first 300 kWh residential consumption block. The economic crisis, in tandem with tariff increases for some customer segments, put the power sector again in a distressed situation, similar to the one faced in 2001. Collections and revenues decreased, and consequently distribution companies were not able to pay for a large part of the generation produced, forcing Independent Power Producers (IPPs) to declare their capacity physically unavailable, since they had no sufficient working capital to purchase fuel. The social consequences of the crisis were significant and extensive. The population expressed dissatisfaction with the situation, and public demonstrations led to violence and claimed many lives.The impact of the shortages was not evenly distributed among the rich and the poor. On one hand, rich people were able to partially mitigate the negative consequences of shortages by installing their own back-up generation systems. Some experts estimate that 1,500 MW of back-up generation is available in the country.[50] While not the ideal solution for businesses and industries, it was still better than not having energy at all. This alternative was not available to the poor. Furthermore, the way that rolling blackouts were designed imposed a higher burden on some less-privileged neighborhoods. This was the essence of the ill-fated Programa de Reducción de Apagones (PRA) plan, which will be discussed in the next section.

3.66 Graph 3.1 illustrates the nature and extent of the recent power cuts in the Dominican Republic. Despite a total utility capacity of 3,000 MW and peak demand of about 1,900 MW, the country has recently curtailed an average of 25 percent of the load, and in some periods even 50 percent. The ups and downs are the direct result of the availability of financial resources to acquire fuel.

[50] Blanlot, Vivianne. República Dominicana. Estrategia y Plan de Acción Para el Sector Eléctrico. USAID November, 2004.

Graph 3.1: Load Shedding in the Dominican Republic



Source: USAID (2004) and World Bank analysis

The Causes of the Power Shortage

3.67 In the mid-1980s the system was capacity-constrained basically due to the lack of investment in the power sector, at that time owned and operated by the government. Lack of funds jeopardized maintenance of existing generation assets, as well as construction of new power plants. In parallel, consumption was outstripping supply at a very fast pace. In the absence of a robust demand-side management program, rolling blackouts were the last and only resort to deal with power shortages.

3.68 The privatization of the power sector in the mid-1990s attracted significant new capital, including revamping the existing generation capacity, expanding assets, and accessing natural gas via the first LNG terminal in the country. Several new IPPs built greenfield generation capacity, relieving constraints and providing additional resources to support the country's growth. CDE, the vertically integrated state-owned company, remained the owner of transmission assets and hydro-generation facilities. Despite the initial success of the reform, the system soon became financially constrained. Subsidized retail tariffs reduced the financial strength of distribution companies, which, in turn, hampered their ability to pay for the energy purchased from generators.

3.69 The power system now is neither capacity- nor energy-constrained, in a purely technical sense. However, the country is still plagued by constant blackouts, as noted earlier usually referred to as "financial blackouts." The vicious cycle starts with the end users, who do not pay their discos [51] for the energy consumed. Cash recovery indices of 50 to 60 percent for discos have been observed for many years in most areas of the country. That means that for 100 units produced, only 50 to 60 percent is collected.[52]

3.70 The Dominican Republic has had a longstanding tradition of nonpayment of electricity. For more than 40 years, electricity was perceived as a "free good." Until privatization, theft was rampant and procedures for cutting off customers in arrears were largely innocuous—customers could re-connect themselves without any ensuing penalty. Theft of electricity was not culturally perceived as a crime and not enforced as such.

3.71 During the periods of scarcity and shortage in recent decades, demand response played a relatively small role in alleviating the crisis. Actually, the opposite occurred: subsidized rates fostered over-consumption and wasteful use of resources. Lack of enforcement of basic property rights encouraged theft and payments in arrears. Needless to say, if an economic good is perceived to be almost costless, its consumption grows exponentially. Theft and nonpayment contributed to the perception of electricity as a free good, fostering demand consumption even further.

Government Actions to Deal with the Shortage and Results

3.72 In the mid-1990s, in an attempt to alleviate the power shortage and to provide electricity to support the country's growth, CDE entered into PPAs with Independent Power Producers, playing a role similar to a single buyer. This action enabled the country to attract new players and investments in generation. Subsequently, in 1999, the distribution business was broken down into three companies and then privatized. Union Fenosa (Spain) and AES (US) acquired the distribution business.

3.73 Those reforms helped the country attract significant new investments, both in generation and in distribution, in order to meet its growing energy needs. The Dominican Republic was at that time one of the few countries in Latin America experiencing significant economic growth. Currently, the existing generation capacity far exceeds the country's load requirements. Old, liquid fuel-powered plants have been refurbished and state-of-the-art technology has been brought into the country, including natural gas-fired generation and an LNG terminal.

3.74 In an attempt to mitigate the impact on tariffs for all customer groups, the government decided to subsidize electricity rates, at levels that did not fully reflect costs. This action served not only to increase consumption, but also to further reduce the power sector's cash generation, leading to escalating rolling blackouts.

3.75 In an attempt to solve both the issues of subsidies and frequent blackouts, the government decided to phase out the amount of subsidies granted to all residential customers and tried to target subsidies to the poor only. Tariffs for other customers were raised to reflect costs. In 2001, the Government established the Programa de Reducción de Apagones (PRA), a two-year program with the objective of targeting subsidies to the poor on a geographical basis and implementing rolling blackouts in a more organized fashion. The program envisaged a provision

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[51] Either due to delinquent payments or to outright, rampant theft.

[52] Cash Recovery Index, or CRI, is defined as (1-Losses)* percentage of collections (in monetary terms)

of about 20 hours of electricity per day in certain designated areas, generally the poorest barrios in the cities. The energy delivered to those neighborhoods was heavily subsidized by the government and by the utility. Roughly speaking, discos would be responsible for covering 25 percent of the required subsidies to serve PRA customers, while the Government was responsible for the remaining 75 percent. Initially the program worked reasonably well. A tariff increase was applied to the rich, who in turn obtained more reliable service. Allegedly, the poor would also benefit, since the number of hours curtailed in low-income areas was reduced to reasonable levels. The program brought some initial relief, but it did not prove to be sustainable. With the aggravation of the macroeconomic crisis, the money available in the power sector started to shrink. That shrinkage implied less money for fuel, fewer hours of generators running, and more frequent blackouts.

3.76 Rates charged to customers in the PRA barrios were nominal, and based on a flat fee, determined as a function of the estimated installed load. A few commercial customers who were located within the boundaries of the PRA were charged regular fees, on a kWh consumed basis. Metering was virtually nonexistent and payment was not based on metered consumption. PRA tried to facilitate the emergence of community self-monitoring groups to increase collection and defray the service costs. However, for practical purposes, the collections in the PRA barrios were negligible.

3.77 PRA was a kind of geographic targeting methodology, also known as a "poverty map." It is widely used in many sectors, due to its simplicity, when poverty is spatially concentrated, which seemed to be the case in Dominican Republic. However, one of its negative aspects has to do with incentive costs. It may affect people's behavior to become eligible, such as relocation and migration to those designated areas. Perhaps even more serious is the fact that there is no metering for any customers. Such "negative incentive effect" induces higher consumption of a subsidized commodity, leading to waste and crowding out private and public transfers.[53]

3.78 PRA created very perverse economic incentives, jeopardizing its medium-term sustainability. Initially, subsidies were about US$30 million per year. In 2003, the opportunity cost of the energy consumed by PRA grew to US$120 million and it is expected to grow even further, perhaps to US$200 million, in 2005. PRA represents the antithesis of a sound demand management program. The subsidies and the mechanisms for rationing energy need to be completely revamped. Some of the most important issues to be addressed include the resource waste that this system seems to engender and the growth in the number of customers in PRA areas.

3.79 Most of the customers in the barrios do not have meters, and neither the government nor the discos are planning to introduce meters in the short term.[54] Not surprisingly,

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[53] Coady et al (2004).

[54] The introduction of meters is seen by the government and by the discos as a dangerous move as it would be met with staunch resistance from the population and risk jeopardizing the still fragile progress made in having them accept paying their bills. Furthermore, discos have no economic incentives to do so. Installing, reading, and maintaining meters increase investment and operational costs, unlikely to be recovered by the tariffs charged in PRA-designated areas, often at a very high political cost. Discos' real incentive is to extend PRA's life as much as possible. Funding 25 percent of the energy delivered to PRA barrios is still more advantageous than serving those kinds of customers at nominal rates and with a very low cash recovery index.

lack of meters and payments based on a flat fee (as opposed to individual kWh consumption) lead to resource waste. Cases of light bulbs without switches have been documented. Substitution of propane for electricity in cooking has become widespread. Illegal hook-ups abound, and the distribution network in the barrios is overloaded and deteriorated, increasing technical losses and facilitating theft. Discos have virtually no incentives to fix this technical problem. For them, providing 25 percent of generation costs to those barrios as subsidies to the poor is more advantageous than delivering regular services to those poor customers, where losses and non-payment are a chronic problem.

3.80 PRA subsidies and the expectation of a service of "decent" quality led to an organic growth in the number of customers in those areas. Also, discos worked actively with the government to qualify more and more areas and customers under the PRA umbrella. The population under the PRA grew substantially. In early 2003, the barrios consumed an estimated 10 to 12 percent of energy produced in the Dominican Republic.[55] In late 2003, it was estimated that more than 400,000 customers, or one-third of the country's total client base, were located in PRA-designated areas. The current size of PRA may jeopardize the financial sustainability of the entire power sector.

3.81 In addition to those perverse incentives, PRA did not seem to be a very well-targeted subsidy scheme, which is a usual drawback of geographically targeted subsidies.[56] This is because the population within the qualified barrios is heterogeneous in terms of income and consumption. However, customers are treated equally in terms of subsidies and quality of service provided. This "one size fits all approach" is a very inefficient way to allocate subsidies and to ration energy, as customers' willingness to pay for kWh and reliability are not taken into account. The PRA should be revised, both in terms of its subsidies as well as in terms of how load shedding is implemented. In principle the geographic targeting scheme may be preserved, at least as an interim measure. However, it has to be combined with something else, such as metered consumption level. In terms of lifeline rates, subsidies to the poor should come as "vouchers" or fixed monthly payments to be deducted from individual bills. Those two actions combined would provide a great incentive to save, from the very first kWh consumed, therefore contributing to the feasibility of the scheme. The more the community saves, the fewer hours of blackouts will be necessary. The difficulties in metering, billing, and collections cannot be overlooked, and they should be worked in gradually. However, it is not acceptable to maintain the current scheme in perpetuity, given the perverse incentives created. Other countries faced similar difficulties and were able to significantly reduce losses and increase collections. There is no political consensus among distribution companies and the several branches of the government on what needs to be done. The blackouts are just the tip of the iceberg. Resolving the problems of the power sector requires a much more comprehensive approach. The role of demand in response to prices (or the lack thereof) has to be better understood and taken into account in the design of a new subsidy and rationing scheme.

[55] In the same period hydro power represents 15 percent of national production.
[56] Coady et al. (2004).

Japan [57]

3.82 The 2003 energy crisis in Japan described here was resolved without blackouts or other rationing measures. High consumer awareness about the need to conserve energy, combined with already existing high energy-efficiency standards for appliances, helped avert a more serious crisis.

The Extent of the Power Shortage and Its Economic and Social Impact

3.83 The Tokyo Electric Power Company (TEPCO) is the largest utility in Japan and provides one-third of the electricity in the entire country. It serves 27 million customers with annual sales of about 280 TWh. Its peak load may reach 64 GW in summer months.

3.84 In April 2003 TEPCO stopped operation of all of its 17 nuclear power plants for safety analysis. At that point in time, it was not clear for how long those plants would remain inoperative. Nuclear plants represented more than 17 GW, or 29 percent of TEPCO's generating capacity. Even considering imports from other regions, the nuclear plants produced 44 percent of the power output. In sum, almost half of TEPCO's market was potentially in jeopardy if immediate actions were not taken on both the supply and demand sides.

3.85 A month later the plants were shut off for inspection, and only one returned to normal operation. A power shortage between 5 GW and 8.5 GW was expected, depending on the temperatures in the upcoming summer.

3.86 On the supply side, TEPCO was able to secure approximately 4 GW of additional capacity, including imports. Despite all the efforts, there was still a significant gap to be bridged, which could range from 1 to 4.5 GW to meet summer peak load, depending on load response and climatic conditions.

3.87 Such a high risk of blackouts is very unusual in Japan, a country with one of the most reliable power sectors worldwide. For example, in 1999, power outages caused by accidents was 9 minutes per year per household in Japan, compared to about 63 minutes in the United Kingdom, 57 in France, and 73 in the United States. Furthermore, quality of service in Japan has consistently improved: power outages in the 1990s were, on average, 10 percent of those in the 1980s. In such a reliable environment, the risk entailed by the loss of 17 power plants was something unthinkable.

The Causes for the Power Shortage

3.88 The crisis in Japan was caused by a very unique supply shock resulting from a sudden loss of generation capacity, provoked by operational security issues.

3.89 In May 2002, or almost a year before the crisis erupted, TEPCO started an internal investigation into the alleged concealment of cracks and the falsification of inspection and maintenance records at its nuclear power plants. In August 2002, TEPCO announced that there were problems with maintenance work at its nuclear power plants between late 1980 and early 1990. An internal investigation report was made public in September 2002, admitting systematic and inappropriate management of nuclear power inspections and repair work for a

[57] Adapted from presentation from Shibata (2003).

long time. Given the seriousness and magnitude of the crisis, top executives were forced to resign.

3.90 Finally, in April 2003 TEPCO stopped all of its nuclear power plants for further safety and analysis. Those plants would remain inoperative until they were able to obtain permission to re-open from residents and local governments in the vicinity of the power stations.

Government Actions to Deal with the Shortage and Results

3.91 Government actions included reactivation of 2.2 GW of thermal plants that were not operative, 0.7 GW imports from other utilities, and 0.8 GW by accelerating the commissioning of plants under construction or even postponing maintenance programs.

3.92 In total, efforts on the supply side contributed about 4 GW, but there was still a significant gap to bridge. The regulatory system enabled about 2 GW to be called as planned-adjustment contracts (1,200 MW) or adjustment-anytime contracts (800 MW). The government made an effort to additionally acquire 360 MW. Therefore, there was already some demand response planned and built into the system.

3.93 In addition, TEPCO launched an ambitious savings campaign across multiple consumption categories. The campaign called for energy conservation efforts by advertising on Web sites, television, radio, newspapers, magazines, brochures, and other channels, showing customers the seriousness of the situation and teaching them how to reduce consumption. This was a particular challenge, given the need to regain public trust.

3.94 Residential customers were asked to contribute by reducing air conditioning usage, making more rational use of appliances, and reducing lighting. Industrial customers were asked to self-generate or shift production to non-strained areas in the country. Office buildings had to contribute by reducing the consumption of air conditioning, lighting, and elevator use. Likewise, railroads had to reduce air conditioning consumption and crank up their self-generators.

3.95 Customers reacted very favorably. A survey of 1,420 customers revealed that 94 percent reduced lighting consumption, 58 percent changed the setting of their thermostats, 56 percent turned off their televisions while not watching, and so forth. The Japanese have a high degree of awareness about the importance of energy conservation. A similar poll revealed that 89 percent of the respondents conserve energy on a regular basis, while 10 percent are likely to do so; only 1.5 percent are not engaged in conservation efforts. More than 80 percent of the respondents believed that saving energy was necessary to prevent blackouts. The degree of consciousness and preparedness were also remarkable. The population in general was aware of what to do in the worst-case scenario, that is, if rolling blackouts became inevitable.

3.96 Energy conservation is ingrained in the culture of the average consumer and supported by information, laws, and voluntary efforts. Furthermore, over the last 15 years, Japan has significantly improved energy efficiency standards for commercial products. For example, a large refrigerator (>500 liters) in Japan consumes today half of the energy consumed in 1995. Improvements in the efficiency of air conditioning systems are also remarkable. Even the stand-by consumption of televisions has decreased by a factor of 10. Japan has also made significant investments in new technologies and processes, including new types of LEDs (Light Emitting

Diodes), considered the "light of the 20th century," heat pump water heaters, co-generation systems for small users, and home energy management systems.

3.97 The Japanese experience is an interesting case study regarding the effect of ongoing emphasis on efficiency and demand side responses for the continued reliability and affordability of the power system.

3.98 A strong knowledge and consciousness about energy problems undoubtedly helps a country deal with emergency situations, when a very fast response from the population is required. The required response was achieved, and the country was able to overcome a sudden and massive reduction in generation capacity without the need to resort to blackouts.

4

The Brazilian Crisis

4.1 The Brazilian power system experienced its major supply crisis in 2001 and 2002. As a result, the country was forced to implement an aggressive energy rationing plan from June 2001 through February 2002. Rationing encompassed the most important areas in the country, corresponding to about 80 percent of its population, GDP, and electricity consumption. Twenty-two out of the 27 states of the Federation were subject to some degree of rationing. Aggregate consumption was reduced by almost 20 percent from the previous year's levels, and, more importantly, the system was able to overcome this long period without blackouts and brownouts.

4.2 There were no excuses for the fact that Brazil got into this dire situation. However, the way that the government managed the crisis, the possibility of allowing people to make their own decisions on how to save energy, as well as the effective customer response to self-rationing, represent an international best practice.

4.3 This chapter details the various features of the Brazilian crisis, highlighting aspects of the crisis management process. Understanding how Brazil handled this crisis may help other countries face similar situations.

Main Causes of Rationing

4.4 As in most other energy crises around the world, there were several causes for the Brazilian 2001–2002 power sector crisis. Some of them were evident, while the cause-effect relationships of others are more difficult to interpret.

4.5 As the Brazilian system is mostly hydroelectric, the immediate cause for the energy crisis was a sequence of years drier than usual. The system would not have experienced an energy shortage if rainfall in the years preceding and during the crisis had been close to historical averages.[58] A major drought was the "official" explanation offered by the government to justify the extent of the crisis. However, the system was designed and should have been able to withstand low rainfall without the need for severe rationing measures, had supply and demand been in equilibrium. This structural imbalance was the most important cause that precipitated rationing.

[58] Kelman et al (2001).

4.6 Unexpected demand growth is usually dismissed as a major driving factor for the crisis, since the difference between actual electricity consumption in the period 1998–2000 and corresponding forecasts performed in 1997 was below one percent.[59] Therefore, and contrary to the rationing experienced by China in 2003, the crisis in Brazil was not caused by a significant demand shock. The imbalance between supply and demand could be primarily credited to insufficient new generation capacity. The immediate causes for this imbalance were as follows:

- Delays in the commissioning of several new generation plants under construction, which accounted for roughly one-third of the energy deficit, including the Angra II nuclear power plant (1,300 MW), delays in Porto Primavera (1,800 MW), and technical problems with the third circuit of Itaipu Power Plant;
- Lack of incentives for distribution companies (discos) to contract, by entering into PPA arrangements backed up by new generation. PPAs were, and still are, almost a prerequisite for system expansion in Brazil. Discos' lack of willingness to contract was due to many regulatory and commercial reasons, particularly the uncertainty related to the pass-through of power purchase costs.[60]

4.7 The second alleged reason was a false sensation, on the part of industry players, that supply and demand was "physically" balanced. From a contractual standpoint, discos had the energy to meet their current and future market requirements. Therefore, no new contracts seemed to be necessary. However, the independent system operator's predecessor overestimated the volumes of available physical energy specified in the contractual arrangements when those contracts were put in place.[61] That was tantamount to saying that the risk of deficit at the outset was much higher than the 5 percent traditionally used for planning purposes. That phenomenon accounted for approximately two-thirds of the energy deficit. [62]

4.8 The root causes of the supply–demand imbalance are complex and intertwined. Many blame the power sector reform initiated in 1997. It is an oversimplification to ascertain that the market-driven reforms partially implemented in the late 1990s were the culprits for the crisis, as it is oftentimes alleged. On the contrary, those reforms triggered an unprecedented wave of investments in Brazil.

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[59] Kelman et al. (2001). This is a conclusion drawn by this independent report commissioned by the Government right after the crisis took place. While the argument of dismissing market growth is somewhat legitimate, it is also true that demand forecasts have historically exceeded actual consumption. The fact that actual demand outstripped market forecasts in the years preceding rationing was something unusual that cannot be ignored as a potential contributor to rationing.

[60] A detailed discussion about this subject can be found in Arizu, Maurer, and Tenenbaum (2002)

[61] Usually referred to as Assured Energy, which is the volume of energy that a power plant, integrated with the rest of the system, is able to deliver on a sustainable basis for a certain level of risk. Assured Energy is statistically defined for a risk of 5%. The figures utilized in the vesting contracts corresponded to a risk of about 8-9%. This information was not made public when the vesting contracts were being drafted.

[62] Some argue that while the gap between the physical and contractual reality was legitimate, it was not a surprise to generators or discos. They knew about this mismatch, far in advance, when the Assured Energy for hydro plants was defined. Therefore, distribution companies could have contracted more aggressively if they wanted to do so, despite not being strictly mandated by regulations. This contracting attitude seemed to be more a result of lack of individual incentives to provide reliability to the system as a whole and lack of industry players' willingness to hedge them against a potentially high risk entailed by rationing. To a large extent, rationing was perceived as a collective problem, and there were implicit expectations that the government would bail out the industry in the worst-case scenario.

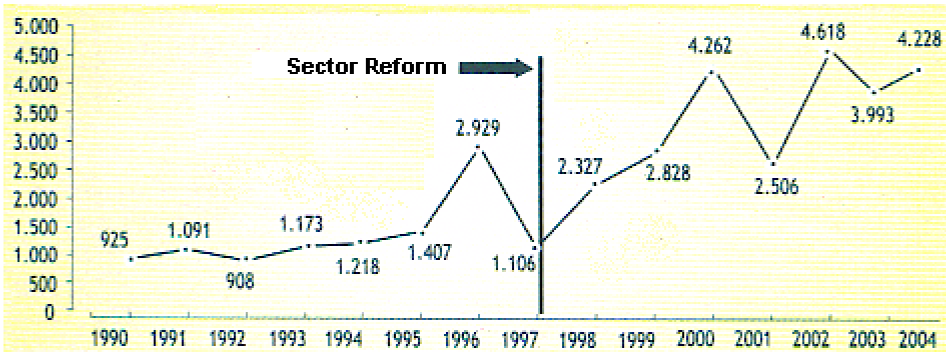
4.9 The conceptual consistency of the reforms being put in place attracted the attention of new potential investors. The country ranks first in the world in terms of attracting capital to its power sector. About two-thirds of the investments were used to acquire existing assets via privatization of state-owned companies, while the remaining part was used to developed new, greenfield projects and improve the existing network. Table 4.1 illustrates the capital attracted to the power sector worldwide from 1990 until 2003.

Table 4.1: Capital Attracted to the Power Sector

Private Investments in the Power Sector		
Period 1990-2003 - US$ Million		
	Greenfield & Concessions (*)	**Divestiture**
Brazil	17,689	38,983
China	16,861	5,455
Philippines	12,610	1,604
India	12,126	563
Indonesia	10,547	188
Malaysia	8,525	2,595
Thailand	8,098	2,176
Argentina	6,765	19,223
Total	**160,392**	**109,464**
(*) Excludes Management Contracts and Leases		

4.10 As a result, the pace of construction of generation capacity increased significantly after 1997, as depicted in Graph 4.1.

Graph 4.1: Annual Generation Capacity Additions (MW)

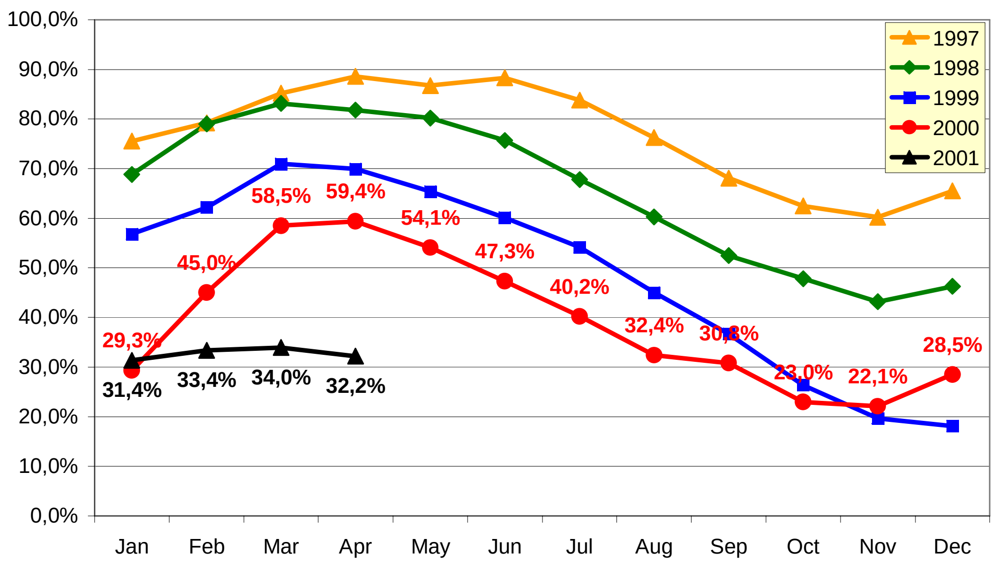


Source: Adapted from Boletim Energia. Aneel. January 2005.

4.11 The reform-driven component of the crisis was in fact caused by lack of coordination and orchestration of a complex industry. The blueprint for reform was put together in 1997, but the sector still needed a lot of guidance and support to move in the right direction. The complexity of the model required detailed further regulations, good orchestration among the multiple (some of them new) players, and more importantly, continued top government support. None of those ingredients was present in the early stages of the power reform in Brazil, in particular during the second term of President Cardoso. The reform itself cannot be blamed. However, halfway through implementation process in tandem with poorly coordinated restructuring efforts were indeed important factors that contributed to the crisis.

Graph 4.2: Multi-Year Reservoir Depletion— Southeast

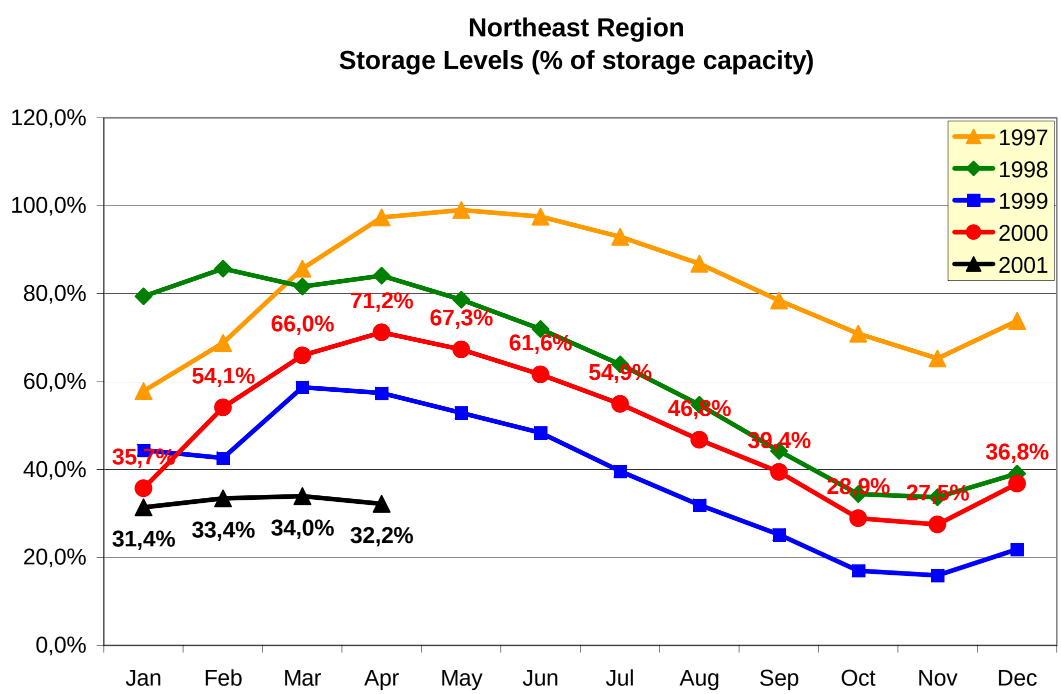
Southeast and Center-West Regions
Storage Levels (% of storage capacity)



4.12 For the professionals involved in the power sector, rationing was not a surprise at all. The situation had been steadily deteriorating since 1997. Graph 4.2 and 4.3 depict a long-term depletion trend of the reservoirs. The water available for power generation declined over several years, and it never reached the previous years' levels, even after abundant seasonal rainfalls had taken place. Actually, stored water in the reservoirs was making up for the additional generation capacity that was not materializing. Typically, reservoirs deplete about 30–40 percent of their capacity in a dry season. Considering the low levels at the end of the rainy season in 2001, there was no doubt at that point that rationing was necessary and urgent.

4.13 Load reduction measures would probably have been advisable as early as 1999. However, the government preferred to work only on the supply side, by conceiving an ambitious thermal generation program (PTT), which was partially implemented and not able to prevent the crisis. This plan envisioned the installation of about 40 natural gas-fired power plants over a time horizon of three to four years. Just a few plants were built, some only commissioned a few months after rationing was in place. Therefore, they did not help much in avoiding the secular depletion of the reservoirs. In March 2001 the real dimension of the crisis was acknowledged, as well as the size and urgency of the ensuing load reductions. It was only at this time that top government officials allegedly became fully aware of the gravity and urgency of the situation.[63]

Graph 4.3: Multi-Year Reservoir Depletion—Northeast



[63] Industry players, in many opportunities, had the chance to fully explain the gravity of the situation to top-level government officials in several ministries, including at the Ministry of Finance. However, due to a long historic tradition in the power sector to "cry wolf" in order to attract government funds for new public investments, disbelief and second guessing hindered an open and frank dialogue between the power sector and government authorities.

Previous Experiences in Energy Rationing

4.14 When the crisis hit in 2001, there were a few instances of energy shortages in Brazil from which experiences could have been drawn. However, the 2001–2002 crises by far dwarfed its predecessors in size, geographical scope, and, therefore, complexity. Furthermore, many of the new players were private companies, as opposed to previous crises when the power sector was basically in government hands.

4.15 Historically, the power sector in Brazil has been plagued by multiple power crises of different duration and geographical scope. Some of the more distant power shortages affected the heartland of the country, comprised of the regions of São Paulo and/or Rio de Janeiro, are shown in Table 4.2. As it can be seen, in the great majority of the cases, crises were associated with climatic conditions, since Brazil has historically been very dependent on hydroelectricity.

Table 4.2: Past Electricity Shortages in Brazil

Period	States/Region	Major Causes
1924-25	São Paulo (SP)	Drought - Tietê river and its tributaries
1938-1947	SP	Difficulty to import equipment due to World War II
1950-57	Southeast	Drought and demand increase
1951-64 Intermittent	Rio de Janeiro (RJ)	Drought in Paraíba river and lack of generation capacity
1963-1964	SP and RJ	Drought - drastic reduction in river flow - Paraíba and Piraí
1967	RJ	Flooding of Nilo Peçanha Plant

Source: A Energia Elétrica no Brasil (1978)

4.16 Table 4.3 summarizes the important crises that occurred in the late 1980s in the South and Southeast regions. In those crises, voltage reductions and some sort of “quota” system were put in place.

Table 4.3: Recent Rationing Episodes in Brazil

SOUTH	NORTH-NORTHEAST
January 86 till March 86	March 87 till January 88
3 States	11 States
6,500 MW, 4.5 MM customers	8,200 MW; 5.3 MM customers
Initial reservoir level = 40%	Initial reservoir level = 35%
Saving target = 20%	Saving target = 15%
Quotas, differentiated by customer class	Quotas, differentiated by customer class
Targets = almost achieved	Target = initially achieved, less so towards the end
Supply side = more imports and thermal generation	Supply side = more imports and thermal generation

4.17 The crisis in the South, which took place in 1986, was similar in many ways to the 2001–2002 rationing episode, but more confined geographically. A rationing system based on monthly quotas was implemented in the beginning of 1986, but fortunately the crisis was very short-lived: heavy rains helped recover the reservoir levels, obviating the need for further rationing. Even though the quota system lasted less than three months, it served as a sort of "proof of principle" when the next event happened in the North-Northeastern regions one year later.

4.18 This next rationing episode, in the North and Northeast, was much more serious and lasted from March 1987 until January 1988. In this episode, an "improved" quota system similar to the one used later in 2001 and 2002 was implemented. The initial aim of the quota system at that time was to achieve a 15 percent reduction in consumption; after September 1987, the target was revised to 10 percent. Overall, the rationing measures accomplished 80 percent of these targets, achieving an average 10.5 percent reduction in consumption during the whole rationing period.

4.19 The third instance was in a relatively important (500 MW) isolated system, encompassing the city of Manaus, in the heartland of the Amazon forest. Manaus suffered severe rotating blackouts in the late 1990s, and a quota system was established, but never used. The rationing ended with the emergence of new, private IPPs. Despite not being a significant power crisis on a national scale, the Manaus crisis had the merit of highlighting the damages caused by rolling blackouts, compared to its predecessors, when energy quotas were established.

Politics of Establishing a Rationing Scheme

4.20 The decision-making process to implement rationing in Brazil was extremely convoluted, in which misinformation, lack of coordination, politics, and vested interests played a major role. Some anecdotal aspects of the political process to be described in this section underscore the confusion and mayhem that often precedes the implementation of an energy shortage program.

4.21 The months of March and early April of 2001 in Brazil were spent mostly in an intense debate on ways to cope with a potential crisis. Initially, the government was reluctant about introducing an aggressive rationing program, under the expectation that reservoir levels would recover at the end of the rainy season. There were hopes in early 2001 that rainfall levels close to 85 percent of the historic average could reduce the risk of a rationing program. Only in late March did the government decide to convey a more forthright message to the population. At that time, it was stated that rainfall levels had been some of the lowest on record and reservoirs were becoming depleted at a very fast pace. Pictures of the reservoirs were taken and disseminated by the media. Despite this mounting evidence, there was still political inertia to start implementation of severe demand-side actions. Some initial cosmetic measures were taken, and a soft message was conveyed to customers, encouraging them to engage in a program to save energy, based only on moral suasion. That message was too soft to change people's behavior and achieve material conservation results. Despite the government's optimism that rationing could be avoided, some industry associations started to publicly alert the government about the necessity to design a rationing scheme based on quotas, leveraging as much as possible the new, albeit incomplete market mechanisms that had been introduced in the power sector since the last rationing scheme. ABRACEEL, the Brazilian Association of Energy Marketers, advocated that rationing should be based on price signals as much as possible, as opposed to arbitrary savings decisions made by bureaucrats in a central office in Brasilia.[64]

4.22 It was not until mid-May, after the end of the rainy period, that the subject was taken seriously. The debate focused on how to implement rationing: either via rolling blackouts, which were being used in California at that same time, or via the quota system, which had been tried in Brazil before with varying degrees of success.

4.23 In mid-May, a joint proposal made by the regulator (ANEEL) and by the independent system operator (ONS), acting on behalf of the Federal Government, was submitted for public consultation. The proposal envisioned the establishment of quotas per customer [65] with strong penalties for noncompliance. The initially suggested penalties implied charging 15 times the price of energy for consumption above the assigned quotas. This penalty factor could increase to 30- and even 45-fold, depending on the number of times the customer violated his or her quota. Service disconnection, if necessary, was also part of the enforcement mechanism. The idea of utilizing the price of energy in the spot market as the basis for establishing the penalties was proposed in that hearing by ABRACEEL, but immediately rejected.[66]

4.24 Some large and influential industry associations immediately rejected the idea of quotas, and proposed rolling blackouts instead, almost until the last minute. The most vocal proponents of rolling blackouts included ABRADEE (the Brazilian Association of Distribution Utilities). Based on its expertise in dealing with customers and in managing the grid, ABRADEE feared that operational and administrative difficulties in implementing quotas would be an insurmountable obstacle. Also, distribution utilities would be overwhelmed by the number of

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[64] Jabur (2001).

[65] A certain percentage of last year's consumption, defined as baseline.

[66] Zimmerman (2001).

customers challenging their initial quota allocations. In retrospect, all of those assumptions proved wrong.

4.25 Despite experience in the use of quotas, opponents also alleged that the rationing targets in the past were much lighter and could have been achieved via a combination of quotas, moral suasion, and some sort of enforcement mechanism, such as the threat of disconnection. However, ABRADEE alleged that achieving 20–25 percent reduction in consumption on a countrywide basis would be an impossible achievement if based on quotas. Quotas could perhaps bring some positive results in the first couple of months, but were doomed to failure as people became increasingly frustrated and unmotivated by the duration of the rationing. The allegation was that in this scenario, rolling blackouts would become inevitable.

4.26 Opponents of the quota system brought to mind the fact that the Northeast rationing in 1987–1988 was effective only for a few months, and its efficiency declined steeply over time. ABRADEE also contended that financial penalties were unlikely to succeed, in part due to the lack of demand elasticity and in part due to difficulties in collecting the proceeds that the mechanism would entail. That was basically the official position taken by the representatives of the distribution companies in a public hearing. ABRADEE represented a large majority of Brazil's distribution companies.

4.27 The days that followed the public hearing were chaotic in terms of the country's understanding of the real gravity of the situation, let alone on how rationing should be implemented. Overreacting to the ANEEL-ONS proposal spelled out in the hearing, the President of the Republic publicly announced that penalties would be overruled, creating even more confusion among the public. Some customers started to buy candles and generators, while some industries increased their production in preparation for an impending crisis.

4.28 President Cardoso's statement was misinterpreted as supporting the immediate implementation of rolling blackouts. What the President meant was that he would substitute the unpopular concept of penalties by some sort of bonus for those who exceeded their reduction targets. Unfortunately, the President made a statement without previous consultation with power sector experts. The lack of information and coordination was such that a plan to implement rolling blackouts was ready to be approved by the National Council of Energy (CNPE), the maximum authority in the country in terms of defining key energy policies. The plan was withdrawn in time, and CNPE was never reconvened during the critical periods of the rationing program.

4.29 As a consequence of President Cardoso's initial statements, the plan was immediately baptized *apagão*, which means blackout in Portuguese. "Apagão" does not correctly reflect the solution subsequently adopted by the government throughout the entire rationing period. However, the rationing is still wrongly referred to as an "apagão." Perhaps due to this mischaracterization, some still believe that the rationing scheme in Brazil relied on blackouts and hefty fines.[67]

4.30 The initial reaction from customers was total perplexity. Was the government lying—again? Who within the government had the legitimacy and knowledge to elucidate, in layperson's terms, what was really going on? How could someone dare to increase the price of

[67] Stoffaes (2004).

energy and penalize customers twice, in terms of both cost and reliability? Furthermore, penalties would benefit the rich—so, why not implement a more democratic form of rationing? The government itself, not customers, should be penalized, the media contended. No coherent explanations were being provided at this stage.

4.31 Even large, generally well-off customers were bewildered. They remained relatively neutral in the initial debate about rolling blackouts versus quotas with price increases. Those customers only supported the idea of quotas at the very end of the decision-making process. In the midst of the initial confusion, consumers were also second-guessing the extent of the crisis. Until customers perceived that the crisis was real and that drastic actions were necessary in some form, they implicitly favored the idea of preserving the status quo, as opposed to paying any additional price for the energy they were already using. Suddenly, they realized that the status quo was no longer a real possibility.

4.32 A much smaller number of industry associations and interest groups supported the idea of the quota system, after it had been officially proposed by ANEEL and ONS in the public hearing. For example, in response to the proposal made by the government, ABRACEEL endorsed the idea of establishing quotas, characterizing the mechanism as a "necessary evil" and proposing modifications to the 15-30-45 penalty system. Instead, ABRACEEL advocated that consumption above the quota should be priced according to the marginal cost of energy in the wholesale market. Despite not being a perfect solution,[68] the price of energy in the wholesale market was the best available proxy to determine the cost of "scarcity," therefore linking the wholesale and retail markets. In addition, ABRACEEL contended, the government would likely face less opposition, given the fact that the additional levy on tariffs was not a penalty per se, but simply a pass-through of a legitimate cost faced by the disco when purchasing this additional energy in the spot market.[69]

4.33 Some renowned economists highlighted the significant economic losses entailed by rolling blackouts,[70] whereby a scarce good was being allocated with no regard to customers' relative value and willingness to pay. A thorough document prepared by a group of UNIFACS professors proposed a rationing scheme based on quotas with economic signals, equally tied to the spot price in the wholesale market.[71] The study also advocated the introduction of bonuses for overachievers up to a certain consumption level, corresponding to those customers eligible for subsidized (lifeline) rates. The proposal had several merits. First, it was aligned with the President's initial orientation. Second, it provided a very elegant solution in terms of protecting the poor, usually the ones who suffer most with rationing and who would be very much exposed to the price increases if they were not able to achieve their conservation targets. Given the direct, personal channel of communication between one of its authors and the President, the study

[68] Despite the spot price being calculated centrally using the generally accepted concept of "marginal value of water," the cost of deficit was an administratively determined parameter. There was a feeling among regulators and industry players that the prevailing cost of deficit, R$684/MWh, was underestimated. Under normal circumstances, the cost of deficit would not have a significant impact on spot prices. However, during rationing, the spot was capped at the cost of deficit. Despite its value being likely underestimated, the spot price during rationing crisis reached about US$300/MWh, which was high enough to entertain sufficient demand response.

[69] Brazil (2001).

[70] Castro (2001).

[71] Zylbersztajn (2001).

helped guide the President and likely had a significant impact on the final outcome of the discussion about quotas versus rolling blackouts.

4.34 To deal with the institutional confusion created by the multitude of actors and proposals on the table, the President appointed a very high-ranking government group to lead the rationing process on a full-time basis. His functions would include making key decisions on the format of the rationing, as well as the steps for implementation. The President nominated Pedro Pullen Parente, his Chief of Cabinet, an extremely loyal and efficient government official, to lead the process. Parente continued reporting directly to the President, with full power to engage any other ministries in this endeavor, in a matrix-like structure.

4.35 Due to the concentration of decisions in his hands, his position was coined "Minister of Rationing." He was also granted full power to prepare decrees, draft laws, and negotiate with the Senate and the Judiciary Power at the highest levels. This was the first clear sign to the country that, from that moment on, the government took the issue of rationing seriously. The Minister of Rationing was not an expert in the energy field. His initial meetings with industry leaders were aimed at taking stock of the situation and converging towards a consensus. He knew that not too much time could be spent in theoretical discussions about the power sector and that some degree of participation and support from the industry would be necessary to the success of any plan. Two meetings held in May were crucial for the Minister to understand the situation, comprehend the different points of view, and decide one of the most crucial decisions of his career: how and when to start rationing.

4.36 The initial meeting with industry leaders did not prove very helpful to the Minister. No one could agree on ideas, diagnostics, or recommendations. Government and industry representatives had very diverse views on what was going on and how to tackle the key issues. For some, the crisis was not as intense as touted by the independent system operator, and the risk of maintaining the current consumption levels was acceptable: in the worst-case scenario, plants would simply operate as "run of river" without major consequences. Others contended that rolling blackouts were the simplest and most effective solution. Some argued that blackouts would not be easy to implement, but quotas with price signals would be ineffective, given the absolute and demonstrated evidence of lack of price elasticity of electricity. Some professionals, newcomers to the power sector in Brazil, were uninformed about how the country had dealt with rationing in the past, and were adamant that quotas would be a nightmare for the utility to implement, particularly if a penalty system had to be charged to those exceeding their quotas. Other actors suggested the government enact a few new regulations, such as having the utilities pay for back-up generation, not even knowing that those regulations were already in place and operational for more than two months. And last but not least, suggestions were made to "switch off" the country at night, therefore minimizing the impact of blackouts.

4.37 The second and decisive meeting took place a week later, involving the same actors. This time, a high-caliber staff of professionals from the power sector was put in place to advise the Minister, given the variety of suggestions brought to the table in the previous meeting. Distribution companies were not so adamant about rolling blackouts and worked with the government in a more collaborative spirit to find ways to implement the quota system and determine how to adjust their commercial processes and systems to accommodate penalties above quotas, if necessary. Distribution companies still preferred rolling blackouts. It was alleged that the definition of quotas would be challenged by more than 20 percent of the customers, creating not only a nightmare for the utilities, but also jeopardizing the effectiveness of the rationing scheme as a whole.

4.38 The Ministerial team promised to announce how the rationing scheme would work in less than two weeks, and it did so in such a short timeframe. The sense of urgency was vital. The rationing scheme had to start in early June. The decision to implement quotas was announced a few days later. Penalties for exceeding the quotas were linked to the price of energy in the spot market. The penalties were made explicit for large customers and implicit for residential and smaller customers.[72] The plan was designed to be effective almost immediately.

4.39 The fact that the decision had been made did not mean the end of challenges or skepticism. On the contrary, some of the new criticism targeted the decision itself, under the arguments of ineffectiveness, unfairness, and likely devastating consequences for the economy. Criticism was widespread from multiple sources such as industry leaders, economists, politicians, and even opinion columnists in some of the most prestigious business newspapers. Table 4.4 presents a small sample of quotes in the media, extracted from prestigious Brazilian newspapers, illustrating chronologically the reactions to key decisions made at the outset of the rationing plan, right after the quota scheme with pricing signals had been officially announced by the Government.

Table 4.4: Quotes from Brazilian Newspapers on the Proposed Rationing Scheme

<u>Prior to the rationing plan's announcement</u>

- May 8 – Rationing will have no penalties, President Cardoso decides
- May 9 – ABRADEE advocates "rolling blackouts," as soon as possible
- May 10 - Not even hospitals will get rid of "apagões"
- May 16 - ABRADEE insists in "rolling blackouts" to achieve rationalization targets

<u>May 18 – Plan is announced. Quotas with price signals. Effective 6/1</u>

- May 19 – Energy crisis leaves economists lost
- May 21 – Plan is based on punitive, unfair logic. Government missed opportunity to have society as an ally. A disastrous plan.
- May 26 – Political Leader. The government should revisit our proposal to have "rotating holidays" as a civilized way to share costs imposed by rationing. There will be 856,000 jobs lost.
- May 28 – Utility CEO. There is still a strong risk of "rolling blackouts." My wife does not know how to conserve energy.

[72] Customers not eligible for special privileges would pay a penalty equivalent to three times the usual tariff for the consumption exceeding their quotas. The regulated full tariff for residential customers was about R$220/KWh. Three times as much would correspond approximately to the assumed spot price during rationing (capped at R$684/MWh). A three-to-one ratio to express this penalty was much easier language for customers to understand and react to accordingly.

Organization and Processes to Manage the Crisis

4.40 The Minister of Rationing was in charge of coordinating, on a full-time basis, a formal, matrix organization called the Electric Energy Crisis Management Board (GCE), created by a Provisional Measure (MP),[73] which was enacted by the President in May 2001. This MP fully empowered the GCE to take any actions necessary to expedite the design and implementation of the rationing program. The GCE was chaired by the President of the Republic and coordinated by the Minister of Rationing. It also included nine ministers, the heads of agencies such as ANEEL, ANA (regulatory agency for water), ONS, BNDES, and other high officials and members nominated by the President. Despite the high level of the commission members, they were supposed to have hands-on involvement in confronting the key issues over the entire rationing period. As a consequence, the power sector became the focal point and the most visible subject in the country for about eight months.

4.41 GCE was granted sweeping powers to manage the crisis, superseding the authority of ANEEL, MAE, and ONS. It could, for instance, set up special tariffs and bonuses; modify the quota regime as initially set up in the law and/or implement compulsory cuts and rotating blackouts, if necessary; and authorize public companies to bypass mandatory bidding procedures for the purchase of new equipment.

4.42 In addition to the management of the rationing effort per se, GCE established five core programs:

1. Rationing measures
2. Emergency increase of generation supply
3. Structural increase of generation supply
4. Agreement between generators and distribution companies;
5. "Revitalization" of the power sector model.

4.43 GCE started to act immediately. Its first resolution was issued on the day following the publication of the first Presidential Provisional Measure. This first resolution on May 16 established interim energy-saving measures for immediate implementation. Connection of new loads and the supply of electricity for nighttime sports events were prohibited. More than material results in terms of consumption, the objective of these measures was to raise awareness about the gravity of the situation.[74]

4.44 After a few days of analysis and consultation with many industry players and in the midst of significant skepticism and criticism, GCE enacted its most important resolutions defining the quota scheme and reduction targets for each customer category. The penalty scheme, to a large extent, mirrored the marginal cost of power (spot price) in the wholesale market.

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[73] A Provisional Measure is an emergency bill that has the effect of law even while under consideration by Congress. If approved by Congress, it is converted into law. If rejected or amended, Congress must say how to deal with the acts performed under its aegis. GCE was in fact instituted by several provisional measures, the first one issued on May 15, 2001, and with each succeeding measure replacing the previous one with alterations.

[74] Loads that had previously been contracted for and new residential and rural loads excepted.

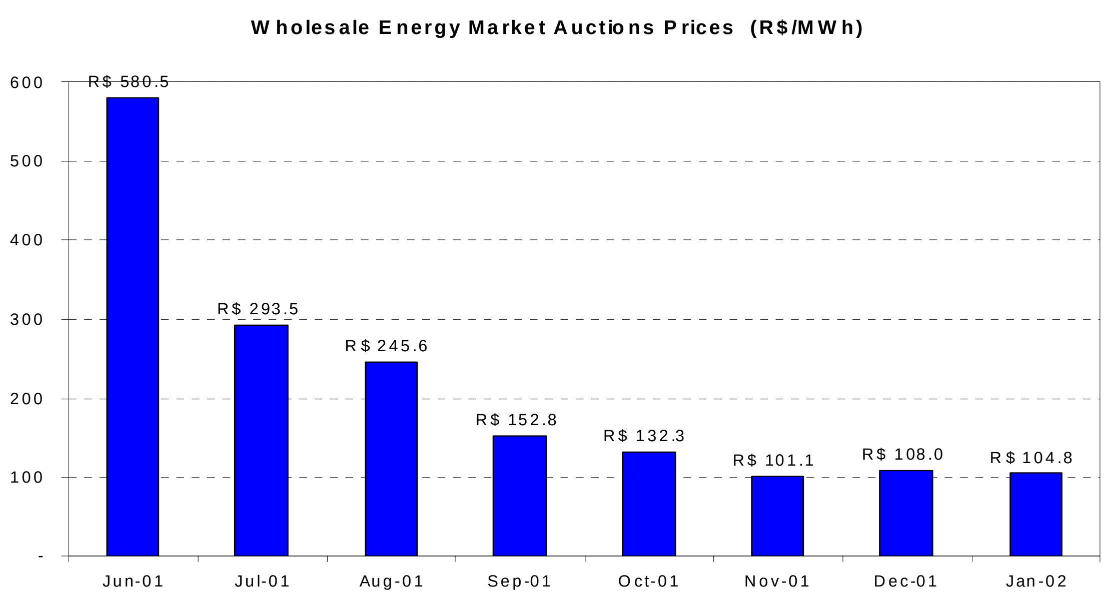
Quota System in Practice

4.45 When rationing started, water storage was at about 30 percent of total equivalent reservoir capacity. Despite not being a comfortable level by any standard, it allowed the government to spend some time in putting together a relatively well-structured plan. Although the plan was subsequently fine-tuned, its core remained the same throughout the entire rationing. This selected approach was based on energy quotas assigned to each individual customer group. The government, in close technical consultation with the independent system operator, initially established the quotas. Aggregate and individual demand reduction targets, or baselines, were established for each customer category.

4.46 The enforcement system for the quotas was based on economic penalties (and, in some cases, incentives) given to consumers via price signals. Penalties were charged to those who exceeded their quotas. Those penalties reflected the marginal cost of energy in the wholesale market. Special mechanisms were created to protect and engage the poor, such as not having specific energy reduction targets, but instead receiving monetary bonuses for any savings beyond the 20 percent defined baseline.

4.47 The system had many interesting features. The most remarkable was the fact that it allowed the trading of quotas for nonresidential consumers, including formal auctions of quota entitlements. The prices in those quota auctions were extremely high at the beginning of the process, close to US$250/MWh, but converged to a value close to the long-run marginal cost of energy after a few months, as shown in Graph 4.4. The high initial prices for the energy reflected, *inter alia*, some imperfection in the ways quotas were assigned among distinct large customer groups, with different levels of willingness to pay.

Graph 4.4: MAE Energy Prices Observed in the Quota Entitlement Auctions



4.48 Bonuses were not available to nonresidential customers. However, the fact that they could trade their quotas meant that nonresidential customers could capture the value of reducing demand below the originally allocated quotas.

Defining the Quotas

4.49 The quota system consisted of monthly energy consumption targets for almost all consumers and a set of rules for trading quotas, setting bonuses for overachievers and penalties for violators. There were different quotas for each consumer class and by consumption level, applicable to the Northeast and Southeast/Center-West electric zones. Quotas were set up as percentages of consumption in a similar period during the previous year. For instance, each residential consumer above 100 kWh per month was assigned a quota corresponding to 80 percent of his or her average consumption during the period of May to July of 2000.[75] Other targets were: 90 percent for rural consumers, 80 percent for commercial consumers, 75 to 90 percent for industrial consumers (depending on the type of industry), and 65 percent for government buildings.

4.50 Table 4.5 shows the main types of quotas assigned in early June 2001, itemized by customer group. Those quotas were enforced at the very beginning of the rationing program.

Table 4.5: Initial Quota Allocation by Customer Group

Type of Consumer[1]	Quota (2,3)
Residential < 100 kWh/mo	100%
Residential > 100 kWh/mo	80%
Low-voltage industrial, commercial and services	80%
High voltage industrial, commercial and services < 2.5 MW	70% to 85%, according to activity
High voltage industrial, commercial and services > 2.5 MW	70% to 85%, according to activity
Rural	90%
Other consumers (mostly government)	65%

1 Some special types of consumers, such as hospitals, schools, prisons, etc, are omitted from this table
2 Quotas expressed as percentages of average consumption in the corresponding three-month period in the previous year, e.g., quotas for June 2001 expressed as a percentage of average consumption in May, June and July 2000
3 Quotas correspond to Provisional Measure 2,198 and GCE resolutions #4, 8, 13 and 16

Surcharges (penalties) and Bonuses

4.51 The enforcement of the quota system was based on financial incentives and penalties. There were stiff tariff surcharges for violators, and threat of service interruptions that could last up to a few days in cases of multiple violations. There was an inducement for further energy savings, beyond the established quotas, in the form of bonuses awarded to overachievers.[76]

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[75] In other words, while consumers had to reduce their monthly consumption, there were no limitations in terms of time of day or days within the month. This is perfectly consistent with the fact that the power system in Brazil was energy-, not capacity-constrained.

[76] From a purely technical standpoint, there is no basis to create bonuses for overachievers. Bonuses imply that those customers are reselling to the market something that in fact they never owned. For a customer to "own" a certain

4.52 Table 4.6 summarizes the penalties as initially established in June 2001. Some fine-tuning took place along the way, but the essence of the enforcement system remained the same throughout the rationing period.

Table 4.6: Tariff Surcharges, Bonuses, and Threat of Service Disconnections

Type of Consumer[1]	Tariff surcharge	Service Disconnection
Residential < 100 kWh/mo	None	Warning on first violation of monthly quota, 3-day service cut on second violation, 4- to 6-day cut for further violations – no service cuts if monthly consumption < 100 kWh
Residential > 100 kWh/mo	Surcharges applied only to violators: Up to 200 kWh/mo: none 200 kWh/mo to 500 kWh/mo: 50% surcharge Above 500 kWh/mo: 200% surcharge	Warning on first violation of monthly quota, 3-day service cut on second violation, 4- to 6-day cut for further violations
Low-voltage industrial, commercial and services	Consumption above quota pays MAE (short-term) price	1-day service cut for each 3% violation of monthly quota
High voltage industrial, commercial and services < 2.5 MW	Consumption above quota pays MAE (short-term) price	1-day service cut for each 3% violation of monthly quota
High voltage industrial, commercial and services > 2.5 MW	Consumption above quota pays MAE (short-term) price	
Rural		1-day service cut for each 6% violation of monthly quota
Other consumers (mostly government)		Warning on first violation of monthly quota, 3-day service cut on second violation, 4- to 6-day cut for further violations

1 Some special types of consumers, such as hospitals, schools, prisons, etc, are omitted from this table.

4.53 Bonuses were also set for smaller customers who were able to reduce load. They were also designed to provide a kind of safety net, to avoid an additional burden on the poor and at the same time try to engage lower-income groups in the conservation effort. Table 4.7 shows the bonuses associated with the quota system.

block of energy, he/she would have to have a contract with a fixed amount with his/her supplier. Any consumption below this contracted amount is indeed owned by the customer and may be re-sold in the market. For an interesting discussion on the subject, refer to Ruff (2002). Ruff contends that no one can sell anything that he/she does not own. The bonus to overachievers in Brazil is a violation of this strict principle.

Table 4.7: Bonuses in the Quota System

Type of Consumer	Bonus
Residential < 100 kWh/mo	Tariff x 2 for consumption below quota
Residential > 100 kWh/mo	Consumption below quota receives bonus that depends on availability of funds
Low-voltage industrial, commercial and services	Consumption below quota receives bonus that depends on availability of funds

4.54 Bonuses always took the form of tariff discounts and could never exceed the total value of the bill, to avoid the utility having to transfer money to final consumers. Residential consumers below 100 kWh per month received their bonuses regardless of availability of funds, while other eligible consumers would only receive funds, on a pro-rata basis, if there were funds collected from the tariff surcharges, net of the payment for customers below the 100 kWh per month consumption bracket.

Impact of Surcharges, Bonuses, and Disconnections

4.55 One of the drawbacks in analyzing the impact of the rationing on a regional basis and understanding customer behavior is the nonexistence of reliable statistics on bonuses and penalties. Those figures were not made public by the distribution companies. Similarly, no statistics are available on the number of violators, the customers earning bonuses, and the number of service disconnections.

4.56 Revenues collected from tariff surcharges were never enough to pay the "firm" bonuses corresponding to consumption of 100 kWh per month or above. To honor its agreement and to keep those customers engaged in the conservation effort, the government had to allocate resources from the budget and compensate discos for the difference between the additional revenues collected via surcharges and the bonuses to be paid to overachievers.

4.57 Table 4.8 shows that the financial deficit coverage by the Treasury was approximately equal to the total revenues collected from tariff surcharges. As can be seen, a small portion of the revenues was assigned to the distribution utilities, to defray some of their operational expenses in the implementation of the rationing measures.

Table 4.8: Amount of Surcharge and Bonuses

Item	Amount (million R$)[1]
Revenues from tariff surcharges	432
Bonuses	833
Implementation expenses	4
Shortage to be covered by the budget	405

[1] Source: Presentation by Ministry of Finance to GCE on Feb 19, 2002. The exchange rate at the time was 1 US$ = R$ 2.43

4.58 The shortage of funds covered by the government was neither planned nor desirable. A few factors contributed to the great imbalance between proceeds from tariff surcharges and bonuses paid to customers. Some of the important factors include:

- Remarkable reaction from the low-income residential customer group in terms of achieved savings. There was an initial belief that the engagement of the poor would be negligible, given their alleged smaller ability to save energy. After all, some contended, poor people are the ones who consume a bare minimum, have inefficient appliances, and have no resources to substitute mini-fluorescent lamps for the traditional incandescent ones;
- Technically speaking, the two-way price scheme was an imperfect arrangement, albeit the best one available, to mimic a real market. Imperfections were two-fold. First, the single, administratively capped "cost of deficit" was far from representing a real demand curve. Second, in the proposed rationing arrangement, customers were still hedged against price increases for a large part of their consumption. As Ruff contends,[77] allowing people to pay regulated tariffs for 80 percent of their consumption and to sell (or receive a bonus) for energy saved above their quotas is tantamount to "grandfathering" them a right that they did not pay for. For people to sell consumption below their quotas they should have been paying a fixed amount to entitle them the "ownership" for the quota assignment;
- In the design of the rationing scheme, bonuses were carved out of the revenue base of the distribution utilities. From a mathematical standpoint, those bonuses should have been estimated and grossed up to the revenue base. This would entail an increase in the average tariff paid by the consumer. This increase would play the role of a cross-subsidy to protect (and somehow engage) the poor. At any rate, and given the unexpected response, any increase in tariffs would not have been enough to pay for the bonuses;
- As the rationing phased out in 2002, bonuses continued to be granted in the same proportion, while quotas for other customers (and consequently revenues from surcharges) were reduced. The decision to continue with the bonuses was more political than based on sound economics or a real need to continue saving energy.

4.59 Some commentators assert that the success of the rationing scheme rested more on the threat of disconnection than in the price signals mechanisms themselves (surcharges or bonuses). These commentators argue that the economic signals were very difficult to interpret by the average customer, who basically understood only the threat of disconnection. If price signals were so efficient, why should they be supplemented by the threat of disconnection at the outset of the rationing program?

4.60 While there may be some element of truth for less price-sensitive customers, such assertions may be rebuffed in light of the following arguments:

- Poor people reacted solely based on price signals. They did not face any threat of disconnection. Financial incentives were the most important motivator, and those customers were able to understand the rules of the game very rapidly. This is an irrefutable and strong piece of empirical evidence;
- No one was absolutely sure about the efficacy of the system at the outset, given its uniqueness, broad and diverse geographical coverage, uncertain duration, and time for

[77] Ruff (2002)

customers to respond. Fall-back positions were necessary, with the threat of disconnection one of them;

- The quota was a mechanism that urged people to look at the cost of energy on an incremental basis. However, most customers think about "averages." Since most of the consumption was still priced at regulated tariffs, the impact of high prices for 20 percent of the entire consumption entailed a relatively modest increase in the total electricity bill. For example, if the price of energy were US$100/MWh (US$40 for the commodity and US$60 for wire and commercial services), a customer using 1,000 kWh per month would face a monthly bill of US$100. If 20 percent of the consumption were then charged at US$360/MWh (US$300 for the commodity and US$60 for wire and commercial services), the total monthly bill would increase to US$152. The customer would perceive a 52 percent increase in the bill, which may not be sufficient to radically change consumption behavior. This is particularly serious given the very wide range of willingness to pay for electricity. It is well known that some customers would be willing to pay a price much higher than the imperfect, administratively determined cost of deficit. The quota was an attempt to force the customer to think and to make decisions on a marginal basis. By doing so, customers would perceive that the unit cost of energy had almost quadrupled;
- The quota scheme alone would not lead to a desired 20 percent energy savings "across the board," in the absence of other enforcement mechanisms. Furthermore, allowing rich customers to spend more than their assigned quota would constitute an indirect subsidy, given the fact that the real cost of energy was US$300/MWh but the customer would only be paying US$40/MWh for the commodity component of 80 percent of the energy used. This would have an equivalent effect of a regressive tax, whereby rich people would be receiving an implicit subsidy of US$260/MWh (US$300–US$40). Unless threats of disconnection were imposed, perverse incentives would be given for affluent customers to continue using scarce electricity at the prevailing patterns.

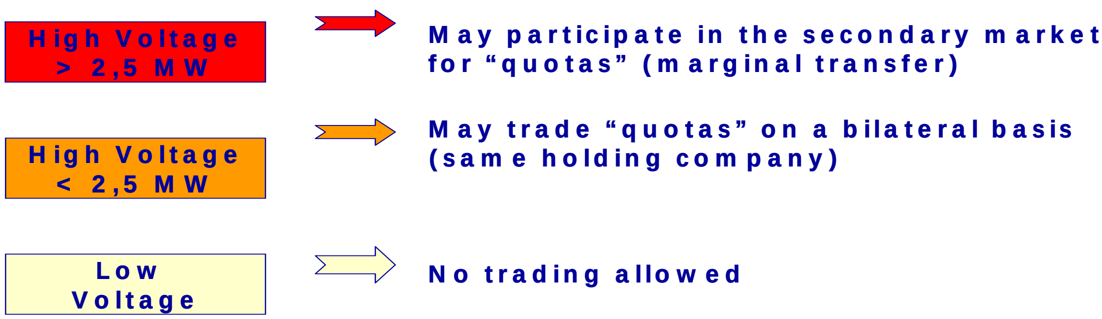
4.61 Every customer needed to contribute to the overall goal of saving energy. It would be politically difficult and technically incorrect to implement a scheme in which customers with very high income or willingness to pay would be allowed to continue using as much energy as they wanted at subsidized prices. This is not simply an issue of equity, but of allocative efficiency as well.

4.62 The willingness to pay for electricity varies significantly among customer categories and income levels. For example, an aluminum plant is likely willing to shut down and transfer production if the energy price goes above US$50/MWh. However, low-energy-intensive companies or high-income residential customers are willing to pay more than US$200 for the energy consumed. A hotel, an airport, or another similar customer will be willing to crank their diesel-fired back-up generator at a variable cost that may exceed US$300/MWh. For high-tech industries, computer centers, or service businesses, the willingness to pay may exceed US$5,000/MWh.

Flexibility and Quota Trading

4.63 The rationing scheme also allowed special categories of customers to "exchange" quotas among themselves. They were large clients, connected to the grid at high voltage levels, and with a demand above 2.5 MW. In theory, this prerogative could have been extended to smaller clients, but it would have created a significant cost of complexity for the discos and for the wholesale market to handle large volume of transactions. Figure 4.1 shows the kinds of customer who benefited from this prerogative, and how the quota trading worked for each.

Figure 4.1: Customers' Eligibility to Exchange Quota Allocations



4.64 The mechanism of quota trading helped improve energy allocation among industrial customers. A study carried out by the Ministry of Finance at the outset of the crisis forecasted that an "optimal" quota trading mechanism would have a significant potential of alleviating the economic impact of the crisis. The study was based on the demand elasticity for more than 40 industrial and service activities. Some of its major (ex-ante) findings suggest: [78]

- Marginal transfers of energy among those sectors can preserve economic growth without significantly impairing macroeconomic growth targets;
- A consumption reduction based on administrative allocation of quotas could reduce GDP growth forecasts for 2001 by 2 percentage points (from 4.4 percent down to 2.4 percent);
- The same reduction in energy consumption may have an impact on GDP of only 0.8 percent if an "optimal" transfer of energy is allowed among all economic activities;
- As a consequence, an optimal quota trading would have the potential to save 1.2 percent of GDP.

4.65 It is difficult to confirm those forecasts on an ex-post basis, given the fact that much of the quota trading took place bilaterally and no reliable statistics are readily available. Some industries even benefited from rationing; capital goods, for example, grew 13 percent. Furthermore, not all economic activities were allowed to trade quotas. At any rate, It became

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[78] Panorama Macroeconômico Brasileiro (2001)

clear that there was indeed room for energy rationalization and conservation in almost every single consumer segment, and that the quota trading mechanism was beneficial.

4.66 The trading of quotas created a market (in fact, several markets) that effectively allowed larger consumers to allocate energy savings among themselves in the most efficient way. Specific rules for trading and notification of incumbent utilities were put in place in a relatively short timeframe. The merit of this scheme was to provide corrective mechanisms to the administratively based decision to have differentiated saving targets for each customer segment. The criteria to establish differentiated targets was based on many subjective factors, such as the government's perception of the essentiality of the services, existence of alternative sources of energy, possibility to produce goods in other facilities in the country or abroad, expectation of usage during rationing, impact on employment levels, and other key parameters. Despite a dose of common sense and some participation from the different customer groups when the conservation targets were defined, the initial, centralized allocation was still somewhat arbitrary and therefore prone to errors. Trading quotas gave customers the possibility to self-correct the initial quota allocation, if they saw fit. Table 4.9 shows the main "flexibility" features built into the exchange system.

Table 4.9: Flexibility Features of the Quota Exchange System

Type of Consumer	Feature
Industrial, commercial and service consumers	Consumers allowed to save part of their quotas for future use Consumers allowed to sell their quotas to local distribution utility by means of auction Consumers units belonging to the same economic group or forming part of the same productive process allowed to consolidate quotas
High voltage industrial, commercial and services < 2.5 MW	Bilateral transactions of quotas between consumers allowed
High voltage industrial, commercial and services > 2.5 MW	Consumers allowed to buy or sell quotas in advance Quota auctions

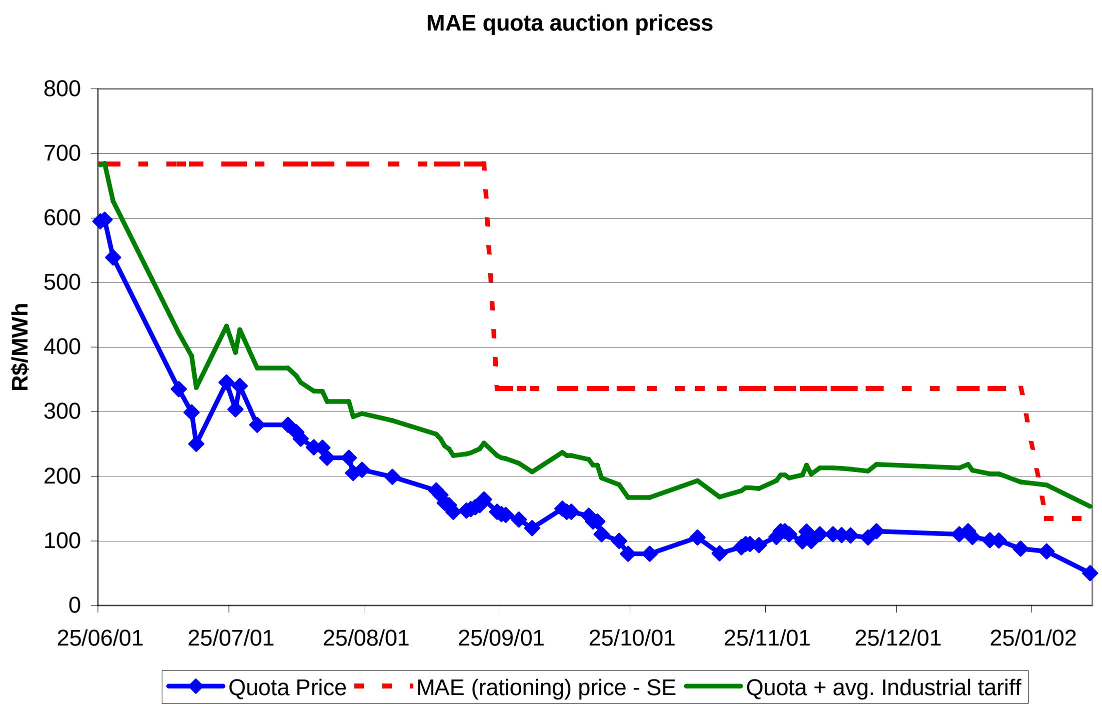
4.67 GCE tried to establish MAE (the Wholesale Energy Market) as the main locus for the sale and purchase of quotas, but it was preempted by bilateral transactions, other local markets set up by utilities, and other organizations such as state chambers of industry associations. Local markets allowed consumers below the 2.5 MW threshold to participate on the basis of their rights to trade quotas through bilateral transactions.

4.68 MAE had the advantage of being an official place to trade quotas and settle financial transactions, with participants from the entire geographical region under rationing. It had transparent rules, without any possibility of spreads between purchase and sale prices. Efficiency, liquidity, and price discovery were some of the desired features of trading quotas in the MAE. Prices for transactions on a bilateral basis or for trading in other markets were not in the public domain.

4.69 The establishment of a vibrant energy trading system represented a big thrust in the power sector reform towards the introduction of retail competition. Marketers traded volume of energy like never before. Customers became more conscious and interested in procuring energy in the cheapest and most convenient way. The quota exchange mechanism created an appetite for more competition at the retail level.

4.70 There was a delay of almost one month between the start of quota-based rationing and the first auction of quotas at MAE. Graph 4.5 shows the prices of energy over time as a result of the quota auctions performed by MAE.

Graph 4.5: Energy Prices in the MAE Auction



4.71 A declining price trend was observed: in the very first day, the energy price was R$595/MWh, which, added to the average industrial tariff for 2001 in the Southeast Region, results in R$682/MWh, quite close to the regulatory value of R$684/MWh that was used as the MAE short-term price.

4.72 There were no trades between June 29 and July 12, in part because of a deadlock where sellers of quotas tried to sell at prices that more or less reflected the R$684/MWh, while prospective buyers, after the first days of quota auctions, were willing to pay much less. When trading resumed, quota prices fell quite quickly, to about R$300/MWh by mid-July, 250 by mid-August and 150 by mid-September. From then on they fell more slowly, hovering around R$100/MWh starting from mid-October.

4.73 Willingness to pay was significantly lower than regulatory MAE deficit prices in the Southeast. One could infer that the administratively established cost of the deficit (R$684/MWh) probably overestimated the real cost of a constraint on the supply of energy. Some exceptions in the graph are in the very early days of quota auctions (learning curve) and the final days of rationing. Another possible interpretation of this declining behavior was that customers who were able to trade represented a small sample of the total universe. Those customers in particular had a willingness to pay lower than the cost of deficit. It is very likely that, if hypothetically the mechanism of quota exchange were extended to the whole universe of customers, prices in the secondary market would have been much higher. One last explanation was that the drop-in-price for quotas possibly reflected increasing supply and reducing demand for quotas as businesses “learned” that there were more options available for reducing their own demand, at a cost lower than they initially thought.[79]

4.74 A total of 51,470 MWh was traded in MAE auctions, or about 0.02 percent of total consumption in the area affected by rationing. This percentage does not reflect the entire volume of trading, since transactions were held in many other places besides MAE. There were various other quota markets sponsored by utilities, trade associations and stock exchanges, but very few statistics on the results of these markets. A few anecdotal figures are presented below, showing that MAE auctions were just a small fraction of the quota trading exchange that took place during the crisis:

1. Up to October 15, 2001, 30,460 MWh of quotas had been traded at the São Paulo stock exchange (BOVESPA);
2. CPFL, a major utility, sponsored an Internet site where 184,000 MWh were traded;
3. Another utility, Bandeirante, stated on July 29 that it had sponsored a total of 30,000 MWh of quota trades in the preceding month.

Implementation Challenges

4.75 The details of the quota system were implemented through several GCE resolutions. The first GCE resolution was issued on May 22, 2001 (Resolution #4). The complexity of the system became obvious, and not all issues could be addressed in a single seven-page document. Several subsequent GCE resolutions were issued, clarifying the relevant points that had not been fully anticipated. There were additional resolutions even before rationing was supposed to start on June 1 (e.g., GCE Resolution # 8, issued on 25 May). Also, the first Provisional Measure had to be re-issued both to modify a few technical details and to overcome legal problems and thus avoid court challenges. On June 28 the Supreme Court, by an 8-to-2 majority suspended all challenges to the measures in lower courts, pending its own final ruling. In practice, this vote meant that the measures were effective for the duration of the curve.

4.76 As time went on, GCE issued additional resolutions, both refining the rules and changing quotas according to perceived needs. Examples of later refinements are special provisions for seasonal consumers (Resolution #20, of June 26, 2001) and rules for treating special circumstances like the presence of additional residents in the same dwelling (Resolution #33, of August 8, 2001).

4.77 One important aspect in implementation was the need to revise quotas for various consumers. Before the quota system was implemented, distribution utilities argued that it might create a nightmare of claims and lawsuits by consumers that might effectively cancel the system’s efficiency. In many cases, the utility was forced to review the quota, in light of persuasive arguments presented by the customers and according to rules set forth by GCE. There are no systematic statistics on how many customers challenged their quota allocations. A few newspaper excerpts, presented in Table 4.10, show the extent of the issue of the claims presented.

[79] Exchange of ideas with Eric Groom (World Bank)

Table 4.10: Quota Revision Claims

Utility	Date	# of claims until date	Comments
CPFL	Oct 3, 2001	~273,000	99% of claims examined by utility staff
COSERN	July 17, 2001	26,000	
Eletropaulo	June 29, 2001	133,584	4.7 million clients 80% of claims accepted
CPFL	Jan 8, 2002	304,332	99.5% of claims examined by utility staff
Cemig	June 29, 2001	76,000	
Light	July 16, 2001	184,110	5.4% of total clients; 56% of claims accepted, 34% denied, 10% pending further documentation
Eletropaulo	Oct 22, 2001	667,481	559,623 claims accepted
Coelce	August 6, 2001	87,000	52% of claims accepted

4.78 According to the same sources, the most common reasons cited for quota revision claims were change of address, vacations, places being refurbished, and the presence of new dwellers in a house or apartment. The main conclusion was that quota revision did not turn out to be the impossible nightmare that some had predicted, and that utilities apparently experienced no serious hardship in dealing with these claims.

Plan B

4.79 In September 2001, a few months after the official kick-off of the rationing program, the government decided to establish a so-called Plan B, to be a fallback position in case the target reductions were not achieved or rainfall was below expectations. Plan B basically relied on rolling blackouts. Plan B was presented to the general public and comments were requested in a formal public hearing. Those who did not believe in the medium-term success of the quota system supported Plan B's emphasis on rolling blackouts. For others, it was nonsense. The initial success of the quota system up to that point was a clear indication that market mechanisms should be preserved, not discarded, if more aggressive load shedding turned out to be necessary. For example, the quotas should be reduced and/or financial bonuses and penalties increased instead. After all, there was a feeling that the administratively set cost of deficit parameter was underestimated, not being a good proxy for customers' real willingness to pay.[80]

4.80 Plan B never came to fruition, given the continued success of the existing quota system. At any rate, it showed the opposition and skepticism faced by the quota system through the rationing process.

Extra Holidays

4.81 Despite its early success, the quota system was probably reaching its limit in the Northeast Region in late 2001. It was becoming less effective, possibly due either to consumer "fatigue" or to the fact that the initially set consumption targets were set at low levels. Energy saving in the region, which had reached a peak of 24 percent in early July[81], had decreased to 14 percent in September and 10 percent in the first week of October. To make things worse, while the inflows in the rest of the country were experiencing a modest recovery, the hydrologic

[80] Maurer (September 2001).

[81] Energy saving was measured by reduction in consumption as compared to the average of the corresponding three-month period in 2000.

situation in the Northeast was not improving at all. In the first two weeks of October 2001, for instance, inflows were 59 percent of the long-term average. According to ONS computations, at the prevailing water usage, the reservoirs in the region would reach the critical 5 percent level in the first half of November, and would reach the 2.3 percent mark by the end of November.[82] At that point, the region would be subject to unplanned interruptions well above the acceptable levels.[83] Imports from other regions were supplying approximately one-third of the Northeast's needs, and they could not be increased due to transmission constraints.

4.82 The government issued a Provisional Measure on October 17, ruling the need for three additional holidays in 2001, to be implemented in eight states in the region.[84] The dates were chosen to bridge existing national holidays and to stimulate four-day shutdowns for various businesses. GCE decreed three further holidays in various states during the month of November.

4.83 According to ONS, the holidays were effective.[85] For instance, during the first holiday, Monday, October 22, energy demand in the affected area was 24.5 percent below daily average demand, while on the previous Sunday it had been 22.8 percent below the same value. On the previous Monday, it had been just 10.8 percent below this average.

4.84 Holidays, of course, could be used only in a limited way. If they were not able to achieve the desired results, other more serious measures would have to be adopted. In fact, the holiday solution was used only at the end of the dry season (which ends in November) in order to ensure that the reservoirs did not drop to dangerous levels. There was a strong belief that the need to implement such drastic measures would be over once the wet season started, and emergency thermal power plants were expected to be commissioned by the end of the next wet season.

Preliminary Lessons

4.85 The Brazilian crisis of 2001–2002 showed that systems that face energy shortages with no severe capacity constraints can, at least in principle, resort to a quota system, without any additional metering technology and with minor changes in the commercial systems and procedures. The crisis also showed that:

- Quota-based rationing can be implemented on a large scale;
- Quota-based rationing can effectively achieve consumption reductions in the 20–25 percent range for a period of several months;
- Quota-based rationing offers many flexibility features that effectively allow price signals to reach final consumers (thus resulting in efficient energy-saving on the part of the consumers) without imposing an excessive burden on low-income consumers;
- There are several degrees of complexity in the implementation of a quota scheme. Not all of them need to be implemented, and the final outcome may still be very efficient. It is impossible to get everything right at the same time. It is an evolutionary

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[82] At the outset of the rationing, the situation in the Northeast region was worse than in other parts of the country, which theoretically should have meant stricter consumption reduction targets. However, different quotas would sound regionally discriminatory and therefore politically unacceptable.
[83] GCE Public Note of 15 October 2001.
[84] Only some states in the region were affected by all the holidays due to specific transmission constraints.
[85] Interview with Mario Santos, head of ONS, on 23 October 2001.

process and countries should have a vision, but not to try to implement all "bells and whistles" of a sophisticated rationing program at the outset;

- A quota scheme gives individual customers the discretion on when, where, and how to save energy by conveying a series of appropriate price signals. It tends to be much more efficient than authorities making decisions centrally on behalf of their customers;
- Consumers tend to be more motivated when they are allowed to make their own energy-saving decisions and much more so when they can profit by outperforming their quotas.

Results of the Measures

4.86 The population's strong commitment to the energy-saving effort was vital to the success of rationing. One key aspect in the avoidance of an economic disaster was that consumption levels from June to December 2001 showed a 20 percent load reduction, compared with the previous year's consumption. If it is taken into account that new customers entered the system in 2001, the real reduction was probably as high as 25 percent. Even the South, which was not forced to ration, engaged in the load reduction effort, as a result of appeals in the media and for the fear of more drastic measures in the upcoming dry season.[86]

Energy Savings per Region

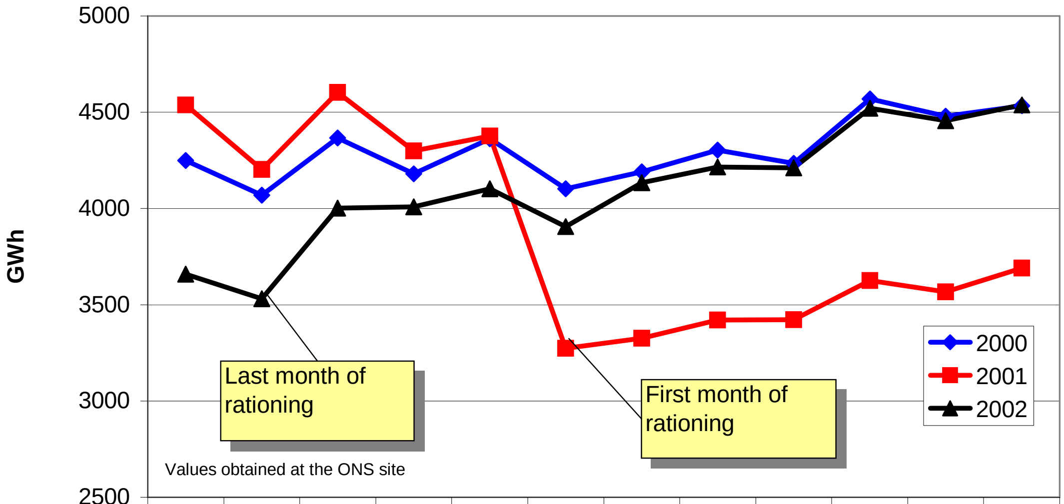
4.87 Graph 4.6 shows the energy savings for the Northeast and for the Southeast/Center-West sub-markets (electric zones). Savings per region are not perfectly comparable, since the rationing programs were differentiated in terms of start and ending dates, as well as different target quotas.[87]

[86] Under normal operating circumstances, the South-East-Central region exports energy to the Southern Region in the summer months, when the reservoirs in the former are being replenished while the smaller reservoirs in the South are depleted at a faster rate. Given the dire situation faced by the Southern region, the South knew that imports would not have been possible for the upcoming dry season.

[87] The graphs show metered, as opposed to billed consumption, which could be affected by variations in losses or theft.

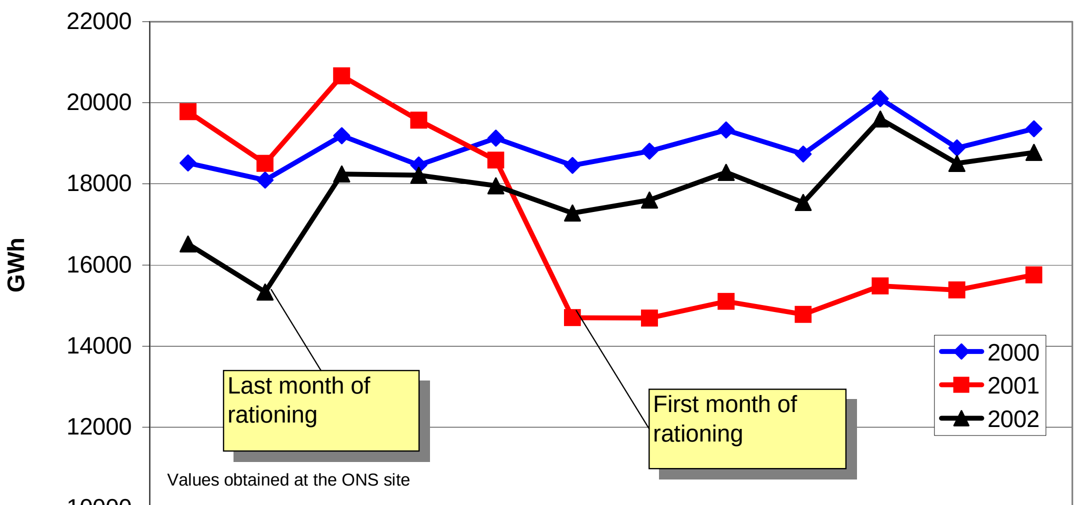
Graph 4.6: Load Reduction Per Region

Load - Northeast Region



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	4250	4068	4367	4179	4361	4103	4191	4303	4235	4569	4479	4534
2001	4537	4202	4603	4299	4376	3274	3327	3420	3422	3625	3566	3690
2002	3659	3532	4001	4009	4102	3906	4135	4216	4211	4522	4456	4539

Load - Southeast + Center-West Regions



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	18513	18095	19186	18464	19126	18457	18803	19327	18732	20097	18883	19354
2001	19783	18505	20667	19569	18590	14698	14688	15096	14776	15484	15383	15753
2002	16516	15329	18245	18217	17956	17282	17605	18289	17537	19597	18505	18781

4.88 Both graphs show clearly the effectiveness of the rationing measures: the drop in consumption was remarkable. The graphs also show that, immediately after rationing, demand recovered very gradually, so that by the end of 2002 it had reached the same level of the year 2000 in the Northeast region, and was at 97 percent of that level in the Southeast. Table 4.11 shows average saved energy as a percentage of total load. If compared to the load forecast for 2001, the average consumption in all regions was above 20 percent, confirming the success of the rationing program

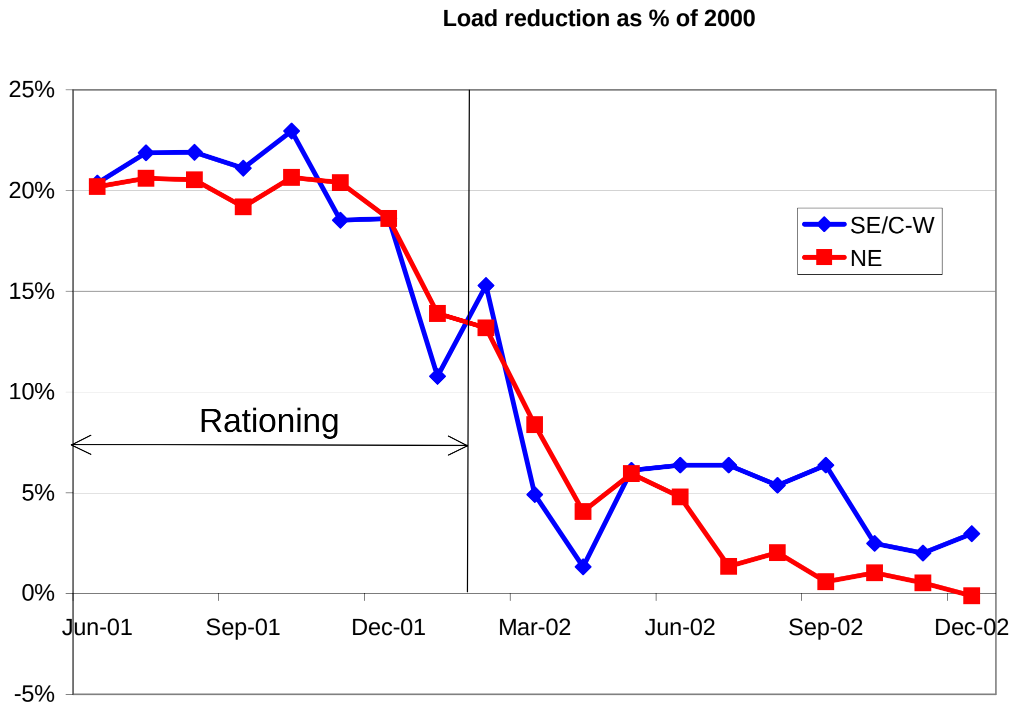
Table 4.11: Average Energy Saved Per Region

Region	Saved energy	
	% of corresponding load in 2000	% of corresponding projected load for 2001
North	18.3%	24.6%
Northeast	19.5%	20.7%
Southeast/Center-West	19.8%	21.2%

Source: Presentation by Min. Pedro Parente, GCE, April 8, 2002

4.89 Graph 4.7 shows the savings for the Northeast and Southeast/Center-West as a percentage of year 2000 load levels on a month-by-month basis. It is interesting to note that even after rationing measures were lifted, there was still some important residual effect on savings. Consumption post-rationing was lower than 2000 levels.

Graph 4.7: Evolution of Load Reduction

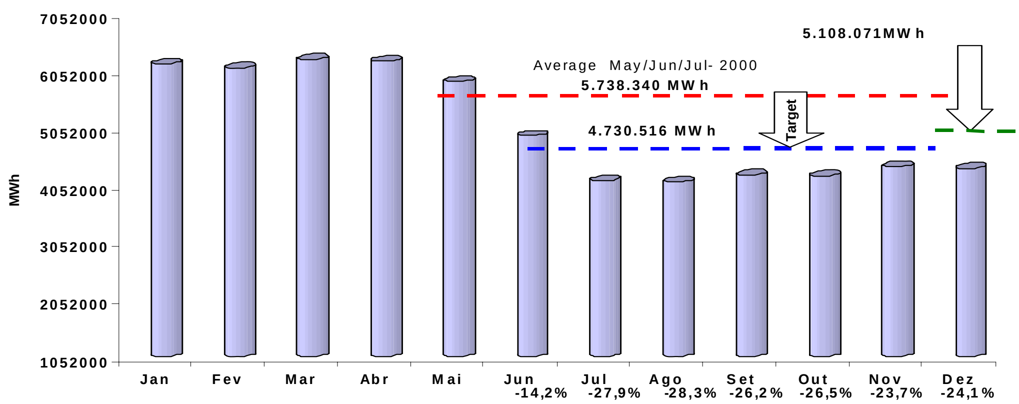


Energy Savings per Customer Segment

4.90 In general, all customers contributed significantly to the demand reduction effort. However, different customer groups responded differently. Those results are summarized in the following paragraphs.

4.91 The residential sector performed remarkably, achieving conservation levels higher than the goals set forth by the government (lower dotted line), as shown in Graph 4.8. Savings in the month of August 2001 resulted in almost 30 percent of the assigned targets. Engagement was strong across all socioeconomic groups.

Graph 4.8: Residential Customer Segment's Actual Savings



Source: Energia Brasil (2002).

4.92 Even when the saving targets were relaxed by the government toward the end of the rationing (center dotted line), consumption did not catch up immediately, which reflects the fact that the population in general learned how to save energy on a more permanent basis.

4.93 Under a self-rationing scheme, it was the customer, and not a government bureaucrat, who determined how and when to conserve energy, given the physical realities of the power system. The array of savings possibilities, shown in Table 4.12, gives an idea of how creative people can be when confronted with a major challenge.

Table 4.12: Conservation Actions Taken by Residential Consumers

(% of Interviewed Households)

ACTIONS TAKEN BY CONSUMERS	TOTAL	SOUTH EAST	CENTER WEST	NORTH EAST
Swtiched off lamps	45	36	46	60
Changed lamps (mini-fluorescent)	39	36	35	45
Reduce time watching TV	31	28	31	36
Ironing - less time, on fewer clothing	23	19	22	31
Swtiched off freezer	23	27	26	15
Reduce time in the shower	22	30	24	8
Reduce use of laundry machine	14	17	11	9
Switched off electric oven & microwave	14	19	10	8
Reduced use of refrigerator	12	11	13	13
Switched off refrigerator	12	12	9	11
Shower with cold water	12	11	18	12
Reduced electric oven & microwave	9	14	8	3
Switched off stereo equipment	8	8	7	9
Reduced use of stero equipment	7	6	7	8
Switched of TV	7	7	7	6
Switched off laundry machine	7	8	6	5
Did not use air conditioning	6	4	9	10
Reduced use of freezer	6	7	7	6
Reduced use of computer	6	6	6	6
Switched off VCR	6	8	4	4

Source: IPESPE/ANEEL Survey (2001)

4.94 The savings achieved by residential customers were remarkable and to a large extent unexpected. In 2003, the average consumption per customer was equivalent to 1994 levels. A significant reduction was observed in the main regions of the country, which presented very different consumption profiles:

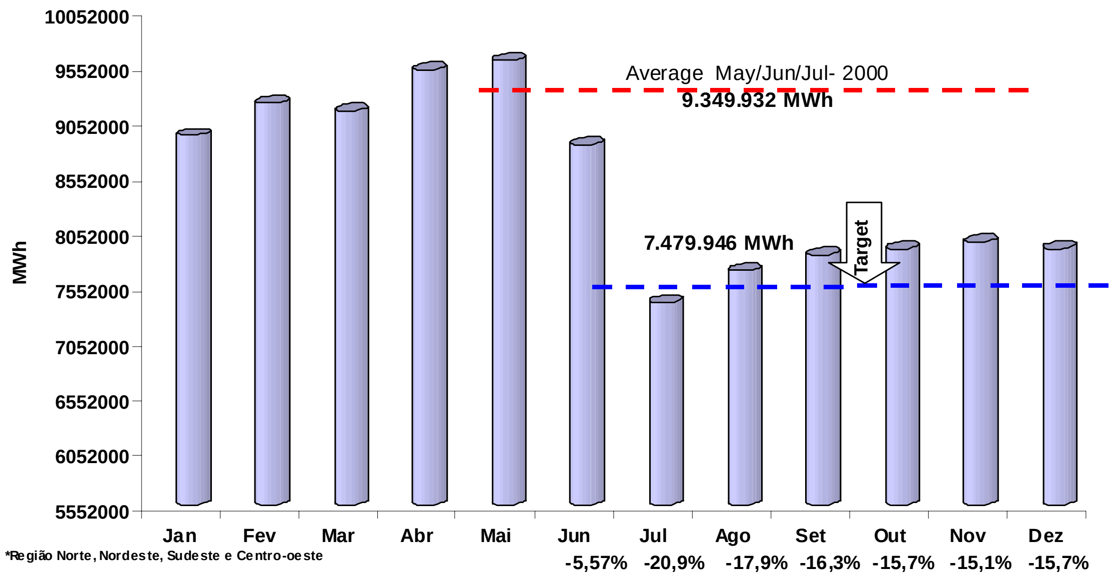
- Southeast/Center West: from 199 kWh per month down to 145 kWh per month;
- North–Northeast: from 113 kWh per month down to 85 kWh per month.

4.95 In a post-rationing survey of customers, 91 percent responded that they changed their consumption habits, while 65 percent still maintained the savings they achieved during rationing. Energy efficiency is now an important criterion in the purchase of new appliances. Prior to the crisis, only 8 percent of customers paid attention to consumption figures on the official labels issued by PROCEL.[88] After rationing, this figure increased to 58 percent.

4.96 The industrial segment also contributed with savings over and above the assigned quotas, as shown in Graph 4.9. This is usually the segment in which a faster and stronger reaction is expected for many reasons, including: (i) their high individual consumption, (ii) more sophisticated metering technology, (iii) more reliable commercial processes, (iv) knowledge about the use of energy, and in many cases (v) the importance of energy in the total cost of production, which is certainly the situation faced by energy-intensive industries such as aluminum, alloys, petrochemicals, glass, chlorine, and many others.

[88] Programa de Conservação de Energia, responsible, inter alia, for labeling domestic appliances.

Graph 4.9: Industrial Customer Segment's Actual Savings



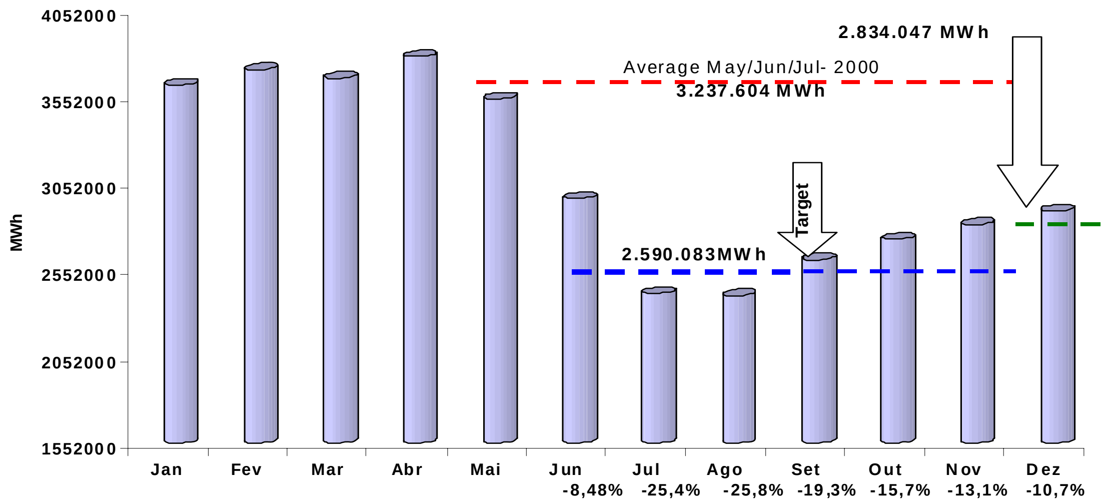
Source: Energia Brasil (2002).

4.97 The commercial customer segment also responded promptly, saving energy beyond the initially established quotas. However, this segment soon experienced some "fatigue," as shown in Graph 4.10. There are no in-depth studies about the behavior of commercial customers, but a few hypotheses may explain why the savings were short of expected targets in a matter of few months, including

- A higher willingness to pay among commercial customers. Electric energy represents a small cost component in these businesses, but has an impact on the final customer in terms of sales promotion (lights), comfort (air conditioning), and convenience (number of elevators, escalators, etc.);
- Proximity of summer months and, therefore, more demand for air conditioning;

Lack of individual metering in large shopping malls might have meant that individual businesses became less sensitive to economic signals and the threat of disconnection.

Graph 4.10: Commercial Customer Segment's Actual Savings



Source: Energia Brasil (2002).

End of the Quota System

4.98 In January 2002, the government suspended rationing in the North and relaxed the consumption targets to 93 percent of the previous year's consumption. The end of rationing and the phase-out of the price signals were gradual. Conservation targets and ensuing penalties were reduced. However, bonuses were not phased out immediately, causing a mismatch between revenues collected from the application of penalties and the bonuses for overachievers. This mismatch between penalties and bonuses, which was alluded to in previous sections, resulted in a significant loss that had to be funded by the National Treasury. Proper planning of the phase-out would have helped to mitigate this imbalance.

Financial Consequences and the Need for an Industry-wide Agreement

4.99 The crisis had a significant impact on the economic and financial situation of most power sector players, who suffered reduction in sales, revenues, and earnings. There was also an important shift of income between those who had "short" or "long" positions. The situation was severe, and players were unable to reach a reasonable agreement on how to better allocate those short and long positions. The government had to step in, by catalyzing an overall industry agreement. This agreement included tariff increases to compensate losses suffered by generators and discos.

4.100 For some, this agreement was vital to put the industry back on its feet. For others, it had strong elements of an overall industry-wide bailout, potentially creating moral hazards down the road that could impact both distributors' and generators' future willingness to contract prudently.[89] It reinforced a perception on the part of many that, whenever a crisis hits hard, the government will step in and provide a bailout for those facing difficulties. This, in turn, can stimulate reckless contracting and undue behavior on the part of these players.

4.101 The crisis revealed that the vesting contracts (called Initial Contracts) between gencos and discos did not provide a good risk allocation in the case of a country-wide shortage of energy. The contracts had specific clauses ruling dry period relief (called Annex V), but hydro plants were still marginally exposed in fulfilling their contractual volume obligations. Any marginal exposure represented a sizable volume of financial resources given the high spot prices during rationing. Despite some provisions contemplated in the vesting contracts, legislation and regulations were silent or ambiguous about rationing. The sector would certainly have benefited from a more structured legal framework set in place long before the crisis had broken out.[90]

4.102 When rationing started, almost all of Brazil's generation and load were covered by Initial Contracts.[91] The Initial Contracts were compulsory bilateral agreements between gencos as sellers and discos as buyers, at regulated prices. They were designed to work as a financial mechanism between buyers and sellers to hedge them against spot price volatility. Initial Contracts were established to allow a smooth transition from the pre-existing rules to the new competitive regime that was being implemented at the time. They started in 1998, and covered almost the entire load up to 2003. Load growth would be met by new PPAs to be signed by discos. The PPAs would be the basis for expansion of the generation capacity. Starting in 2003, the Initial Contracts were to be reduced by 25 percent each year and extinguished by the end of 2005.[92]

4.103 If consumption was reduced by 20 percent as a result of rationing, all generators would be short on their contractual positions by that same percentage.[93] Under the market rules, this exposure would be priced at prevailing spot prices. If this happened, generators would be subjected to energy prices equivalent to the cost of deficit, or R$684 (US$287)/MWh, creating an untenable situation. To avoid this unsustainable exposure, Initial Contracts included Annex V, the dry period relief provision, which would provide a reduction of contracted quantities in the event of extreme hydrological situations, as illustrated in Graph 4.11.

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89 Maurer (2002).

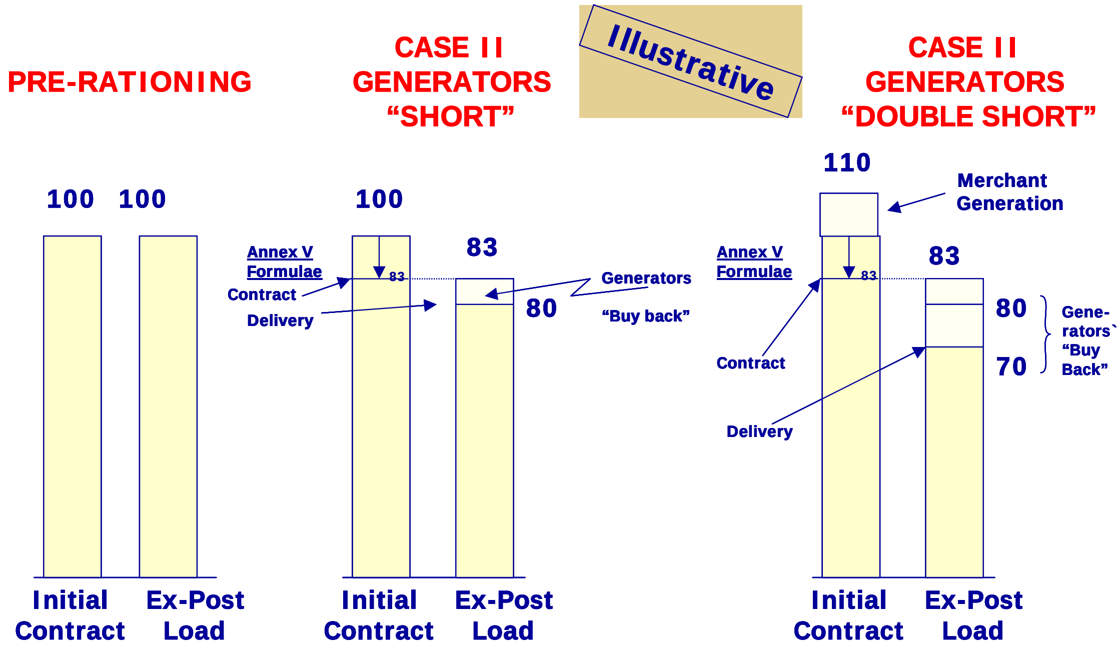
90 When the RE-SEB project was being designed in 1997, top officials in the Ministry of Mines and Energy were advised by independent consultants not to address the issue of rationing, which could politically sound like an implicit acceptance of the failure of new project

91 In Portuguese, Contratos Iniciais or "Vested Contracts" in the specialized literature.

92 This was changed by Law #10,604, enacted in December 2002. This Law allowed an Initial Contract to be extended through a mutually agreed addendum.

93 Because of a risk socialization mechanism between hydro plants called MRE, all hydro generators shared equally the overall 20 percent decrease in power production, even if they were located in non-rationing zones such as the South region.

Graph 4.11: Annex V Contractual Clause – Illustrative Concept



4.104 The assumption in Graph 4.11 is that before rationing, load was 100 percent contracted and there was no "merchant" [94] generation, that is, plants without contracts selling directing in the spot market. Upon rationing, and assuming Annex V in full force, the generator's contractual obligation to deliver would be reduced from 100 to 83 units. This was a result of the dry period relief mechanism. However, assuming that load had reduced from 100 to 80 units, distribution companies would be "long" and generators would be "short" of 3 units. In a purely hydro system, the physical interpretation was that distribution companies had a partial credit for the water still stored in the reservoirs but which had not been used to generate electricity (in this case, 3 units). In the monthly settlement of those contracts, generators had to buy back those 3 units at the prevailing spot price, by definition a very high price. If there were merchant generators with short-run marginal cost lower than the opportunity cost of water (which is the case during rationing), they would have generated 10 units. Hydro generators would have to not only buy back energy from discos, but also reduce part of their production, which should be acquired from those merchant plants. The buy-back volume would increase from 3 to 13 units. This situation was referred as hydro generator's being "double short."

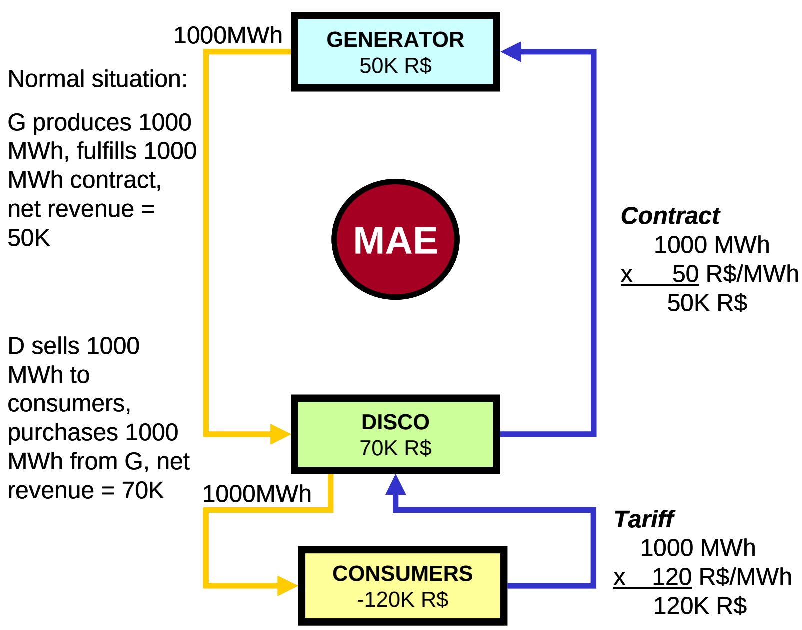
4.105 Despite making sense from an economic standpoint, this situation created a significant financial burden for hydro generators. This situation could have been avoided by a stronger dry period relief mechanism, or alternatively by hydro generators' hedging themselves before rationing took place against the well-known risk of excessive exposure to hydrological uncertainties. Unfortunately, hedges were not available after the rationing crisis erupted. From that point onwards, any relief to the financial situation faced by the generators would be interpreted as a financial bailout, potentially creating moral hazards in terms of future

[94] Generation selling energy directly in the pool, not having contracts with discos, end users, or other retailers.

responsible hedging and contracting. To some extent, that turned out to be a reality as part of the general agreement between generators and distributors orchestrated by the government.

4.106 Figures 4.2 to 4.4 show a numerical example of the functioning of Annex V if rationing were set at a 20 percent level. The numbers are hypothetical, but give an idea of the order of magnitude of the problem prevalent at the time. Even with Annex V relief provision, generators would still be exposed to short-term prices to the point of losing about 80 percent of their revenues. All hydro generators would be more or less equally affected, due to a hydrologic risk-sharing mechanism set forth in the market rules. All the generators shared the same concerns.[95] Figure 4.2 shows a basic settlement in a "normal situation," before any rationing was envisioned and with generators producing their full contracted amount and no merchant generation available.

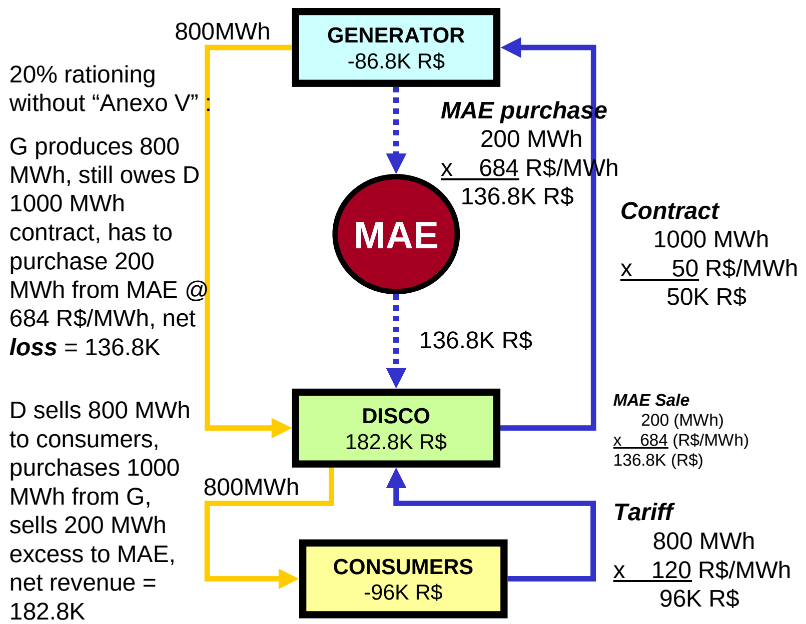
Figure 4.2: Energy Settlement Numerical Example – Before Rationing



4.107 Figure 4.3 presents the settlement results during 20 percent rationing, in the absence of any dry period relief mechanism, such as Annex V. As can be seen, the impact of a generator being "short" at 20 percent is so high that it would still owe a substantial amount of money to the discos. This unsustainable imbalance is the very reason why a dry period relief formula had to be designed at the outset.

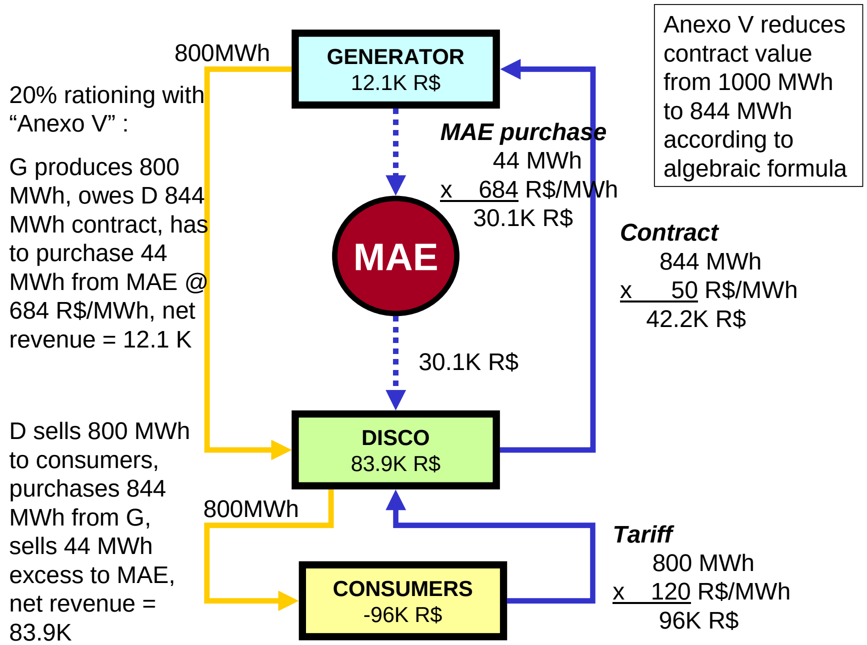
[95] At the time, most thermal generators were also participants in this risk-sharing mechanism, so that they, too, faced the same problems, even though their plants were producing at capacity levels. This happened because of the nature of the socialization mechanism, whereby energy is allocated among generators based on their Assured Energy (a proxy for their average production over time) and not based on their real production.

Figure 4.3: Energy Settlement Numerical Example – No Annex V



4.108 Finally, Figure 4.4 presents the energy settlement assuming Annex V is in full force. Despite it still representing a significant financial relief to generators, their revenues would still be greatly impacted, reduced from R$50,000 (pre-rationing) down to R$12,100 with the application of Annex V. Therefore, their revenues would be reduced by almost 80 percent.

Figure 4.4: Energy Settlement Numerical Example – With Annex V



4.109 With the application of Annex V, distribution companies would be in a "long" position regarding the volumes contracted under the rules of the Initial Contracts. Discos, particularly the ones not vertically integrated,[96] claimed that they had this contractual right and that the financial credit would help them offset part of the decline in revenues and profits. Technically speaking, the discos' claim was legitimate, and there were no doubts about the arithmetic in the application of the contractual clause, since it was based on a straightforward formula. However, the generators contended that the legislation was ambiguous in terms of how to proceed during rationing and those different pieces of legislation could have lead to very different interpretations and therefore results.

4.110 The mechanical application of Annex V, as described above, would represent a significant cost shift between generators and discos. Generators claimed that the 80 percent revenue reduction was unsustainable and that the straightforward application of Annex V would bankrupt all public and private hydro generators in the country. Or, the generators said, Annex V would trigger a system-wide financial default, which could be disruptive to the integrity of the power system, particularly in such a vulnerable situation.

4.111 The conflict between generators and distribution companies became increasingly intense, with back and forth discussions for several months. Each group had a plethora of economic, technical, and legal arguments, supported by the best consulting and law firms in the country. The issue seemed to be impossible to resolve. Furthermore, the lack of consensus on this issue was, *inter alia*, a factor that could impose further delays on the start of a functional

[96] For a vertically integrated company, Annex V was virtually neutral. This raises an important issue about the fairness of risk allocation via contracts when the power industry is de-verticalized.

wholesale market, which had been facing significant difficulties in implementation even before rationing started. The government had a clear understanding that in a rationing scheme that heavily depended on economic signals, a minimally functioning market able to settle "long" and "short" positions was a must to make the rationing scheme work.[97]

4.112 As a consequence, the government decided to mediate the conflict. After several months of intense negotiations, the government found a compromise between generators and discos. An agreement was finally signed in August 2002. In this multi-party agreement, called the General Sector Agreement, both generators and distributor losses were partly compensated by a temporary tariff increase of 2.9 percent for residential consumers and 7.9 percent for other customer segments, with an average duration of six years. Table 4.13 shows the main loss recovery components of this agreement.

Table 4.13: Loss Recovery Components of the General Sector Agreement

Type of compensation	Final recipient	Total value Million R$[1]
Compensation for lost sales	Distribution utilities	6,324
Compensation for past delays in tariff raises[2]	Distribution utilities	1,588
Compensation for extra expenses in MAE purchases	Generators	2,505
Total		10,417

1 The numbers are from the relevant ANEEL resolutions. The values are approximate, since they refer to different periods of time. The exchange rate for the first and last figures is approximately US$1 = R$2.4. The exchange rate for older bills in arrears was computed at US$1 = R$3.8.

2 Those are due to ongoing tariff disputes between discos and regulators which have nothing to do with rationing per se, but bundled in the same package agreement.

4.113 The utilities received loans from BNDES (the National Economic and Social Development Bank, owned by the federal government) totaling R$7.5 billion in anticipation of their expected tariff increases.[98] Thus, they were able to withstand the immediate financial burden caused by rationing, while the consumers were able to stretch their payments over an average period of six years. The General Agreement involved not only financial compensations, but also some contractual amendments between generators and discos. For example, Initial Contract volumes were adjusted during rationing according to ex-post actual load (therefore, not according to Annex V). As a result of this agreement, both generators and discos agreed to drop all pending lawsuits and waive any future rights resulting from this agreement or from any of its related issues. This, plus the fact that all parties had agreed on the main contention points relative to MAE rules, should have led to an immediate start of MAE settlement, but a subsequent dispute taken to court caused further delays.

97 MAE faced multiple problems to become operational over two years. In part, this was due to lack of agreement on the final market rules and in part because some players refused to pay their contractual exposures resulting from delays in the commissioning of some of their important plants. The "zero-sum game" nature of the issues discussed at MAE was a roadblock to reach consensus. The government did not play a key role in facilitating the implementation of MAE. On the contrary, state-owned companies were the first ones to challenge agreed-upon rules.

98 This was perceived by the industry and by the financial community as an interesting arrangement in support of distressed utilities in the process of financial recovery, which does not imply a mere bailout.

4.114 For some, the General Agreement was a necessity, given the significant cost shift among discos and generators, and the alleged risks of bankruptcy for some of them. As a result, the General Agreement was received with very positively. However, changes in existing contracts and rules of the game are not conducive to a continued flow of investments in the long run. This potential effect was greatly overlooked.

4.115 The General Agreement was a disguised bailout. It reinforced the perception among industry players that if things go really sour, the government will provide a safety net, therefore creating a moral hazard.[99] Such an agreement changes the way players behave; they become more risk-prone and more willing to take higher risks instead of covering their exposure in the market. As a consequence, they may contract less and contribute to a possible new crisis. In the absence of economic incentives,[100] and when moral hazards are present, the last resort for the government to make discos contract is to adopt a command-and-control approach, such as deterministic planning in tandem with stronger minimum mandatory contracting requirements.[101]

4.116 While it was true that the loss of revenues and Annex V would have had a great impact on a utility's finances, less has been said about how utilities contributed to the situation and how they could have hedged themselves against the exposure that rationing entailed. In that sense, both generators and discos had some responsibility for the 2001 rationing crisis.

4.117 Generators, both public and private, had been very well informed since 1998 that Assured Energy levels were artificially overestimated and that Annex V would amplify their risks in case of rationing. Despite being a dry period relief mechanism, therefore beneficial to generators during droughts, it was not a perfect hedge, particularly given the fact that Assured Energy supplies were overestimated. There was still some residual volume risk,[102] which could represent several million dollars depending on the intensity of rationing and on the spot price. Perhaps few generators imagined that a country-wide, serious crisis of that magnitude would have occurred. At any rate, Annex V had no limitations on its applicability and would apply to the issue confronted by the power sector in 2001.

4.118 Generators are very sophisticated players and therefore able to understand the risks embedded if Annex V were to be applied.[103] However, they did not hedge themselves against this residual exposure. The most natural hedge would have been having generators themselves build greenfield generation or contract with greenfield thermal power plants. This

[99] For an interesting discussion on the impact of bailouts and moral hazard, refer to Stiglitz (2002).

[100] Including here the perception that bankruptcy is not a credible risk.

[101] The new power sector model under implementation in 2004 strongly limits a disco's flexibility in deciding how and how much energy to contract. The mechanism being put in place eliminates almost all of a disco's discretion in establishing bilateral contracts. Therefore, the potential impact of the moral hazard can be minimized. Despite being criticized as a more command-and-control approach, it is difficult to envision a scenario any time soon when players will follow a responsible contractual attitude, given the ingrained culture of "bailouts" in the power sector.

[102] Represented by the difference between contractual obligations to deliver (post relief) and the load reduction. Given the way the formula was designed, in most cases the obligation to deliver would exceed the load by a small volume.

[103] It was alleged by a few players that the Annex V algebraic formulation was difficult to understand. While this may be true for the general public, Annex V was unambiguous and the algebraic expression that determined the volumes relieved were perfectly understood by sophisticated players such as large generators, particularly the ones who had gone through an excruciating due diligence process prior to privatization.

would have been an elegant solution for the worldwide problem on how reserves should be built. Unfortunately, generators did not take the Annex V risk seriously.

4.119 Discos, on the other hand, also contributed to the difficult financial situation in which they became immersed. It was well known among all industry participants that the reservoirs were being continuously depleted. There was no element of surprise. Rather, there was a clear trend of several consecutive years in which reservoirs were not recovering their original levels after the rainy seasons. Sooner or later, rationing would take place. Discos knew that, contrary to what they subsequently claimed. Furthermore, there was nothing in their concession contracts that would hedge them against the risk of lost revenues and profits, had rationing taken place.[104] Despite this conspicuous risk, discos did not contract enough energy with greenfield plants, an essential ingredient to foster expansion, given the maturity of the power sector in Brazil. Discos had several excuses for their passive behavior, including the fact that they were fully contracted and that those contracts were backed up by "assured energy." Therefore, it would make no sense to further contract, discos contended. They also alleged that the administrative value set by the regulator, capping the pass-through of power purchase costs (Valor Normativo, or VN), was too low and not attractive enough for gencos to build new plants. Both arguments had some element of truth. However, discos were cognizant about the devastating financial consequences that rationing would entail, but did too little and not soon enough to hedge themselves against the worst-case scenarios. In a nutshell, distribution companies ended up being "penny wise," by focusing too much on guaranteeing pass-through of power purchase costs, and under the illusion of having their loads covered by Initial Contracts.[105] Besides, each one of them assumed that system reliability would be somehow achieved by their peers investing in new plants, but individually too little was done to avoid the worst. They ended up paying a high price for their shortsightedness.

4.120 A new risk-sharing mechanism was proposed during rationing, whereby the reduction of the contract amounts would be equivalent to the ex-post load reduction. This solution was applied, but just at the very end of the rationing. Had this solution been agreed upon earlier, all the incentives for discos to really engage in the rationing effort would have been suppressed. It would be equivalent to overruling Annex V at the outset. The "carrot" of Annex V was a strong factor that motivated discos to work hand in hand with their customers to achieve the energy reduction targets. The more they were able to reduce the load in their concession areas, the "longer" their contractual position would be in the wholesale market.

4.121 In the absence of Annex V, discos would not have any financial incentives to reduce their sales, revenues, and profits.[106] Discos were motivated by the possibility of selling their residual "long" position in the MAE. Annex V played a strong role in the success of the rationing. This expectation lingered until the very end, when Annex V was explicitly repealed. Unless other forms of incentives were in place, it was unlikely to imagine that discos would have indeed supported the rationing as much as they did in 2001. In the absence of Annex V or of

[104] Either as rolling blackouts or as self-rationing.
[105] The issue of Assured Energy being overestimated and as a consequence the need for additional contracting and allowed pass-through was never openly discussed with the regulator. Discussions focused more on the pass-through caps (VN).
[106] ABRACEEL's comments delivered during Second GCE Meeting. May 2001.

other economic incentives, a command-and-control approach would have become necessary.[107] The efficiency of command and control vis-à-vis the strength of economic signals has yet to be proved when the time comes.

4.122 The logic presented in the previous paragraphs does not mean that Annex V was a perfect mechanism. It needed to be amended to promote a better distribution of hydrological risks between buyers and sellers. Annex V represented a very high burden to hydro generation and almost a perfect hedge to discos against the negative consequences of rationing. It was not appropriate to provide a perfect hedge to discos either. They had to suffer part of the consequences of lost revenues and profits: after all, their prudent contracting decisions could have contributed to mitigate or even prevent shortages. The real issue is not the nature, but the intensity of the incentive. If the incentive is too high, such as provided by Annex V, discos will have no reason to avoid rationing. Despite all criticism, Annex V (or the perception that it would indeed be applied) significantly contributed to the success of rationing.

Emergency Generation—Government as a Buyer of Last Resort

4.123 A program for contracting emergency generation was put in place in September 2001. The schedule for selection of players, award of contracts, and commissioning of new plants was very tight, as shown in Table 4.14.

Table 4.14: Milestones in Contracting Emergency Generation

Public call for bids	September 2001
Reception of proposals	October 2001
Analysis, selection, and siting	October–November 2001
Contracting	January 2002
Start operation	January–July 2002

4.124 The call for bids generated a lot of interest, with 117 generating units with a total capacity around 4,000 MW submitting bids. Of those, around 2,100 MW (1,500 for the Northeast and 600 for the Southeast) were selected and contracted. The average contract price was R$290/MWh (R$100/MWh as fixed payment, the remainder to be charged as a variable cost). Initial operation dates ranged from February through December 2002, and the average contract duration was 35.7 months. The contract with the longest duration was 46.5 months. All contracts were designed to end on January 1, 2006.

[107] It is often said that Annex V represented an imbalanced distribution of risks, which is certainly true. However, fixing the problems of Annex V does not necessarily imply a complete suppression of economic signals for discos to be supportive to the rationing scheme. In the absence of those signals, discos will covertly boycott any effort to reduce their sales. Despite not being the final users, discos have an important role to play in educating their customers, revising their quotas in a fairly agile manner, providing orientation on how to save energy, and the like. The discos are also directly responsible for reducing public lighting and working to decrease their own technical losses. Given the lack of information symmetry between the regulator and the regulated entities, it will be very difficult to use a command-and control approach, since the discos will always allege that they did everything that was under their control, but that unfortunately the customers themselves were not very supportive to save energy. For this reason, it is difficult to imagine that a command-and-control approach to rationing would be effective.

4.125 The contracting of emergency plants was subject to intense criticism. Many of them became operational at the very end of the rationing period. In addition, the government was blamed for paying such a high price for energy.[108] Even suspicions of malpractice and corruption were raised, but never proved.[109]

The Crisis and Power Sector Reform

4.126 The 2001 crisis revealed the complexities and idiosyncrasies of the power sector reform process in Brazil. When the crisis hit, the Brazilian electric sector was undergoing a reform process that had started in the mid-1990s. The reform aimed at substituting the existing system based on centralized expansion planning, cost-based tariffs, and verticalized monopoly utilities with a new framework based on markets and competition for generation and retailing, private capital, unbundled activities, regulated monopolies for transmission, and competitive bids for the granting of any concessions.[110]

4.127 The crisis struck at a critical juncture in this process, when the reform was being challenged on political and legal fronts. Despite all existing momentum to reform the sector through the end of 1998, the process stalled at the beginning of 1999. Three of the four large federal-owned utilities were neither unbundled nor privatized as planned. MAE, the Wholesale Electricity Market, had not been able to function due to a series of lawsuits. The government decided to focus on a plan to build more than 10,000 MW of natural gas-fired power plants. For several reasons, this plan never took off. Had those plants been built, the power sector would certainly have avoided the 2001 crisis. This thermal generation capacity would also have helped Brazil to reduce its overdependence on hydroelectricity.[111]

4.128 GCE recognized that the proposed new framework had to be urgently revisited. In June 2001, the government created a special task force, called the Brazilian Power Sector Revitalization Committee, with the objective of proposing corrections and improvements to the electricity sector model. In practice, the Ministry of Mines and Energy, the regulator, the wholesale market, and the system operator had their authorities superseded by GCE during rationing. The Revitalization Committee provided valuable technical inputs to GCE to help revisit the power sector model. The Revitalization Committee was coordinated by the president of BNDES (National Economic and Social Development Bank) and had high-level representatives from the Ministry of Mines and Energy, ANEEL, the Ministry of Finance, the Ministry of Planning, and the General Attorney (AGU), among others.

4.129 The rationing put the electric sector in the spotlight. Its visibility and perceived importance were undoubtedly factors that facilitated the continuation of reform, since decisions that cut across Ministries could be tackled in a holistic way. More importantly, the Committee

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[108] The average cost (R$290/MWh) was well above the price at which quotas traded (about R$100/MWh over the last months of the scheme). This may suggest that the costs of this short-term supply solution were greater than the available demand management (DM) capacity, at least for the existing supply-demand balance.

[109] Batista (2002)

[110] The conception and initial implementation of the power sector reform was developed as part of the RE-SEB project, carried out from August 1996 until November 1998, under the coordination and intellectual leadership of Peter Greiner, the Energy Secretary of the Ministry of Mines and Energy

[111] With the benefit of hindsight, the thermal expansion plan and the implementation of the reform designed in 1998 were not mutually exclusive, but complementary.

filled a void of coordinating such a complex reform process. In January 2002, the Revitalization Committee proposed several recommendations to put the power sector back on its feet.[112] Despite all the criticism around the existing structure of the power sector, the Revitalization Committee reiterated most of its key principles such as the introduction of competition, industry structure, and the need to de-verticalize and privatize the power sector. Specific, practical recommendations were made to fix some features of the existing institutional framework that had been poorly designed; implement portions of the model that had not been put into practice; and address aspects that had been poorly implemented.

4.130 Most of the recommendations had to do with poor or incomplete implementation of recommendations made when the power sector was restructured in 1998. In that sense, the momentum created by the Revitalization Committee represented a unique opportunity to push reform forward. Some of the recommendations represented significant changes, such as the possibility of hydro generators bidding prices into the pool. The rationale was to have a spot price better reflect the price of scarcity. The way the spot price was being calculated relied on simulation models that tried to predict the economic value of water. Empirical evidence demonstrated that those models consistently underestimated the price of energy and did not provide the necessary warning signs when a crisis was already imminent.

4.131 Table 4.15 summarizes the recommendations made at that time. Most of the proposed measures confirmed the principles of the ongoing reform, but recommended an accelerated implementation schedule, with more coordination across Ministries. Some new ideas included:

- Incentives for peak capacity, such as a capacity fee payment;
- Incentives for energy conservation;
- Separation of the "wires" and "energy" components in final prices to regulated consumers;
- Quicker environmental licensing procedures;
- Use of price bids by hydro generators instead of a computer model to calculate MAE prices;
- Improvement and definition of rules for periodic tariff revisions of distribution utilities;
- Universal access (or "Universalization") – make electric energy available to every citizen.

4.132 Despite strong commitment from the government, there was not sufficient time to fully implement the recommendations of the revised model. In January 2003 a new administration took office, proposing to revisit the power sector entirely.[113] Once more, reform lost momentum, creating more uncertainty among investors. The proposed recommendations made in early 2002, grouped into eight general themes, are shown in Table 4.15.

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[112] Revitalization Committee. Progress Report #2. This report contained 33 main recommendations.
[113] As reflected in President's Lula reform plan for the power sector made public in mid-2002.

Table 4.15: Reform Measures Proposed by the Revitalization Committee

Theme	Measures
* Resume market operation – series of measures designed to allow the sector model to function as quickly as possible. The general aim was putting an end to disputes and litigation that were paralyzing MAE and hampering ONS	• General Sector Agreement – compensations for losses, clarification of market rules, changes in Initial Contract provisions, lifting of court injunctions • MAE restructuring • Reform of dispatch rules
* Reinforce market-based mechanisms – measures designed to make the system more market-oriented	• Use of price offers by generators instead of a computer model to calculate MAE prices • Sale of government-owned energy by public auction – amendment to deal with the still dominant position of continued government-owned generation • Rules to stimulate the emergence of “free” (i.e., unregulated) consumers – changes in model design caused by the fact that very few consumers had become unregulated
* Ensure adequate expansion of supply – measures designed to ensure adequate generation expansion within a market-driven framework	• Revision of the Assured Energy certificates – the possession of assured energy certificates is a requirement for a seller to sign a PPA in Brazil; existing certificates overestimated plants’ abilities to deliver energy • More stringent requirements in bilateral contracting – minimum contracting level for loads raised from 85% to 95% • Contracts for reserve generation • Incentives for peak capacity, such as a capacity fee • Incentives for energy conservation • Quicker environmental licensing procedures – protracted licensing procedures were seen as an impediment to adequate expansion
* Monitor supply reliability – assigned clear responsibilities in warning of impending energy crises, mitigating a flaw in the models which set the price	• Alert procedures for supply difficulties – a series of alarm levels with who, when, and how to activate them • Assignment to the Ministry of Mines and Energy full responsibility for overseeing the supply situation
* Improve interface between market and regulated segments – mostly regulatory measures that were not fully addressed in the original model design	• Changes in the limits in the pass-through of energy costs to regulated customers • Revision of the transmission tariffs • Improvements in transmission expansion methodology
* Stimulate fair competition – these are more stringent rules to prevent the use of market power	• Continued unbundling • More stringent limits for self-dealing and cross-ownership – self-dealing by discos was a serious problem • Separation of the “wires” and “energy” components in final prices to regulated consumers – regulation to stimulate more competition • Improvement and definition of rules for periodic

Theme	Measures
	tariff revisions of distribution utilities, nonexistent in the original concession contracts • Regularization of all concession contracts – many had expired and not been renewed, which created still more regulatory uncertainty
* Realistic tariffs and consumer benefits – a group of measures designed to provide a realistic tariff framework, eliminate remaining cross-subsidies, clearly define what was to be subsidized and how – the original framework had the principle, but not the details	• Universalization – make electric energy available to every citizen • Subsidies for low-income consumers • Subsidies for alternative forms of energy • Funds for gas pipelines • End of cross-subsidies
* Improve functioning of institutional players – a group of changes aiming at improving or further detailing the original model	• Restructuring of Ministry of Mines and Energy • New governance rules for ONS • Improvements in ONS Grid Procedures • Improvements in ONS dispatch models • Improvements in MAE rules • Improvements in MRE rules (MRE is a hydrologic risk-sharing mechanism involving all hydro generators and embedded in MAE rules)

Source: Revitalization Committee – Progress Report # 2

4.133 The proposals of the Revitalization Committee that required approval by Congress were submitted in the form of provisional measures (MPs) and were the subject of intense negotiations. The resulting law, as approved by Congress in April 2002, represented a significant departure from the original recommendations proposed by GCE. Some amendments were necessary to accommodate parochial political interests, to the detriment of the consistency of the reform plan.

4.134 In June 2002, the government decided to terminate GCE and put the Revitalization Committee under the coordination of the Minister of Mines and Energy, but still with the same composition. By the end of 2002, two more progress reports had been produced: Progress Report #3, which detailed some of the 33 measures (those considered more urgent), and Progress Report #4, which provided final recommendations on measures that still had not been implemented. One more law was necessary to solve pending issues, but Congress voted on this law in November 2002, after the presidential elections won by the opposition party (PT, or Worker's Party). The resulting text reflected the loss of political power of the administration at that time.

4.135 The energy crisis was a key issue raised in the October 2002 presidential elections. The new government, which took power in January 2003, presented its first draft proposals for changes in the electric sector institutional framework. The proposals were a radical departure to what had been developed so far.

The Crisis and the New Institutions

4.136 The crisis had a strong impact on the new institutions that were in the fulcrum of the reform being implemented in the Brazilian system at the time. To some extent, they were all blamed for the crisis and its consequences. The role of key institutions such as MAE, ONS, ANEEL, and even the Ministry of Mines and Energy were superseded by the GCE's authority and broad powers. The situation was so chaotic in the months that preceded rationing that strong and decisive coordination became imperative.

4.137 Despite the merits of such an entity, it cannot be denied that the presence of GCE somewhat preempted and weakened the role of the existing institutions. To some extent, this preemption defeated some of the objectives of power sector reform, which envisioned an independent regulatory agency (ANEEL), an independent system operator (ONS), and a self-regulating wholesale market (MAE), with its own governance system, separate from the government. To make matters worse, those fledgling institutions were experiencing difficulties in establishing themselves. The crisis had a major impact on their credibility and independence, as described below.

ANEEL

4.138 ANEEL, the federal regulator, was created in December 1996 by Law #9,427, but started to function effectively only in late 1997, after its first board of directors was confirmed by the Senate. It has a board of five directors. Each director is nominated by the President and confirmed by the Senate to a four-year term. This process was designed to guarantee independence to the agency. One of the first problems faced by ANEEL was the fact that there was little tradition of independent regulating institutions in Brazil. Moreover, ANEEL started functioning in an environment of companies that were still largely owned by the federal government and various state governments, where many of its functions had been effectively exercised by these companies.

4.139 This problem was compounded by difficulty in finding qualified permanent staff: ANEEL started out with temporary personnel and was supposed to hire permanent employees. However a court injunction effectively denied this prerogative. According to the court ruling, ANEEL could hire personnel for terms of three years at most, after which they had to be replaced. This issue was solved only in 2003. The difficulty in hiring staff, and the immense workload associated with the lack of tradition in regulation (and hence the need to write and approve a large number of new regulations in a very short time), and at the same time the need to ensure the independence and authority of the agency, are probably part of the reason for the seemingly "stop-and-go" attitude adopted by the agency.[114]

4.140 However, ANEEL cannot be blamed for the rationing crisis. The weakness of the institutional system was deep rooted. No one, not even the Ministry of Mines and Energy, was de facto in charge of checking the overall "logic" of the reform process. No one was exerting

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[114] An interesting discussion on the institutional role and difficulties faced by ANEEL can be found in Brown and de Paula (2004).

coordination among the multiple spheres of government, to make sure that the several pieces of the new sector would not fall apart.[115]

4.141 The point is that no institution, including ANEEL, was clearly accountable for raising the flag of an impending crisis. As ANEEL was overwhelmed by so many other regulatory problems, it did not take any initiative until December 2000, when it ruled that MAE should contract 2,500 MW of emergency power before 2003. This capacity was never contracted. This episode illustrates many of the difficulties that ANEEL and MAE experienced: at the time, the focus of MAE was on lifting the court injunctions and making the market minimally functional. Immediately before the crisis, in March 2001, ANEEL proposed some relatively soft energy-saving and supply-enhancing measures, which, at that point, were insufficient for the size of the crisis in the making.

4.142 Although ANEEL's chief director was a member of GCE by statute and another of ANEEL's directors was a permanent member, the establishment of GCE clearly undermined ANEEL's authority. The articles in the provisional measures that created GCE simply transferred much of ANEEL's regulating power to it. As a result, from May 2001 until June 2002 (when GCE was disbanded), ANEEL's regulating authority became virtually subordinate to GCE.

4.143 Also as a consequence of the crisis, the same act that disbanded GCE (Presidential Decree # 4,261, issued in June 2002) enhanced the powers of the CNPE (National Energy Policy Council), and created within this council a committee called CGSE (Electric Sector Management Committee). CNPE is composed of various ministers and is coordinated by the Minister of Mines and Energy. Since ANEEL's regulations are subordinated to national energy policy considerations, ANEEL's power to define policies was effectively reduced on a more permanent basis. CNPE's statutes ruled that such a council should only deal with matters of general energy policy interest, and therefore should not interfere with ANEEL's regulatory responsibilities.[116]

4.144 In its capacity CNPE issued resolutions (confirmed by presidential decree) dealing with broad aspects such as the exact form of transmission tariffs and the way discos should purchase energy through auctions. It became clear that the gaps of accountability in defining energy policy issues were being bridged.

ONS

4.145 ONS, the Independent System Operator, was created by Law #9,648, of May 1998. Before ONS was established, system operation functions were coordinated by GCOI (a committee formed by representatives of the major utilities, with special powers for Eletrobrás representatives). Law 9,648 ordered a gradual transition of GCOI's responsibilities to ONS, culminating with dissolution of the former in less than a year. ONS assumed control of system dispatch in March 1999. Its initial staff was composed mostly of former employees of federal utilities, and initially most were formally still employees of these utilities seconded to ONS. Soon after ONS began its official operation, on March 11, 1999, a major blackout affected a great portion of the interconnected system. This event proved to be traumatic for the new institution, as neither the public nor the government was fully aware that a new institution had

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[115] An interesting discussion on how dysfunctional the process was can be found in Kelman et al. (2001).

[116] Technically speaking, ANEEL was not supposed to define broad energy policy issues. However, given an existing, undefined vacuum of accountability, ANEEL had, in a few instances, stepped in and defined some basic regulatory policy issues to carry on its work.

complete responsibility for system security. The Minister of Mines and Energy called upon himself to control the situation, and there was discussion about new legislation, in the form of a provisional measure, to postpone the end of GCOI for some years. Although no new legislation was issued, in practice ONS' independence and credibility were affected.

4.146 The creation of GCE affected ONS much the same way it affected ANEEL: major system operations criteria used by ONS started to be challenged by GCE, and some of them are still in force (e.g., GCE Resolution #109, setting parameters for system operation and establishing risk aversion curves for hydrothermal operation). At a certain point, GCE started to make even individual operational decisions.

4.147 ONS cannot be exclusively blamed for the crisis. However, strong criticisms were made that ONS never showed the government and the public the seriousness of the impending crisis. This silence was partially due to the fact that the governance of ONS was still dominated by a large group of federally owned generators, who were following marching orders from the government to avoid any unnecessary disclosure of a crisis which could be potentially avoided. As a result, ONS, like ANEEL, had a large part of its key responsibilities preempted by GCE, at least in the months following the crisis.

MAE

4.148 MAE is the Portuguese acronym for Wholesale Energy Market. MAE was meant to be the environment for settlement between contracted amounts of energy and the actual production or consumption of individual buyers and sellers. It operated as a balancing market. Each participating player would purchase from or sell to MAE the differences between its production and consumption. These purchases would be priced at the MAE prevailing spot price, which was in fact the short-run marginal cost computed using ONS dispatch optimization methodology.

4.149 MAE was created by Law # 9,648, of 1998 (the same law that created ONS). Of the three new institutions—ANEEL, ONS, and MAE—MAE had the most difficulty in starting to function. In fact, even though it had been established in 1998 and immediately started to hire its own staff, MAE had been unable to perform a single settlement when the crisis started. Upon its official start in September 2000, there was still a backlog of six months of overdue settlements.

4.150 Reasons for this delay were many. At first, MAE players, representing buyers and sellers, had to agree on the rules for the short-term market, with a deadline of November 1998. With major contradictory interests at stake, players were deadlocked for many months, and the initial rules were issued only in mid-2000, to become effective starting in September 2000. Meanwhile, ANEEL had issued provisional pre-MAE rules for contract settlement (ANEEL Resolution 222/1999). The application of these pre-MAE rules, as well as MAE settlement itself, was contested and had to be stopped by court order.

4.151 As the crisis went on, GCE tried to turn MAE into the main environment for energy quota auctions, but it was not very successful,[117] since the settlement process was still

[117] MAE was designed to settle large contractual imbalances for a relative small number of contracts and players. Settling quotas among large and mediu-size customers would entail a significant cost of complexity to its operations.

paralyzed. MAE's survival depended on being able to actually perform settlements. At first, it was hoped that a provision in the Generators and Discos Agreement, in which the parties withdrew their lawsuits, together with a radical change in MAE's governance, would be enough to get actual settlement started. However, another court injunction resulting from disputes over energy produced by the Itaipu once again postponed actual settlement. MAE's first settlement happened in December 2002, 27 months late. There was R$2.5 billion to be settled for the September 2000–September 2002 period.

4.152 One of the main reasons for contract disputes was the high prices preceding rationing. Generators (and some distributors) short in the market preferred to resort to legal disputes to paralyze the entire settlement process. They had vested interests in upsetting the process, given the amount of money at stake. Despite the lack of merit of their claims, they knew that the excessive time to resolve a legal dispute by courts in Brazil would force MAE to look for a negotiated solution. On the other hand, potential investors who might have installed and produced emergency power in order to profit from very high short-term prices were discouraged because MAE was not functioning and its settlement rules, including pricing, were being challenged. The paralysis in MAE operation was not helping the government to implement a market-driven rationing program. Furthermore, it was detrimental to the overall image of MAE and "markets" in general. Some even compared MAE's operation to a Las Vegas casino. The California crisis, happening almost simultaneously, helped reinforce this perception.

4.153 The crisis became a political issue that likely had some influence on the results of the Presidential elections in late 2002. The incumbent government lost credibility for not properly coordinating the reform process and for not taking the necessary measures in advance to avoid the crisis. The situation of the power sector became a fulcrum of Lula da Silva's campaign. In April 2002, about six months prior to the election, the opposition party launched a radical plan to reorganize the power sector, built upon the failures of the previous reform carried out by the incumbent administration, which allegedly led to the rationing crisis.[118] Apart from the merit and feasibility of the recommendations, PT was the only political party to articulate a plan. This showed how sensitive and politically visible the issue of reliability of the power sector had become, and how it could be capitalized to gain voters' support.

4.154 No other sector in the economy received so much attention in the ensuing presidential debates. Furthermore, no other political party put together such a comprehensive plan to restructure the power sector as PT did. This showed the importance of the subject in the electorate's mindset. It is likely that this was one of the factors that guaranteed Mr. Lula's victory in the November 2002 presidential election. Furthermore, the PT elected many deputies, two-thirds of the Senate, and state governors. Their success illustrates how a crisis of this nature may have a far-flung impact, not only in the power sector, but also in the political arena.

Economic Impact

4.155 When rationing started, economic prospects were quite gloomy. A significant reduction in economic activity was expected, in terms of unemployment, price increases, and deterioration in the balance of trade. This was not the case.

[118] Diretrizes e Linhas de Ação para o Setor Elétrico Brasileiro (2002).

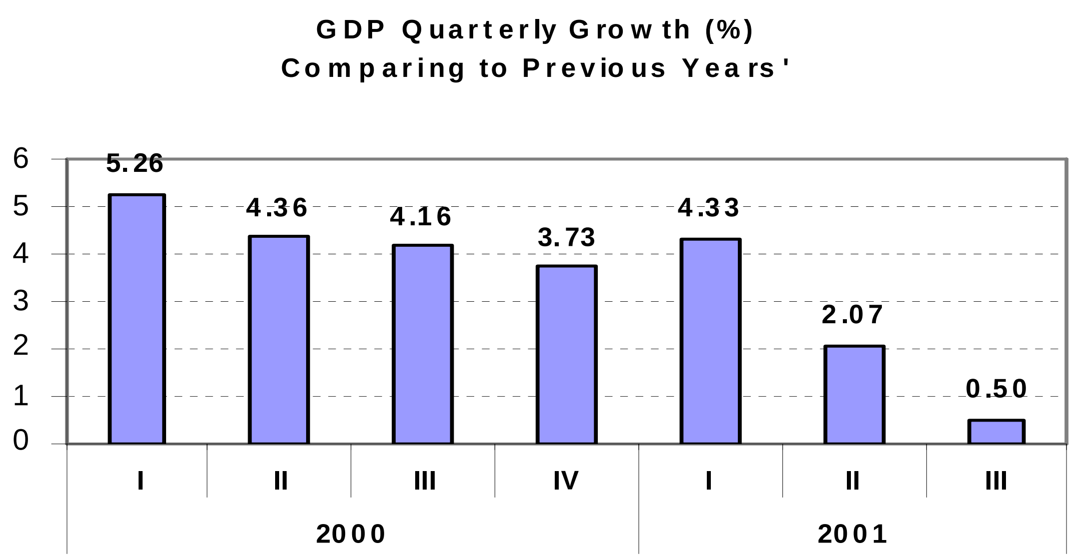
Impact on the Economy as a Whole

4.156 As of the time of this report's publication, there are no analytical studies on the economic impact of the electricity crisis. Preliminary estimates for losses in 2001 indicated a reduction between 1 percent and 2.5 percent of GDP. This would imply losses between US$5 and 13 billion. The difficulty in estimating the real economic impact derives, in part, from the influence of other important, nonetheless exogenous crises happening almost at the same time, such as the events of 9/11/2001 and the Argentine macroeconomic crisis.

4.157 Due to a well-designed rationing scheme, none of the gloomy predictions materialized. A quick and strong reaction from residential customers freed up energy for other, more productive activities.

4.158 Despite the extremely unfavorable international macroeconomic scenario in late 2001, the performance of the economy proved much more robust than most had anticipated by most skeptics. For example GDP continued to grow, even though at a lower pace, as shown in Graph 4.12.

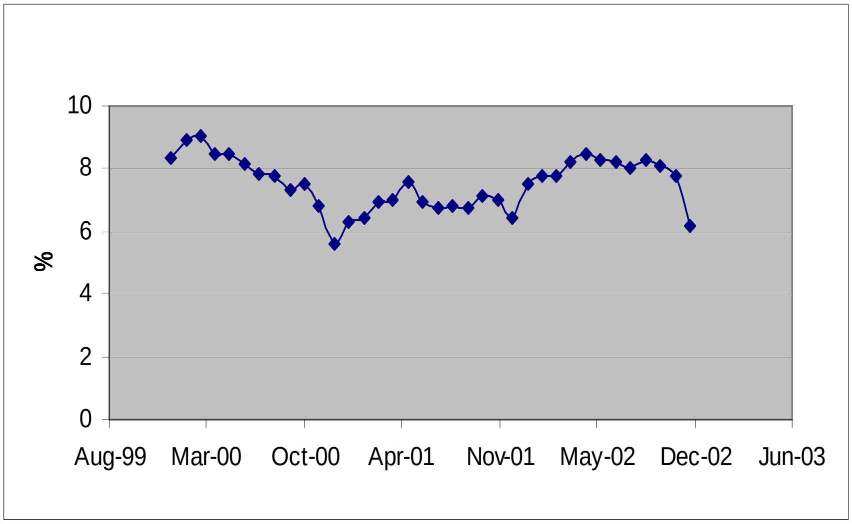
Graph 4.12: Economic Growth During the Energy Crisis



Source: Eletrobrás.

4.159 Formal unemployment levels were relatively stable, as shown in Graph 4.13. Initial forecasts were much less optimistic, and assumed a reduction of almost one million workers in the labor force.

Graph 4.13: Formal Unemployment Pre- and Post-Rationing (%)

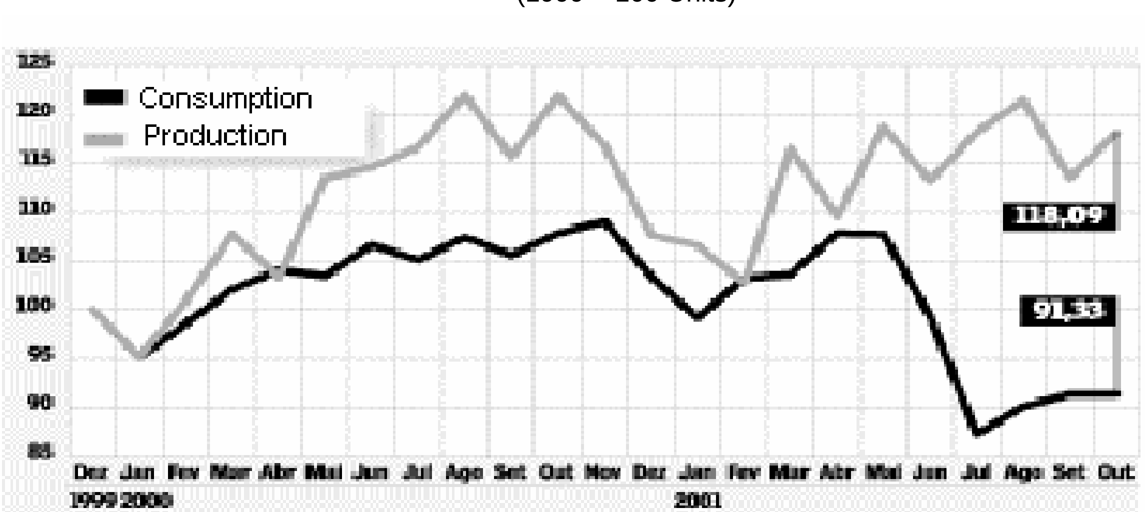


Source: IBGE

4.160 Total physical production increased in the most critical months of rationing, despite a significant reduction in the consumption of electricity to produce those very same goods, as illustrated in Graph 4.14. Again, this is a testimony of the potential of energy rationalization unveiled by the crisis and the way rationing was carried out.

Graph 4.14: Electricity Consumption vs. Physical Production

(1999 = 100 Units)



Source: Eletrobrás, IBGE, and Valor Pesquisa Econômica

4.161 Some initial estimates indicate that the country saved at least 1 percent of its GDP due to the way rationing was implemented, via use of quotas and price signals, in tandem with the prerogative given to large customers to exchange quota entitlements.

Impact on the Power Sector

4.162 Financial losses experienced by the power sector were not negligible. There was a significant reduction in revenues and margins. The government plan to bail out the industry and to compensate utilities for their incurred losses (General Sector Agreement) involved approximately R$8.3 billion. From this amount, R$405 million compensated utilities for bonuses granted to consumers that were not covered by tariff surcharges. R$1.6 billion was paid by the customers for emergency thermal generation capacity installed during the crisis. The total losses represented more than R$10 billion, or approximately US$4 billion.

Aftermath

4.163 The energy crisis of 2001–2002 affected Brazilian citizens' lives, even though the negative impact was effectively minimized by the rationality of the measures that were adopted. The most important consequence of the rationing was the financial crisis inflicted on the power industry itself. Discos experienced significant demand and revenue reduction. As part of the overall agreement with the government, they were allowed to increase tariffs to partially compensate for their reduced margins and revenues. However, there was a practical limit to increased tariffs, given customers' willingness to pay and the fact that tariff increases have an impact on fraud and late payments. Generators also suffered significant losses. During rationing, their revenues shrank about 20 percent. If supply contracts had been enforced, losses incurred by the generators would have been higher, since they had to buy part of their contractual exposure at the prevailing spot prices. The contractual clause that governed this matter was Annex V, as discussed earlier.

4.164 The financial distress of the utility industry was not solved after the rationing measures were lifted. To some extent, they still remain as this paper goes to press. Three major factors contributed to the post-rationing crisis.

4.165 First and most importantly, customers learned how to save energy as a result of the crisis. They identified savings potential, changed their habits, invested in conservation devices, and became more conscious about the importance of electricity in their lives. They made large investments in energy efficiency, co-generation, and self-generation, or even shifted to other sources of energy in order to save electricity. This conservation "capability" is still in place.

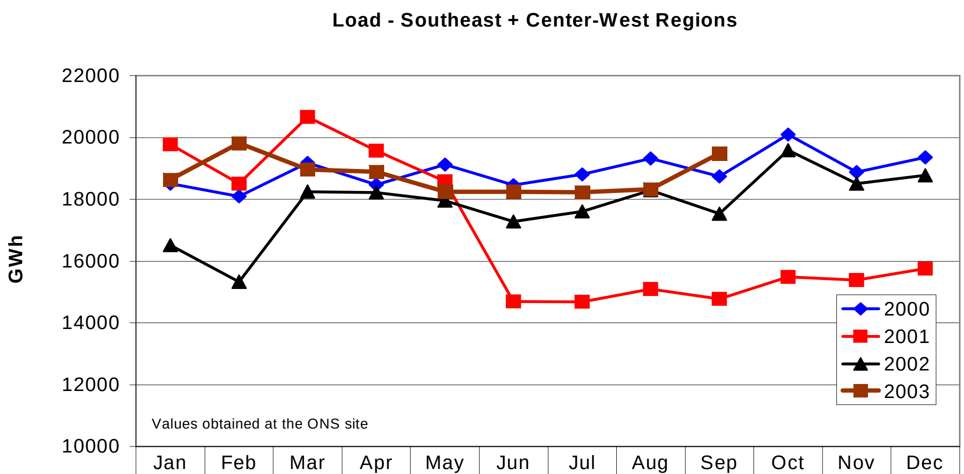
4.166 Second, there was a remarkable expansion of capacity during the rationing period. Some of the plants under construction accelerated their schedules, particularly those designed to operate on a merchant basis. The government worked hard to eliminate some environmental barriers that were delaying construction or operation of new plants. Investments were made in co-generation, and some transmission bottlenecks were relieved. Distribution companies were allowed to pass through higher energy costs to their retail rates and in some cases self-dealing transactions were also allowed. The objective was to stimulate the construction of new plants by a larger number of players. Petrobrás was encouraged to participate as a gas supplier and as a partner in new, greenfield thermal power plants. The government also played a role of provider of last resort, commissioning about 3,000 MW of emergency thermal plants in a record-breaking period of time. In addition to all the new investments made in thermal plants, hydrology in 2002, particularly in the Southeast, was very favorable, therefore contributing to rapidly replenishing the reservoirs. Energy and capacity became abundant again, less than a year after the eruption of the crisis.

4.167 On the other hand, some of the 3,500 average MW of "excess" supply (i.e., supply above demand forecasted for 2003) was also largely due to various incentives to build new plants that were introduced as a response to the supply situation, both before and during crisis.

4.168 Those two factors contributed to a supply overhang of about 16 percent or 8,500 MW immediately after the rationing measures were suspended. From this capacity, about 3,500 MW were solely due to "excess" supply (i.e., supply over and above the demand forecasted for 2003) and the balance, or 5,000 MW, due to demand response.

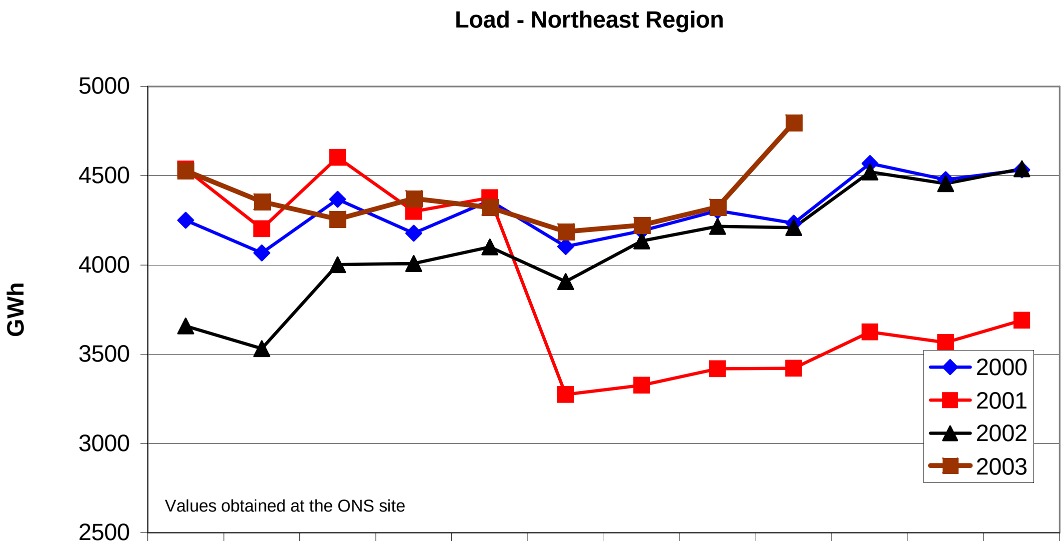
4.169 Graph 4.15 and 4.16 illustrate the dimension and magnitude of this "new" supply glut crisis. Even 18 months after the end of the crisis, total demand in both regions was still below pre-rationing levels, when it had been growing at a rate of 4 to 5 percent a year.

Graph 4.15: Demand in the Southeast/Center-West Regions



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	18513	18095	19186	18464	19126	18457	18803	19327	18732	20097	18883	19354
2001	19783	18505	20667	19569	18590	14698	14688	15096	14776	15484	15383	15753
2002	16516	15329	18245	18217	17956	17282	17605	18289	17537	19597	18505	18781
2003	18634	19806	18970	18889	18254	18251	18224	18322	19489			

Figure 4.16: Demand in the Northeast Region



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	4250	4068	4367	4179	4361	4103	4191	4303	4235	4569	4479	4534
2001	4537	4202	4603	4299	4376	3274	3327	3420	3422	3625	3566	3690
2002	3659	3532	4001	4009	4102	3906	4135	4216	4211	4522	4456	4539
2003	4527	4353	4258	4371	4322	4187	4222	4324	4796			

4.170 To aggravate matters for generators, 25 percent of the energy under the Initial Contracts was scheduled to be freed up in early 2002. Under normal circumstances, generators would celebrate this event, given the fact that the regulated prices were significantly below the long-run marginal price of energy. However, due to the supply overhang, a lot of the existing capacity was not re-contracted and therefore generators were forced to sell energy on a merchant basis, at very low spot prices. Many discos had difficulties paying for the energy purchased, creating a difficult financial situation for the generators. Many became immersed in a serious financial crisis.

4.171 Oversupply and further regulatory instability have discouraged investors to initiate new generation projects. If this issue is not dealt with properly, there are risks of another supply crisis in the medium range. The investment climate is not favorable due to a combination of factors: (i) incomplete reform; (ii) lack of contract sanctity; and (iii) mixed signals provided by the new administration about major changes in the power system. One of the clear signals initially given in Lula’s presidential campaign was that there was no room for competition in generation, and existing and future MW would be cost-plus regulated, operating in a single buyer type of commercial arrangement. Proposed changes have been reconsidered and some never came to fruition. However, this regulatory flip-flop and the risks entailed have contributed to exacerbate the climate of regulatory uncertainty.

4.172 Experts say that existing excess supply will probably be fully utilized only in 2007–2008. Despite the apparent capacity “cushion” in the system for the years to come, decisions on new investments, particularly in hydro generation, have to be made now, due to the lead times involved in environmental licensing and construction. A combination of excess supply in the short run and regulatory instability has inhibited potential new investors, and practically no new projects have begun following the rationing crisis. The bright side of this supply overhang, amid so many difficulties faced by the power sector, is the fact that the country has ended up having sufficient generation capacity to finance its economic development for several years without additional investments and that customers are much more conscious about the importance of using electricity in the most effective way. It was certainly a creative lesson in how developing countries can bridge the gap between demand growth and capital availability.

4.173 When the current administration took office in early 2003, about 8,500 MW of excess Assured Energy was available. At the expected economic growth levels, this capacity will be able to support the country's economic growth for one entire four-year presidential term, with minimal likelihood in service disruption or a new rationing crisis. To some extent, this was a "windfall profit" received by the current administration who so passionately criticized its predecessor.

5

Issues in Rationing

5.1 Every rationing episode is unique. Distinctive physical characteristics, previous experiences faced in each jurisdiction, economics, politics, and many other factors make each rationing crisis idiosyncratic. Also, consumers may react differently, sometimes in unexpected ways. Some of the key attributes that distinguish rationing episodes include

- Physical factors, such as availability of hydropower, fuel, generation capacity, or reserves;
- Technical factors, such as energy scarcity or low reserve margins;
- Metering technology;
- Financial factors, such as availability of financial resources to import energy, to run the plants, or to buy fuel;
- Regulatory factors, such as form of regulation, strong or weak;
- Institutional factors, such as the strength of legislative bodies and other institutions;
- Commercial factors, such as existing contracts, effectiveness of the commercial processes and systems, theft, and non-payment;
- Structure of market and competition;
- Socioeconomic factors, such as a rural versus urban environment;
- Tolerance by customers.

5.2 Other factors also contribute to the uniqueness of each rationing episode. Similar energy crises with the same underlying causes and managed similarly may trigger different reactions from customers. Some may be more cognizant of the problems and how to save energy, while others may be less tolerant or not motivated to engage in conservation efforts. Also, in a second episode, authorities will likely be more experienced and possibly more willing to take a long-term approach in trying to eliminate the causes of the problem. The opposite may also occur: some experiences have shown that the "memory" of how to deal with a crisis may vanish very rapidly.

5.3 In spite of each crisis being unique, there are some common features, which are discussed in this chapter. They provide some guidance to decision makers on key aspects that need to be examined when planning for and administering a power crisis.

Demand and Supply Shocks

5.4 Major crises rarely happen due to one single reason. The crises described in this paper are the result of multiple factors, where at least one supply and one demand shock played a major role.

5.5 Lack of rain constitutes an important supply shock in countries heavily dependent on hydroelectric generation. The 1998–1999 crisis in Chile, for instance, was associated with very severe droughts. In 1998, 62 percent of the installed capacity of the Chilean system was hydro, and in 1998–1999, arguably the worst year on record, hydro generation could supply just 40 percent of the country's needs, as opposed to the traditional 80 percent

5.6 The crisis in Brazil was also associated with a major drought. In 2001 when the Brazilian interconnected system was 88 percent dependent on hydro, the drought that triggered the crisis was the fourth worst in a 70-year record for the Southeast subsystem (by far the largest in the country), and the worst on record for the Northeast subsystem.

5.7 Demand growth may also play an important role. China is probably the most remarkable example. After several years of continued economic growth, the country hit a record-breaking GDP increase of about 15 percent in 2003. Such an increase entails more electricity not only to support additional industrial and commercial activities, but also more electricity, on a per capita basis, to support the needs of a population able to afford more home appliances such as air conditioning, electric stoves, and other energy-hungry devices. Brazil also experienced significant economic growth and improvement in income distribution in the late 1990s, when more citizens had access to the comfort and luxuries provided by electricity. Similarly, California had experienced a significant economic growth in the 10 years preceding its power crisis.

Difficult Transition from a Regulated to a Market System

5.8 The transition from a regulated to a market-driven power sector is not an easy one. It is often tortuous; many things may go wrong and they usually do. Lack of leadership and orchestration has been a common point in most of the crises discussed in this paper.

5.9 For example, in the views of some, the shortages in China reflect the difficulties in making a transition from a command-and-control economy to a market-based economy.[119] This hybrid model, half regulated and half deregulated, has resulted in gaps of accountability and responsibility. China's approach to energy policy, according to one observer, is of "complete incoherence". There is no energy ministry, no center for decision making, and no one place responsible for pulling it all together. Different strands of the energy question thread through a tangle of different offices. Companies and agencies fight it out at the highest levels.[120]

119 Faruqui (2004).

120 Philip Andrews-Speed, Energy Policy Institute at Scotland's University of Dundee. Quoted in Fortune Magazine.

5.10 To some extent, this was the situation faced in Brazil. Power sector reform lacked coordination. In 1998, when the first real steps of reform were taken, new organizations were created and important shifts of responsibilities took place. The power sector and the oil & gas regulators had just been created, with a minimum of communication between them. The independent system operator (ONS) was solidly established, with a clear functional and organizational blueprint. Most of ONS' functions were previously carried out by a similar department reporting to Eletrobrás, the Federal Holding Company. However, the wholesale energy market (MAE) was totally new: the organization had to be established from scratch and market rules had to be agreed upon by existing and new participants. In parallel, the federal government and several states were in a frenetic move to sell their utility assets, with the objective of maximizing sales revenues. Finally, the Ministry of Mines and Energy was focusing most of its attention on the development of an ambitious natural gas thermal generation program. In a nutshell, there were many loose strings and need for orchestration, but no one was in control.

5.11 Gaps of responsibilities and doubts about the accountability of new organizations took place in California as well. The independent system operator was cognizant about the need for changes in the market rules. However, a cumbersome governance system at the Board level and strong vested interests from most players made change virtually impossible. The state government expected stronger action from FERC, the federal regulator, which took place much later in the process. Again, it seemed that no one was in full control of the situation.

5.12 In most of the examples provided, the actions (or lack thereof) at the root of the crises can be assigned either to faulty regulation or to faulty regulatory action. In both Brazil and in California, flaws in the market structure added a risk component to investments in generation. An important lesson to be learned from those experiences is that the transition period—the period of time it takes to move from the initial decision to undertake reform until at least the rules of the game are clear—has to be completed as quickly as possible. This will minimize the period of high uncertainty that is discouraging to private investments. In California, no one was willing to invest until the rules specifying the details of how the new system would operate were known.

5.13 In Brazil, a longer than expected reform period, from 1995 until 2001, with lost momentum and some changes in direction increased the levels of uncertainty in investors' minds, discouraging them from developing new generation projects except in conjunction with governmental entities.[121]

Government Reluctance to Give Bad News—Or Lack of Reliable Warning Signs?

5.14 A common feature in most of the cases analyzed in this document is the absence of a timely action plan capable of preventing or mitigating the impact of energy shortages. Three basic reasons explain the sheer absence of planning:

- Undoubtedly, there is an element of uncertainty. Supply–demand imbalances are probabilistic events. This means that up to the last moment, there is a chance that

[121] Barriers for Purely Private Investment in Brazilian Generation. Final Report. NERA. Prepared for Duke International do Brasil. April 25, 2001.

strong rains, ice melting, mild weather, fuel availability, or an unexpected reduction in consumption may take place and avoid the crisis;

- Long-term plans to deal with rationing are not perceived as politically correct. As mentioned, policymakers and regulators tend to look at ex ante rationing plans as a measure that defeats the purpose of the entire power sector reform;
- Even if there is a plan, implementing preventive measures designed to avoid or mitigate energy crises are extremely unpopular. Governments may be reluctant to impose a sacrifice in terms of well-being of their citizens unless they are absolutely sure that a crisis is going to happen. The uncertainty element creates a dilemma for incumbent regulators or policymakers.

5.15 Given this lack of symmetry between risks and returns, governments tend to “wait and see” up to the last minute, before any concrete action is taken. It is natural that authorities tend to postpone breaking the news of a possible or imminent energy crisis. Governments may prefer starting with very soft consumption reduction campaigns, with the objective of achieving some savings but without incurring the political burden of imposing more drastic measures such as mandatory rationing.

Reliable Warning Signs

5.16 Power sector reforms have checks and balances to deal with the government bias to hold bad news. The most important of them is the creation of an independent system operator (ISO). This organization possesses real-time knowledge about the system, has the necessary technical capability, and is meant to be sufficiently neutral to make technical recommendations in a transparent and unbiased manner.

5.17 Public, reliable information on medium- to long-term supply–demand balance should play an important role in raising awareness about an incoming crisis and provide a basis for future investments. To give more visibility to those issues, some countries have a system of short-, medium- and long-term system adequacy assessments and reports that have helped stimulate awareness of investments needs.[122]

5.18 However, operators do not always operate independently as their names suggest. Their actions are to a large extent preempted or restricted by the government.

5.19 For example, in Chile, consumers became aware of the seriousness of the situation after a major blackout took place on November 11, 1998, in the central and southern parts of the country. Only then the authorities issued a rationing decree. However, the possibility of rationing had been the subject of discussion at the technical level since July 1998, and the government had considered issuing a specific decree in early September. The overuse of hydro reserves in July 1998 was an indication that CDEC, the ISO, was not able to fully implement optimal operation.

[122] As reported in an informal exchange of ideas with Eric Groom (World Bank), Australia has developed such an information awareness mechanism on a systematic basis.

5.20 In California, there were warning signs of an impending crisis, when the first electricity price spikes occurred in August 1999. However, the sustained rise in electric prices started only in May 2000, and the first blackout occurred on June 14, 2000. From most customers' point of view, this crisis was totally unexpected, and apparently no preventive or mitigating measures were taken in advance.

5.21 A classic example took place during the rationing crisis in Brazil. The power sector was cognizant, almost two years in advance, about the fast depletion of the reservoirs and the risk of a serious crisis. An official report, prepared after the crisis, stated that the regulator and most industry players were aware about the critical situation almost two years before it took place, but the system operator instructed the Ministry of Mines and Energy (MME) not to disclose or give any publicity to the risks and severity of the situation, in order to avoid exaggerated worries on the part of society. The independence of the system operator (ONS) was seriously jeopardized.

5.22 Public acceptance of an imminent crisis in Brazil took place only in early May 2001, when the regulator openly communicated the need to initiate an aggressive savings program. At that time, reservoirs in the Southeast were at about one-third of their capacity. At the prevailing consumption rate, all the water would be used to produce energy before the end of the dry season. The situation was dramatic. The President, top government officials, the press, and citizens in general were appalled. Why did it take so long for energy authorities to disclose the magnitude of the crisis?

5.23 In part, different perceptions about the extent and nature crisis reveal differences in the way the information is codified, presented and processed by the multiple parties involved. In the power sector, it is usual to refer to a certain "probability of deficit" as a usual way of measuring system reliability. The usual probability is 5 percent, but a few months prior to rationing it was as high as 30 percent. Despite the extremely high risk, the government was still confident that there was a good chance (70 percent) that rationing would not be necessary. There was a clear mismatch in the perception of risks and likely outcomes entailed. For someone familiar with the power sector, a 30 percent risk of rationing is very high, particularly given the fact that the cost of non-served energy is more than an order of magnitude higher than the existing regulated tariffs. As a consequence, people in the power sector had been recommending some form of rationing long before it became an official government program.[123] However, in innumerable occasions, the government, the regulator, and the ISO publicly denied the pressing need to implement a serious rationing scheme.

When the Decision to Ration Is Unavoidable

5.24 Despite the reluctance and disincentives of policymakers and regulators to avoid disclosing bad news, at some point in time the decision to ration becomes inevitable. In two of the cases addressed, the decision to ration was taken *after* the physical symptoms of the crisis had manifested themselves. In Chile, the rationing decree was issued on November 12, 1998, one

[123] Garcia (2000).

day after the first major blackout. And in California, although no formal rationing legislation was issued, the first measures started after the blackout of June 14, 2000.[124]

5.25 In Brazil, rationing was implemented when the system still had some reserves able to meet demand for a few additional months, when reservoirs were at about 30 percent of their capacity. In other cases, such as the Dominican Republic and to some extent a few Sub-Saharan countries, rationing is a consequence of the physical characteristics of the system and the fuel availability at any given moment in time. Preparation is virtually nonexistent and the system is often “stretched” to a maximum.

5.26 As explained in Chapter 3, the Dominican Republic tried to impose some discipline in the widespread blackouts that were affecting the country in 2002. The PRA, a plan to reduce blackouts, was developed and implemented, reducing power curtailment in poorer areas. For some time, all customers benefited from a better quality of service, receiving about 18 to 20 hours a day of service, with more predictability in terms of interruption. For the reasons described earlier, the proposed plan was not sustainable, and the rationing became widespread and with no planning whatsoever.

5.27 In terms of the formality of a rationing decision, each system had its own peculiarities. In California, whenever demand threatened to exceed supply, the ISO has authority to order both service interruptions (which affect only the so-called non-interruptible customers) and blackouts (power cuts to both firm and non-firm customers in a specific geographic area). Hence, there was no need for the authorities to issue formal rationing legislation. In Chile, the law empowered the government, through its Minister of Economy, to issue a rationing decree if the situation so warranted. Once the situation became critical, the government was able to adopt the necessary measures without having to enact new legislation.

5.28 In terms of an ex ante framework for rationing measures, the Chilean system had rules for dealing with scarcities that were, in principle, supposed to resolve all relevant issues. In practice, there were gaps in these rules, especially in terms of compensating industry players for their losses due to rationing. Many disputes took place regarding the commercial aspects of the measures. Important economic and regulatory issues remained unresolved during the crisis, which likely affected the price signals received by producers and consumers.[125]

5.29 In Brazil, a formal decree specified how to deal with rationing situations, but it was not very useful. It was vague and had been issued before the new 1988 Constitution and before the new rules of the power sector reform were put in place in 1998. So the government felt the need to prepare and enact completely new legislation, issuing a string of provisional measures (emergency bills that have the effect of law while being voted by Congress). The absence of specific legislation forced the government to prepare a complex legal and regulatory framework in a relatively short timeframe. The advantage was that the government was not bound by existing legislation, and so had much more latitude in drafting its proposals.

[124] California Public Utilities Commission: Report on Wholesale Electric Energy Investigation – September 2002

[125] Balbontín (1999).

Emergency Decisions

5.30 Sometimes, there are no warning signs. Emergencies occur, and countries must deal with unexpected events. The success of handling such situations depends, once again, on the existence of a well-designed and coherent plan to deal with emergencies that happen with short notice or with no notice at all.

5.31 This was the case, for example, when in April 2003, the Japanese utility TEPCO shut down its 17 nuclear power plants for safety analysis. TEPCO predicted a shortfall between 5 GW and 8.5 GW in case of a very hot summer. The utility was able to secure an additional supply of 4 GW, which means that the difference would have to be saved in a hurry. A massive campaign was launched asking residential, commercial, transportation, and government customers to conserve electricity. This campaign had a strong educational component, showing different customer groups how to effectively conserve energy and prepare for a blackout.[126]

5.32 A typical "energy" crisis, by its very nature, does not require immediate action (i.e., within hours or a few days). In the case of Brazil, two months elapsed between public awareness of the crisis and the issuance of the first provisional measures dealing with the shortage. The risk of spending much time on planning is that delays in implementation increase the chance of a crisis of much higher proportions.

Dealing with Different Types of Crises and Scarcity

5.33 Capacity and energy crises affect consumers in different ways and require different actions from regulators.

Energy Crisis

5.34 As discussed, an "energy" crisis is a type of shortage where the system can supply instantaneous demand in any given moment, but cannot supply demand in a continuous, sustainable way.

5.35 Energy crises may be caused by many factors generally associated with lack of fuel. For example, a physical disruption in the regular supply of liquid fuels to run thermoelectric plants may trigger an energy crisis. The same applies when a country has sufficient thermal generation capacity but is seriously constrained in its ability to afford expensive imported fuels. This is the situation faced in the Dominican Republic and Tanzania. Similarly, this situation is now being faced by China, where provinces that have no access to cheap, subsidized coal are being forced to reduce generation and shed consumption. The duration and intensity of the crises depend on the underlying factors that drive the lack of energy in a region. Transmission constraints, limiting the use of cheaper source of energy, may also be factors that play an important role in aggravating energy crises.

5.36 Very often, energy crises happen in power systems that are heavily dependent on hydro resources. In these systems, steady electricity production during the entire dry season usually depends on water stored in the system's reservoirs. If the levels of these reservoirs are too low at the beginning of the dry season, water may not be enough to secure production until

[126] Jyukankyo Research Institute (2003).

the beginning of the next wet season, even though the system had enough capacity to supply instantaneous peak demand at any given moment.

5.37 In principle, energy crises may be handled through rolling blackouts or other mechanisms that encourage or oblige customers to reduce their consumption by a certain percentage as determined by the system operator. The current rationing program faced in China, for example, has utilized extensive and widespread rolling blackouts. At the same time, the government has tried to work on the demand side by developing campaigns and in many cases by establishing harsh penalties for the use of certain energy-intensive appliances. The government has also discouraged the use of existing energy for the production of energy-intensive products such as aluminum.

5.38 The Brazilian rationing program of 2001–2002 is a typical example of an energy crisis. When the first measures were taken in June 2001, two months after the end of the rainy season, average reservoir levels were at only 27 to 30 percent of their capacity. As discussed more fully in Chapter 4, rationing measures were implemented via a quota system, which allocated to each individual customer a maximum of energy that he or she was allowed to consume on a monthly basis. Financial penalties and incentives were designed to encourage customers to comply. Power disconnections were considered the last resort. Despite the serious energy shortfall, at no point throughout the duration of the crisis did the power system become capacity-constrained. Due to the positive results of the quota system, and the fact that the system was not capacity-constrained, blackouts were not necessary. In the most critical moments, as the situation got worse in late 2001 in the Northeast, extended holidays were imposed in an effort to further save energy. There was a concern that the quota system alone would not achieve the necessary reduction in consumption.[127]

Capacity Crisis

5.39 A capacity crisis is a shortage in which the system is physically unable to supply part of its demand during peak hours. Capacity crises are associated with a shortage of generation equipment. They reflect an inadequacy in the total installed capacity. Capacity crises require an immediate reduction in the total demand during the critical periods, when the system is unable to supply peak load. These reductions may be achieved through various forms, ranging from moral suasion (pledges by customers to reduce consumption) to rotating blackouts. If the supply–demand imbalance may be forecasted based on a set of variables such as load profile, day of the week, and expected temperatures, then it is possible to organize the blackouts on a rotating basis. In some instances it is not possible to develop a reliable forecast, since unexpected and uncontrollable events occur. In this case, blackouts have to be implemented in a last-minute, often haphazard way.

5.40 An interesting characteristic of capacity-constrained systems is that mitigating actions to balance supply and demand only need to be put in practice in very specific periods of the day (or week). Capacity scarcities pose no restrictions to consumers during off-peak periods.

[127] As discussed earlier, Provisional Measure #5, issued on October 17, 2001, instituted three new holidays in 2001 for some states in the Northeast region and granted GCE the power to create further holidays and to revoke the three new holidays and the other holidays it created.

5.41 California had a capacity-constrained system. When the market was designed, the idea was that power scarcity would result in high short-term prices, which, in turn, would attract additional generation and at the same time induce consumers to save energy. If this were not enough, then the ISO could resort to service interruptions, which affect only "non-firm" loads, and rotating blackouts. Therefore, there was an intention to initially balance supply and demand using price signals, pursuant to a market-based approach. If that were not sufficient, a quasi-market-based approach would be attempted, in which service interruptions would only affect customers designated as "non-firm." In exchange for this lack of firmness, those customers were given a lower tariff. If those actions were still not enough, the government would resort to rotating blackouts. In reality, the market-based system proved to be ineffective, given the fact that not many customers had interval meters. Therefore, it was not possible to convey a price signal to those customers and measure their consumption during the critical periods. In practice, market signals were not sufficient, and the state had to resort to rolling blackouts.

5.42 A similar situation happened in Chile. Despite being one of the pioneers in power sector reform, correct market and price incentives were not in place when the crisis occurred in 1998. One important reason was that only generators but not customers were exposed to price signals. Hence, spot prices offered no direct incentives for demand-side response. Moreover, there were market design flaws. Spot prices for generators did not reflect the full seriousness of the crisis, and provided the wrong incentives for optimal operation. As a consequence, thermal units were turned off and their power replaced by hydro generation less than four months before the first blackouts. Had the value of the water reflected the imminent crisis, dispatch and operation decisions would have been very different.

5.43 When rationing finally became unavoidable, it was implemented by means of a 7.5 percent drop in voltage, a reduction of "unnecessary" consumption in public offices, and an energy-saving campaign. A rationing decree, which allowed discos to cut service without being fined and which forced generators to ration their clients, had a major impact. Actual rationing was accomplished by means of complex rules that involved daily projections of supply and demand and allocation of deficits among different consumers. In sum, economic signals were confusing and, as in California, did not play a significant role.

Energy-and-Capacity Crises Combined

5.44 When an energy crisis becomes too severe—e.g., if the system's reservoirs are depleted to the point where many plants are not able to run or run at very low efficiency levels—then the crisis becomes both an energy-and-capacity crisis. From the point of view of the consumer, there is an overall shortage, with the constant need to save electricity, aggravated by the curtailment of power during peak periods.

5.45 At its worst moments, the Chilean crisis of 1998–1999 was an energy-and-capacity crisis. For instance, the first actual restriction was the blackout of November 11, 1998. From that point onwards, the amount of rationing was decided on a daily basis, based on the deficit (projected demand minus available energy) computed the previous day. This environment precluded the use of monthly energy quotas as the mainstay of energy-saving efforts.

5.46 Energy-and-capacity crises have also been observed in some countries in Sub-Saharan Africa, where hydroelectricity is the predominant form of energy. In most cases, reservoirs are depleted at a very accelerated pace, resulting in a loss of head and consequent reduction in plant nominal capacity. Unfortunately, the operation of the power system and the use of water resources are not driven by economics (for example, the concept of value of water) or by good operational practices. They are simply driven by the country's need to postpone, as much as possible, the operation of thermal generation plants, due to a lack of financial resources to acquire expensive, often imported, fuel. That is the main reason why reservoirs become overdepleted, under the operator's expectation that the next rainy season can bring the necessary relief. If this expectation does not materialize, the country is then forced to buy fuel on a last-minute basis. However, combined hydro and thermal generation (even including the most expensive plants) is unlikely to be able to meet both peak and energy requirements. Thus, the system becomes both capacity- and energy-constrained. An optimal, more prudent operation of the power system would likely had recommended the use of thermal generation at earlier stages, therefore alleviating and perhaps even eliminating the lack of energy and capacity during the dry season.

Institutional Arrangements to Implement Rationing

5.47 The idea of centralizing all efforts under a single, high-level authority seems to be not only effective, but also necessary when a major crisis breaks out. That was the solution that Brazil adopted. It allowed all measures to be closely coordinated. For instance, the purchase of emergency power was linked to the savings achieved by the quota system, and its costs had to be defrayed by tariff increases. It was essential to have all of those decisions under the jurisdiction of one single, high-level committee. This committee also dealt with the breach of the contractual agreements and with the need to untangle a piecemeal legal and regulatory framework.

5.48 The drawback is that this excessive centralization of power preempts and undermines the authority of other government agencies in the power sector. Even in retrospect, however, it is difficult to imagine how a more decentralized decision-making process would have worked, given the prevailing circumstances of the power sector.

5.49 At the other end of the spectrum lies the California crisis, where many players had a say. The state regulatory agency and the Federal Energy Regulatory Commission (FERC) had different views on the causes of the crisis and how it should be handled. Responsibilities and accountability were not clear, and no single mechanism was in place to ensure proper harmonization and coordination of the multiple views. This convoluted decision-making process is one reason why an initially modest crisis, which could have been tamed with the introduction of effective demand response tools, gained such colossal proportions.

5.50 Centralization of decision making seems to be the way to go when the government has to handle a crisis. One option of minimizing the potential adverse impact on other institutions is to establish credible, transparent, and objective triggers for the pre-specified processes for entry to and exit from quotas. Such triggers not only reduce discretionary power from the government, but also call for immediate action when a crisis is imminent.

Results Achieved and Economic Consequences

5.51 In several of the cases analyzed, rationing measures in one form or another ended up being efficient in achieving the initially stated energy-saving objectives:

- In Brazil, electricity consumption was reduced by more than 20 percent during the crisis in the affected areas, in an orderly fashion;
- In California, there was no general collapse of supply, and the ISO was able to manage the crisis despite all the publicity;
- In Chile, after the blackouts of November 1998, service did not collapse, even though the crisis lasted until June 1999;
- In the Dominican Republic, the PRA was able to impose some discipline in the widespread, haphazard blackouts affecting the country, and was also able to provide a minimum of hours of reliable power for low-income customers.

5.52 Achieving the desired demand reduction targets is a very simplified way to measure the effectiveness of a rationing plan. The key issue is to minimize the impact of scarcity on the overall economy. In other words, the challenge for politicians and regulators is to assure that the scarce resource is allocated in the most effective way, which is seldom the case.

5.53 It is difficult to estimate the economic losses associated with a major crisis in the power sector. Studies on the economic impact of power rationing are scant in the literature. Some studies calculate the load shed, by attributing an opportunity cost to the non-served energy and deriving the total economic loss of the rationing based on the total amount of energy curtailed.

5.54 That is the way the impact of the U.S. blackout in August 2003 was calculated. Costs include loss in industrial production, unproductive time, costs to recover the entire power system, loss of revenues for utilities, and other cost impacts, which were estimated for the period when energy was curtailed. Any loss in production, revenues, or discomfort via-à-vis a certain baseline may be attributed to the crisis when evaluating its economic impact.

5.55 With a crisis of longer duration, when load is curtailed for several months in a row, it becomes more difficult to determine a reasonable baseline for comparison. For example, what would the GDP in Brazil be if rationing had not taken place for nine months? Over such a long period, multiple variables play a significant role. For example, between June 2001 and February 2002, the entire world was shaken by the 9/11 terrorist attack. Argentina, one of the traditional commercial partners of Brazil, declared default and entered into a deep economic crisis almost at the same time. To make things worse, the demise of Enron in December 2001 brought a lot of uncertainty and financial distress to the energy industry and to the U.S. stock market. Those are events that, even in the absence of rationing, could have resulted in a GDP decline. Brazil ended up experiencing modest GDP growth in the period. It is very difficult to know what the GDP growth would have been if the country had not suffered a power crisis.

5.56 There are as yet no comprehensive studies of the full impact of the 2001–2002 crisis on the Brazilian economy. Some very preliminary estimates indicate that the rationing was responsible for a 1 percent reduction in GDP. The reduction would have been 2 percent of GDP if rolling blackouts had been implemented in lieu of the quota mechanism. Those figures do not include taxpayer money spent by the government in providing financial support to the power industry. The figures also exclude the resources utilized by the government in providing bonuses to engage the poor in the conservation effort. Those issues will be discussed in detail in the next chapter.

5.57 In Chile, the estimates of the economic impact of the 1998–1999 crisis are relatively small, totaling about 0.2 percent of GDP for November 1998. This last figure does not include the full impact of the crisis on GDP, but only the loss corresponding to the reduction in the production of electricity.

5.58 The impact of a crisis of longer duration and chronic shortages of power is even more difficult to estimate. Lack of power can deter new investments, job creation, and economic development in general. In countries where the power system is not reliable, customers who can afford it invest in the installation of back-up generators, significantly increasing the cost of "doing business." For example, in the Dominican Republic, it is estimated that the capacity installed in back-up generation is about half of the capacity owned by utilities and IPPs. There is an implicit additional cost for those who want to have reliable access. The poor, who cannot afford this level of sophistication, are the ones mostly hit by an unreliable power system.

5.59 An interesting example of the consequences of an unreliable power system in India is presented in Box 5.1. It shows the complex interactions between reliable water, reliable power, and poverty.

Rationing and Power Sector Reform

5.60 The energy crises discussed in this document, particularly those in Brazil and California, had very serious consequences for the development of the power industry and its main institutions. Energy rationing is a traumatic event. In the eyes of the public, it puts into question the very laws, rules, and institutions that should be responsible for guaranteeing supply reliability. When "back to normal" happens after a serious energy crisis, it is not the same "normal" that existed before the crisis. Society is naturally more aware about the intricacies of the power sector and more cognizant that electricity supply is not as reliable as they had imagined. Rules and institutions are bound to change as a result of the crisis. In sum, the power system will likely be challenged and undergo change.

5.61 In the cases of Brazil and California, the power systems had been completely or partially reformed in the years preceding the rationing episodes. The crises represented a serious challenge for the reformed systems, both in terms of their ability to cope with the crisis and in terms of their ability to survive the actual and perceived blame that might be ascribed to them. Rules and institutions ended up being revisited as a direct result of the energy crisis.

5.62 In Brazil, a partially completed power sector reform, which had been contested politically and in the courts (each privatization was preceded by a legal battle, and some privatizations were effectively prevented), was further challenged by the crisis. Top government officials, during and immediately after the crisis, spent almost a year confirming the diagnostic for the crisis, reviewing the power sector reform blueprint, and implementing urgent actions that, for one reason or another, had been postponed in the period from 1999 until the beginning of the crisis. The crisis became an issue in the 2002 presidential election in Brazil, which was won by the opposition PT party. As a result, the new administration has gone through another round of sector reform, which will result in a much government-intensive, less market-based system.

Box 5.1: Shortages, Rationing Practices, and Poverty Alleviation in India [128]

Significant shortages in the supply of power, drinking water, and wastewater services exist across India. Power shortages are, to a large extent, due to highly subsidized energy prices, particularly for irrigation in the agricultural sector. Nationally, farmers consume 33 percent of the total power supply, while paying only 2.5 percent of its total revenues. Since farmers face little or no marginal electricity burden when pumping, they have little financial incentive for efficient use of water and power. Poor incentives have led over the years to underinvestment in the agricultural/rural power distribution grid and a chronic shortage of power.

Several consequences result from the poor quality of power. First, frequent electric motor burnouts of irrigation equipment occur, causing continual anguish to the farmer and leading to additional costs of having motors rewound. Secondly, farmers tend to select robust motors that have thicker armature coil windings and thus can withstand large current and localized heat generation without real coil burnout. From a farmer's viewpoint, a 10 hp motor operating under low voltage conditions is likely to perform as well as a 5 hp motor. However, the power system becomes more overloaded. Compounding the problem of poor quality of power is the issue associated with management of load by local substations. The local substations implement a power rationing process called "rostering," whereby power is rotated among farmers in two blocks of 4–8 hours per day. This system of power rationing causes undesirable practices to creep in that further increase system losses and affects power quality, and eventually leads to a system collapse. For example, a common practice is for farmers to keep their motor switches turned on in the hope that whenever the "rostering" schedule is in effect for a particular block of farmers, water is pumped. Ad hoc changes in the schedule have caused farmers to follow such practices, which lead to a number of pumps coming on together at the same time—a load demand diversity of near unity. This causes the transformer fuses to trip—or if those safety devices have been tampered with, the transformer will likely burn out. Restoration of power takes several days and sometimes weeks, further impacting farmers' financial situation.

In sum, lack of proper tariffs and incentives lead to a "vicious cycle" in energy and water use in agriculture, inefficient distribution systems with poor voltage profiles and high distribution losses result in motor burnouts. Low diversity factor caused by load shedding procedures in rural areas also result in a high rate of distribution transformer burnouts. As a result, customers are dissatisfied with the utility power supply and install high-capacity motors. Since they also have to incur expenditures on account of frequent motor rewinding, their operational expenditures escalate and they are reluctant to pay more to the utility on account of higher capacity motors. This leads to the use of violated nameplates on agricultural pump sets and resistance to tariff increases. Customers also resist metering of pump sets. Utility revenues deteriorate and fewer resources are available for maintenance and rehabilitation of distribution systems. This result in suboptimal planning and low quality of works, and further forces the utility to consider load shedding. The vicious cycle is completed.

Substantive research undertaken over the past two decades by Amartya Sen, Robert Chambers, and Thushaar Shah, among others, has demonstrated strong linkages between

[128] Adapted from Padmanaban (2001).

poverty alleviation and reliable access to power and water services. Without reliable water supplies, the risk associated with agricultural activities is quite high, since everything can be lost due to variations in precipitation. When droughts hit, farmers without access to reliable irrigation are often forced to migrate or sell their limited assets. This results in a continuing cycle of poverty. However, groundwater availability is relatively independent of recent fluctuations in rainfall, which makes groundwater irrigation advantageous when compared to surface irrigation as far as poverty alleviation is concerned. Groundwater irrigation will only be reliable if the power supplies are reliable. Poor quality and poor reliability of purchased power have forced farmers and other customers to install expensive back-up generation whenever they can afford it.

5.63 The California crisis had serious consequences inside and outside of the state. The commercial framework underwent major changes: the California Power Exchange (the major wholesale market) went bankrupt and ceased operating in January 2001. Another law, signed in May 2001, created the California Power Authority, with power to build, own, and operate electric power facilities. Finally, in September 2001, the California Public Utilities Commission suspended retail choice in California. Beyond California, retail competition initiatives were, in general, slowed down throughout the United States, except in Texas, which decided to pursue its power sector reform plan despite the California and Enron demises.

5.64 The Federal Energy Regulatory Commission has also been trying to accelerate the process of creating effective wholesale competition across the United States, and came up with a blueprint called Standard Market Design (SMD). The proposed market design embedded in SMD was a significant departure from the California model and had many of the features of some of the most successful power pools in the United States, such as PJM, NEPOOL, and NYPOOL. The jury is still out in terms of an ideal single market design in the United States. At any rate, both in the SMD blueprint and in some of the most successful power pools in the United States, the subject of demand response received much more attention from regulators and policymakers.

Government as a Buyer of Last Resort

5.65 In two of the cases analyzed in this document, namely California and Brazil, the government decided to play a significant role as a buyer of last resort, by securing new supplies in relatively short timeframes.

5.66 In February 2001 a law was signed authorizing California's Department of Water Resources (DWR) to purchase power under long-term contracts for sale to distribution utilities. The fact that the state itself began to play a role of an almost "single buyer" in a state with a long tradition for private participation gives an idea of the extent of the aftershocks provoked by the crisis.

5.67 In Brazil, the federal government decided to procure 2,100 MW of new thermal generation to operate as reserves. Contracts with durations ranging from two to three years were signed with private companies committed to installing those reserves in less than a one-year timeframe. The additional capacity was designed to work as a hedge or insurance in case the hydrological situation worsened.

5.68 Both the governments of Brazil and California were harshly criticized for their roles as buyers. In California, DWR signed contracts at extremely high prices. Some of them were subsequently renegotiated, raising doubts about contract sanctity. Contract prices were reduced as part of the renegotiation process. The state agreed to pay US$42 billion over 10 years at an average price of US$69/MWh, while estimates for the wholesale price of electricity were in the range of US$50/MWh.[129]

5.69 Despite contract renegotiations, there are still huge stranded costs to be paid either by the taxpayers or by the customers. The current US$8 billion budget deficit in California, which to some extent led to a State Government recall, is greatly due to the expenses incurred in the purchasing of energy. The lesson here seems to be to try not to solve immediate energy shortages with long-term contracts, as the (high) short-term prices will contaminate these contracts and bring long-term prices to levels higher than long-term costs, and probably will not contribute to the solution of the crisis at hand.

5.70 In Brazil, there was a lot of criticism about the form and the price of the government- procured reserves. In some instances, reserves were only available after the rationing was over. Prices were criticized as being too high, as they embedded a significant component of recovery for fixed investments, via a contractual capacity fee. Most of the reserves remained unused, but some of them proved to be extremely necessary in a subsequent shortage crisis in the Northeast.[130]

Transfers of Income

5.71 Power rationing often implies significant shifts in income among different stakeholders. End results are not always easy to predict. Solving post-rationing crises has proven to be more difficult than dealing with the blackouts and other physical aspects of the crisis. This has happened, for example, in Brazil, Chile, and California.

5.72 Rationing entailed a significant cost and revenue shift in Brazil. Electric utilities and independent hydro power producers suffered major financial losses during the crisis and in its aftermath. Distribution companies and generators saw their sales and profit margins shrink. Some hydro generators were not able to fulfill their contractual obligations and were supposed to procure the shortfall in the wholesale market at very high prices. Given the significant amounts involved, generators challenged rules and contracts. Consumers, in general, invested in conservation and learned how to use energy more efficiently; therefore reducing their consumption levels even after rationing was over. In most cases, the total electricity bill was also reduced for those customers not affected by the penalties for exceeding their quotas.

5.73 This change in consumption patterns aggravated the already precarious situation of the distribution companies post-rationing, maintaining their revenues at 1998 levels. Furthermore, the completion of several generation projects, some of them on an accelerated

[129] Taylor and VanDoren (2001).

[130] A similar situation happened in New Zealand, following the 2001 shortage crisis. The government acquired expensive back-up generation as a buyer of last resort. The expectation is the plants will never be needed to provide back-up.

schedule due to the crisis, produced a major supply overhang and a price drop in the spot and short-term market contract prices. Two years have already passed and there is excess capacity in the system, which will likely be sufficient to meet the country's needs for the next three years. The power sector is still trying to recover from this financial hardship.

5.74 Brazilian discos and generators were compensated for some of their losses during rationing. These compensations, which were part of the General Sector Agreement, represented a total amount of approximately R$8.2 billion, or about US$3–4 billion.[131] Even with these compensations, the financial situation of many distribution utilities remained precarious, and an additional R$3 billion was lent by the government's National Economic and Social Development Bank in order to keep them financially afloat. It is arguable to what extent those companies should (or should not) have been bailed out by the government. These issues will be explored in the next chapter. Despite this issue, it is beyond any doubt that rationing entailed significant losses to many players.

5.75 In California, there were two important income transfer effects. The first took place in the region of San Diego, where the local utility was initially authorized to pass through the cost of purchased power to its retail customers. Given the considerable increase in wholesale prices, tariffs to the final customer moved accordingly, resulting in politically unacceptable increases to end-users.[132] In other areas of the state, utilities were not authorized to pass through the increases in power purchase costs to the final customer. Actually, tariffs to end-users remained stable, at levels that had been frozen for 10 years, since reform took place. This mismatch between the price paid by the utility in the wholesale market and the amount allowed to be passed through to end-users had a devastating impact on the utilities' finances. PG&E, for example, considered one of the most solid utilities in the United States, filed for Chapter 11 bankruptcy. One reason that the state government stepped in as a single buyer was a desperate attempt to obtain power at lower costs. Prices paid in the contract market continued to be high, generating billions of dollars in stranded contracts as soon as the crisis was over. In 2005, this still represented a significant part of the state's public debt.

5.76 In Chile, hydro generators had to buy energy at very expensive prices, from inefficient thermal plants, to honor their commercial contracts. Changes in the regulation while the rationing crisis was going on eliminated some financial relief the generators expected, creating legal disputes. The subject was finally settled, but generators had to bear significant losses.

Regressive Taxation

5.77 There is another phenomenon associated to power crises, particularly in developing countries. However, its effects are not so conspicuous and do not manifest themselves immediately. The electricity bill paid by customers and the balance sheets of incumbent utilities are not impacted in the short term. This phenomenon happens when the

[131] The nature and breakdown of the compensation made to the Brazilian utilities were discussed in Chapter 4.
[132] Full pass-through was subsequently disallowed, since rates were capped.

government decides to provide financial support to "keep the lights on," either by subsidizing fuel or by providing it at no cost at all to the incumbent utilities.[133]

5.78 Despite the good intentions, this is a kind of subsidy that does not necessarily help those who will suffer most from the power crisis. In countries with very low electrification rates, such as in the Sub-Saharan region, where 10 percent or less of the total population has access to modern forms of energy, subsidizing the cost of electricity will benefit only a minor fraction of the population, usually the rich, to the detriment of the remaining 90 percent, usually the poor who do not benefit from the subsidies and are often the most vulnerable to the effects of the crisis. [134] The subsidies have a long-term effect on deteriorating the government's finances, crowding out public investments, and reducing the quality of social services such as health, education, and even food relief programs, if necessary.

5.79 Despite being an obviously perverse taxation scheme, subsidizing fuel has a strong political appeal because it avoids rolling blackouts, making customers, utilities, and their managers happy. To keep the lights on, governments prefer to run the most expensive reserve units, usually diesel fired, at a cost that may well exceed US$250/MWh. Despite being expensive, it may still be cheaper to subsidize fuels than allow rolling blackouts, politicians contend.

5.80 The fallacy of the argument is that a significant part of the demand may (and should) be reduced at a cost significantly lower than the most expensive generation units available. Those units ultimately set the marginal cost for each additional MWh of energy generated. It is likely that 10 to 15 percent of the country's demand, from which a large part is wasteful consumption, could be reduced at a cost lower than US$250/MWh. In most cases, there is a lot of inefficiency and wasteful consumption that may be reduced.

5.81 Self-rationing, combined with a well-designed price signal scheme, is the most efficient way to achieve demand reduction and therefore minimize the total cost of producing energy.[135] Therefore, the tradeoff is not between subsidizing versus rolling blackouts, as politicians contend, but between subsidizing wasteful consumption versus using energy more efficiently and avoiding the perverse taxation scheme.

5.82 Subsidies end up working in the very opposite direction intended. By artificially reducing the price of energy, governments invite customers to consume more, often leading to more wasteful use of energy. A demand increase, spurred by artificial prices, ends up requiring more energy production at increasingly higher marginal prices. Sometimes, new emergency units are also necessary, increasing the need for more investments and therefore subsidies.

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[133] This has been the approach followed by Tanzania in early 2004 and by the Dominican Republic in 2003.

[134] Contrary to what it may look like at first sight, the poor are also taxpayers, as they buy food, transportation, and services in general. The poor are also affected by a government's choking in public debt, crowding out public investments in health, education, and infrastructure.

[135] The reduction in the cost of producing energy derives from the fact that the most expensive generation units do not need to be dispatched under a sound demand-side management program. The statement on how much energy should be curtailed by self-rationing depends on the characteristics of the supply and demand curves.

Crisis Publicity

5.83 Crises get a lot of attention from the government, affected citizens, and the media. The general public becomes more cognizant of many of the power sector's weaknesses and tends to blame any reform that the sector has undergone for the negative consequences that led to a rationing crisis.

5.84 The "poster child" of publicity and press coverage is the crisis in California. As mentioned, no single event in the power sector worldwide attracted so much local and international attention. However, looking at the real number of customers who suffered rotating blackouts and how long the blackouts lasted, the impact of the crisis seems to be relatively negligible.

5.85 The crisis in California was perceived as a major failure of power sector reform, as portrayed in the media. However, successes of power sector reform never receive equivalent press coverage. The general public knows little about best practices in market design, such as the power pools in the U.S. Northeast, Nordic countries, Australia, Argentina, New Zealand, UK, and many others. Even in the specialized literature, failures get more attention than successes.

5.86 In addition to the obvious reason that the press covers more catastrophic events than examples of success, two other reasons may explain this information bias. The first is due to the assumption, by default, that lights should go on with a mere flip of a switch. Few people are interested in learning what happens to get lights on and how much it costs. Therefore, there is an implicit obligation from the utilities and from the government to deliver electricity services with no failures. If the lights are not kept on, something went terribly wrong, in the general public's views.

5.87 The second reason has to do with the definition of a baseline for comparison. What would have happened if the power sector had not been restructured and/or privatized? Could rationing be avoided? Delayed? Or perhaps the opposite? Given the difficulties of conceptualizing a hypothetical baseline scenario, people assume that rationing and crises are due to power sector reform, despite the countless number of countries that are suffering chronic blackouts because they had the chance to restructure their power sectors. This information bias will always be present. As a consequence, it will be more difficult for government, politicians, regulators, and the general public to understand the real nature of each crisis and be prepared to avoid future ones.

6

Comparison between the Quota System and Rolling Blackouts

6.1 Once a government has established that rationing is needed, it is faced with choosing what type of program to implement. As noted throughout this publication, a quota system can be efficient, effective, and equitable, particularly in an energy-constrained system. This chapter further compares countries' experiences with quota systems and with rolling blackouts.

Implementation Simplicity and Effectiveness

6.2 Blackouts are, at first sight, easier to implement and more effective than quota systems. They are often considered the "default solution," particularly when urgent measures are necessary in a crisis. Their apparent simplicity is misleading. More often than not, the distribution network is not automated, resulting in time-consuming on-off operation of circuit breakers and switch gears. Due to the need to preserve special loads, the disconnection of feeders at the substation level is rarely feasible, resulting in a very labor-intensive operation on the streets. Also, due to the complex nature of those operations, it becomes difficult for the utility to determine exactly the time when blackouts will start and end, unless they are applied to a geographically confined region, with no due regard to preferential loads.[136] Despite its apparent simplicity and support from the distribution utilities, this arrangement would be discriminatory and would likely be politically unacceptable in other jurisdictions.

6.3 Because preferential loads cannot be electrically isolated in most cases, and given the intermeshed nature of the distribution network, non-preferential loads hooked to the same feeders as preferential loads may simply be immune to any form of load shedding throughout the entire rationing period. This creates a perception of "free-riding" and absolute lack of fairness, reducing people's willingness to contribute by saving energy when it is available and to pay for service of sub-standard quality.

6.4 In capacity-constrained systems, there may be more organized ways to structure blackouts, such as implementing them on a rotating basis, as in California. Based on the day-

[136] This has been in most cases the approach used in the Dominican Republic, where the utilities shed load in designated slum areas defined by the Programa de Reducción de Apagones (PRA).

ahead weather forecasts, expected plant capacity availability, and transmission constraints, the independent system operator in California was able to determine the loss of load probability and the required reserve margin to operate the system at safe levels. If load shedding was necessary, a calendar was established ex ante and customers would be informed ahead of time which areas and for how long they would be subject to disconnection. The system worked relatively well.

6.5 However, it is worth remembering that blackouts were only called during a few days during the entire period of crisis in California. Load curtailment rarely exceeded 4 to 5 percent of the total state consumption at any given moment in time, and took place for a few hours. The social and economic consequences of more frequent and lasting rolling blackouts would be much more perverse if 20 to 25 percent of the load had to be shed for eight consecutive months in a very large region, as occurred in Brazil. Those consequences would still be more serious in large cities in developing countries, where crime rates, traffic jams, and other problems would skyrocket as a result of blackouts, even if announced far in advance. The poor level of preparedness of cities in developing countries to deal with major crises is a real issue that cannot be ignored.

Effectiveness of Blackouts in Energy-Constrained Systems

6.6 A subtle flaw of rolling blackouts is that they are likely to be very inefficient in energy- constrained systems like in Brazil. To make them work, it would be necessary to impose a significant burden to society in terms of an increasing number of hours without electricity. In energy-constrained systems, it is irrelevant whether or not the customer uses energy at peak or non-peak periods. What does matter is that, for any MWh used at any time of the day or week, "x" cubic meters of water are depleted from the reservoirs. Rolling blackouts are designed to interrupt service for some period of time. However, when the customer has the possibility to shift consumption (intra-day), a 20 percent target consumption reduction can no longer be achieved by curtailing customers five hours a day.[137]

6.7 To a large extent, load shift undermines the effectiveness of the rotating scheme. This is true for most energy-intensive loads, such as water heating, air conditioning, refrigeration, and use of appliances at the residential level. Similarly, industries could move production shifts to non-blackout periods.

6.8 Several additional hours of load shedding would have been necessary to achieve the desired savings. Preliminary calculations indicated that a curtailment of more than 16 hours a day would have been needed to achieve the reduction goals, which would imply significant production losses and discomfort.[138]

6.9 More elaborate studies developed by Eletropaulo and Bandeirante, the two largest utilities in the State of São Paulo, illustrate the complexities and ineffectiveness associated with the implementation of implementing of rolling black-outs, particularly if customers were assigned different consumption reduction targets. Box 6.1 spells out some of the practical issues involved.

[137] This is a simplified assumption only to illustrate the point. In reality, and regardless of the load shift effect, some priority loads are to be protected, which impose an additional curtailment period on non-priority loads.

[138] Preliminary analysis developed by Elektro Eletricidade e Serviços, a distribution utility in the State of Sao Paulo.

Box 6.1: Implementing a "Linear" Rolling Blackout in an Energy-Constrained System [139]

"The "selective" rolling blackouts, as initially proposed by the government, are impossible to execute, Mr. Borgh, a Vice-President of Eletropaulo contends.

It is impossible to shed load in an entire neighborhood and to maintain services to a hospital. This would only be feasible if the hospital had a dedicated feeder, such as Hospital de Clínicas, which is rarely the case. Most of the 340 hospitals are in the same feeders as other customers.

An example is the region of Lapa in the city of São Paulo. There are 14 feeders and each one is responsible for approximately 5,000 customers, including households, hospitals and shopping centers.

The city of São Paulo has 1,700 feeders. From those, 1,250 feeders serve "essential" customers, such as hospitals, health centers, police stations, prisons, fire stations, telephone and water services, and 327 intense care centers installed in households. If power is to be preserved to those customers, the remaining 450 feeders will have to have electricity shed for more than nine hours per day, 7 days a week".

"It would be impossible to reach the 20 percent savings target by shedding load for only 2-4 hours per day, as the government desires. Those 450 feeders cannot be further discriminated geographically", alleges Mr. Fernando Cunha from Eletropaulo. "It will have to include services to Capão Redondo (a poor neighborhood in the outskirts of São Paulo), as well as Higienópolis, where President Cardoso's apartment is located.

Traffic lights are not included as part of the "essential services." If those have to be classified as such, there will be no remaining feeders to be shut off".

"It will be even more difficult to achieve differentiated consumption targets per customer group, as proposed by the government. It is not possible to curtail 15 percent of consumption for the industrial customers, and 20 percent for residential ones. "If the government knows how to do it, they would better teach us," Mr. Borgh from Eletropaulo contends.
Source: Fernandez (2001).

6.10 Quota-based rationing usually performs much better than rolling blackouts in this regard. A few instances of the discomfort associated with rolling blackouts:

Fairness and Customer Motivation

6.11 At first sight, rationing via blackouts seems fair. After all, both the rich and the poor have to be equally bound by the rules. A pricing mechanism may seem unfair and discriminatory, due to the perception that it benefits the affluent and financially penalizes the

[139] Fernández (2001).

people who spend least. This wrong perception is part of the "conventional wisdom" about rationing energy.

6.12 The fallacy is that rolling blackouts are unfair to everyone, rich or poor. They do not give people the possibility to choose and allocate their resources where they think that the energy will give them greater wealth or well-being. Rolling blackouts do not give people the option to use or save. Even worse, some priority loads and critical installations, such as hospitals and police stations, need to be exempted from blackouts. As already mentioned, many of those loads are electrically intermeshed with non-priority loads. As blackouts cannot be assigned to individual consumers, but rather to relatively large groups of consumers, each of these critical installations would exempt its neighbors from the blackouts, with the net result that a significant portion of the consumers would never get disconnected. Therefore, the remaining consumers would have to bear the extra hours of blackouts, creating among them a perception of unfairness in a very visible way. Furthermore, this distinction between preferential and non-preferential loads is not as clear as it should be. The customer knows that this definition or its implementation is subject to nepotism and corruption.[140]

6.13 The quota system is more equitable because it gives people the option to choose how and when to consume energy. It is fair in the sense that whoever saves more, rich or poor, will receive an incentive, while those who do not will be penalized. Needless to say, a good quota system has to be designed in tandem with effective social protection for the poor. This is not an insurmountable difficulty, as witnessed by the success in Brazil.

6.14 In any rationing situation, a necessary condition for positive participation of the affected population is a perception that scarce resources are being allocated fairly among consumers, and that there are no "free riders." Each consumer has to have the necessary motivation to genuinely engage in the conservation effort. A consumer that feels that his or her individual efforts are making a difference and helping to solve the situation is usually motivated, even more so with a perception that everyone is involved. Financial incentives and penalties are a strong motivation factor, if customers perceive that they are fair, understandable, and directly linked to their conservation actions. In Brazil, individual consumers became conscious about their decisions and received the ensuing awards.

6.15 Rolling blackouts, in contrast, appear to be inherently incapable of inspiring motivation and probably taint any perception of fairness that the system may initially suggest. Furthermore, rolling blackouts create animosity, and some customers who usually pay their bills refuse to do so for a poor quality of service, when energy is not available when it is needed most. The issue of motivation appears to be even less amenable to solutions: in rolling blackouts consumers are passive in the energy-savings effort, and are not active savers of energy. The response of the population in Brazil, as well as the remarkable results achieved in terms of energy savings, is a clear example of the importance of motivation and engagement as a factor to the success of overcoming any energy crisis.

[140] The movie *Power Trip*, produced by Paul Devlin (www.powertripthemovie.com), illustrates some of the favoritism and nepotism taking place in the power sector in the country of Georgia, pre-privatization, to allocate blackouts among customers. Distribution feeders of influential citizens and politicians were identified at each substation and not subject to blackouts.

Allocative Efficiency

6.16 Rationing via quotas was a traditional way of allocating scarce resources in former Soviet-like planning regimes. It reflected an intrinsically flawed economic outcome: it implied that supply and demand had not "cleared" due to distortions in the pricing of a scarce commodity. In the power sector, the need to ration reflects, in most cases, distortions in how prices were determined. Had prices been freely set, rationing would be less likely to happen. However, this is not always possible, particularly in the noncompetitive segments of the industry. Since prices do not closely track marginal costs, some rationing or excess is a likely outcome.

6.17 If rationing has to be confronted, given the regulated, distorted price system at the outset, quotas become a necessary evil. They are necessary because there is no other comparable solution in terms of the effectiveness-fairness tradeoff and evil because no matter the virtues of the quota system, they are still an imperfect allocation process.

6.18 The quota allocation mechanism, in its purest sense, does not take into account people's willingness to pay. If everyone were to save exactly the same amount of energy necessary to balance supply and demand, quotas would be tantamount to a leftward shift on the aggregate demand curve. Despite not being a desirable outcome, it would still be a superior solution compared with rolling blackouts, since the customer would have the opportunity to make inter-temporal choices. However, a properly designed quota system may overcome some of its limitations by trying to mimic some conditions observed in real markets, in an attempt to make the allocation process far more effective.

6.19 The first step in making quotas more effective is to define differentiated baseline criteria by customer groups. By doing so, regulators try to allocate more energy to those who they perceive give energy a higher value. While the goal should be praised, this is still an administrative, not market allocation, mechanism. Regulators and policymakers do their best to second-guess customers' willingness to pay, but this is still a very crude approximation.

6.20 Second, once quotas have been differentiated based on the government's perception of value, further efficiency can be achieved if users are allowed to exchange energy allotments among themselves. In theory, customers with the highest willingness to pay (those to whom energy is more valuable) would be willing to buy from those willing to curtail load, if price rises above a certain threshold level. The quota-trading mechanism in Brazil had this objective of enhancing the initial grandfathering process by giving the market the possibility to self-correct the allocation process.

6.21 Some practical aspects of the quota-trading mechanism do not make it suitable for all classes of customers. For example, it is difficult to put in place processes and systems to allow mass market retail customers to exchange quotas. It is not impossible in the near future, considering the evolution in Internet trading and auctions, but certainly difficult to implement in such a short timeframe.

6.22 The third possibility is to extend the concept of competition, not simply between using versus conserving energy and by exchanging quotas, but also by giving customers the flexibility to look for the most effective combinations of production factors including investing in conservation, switching to other types of energy, self-producing (co-generation and other forms of distributed generation), and other measures.

6.23 There are other, subtle ways for regulators to build more flexibility into the system among customers who do not formally trade quotas, such as the way incentives and penalties are set. If there are both bonuses and penalties, people will perceive a range of possible consumption levels and adjust their usage patterns accordingly. This would lead to a more efficient allocation of energy than simply ruling that everyone had to reduce consumption by a percentage of the baseline. People would not feel discouraged to stop saving once they reached their quota allocation.

6.24 Furthermore, customers know that rules may be slightly stretched without necessarily incurring extreme penalties such as disconnection. This was to some extent the case in Brazil. The regulator and utilities publicly acknowledged that it was operationally impossible to disconnect all violators. Disconnections were decided either on a random or geographical basis and could not be carried out comprehensively. Given this leeway, some people would be willing to pay the financial penalties and exceed their quotas, while others would be motivated by continuous reductions in consumption. The end result was as if customers were notionally exchanging quotas among themselves. If the aggregate saving reductions targets are met, this flaw in the enforcement mechanism becomes beneficial, marginally contributing to a more efficient allocation of resources.[141]

Poor Metering, Billing, and Collection Systems

6.25 Quotas are in most cases a superior solution to rolling blackouts, but not always enforceable. An almost precondition of the quota system is the existence of minimally acceptable metering, billing, and collection systems. In a power sector lacking basic things such as meters, where fraud is rampant and where there is a culture of nonpayment of electricity, quotas can be of limited value, particularly if the enforcement mechanism relies on some form of financial penalties and incentives. In commercially distressed power systems, quotas may even compound the problem. If fraud is perceived as "socially acceptable" and not considered a crime, or if customers may be reconnected when caught conspicuously stealing energy without further consequences, or even if customers are not disconnected by not paying their bills, there will be implicit incentives for customers to increase energy theft and non-payments if their energy bill increases. This attitude will significantly undermine the effectiveness of the quota system.

6.26 Establishing quotas may be a fruitless exercise, unless there is control of the energy sold and invoiced, and a threat of disconnection or the payment of fines are perceived as credible propositions by the consumers. Commercially distressed systems represent an unfortunate situation where rolling blackouts, which should normally be the last resort, end up being the only alternative in the hands of policymakers and regulators.

Capacity- versus Energy-Constrained Systems

6.27 Quotas are less effective to handle capacity-constrained systems. With traditional, metering technology used in most countries for the great majority of customers, it becomes virtually impossible to determine the period of the day when a customer is saving (or using)

[141] This assumes correct pricing for energy on a marginal basis. If that is not the case, this loophole will create a bias towards higher average consumption.

energy. Traditional meters are able to measure total consumption accurately, but not peak consumption during a particular time of the day. Capacity-constrained systems require customers to change their behavior during a specific period during the day, and only during that period. Therefore, in the absence of adequate metering technology, it is virtually impossible to know when the customer is saving or using, and how to price accordingly. Other mechanisms would be necessary.

6.28 However, technology is becoming less of an issue. The costs of real-time metering, particularly for medium and large customers, are becoming progressively more affordable. Many jurisdictions are deploying interval metering on a massive scale. Also, in most restructured markets, there is a spot price that reflects the short-run marginal cost of energy at intervals that may range from five minutes to a few hours. Quotas in a capacity-constrained system with real-time pricing and interval metering may be as effective as quotas in energy-constrained systems.

6.29 In most of the Bank's client countries, it is difficult to conceive of a massive deployment of real-time metering or the structuring of efficient markets any time soon. However, this reality does not refute the merit or the potential of using quotas for capacity-constrained systems. A simplification of the metering and pricing systems may still be almost as effective. For example, interval meters can initially be deployed in large customers, and there can be a definition of the short-run marginal cost based on the least efficient plant expected to be dispatched, to serve as the basis for pricing during peak periods. Transaction costs can be reduced significantly, without materially hampering the effectiveness of the scheme.

Time to Design, Learn, and Internalize Quotas

6.30 Despite its shortfalls, a system of rotating blackouts can be established almost immediately. In contrast, setting up a quota system may take a few weeks, or even longer, particularly in countries with no experience in this kind of arrangement. Furthermore, it is unlikely to get all aspects of the system right at the outset. The system needs fine-tuning, often by trial and error. Unless there is a previous quota system in place that has been used successfully, strong preparation is always required. A country should not expect to implement a quota system immediately. Sometimes, a crisis cannot be anticipated. This was, for example, what happened in Japan in 2001, when 17 nuclear plants were shut off overnight due to potential safety hazards. However, it is worth noting that the period to design and implement a quota system can be greatly shortened with commitment and leadership at the highest echelons in the government. This was the case in Brazil, where the system was designed and became operational in less than a month, despite all the confusion, political opposition, and public outcry described in Chapter 4.

6.31 In a quota system, there is also a learning curve for most consumers to understand and react, until the system becomes fully effective. In the case of rolling blackouts, this is not an issue, since the customer is entirely passive as far as consumption decisions are concerned. The lag between the decision to set up a quota system and its full operation may entail delays in its effectiveness. Since consumers are billed monthly, there is a lag time between reading the meter and presenting the bill, when the first penalties and bonuses are really seen by the customer. Forty to 50 days, depending on the billing cycle, may elapse between the time that the crisis is announced and customers start feeling the effect of their consumption or savings decisions. The customer will not pay a bill until two months of consumption have elapsed.

6.32 In the case of Brazil, the lead time was significantly reduced through major media campaigns that conveyed an honest perception of the crisis, educated customers how to save energy, and even explained how to read their meters and control consumption on a weekly basis. The campaigns achieved remarkable results, even among low-educated people, who were able to systematically read their meters and evaluate if their targets could be achieved on a frequent basis.

Gaming the System

6.33 The transition from a purely regulated system (pre-rationing, with no consumption restrictions and regulated prices) to a partially deregulated one (quotas, whereby part of the consumption pays market prices) entails challenges for regulators. One such challenge is the possibility of customers “beating the crisis” by anticipating electricity consumption.

6.34 In Brazil, there is anecdotal evidence of industrial consumers scaling up production and stockpiling as soon as the possibility of rationing was announced, thus consuming more energy than normal just before rationing.[142] In others instances, gaming took place, but was based on wrong assumptions made by the customers. While the debate was still going on regarding the way to reduce load, many customers expeditiously started to acquire back-up generation, no-break systems, and other devices to minimize their losses under rolling blackouts. Speculation for legitimate reasons resulted in additional investment costs to those customers.

6.35 The best way to handle potential gaming and losses due to speculation is by having the government minimize the time to design and implement the rationing scheme, if possible, by giving clear and unambiguous messages on how and when rationing should start. To avoid consumption immediately before rationing influencing the determination of the quota per customer, it is advisable to define the historic baseline consumption a year or more back, making adjustments for seasonality and market growth, if appropriate.

Dealing with Crises in an Organized Way

6.36 There are some lessons to be learned, in order to give government and customers a unique opportunity to deal with crisis in a more organized, less painful way:

- It is very important to have an early warning system, with responsibility for warning clearly assigned to some entity;
- The rationing scheme should be ready *before* a crisis hits;
- There must be clear commercial rules that apply to energy crises;
- Price signals should be used if possible in allocating resources;

[142] This is one of the reasons (besides seasonality considerations) why the benchmark for quotas should be based on consumption one year before the fact.

- Time-sensitive tariffs and supporting technology should be deployed among large and medium-sized customers.

7

Special Topics and a Forward Approach

7.1 This chapter presents a hypothetical case illustrating how a rationing scheme based on quotas can work. Although simplified, it highlights the types of decisions that must be dealt by governments in order to optimize the use of scarce resources at the lowest possible cost to society. This chapter also discusses other innovative ways to set up quotas and looks at alternative tariff schemes now in use in France, South Africa, and the United States.

Designing a Simple Rationing Scheme

7.2 This section illustrates a simple application of a rationing scheme based on energy quotas assigned to individual customers. It is assumed that the enforcement mechanism relies on pecuniary penalties charged to customers who exceed their assigned quotas. For simplicity, it is also assumed that customers are allowed to exchange quotas, either via formal mechanisms or regulatory loopholes, as discussed before. Despite being a simple methodology, its application has the potential to produce very effective results.

7.3 The example assumes a hypothetical power sector that has seven generation plants, A to G, as depicted in Table 7.1. The generation costs per plant vary within a wide range, from US$20/MWh to US$250/MWh. Hydro plants are naturally the cheapest, while diesel-powered thermal plants are the most expensive and are designed to be used only to meet peak demand or when cheaper base-load plants, such as hydro, are unavailable (for example, due to low rainfall).

7.4 If average demand is equal to 3,400 MW, the least-cost solution recommends plants A, B, and C to be dispatched. If poor hydrological conditions lead to an over depletion of Plant A reservoirs, the country still has the option to run Plants B to G, which have a capacity of 3,450 MW. Needless to say, this is an expensive proposition, particularly due to the fact that the last MW of demand is served by the least-efficient plant at a cost of US$250/MWh.

Table 7.1: Existing Generation Plants and Least-Cost Dispatch

			Load Dispatched (MWh/h)				
Unit	Available Capacity (MWh/h)	Cost (US$/MWh)	3550	3400	3000	2600	2200
Load Curtailment			-4%	0%	12%	24%	35%
A – hydro (Unavailable)	2,000	15	0	0	0	0	0
B - hydro	1,000	20	1000	1000	1000	1000	1000
C – thermal - natural gas I	500	50	500	500	500	500	500
D – thermal - natural gas I	700	80	700	700	700	700	700
E – thermal fuel oil	350	120	350	350	350	350	0
F – termal fuel oil	300	180	300	300	300	50	0
G – termal diesel	700	250	700	550	150	0	0
				Base Case			

7.5 Given the high generation costs implicit in this very steep supply curve, the policymaker is confronted with the dilemma of meeting all demand at any cost or trying some form of rationing program. The answer to this question fundamentally depends on the value of electricity to society. If, on the margin, society is willing to pay more than the cost of the least efficient plant (US$250/MWh), there is no point in rationing energy as long as there is generation capacity, available fuel, and customers with financial resources to pay the full costs. However, if the foregone benefit is less than US$250/MWh (which is usually the case for modest levels of load shedding), it is certainly worth rationing.

7.6 Empirical analyses have shown that minor reductions in consumption (e.g., via self-rationing) can be achieved with relatively minimal loss of production or comfort from affected customers. Policymakers should pursue a rationing level where the marginal benefit of saving one MWh (cost of energy not delivered) is equal to the marginal benefit of having that MWh delivered. The cost of energy not delivered is the societal cost of deficit (or the cost of society's being deprived of that very same MWh) for that particular level of rationing.

7.7 Table 7.2 is an attempt to represent the marginal benefit of electricity, whose proxy is a "Cost of Deficit Curve," usually assumed for power system planning purposes. For energy rationing representing 400MWh/h of load curtailed, the cost of deficit (or the cost of the non-served energy) is US$50/MWh. This amount represents how much society would forego if that MWh is not made available. Therefore, it is equivalent to the customers' maximum willingness to pay. According to the same "Cost of Deficit Curve", for an energy rationing representing 1000MWh/h of load curtailed, the cost of deficit may be as high as US$150/MWh.

Table 7.2: Cost of Deficit

MWh/h Curtailed	Cost of Deficit (U$/MWh)
400	50
400 to 700	80
700 to 1,000	150
More than 1,000	200

(*) Proxy for willingness to pay

7.8 Table 7.3 illustrates the marginal costs of generation and deficit, for different levels of load. In this example, customers would not be willing to pay more than US$50 for the last MWh delivered. Therefore, it would not make sense to generate at a cost of US$250/MWh to serve the load in its entirety. A load reduction of 401 MWh/h would imply a marginal benefit of US$250/MWh (money not spent on generation costs) and a societal cost of US$80/MWh. Rationing is a feasible proposition. A load reduction equivalent to 800 MWh/h represents a marginal cost of generation of US$180/MWh and a cost of deficit of US$150/MWh..

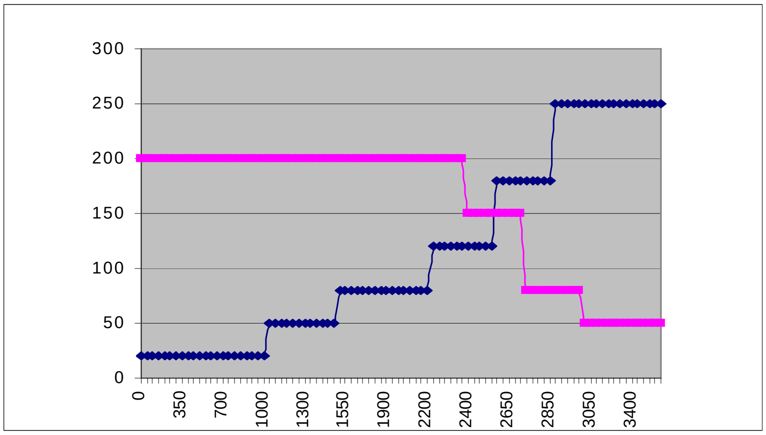
7.9 The optimal generation point occurs when the marginal cost of generation is equal to the marginal cost of deficit. According to Table 7.3, this happens for a generation level in the range between 2,400 to 2,600 MWh/, corresponding to a load shedding between 800 and 1,000 MWh/h.

Table 7.3: Marginal Cost of Generation and Cost of Deficit Curves

Load (MW)	3550	3400	3000	2850	2600	2400	2200
Load Reduction	-4%	0%	12%	16%	24%	29%	35%
Marginal Cost of Generation (U$/MWh)	250	250	250	180	180	120	80
Cost of Deficit (U$/MWh)	0	50	80	80	150	200	200

7.10 In Graph 7.1, the cost of generation is represented by a supply curve (in blue) and the cost of deficit by a price-elastic demand curve (in red). For the purposes of this exercise, the cost of deficit is the best available proxy to the demand for electricity. The optimal generation is given by the intersection of those supply and demand curves, corresponding to 2,550 MWh/h. Therefore, the optimal solution implies a rationing level of 850MWh/h, or about 25% of the existing load.

Graph 7.1: Supply and Demand Curves



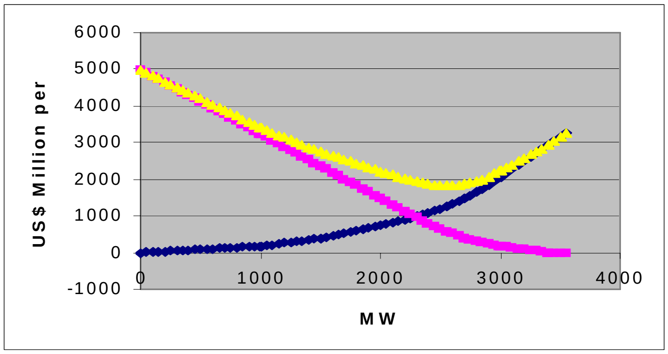
7.11 Table 7.4 presents the total costs of generation and costs of deficit for different levels of load being met. The optimal policy is the one minimizes the sum of the total costs of generation and the costs of deficit. As previously stated, it corresponds to a power rationing of 850 MWh/h. At this level, annual costs of generation are about US$1.25 billion, while costs of deficit are about US$583 million, totaling US$1.8 billion At the baseline consumption level of 3,400 MWh/h, with no rationing, the total cost exceeds than US$2.9 billion.

Table 7.4: Total Cost of Generation and Cost of Deficit

	Annual Generation and Deficit Costs (US$ Million)							Optimal Generation
Unit	Available Capacity (MWh/h)	Cost (US$/MWh)	3550	3400	3000	2600	2200	2550
Load Curtailment			-4%	0%	12%	24%	35%	25%
A – hydro (Unavailable)	2,000	15	$0	$0	$0	$0	$0	$0
B - hydro	1,000	20	$175	$175	$175	$175	$175	$175
C – thermal - natural gas I	500	50	$219	$219	$219	$219	$219	$219
D – thermal - natural gas I	700	80	$491	$491	$491	$491	$491	$491
E – thermal fuel oil	350	120	$368	$368	$368	$368	$0	$368
F – termal fuel oil	300	180	$473	$473	$473	$79	$0	$0
G – termal diesel	700	250	$1,533	$1,205	$329	$0	$0	$0
Generation Costs (US$ Million)			$3,259	$2,930	$2,054	$1,332	$885	$1,253
Cost of Deficit (US$ Million)			$0	$0	$175	$517	$1,130	$583
TOTAL ANNUAL COST (US$ Million)			$3,259	$2,930	$2,229	$1,849	$2,015	$1,836

7.12 Graph 7.2 plots the annual generation costs (blue), the costs of deficit (violet), and total cost (yellow), corresponding to different production levels (and therefore rationing). The optimal point is not the one where cost of total cost of generation is the same to the total cost of rationing, but where the respective marginal costs are equivalent.

Graph 7.2: Optimizing Cost of Generation & Cost of Deficit



7.13 The financial and economic equilibrium of the power sector is extremely sensitive to the rationing policy adopted. If the government prefers not to implement any rationing measure, the additional generation cost vis-à-vis the optimal load shedding policy may be as high as US$1.7 billion per year.[143] If, to make things worse, the government decides to keep tariffs frozen and not to implement any kind of conservation program, demand may further increase – either due to price elasticity or fuel substitution. Any increase over and above the baseline consumption represents a marginal generation cost of US$250/MWh. Given the "steepness" of the supply curve, the alternative of "doing nothing" represents a very expensive proposition in times of scarcity.

7.14 A more rational decision would be to mandate a rationing program based on quotas and economic signals. An average 25 percent reduction in consumption would imply a decrease in the generation costs from US$2.93 billion down to about US$1.25 billion. If the US$580 million societal cost is taken into account (cost of deficit), the net gain would still be US$1.1 billion. Given the magnitude of those figures, one can underscore the importance of a properly managed rationing program. Otherwise, the macro-economic consequences may be very severe for the country.

Should "Quotas" Be Permanent?

7.15 Several scholars and consultants have recently discussed the possibility of implementing variations of the quota-like system on a more frequent basis, even if crises are not present. The rationale is to expose customers (or part of their consumption) to the marginal price of energy at the wholesale level. The idea has not been implemented in any of the cases discussed in this paper, but it may be worth exploring further, given its potential application among the Bank's client countries.

7.16 The proposal is not only designed to deal with situations of scarcity, but also to entertain demand response in a broader sense, using price signals. Therefore, the underlying objective is not always to save energy, but also to use it in the most rational way. In times of

[143] For an additional cost of deficit of about US$600 million.

scarcity, when energy is expensive, customers should be given incentives to save. Conversely, if energy is abundant, customers should have incentives to boost usage, increase production, and substitute fuels. By responding to price signals in advance, customers would be contributing to mitigate or even in some cases avoid the necessity to implement drastic rationing measures. Implementation of this proposal may entail significant changes in the way energy is currently metered and prices are regulated.

7.17 The rationing scheme implemented in Brazil enabled a large number of customers to "see" the price signal for their consumption above (and in some cases below) their assigned quotas. The price of energy paid for consumption above the quotas, sometimes referred to as a "penalty," was similar to the cost of the energy in the wholesale market—therefore, the best available proxy for the cost of scarcity. Brazil's rationing scheme was not originally designed to deal with times of abundant energy. However, the concept could potentially have encompassed both shortage and scarcity occurrences. For example, if quotas had been maintained post-rationing, customers could hypothetically be allowed to buy energy above their quotas at short-run marginal costs, which were significantly lower than regulated prices. Industries could have benefited from a lower tariff by increasing their production and exports. Under a rigid regulatory tariff structure such as the one prevailing in Brazil and in most places, this kind of demand response would not have happened naturally.[144]

7.18 The quota system implemented in Brazil was extremely useful to deal with a crisis, but it is doubtful that it should be used on a permanent basis. Some necessary improvements would need to be addressed before broadening its application to non-crisis situations. The major problem is the definition of the quota itself. As mentioned, setting quotas on an administrative basis is unlikely to achieve an efficient outcome. Bureaucrats and regulators do not have the necessary clairvoyance to allocate a scarce resource based on their own perception of value to society. Furthermore, the regulated price of the energy within the quota is different from the market price, creating an equity issue, with important ramifications in terms of influence and lobbying. Customers would lobby to have larger quotas in times of scarcity and would try to reduce their allocated quotas otherwise. It would become very difficult for governments to manage this pressure, particularly given the economic cycles and the idiosyncrasies of each industry. Also, it would be difficult to define quotas new customers joining the system.

7.19 An alternative approach able to circumvent part of those problems is to ask the customers to build their baseline (Build Your Own Baseline, or a BYO approach). Customers would buy and own a certain amount of energy (their quotas) and would pay a fixed price per kWh for this negotiated tranche. For any consumption above (or below) this tranche, customers would pay (or receive) the short-run marginal cost for the energy. The incumbent utility (or the marketer) would play the role either of a net buyer or seller. In the latter role, the utility would buy the energy back from the customer who did not fully use his or her tranche of energy.

[144] Some special subsidized rates were implemented in the mid-1980s in Brazil to foster industrial customers to substitute electricity for oil products. This was in part due to a significant increase in international oil prices, as well as an excess capacity in the power system deriving from the commissioning of investments in hydro generation such as the 12.6 GW Itaipu Power Plant.

7.20 This pricing scheme would give customers the prerogative to decide about their desired level of consumption, and also allow them to hedge as much price risk as they want. Customers would receive the correct price signals to make contracting and consumption decisions. Contrary to the traditional two-part tariff, or even time-of-use (TOU) rates, the scheme leads to a much more proactive demand response, as the customer will always "see" the price signal on a marginal basis. Even if customers are fully hedged (contracted) for their entire power needs, they will still have incentives to conserve energy by selling their "long" positions to the incumbent utility or to any marketer.

7.21 The attractiveness of the scheme is that it is able to achieve two apparently contradictory objectives: first, to have customers hedging against extreme volatilities in short-run marginal costs (by contracting a fixed tranche); second, to assure that the customer "sees" the real cost of energy at any given point in time and for any consumption level, either above or below the negotiated tranche volume. This tariff regime, previously referred to as "permanent quotas," would allow power systems and customers as a whole to benefit from more active demand response, with positive results in terms of energy affordability and reliability for all.

7.22 Under retail competition, this scheme may be straightforward to implement. If sophisticated metering is available under retail competition, customers would receive correct pricing signals on a timely basis, and could even adjust their demand accordingly. Therefore, demand response would be more timely and efficient. If, in addition to real- time metering, the power system has the tools to provide some sort of price signals related to location (sometimes referred to as location marginal pricing, or LMP), a much more efficient demand response can be entertained, taking into account the time and space dimensions.[145]

Fixed Variable System (Fi/Va) [146]

7.23 The Fixed-Variable (Fi/Va) tariff system is based on the concept of Customer Base Load (CBL), or more appropriately, on the concept of the customer building his/her own baseline (BYO). [147] According to this scheme, the rate to be paid by a customer has two parts. In the first part, the customer would pay the existing rate for a pre-specified level of consumption (CBL). There are several ways to compute the CBL, the easiest being to set it equal to the average of the customer's past 12 months of usage. Alternately, the CBL might be negotiated between utility and consumer. In the variable part of the rate, the customer would be billed at the marginal cost of electricity. This would apply to increases or decreases in usage from the CBL. Thus, at the margin, the customer would see the true price of electricity. In other words, consumers would agree to purchase a specific amount of energy at fixed, regulated prices. Any additional consumption would be priced at a variable, pre-determined "market" price set each month, and any reduction in consumption would be credited at the variable "market" price.

7.24 The Fi/Va system is a superior approach to the traditional administratively set quota mechanism set forth in Brazil, to the extent that quotas reflect each customer's

[145] The discussion about the prerequisites and benefits in implementing LMP goes beyond the scope of this paper. It constitutes an ideal pricing system to be pursued by power sectors worldwide. However, countries have to be aware of the complexity of implementing such a scheme, and costs and benefits should be carefully weighed.
[146] Adapted from Faruqui (2004).
[147] Parmesano (2003).

consumption and risk preferences. Needless to say, it would not be practical to try to implement any form of quota negotiation in times of rationing, since the customer would know, ex ante, about the differences between the regulated and deregulated prices and would try to artificially jack up the CBL to maximize short-term arbitrage opportunities. The advantage of the Fi/Va approach over Real-Time Pricing (RTP) is its simplicity and the fact that it does not involve a change in the customer's meter. It is possible for customers to signal their willingness to adjust their usage to both rising and declining prices without fancy meters. However, unless real-time metering is deployed, the approach will not be very effective to deal with capacity-constrained systems, but only with energy-constrained ones. This is because customers have the same incentive to reduce usage at the time of the system peak and at all other times. California's 20/20 program, implemented during the 2001 crisis, bore some resemblance: it gave customers a credit of 20 percent on their monthly bill if they were able to reduce their monthly usage by 20 percent.

7.25 The Fi/Va idea is promising, but may present some implementation difficulties that have not been tested in the field. A possible obstacle to the success of such a system, particularly for mass retail customers, is to make sure that they engage and make conscious decisions about their expected consumption, as opposed to simply opting out. Wrong contractual decisions would likely overexpose customers to the short-run marginal cost, creating, in the eyes of customers and regulators, undesirable volatility that may undermine the entire program. It would also entail a more complex administrative process to enable customers to contract (or re-contract) their desired volumes of energy. Despite these difficulties, which by no means seem to be insurmountable, the proposed scheme would give all the benefits of an "enhanced quota system," in a more elegant, market-based approach. Special arrangements have to be made to deal with new customers.

7.26 It is certainly an idea to be further explored by regulators who are interested in re-examining the conventional tariff system in order to foster energy conservation without necessarily increasing average tariff levels.

Innovative Tariff Systems—Successful Case Studies

7.27 It is possible to implement tariff schemes that can entertain demand response in very effective ways, even in the absence of retail competition, by designing mechanisms that raise prices when energy is expensive and reduce prices when it is cheap. Such tariff schemes can be implemented at any stage of power sector reform. The first stage involves the introduction of Time of Use (TOU) tariffs, usually for large customers. Despite being an important step, TOU tariffs do not properly reflect any short-term variation in the supply-demand balance. They are not designed to capture or price extremely critical periods, when demand response is most needed. Even if price is set on an ex-post basis, TOU tariffs are of little value: if applied in California, they would have been able to capture only about 20 percent of the variation in the day-ahead market price. TOU fails to send the information that customers need to make load adjustments on a timely basis.[148]

7.28 They may target any class of customers, ranging from the residential to the commercial to the industrial class. More often, they begin with the industrial class, particularly

[148] Borenstein, Jaske and Rosenfeld (2002).

by targeting large customers. Reasons are two-fold: first, a few large customers are more likely to have a significant impact on demand response, therefore reducing implementation and transactional costs; second, cost of metering represents a minor fraction of a large customer's total bill.

7.29 Successful experiences do exist internationally, not only for large industrial customers, but also in the mass retail market. The subject goes beyond the scope of this paper, but a few interesting international cases are worth mentioning: EDF in France, Georgia Power in the United States, and ESKOM in South Africa. In those jurisdictions, aggressive and successful demand programs were implemented by vertically integrated companies, in an environment with no retail competition.[149]

France: The TEMPO Tariff

7.30 EDF, the state owned utility in France, runs one of the most successful demand response programs for residential customers, called TEMPO. It was introduced in 1993 and currently encompasses about 120,000 residential customers. TEMPO relies on a TOU design combined with a critical peak pricing (PCP) tariff system.

7.31 TEMPO customers are on TOU prices and are expected to face very high prices during the most expensive 100 hours of the day. The year is divided into three types of days, named after the colors of the French flag. Blue are the most numerous (300) and the least expensive; white days are the next most numerous (43) and mid-range in price; and red days are the least numerous (22) and the most expensive. The ratio of prices between the most expensive time period (red peak hours) and the least expensive time period (blue off-peak hours) is about fifteen, reflecting the corresponding ratio in the marginal cost to serve the load. Customers can learn what color will take effect the next day by checking a variety of media sources (Internet, e-mail subscription, phone, and TEMPO-specific technologies), therefore adjusting their consumption pattern accordingly.

South Africa: Real-Time Pricing

7.32 Real-time pricing (RTP) rates are also used by ESKOM, the state-owned utility in South Africa, for its largest customers, including the fabled gold mines. ESKOM has 1,400 MW of load on day-ahead RTP. These customers drop their load by 350–400 MW for up to three consecutive hours when faced with high prices. While RTP is set up on a day-ahead basis, customer response is not used to optimize the dispatch of the power system.

7.33 Electricity prices are based on the Pool Output Price and do not change in response to changes in customer demand that may be induced by RTP. The utility is not aggressively marketing the program for this reason. It hopes that once a competitive energy market has been created, with a functioning Power Exchange, RTP will then be able to play its proper role in system operations.

[149] Adapted from Faruqui (forthcoming).

United States: Georgia Power

7.34 Utilities in the southeastern United States have implemented RTP prices for about 2,000 customers, on a day-ahead or hour-ahead basis. Those companies include Georgia Power, Duke Power, and the Tennessee Valley Authority.

7.35 Georgia Power runs the world's largest and possibly the most successful RTP program. The company estimates that during emergency conditions, its customers drop demand by 17 percent, freeing up 800 MW of capacity. A load drop of this magnitude eliminates the need for several expensive power plants that would otherwise be needed for meeting the peak load for a few hours.

7.36 Georgia law permits customers with 900 kW or more of connected load to put their load out to bid and be served by any supplier in the state. In part to increase its competitiveness, Georgia Power began looking into RTP. In 1992 it began a two-year controlled pilot working with customers to curtail load in an organized fashion when needed to balance supply and demand.

7.37 Georgia Power has a two-part RTP tariff. Customers are billed for "baseline" use at their standard rate, and pay (or receive credits) for energy used above (or below) the baseline each hour at the hourly price. The hourly price is composed of a measure of marginal energy costs, line losses, a "risk recovery factor" (a fixed adder), and—near peaks—marginal transmission costs and outage cost estimates. Marginal transmission costs are triggered by load and temperature. Outage cost estimates are based on loss of load probabilities, as well as customer surveys on the costs of having an outage.

7.38 Georgia Power offers a "day-ahead" program, in which customers are notified of price schedules by 4 p.m. the day before they go into effect, and an "hour-ahead" program, in which customers are given an hour's notice on price. Currently, interruptible customers are served on the hour-ahead program. These customers' Consumption Base Load drops to their firm contract level during periods of interruption. Customers who do not interrupt to their firm levels pay interruption penalties plus the hourly prices. The utility has filed to allow interruptible customers on the day-ahead rate as well.

7.39 Georgia Power offers a variety of products that allow customers to influence their exposure to RTP price risk. One product, the adjustable CBL, allows customers to temporarily adjust their CBLs. For example, if customers want to lower their exposure to price volatility, they would increase CBLs. Customers wanting to raise their CBLs must be on the RTP rate for one year, so that Georgia Power can determine how high the CBL can be raised. Customers wanting to expose more loads to real-time prices—presumably because they believe it will be a cool summer—can lower their CBLs. Of the roughly 1,650 customers on RTP, 600 currently have adjustable CBLs. About 60 percent of the incremental energy sold on the RTP rate (i.e., usage above baseline) is now protected by this product.

7.40 Georgia Power also offers a variety of financial products to limit customers' exposure to RTP price volatility. These products include price caps, contracts for differences, collars, index swaps, and index caps.[150] Georgia Power has sold these Price Protection Products (PPPs) for three years. It currently has 250 contracts with about 90 customers. (Customers have multiple contracts to cover different time periods.) Georgia Power believes that offering these products has probably not increased the number of customers on the RTP program, but it has increased customer satisfaction. The utility has examined whether offering PPPs has dampened price responsiveness and found no evidence of this.

7.41 Georgia Pacific has also found that intense manufacturers, such as chemical and pulp and paper companies, are generally the most price-responsive customers. It also learned that some commercial customers would respond to price. Office buildings, universities, grocery stores, and even a hospital (that changes cooling chiller use based on hourly prices) are all responsive to real-time pricing.

7.42 Georgia Power's experience highlights that RTP can deliver substantial peak savings, despite the fact that many customers are not very responsive to price. When the hourly price reached US$6.40/kWh, Georgia Power saw 850 MW of load reduction (out of 1,500–2,000 MW of incremental or above-baseline load) from its RTP customers. Georgia Power also believes that customers have responded to the availability of low off-peak prices by expanding in Georgia.

Interval Metering

7.43 Interval metering represents an important technological development to foster demand-response programs. This technology enables customers to see the prices on a real-time basis and react accordingly. Therefore, the concept of quotas (CBLs or BYOs) can be effective to deal both with capacity- and energy-constrained systems.

7.44 Several time-sensitive load curtailment programs or dynamic pricing programs have been recently introduced in the United States. Load curtailment programs that target the very largest customers can be established to introduce price responsiveness in the marketplace. Dynamic pricing programs can target all customer classes. Sometimes those programs are mandatory, or sometimes the new tariff systems are offered to customers on an opt-in basis.

7.45 In Australia and in two large provinces in Canada, regulators have concluded that interval metering even for residential and small business customers is essential to the efficient functioning of the power market. Ontario, Canada, has decided to deploy about 800,000 smart meters in homes by 2007 and to have universal deployment in five years time.

7.46 In an address to the Ontario Legislative Assembly in spring 2004, Premier McGuinty signaled his government's intent to price electricity more rationally by installing "a smart electricity meter in 800,000 Ontario homes by 2007… and in each and every Ontario home by 2010." These smart meters, "combined with more flexible pricing," would provide an

[150] Georgia Power's price-cap product guarantees that average RTP prices over a specific time period will not go above the cap. Its contract for differences gives a fixed price guarantee on the average RTP price. The collar has a cap and floor on the average RTP price over a specific time period. The index swap is a financial agreement that ties the RTP price to a commodity price index. If the commodity price index increases, so does the RTP price. If it decreases, so does the RTP price. The index cap is a financial agreement that ties an RTP price cap to a commodity price index. As the commodity price increases or decreases, so does the price cap.

economic incentive for consumers to reduce energy consumption during the peak hours of the summer season when the cost of generating electricity is much higher than at other times of the year.[151]

7.47 In a similar vein, the province of Victoria, Australia, has determined that "interval meters enable retailers and customers to measure real time electricity consumption and to send and respond to the cost-related price signals that are essential for the market responses needed to underpin more sustainable and efficient energy supply and consumption practices and patterns." [152] The Essential Service Commission of Victoria has stated that all large customers consuming greater than 160 MWh will have interval meters by 2008 and customers, including residential customers, by 2013.

Revisiting Electricity Lifeline Rates to Achieve Energy Conservation

7.48 In many countries, energy subsidies utilize far more resources than those devoted to food or other commodities. This was the case in the countries of the former Soviet Union and Eastern Europe.[153] It is commonly accepted that the most practical way to provide power subsidies to the poor is through a mechanism called inverted block tariffs, which means that the prices charged for the first blocks of consumption are subsidized. As individual consumption increases, subsidies are gradually eliminated. The first block of consumption varies a lot country by country. It may range from 50 kWh up to 2,200 kWh per month per customer. The subsidies granted also vary significantly, but there may be cases in which the unit cost of the kWh in the first block of consumption may be as low as 20 percent of the long-run marginal cost of energy. Often, there are several subsidized blocks and other mechanisms to provide better targeting with a minimum leakage to the non-needy. This kind of lifeline rate, based on increasing block tariffs, has been praised and widely adopted for providing the best tradeoff between adequate targeting and administrative simplicity.

7.49 Despite the system's undeniable merits in terms of simplicity of implementation, less attention has been given to the disincentives created by the extremely high energy subsidies in the first consumption bracket (s). Selling energy at one-third or one-fourth of the marginal cost significantly impacts consumption decisions. This aspect has been ignored in many of the discussions about subsidies in the power sector. Usually the debate centers on the definition of the bracket structure and on the level of subsidies. Not much has been said and done in terms of looking for alternative ways to grant the subsidies to avoid wasteful use of resources.

7.50 The experiences in Brazil, where low-income customers significantly cut their consumption in response to price signals (bonuses) and in the Dominican Republic, where PRA qualified customers increased their consumption when meters were removed, show unequivocally that much demand response can be harnessed, even among the lowest- income customers.

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[151] For the complete text of the April 19, 2004 speech to the Ontario Legislative Assembly, go to http://www.premier.gov.on.ca/english/news/Energy041904_speech.asp.

[152] Essential Services Commission, "Mandatory Rollout of Interval Meters for Electricity Customers: Final Decision," Melbourne, July 2004.

[153] World Bank, 2000. "Maintaining Utility Services for the Poor: Policies and Practices in Central and Eastern Europe and the Former Soviet Union." Europe and Central Asia Region. Processed.

7.51 The issue then becomes how to find new, creative ways to provide those subsidies without muting the price signals for efficient energy usage. A thorough analysis of the subsidies in the power sector goes beyond the scope of this paper. The objective here is simply to show that it is possible to reconcile the goals of providing a well-targeted safety net and giving proper price signals for energy conservation. The safety net system in Brazil during the rationing crisis was an initial attempt to reconcile those objectives and has accomplished significant results. It unveiled the unexpected demand response potential among low-income users. The same system may be applied in other jurisdictions faced with similar challenges when dealing with energy-constrained systems.

7.52 On a permanent basis, other, more elegant solutions have been proposed, including the provision of fixed rebates or "voucher" schemes. In all cases, the customer is metered. However, the subsidies are not embedded in the tariff structure, but are granted separately. Therefore, there are no subsidized consumption brackets, and the customer in theory "sees" the real price of energy from the first kWh of energy consumed. There are a few, recent empirical experiences of use of rebates in the power and water sectors. Preliminary results have been very promising, both in terms of correct targeting and incentives to rational use of energy. Some design issues still need to be further investigated and tested.

7.53 One criticism of the voucher/fixed rebate system is that it is administratively more complex, as the policymaker has to identify, ex ante, the target population using exogenous, socioeconomic criteria. The inverted block tariff system used today, albeit imperfect, is relatively straightforward since it is based on total metered consumption or on the region where the customer is located.[154]

7.54 While this argument is legitimate, it may be worth pointing out that several countries have already moved towards subsidy schemes that rely on ex-ante identification of beneficiaries based on their socioeconomic characteristics, or are in the process of doing so. This has been the case in Brazil for the last few years, where subsidies for primary scholarship, children's food, and even liquefied petroleum gas have been granted on a common eligibility criteria basis. Under the current administration, some additional benefits have been provided and consolidated into a single package, called the "Bolsa Família." Leveraging on the mechanism to provide subsidies for power is a relatively simple and costless exercise.[155]

ISO-Sponsored Programs

7.55 Experience has clearly and unequivocally demonstrated that demand-side response is perhaps the only short-term competitive discipline available to moderate escalating prices. It also has long-term beneficial effects. In the United States, for example, power pools

[154] This statement does not hold in the absence of metering.

[155] Interestingly enough, despite the success of the target subsidies, mechanisms created by the previous government and expanded by the current administration, no consideration has ever been given to use the same subsidy scheme in electricity, despite the definition of beneficiaries being based on the same target population. An additional advantage, as far as targeting is concerned, is that the subsidies for energy could be granted not only to the population who is currently connected, but also to the 10+ million inhabitants who have no access to modern fuels, but still spend a significant part of their income to pay for other forms of energy such as wood, charcoal, and kerosene.

like California Independent System Operator, PJM, New England, and other regional market operators are in the process of opening up their bidding systems to allow for the demand side to bid against supply-side options. There is considerable consensus among energy economists that taking such steps will help make the market more competitive, reliable, and capable of disciplining prices.

7.56 Market operators are counting on demand response for adequacy and reliability and taking strong leadership to launch such programs, in orchestration with regulators, consumers, and local utilities. Several programs have been successfully operating in the United States for the last couple of years. There is some variation in program design, but in essence they attempt to attract sufficient demand response to deal with contingencies or temporary lack of sufficient capacity and reserves. Table 7.5 provides examples of the three types of demand side management programs developed by the Independent System Operator in New York. Customers have actively engaged in the program and are aware of the critical situation that could develop without programs like these. The programs help keep prices reasonable during high electric demand. Customers understand the inherent value in developing good energy management habits.

7.57 Payments for load curtailment (on a voluntary or compulsory basis) depend on the nature of the program and on how critical systems conditions are at each moment in time. Some forms of programs provide payments that are contingent upon the load's location, the rationale being that it is much more valuable for the system that a customer in a "load-pocket," such as in New York City, shed its load than a customer located in a place next to a generation source. The pricing system in the northeastern states in the United States, based on locational marginal pricing (LMP), correctly allows the ISO to provide differentiated payments in time and space based on the criticality of the power system—here including both generation loss of load probability and transmission constraints.

Table 7.5: Load Management Programs in New York

New York Independent System Operator Load Management Programs

Year 2002 Results

Program Name	Description	Customers Engaged	MW or MWh Offered	Prices Paid	Resources Involved
Emergency Demand Response Program (EDRP)	Short-notice program relying on the ability of many to voluntarily reduce their demand for a short period of time, in exchange for payment	1700	650 MW	Higher of U$ 500/MWh or the spot price	US$ 3.5 million
Day-Ahead Demand Respose Program (DADRP)	Customer-initiated econonomic bidding program, where participants offer their load reduction into the wholesale market one day in advance	Retail Electricity Customers	1,468 MWh of load reduction bids accepted	Average of U$ 68/MWh, differentiated in time and space	> U$$ 100,000
Installed Capacity Special Case Resources (ICAP SCR)	Reserve capacity program that contracts resources to meet NYISO supply requirements over a specific contract period	Retail Electricity Customers, committing a minimum load reduction of 100 kW	650 MW of registered capacity	Monthly payment ranged from US$ 1.15/Mwh Statewide to US$ 6.5/MWh in New York City	N/A

Source: Keep the Power Flowing with Three Electric Load-Management Programs. New York State Energy and Development Authority. Demand Reponse program Primer. 2003 Season. www.nyiso.com/services/documents/manuals

Price and Quantity Rationing Combined—A Promising Approach

7.58 Very recent experiences developed in the State of California on a pilot basis have shown that the most effective ways to deal with power shortages involve a careful combination of demand side actions in terms of both price and quantity rationing.

7.59 Table 7.6 conceptually illustrates some few possibilities in terms of price and quantity rationing. The “quantity” dimension herein alluded does not bear any resemblance to the mandatory and often ad-hoc blackouts described earlier in this document. Quantity rationing refers to the fact that the system operator (or the utility) agrees with the customer to shed its load or ask him to do so upon certainly previously agreed-upon terms and conditions. One typical example is the use of “interruptible rates,” whereby the client specifies a certain desired level of adequacy and pays accordingly. If energy is scarce, those customers are the first ones required to shed load. Contrary to the rolling blackouts, there is nothing administratively imposed on the customers, but the agreed volumes and rates simply reflect their own, individual consumption preferences.

Table 7.6: Price and Quantity Rationing Schemes in California

Price and Quantity Rationing Schemes in California

Price Rationing Programs	* Real Time Pricing * Time of Use/Day Rates * Critical Peak Pricing * Price Dispatched Curtailable plans	* Customer friendly; less intrusive * Linked to market prices
Quantity Rationing Programs	* Interruptible Rates * Curtailable Rates * Direct Load Control Programs	* Used when the [perception of] certainty of reducing load is critical * Metering costs can be lower

Source: PRL Webinar. Presentation by UtiliPoint International. September 26, 2004.

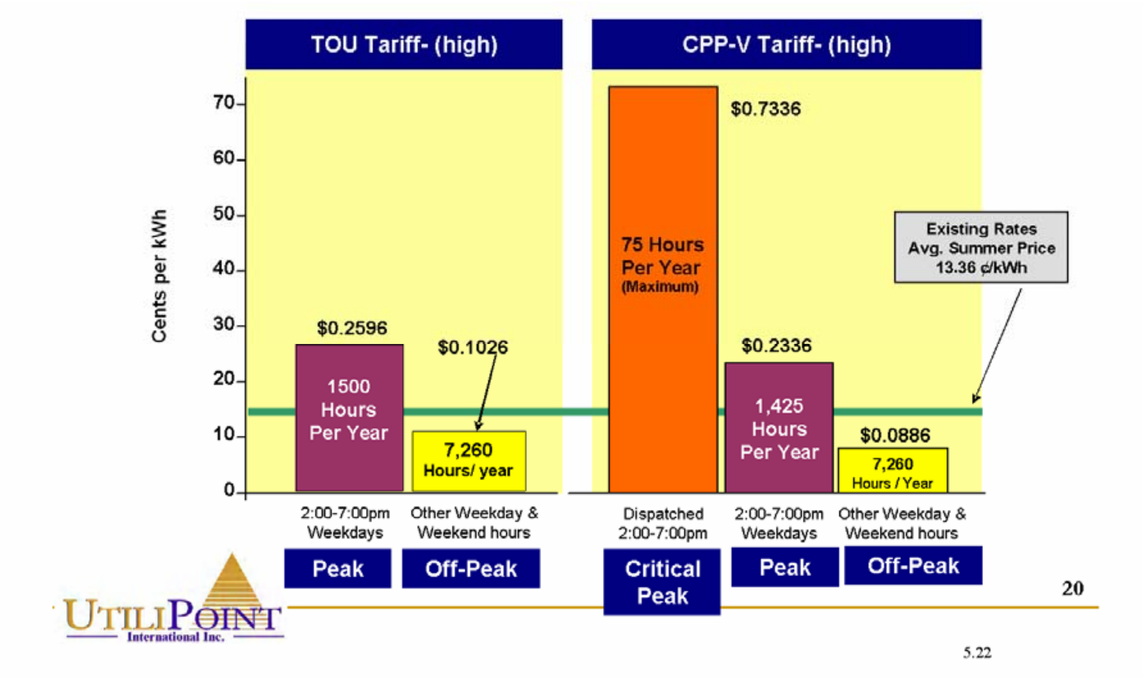
7.60 Approximately 2,500 users from different consumption categories participated in a landmark cooperative joint-venture pilot carried out in 2003, involving three major utilities in California, SCE, PG&E, and SDG&E. The objective of the experiment was to show that even mass market customers are able to respond to prices by reducing their demand in a meaningful way. To be sustainable, this reduction has to benefit the customer and the utility, in a kind of "win-win" approach.

7.61 The approach encompassed several tariff schemes designed to properly convey the costs of scarcity. When the program was launched, an inverted tier type of tariff was already in place, whereby rates increased in stages based on monthly usage. Three experimental rates were layered on the top of those inverted tier rates:

- Time of Use (TOU): applicable statewide, with seasonal, different rates for fixed on-peak and off-peak time periods;
- Critical Peak Fixed (CPP-F): also applicable statewide, as a variation of TOU with an additional "critical peak" price that could be dispatched during the peak period for up to 15 times each year, with day-ahead notice;
- Critical Peak Variable (CPP-V): applicable to target populations only, where participants were already linked to existing thermostat pilots. CPP-V is a variation of CPP-F, in which the critical peak price can be dispatched during the peak period for two to five hours, with four-hour advance notice.

7.62 Price differentials between CPP-V and TOU were noteworthy. Those differentials were purposefully designed to entertain a more aggressive demand response. Graph 7.3 provides examples of TOU and CPP-V tariffs for residential customers.

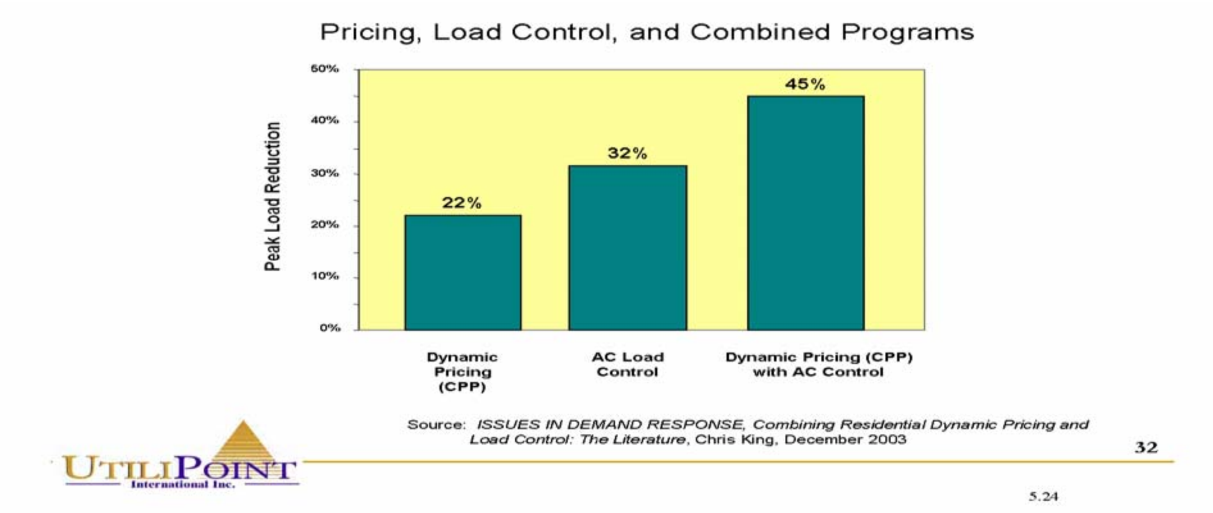
Graph 7.3: TOU and CPP-V Tariffs for Residential Customers in California



Source: PRL Webinar (2004)

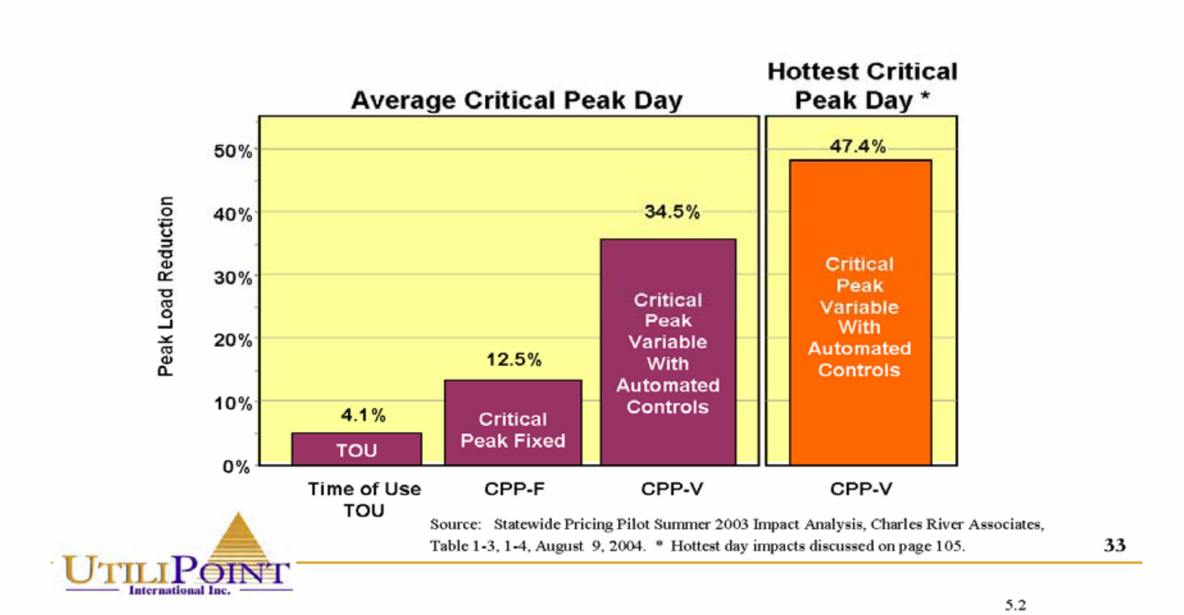
7.63 The average energy price for the summer was US$133.6/MWh in both cases. However, while the price range for TOU varied from US$102.6/MWh up to US$259.6/MWh (about a 1:2.5 ratio), the range for CPP-V ranged from US$88.6/MWh up to US$733.6/MWh (about a 1:9 ratio). The results of the experiment in terms of demand response and load reduction were remarkable. The combination of price and quantity rationing proved extremely effective, as shown in Graph 7.4. When critical price period tariffs (price rationing) were implemented in isolation, a 22 percent load reduction was achieved. With air conditioning (AC) load control, about 32 percent was achieved. With both combined, the total reduction reached 45 percent of the base-load.

Graph 7.4: Effectiveness of Price and Quantity Rationing in Reducing Peak Load



7.64 Graph 7.5 illustrates the increasing effectiveness of the TOU, CPP-F, and CPP-V (which combines both price and quantity rationing) rates. While in an average critical period day, TOU tariffs were able to only reduce 4.1 percent of load, CPP-V was able to reduce load by 34.5 percent. The scheme becomes more effective under extremely critical circumstances, as the pricing reflects the cost of scarcity in the wholesale market. Therefore, on the hottest day in the summer, 47 percent of the load was reduced, corresponding to almost half of the baseline. Again, results show the remarkable efficiency of price and quantity rationing schemes combined.

Figure 7.5: Efficiency of Time of Use versus Critical Peak Pricing



8

Twelve Lessons about Implementing Power Rationing and Demand Response in a Sensible Way

8.1 Good examples and best practices of rationing power are few. The literature is sketchy in terms of empirical, real case studies. Perhaps because politicians and regulators avoid talking about the subject, let alone planning for it in advance. “Planning” for rationing creates a political perception of failure, usually difficult to be dealt with in the open, particularly when power sector reforms are being carried out. Recent important energy crises, such as in California and Brazil, have aroused interest in the subject, but lessons learned and best practices have not been disseminated as they should. In many of the Bank’s client countries, governments continue to handle crises in a last-minute, old-fashioned command-and-control way, as if rolling blackouts were the only possible resort.

8.2 By examining good and bad examples of countries’ handling their crises, a few lessons learned and recommendations have been extracted. Despite the idiosyncrasies of each jurisdiction and each crisis, they represent a body of acquired knowledge that may be applicable in a wide spectrum of circumstances.

Blackouts are the worst possible way to deal with electricity shortages.

8.3 Blackouts should be the last resort to deal with rationing crises, only after all other alternatives have been honestly exhausted and everything else has failed. Some blackouts may be more organized than others, but no matter how well designed and planned blackouts turn out to be, they fail for not providing choices to society on how to allocate a scarce resource in the most efficient way. Contrary to a generally accepted belief, blackouts are neither simple to implement nor effective. In energy-constrained systems, where intra-day load shift is possible, load has to be shed for a very large number of hours to render the mechanisms minimally effective. Social and economic consequences of blackouts may be devastating.

There are smart ways to deal with shortages. Brazil is an example of an international best practice.

8.4 The example of Brazil represents a best practice in dealing with power shortages in energy-constrained systems. In a very short timeframe, Brazil was able to design an effective quota system combined with price signals to entertain demand response. The system was able to achieve a reduction of more than 20 percent of previous year’s consumption, on an almost country-wide basis, for nine consecutive months. No blackouts or brownouts were necessary. Some enhancements built into the systems, such as the possibility offered to some customers to trade quotas, as well as a well-designed safety net to protect the poor, enabled a broader engagement of all customer categories and a more efficient allocation of a scarce resource. A well-managed process and a constant and honest perception of the crisis were vital ingredients to the rationing program success.

Price signals work to entertain demand response and help bridge the supply–demand gap.

8.5 Common wisdom states that price elasticity is low in the power sector, particularly in the short term. Some successful experiences, such as the rationing in Brazil and the post-crisis in California, have shown unambiguously that there is a lot of price elasticity that can be harnessed to entertain demand response. The old belief that demand is price-inelastic results, in part, from years of regulated and, in many cases, subsidized tariffs, where correct price signals have been completely muted. Customers have not been given the chance to express their preferences in such a rigid environment. Empirical evidence in the last few years has unveiled the untapped potential of demand response, both at wholesale and retail levels, for virtually any class of customer. Correct prices, a sound regulatory framework, and appropriate commercial mechanisms have to be put in place to achieve customer response to prices. First and foremost, customers need to be exposed to the cost of shortage. There is a need to link the wholesale and the retail markets as much as possible. Price signals are the most effective way to indicate abundance or scarcity. Complementary regulatory mechanisms should be built into the system to provide a good safety net and a reasonable hedge against price volatility, without destroying the proper incentives for energy conservation.

A good rationing program should be tailored to the specifics of each power system.

8.6 It does not matter how small or large a power system is, how long a country has had a crisis situation, how serious or mild the crisis is or is expected to be, there will always be a possible way to implement rationing in a more sensible way. Rationing programs should be tailored to the specifics of each crisis and jurisdiction. The rationing program used in Brazil, for example, achieved success for an energy-constrained system. The quota system and some of its enhancements were successful, to a large extent, given the efficient metering and commercial procedures in place.

8.7 However, smaller countries, with less efficient commercial systems, can also benefit from self-rationing. The small size of a country should not be evoked as an excuse for not establishing a simpler rationing plan. If quotas cannot be implemented immediately for the entire customer base, it is still worth trying an ABC Pareto approach, where large, reliably metered customers are the initial target market for energy conservation. The approach allows different degrees of implementation complexity and can still be very effective. Simplifications are perfectly possible and are likely second-best solutions. For example, even if a wholesale market is not in place, the cost of the most expensive plant to be dispatched is a reasonable proxy of the short-run marginal cost of energy.

Capacity and energy shortages affect power system reliability in different ways, but similar concepts may be applied to manage the crisis, particularly if technology is available.

8.8 Capacity- and energy-constrained systems impact reliability in different ways. In capacity-constrained systems, there is not sufficient installed capacity to meet peak load.

Therefore, loss of load probability (LOLP) is high. Once reserves are exhausted, load shedding is inevitable. It becomes vital to reduce consumption in peak hours. Once the system passes this hump, demand reduction is not as necessary. Techniques of "peak shaving," that is, reducing consumption during peak hours, and "valley filling,", that is, shifting this consumption to other hours of the day, are applicable.

8.9 Conversely, energy-constrained systems entail an increasing risk of deficit, or energy not served. Crises of this nature are usually caused by lack of money for fuel, or sufficient water in the reservoirs in hydro-based systems. The challenge is to reduce overall consumption, every hour of the day, every day of the month. This was the case in Brazil, from where most of the best practices in this paper were drawn. Managing energy-constrained systems is less demanding in terms of metering and pricing technology. After all, it does not matter when the MWh are saved.

8.10 On the other hand, managing a capacity crisis is a more complex endeavor, since it requires the customer to change consumption behavior only in very specific hours of the day, on a few critical days. To use price signals effectively, the correct prices on a hourly basis must be conveyed to meter and bill accordingly. Even if real-time metering technology is not fully deployed, it is possible to use the quota and marginal price mechanism with a smaller number of customers, usually large industrial and commercial customers, who more often than not have some form of time-sensitive tariffs. This action can contribute significantly to reduce consumption during critical peak hours and possibly avoid any need to shed load. Joint quantity and price rationing have proven to be extremely effective ways to reduce peak load.

Plan in advance, long before rationing is necessary and also as a way to avoid it.

8.11 Planning a crisis is very often perceived as a taboo. Discussions about rationing, particularly when a reform is taking place, are wrongly perceived as politically incorrect. But realistic planning may help mitigate the effects or completely eliminate the need for rationing. Brazilian authorities spent years depleting the hydro reservoirs, several months hoping for the best rainfall on record, and a few weeks deciding and planning on the kind of rationing scheme to be implemented. Precious time was wasted: if plans to deal with scarcity had started earlier, rationing could have been mitigated or even avoided.

Have good early warning signals before the situation gets out of control.

8.12 It is imperative to have reliable tools to detect an incoming crisis and raise the flag on a timely basis. This entails technical competence and political independence. Customers and regulators have to have early warning mechanisms. It is essential to have an independent institution fully vested with the authority and in charge of constantly monitoring the situation of the power system. There are many vested interests that will try to deny the existence of a crisis or the need for urgent actions. This authority must have full access to all the data and models needed to assess the real situation of the system. Customers should be informed in honest and straightforward language. This entity should not have vested interest in either hiding the facts of an impending crisis, or in exaggerating the seriousness of a trivial situation. It should take the blame, at least formally, if a crisis happens without timely warning. The difficult decision on when to start and when to end rationing is also part of the advice. Needless to say, ultimate decisions will be in the hands of politicians, but sound technical analysis and independent recommendations should be absent from political considerations.

Explore creative ways to foster the rational use of energy on a permanent basis, using new tariff systems and quota-like arrangements or a similar concept.

8.13 The rationing in Brazil and ongoing load reduction programs in California and in other states, as well as ISO-sponsored initiatives, have shown that demand response can be a useful tool not only in times of scarcity, but also when energy is abundant. However, the traditional tariff systems need to be revisited. A promising scheme is a two-part tariff, in which the customer acquires a fixed block of energy and pays the short-run marginal cost for differences between the block and real consumption. This scheme is gaining acceptance among practitioners. Instead of administratively imposed quotas, which are arbitrary and potentially inefficient, regulators should give customers the right to choose the amount of energy to be acquired at regulated rates. If properly designed, the two-part tariff is a good tradeoff between the objectives of exposing the customer to the real cost of energy and providing a financial hedge against volatility in the spot market.

8.14 Real-time pricing, critical pricing, time of use, location marginal pricing vouchers, and rebates for low-income customers are all types of tariffs that can be applied to entertain more demand response. They should be time- and location-sensitive as much as possible. The choice will depend on the challenges faced by the regulators, the stage of development of the power sector, and the country's ability to deploy adequate metering and pricing technologies.

Put someone in control with across-the-board authority to deal with a crisis.

8.15 Energy crises are major events in the life of any power sector or even for a country. Managing a crisis requires technical and political competence. It affects the life of the population and the economy as a whole. It may represent a significant cost shift with important financial consequences for consumers and producers. Managing the crisis is a multi-faceted endeavor, involving interfaces with virtually all segments of the executive branch, as well as a good liaison and support from the legislative and judiciary branches of the government. It is a task to be carried out by a top government official, assigned on a full-time basis. This official should report to the highest authority in the country, be fully vested to deal with all aspects of the crisis, and orchestrate the necessary actions among the multiple parties involved. If authority is spread among various agencies, proper coordination will not be possible and different players affected by the crisis will tend to appeal to different authorities in order to deal with their specific, parochial interests, resulting in uncoordinated responses.

Protect the poor from the consequences of rationing.

8.16 The poor are often the most vulnerable to confront any kind of crisis. They immediately suffer the consequences of an economic downturn. In terms of guaranteeing a power supply, the rich may buy back-up generation, which is not an option for the poor. In a quota-like rationing system with price signals embedded, the poor may not afford the price increases, unless a special security net is put in place. Good social protection should also provide incentives for the poor to engage in the conservation efforts and, if successful, be paid for the amount of energy saved to the system, at the short-run marginal costs. The crisis in Brazil showed that it is possible to reconcile prices with a good safety net, and, contrary to most people's expectation, the poor also had the potential and the ability to save energy, with the proper incentives in place.

Do not socialize losses and gains.

8.17 Effective mechanisms to entertain demand response and deal with a power rationing crisis should rely heavily upon financial incentives. Those who save energy are meant to win and those who do not are meant to lose. Similarly, generators who can produce more, earlier, and in the right location, should capture the gains for helping the power system. Generators that are not reliable, have energy behind a transmission constraint, or have delayed commissioning of contracted energy are supposed to lose. Given the high prices during a crisis, winners are likely to make a lot of money and vice-versa. In principle, there is nothing wrong with that. Any government attempt to socialize gains or losses will defeat the purpose of providing market incentives. Politicians should refrain from the temptation to socialize gains and losses. Socialization and bailouts create moral hazards, weakening incentives for contracting, consumption, and expansion. Price signals and socialization cannot and are not meant to be reconciled.

Finally, honor contracts—always.

8.18 Contracts are building blocks in the power sector. In such a high capital-intensive industry, where costs once committed are virtually sunk, property rights have to be clearly and unambiguously defined. In places where contracts are not honored, privatization and power sector reform are structurally doomed to failure. Not even the most rudimentary forms of power sector reform, such as the implementation of a single buyer model, are bullet-proof to lack of contract sanctity. Honoring contracts should be a basic pillar both in good times and in times of crisis. Rationing and load shedding are no exceptions. The government’s temptation to meddle with power contracts is comprehensible, given the considerable amount of money, cost shifts among players, and lobbying involved when a crisis takes place. As mentioned in the last recommendation, an effective rationing scheme will entail winners and losers. Any attempt to mitigate exposure will create moral hazards, either in terms of present consumption or future contracting and investment decisions. Needless to say, how risk is allocated and priced (ex ante) is a sensible part of power sector reform and the art of planning for a crisis. Unbearable risks, which were not properly evaluated or priced, end up leading to non-enforceability of commercial contracts and of the regulatory compact as a whole.

Annex 1

Characteristics of Hydro-Based Systems

A.1.1 One important characteristic of hydro-based electric systems is that they are subject to occasional energy rationing episodes.

A.1.2 This happens because predominantly hydro systems are not planned to provide absolute energy reliability. If the systems were to provide absolute reliability, they would have to be able to withstand any drought, no matter how severe it turned out to be. The only way to do so would be to have such an amount of excess hydro capacity and/or backup thermal capacity that the system would be too expensive to be economically feasible.

A.1.3 In a well-planned hydro-based system, rationing must be a rare phenomenon, occurring only in the event of extremely severe droughts. Some hydro-based systems, such as the Brazilian one, have a criterion for energy reliability, usually in the form of a deficit probability.

A.1.4 In the case of Brazil, the official planning criterion was the so-called 5 percent yearly deficit probability criterion. This means that the system was planned in such a way that at any moment, existing plants were enough to supply total load with a 5 percent probability of deficit in any given year. This means that there should be enough capacity to ensure that, in any given year, there is at most a 1-in-20 chance that the year will be so dry that it will be impossible to supply the full load.[156]

A.1.5 Reliability criteria provide a benchmark for adequate supply in hydro-based systems. Thus, using the 5 percent deficit probability, one can say that the system is "adequately supplied" during a certain year if the probability of deficit in the year is 5 percent or less. This means that even though the system is adequately supplied, there is still a chance of deficit.

[156] This is a simplified statement of the problem, as planning criteria must take into account the possibility of multi-year droughts. In fact, as the Brazilian system possesses multiyear reservoir regulation, multiyear droughts are responsible for the bulk of the deficit situations. The actual criterion is that "in no year the probability of deficit shall exceed 5% in any region," and deficit probabilities are measured by stochastic simulation models.

Annex 2

Note on Exchange Rates

A.2.1 Many of the monetary values used in this report are quoted in the Brazilian currency *Real* (plural *Reais*), abbreviated R$. As the exchange rate was volatile during the rationing period, sometimes it is difficult to convert R$ values to US$, particularly in the case of totals or averages over a large period. The report contains exact conversions in some cases, and approximate conversions in others. In the latter case, the relevant exchange rate is quoted.

A.2.2 The following table shows average monthly exchange rates in 2001 and 2002.

Month	Exchange rate (R$/US$)
Jan-01	1.97
Feb-01	2.04
Mar-01	2.16
Apr-01	2.18
May-01	2.36
Jun-01	2.30
Jul-01	2.43
Aug-01	2.55
Sep-01	2.67
Oct-01	2.71
Nov-01	2.53
Dec-01	2.32
Jan-02	2.42
Feb-02	2.35
Mar-02	2.32
Apr-02	2.36
May-02	2.52
Jun-02	2.84
Jul-02	3.43
Aug-02	3.02
Sep-02	3.89
Oct-02	3.64
Nov-02	3.64
Dec-02	3.53

Annex 3

A Synopsis of Brazilian Power Sector Regulation

Overview

A.3.1 The institutional reform process that led to the current regulation started in 1996 and was motivated by the following concerns:

- Inability of the public sector's capacity to invest in infrastructure at the scale required in order to meet load growth;
- Need to promote economical efficiency, i.e., to guarantee a reliable supply of electric power at the lowest possible cost.

A.3.2 In order to achieve these objectives, the new regulation of the power sector was designed to encourage private investment and competition in generation and retailing. In particular, generation and retailing would no longer be public service concessions, subject to regulated tariffs. In turn, transmission and distribution remained regulated, with provisions for open access.

Market Players

A.3.3 The introduction of competition in generation and retailing required the formulation of a new set of commercial rules, as well as the creation of new institutions, such as:

1. Regulatory agency - ANEEL
2. Wholesale Energy Market - MAE
3. National System Operator - ONS
4. National Energy Policy Council - CNPE

A.3.4 ANEEL's mandate includes: (i) "to regulate tariffs and to establish the general conditions for contracting the access and the use of electric power transmission and distribution systems by utilities and free consumers;" (ii) "to promote the auctions for contracting public service utilities for electric power production, transmission and distribution as well as the concession to use the hydraulic potentials;" and (iii) "to manage the concession or electric power public services permission contracts, of public use concession; to issue the authorizations, as well as to inspect them." In addition, ANEEL is responsible for defining the Market Rules and for authorizing ONS activities. ANEEL's decisions are made by a board composed of five directors with non-coincident four-year terms. These directors are nominated by the President and approved by the Federal Senate.

A.3.5 MAE is the place where all electric power purchase and sale transactions take place. It is a balancing market. It was created by a Market Agreement underwritten by generators, traders, importers, exporters, and consumers.[157] MAE's governance comprises a General Assembly and an Executive Board with five voting members.[158] Two of the board members are appointed by ANEEL, two by the Assembly, and one by the Ministry of Mines and Energy.

A.3.6 ONS is a private company that acts by authorization of and is regulated by ANEEL. It has the following responsibilities:

- Develop operational planning, scheduling, and dispatch of system generation with the objective of optimizing the national electric energy system;
- Supervise and control the operation of the national interconnected electric energy system and of the international interconnections;
- Contract and manage the electric power transmission services and of the respective access conditions, as well as of ancillary services;
- Propose to ANEEL new additions to the interconnected electric system (basic network transmission installations), as well as reinforcements to the existing system, to be auctioned or authorized;

A.3.7 ONS is governed by a General Assembly,[159] by an Administrative Council, and by Executive Directors. The Administrative Council, elected by the General Assembly, is composed of seven Production, four Transportation, and seven Consumption representatives, as well as of a representative of the Ministry of Mines and Energy.[160] The Administrative Council chooses the Executive Directors, who are responsible for the day-by-day ONS operations.

A.3.8 CNPE is a high-level advisory board, composed of the Ministers of Mines and Energy, Finance, and Planning; the President's Chief of Staff; the heads of ANEEL, ANP, and ANA;[161] and representatives from academia and other segments of society. CNPE's role is to

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[157] In 2002, as part of the Revitalization program, MAE was reorganized as a private, nonprofit organization regulated and inspected by ANEEL. This means that ANEEL became responsible for the Market Agreement commercial rules.

[158] The Assembly is composed of Production (generators and importers) and Consumption (marketers, exporters. and free consumers) representatives. Each category has half of the total votes; 10 percent of the votes in each category are distributed among all members of that category; the remaining 90 percent are distributed in proportion to their production or consumption.

[159] The General Assembly has 21,000 votes; 9,000 for Production (generators and importers); 3,000 for Transportation (transmission companies); and 9,000 for Consumption (discos, exporters and free consumers). In each category, 70 percent of the votes are distributed equally among all players; the remaining 30 percent are distributed taking into account their relative importance to the category.

[160] The MME representative can veto any "deliberation that conflicts with the guidelines and government policies for the electric power sector."

[161] ANP and ANA are the regulatory agencies for oil/gas and water resources, respectively.

establish the country's energy policy, including guidelines for the regulatory agencies. It has played a more active role only since August 2002, but all presidential candidates stated that they intend to strengthen its participation in the future.

Unbundling and Privatization

A.3.9 In order for the competitive market to operate efficiently, most of the formerly vertically integrated utilities were unbundled into generation, transmission, distribution, and trading companies (marketers), with separate owners. Regulations that limit cross-ownership of power sector companies, with the objective of preventing market power, have also been established.

A.3.10 An important tool for the effective operation of the competitive market is the privatization of government-controlled power companies. On the distribution side, about 80 percent of the sector has been privatized. However, only about 20 percent of the generation sector has been transferred to private ownership. This created some difficulties in the implementation of the power sector model, as will be discussed later.

The Power Market

A.3.11 The regulation topics underlying the power market are:

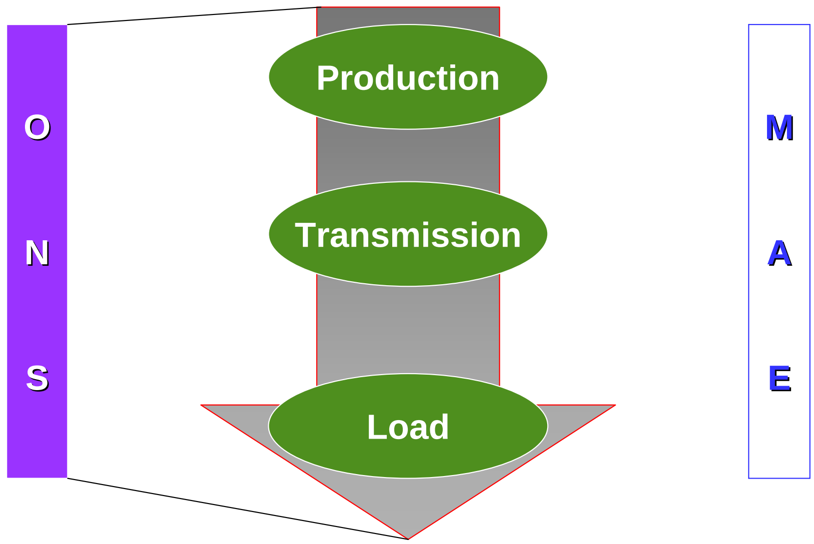
1. Cost-based dispatch by the ONS
2. MAE settlement
3. Bilateral contracts
4. Power trading
5. Transmission tariffs.

1. Cost-based Dispatch by the ONS

A.3.12 Both generation and transmission resources are dispatched on a least-cost basis by the ONS, with basis on a suite of computational models (least cost, security constrained dispatch).[162] This least-cost dispatch does not take into account any commercial arrangement, i.e. the plants are operated as if they had a single owner. Therefore, it resembles a power pool, not a bilateral contract kind of environment. Dispatch is cost- based and there are no price bids or any other competitive schemes in the system.[163] This is illustrated in Figure A.3.1, which shows the dispatch sequence separated from MAE activities.

[162] These computational models are fairly complex, because they have to calculate the dispatch of hydro based on a very large number of future inflow scenarios.
[163] The Revitalization Committee recommended a price-bidding scheme, which was scheduled for early 2003, but never came to fruition.

Figure A.3.1: ONS is Responsible for the Physical System Dispatch



2. MAE Settlement

Ideal Dispatch and Submarkets (Electric Zones)

A.3.13 There is currently no bid-based dispatch or any other market-based procedure for the market pricing of power. The MAE settlement is based on two concepts:

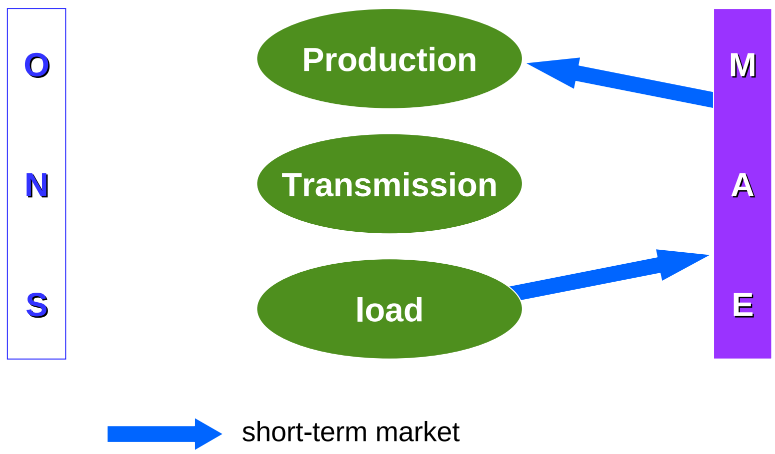
- The *Ideal Dispatch*, which is a cost-based dispatch with the same computational models and data used by the ONS, but with a simplified representation of the transmission network into zones, or submarkets (or electric zones),[164] where only the interconnections among these submarkets are represented as shown in Figure A.3.2. Locational Marginal Pricing is not used and all congestion costs are socialized.
- The use of *short-run marginal costs* (SRMC)[165] (R$/MWh) in lieu of "prices" in the settlement process. By design, all generations and loads in the same submarket have the same SRMC, or spot price.[166] Also, two separate submarkets have different spot prices only if there is transmission constraint between them.

[164] There are currently four submarkets in the country (electric zones), corresponding to the North, Northeast, South, and Southeast/Center-West regions. A CNPE Resolution of August 2002 determined the aggregation of North/Northeast and South/Southeast/Center-West as two submarkets, but an injunction suspended the deliberation.
[165] The SRMC indicates the additional cost of supplying a one-MWh load increment in each sub-market. Mathematically, it is calculated as the Lagrange multiplier associated to the load supply equation (sum of generations plus imports minus exports equals load) in the computational model used in the least-cost dispatch.
[166] Generation and loads in each submarket are adjusted for losses prior to MAE settlement.

Energy Contracts Settlement

A.3.14 Given that both energy production and spot prices are calculated in the Ideal Dispatch, with no intervention by market players, the MAE settlement is actually an accounting procedure. This is illustrated in Figure A.3.2, which shows the ONS dispatch sequence separated from MAE activities.

Figure A.3.2: MAE Energy Contract Settlement



A.3.15 MAE works as a "shallow" balancing market. It settles the net difference between the energy produced and the energy volumes registered in bilateral contracts. In other words, each company sells to MAE in each submarket using the following formula:

> (energy production in the submarket – energy consumption in the submarket + energy contracted in the submarket from third parties – energy contracted in the submarket to third parties) x short-term "price" for the submarket

A.3.16 These values are added for all submarkets, so that the actual formula for computing the short-term market revenue of a company is:

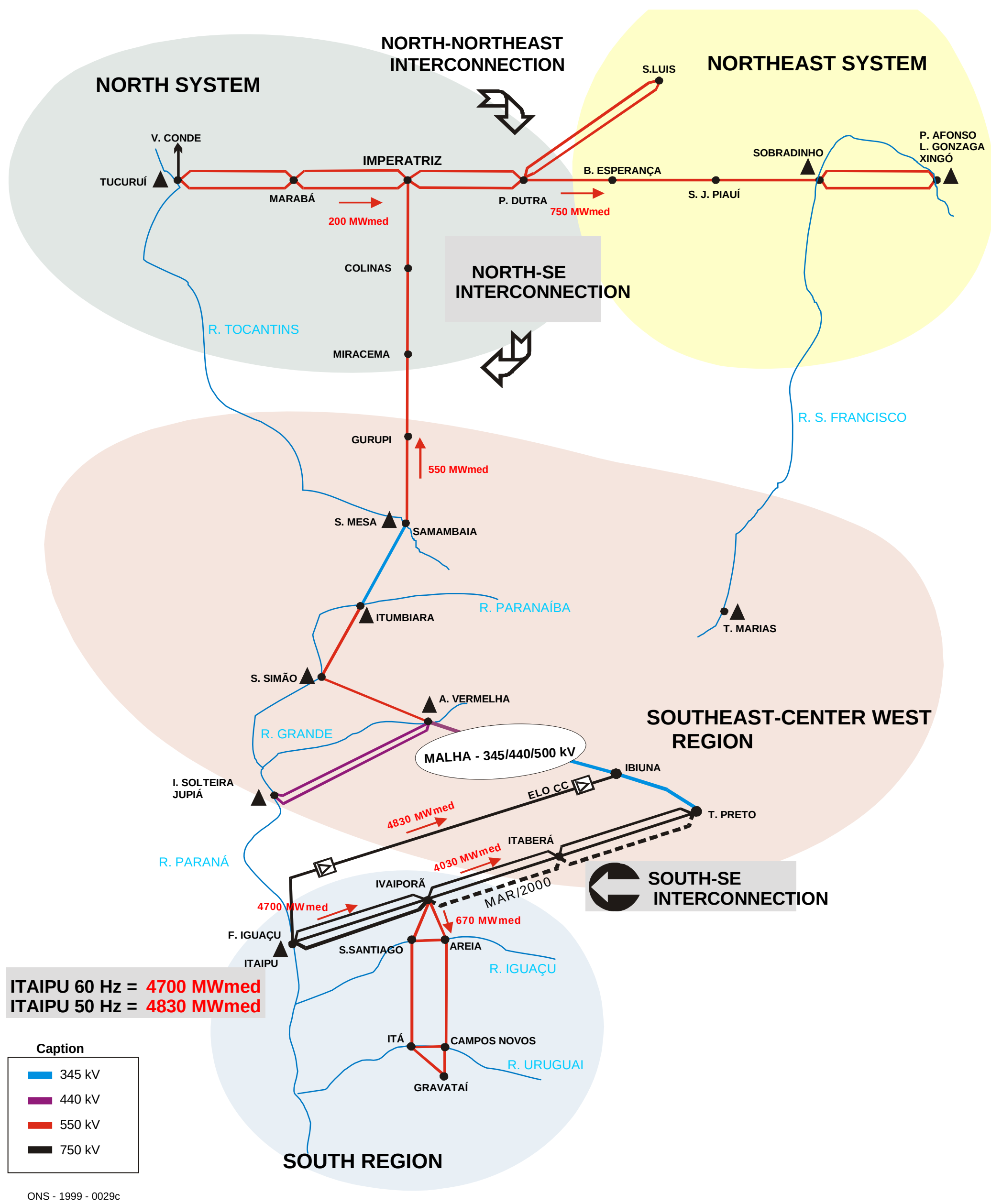
$$\Sigma_{[\text{All submarkets } s]} \text{Price}_s \times (EP_s - EC_s + CP_s - CS_s)$$

Where:

Price_s:	MAE price for submarket *s*
EP_s	Energy production in submarket *s*
EC_s	Energy consumption in submarket *s*
CP_s	Contract purchases (energy amounts) in submarket *s*
CS_s	Contract sales (energy amounts) in submarket *s*

A.3.17 If the algebraic result is negative, the company will be purchasing the net amount from the MAE. The equation also shows that a company may have a perfect balance between its contracts and its energy production and consumption (for instance, a consumer whose contract volumes are exactly equal to its consumption) and still have a negative or positive income in the short-term market—if consumption happens in one submarket and the contract amounts are entitles in another submarket, with a different price.

Figure A.3.3: Zonal Pricing - Sub-Markets (Electric Zones) in MAE

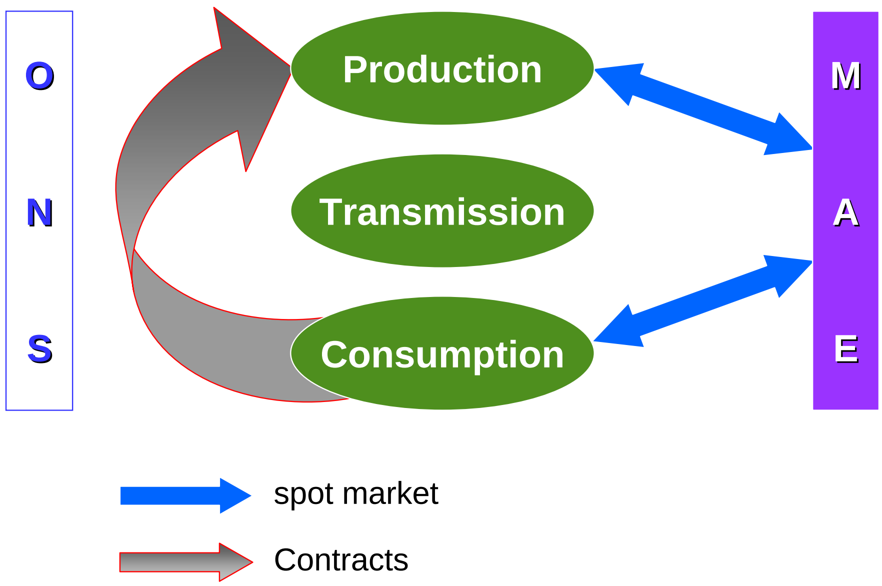


3. Bilateral Contracts

A.3.18 MAE spot prices are extremely volatile. They also have a skewed distribution, where prices are very low for most of the time and the remaining few are quite high when shortages approach. This creates significant commercial risks for merchant plants, and makes contracts an essential element in the market design.

A.3.19 As illustrated in Figure A.3.4, bilateral contracts in MAE are a purely financial hedge, which are designed to protect generators from low prices and, conversely, loads from high prices. In other words, there are no physical bilateral contracts, in which generators and loads agree on a production schedule independently of pool prices.[167]

Figure A.3.4: Bilateral Contracts As Financial Hedges



Normative Value

A.3.20 The *Valor Normativo* (Normative Value or VN) is a cap on the R$/MWh value that distribution companies can pass through to tariffs of their captive customers. It applies to energy contracts signed between a generator and a distribution company.

A.3.21 In August 2002, the VN was set at R$84/MWh. This corresponds to the price of a new hydro plant, which is perceived to be the technology that drives marginal prices. Readjustments clauses for each bilateral contract are based on a weighted average of IGP-M, prices of the relevant fuel and the exchange rate, the weights being chosen by the contracting parties within certain regulatory limits.

A.3.22 Although VN is supposed to be a *cap* on the contract price, in the past it became the “de facto” reference price for PPAs. The reason is that there was little pressure on distribution companies to find better deals, as they were allowed to pass through VN-priced contracts to their captive customers.

[167] Note that generators are allowed to declare “inflexible” dispatches that result, for example, from “take or pay” gas contracts.

A.3.23 After the power sector revitalization, this situation changed, and the VN works as it should as a cap on the contract price.

A.3.24 More recently, new alternatives have been examined to replace the VN, given the problems of an administratively set parameter. The solution proposed by the last two governments is that energy acquired by discos should be a result of a competitive auction.

Initial Contracts

A.3.25 The *Contratos Iniciais* (Initial Contracts, or vesting contracts) are compulsory bilateral agreements at regulated prices, intended to serve as a transition mechanism from the old rules to the new structure. They started in 1998, and covered essentially all loads up to 2001. In 2002, the Initial Contract amounts were the same as 2001; as a consequence, the new load in 2002 would have to sign PPAs with new generation. In 2003, the Initial Contracts started to be reduced by 25 percent a year, which means they will end by 2006.[168] Most of the energy under the Initial Contracts is now being traded in a competitive environment (auctions) or sold on a merchant basis.

Compulsory Load Contracts

A.3.26 Following a recommendation of the Revitalization Committee, the government mandated a minimum of 95 percent of all load to be served by discos should be covered by long-term contracts.[169] The minimum term for these contracts is two years. The objective is to contribute to the financial feasibility of new generation and, thus, to provide an adequate reliability level. In other words, the demand for new contracts to cover load growth is meant to be the main "driver" for generation expansion.

4. Power Trading

A.3.27 Energy trading in competitive markets has two basic roles:

- Supply-demand balancing mechanism – in Brazil, there are some unique aspects in the functioning of this market: (i) the spot price is determined by a computational model; (ii) generators are not free to self-dispatch; (iii) there are no physical bilateral contracts; (iv) there is a fairly small number of non-franchised consumers.
- Contracting and risk management – by setting up a portfolio of physical and financial assets, a marketer can offer suitable contracts to mid-sized players (e.g., a shopping center or a factory), which would have neither interest nor knowledge to negotiate directly with generators. This activity is likely to be of interest in Brazil. Marketers are required to "back" each contract with a "physical" generation capacity. This requirement aims at ensuring adequate supply reliability to the system. As a consequence, there is less room for purely financial hedging, which is a strong point in European or U.S. trading.

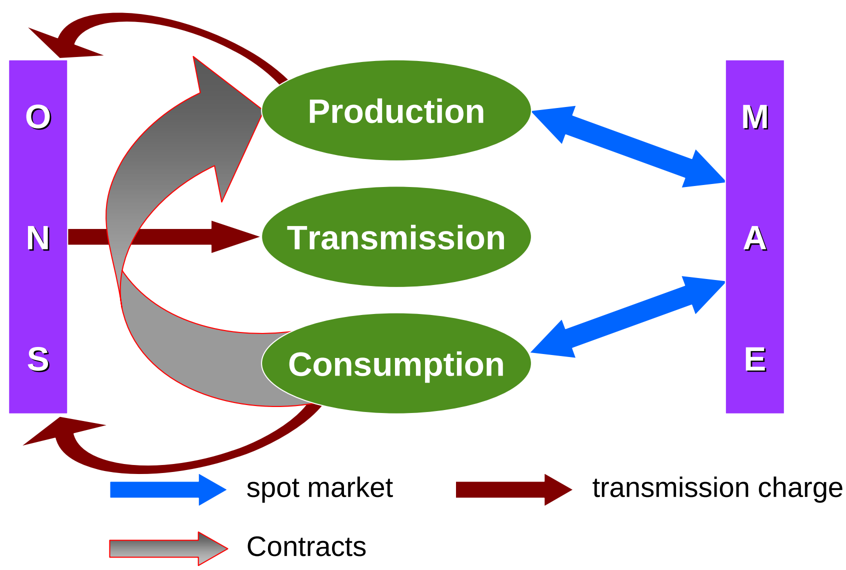
[168] Law #10604, from December 2002, allowed Initial Contracts to be re-signed through an amendment, which must be mutually agreed by the parties.
[169] Before August 2002, this requirement was 85 percent. Currently, the requirement is 100 percent.

A.3.28 In summary, energy trading is allowed in Brazil, and several companies have been created for that purpose. However, because of centralized dispatch and the requirement for "physical" guarantees, the role of marketers in Brazil is different from the role played by marketers in other countries.

5. Transmission Tariffs

A.3.29 Transmission investments are remunerated on the basis of regulated transmission charges. The tariff scheme is the so-called "nodal pricing," where transmission charges are fixed (R$/installed kW in the case of generators and R$/peak load value in the case of loads) and differentiated per node. Currently, only a minor fraction of the transmission tariffs are nodal, while most of are still based on postage stamps, therefore heavily attenuating the influence of the locational signal. The objective of providing adequate economic signals for the location of new plants and loads is being partially defeated.[170]

Figure A.3.5: Use of Transmission Tariffs Have a Fixed Nodal Charge



Allowed Revenues

A.3.30 The total amount to be paid to the transmission asset owners in a given year is determined by allowed circuit revenues, established by a regulatory formula. Those allowed revenues are determined by ANEEL, and can vary in accordance with the actual availability of the transmission facility (transmission asset maintenance remains the owners'

[170] Congestion is relatively location insensitive, and is fully socialized for intra-submarket transmission constraints.

responsibility). The same rules apply to equipment reinforcements that do not require a new concession.

Calculation of Transmission Charges

A.3.31 ONS is responsible for collecting from generators and loads the resources required for the payment of allowed transmission revenues. As mentioned previously, each generator pays a fixed amount (R$) corresponding to the product of its nodal charge (R$/kW) and peak annual load (in the case of consumers) or peak generation capacity (in the case of producers).[171] Those tariffs are calculated in such a way that generators and loads contribute equally to the total required revenues earned by transmission companies.

Transmission System Expansion

A.3.32 The planning of new transmission facilities is carried out by working groups coordinated by the Ministry of Mines and Energy. Construction contracts are awarded on a competitive basis (auctions) for each new concession, where candidates bid on the required yearly revenue. The new facilities operate in the same way as the existing ones, and are granted an allowed revenue stream will correspond to the lowest tariff bid. This BOT kind of arrangement has worked relatively well. It has supported necessary expansion and has attracted the attention of many international players.

[171] Net of internal consumption

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Joint UNDP/World Bank

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMME (ESMAP)

LIST OF REPORTS ON COMPLETED ACTIVITIES

Region/Country	*Activity/Report Title*	*Date*	*Number*
	SUB-SAHARAN AFRICA (AFR)		
Africa Regional	Anglophone Africa Household Energy Workshop (English)	07/88	085/88
	Regional Power Seminar on Reducing Electric Power System Losses in Africa (English)	08/88	087/88
	Institutional Evaluation of EGL (English)	02/89	098/89
	Biomass Mapping Regional Workshops (English)	05/89	--
	Francophone Household Energy Workshop (French)	08/89	--
	Interafrican Electrical Engineering College: Proposals for Short- and Long-Term Development (English)	03/90	112/90
	Biomass Assessment and Mapping (English)	03/90	--
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	Africa Gas Initiative – Main Report: Volume I	02/01	240/01
	First World Bank Workshop on the Petroleum Products Sector in Sub-Saharan Africa	09/01	245/01
	Ministerial Workshop on Women in Energy	10/01	250/01
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	Énergies modernes et réduction de la pauvreté: Un atelier multi-sectoriel. Actes de l'atelier régional. Douala, Cameroun du 16-18 juillet 2003. (French Only)	09/04	286/04
	Energy and Poverty Reduction: Proceedings from the Global Village Energy Partnership (GVEP) Workshops held in Africa	01/05	298/05
Angola	Energy Assessment (English and Portuguese)	05/89	4708-ANG
	Power Rehabilitation and Technical Assistance (English)	10/91	142/91
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Benin	Energy Assessment (English and French)	06/85	5222-BEN
Botswana	Energy Assessment (English)	09/84	4998-BT
	Pump Electrification Prefeasibility Study (English)	01/86	047/86
	Review of Electricity Service Connection Policy (English)	07/87	071/87
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	Petroleum Supply Management (English)	01/84	012/84
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	Improved Charcoal Cookstove Strategy (English and French)	09/85	042/85
	Peat Utilization Project (English)	11/85	046/85
	Energy Assessment (English and French)	01/92	9215-BU
Cameroon	Africa Gas Initiative – Cameroon: Volume III	02/01	240/01
Cape Verde	Energy Assessment (English and Portuguese)	08/84	5073-CV
	Household Energy Strategy Study (English)	02/90	110/90
Central African Republic	Energy Assessment (French)	08/92	9898-CAR
Chad	Elements of Strategy for Urban Household Energy The Case of N'djamena (French)	12/93	160/94
Comoros	Energy Assessment (English and French)	01/88	7104-COM
	In Search of Better Ways to Develop Solar Markets: The Case of Comoros	05/00	230/00
Congo	Energy Assessment (English)	01/88	6420-COB
	Power Development Plan (English and French)	03/90	106/90
	Africa Gas Initiative – Congo: Volume IV	02/01	240/01
Côte d'Ivoire	Energy Assessment (English and French)	04/85	5250-IVC
	Improved Biomass Utilization (English and French)	04/87	069/87
	Power System Efficiency Study (English)	12/87	--
	Power Sector Efficiency Study (French)	02/92	140/91
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	Agricultural Residue Briquetting Pilot Project (English)	12/86	062/86
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	Energy Assessment (English)	02/96	179/96
Gabon	Energy Assessment (English)	07/88	6915-GA
	Africa Gas Initiative – Gabon: Volume VI	02/01	240/01
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	Solar Water Heating Retrofit Project (English)	02/85	030/85
	Solar Photovoltaic Applications (English)	03/85	032/85
	Petroleum Supply Management Assistance (English)	04/85	035/85
Ghana	Energy Assessment (English)	11/86	6234-GH
	Energy Rationalization in the Industrial Sector (English)	06/88	084/88
	Sawmill Residues Utilization Study (English)	11/88	074/87
	Industrial Energy Efficiency (English)	11/92	148/92
	Corporatization of Distribution Concessions through Capitalization	12/03	272/03
Guinea	Energy Assessment (English)	11/86	6137-GUI
	Household Energy Strategy (English and French)	01/94	163/94
Guinea-Bissau	Energy Assessment (English and Portuguese)	08/84	5083-GUB
	Recommended Technical Assistance Projects (English & Portuguese)	04/85	033/85
	Management Options for the Electric Power and Water Supply Subsectors (English)	02/90	100/90
	Power and Water Institutional Restructuring (French)	04/91	118/91
Kenya	Energy Assessment (English)	05/82	3800-KE
	Power System Efficiency Study (English)	03/84	014/84
	Status Report (English)	05/84	016/84
	Coal Conversion Action Plan (English)	02/87	--
	Solar Water Heating Study (English)	02/87	066/87

Region/Country	Activity/Report Title	Date	Number
Kenya	Peri-Urban Woodfuel Development (English)	10/87	076/87
	Power Master Plan (English)	11/87	--
	Power Loss Reduction Study (English)	09/96	186/96
	Implementation Manual: Financing Mechanisms for Solar Electric Equipment	07/00	231/00
Lesotho	Energy Assessment (English)	01/84	4676-LSO
Liberia	Energy Assessment (English)	12/84	5279-LBR
	Recommended Technical Assistance Projects (English)	06/85	038/85
	Power System Efficiency Study (English)	12/87	081/87
Madagascar	Energy Assessment (English)	01/87	5700-MAG
	Power System Efficiency Study (English and French)	12/87	075/87
	Environmental Impact of Woodfuels (French)	10/95	176/95
Malawi	Energy Assessment (English)	08/82	3903-MAL
	Technical Assistance to Improve the Efficiency of Fuelwood Use in the Tobacco Industry (English)	11/83	009/83
	Status Report (English)	01/84	013/84
Mali	Energy Assessment (English and French)	11/91	8423-MLI
	Household Energy Strategy (English and French)	03/92	147/92
Islamic Republic of Mauritania	Energy Assessment (English and French)	04/85	5224-MAU
	Household Energy Strategy Study (English and French)	07/90	123/90
Mauritius	Energy Assessment (English)	12/81	3510-MAS
	Status Report (English)	10/83	008/83
	Power System Efficiency Audit (English)	05/87	070/87
	Bagasse Power Potential (English)	10/87	077/87
	Energy Sector Review (English)	12/94	3643-MAS
Mozambique	Energy Assessment (English)	01/87	6128-MOZ
	Household Electricity Utilization Study (English)	03/90	113/90
	Electricity Tariffs Study (English)	06/96	181/96
	Sample Survey of Low Voltage Electricity Customers	06/97	195/97
Namibia	Energy Assessment (English)	03/93	11320-NAM
Niger	Energy Assessment (French)	05/84	4642-NIR
	Status Report (English and French)	02/86	051/86
	Improved Stoves Project (English and French)	12/87	080/87
	Household Energy Conservation and Substitution (English and French)	01/88	082/88
Nigeria	Energy Assessment (English)	08/83	4440-UNI
	Energy Assessment (English)	07/93	11672-UNI
	Strategic Gas Plan	02/04	279/04
Rwanda	Energy Assessment (English)	06/82	3779-RW
	Status Report (English and French)	05/84	017/84
	Improved Charcoal Cookstove Strategy (English and French)	08/86	059/86
	Improved Charcoal Production Techniques (English and French)	02/87	065/87
	Energy Assessment (English and French)	07/91	8017-RW
	Commercialization of Improved Charcoal Stoves and Carbonization Techniques Mid-Term Progress Report (English and French)	12/91	141/91
SADC	SADC Regional Power Interconnection Study, Vols. I-IV (English)	12/93	-
SADCC	SADCC Regional Sector: Regional Capacity-Building Program for Energy Surveys and Policy Analysis (English)	11/91	-
Sao Tome and Principe	Energy Assessment (English)	10/85	5803-STP
Senegal	Energy Assessment (English)	07/83	4182-SE
	Status Report (English and French)	10/84	025/84
	Industrial Energy Conservation Study (English)	05/85	037/85

Region/Country	Activity/Report Title	Date	Number
Senegal	Preparatory Assistance for Donor Meeting (English and French)	04/86	056/86
	Urban Household Energy Strategy (English)	02/89	096/89
	Industrial Energy Conservation Program (English)	05/94	165/94
Seychelles	Energy Assessment (English)	01/84	4693-SEY
	Electric Power System Efficiency Study (English)	08/84	021/84
Sierra Leone	Energy Assessment (English)	10/87	6597-SL
Somalia	Energy Assessment (English)	12/85	5796-SO
Republic of South Africa	Options for the Structure and Regulation of Natural Gas Industry (English)	05/95	172/95
Sudan	Management Assistance to the Ministry of Energy and Mining	05/83	003/83
	Energy Assessment (English)	07/83	4511-SU
	Power System Efficiency Study (English)	06/84	018/84
	Status Report (English)	11/84	026/84
	Wood Energy/Forestry Feasibility (English)	07/87	073/87
Swaziland	Energy Assessment (English)	02/87	6262-SW
	Household Energy Strategy Study	10/97	198/97
Tanzania	Energy Assessment (English)	11/84	4969-TA
	Peri-Urban Woodfuels Feasibility Study (English)	08/88	086/88
	Tobacco Curing Efficiency Study (English)	05/89	102/89
	Remote Sensing and Mapping of Woodlands (English)	06/90	--
	Industrial Energy Efficiency Technical Assistance (English)	08/90	122/90
	Power Loss Reduction Volume 1: Transmission and Distribution System Technical Loss Reduction and Network Development (English)	06/98	204A/98
	Power Loss Reduction Volume 2: Reduction of Non-Technical Losses (English)	06/98	204B/98
Togo	Energy Assessment (English)	06/85	5221-TO
	Wood Recovery in the Nangbeto Lake (English and French)	04/86	055/86
	Power Efficiency Improvement (English and French)	12/87	078/87
Uganda	Energy Assessment (English)	07/83	4453-UG
	Status Report (English)	08/84	020/84
	Institutional Review of the Energy Sector (English)	01/85	029/85
	Energy Efficiency in Tobacco Curing Industry (English)	02/86	049/86
	Fuelwood/Forestry Feasibility Study (English)	03/86	053/86
	Power System Efficiency Study (English)	12/88	092/88
	Energy Efficiency Improvement in the Brick and Tile Industry (English)	02/89	097/89
	Tobacco Curing Pilot Project (English)	03/89	UNDP Terminal Report
	Energy Assessment (English)	12/96	193/96
	Rural Electrification Strategy Study	09/99	221/99
Zaire	Energy Assessment (English)	05/86	5837-ZR
Zambia	Energy Assessment (English)	01/83	4110-ZA
	Status Report (English)	08/85	039/85
	Energy Sector Institutional Review (English)	11/86	060/86
	Power Subsector Efficiency Study (English)	02/89	093/88
	Energy Strategy Study (English)	02/89	094/88
	Urban Household Energy Strategy Study (English)	08/90	121/90
Zimbabwe	Energy Assessment (English)	06/82	3765-ZIM
	Power System Efficiency Study (English)	06/83	005/83
	Status Report (English)	08/84	019/84
	Power Sector Management Assistance Project (English)	04/85	034/85
	Power Sector Management Institution Building (English)	09/89	--

Region/Country	Activity/Report Title	Date	Number
Zimbabwe	Petroleum Management Assistance (English)	12/89	109/89
	Charcoal Utilization Pre-feasibility Study (English)	06/90	119/90
	Integrated Energy Strategy Evaluation (English)	01/92	8768-ZIM
	Energy Efficiency Technical Assistance Project: Strategic Framework for a National Energy Efficiency Improvement Program (English)	04/94	--
	Capacity Building for the National Energy Efficiency Improvement Programme (NEEIP) (English)	12/94	--
	Rural Electrification Study	03/00	228/00

EAST ASIA AND PACIFIC (EAP)

Region/Country	Activity/Report Title	Date	Number
Asia Regional	Pacific Household and Rural Energy Seminar (English)	11/90	--
China	County-Level Rural Energy Assessments (English)	05/89	101/89
	Fuelwood Forestry Preinvestment Study (English)	12/89	105/89
	Strategic Options for Power Sector Reform in China (English)	07/93	156/93
	Energy Efficiency and Pollution Control in Township and Village Enterprises (TVE) Industry (English)	11/94	168/94
	Energy for Rural Development in China: An Assessment Based on a Joint Chinese/ESMAP Study in Six Counties (English)	06/96	183/96
	Improving the Technical Efficiency of Decentralized Power Companies	09/99	222/99
	Air Pollution and Acid Rain Control: The Case of Shijiazhuang City and the Changsha Triangle Area	10/03	267/03
	Toward a Sustainable Coal Sector In China	07/04	287/04
Fiji	Energy Assessment (English)	06/83	4462-FIJ
Indonesia	Energy Assessment (English)	11/81	3543-IND
	Status Report (English)	09/84	022/84
	Power Generation Efficiency Study (English)	02/86	050/86
	Energy Efficiency in the Brick, Tile and Lime Industries (English)	04/87	067/87
	Diesel Generating Plant Efficiency Study (English)	12/88	095/88
	Urban Household Energy Strategy Study (English)	02/90	107/90
	Biomass Gasifier Preinvestment Study Vols. I & II (English)	12/90	124/90
	Prospects for Biomass Power Generation with Emphasis on Palm Oil, Sugar, Rubberwood and Plywood Residues (English)	11/94	167/94
Lao PDR	Urban Electricity Demand Assessment Study (English)	03/93	154/93
	Institutional Development for Off-Grid Electrification	06/99	215/99
Malaysia	Sabah Power System Efficiency Study (English)	03/87	068/87
	Gas Utilization Study (English)	09/91	9645-MA
Mongolia	Energy Efficiency in the Electricity and District Heating Sectors	10/01	247/01
	Improved Space Heating Stoves for Ulaanbaatar	03/02	254/02
Myanmar	Energy Assessment (English)	06/85	5416-BA
Papua New Guinea	Energy Assessment (English)	06/82	3882-PNG
	Status Report (English)	07/83	006/83
	Institutional Review in the Energy Sector (English)	10/84	023/84
	Power Tariff Study (English)	10/84	024/84
Philippines	Commercial Potential for Power Production from Agricultural Residues (English)	12/93	157/93
	Energy Conservation Study (English)	08/94	--

Region/Country	Activity/Report Title	Date	Number
Philippines	Strengthening the Non-Conventional and Rural Energy Development Program in the Philippines: A Policy Framework and Action Plan	08/01	243/01
	Rural Electrification and Development in the Philippines: Measuring the Social and Economic Benefits	05/02	255/02
Solomon Islands	Energy Assessment (English)	06/83	4404-SOL
	Energy Assessment (English)	01/92	979-SOL
South Pacific	Petroleum Transport in the South Pacific (English)	05/86	--
Thailand	Energy Assessment (English)	09/85	5793-TH
	Rural Energy Issues and Options (English)	09/85	044/85
	Accelerated Dissemination of Improved Stoves and Charcoal Kilns (English)	09/87	079/87
	Northeast Region Village Forestry and Woodfuels Preinvestment Study (English)	02/88	083/88
	Impact of Lower Oil Prices (English)	08/88	--
	Coal Development and Utilization Study (English)	10/89	--
	Why Liberalization May Stall in a Mature Power Market: A Review of the Technical and Political Economy Factors that Constrained the Electricity Sector Reform in Thailand 1998-2002	12/03	270/03
	Reducing Emissions from Motorcycles in Bangkok	10/03	275/03
Tonga	Energy Assessment (English)	06/85	5498-TON
Vanuatu	Energy Assessment (English)	06/85	5577-VA
Vietnam	Rural and Household Energy-Issues and Options (English)	01/94	161/94
	Power Sector Reform and Restructuring in Vietnam: Final Report to the Steering Committee (English and Vietnamese)	09/95	174/95
	Household Energy Technical Assistance: Improved Coal Briquetting and Commercialized Dissemination of Higher Efficiency Biomass and Coal Stoves (English)	01/96	178/96
	Petroleum Fiscal Issues and Policies for Fluctuating Oil Prices In Vietnam	02/01	236/01
	An Overnight Success: Vietnam's Switch to Unleaded Gasoline	08/02	257/02
	The Electricity Law for Vietnam—Status and Policy Issues—The Socialist Republic of Vietnam	08/02	259/02
	Petroleum Sector Technical Assistance for the Revision of the Existing Legal and Regulatory Framework	12/03	269/03
Western Samoa	Energy Assessment (English)	06/85	5497-WSO

SOUTH ASIA (SAS)

Region/Country	Activity/Report Title	Date	Number
Bangladesh	Energy Assessment (English)	10/82	3873-BD
	Priority Investment Program (English)	05/83	002/83
	Status Report (English)	04/84	015/84
	Power System Efficiency Study (English)	02/85	031/85
	Small Scale Uses of Gas Pre-feasibility Study (English)	12/88	--
	Reducing Emissions from Baby-Taxis in Dhaka	01/02	253/02
India	Opportunities for Commercialization of Non-conventional Energy Systems (English)	11/88	091/88
	Maharashtra Bagasse Energy Efficiency Project (English)	07/90	120/90
	Mini-Hydro Development on Irrigation Dams and Canal Drops Vols. I, II and III (English)	07/91	139/91
	WindFarm Pre-Investment Study (English)	12/92	150/92
	Power Sector Reform Seminar (English)	04/94	166/94
	Environmental Issues in the Power Sector (English)	06/98	205/98

Region/Country	Activity/Report Title	Date	Number
India	Environmental Issues in the Power Sector: Manual for Environmental Decision Making (English)	06/99	213/99
	Household Energy Strategies for Urban India: The Case of Hyderabad	06/99	214/99
	Greenhouse Gas Mitigation In the Power Sector: Case Studies From India	02/01	237/01
	Energy Strategies for Rural India: Evidence from Six States	08/02	258/02
	Household Energy, Indoor Air Pollution, and Health	11/02	261/02
	Access of the Poor to Clean Household Fuels	07/03	263/03
	The Impact of Energy on Women's Lives in Rural India	01/04	276/04
	Environmental Issues in the Power Sector: Long-Term Impacts And Policy Options for Rajasthan	10/04	292/04
	Environmental Issues in the Power Sector: Long-Term Impacts And Policy Options for Karnataka	10/04	293/04
Nepal	Energy Assessment (English)	08/83	4474-NEP
	Status Report (English)	01/85	028/84
	Energy Efficiency & Fuel Substitution in Industries (English)	06/93	158/93
Pakistan	Household Energy Assessment (English)	05/88	--
	Assessment of Photovoltaic Programs, Applications, and Markets (English)	10/89	103/89
Pakistan	National Household Energy Survey and Strategy Formulation Study: Project Terminal Report (English)	03/94	--
	Managing the Energy Transition (English)	10/94	--
	Lighting Efficiency Improvement Program Phase 1: Commercial Buildings Five Year Plan (English)	10/94	--
	Clean Fuels	10/01	246/01
Regional	Toward Cleaner Urban Air in South Asia: Tackling Transport Pollution, Understanding Sources.	03/04	281/04
Sri Lanka	Energy Assessment (English)	05/82	3792-CE
	Power System Loss Reduction Study (English)	07/83	007/83
	Status Report (English)	01/84	010/84
	Industrial Energy Conservation Study (English)	03/86	054/86
	Sustainable Transport Options for Sri Lanka: Vol. I	02/03	262/03
	Greenhouse Gas Mitigation Options in the Sri Lanka Power Sector: Vol. II	02/03	262/03
	Sri Lanka Electric Power Technology Assessment (SLEPTA): Vol. III	02/03	262/03
	Energy and Poverty Reduction: Proceedings from South Asia Practitioners Workshop How Can Modern Energy Services Contribute to Poverty Reduction? Colombo, Sri Lanka, June 2-4, 2003	11/03	268/03

EUROPE AND CENTRAL ASIA (ECA)

Region/Country	Activity/Report Title	Date	Number
Armenia	Development of Heat Strategies for Urban Areas of Low-income Transition Economies. Urban Heating Strategy for the Republic Of Armenia. *Including a Summary of a Heating Strategy for the Kyrgyz Republic*	04/04	282/04
Bulgaria	Natural Gas Policies and Issues (English)	10/96	188/96
	Energy Environment Review	10/02	260/02
Central Asia and The Caucasus	Cleaner Transport Fuels in Central Asia and the Caucasus	08/01	242/01
Central and Eastern Europe	Power Sector Reform in Selected Countries	07/97	196/97
	Increasing the Efficiency of Heating Systems in Central and		

Region/Country	Activity/Report Title	Date	Number
	Eastern Europe and the Former Soviet Union (English and Russian)	08/00	234/00
	The Future of Natural Gas in Eastern Europe (English)	08/92	149/92
Kazakhstan	Natural Gas Investment Study, Volumes 1, 2 & 3	12/97	199/97
Kazakhstan & Kyrgyzstan	Opportunities for Renewable Energy Development	11/97	16855-KAZ
Poland	Energy Sector Restructuring Program Vols. I-V (English)	01/93	153/93
	Natural Gas Upstream Policy (English and Polish)	08/98	206/98
	Energy Sector Restructuring Program: Establishing the Energy Regulation Authority	10/98	208/98
Portugal	Energy Assessment (English)	04/84	4824-PO
Romania	Natural Gas Development Strategy (English)	12/96	192/96
	Private Sector Participation in Market-Based Energy-Efficiency Financing Schemes: Lessons Learned from Romania and International Experiences.	11/03	274/03
Slovenia	Workshop on Private Participation in the Power Sector (English)	02/99	211/99
Turkey	Energy Assessment (English)	03/83	3877-TU
	Energy and the Environment: Issues and Options Paper	04/00	229/00
	Energy and Environment Review: Synthesis Report	12/03	273/03

MIDDLE EAST AND NORTH AFRICA (MNA)

Region/Country	Activity/Report Title	Date	Number
Arab Republic of Egypt	Energy Assessment (English)	10/96	189/96
	Energy Assessment (English and French)	03/84	4157-MOR
	Status Report (English and French)	01/86	048/86
Morocco	Energy Sector Institutional Development Study (English and French)	07/95	173/95
	Natural Gas Pricing Study (French)	10/98	209/98
	Gas Development Plan Phase II (French)	02/99	210/99
Syria	Energy Assessment (English)	05/86	5822-SYR
	Electric Power Efficiency Study (English)	09/88	089/88
	Energy Efficiency Improvement in the Cement Sector (English)	04/89	099/89
	Energy Efficiency Improvement in the Fertilizer Sector (English)	06/90	115/90
Tunisia	Fuel Substitution (English and French)	03/90	--
	Power Efficiency Study (English and French)	02/92	136/91
	Energy Management Strategy in the Residential and Tertiary Sectors (English)	04/92	146/92
	Renewable Energy Strategy Study, Volume I (French)	11/96	190A/96
	Renewable Energy Strategy Study, Volume II (French)	11/96	190B/96
Yemen	Energy Assessment (English)	12/84	4892-YAR
	Energy Investment Priorities (English)	02/87	6376-YAR
	Household Energy Strategy Study Phase I (English)	03/91	126/91

LATIN AMERICA AND THE CARIBBEAN REGION (LCR)

Region/Country	Activity/Report Title	Date	Number
LCR Regional	Regional Seminar on Electric Power System Loss Reduction in the Caribbean (English)	07/89	--
	Elimination of Lead in Gasoline in Latin America and the Caribbean (English and Spanish)	04/97	194/97

Region/Country	Activity/Report Title	Date	Number
LCR Regional	Elimination of Lead in Gasoline in Latin America and the Caribbean - Status Report (English and Spanish)	12/97	200/97
	Harmonization of Fuels Specifications in Latin America and the Caribbean (English and Spanish)	06/98	203/98
	Energy and Poverty Reduction: Proceedings from the Global Village Energy Partnership (GVEP) Workshop held in Bolivia	06/05	202/05
	Power Sector Reform and the Rural Poor in Central America	12/04	297/04
	Estudio Comparativo Sobre la Distribución de la Renta Petrolera en Bolivia, Colombia, Ecuador y Perú	08/05	304/05
Bolivia	Energy Assessment (English)	04/83	4213-BO
	National Energy Plan (English)	12/87	--
	La Paz Private Power Technical Assistance (English)	11/90	111/90
	Pre-feasibility Evaluation Rural Electrification and Demand Assessment (English and Spanish)	04/91	129/91
	National Energy Plan (Spanish)	08/91	131/91
	Private Power Generation and Transmission (English)	01/92	137/91
	Natural Gas Distribution: Economics and Regulation (English)	03/92	125/92
	Natural Gas Sector Policies and Issues (English and Spanish)	12/93	164/93
	Household Rural Energy Strategy (English and Spanish)	01/94	162/94
	Preparation of Capitalization of the Hydrocarbon Sector	12/96	191/96
	Introducing Competition into the Electricity Supply Industry in Developing Countries: Lessons from Bolivia	08/00	233/00
	Final Report on Operational Activities Rural Energy and Energy Efficiency	08/00	235/00
	Oil Industry Training for Indigenous People: The Bolivian Experience (English and Spanish)	09/01	244/01
	Capacitación de Pueblos Indígenas en la Actividad Petrolera. Fase II	07/04	290/04
	Estudio Sobre Aplicaciones en Pequeña Escala de Gas Natural	07/04	291/04
Brazil	Energy Efficiency & Conservation: Strategic Partnership for Energy Efficiency in Brazil (English)	01/95	170/95
	Hydro and Thermal Power Sector Study	09/97	197/97
	Rural Electrification with Renewable Energy Systems in the Northeast: A Preinvestment Study	07/00	232/00
	Reducing Energy Costs in Municipal Water Supply Operations “Learning-while-doing” Energy M&T on the Brazilian Frontlines	07/03	265/03
Chile	Energy Sector Review (English)	08/88	7129-CH
Colombia	Energy Strategy Paper (English)	12/86	--
	Power Sector Restructuring (English)	11/94	169/94
Colombia	Energy Efficiency Report for the Commercial and Public Sector (English)	06/96	184/96
Costa Rica	Energy Assessment (English and Spanish)	01/84	4655-CR
	Recommended Technical Assistance Projects (English)	11/84	027/84
	Forest Residues Utilization Study (English and Spanish)	02/90	108/90
Dominican Republic	Energy Assessment (English)	05/91	8234-DO
Ecuador	Energy Assessment (Spanish)	12/85	5865-EC
	Energy Strategy Phase I (Spanish)	07/88	--
	Energy Strategy (English)	04/91	--
	Private Mini-hydropower Development Study (English)	11/92	--
	Energy Pricing Subsidies and Interfuel Substitution (English)	08/94	11798-EC
	Energy Pricing, Poverty and Social Mitigation (English)	08/94	12831-EC
Guatemala	Issues and Options in the Energy Sector (English)	09/93	12160-GU
	Health Impacts of Traditional Fuel Use	08/04	284/04

Region/Country	Activity/Report Title	Date	Number
Haiti	Energy Assessment (English and French)	06/82	3672-HA
	Status Report (English and French)	08/85	041/85
	Household Energy Strategy (English and French)	12/91	143/91
Honduras	Energy Assessment (English)	08/87	6476-HO
	Petroleum Supply Management (English)	03/91	128/91
Jamaica	Energy Assessment (English)	04/85	5466-JM
	Petroleum Procurement, Refining, and Distribution Study (English)	11/86	061/86
	Energy Efficiency Building Code Phase I (English)	03/88	--
	Energy Efficiency Standards and Labels Phase I (English)	03/88	--
Jamaica	Management Information System Phase I (English)	03/88	--
	Charcoal Production Project (English)	09/88	090/88
	FIDCO Sawmill Residues Utilization Study (English)	09/88	088/88
	Energy Sector Strategy and Investment Planning Study (English)	07/92	135/92
Mexico	Improved Charcoal Production Within Forest Management for the State of Veracruz (English and Spanish)	08/91	138/91
	Energy Efficiency Management Technical Assistance to the Comisión Nacional para el Ahorro de Energía (CONAE) (English)	04/96	180/96
	Energy Environment Review	05/01	241/01
Nicaragua	Modernizing the Fuelwood Sector in Managua and León	12/01	252/01
Panama	Power System Efficiency Study (English)	06/83	004/83
Paraguay	Energy Assessment (English)	10/84	5145-PA
	Recommended Technical Assistance Projects (English)	09/85	--
	Status Report (English and Spanish)	09/85	043/85
Peru	Energy Assessment (English)	01/84	4677-PE
	Status Report (English)	08/85	040/85
	Proposal for a Stove Dissemination Program in the Sierra (English and Spanish)	02/87	064/87
	Energy Strategy (English and Spanish)	12/90	--
	Study of Energy Taxation and Liberalization of the Hydrocarbons Sector (English and Spanish)	120/93	159/93
	Reform and Privatization in the Hydrocarbon Sector (English and Spanish)	07/99	216/99
	Rural Electrification	02/01	238/01
Saint Lucia	Energy Assessment (English)	09/84	5111-SLU
St. Vincent and the Grenadines	Energy Assessment (English)	09/84	5103-STV
Sub Andean	Environmental and Social Regulation of Oil and Gas Operations in Sensitive Areas of the Sub-Andean Basin (English and Spanish)	07/99	217/99
Trinidad and Tobago	Energy Assessment (English)	12/85	5930-TR

GLOBAL

	Energy End Use Efficiency: Research and Strategy (English)	11/89	--
	Women and Energy--A Resource Guide The International Network: Policies and Experience (English)	04/90	--
	Guidelines for Utility Customer Management and Metering (English and Spanish)	07/91	--
	Assessment of Personal Computer Models for Energy Planning in Developing Countries (English)	10/91	--
	Long-Term Gas Contracts Principles and Applications (English)	02/93	152/93

Region/Country	Activity/Report Title	Date	Number
	Comparative Behavior of Firms Under Public and Private Ownership (English)	05/93	155/93
	Development of Regional Electric Power Networks (English)	10/94	--
	Roundtable on Energy Efficiency (English)	02/95	171/95
	Assessing Pollution Abatement Policies with a Case Study of Ankara (English)	11/95	177/95
	A Synopsis of the Third Annual Roundtable on Independent Power Projects: Rhetoric and Reality (English)	08/96	187/96
	Rural Energy and Development Roundtable (English)	05/98	202/98
	A Synopsis of the Second Roundtable on Energy Efficiency: Institutional and Financial Delivery Mechanisms (English)	09/98	207/98
	The Effect of a Shadow Price on Carbon Emission in the Energy Portfolio of the World Bank: A Carbon Backcasting Exercise (English)	02/99	212/99
	Increasing the Efficiency of Gas Distribution Phase 1: Case Studies and Thematic Data Sheets	07/99	218/99
	Global Energy Sector Reform in Developing Countries: A Scorecard	07/99	219/99
	Global Lighting Services for the Poor Phase II: Text Marketing of Small "Solar" Batteries for Rural Electrification Purposes	08/99	220/99
	A Review of the Renewable Energy Activities of the UNDP/ World Bank Energy Sector Management Assistance Programme 1993 to 1998	11/99	223/99
	Energy, Transportation and Environment: Policy Options for Environmental Improvement	12/99	224/99
	Privatization, Competition and Regulation in the British Electricity Industry, With Implications for Developing Countries	02/00	226/00
	Reducing the Cost of Grid Extension for Rural Electrification	02/00	227/00
	Undeveloped Oil and Gas Fields in the Industrializing World	02/01	239/01
	Best Practice Manual: Promoting Decentralized Electrification Investment	10/01	248/01
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