ESMAP

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Briefing Note 008/11

Best Practices for Market-Based Power Rationing

Implications for South Africa

LOW CARBON GROWTH COUNTRY STUDIES PROGRAM

MITIGATING CLIMATE CHANGE THROUGH DEVELOPMENT

CARBON FINANCE ASSIST

Contents

LOW CARBON GROWTH COUNTRY STUDIES PROGRAM

Annexes

Boxes

Figures

Tables

Best Practices for Market-Based Power Rationing: Implications for South Africa

SOUTH AFRICA'S POWER CRISIS

South Africa is the largest economy on the African continent, accounting for about 35 percent of the region's GDP. South Africa is also the only country in Sub-Saharan Africa that belongs to the ranks of upper middle-income countries.

The economy of South Africa is quite energy-intensive. This is the result of both rapid urbanization and electrification, and a mechanized manufacturing sector that requires heavy use of electric power. Mining, which has historically been the mainstay of South Africa's economy, is a particularly energy-intensive activity. As a result of high energy intensity and reliance on coal for electric power generation, the South African economy is also carbon-intensive.

After several years of sustained economic growth, supported by reliable and sufficient electricity supply, South Africa's electricity system came under considerable strain in 2008 when the electricity sector, though generally operationally efficient, ran into major capacity constraints. The power crisis beginning January 2008 was brought on by a combination of supply-side problems, including coal availability, maintenance needs, and unplanned outages that caused power system reserve margins to fall, virtually overnight, from 10% to almost zero. South Africa experienced a "power crunch" as demand for electricity by industry and households increased by 60% from 1994–2006, with little new generating capacity added by the national electric utility, Eskom. The size of the power shortage was staggering—about 3,500 MW or about 10% of peak demand, every weekday from 6 am to 10 pm. Power rationing and other measures were instituted to prevent the electricity system from collapse, affecting the entire economy and especially the country's mining industry.

The Government responded quickly to the power crisis, giving high priority to improving the generation capacity and the reliability of electricity supply. To meet the country's forecasted demand growth (more than 12 GW in 5–7 years), Eskom started constructing two new coal-fired plants, but it would take a few years for those units to be commissioned.

At the time of the power crisis, the World Bank, assisted by the United Nations Development Program and the Energy Sector Management Assistance Program (ESMAP), was providing support to South Africa's efforts to develop a low-carbon strategy. Several scenarios were considered where energy efficiency was seen as an essential dimension in reducing South Africa's carbon footprint. The power crisis further emphasized the urgency for near-term, practical assistance to implement the energy efficiency and demand side management (EE/DSM) measures. An associated program of technical assistance in EE/DSM—a cost-effective, quickly scalable approach to mitigating power shortages and reducing load shedding—was therefore developed to provide timely support to South African counterparts.

World Bank support to South Africa encompassed several initiatives on the demand side, to help the country save energy, reduce greenhouse gas emissions,[1] and help South Africa cope with a power crunch which is likely to last until the Medupi Coal Power Plant is fully commissioned in 2015. South Africa's energy efficiency (EE) efforts included, *inter alia,* a massive distribution of efficient lighting, development of a program to install one million solar water heaters, implementation of demand response arrangements with large clients, and innovative

[1] In the case of South Africa, Demand Side Management, or reduction of MW during peak hours or system contingencies is also aligned with the objectives of reduction of CO_2. In contrast to other regions in the world, where natural gas plays the role of peaking units and coal is base load, South Africa needed (and still needs) to resort to diesel generation to meet peak load. Those units are more polluting than base load coal generation. Therefore, both energy efficiency (MWh) and demand management (MW) were perfectly aligned with LTMS objectives and with the needs of the power sector in South Africa. It was a clear win-win situation.

BOX 1.

Historical Background

Since 2007, the World Bank, assisted by the United Nations Development Program and the Energy Sector Management Assistance Program (ESMAP), has supported implementation of South Africa's Long-Term Mitigation Scenarios (LTMS). This included an international peer review of the LTMS prior to their submission to the Cabinet and the provision of substantial technical assistance on energy efficiency, demand-side management, and power rationing—in light of the urgency of these issues for the near term due to the acute power crisis which struck South Africa in January 2008.

This briefing note focuses on implementation support for market-based power rationing. It discusses best practices and lessons from Brazil's power rationing experience and California's response to a power crisis and identifies the key options and issues for the implementation of a market-based power rationing program in South Africa.

financing schemes to support EE efforts among small and medium size enterprises.[2] The support also included a market-based power rationing program, known as the Power Conservation Program (PCP), which is the main subject of this briefing note.

This briefing note captures lessons from international experience in dealing with power shortages including key options and issues for implementing a PCP in South Africa. This work was implemented in support of South Africa's Long-term Mitigation Scenarios (Box 1) and has helped highlight many of the critical challenges facing the country in its efforts to reduce its energy intensity and mobilize cleaner energy sources.

SOUTH AFRICA'S EFFORTS TO LIMIT CO_2 EMISSIONS

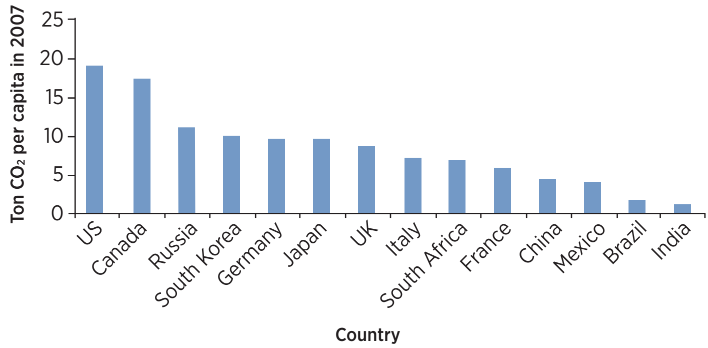
South Africa's historically low-cost energy supplies together with the predominance of extractive industries have combined to create a highly energy-intensive economy. At present South Africa is the largest contributor to greenhouse gas (GHG) emissions in Africa. On a per-capita basis, its GHG emissions are higher than in most other major emerging economies, including Brazil, China and India, as shown in Figure 1.

The Department of Environment collaborated with the University of Cape Town to develop Long-term Mitigation Scenarios[3] with the aim to provide a platform for low carbon investment planning. Several mitigation scenarios have been developed to illustrate how the huge gap between the "Growth Without Constraints" and the "Required By Science" scenarios could be closed (Figure 2). The LTMS identified energy efficiency, renewable energy, nuclear energy, passenger modal shift, and improved vehicle efficiency as the priority mitigation "wedges," or options to reduce carbon emissions.

[2] Such as Standard Offers, a mirror-image of feed-in-tariffs, but tailored to reduction of MWh and MW. A detailed discussion of Standard Offers in South Africa is provided in briefing note 007/11 of this ESMAP series.

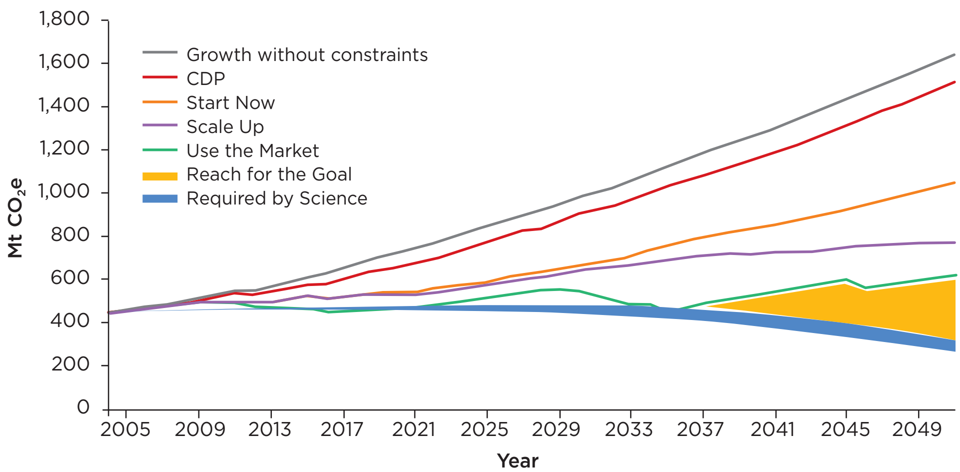
[3] http://www.environment.gov.za/HotIssues/2008/LTMS/LTMS.html

Figure 1 | Cross-country Comparison of CO_2 Emissions per Capita



Source: OECD Factbook, 2010.

Figure 2: Long-term Mitigation Scenarios



Source: Government of South Africa, Department of Environmental Affairs, 2008.

SOUTH AFRICA'S REGULATIONS AND THE NEED FOR DSM AND EE

The South African government has recognized the importance of EE and DSM as key elements in a strategy to minimize environmental impacts and contribute to a sustainable development strategy. The "White Paper on Energy Policy," published by the South African Government through the Department of Minerals and Energy (DME) in 1998, emphasized the goal of providing the nation with wider access to energy services, while ensuring that the environmental impacts of energy conversion and use are minimized as much as possible. The need for EE/DSM led to the formulation of specific policies and regulations, such as the Energy Efficiency Strategy and a new Regulatory Policy on Energy Efficiency and Demand-side Management (Box 2).

BOX 2.

Energy Efficiency Strategy of the Republic of South Africa

Vision

To encourage sustainable energy sector development and energy use through efficient practices thereby minimizing the undesirable impacts of energy usage upon health and the environment, and contributing toward secure and affordable energy for all.

Goals

Social Sustainability

1. Improve the health of the nation
2. Create jobs
3. Alleviate energy poverty

Environmental Sustainability

4. Reduce environmental pollution
5. Reduce CO_2 emissions

Economic Sustainability

6. Improve industrial competitiveness
7. Enhance energy security
8. Reduce the need for additional generating capacity

Source: Department of Minerals and Energy, 2005.

INTERNATIONAL EXPERIENCE WITH POWER RATIONING PROGRAMS

Power shortages are a fact of everyday life in many parts of the world. Even developed countries are subject to power shortages; however, they are usually short-lived (weeks or months) affairs. In developing countries, especially in regions like Africa, it can take several years for new generating capacity to be constructed or for the contributing factors (e.g., drought, civil strife, financing) of the shortage to be resolved (Wines, 2007).

The past 10 years have seen an increased frequency in the occurrence of power shortages in both the developing and the developed world (Heffner et al., 2009). Power shortages seldom have a single cause. However, a typical pattern begins with underinvestment or very rapid growth that degrades reserve margins below accepted reliability levels, with an acute crisis then brought on by unusual conditions of weather, fuel supply, plant availability, or all three. As was observed during the California power sector meltdown, "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."[4] In that sense, the Brazil, California, and South Africa crises shared this feature of long years of mispricing a scarce good, impairing the power sector's ability to invest in new capacity.

[4] Taylor and Van Doren, 2001.

Table 1 | Notable Power Shortages since 2000—Developed and Developing Economies

COUNTRY/REGION/STATE	PERIOD	CAUSE(S)
Tanzania, Kenya	2001	Drought
California	2000–01	Drought, heat, failed sector reforms
New Zealand	2001	Drought exacerbated by transmission failure
Brazil	2001–02	Drought, sector reform, insufficient investment
Dominican Republic	2002	"Financial blackout," no money to buy fuel
Tokyo	2003	Nuclear power plant safety shutdowns
Norway	2003	Drought, unusually cold weather
Europe	2003	Drought, hot weather, plant shutdowns
China	2004–07	Very rapid demand growth, deteriorating load factors, insufficient investment
Bangladesh	2005–ongoing	Demand growth, lack of investment
Tanzania	2006	Drought, depleted reservoirs, demand growth
Uganda	2006–ongoing	Drought, insufficient investment, demand growth
Vietnam	2007	Very rapid demand growth
Rwanda	2006–ongoing	Insufficient investment, demand growth
Ethiopia	2006–ongoing	Insufficient investment, demand growth
Ghana	2006–ongoing	Insufficient investment, demand growth
Pakistan	2007	Rapid demand growth, lack of investment

Source: Heffner et al., 2009.

The practical experience gained with respect to causes of power shortages and possible response and solutions have been documented by the International Energy Agency (2005) and Maurer et al. (2005). Power shortages can be classified according to whether they are capacity or energy related (or both) and whether the shortage outlook is acute or chronic. For example, in Brazil in 2001, the convergence of a stalled deregulation effort and severe drought resulted in an energy shortfall that lasted until the seasonal rains returned and some thermal power generation was brought on-line. In California, a combination of factors, including serious flaws with the restructuring of the electricity market, a drought, a shortage of natural gas, and policy bottlenecks between regional and federal authorities led to a serious capacity shortage.[5]

Of the notable electricity shortages listed in Table 1, the most serious have been shortages of both energy and capacity. The lessons learned from the responses to the power crises in Brazil (Lock, 2005) and California were the most useful for South Africa, where failure to keep up with rapid demand growth led to a lack of intermediate and peaking thermal resources. The Brazilian case, a typical energy constrained one, used demand response to reduce MWh while California had to confront a MW power crunch. South Africa was unique in the sense that the power system was both energy and capacity constrained—therefore, successful experiences from those two places proved to be very useful.

Brazil's Power Shortages

The 2001 supply crisis remains a defining moment in the development of the Brazilian power sector. As with most crises, it was the result of several intersecting trends and bad timing. A power sector reform effort begun in 1998 successfully privatized the distribution sector but did not create the proper incentives for ex-

[5] The California power crisis has been referred to as the "perfect storm," –See International Energy Agency, op cit.

isting utilities or independent power producers (IPPs) to invest in green field generation.

The overall sector reform strategy called for new investment flowing into the sector to stimulate rapid development of a new fleet of gas-fired power plants using the natural gas imported from Bolivia. While these plants were gradually taking off, along with the new regulatory framework, the ongoing power needs would be met by drawing on the stored hydropower reserves.

This overall strategy was undone by delays in construction, inability to execute long-term contracts for gas, and development of a new grid code. As a result, the forecasted short-term power supply became badly deficient. Despite dwindling reserves, the Government did not take any firm action until a lack of rainfall in 2000 and 2001 made it clear that drastic demand reduction schemes would be necessary to avoid extended blackouts.

In June 2001, the Government of Brazil created the Electric Energy Crisis Management Board, known as the GCE. The full Board was chaired by then—President Cardoso, and GCE was granted special powers that superseded the regulator and included the authority to set up special tariffs, implement compulsory rationing and blackouts, and bypass normal bidding procedures for the purchase of new plants and equipment. After considering a load shedding approach, the GCE opted for a Quota System in which each customer was obligated to reduce their consumption relative to a "baseline" with financial penalties and disconnection for non-compliance. The Quota System was considered more appropriate even though it was likely to be administratively complex, as it was expected that many users would challenge their assigned quotas and consumers in general would challenge the mechanism in court (Box 3).

The Brazilian case demonstrated that a rationing scheme can complement other DSM and EE market intervention strategies, especially customer awareness building, promotions, and incentive schemes to influence customer behavior. The decision to adopt a semi-voluntary quota system rather than a totally involuntary rolling blackout scheme proved highly successful, yielding sufficient reductions in usage (residential customer savings of up to 25%, industrial reductions of 15–20%, and commercial reductions of 10–25%), and eliminating the need for any load shedding or blackouts.

The self-rationing scheme for mass market customers and the market-based entitlement trading scheme for large users resulted in a 20% reduction in demand for the 9 month period needed for the peak of crisis to pass. Furthermore, a massive educational campaign resulted in permanent savings in terms of EE investments, as well as a minimal impact on GDP growth as businesses were able to use the secondary quota entitlement market to set their own optimal level of power consumption. The demand response to compulsory rationing was very successful. Actual savings exceeded the 20% target and remained

BOX 3.

Brazil's Power Rationing Measures

- Electricity rationing
- Penalties for failure to cut consumption
- Extensive coverage of shortage by media
- Daily reports on reservoir status
- Distribution of conservation devices to the poor
- Strong national commitment to conservation
- Higher savings goal for public sector
- Fuel switching

Estimated electricity savings: 20%

Duration of shortage: approximately 10 months

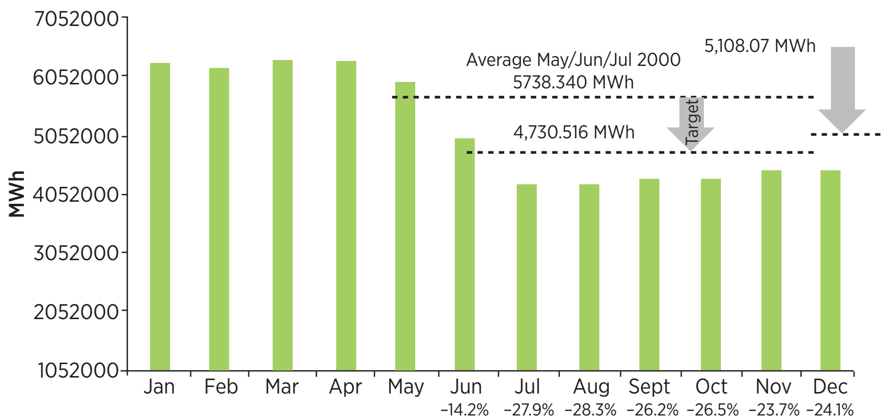
Advanced warning: approximately 5 months

Source: IEA, 2005.

high even when the targets were relaxed from 4.7 to 5.1 TWh per month for residential customers in the affected area (Figure 3). The program was so successful that the Government paid over US$200 million in bonuses to customers who met and exceeded their reduction quotas (PSRI 2002).

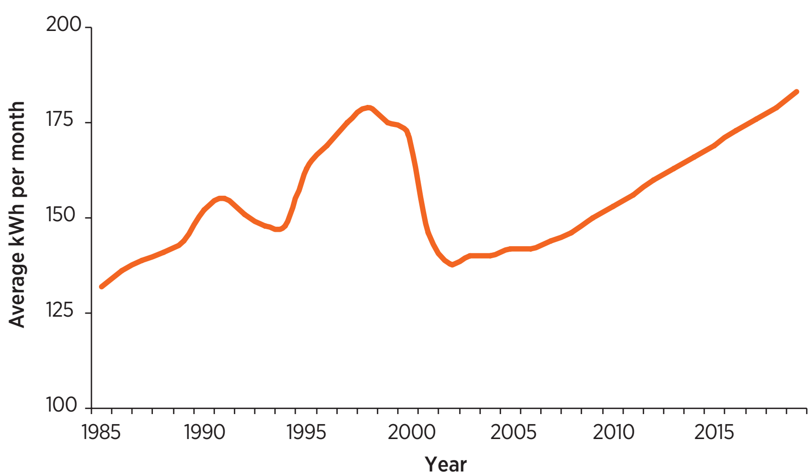
Perhaps the most notable result of the power rationing scheme in Brazil was the "permanency effect." Energy savings lingered long after the rationing measures were lifted. For example, in the residential sector, the average monthly consumption per household dropped from about 180 kWh to 140 kWh and never recovered. Due to changes in consumption habits, more efficient appliances, and tariff realignment, the average consumption per household is only expected to reach pre-rationing levels in 2019, in spite of the overall increase in per capita income and standard of living during this period.[6] (Figure 4)

Figure 3 | Power Rationing Results in Brazil



Source: Maurer, Pereira and Rosenblatt, 2005.

Figure 4 | Consumption per Household in Brazil (average kWh per month)



Source: Hubner, N. Presentation at the George Washington University. Washington DC, 2011.

[6] Only modestly offset by a large number of new, low income customers connected under the Luz para Todos program.

California's Electricity Crisis

California's electricity crisis of 2000–01 was caused by a combination of factors that led to a severe shortage of both energy and capacity (Bushnell, 2003).

In June 2000, a series of rolling blackouts and power emergencies occurred throughout the state as the grid operator (the California Independent Service Operator, or CAISO) was forced to shed loads to protect the entire power system. Firms with interruptible power contracts suffered because they were not prepared for interruptions of electricity supply. In January 2001, California Governor Gray Davis declared a state of emergency, signifying the official start of the electricity crisis. Gradually, a consensus evolved that electricity conservation would be a necessary part of any solution to California's (and the entire West Coast's) electricity crisis. In spite of disagreements about all other aspects of the electricity crisis, the state legislature quickly allocated over half a billion dollars to fund conservation programs (Box 4).

BOX 4.

Summary of Measures Adopted in California

- Over 200 different programs involving all sectors
- Rebates to customers who used less electricity than in the previous year
- Public Awareness Campaign
- Extensive daily coverage in the media
- Rebates for purchase of efficient appliances and equipment
- Business partnerships
- Updated efficiency standards
- Higher electricity prices to some consumers

Estimated electricity savings: 14%
Duration of shortage: approximately 9 months
Advanced warning: approximately 12 months

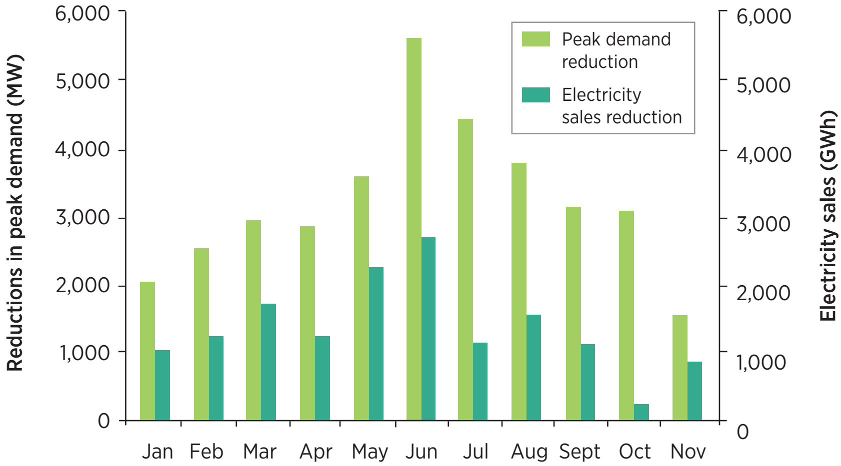
Source: IEA, 2005.

One of the innovative programs adopted In California was the "20–20 program," under which customers were rewarded for voluntarily reducing their monthly consumption compared to the prior year by providing a 20% rebate on the commodity portion of their electricity bill for a 20% minimum reduction in monthly consumption. The rebate applied only to the summer months of June through September. All customers were eligible to participate, but the rebate for large commercial and industrial customers with time-of-use meters was based on savings in on-peak demand.

California was able to create a crash program and quickly spend US$1.3 billion because it already had the infrastructure in place to save electricity. Existing programs could be rapidly scaled up by substantially increasing the subsidies and rebates provided. The utilities and government agencies already had lists of participating manufacturers, stores, and services; these groups could be easily invited to participate in new programs (Figure 5).

A survey of consumers found that almost 80% of all consumers undertook one or more measures to cut electricity demand. However, most of the savings occurred in a smaller group of consumers (about 37%) (Goldman, Eto, & Barbose, 2002).

Figure 5 | Energy and Capacity Savings in California



Source: Goldman, Eto and Barbose, 2002.

DESIGNING A POWER CONSERVATION PROGRAM FOR SOUTH AFRICA

A Customized Market-Based Rationing Program

Both Brazil and California can provide useful lessons in how to overcome power shortages but the longer term nature of South Africa's situation required a customized solution. Furthermore, South Africa's power system was both capacity and energy constrained. Support to South Africa therefore included an examination of the features and results of power conservation approaches used in Brazil and California as shown in Table 2.

PCP design was tailored to the specific characteristics of the power sector in South Africa. At the outset, a number of issues were identified as important for the design and implementation of an effective power rationing program and were discussed with key stakeholders:

- Targeting customer groups for a Phased Implementation;
- Differentiating quotas and establishing criteria for differentiation among industrial customers;
- Trading quotas in the marketplace;
- Establishing quotas for distribution utilities;
- Nature of incentives and penalties—should threat of disconnection be used to enforce quotas?
- Pre-paid meters and smart meters;
- Who should make key decisions about PCP implementation issues;
- Adequacy of the 10% reduction target quota;
- Communication—identifying messages and key players; and
- Integrating PCP, demand side management (DSM), EE, demand participation, co-generation, and other initiatives.

Table 2 | Comparing Power Crises in Brazil and California

	BRAZIL (1)	CALIFORNIA (2)
Shocks	Supply	Supply and Demand
Shortage	Energy only	Capacity (Energy)
Action	Cap (and Trade)	20/20
Mandate	Compulsory	Voluntary
Load Shedding?	No	Some
Duration	6/01–02/02	11/00–05/11
Government Action	Fast	Slow
Cost of Demand Response	US$7/MWh	US$276/kW-yr
Second Best	US$150/MWh or shedding (US$300/MWh)	US$55/kW-yr (peaking) or shedding
Measuring Deployment	No	No

Sources: (1) Maurer, Pereira, Rosemblatt. *Implementing Power Shortages in a Sensible Way: Lessons Learned and International Best Practices.* Washington, DC. ESMAP Formal Report 305/05. (2) Sweeny. J. *The California Electricity Crisis.* Stanford, CA. The Hoover Institution Press, 2002.

After extensive consultations and drawing on international best practice, an inter-ministerial committee formally agreed to develop a market-based program relying upon the experience in Brazil, as summarized in Annex 1.

Eskom, the local utility, formed a special unit to deal with the multi-faceted aspects of implementing a mechanism to manage power shortages. The description which follows illustrates some of the issues and options to be taken into account when a country like South Africa decides to design a PCP program. Experience from other countries was useful as a starting point, but the whole design had to be customized to the objectives and constraints of the power system in South Africa.

Targeting Customer Groups for a Phased Implementation

In principle, all customers should be subject to quotas. Exemptions, if any, should be treated as such. The PCP is equivalent to a "social compact," where the Government is asking the whole society to change consumption habits, conserve energy, make investments in energy efficiency, and share some of the burden of balancing power supply and demand. As a *quid pro quo,* the government should promise energy supply all day, every day and no more rolling black-outs. Since the power shortage was a nationwide problem, it was decided that every single customer should contribute to solving it. Without broad engagement of all customers, there was concern that the power crunch could be perceived as somebody else's problem or a problem that only the large customers need to address. Eskom identified the necessary measures to engage all customers. However, a decision was made to start with the largest customers first and then move to the whole customer base, if necessary. Given the relief in operating margins provided by the late-2008 economic crisis, it was not necessary to expand the customer base to achieve the 10% desired savings.

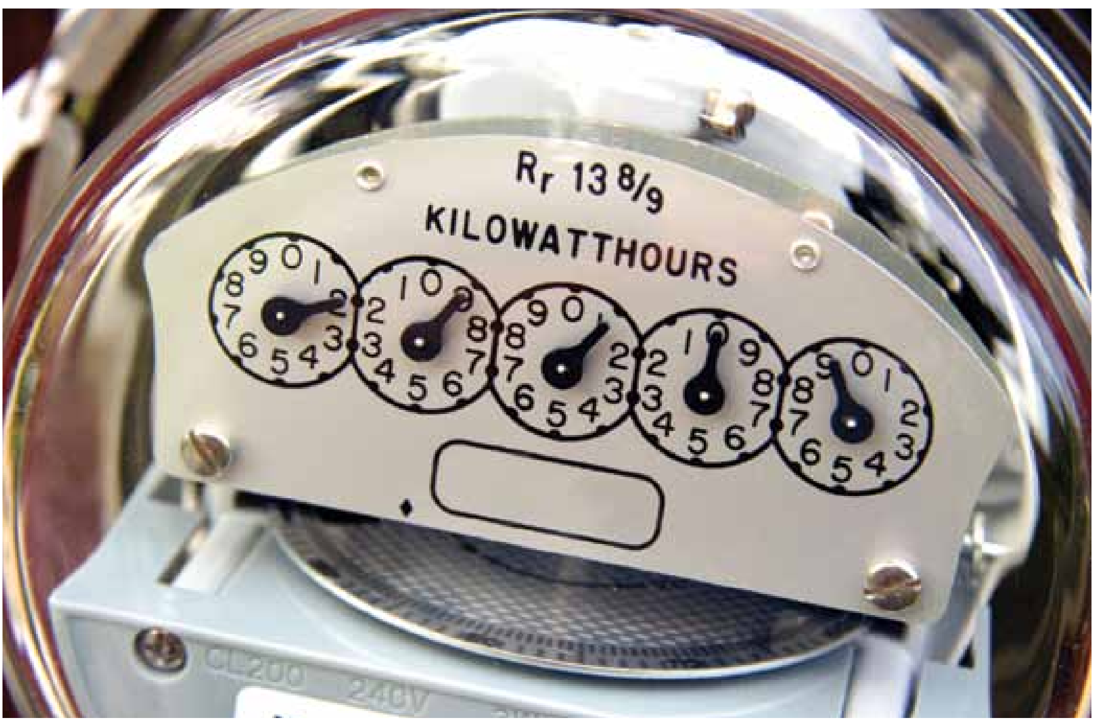
A phased implementation of the quota system was justifiable since Eskom believed that it was going to be very complex to develop a comprehensive program encompassing the entire customer base from the outset. Eskom believed that a relatively small group of customers could be targeted at the outset, representing a large percentage of consumption and therefore with potential to achieve immediate savings. Furthermore, the power sector in South Africa had some unique characteristics, such as a very large number of utilities and extensive use of pre-paid meters, which might require additional work when compared to, for example, Brazil.

Utilities in Brazil also believed that a quota system to the entire customer base would be extremely complex. Both the South African and the Brazilian experience indicated that implementation complexity was less than originally envisioned by the utilities.

Differentiating Quotas across Customer Groups

The initial assumption was that quotas should be differentiated across customer groups. The reason to differentiate quotas was the substantial variation between customers in their willingness to pay for electricity (as a proxy for its economic value). In addition to avoiding load shedding, a goal of the PCP program was to allocate a scarce resource in the most efficient way. While a single quota would be simpler to implement it would not achieve this goal.

A study carried out in Brazil, involving only industrial customers, showed that a single quota would reduce GDP by at least 1% (vis-à-vis the proposed differentiated quotas). It highlighted the importance of differentiation being determined by the government at its highest level and of differentiation across customer groups and within the same group. For example, in the case of Brazil, poor households had no quota assigned (but they did have bonuses). In contrast, differentiation among industries was based on the: (i) contribution of electricity to GDP; (ii) labor intensity, to preserve jobs; (iii) generation of foreign reserves; and (iv) activities contributing to increased power supply, such as electric equipment.



Trading Quotas in the Marketplace

A market should be established to trade quotas to achieve a more efficient allocation of energy reductions. The market for quotas should be available from the outset, and could be relatively simple. Multiple markets should be encouraged. Over-the-counter transactions should be accepted, as long as there is an agreed process where trading parties can inform the utility about the volumes transacted.

It was noted that the initial allocation of energy reductions was an administrative process, which did not necessarily take into account the value of energy for each industrial end-use.

It was also noted that, if quotas were not differentiated at the outset, the role of a market and trading scheme would be even more important. The government could additionally establish a trading platform, to facilitate price discovery and give more liquidity. The trading of quotas was an option that would not defeat Eskom's role as a single buyer. Eskom could continue to procure and supply energy, invoice, bill, and collect, as well as provide customer service.

Establishing Quotas for Distribution Utilities (including Municipalities)

Distribution utilities (including municipalities) were not the final users of electricity but they should play a major role in helping the customer achieve the targets, by educating and providing support on energy savings, revising the quotas, and reducing their own use for street lighting, disconnecting offenders, etc.

The energy contract between Eskom and the municipalities was a "full-requirement" type. This contractual relationship did not create any incentives for municipalities to reduce sales to their captive load—and thereby reduce their revenues and profits. Municipalities would prefer to "free-ride" the system, and it was recommended that the PCP considered some incentives for municipalities to engage in the power conservation effort. A two-part tariff was an option. For example, a large percentage (95-98%) of the municipality's requirements could be priced at regulated tariffs and the balance at short run marginal cost (SRMC).

Nature of Incentives and Penalties

From an economic perspective, the most efficient incentive is to price consumption above the quota at Short Run Marginal Cost (SRMC). If there is a functional wholesale energy market, the best proxy for SRMC is the spot price. If there is no such market, the best proxy for SRMC is the variable cost of the most expensive generation unit.

In the case of Eskom, the variable cost of diesel plants was about US$400 per MWh (assuming US$90 per barrel of oil). Economic efficiency results from the fact that the real cost of energy percolates the entire supply chain and is directly perceived by the end user.

In the same way, bonuses given to those consuming less than their quotas should be priced at SRMC.[7] In the case of Brazil, there were many practical considerations in finessing the incentives and penalties. For example, large customers were indeed charged SRMC for consumption exceeding the quota. In the case of smaller customers, for the sake of simplicity, the same figure was expressed as a fixed ratio of the existing tariff (e.g., three times more expensive). Incentives were also designed to create a safety net for the poor. As mentioned above, households were not formally subjected to quotas, since they did not reach a minimum consumption threshold. If smaller customers were to join PCP, it would be necessary to implement a "safety-net" to lifeline rate customers. In the case of Brazil, there were no quotas for low-income customers, but they were given incentives to reduce their prior year's consumptions. Contrary to initial expectations that poor customers had little ability to save, this bonus scheme in Brazil had a major impact with low income customers achieving the largest savings among all customer groups.

A thorny issue in South Africa was whether or not to include the threat of disconnection for offenders. Based on the Brazilian experience, there was a strong rationale for implementing this measure, even though it might be perceived as draconian. The economic argument was based on the fact that only a minor fraction of the consumption was priced at SRMC. The quota was

[7] In functional wholesale markets, the spot market is a good proxy for SRMC. Since South Africa does not have an active wholesale market, this difficulty could be circumvented by specifying the variable cost of the least efficient plant in the merit order for dispatch.

being grandfathered at regulated tariffs. Therefore, customers would not make rational decisions on energy savings. Additionally, in the absence of the threat of disconnection, the mechanism was unlikely to be perceived as equitable, since the rich will continue consuming and the poor will be penalized. This is still an open issue that may be addressed if South Africa decides to expand the PCP.

Pre-paid Meters and Smart Meters

At the time of the crisis, South Africa had about 7 million pre-paid meters installed. It seemed to be impossible to enforce a quota mechanism in those cases. However, given the technology available for recharging meters, it was possible for Eskom to figure out a simple way to enforce a quota allocation scheme.

Eskom was already considering the installation of smart meters prior to the 2008 power crunch. In part, this measure responded to the need for better load management—for economic and reliability reasons. The rationale for implementing smart metering had to transcend the specific needs of the PCP.

From a communication perspective, Eskom tried to de-link the implementation of smart metering from implementation of the PCP—otherwise it could be perceived as punitive to customers. That being said, there was no doubt that once implemented, smart metering could help Eskom implement the PCP. With smart metering, both consumption (MWh) and demand (MW) could be monitored and quotas for both enforced.[8] Since South Africa's power system is both energy and capacity constrained, this technology would be welcome, if economically justifiable on several merits.

Key Decisions for PCP Design and Implementation

Eskom had been proactive in designing an energy conservation program to avoid load shedding and benefit the country as whole. Eskom had taken into account the economic growth of South Africa and the quality of service to its customers.

However, the PCP as a "social pact" required key decisions to be made at high levels of government. While Eskom could provide technical expertise, there were some design issues that transcended its technical sphere of influence and reflected government policies. For optimal PCP design, there needed to be strong coordinated engagement by the Department of Minerals and Energy (DME), the National Energy Regulator of South Africa (NERSA), and other Ministries on the PCP. This coordination did not exist initially.

One of the reasons for the success of the Brazilian program was the strong leadership and coordination by a high level government official, who reported directly to the President and was fully empowered to liaise directly with all involved stakeholders (the so-called "energy czar"). No one played this role in South Africa. Nevertheless, Eskom managed to address some implementation difficulties.

Targeting a 10% Reduction in Peak Demand

The selection of a particular target (or quota) has to be based on a technical rationale. The targeted reduction depends on the nature of the crisis, its duration, the

[8] Given the absence of real time metering, California was not able to set a demand reduction quota during the peak hours.

expected growth in power supply and demand, and other important variables.[9] In a scenario of uncertainty, it would be better to start with a higher reduction target and reduce it gradually. The opposite approach would be politically problematic and might be perceived as breach of the social pact (unless some emergency or unexpected event occurred).

Communication

Communication would be a key success factor for the program. Communication should be candid, straightforward, and action-oriented. The experience in Brazil showed that there has to be several layers of communication, from the President down to the state energy secretaries, down to the utility branch manager. Eskom had accumulated very good experience in mass market communication during the 2007 power crisis in Cape Town, when one unit of the Koeberg power plant had to be shut down for maintenance. At that time, quick and decisive actions on demand side management had to be made, including massive distribution of CFLs, frequent and candid communication, including banners on TV reporting the reserve margins and need for people to take immediate load reduction actions. Eskom brought a strong communication team and designed an effective communication campaign to implement the PCP.

[9] In a similar vein, if a cap and trade system is implemented amongst the largest CO_2 producer, there has to be an initial target based on the expectation of achieving 450 ppm by a certain date. In that sense, a PCP and market based rationing scheme are very similar mechanisms.

Integration of PCP with Other EE and DSM Initiatives

PCP was an umbrella program designed to accomplish a 10% demand reduction. This reduction goal could have been achieved by urging people to use energy more efficiently, and non-compliance would be subject to penalties. However, there were many well known barriers to energy efficiency—knowledge and awareness being among the most important. In South Africa electric rates were not fully cost-reflective (and significantly lower than the system's LRMC and also SRMC during the power crisis) and customers would likely be reluctant to make significant investments to reduce their electricity consumption. Therefore, it would make sense for Eskom and for the Government to provide incentives for people to engage in EE and DSM. These included a standard offer,[10] distribution of CFLs, subsidies on solar water heaters, and a demand participation program to achieve the overall 10% reduction target. Annex 2 presents a summary of the main programs aimed at achieving energy savings (MWh) and peak reduction (MW) during the power crunch in South Africa in 2008.

Some form of coordination among these measures and the PCP is necessary. However, to create a more energy efficient economy, where the government expected that EE and DSM continue even after the power crunch, it is advisable that DSM and EE be structured as separate organizations able to fulfill their roles when the PCP came to an end.

[10] A detailed discussion of Standard Offers in South Africa is provided in briefing note 007/11 of this ESMAP series.

IMPLEMENTATION OF SOUTH AFRICA'S POWER CONSERVATION PROGRAM

The goal of PCP initiated by Eskom in early 2008 was 10% reduction (or about 3,000 MW) in peak demand. The initial focus of the PCP was on the large industrial users, particularly mines and smelters. PCP and other demand side measures achieved the intended goal. In less than a month, the country was able to virtually eliminate load shedding. The quotas were applied to large customers only, as part of a phased implementation plan. By the end of 2008, as a result of the impact from the global economic slowdown, power demand in South Africa declined dramatically.

In conjunction with the PCP, the country was able to restore some decent operating margins. By January 2009, Eskom reported that the load on the Eskom's power system was reduced by 1,500 MW compared to the previous year. Despite the reduced electricity demand, however, Eskom continued the PCP program for the large industrial customers in 2009 (*Energy Tribune* 2009). There was no need to increase quotas or include smaller customers. The economic crisis and the results of the PCP program gave Eskom some breathing space to manage the power crunch.

The PCP has proved its effectiveness. The economic benefits of the program include the reduced need for dispatching expensive, oil-fired power plants. Eskom has maintained the PCP as an option that can be expanded beyond the large industrial customer base, if further power shortages arise due to an imbalance between electricity supply and demand. The system is well understood among Eskom's staff, integrated into business processes, and it can be adjusted to accommodate a larger customer base, if necessary. It is an excellent hedging mechanism that can help Eskom to manage power system reliability if the reserve margins deteriorate in the future.

In terms of CO_2 emission reduction, the PCP was a "saving in a hurry" kind of program designed to promote changes in habits and foster investments in energy efficiency. Under such a scheme, customer reaction is quite different from the one resulting from rolling black-outs or from the installation of emergency power generation—those lead customers to "use as much as possible" when the energy is available. For simplification, it may be assumed that the impact of the PCP program was felt only among industrial customers, which were the ones subject to quotas. A 10% reduction in the industrial load corresponds roughly to 6% of the country's electricity consumption. Over a 6 month period, this translates into savings of 6 TWh or 6.1 million tons of CO_2.[11] This is equivalent to a societal benefit of about US$120 million.

This calculation does not take into account any sort of "permanency factor," which may be very pronounced as shown in the case of residential customers in Brazil. However, it is also reasonable to expect this effect to take place among large industrial users in South Africa. Those customers invested in energy efficiency to meet their targets and possibly sell any surpluses in the market, and those investments continue to produce energy savings. The authors are not aware of any detailed analysis of lingering effects of the PCP program, but it is

[11] Eskom's average GHG emission factor is 1.015 kg CO_2e/kWh.

reasonable to expect that they do exist. Therefore, the electricity and CO_2 savings are likely to be much higher than the ones calculated solely for a 6 month period while the rationing lasted.

South-South Cooperation

Support for the design of a tailored PCP showcased an interesting triangular South-South Cooperation approach. The World Bank provided technical support to help South Africa adapt the Brazilian power rationing scheme to the specifics of the South African Power System, taking into account the expected nature and duration of the power crisis. The World Bank also provided a conceptual framework, as described above. The World Bank facilitated a dialogue between the two countries—a South African delegation visited Brazil and shared experiences with key actors. Finally, the World Bank, with support from the Energy Sector Management Assistance Program (ESMAP), hired Brazilian and US consultants that had hands-on experience with handling the power crises in 2001 in their respective countries.

Annex 1

Interventions to Address Electricity Shortages

Power Conservation Programme

The concept proposal draws heavily from the publication, *Implementing Power Rationing in a Sensible Way: Lessons Learned and International Best Practices* (ESMAP Formal Report 305/05, August 2005), which commends the energy rationing applied in Brazil in 2001 as best practice in the event of an energy crisis. The key elements of the programme would be as follows:

Quota Allocations

- The programme is designed to achieve the overall savings target of between 10–15% over time. This target allows for a moderate growth of approximately 3.6% in electricity consumption. The quota allocation allows for differentiation of customers by class. To illustrate this, for example, based on a possible target of an immediate 8% overall savings, the large energy consumers could be required to reduce their consumption based on the following targets:
  - Industrial = 10%
  - Commercial (general) = 15%
  - Hotels, resorts, shopping malls & conference centers = 20%
  - Large office buildings, government, municipal & electricity utility offices = 15%
  - Agriculture = 5%
  - Residential = 10%
- For special cases, no targets will be imposed. The special cases include, but not limited to hospitals, essential and security installations.
- Focus team to look at 2010 requirements

Penalties & Cut-offs

- Various penalty measures are being explored. The measure that are currently being explored include, but not limited to:
  - Penalty tariff rates for energy use above the allocated quota
  - Cut-offs for a specific period for repeat offenders
  - Special cases will be exempt from penalties

Incentives

- An incentive scheme is being established for the smaller consumers that exceed their savings targets
- *Trading*
  - Large consumers can trade in their unused portion of quota allocation. There will also be possible provision for larger consumers to "take or pay" their allocated portion.
- *Built-in Flexibility*
  - The plan will be designed to ensure that there are possibilities to be able to adjust the quotas and penalties to address the possible changing needs in the future.

Excerpt from: The Government of South Africa. National Response to South Africa's Electricity Shortage. Interventions to Address Electricity Shortages. Inter-Ministerial Briefing. January 2008.

Annex 2

Complementary Demand Side Management Programs to Deal with Power Crunch in South Africa*

	RATIONING	ENERGY EFFICIENCY	DEMAND-SIDE PARTICIPATION
Approach	"Quasi-Market Based Rationing"	Standard Offer	Demand Response—reliability (and possibly economic)
Product	MWh and indirectly MW reduced	MWh and indirectly MW reduced	MW (capacity) reduced in different timeframes; negligible on MWh
Primary Target Market	All customers at the outset	Medium and large. Smaller with "aggregators"	Primarily large
Incentives	Bonuses, penalties, disconnection, differentiated quotas per customer group	Fund to subsidy; difference between price paid and regulated tariff (per kWh); differentiated by technology	Pecuniary incentives for reliabilty; differentiated by speed of response.
Safety Net for the Poor	No quotas, only bonuses	Programs targeting poor customers (e.g., efficient appliances)	Not applicable
Speed of Implementation and Load Response	Very short term	Medium and long term	Short term
Permanence Factor	Medium term for conservation, long term for energy efficiency	Long term for energy efficiency	Duration of program
Possible Rebound Effect	No	Yes	No
Status of Implementation	Under consideration	ESKOM/ESCOs driven DSM program	About 500–1000 MW of short term response; curtailable load; potential to expand
Plan B	Increase incentives	Increase subsidy price paid per MWh	Increase incentives
Fall Back Position	Blackouts	Blackouts	Scheduling rolling blackouts
International Best Practices	Brazil (and a California 20/20 version)	Several states in the US (ongoing)	US Utility and ISO/RTO (PJM, New York ISO, New England ISO driven programs—ongoing)
Cost of the Program	Possible imbalance between incentives and penalties; administrative and marketing costs	Fund subsidy and difference between price paid and regulated tariff; administrative marketing costs	Incentives; real time metering deployment

Source: World Bank.

* Not meant to be comprehensive. Other ad-hoc programs include solar water heaters, CFLs, co-generation, etc., which are also complementary.

ABBREVIATIONS AND ACRONYMS

CAISO	California Independent Service Operator
CFL	compact fluorescent lamp
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DSM	demand-side management
EE	energy efficiency
ESCO	Energy Service Company
Eskom	Eskom is a South African electricity public utility[12]
GCE	Electric Energy Crisis Management Board (Brazil)
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
GWh	gigawatt hour
IEA	International Energy Agency
IPP	independent power producer
ISO/RTO	Independent System Operator/Regional Transmission Operator
kWh	kilowatt hour
LRMC	long-run marginal cost
LTMS	long term mitigation scenario
Mt	million tons
MW	megawatt
MWh	megawatt hour
NEEA	National Energy Efficiency Agency (South Africa)
PCP	Power Conservation Program (South Africa)
PJM	Pennsylvania-New Jersey-Maryland Power Pool (United States)
SRMC	short-run marginal cost
US$	United States Dollar

[12] Eskom was established in 1923 as the Electricity Supply Commission (ESCOM) by the government of South Africa in terms of the Electricity Act (1922). Following the appointment of Dr. John B. Maree as Chairman in 1985, Escom was restructured to meet the electricity demands of a changing South Africa. The Electricity Supply Commission (Escom) was replaced by an Electricity Council (appointed by Government) with a Management Board appointed by the Electricity Council. In 1987, Escom was renamed Eskom.

REFERENCES

Audinet, P., Rodriguez Pardina M. 2010. *Managing an Electricity Shortfall, a Guide for Policy Makers.* Washington, DC. The World Bank Energy Sector Management Assistance Program Report 52106-LAC.

Bushnell, James. 2003. *California's Electricity Crisis: A Market Apart?* Center for the Study of Energy Markets, Paper CSEMWP-119. University of California Energy Institute, Berkeley, CA.

Business Day. 2010. *South Africa: Eskom Secures Ample Power for Cup.*

Energy Tribune. 2009. *South Africa Power Improves, Rationing at Mines Remains.*

Goldman, Charles A., Joseph H. Eto, and Galen L. Barbose. 2002. *California Customer Load Reductions during the Electricity Crisis: Did they Help to Keep the Lights On?* LBNL 49733. Berkeley, CA. Lawrence Berkeley National Laboratory.

Government of South Africa. 2008. *National Response to South Africa's Electricity Shortage. Interventions to Address Electricity Shortages.* Inter-Ministerial Briefing.

Heffner, Grayson, et al. 2009. *Minding the Gap: World Bank Assistance to Power Shortage Mitigation in the Developing World.* Washington DC, The World Bank.

International Energy Agency (IEA). 2005. *Saving Electricity in a Hurry: Dealing with Temporary Shortfalls in Electricity Supplies.* Paris, France.

Letete, T. et al. 2009. I*nformation on Climate Change in South Africa: Greenhouse Gas Emissions and Mitigation Options: Carbon Accounting for South Africa.* Energy Research Centre—University of Cape Town.

Lock, Rainier. 2005. *The New Electricity Model in Brazil: An Institutional Framework in Transition.* The Electricity Journal.

Maurer, L. Pereira, M., and Rosenblatt, J. 2005. *Implementing Power Rationing in a Sensible Way: Lessons Learned and International Best Practices.* Washington, DC. The World Bank Energy Sector Management Assistance Program. ESMAP Formal Report 305/05.

OECD Factbook. 2010.

PSRI. 2002. *Review of the Brazilian Power Sector.* Prepared for the International Development Bank by PSRI.

Taylor, Jerry, and VanDoren. 2001. *California's Electricity Crisis—What is Going on, Who's to Blame, and What to Do?* Policy Analysis. Cato Institute.

The Africa Report. 2010. *Eskom Sees Power Supply Tight in 2011–2012.*

Wines, Michael. 2007. Toiling in the Dark: Africa's Power Crisis. *New York Times.*

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