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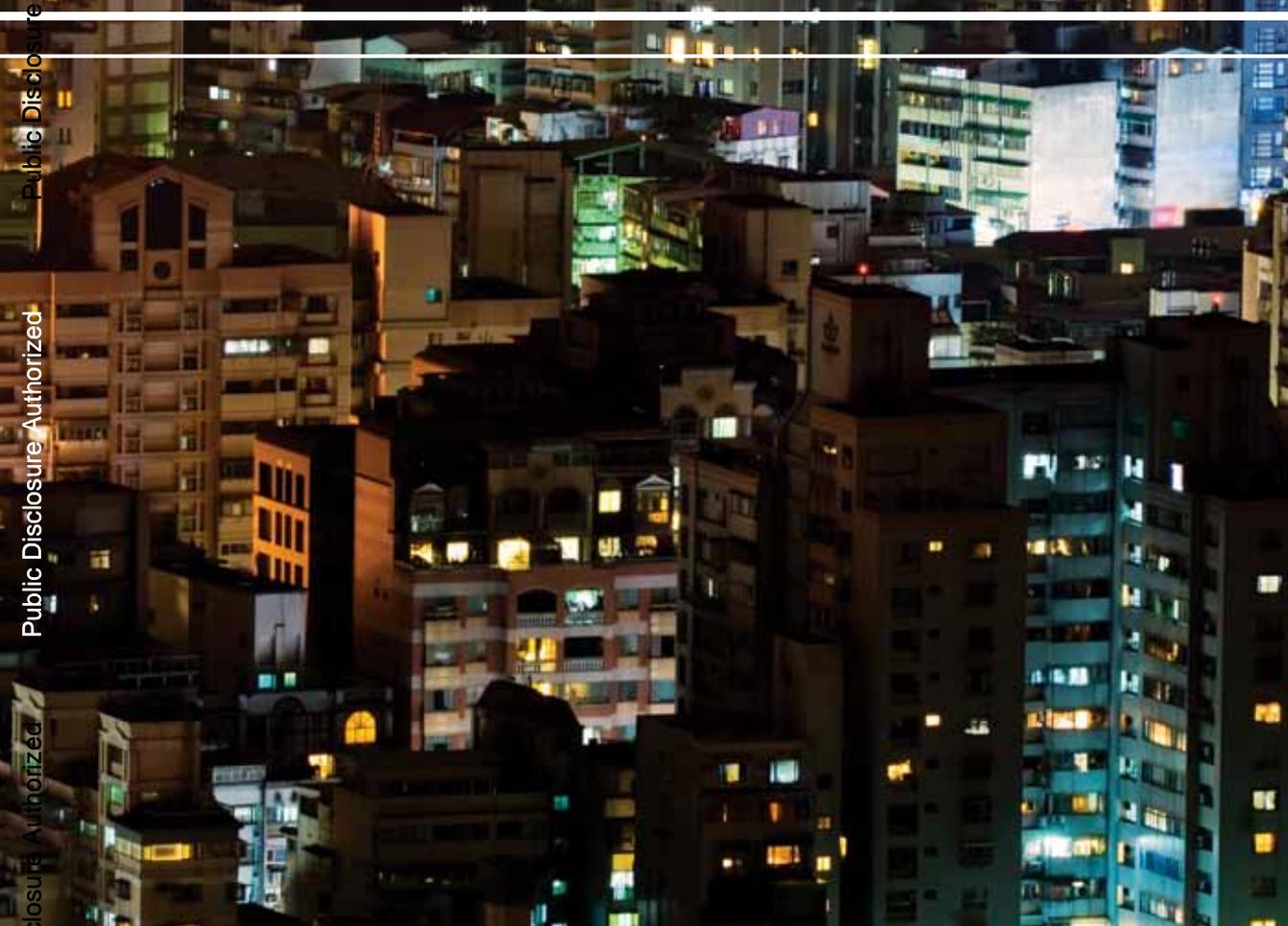
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MANAGING AN ELECTRICITY SHORTFALL

▶ A Guide for Policymakers

Energy Cluster
Sustainable Development Department
Latin America & Caribbean Region



The World Bank

Managing An Electricity Shortfall

Supply-demand tension has taken its toll in various countries around the world over the last several years. Governments and utilities have faced gaps between electricity supply and demand, which has led to blackouts and load shedding and translated into electricity shortfalls. While countries look to avoid the prospects of supply shortages by, inter alia, strengthening their planning capacity and working to achieve a sounder and more sustainable electricity sector, the possibility of shortages in the future remains.

This document summarizes the framework for action and a broad menu of options available to policymakers to bridge a supply-demand gap in the short- to medium-term. These topics are covered more extensively in the report “Managing an Electricity Shortfall: A Guide for Policymakers.” It is our hope that the information in this note will provide valuable insights for energy policymakers around the world.



ELEMENTS OF A PROGRAM TO MANAGE AN ELECTRICITY CRISIS

While it may not be known when or why, it is certain that there will be future electricity crises and that they are likely to occur in both industrialized and developing countries.

An electricity crisis is characterized by an occurrence of electricity shortages which can find their origin in:

- » **Capacity constraints:** the available capacity (generation and/or transmission) is insufficient to meet peak demand; or
- » **Energy constraints:** the desired electricity consumption of all end-users, over an extended period of time, exceeds the production levels (e.g., as a result of insufficient fuel availability, such as water resources or fossil fuels or a surge in energy demand).

Elements of a tailored response to an electricity crisis will depend on: (i) the origin of the supply-demand gap, (ii) the expected duration of the shortfall (and the lead time available), (iii) the identification and evaluation



of measures that can realistically be implemented (from both the supply and demand side) and, (iv) the institutional organization of the sector. There is no one-size-fits-all solution to an electricity crisis. Policymakers should design a tailored response on the basis of these four factors.

One of the most important elements of an electricity emergency response program is anticipating and preparing for the possibility of a crisis.

Emergency Response Actions

Managing an electricity crisis involves actions to alleviate the capacity or energy constraints through a combination of measures affecting either the demand for electricity or the supply. International experience shows that successful management of an electricity crisis requires the implementation of a range of measures including strong energy conservation campaigns, actions to reduce end-use consumption, efforts to reduce energy production losses and remove transmission bottlenecks, and measures to increase supply.

Demand Side Measures

Demand side measures are an essential dimension to mitigate electricity crises. Demand side measures focus on reducing the quantity of electricity consumed such as through modifying tariffs, increasing energy efficiency, or affecting consumption behavior. Because the demand for electricity is a derived demand for lighting, cooling, heating, power for commercial and industrial processes, and other electricity uses, demand side measures will seek to affect end-uses. International experience indicates that successfully dealing with electricity crises entails using demand side instruments to limit the quantity of electricity consumed. The optimal mix of instruments will depend on the timing and nature of the crisis.

Demand side adjustments act through direct or indirect price signals and through quantity restrictions. Direct price signals—increases in the price of electricity create incentives for users to save electricity (through the price elasticity mechanism). Indirect signals include, for example, subsidies for the purchase of more energy-efficient appliances. Quantity restrictions—or rationing—are an alternative way of ensuring that demand and supply balance in the short run. Rationing can be specific or general. Specific rationing takes the form of an administrative rule determining which users will cut back, when, and by how much. A general rationing rule will be based on geographical area or economic activity (such as a neighborhood or an industry) or type of users (such as consumers with an electricity load exceeding 1 MW).

Electricity tariffs are one of the key elements in determining the rational use of energy. There are two important caveats, however, to keep in mind when considering the effectiveness of tariffs. First, for many small users there is a time lag between when electricity is consumed and when the electricity bill is paid. For a short-term crisis, this delay could limit the impact of a tariff adjustment. Secondly, the effectiveness of tariffs will depend on the nature of the crisis. For example, capacity constraints require a reduction in peak demand which occurs at specific times during the day and

varies according to seasons. Unless the tariff structure includes time-of-day or seasonal pricing, rather than the typical structure based on the overall volume of consumption, a general tariff increase will not ameliorate a capacity-constrained crisis.

Table 1 provides a list of demand side options available for managing an electricity crisis, covering adjustments in electricity prices, behavioral changes, and the introduction of more efficient technologies.



▲ World Bank financed Nicaragua Off-grid Electrification Project. Source: Project Coordinating Unit of Nicaragua Ministry of Energy and Mines.

Table 1. Menu of Demand Side Options for Managing Electricity Crises

Measure	Main characteristics	Time Frame	Est Cost US\$/KWh	Prerequisites	Best Practice	Comments
<i>Increase electricity prices</i>						
Increase Industrial Tariffs	Signal through price mechanisms crisis intensity; decentralize savings decisions.	Short Term	(Varied)	Need smart meters in place; use of wire transfers available; existence of long-term contracts, ability to resell contracted energy		Powerful signal to induce desired changes in behavior acting on both supply and demand. Efficient structure will signal advantage to consume or shut down an sell power to the market.
Increase Residential Tariffs	Signal scarcity to residential users.	Short and Medium Term	(Varied)	Need data on residential consumption (load curve and elasticities), political willingness, able to wait for delayed response	Chile 2007-08 Electricity Crisis Management	Best suited for energy crisis as residential consumers have no time of use meters. Complement of media campaign rather than substitute.
<i>Induce Changes in Behavior</i>						
Launch a Mass Media Campaign	Involves communicating to consumers about electricity crisis information and proposed measures for saving energy	Immediate Term	(Varied)	Need to identify channels and choose message content to use; ability to sustain media campaign over time	South Africa Power Alert	This is a key element of a crisis strategy, but often needs to be complemented by other measures. Users need to understand that their actions affect the outcome of the crisis.
Mandate/Encourage Public Sector Energy Conservation	Re-allocating public sector uses of energy to more socially responsible purposes that conserve electricity	Short and Medium Term	(Varied)	Need to conduct energy audits and data on energy consumption.	Chile Energy Efficiency Policies for Public Sector	High visibility of government actions signals strong commitment and increase likely response by public. Increasing public service uses of energy can have large impact (water pumping).
Encourage Voluntary Rationing	Involves voluntarily reducing electricity consumption	Immediate and Short Term	VOLL	Need appropriate data to implement efficient partial rationing	Government voluntary rationing; Brazil, Ontario, and Tokyo	Often the government is the first to engage in voluntary rationing, with hopes that industry and residential consumers will follow by example.
Mandate Compulsory Rationing	Consumers are given restricted electricity usage by mandate.	Immediate Term	VOLL	Need data to implement efficient partial rationing; ability to compensate for or justify the social and economic disruption costs.	Norway "10 for 10" Campaign	Involuntary rationing should be used only as a last resort to preserve the integrity of the electricity system in the immediate term.
<i>Introduce More Energy-Efficient Technologies</i>						
Launch CFL Replacement Program	Improvement of light bulb efficiency, including public lighting (traffic lights, street lights)	Medium Term	0.023	Need an in-place distribution channel and mechanism; a method of ensuring destruction of old bulbs	Cuba CFL Replacement Program	Introduction of efficient lighting through the distribution of CFLs is the most cost effective measure to reduce demand.
Launch Appliance Replacement Program	Replacement inefficient appliances for residential & industrial users.	Medium Term	0.150	Need an in-place distribution channel and mechanism; a method of ensuring destruction of refrigerators	Cuba Appliance Replacement Program	Need detailed information on existing stocks and use habits to design efficient campaign.

Supply Side Measures

Supply side responses to electricity crises primarily involve increasing generation capacity and its availability. In addition to a country's long-term electricity expansion plan, there are short- and medium-term opportunities to improve the performance of currently installed equipment which can be the most expeditious means to increase effective generating capacity. This can include increasing the availability of generating capacity (such as by improving maintenance), or by reducing losses in transmission or distribution. Any measures which involve investments in capital equipment are unlikely to be effective in relieving a short-term electricity crisis. However, if the crisis is longer than a few months, such measures may become feasible.

Although many countries perceive diesel fuel based power generation as the most effective way to increase generating capacity, this may not always, or even generally, be the case. Most countries have implemented emergency generation plans that include reciprocating high speed engines using diesel fuel or medium speed engines using heavy fuel oil (HFO). However, diesel fuel is a high-cost option and also suffers from price volatility. In addition, time can still be a constraint to implementing petroleum-based generation capacity. Medium speed engines may take as long as 24 to 30 months to engineer, procure, and construct. The rehabilitation of existing facilities, repowering, and the mobilization of back-up generation are typically quicker and more efficient ways to increase the supply of electricity.

To manage electricity crises, the authorities in several countries have resorted to leasing temporary mobile generating stations and implemented other measures focusing largely on increasing electricity supply. This is often a costly and suboptimal solution.

Deciding which technology or solution to implement will depend on the particular circumstances of the country. The costs of bringing in new capacity quickly should be analyzed against slower measures that are cheaper. Also, every solution will have implementation costs such as for incentive payments, expediting costs, spare parts, and additional capital, which should also be assessed on a case-by-case basis.

Table 2 provides a menu of supply side options for managing electricity crises.

CRAFTING AN EMERGENCY RESPONSE PROGRAM

The selection of measures will depend on an evaluation of the options given the nature of the crisis and other key factors. The choice of measures will depend on how rapidly the impacts need to be felt. For any system there will be multiple combinations of options to increase supply and reduce demand. In the short run (less than six months) there are generally very limited opportunities to increase generation capacity. Some supply side measures

Table 2. Menu of Supply Side Options for Managing Electricity Crises

Rank	Measure	Main characteristics	Time Frame	Est Cost US\$/KWh	Prerequisites	Best Practice
1	Improve Generation and Transmission Outputs (Increase Availability)	Allows improvements in the output of existing assets in the sector; valid for generation and transmission assets.	Short Term	(Varied)	Data on availability limitations needs to be readily available.	Philippines Overhaul of Diesel Plant
2	Rehabilitate Existing Equipment (Increase Capacity)	This increases capacity by Improving the operation of existing equipment or rehabilitates retired or de-rated units	Short Term	(Varied)	Data on capacity limitations needs to be readily available.	Philippines Overhaul of Diesel Plant
3	Expedite Completion of Plants Under Construction	Start with plants and transmission lines in Expansion Plans and advance the completion date to prevent schedule slippages.	Medium Term	(Varied)	Cost of expediting efforts or incentives to contractors and owners to adhere to reduced schedule; need to determine effectiveness of expediting the schedule	
4	Offer PPAs on a short term basis	Integrate backup generation into the dispatch pool for peaking by offering PPAs to make use of existing operating equipment.	Immediate and Short Term	(Varied)	Need to create PPAs with appropriately lined and priced incentives to effectively target backup generation options.	
5	Increase availability of bagasse fueled plants	Bagasse fueled plants are used by sugar cane mills only during the sugar cane harvest —use for alternative fuels after harvest	Immediate and Short Term	0.147	Need to obtain data on existing on-site generation available plants. Rules and tariffs for use of wires and standardized PPA needed.	
6	Add Capacitor Banks to Reduce Transmission Losses	Add capacitor banks at sites which reduce transmission system losses and can increase the operating MW capacity of existing generators.	Short Term (8 months)	\$4.5 million for 90 MVAR at 230 kV	Need to cover cost of capacitor installations; need to update transmission system data	
7	Install Advanced Metering Systems to Reduce Losses	Reducing technical and non-technical losses through installing new metering technologies	Short and Medium Term	(Varied)	Data on sources of losses (technical, commercial); social and political feasibility; public acceptance of new metering technologies.	Colombia Integrated Power System (Cartagena)
8	Install High Speed Reciprocating Engines	Install high speed reciprocating engines to operate on a temporary basis.	Immediate Term (90 days)	0.151	Need to obtain pricing data; need to be able to pay for high fuel costs and rental fees.	
9	Lease Power Generation Barges, or Fixed Gas Turbine, Simple Cycle	Install leased power generation barges equipped with reciprocating engines or combustion turbines.	Immediate Term	\$500 to \$700/kw for used barges; \$650/kw to \$850/kw for simple cycle	Need to obtain pricing and other available data, and be able to pay high cost fuel and rental fees or purchase costs, cost to prepare waterfront site, or land site	
10	Lease or Purchase Used Power Plant Equipment	Lease or purchase used power plant equipment with a warranty less than for new equipment.	Short and Medium Term	(Varied), with high risk due to limited warranty	Need a defined schedule to implement use power plant equipment as soon as possible to minimize warranty risks	

targeting the availability of existing plants and/or purchases from captive generators can be effective in this time period. This means that in the short run the burden of adjustment will generally lie on the demand side.

The impacts of measures can be classified according to the time period in which they take effect:

- » **Very short run (a few weeks):** No supply response is easily available. Demand responses are limited to changes in behavior given existing technology (such as switching off lights, air conditioning, hot-water heaters, and other non-essential equipment) that are normally induced voluntarily or through quantity restrictions (general rationing).
- » **Short run (within six months):** Little supply response is easily available. A wider range of demand responses is available, including some minor technical changes which involve capital expenditure to replace existing appliances (such as CFLs). A wider range of price (changes in tariffs) and quantity incentives (specific rationing) can also be used.
- » **Medium run (up to 24 months):** Some supply responses are likely to be available (such as increasing the availability of existing plants, co-generation from existing capacity, and speeding up projects under construction). Demand responses include making 'easy' switches in technology. A full set of price and quantity incentives are available.
- » **Long run (years):** The full range of supply and demand responses is possible.

Lessons from a wide range of international experience show that successful crisis management depends on implementing an emergency response package composed of a variety of complementary measures. Those measures will depend on the cause and nature of the crisis, the institutional capacity of the country to rapidly deploy short-term measures, and the cost and benefits of those measures as well as their public acceptance.

Identifying emergency responses will require a thorough examination of the effectiveness of individual measures, and of combining measures, to achieve the desired results. For example, in some cases, price and rationing mechanisms can be used simultaneously. A useful principle is to assign each customer with a quota of electricity. If their consumption exceeds that quota, they face a financial penalty. If they save in relation to the given quota they receive a financial bonus. To be efficient and cost effective, rationing should be designed in such a way that it provides an incentive for consumers to reduce their lowest-value consumption. When the crisis arises from a capacity constraint, energy savings are needed during peak consumption. In many cases the metering equipment in place does not measure the time of consumption and thus cannot send an appropriate price signal to miti-

gate the crisis. Only a few countries use peak-load tariffs for large electricity consumers, which can reward off-peak and penalize on-peak consumption. Residential users typically pay energy-only tariffs and have meters which only record total electricity usage.

Measures to mitigate the social impacts of the crisis are needed and should be well targeted. In a market-based system, there is always a danger that a severe supply-demand gap could result in a price spike. If shortages last for more than a few days, price increases to final consumers are sometimes necessary. This in turn, can generate affordability problems, especially for low income consumers. However, responding to an increase in electricity prices with direct or indirect subsidies could exacerbate the energy crisis if there is no incentive for consumers to reduce their electricity consumption. Large-scale subsidies could also create a fiscal crisis. Market-based pricing and rationing schemes should be used to reduce electricity demand, while direct or indirect subsidies should be used to guarantee minimum electricity supplies for the poor.

Regulatory constraints can affect the range of options available and the impact on different stakeholders. Legal or administrative restrictions often prevent the use of certain instruments. For example, tariff changes may have to be approved through a pre-defined administrative process that involves public hearings, which means that increasing tariffs may not be a possible solution in the short term. The regulatory regime can also affect the impact of emergency response measures on different stakeholders. For example, a demand reduction can negatively affect the financial situation of a distribution company working under a price cap, even if the crisis originated in the generation sector.

Taking into account possible negative effects on stakeholders is therefore critical. The challenge facing decision makers is to find the optimal combination of demand and supply measures which will impose the least cost on the economy in terms of reduced output, employment, and social disruption. In addition, demand-side management, as a general proposition, has a smaller environmental footprint (for both local and global pollutants) than supply-side interventions involving increased generation.

When formulating an emergency response to an electricity crisis the following steps should be taken:

- » **Identify the nature of the problem, including:**
 - **The nature of the electricity shortfall.** Every crisis is unique and the shortfall could be in peak capacity or in energy.
 - **The probable duration of the shortfall.** Appropriate responses will depend on the estimated duration of the shortfall.

**STEPS TO
FORMULATE AN
EMERGENCY
RESPONSE
PROGRAM**



▲ World Bank
financed Peru Rural
Electrification Project.
Source: Rural
Electrification
Department of Ministry
of Energy and Mines.

- **The breakdown of energy consumption by end-uses during the shortfall period to understand potential crisis impacts and to better define mitigation measures.** The most reliable approach is to build on existing detailed customer surveys, provided these include end-use monitoring, load surveys, appliance saturation surveys, and other available data. Obtaining details on the energy consumption of the largest customers is essential. This information will detail how much electricity is consumed by each sector, what appliances and equipment are responsible for the energy used, and under which contractual terms energy is consumed. This can in turn allow an assessment of the feasibility of temporarily disconnecting some large users.
- » **Identify a wide array of emergency measures** to both reduce/manage demand and increase supply. Emergency responses tend to focus more on supply responses than on demand. International experience shows that success in mitigating electricity crises comes from an integrated use of demand and supply measures.
- » **Identify and measure the impacts of the proposed emergency responses to ensure their fiscal feasibility and social acceptability.** Having a fair distribution of costs and having people perceive it as such is critical to effectively implement emergency response measures and to obtain broad public support. Good practice in this regard involves providing funds to shield the poor from price increases through a clear and transparent targeting mechanism.

- » **Rank measures according to their costs and benefits to understand orders of magnitude and to set expectations.** A rapid evaluation carried out by the World Bank on six different measures showed that demand side measures focused on appliance replacement (lamps, refrigerators and electric showers) have lower costs for the savings achieved (levelized cost per kWh saved) than supply side measures focused on adding short term capacity. Costs range from \$0.02 per kWh saved for a program replacing light bulbs with efficient compact fluorescent lamps (CFLs) to \$0.20 or more for leasing high speed diesel engines. In addition, supply side measures add a significant energy price volatility element through the added fuel price risk.

International experience shows that emergency response preparation and crisis management has been better handled in countries that anticipated a potential crisis and that prepared a detailed emergency response plan before the crisis struck. Some of the key enabling factors are:

PREPARING FOR THE “NEXT” CRISIS

- » The ability to mobilize a coordinated response, which combines demand and supply measures and draws on a variety of existing entities (electricity utilities, regulators, line ministries) and policy mechanisms.
- » The quality of information on energy supply and demand.
- » The quality of information available to clearly identify entities and citizens at risk of being most impacted by an electricity crisis, and those which could potentially contribute to mitigate the impact of a crisis (such as identifying large consumers whose electricity consumption can be interrupted or rescheduled).

Ideally, countries will be able to reduce the likelihood of a crisis through strong planning. However, external shocks and the possibility of weaknesses in planning, or the combination of various factors, make the probability for an electricity crisis sufficiently high to warrant the active preparation of an emergency response plan. In addition, many of the actions set out above (such as energy efficiency, rehabilitation, or repowering) remain relevant under normal planning situations and may in fact be least-cost. Most importantly, experience shows that the better a government is prepared and equipped to address a potential electricity crisis, the higher the chances for sound energy sector growth and for mitigating the social and economic impacts in the event of such a crisis.

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