CENTRAL ELECTRICITY BOARD

Integrated Electricity Plan 2003 – 2012

November 2003

CENTRAL ELECTRICITY BOARD

Message from the Manager

Corporate Planning & Research

Electricity is a vital part of our daily lives. We depend on electricity to run our appliances, equipment and industrial plants, and to light and air condition our homes, communities, and businesses. The production and delivery of electricity is itself a source of economic activity for Mauritius, employing thousands of people directly and indirectly.

In Mauritius, we do not have an abundant supply of natural energy resources, therefore we must plan carefully to ensure a reliable electricity supply that is also affordable and sustainable. This Integrated Electricity Plan—the first of its kind produced in-house at CEB—has been prepared to guide Mauritius to a more stable electricity future. Its cornerstones are to optimise the use of the existing power system, to keep electricity prices as low as possible through least-cost capacity expansion, to encourage our customers to participate in energy efficiency and conservation, and to provide for continued private sector opportunities in the electricity sector.

We invite all our customers, employees, business partners, suppliers, and stakeholders to share this Plan with us. By sharing our Plan in this open way, we hope to foster a two-way exchange of information that will build a better electricity future for Mauritius and contribute to economic growth and prosperity for the country.

Donna G. LeClair, P. Eng.
Manager, Corporate Planning & Research

Executive Summary

The Integrated Electricity Plan is concerned with the demand for and supply of electricity in Mauritius and Rodrigues. The focus of the Plan is on meeting CEB's obligation to provide reliable, secure, and cost effective electricity service. As such, it presents our framework and master plan for generation, transmission, and distribution expansion and reinforcement required to meet the forecasted demand for electricity.

The Integrated Electricity Plan clearly shows that, based on the forecast of probable demand as compared to the capability of existing and committed supply resources, CEB will need to make investment in new resources. Demand for electric energy is projected to grow to about 1.6 times its 2002 level in Mauritius and two times its 2002 level in Rodrigues by the end of the planning horizon in 2012. At the same time, the capability of existing generating resources will diminish as CEB retires some older generating units in both Mauritius and Rodrigues.

We estimate that capital expenditures on the order of Rs 12 billion will be required to cover the electricity supply infrastructure needed over the 10-year horizon covered by this Integrated Electricity Plan. Approximately 60 percent of this amount will go to new sources of electricity generation, with investments in generation coming from both the private sector and CEB, and the remaining 40 percent will be devoted to expanding and enhancing our electricity delivery network. About one-third of this investment will be made in the next three years to cover committed projects and relieve system constraints. CEB will also use its own cash flow to pursue a number of customer-based and policy initiatives targeting energy efficiency and demand-side management.

Key findings of the Integrated Electricity Plan include:

- Demand for electricity in Mauritius, as exemplified by electricity sales, is expected to rise from 1,492 GWh in 2002 to 2,436 GWh in 2012. This represents an average cumulative annual growth rate of 5 percent. The increase in demand of about 90 GWh per year is equivalent to the energy needed to supply more than 50,000 Mauritian households or, for example, every household in the District of Pamplemousses.

- Today's need for new generation is driven primarily by capacity requirements. The next generating resource additions in Mauritius are needed in 2006 and continued additions of some 150 MW to 170 MW will be required after 2006 and through 2012 to meet growing demand with adequate reserve margins. Most of these additions are expected to come from the private sector.

- Implementation of the first phase of works for strengthening the 66 kV transmission network has relieved the system congestion constraints which arose in the late 1990s. Committed investments for the near term which will continue to improve load flow conditions and overall grid efficiency include the completion of substations at Dumas in Port Louis, Sottise in the north, Amaury in the northeast, Union Vale in the south of the island, and Le Morne in the southwest. Three new 66 kV lines will improve delivery throughout the south, southeast, and southwest of the island.

- The long-term transmission plan provides a solid base for distribution planning. By proposing the locations of new and the optimum loading of existing bulk supply points, sufficient capacity will be provided to keep distribution feeder lines to reasonable lengths and loadings. This will enhance the operational flexibility of the network and reduce restoration times in the event of outages, thereby improving the quality of electricity supply to our customers.

- Energy generation to meet demand in Rodrigues is expected to roughly double, rising from 23 GWh in 2002 to 42 GWh in 2012, or to 50 GWh in 2012 if the proposed seawater desalination project is implemented in the near future. Peak demand will grow at an average cumulative annual rate of 5.4 percent, or about 300 kW per year over the same period. Two new generating units of 1.9 MW capacity are scheduled to come into service at a new power station at Pointe Monnier by the end of 2004. A third unit of the same size will be required in December 2005 to meet demand growth and allow for the retirement of the older units at Port Mathurin. A fourth new generating unit will be required at the time the proposed seawater desalination project is implemented.

- CEB faces the challenge of supplying a highly uneven demand profile. The quantity of electricity our customers demand varies by a factor of two to three, depending on time of the day, day of the week, and season of the year. This means that we must have sufficient generating capacity and capability in our electric system to meet the periods of highest demand. We must spend large sums of money to acquire and maintain this capacity which may sit idle or underutilised for large periods of time. This obviously comes at a cost to our customers. The uneven shape of the daily demand profile means CEB must plan carefully the mix of generation capacity and system expansion for future years to make efficient use of invested capital and investments yet to be made.

- One of the most economically and socially desirable ways of meeting growing demand is through conservation and energy efficiency. Although CEB's own activities in the area of energy conservation are nascent, we recognise the imperative for more demand-side and load management in the short term. Tariffs are an effective means of achieving energy efficiency, and we will be introducing the necessary time-differentiated rates and rate structures in the coming years to encourage customers to shift their demand outside of the current two- to three-hour evening peak period. We also plan to disseminate information to our customers to raise general awareness of energy efficiency and to promote substitute technologies in applicable end uses, such as energy-saving appliances and lighting, high-efficiency ventilation and air conditioning systems, and advanced electric motor and drive systems.

This Plan presents CEB's current outlook for electricity demand and supply and should be understood to be a snapshot in time. The fundamentals of the Plan that give rise to the 10-Year Outlook will change over time and this means that the Plan will need to be updated periodically.

CEB remains committed to serving the needs of our customers by prudent planning and resource acquisition decisions. This Plan is available to the public from CEB and on our website at www.ceb.intnet.mu.

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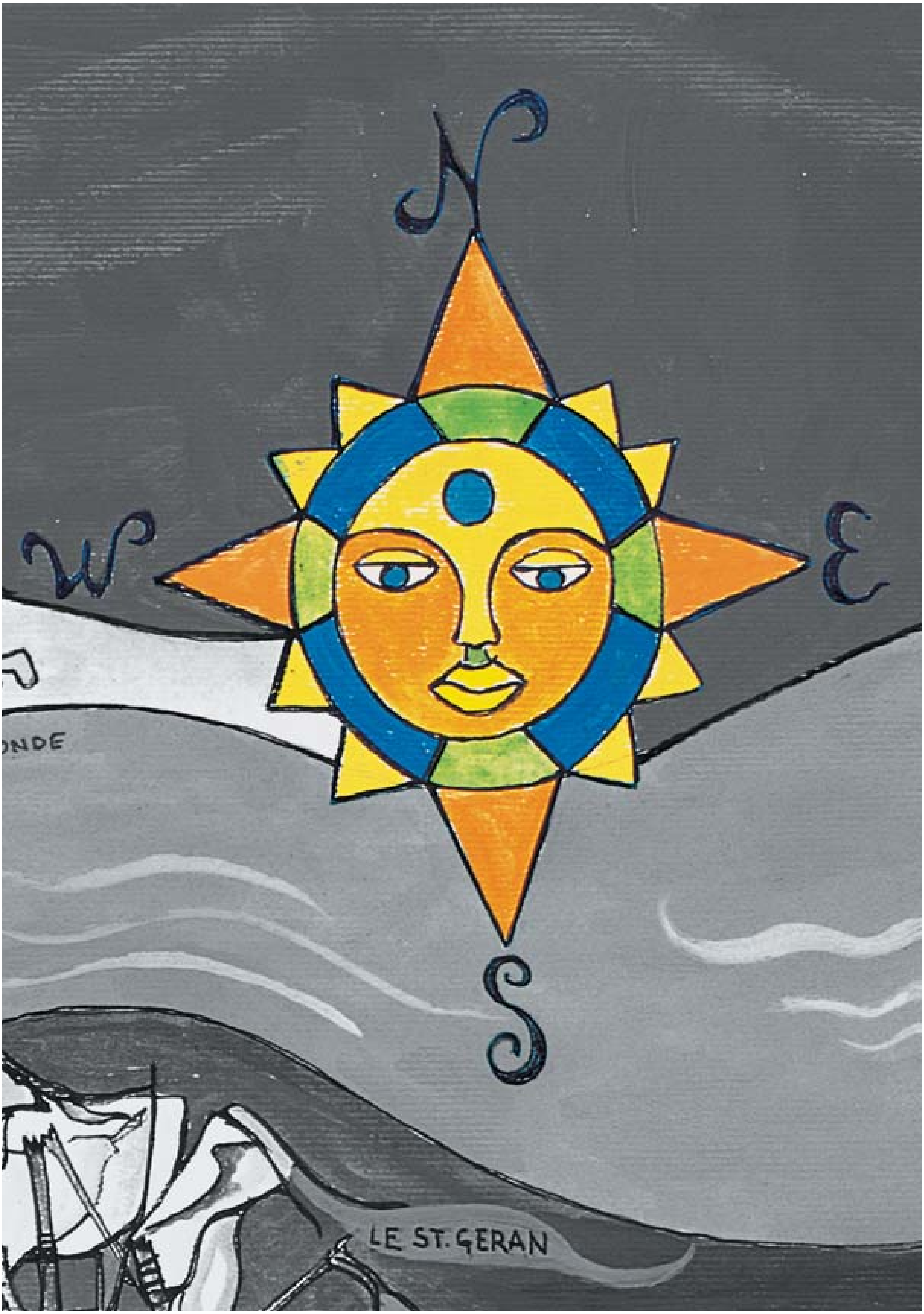

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CENTRAL ELECTRICITY BOARD

Chapter 1

Introduction

The Integrated Electricity Plan (the Plan, or IEP) constitutes CEB's master plan and framework for the rational and successful development of generation, transmission, and distribution resources required to meet the forecasted demand for electricity. As such, the IEP focuses on our obligation to provide reliable and secure electricity service to Mauritius at a reasonable cost and in a socially responsible manner.

In this way, the IEP is fundamentally linked with our Vision of being a world class, commercial electricity utility enabling the social and economic development of the region. Further, it illustrates progress in meeting our strategic goal to build an integrated planning capability. A detailed outline of our Vision, Mission, Values, and Goals is presented in our Corporate Plan which we released earlier this year.

The purpose of the Integrated Electricity Plan is to present our current estimate of the evolution of demand for electricity over the next decade and our perspective on the options available to meet that demand. We recognise that it is not possible to know the precise conditions that will set electricity demand or the options to meet it in the future. Nevertheless this Plan presents a way forward that hinges on optimising the use of the existing power system, keeping electricity prices as low as possible through least-cost capacity expansion, encouraging our customers to participate in energy efficiency and conservation, and providing for continued private sector opportunities in the electricity sector. The "integrated" approach used to develop this Plan is to include simultaneous consideration of demand and supply.

After this introductory chapter, the Plan is organised as follows:

Chapter 2 is a discussion of **Electricity and Electric Sector Perspectives**. Here we put electricity issues together in a Mauritian context, talking about how we came to be where we are today, what some of the global and national emerging issues are, and what we see as important directions for the future.

Chapter 3 establishes the **Demand-Supply Outlook**, in other words how our existing ability to supply electricity compares with the projected demands of our customers in the future. This chapter clearly shows that new investment in additional generating capacity is required, not simply to meet growing demand, but also to allow for the retirement of older generating units at some of our power stations, to make room for more efficient and less expensive sources of generation.

Chapter 4 provides a detailed look into the development of the **Demand Forecast**. It describes the assumptions, information, and process used to prepare the 2003 to 2012 forecast of electricity demand. It also includes a discussion of demand-side management—an area to which we expect to dedicate much more attention in the years to come.

Chapter 5 discusses the **Generation Plan**, that is, the options for meeting the gap between electricity demand and available supply. It defines our plan to fill the gap in terms of the size and timing of new generation additions. This chapter also presents our **Generation Resource Acquisition Policy**, which will be of interest to all potential suppliers of power generation.

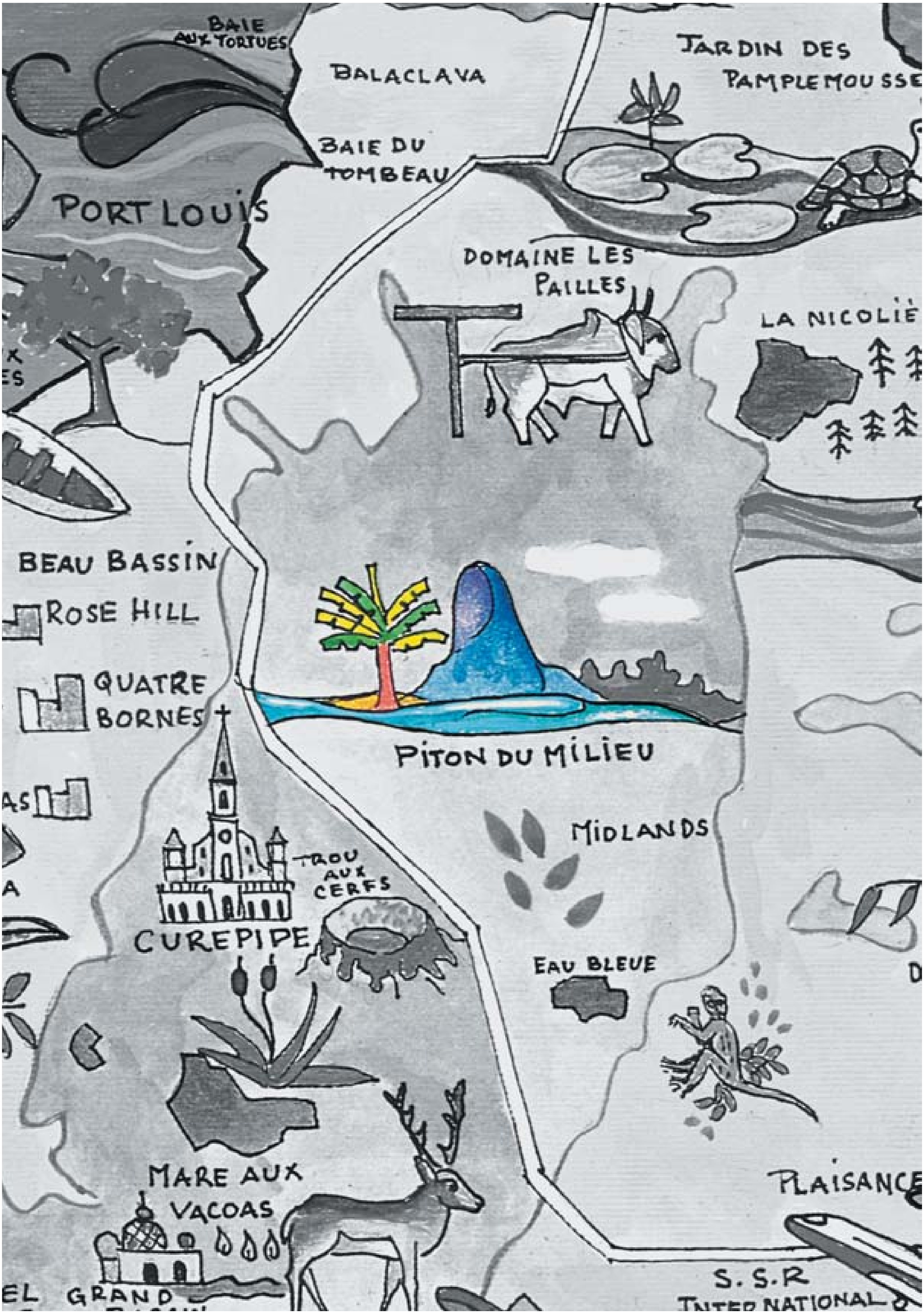
Chapter 6 deals with the **Transmission and Distribution Plan** for continuing development and improvement of the network which delivers electricity from the power stations to our customers' premises.

Chapter 7 deals exclusively with the island of **Rodrigues**, presenting both the demand forecast and expansion plans for generation and the distribution network.

Chapter 8 consolidates all the elements of the Plan into a **10-Year Outlook** that is the summary of our integrated planning process. It presents CEB's current view on the long-term electricity requirements for Mauritius and our master plan to meet those requirements.

Chapter 9, the concluding chapter, puts forward our **Action Plan** which is an outline of the activities required in the near term to acquire or maintain the availability of the new projects and programs embodied in the 10-Year Outlook.

A **Glossary** is provided at the end of this document to explain technical terms and words as they are used in this Plan.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BALACLAVA
JARDIN DES PAMPLEMOUSSES
BAIE DU TOMBEAU
PORT LOUIS
DOMAINE LES PAILLES
LA NICOLIÈ
BEAU BASSIN
ROSE HILL
QUATRE BORNES
PITON DU MILIEU
MIDLANDS
TROU AUX CERFS
CUREPIPE
EAU BLEUE
MARE AUX VACOAS
PLAISANCE
S.S.R INTERNATIONAL
GRAND

Chapter 2

Electricity & Electric Sector Perspectives

2.1 Introduction

Since this is the first Integrated Electricity Plan CEB has produced, and since we are in our golden anniversary year marking 50 years as a public utility, we thought it appropriate to put into this Plan a discussion of our past and our future which bring together in a Mauritian context the issues that have shaped, are shaping, and will shape our electricity future.

2.2 A Look Back

2.2.1 Beginnings

In the mid-1900s the national economy and the electricity sector looked very different from today.

The Central Electricity Board was constituted on December 8, 1952 in accordance with the provisions of the first Central Electricity Board Ordinance 1951. CEB took over the functions and assets of the individual electricity undertakings operated by the Department of Electricity & Telephones and the Electric Generating Power Company which supplied the districts of Grand Port and Savanne. At that date, other private electricity suppliers included the General Electric Supply Company of Mauritius Ltd., the Mauritius Hydroelectric Company Ltd. and the Port Mathurin Electric Supply Co. (Rodrigues.)

During its first year of operations, CEB bought the Electric Generating Power Company for the sum of Rs 1,177,000. By the end of 1953, CEB personnel numbered a total of 141. Meanwhile, the General Electric Supply Co., which supplied an area including the townships of Curepipe, Vacoas, and Phoenix, purchased the Mauritius Hydroelectric Co. Ltd. and received a license to supply the areas of Rose Hill/Beau Bassin, Moka and Quatre Bornes. That license expired on August 31, 1963 at which time CEB took over.

In 1953, virtually all of the energy produced by the General Electric Supply Company came from the Tamarind Falls and Réduit Power stations with a nominal installed capacity of 8,600 kW. Sales to 31,050 customers amounted to 28.9 GWh and the maximum demand reached 7 MW. In 1954 a shortage in rainfall resulted in a shortage in power supply from the hydroelectric stations. This prompted CEB to build the first thermal power plant at Plaine Lauzun on what is now the site of the St. Louis power station. The first 1,750 kW diesel generating set was put into commercial operation on December 24, 1954, just thirty weeks after turning the first sod for the power station foundations.

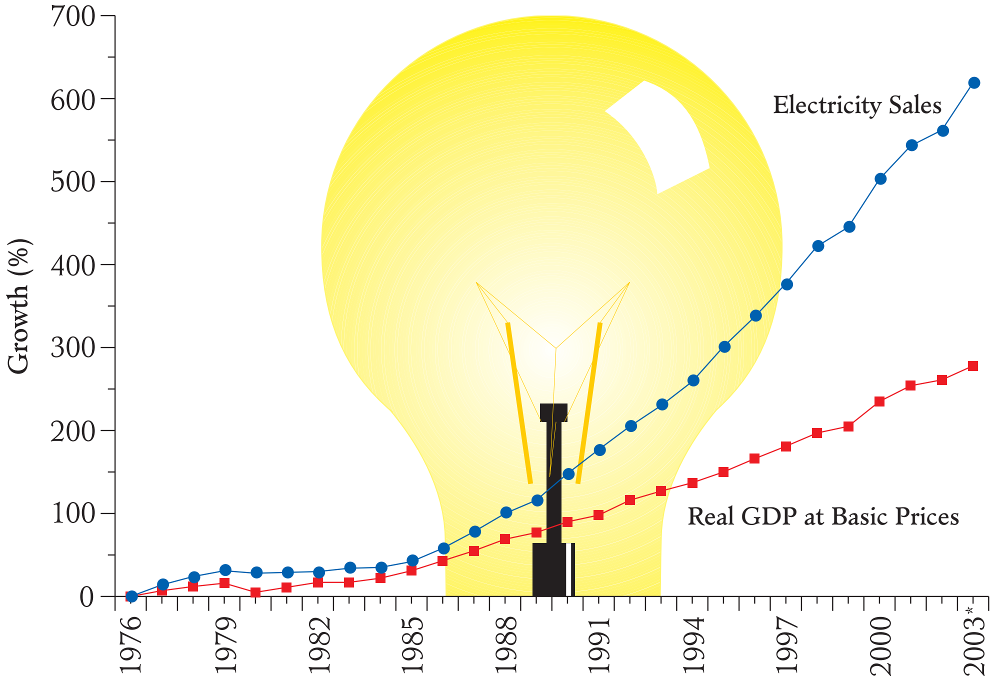
2.2.2 Independence and Beyond

At the time of Independence in 1968, the national rural electrification program got underway. Peak demand that year reached 31 MW and total energy sales to 91,234 customers reached 98 GWh. As the population increased and habitations cropped up all over the island, CEB was called on to connect schools, Central Water Authority pumping stations, housing estates and morcellements. Stone crushing plants, poultry farms, irrigation stations, and construction sites also appeared on the list of CEB's customers. From the early 1970s, our networks have continuously been extended to supply, for example, new industries such as those in the export processing zones. As the tourist sector, the textile industry, and the construction sector flourished in the 1980s, we expanded our transmission and distribution networks in all directions across the country.

By 1981, the national rural electrification program was completed when Chamarel became the last of a long list of about 153 villages and housing estates to be electrified. Today CEB serves more than 330,000 customers. Sales reached 1,492 GWh in 2002 and the system peak demand has risen to more than 320 MW.

Today, the country enjoys a more diversified economy, an extensive network of electricity supply facilities, and the benefits of a stable and continuous electricity supply. CEB has a proven record of providing reliable electricity for the country and this has come as a result of massive capital investment into the development of electricity infrastructure. We are particularly proud of our recent performance in post-cyclone reinstatement. In Rodrigues when 80 percent of our network infrastructure was heavily damaged from the passage of cyclone Kalounde earlier this year, electricity supply was restored in Port Mathurin

Figure 2-1. Trends in Electricity Sales and GDP



** Forecast*

Source: Central Statistical Office; CEB

and other principal villages within four days and over the whole island within a period of three weeks. After the passage of Cyclone Dina in 2002, electricity service was restored to 90 percent of our customers within seven days and to all of the island of Mauritius within ten days.

2.2.3 Rodrigues

In June 1972, the diesel generating plant operated by the Port Mathurin Electric Supply Co. was shut down and on November 7, 1972, CEB inaugurated the Port Mathurin generating station. With this, CEB began the electrification of Rodrigues island. An annual program was established for the progressive electrification of all villages, and the last six villages were lit up in 1994.

Although our operations in Rodrigues still do not break even, we have always regarded the supply of electricity to the population as an important social and developmental service. With the rising standard of living in Rodrigues and the resultant increase in electricity demand, Port Mathurin power station was extended by 400 m^2 in 1995, making room for three 1 MW generating sets which were commissioned over three years. CEB is now in the process of installing the first of two 1.9 MW generating sets to be commissioned in 2004 on a new site at Pointe Monnier and reinstating the wind power generation site at Trèfles.

2.3 Electricity and an Economy in Development

As the preceding sections have shown, CEB has had the important job of ensuring an adequate supply of electricity to enable—and to not constrain—the economic growth of Mauritius. As is typical in developing economies, Mauritius saw the growth in demand for electricity significantly outpace the growth in the national economy, as represented by Gross Domestic Product, or GDP. Figure 2-1 shows that electricity sales have grown by 625 percent in the years from 1976 while GDP has grown by less than half that amount, 275 percent, over the same period.

The economy in Mauritius is now maturing and growth in electricity demand is expected to slow compared to the impressive growth rates of the last two decades. What does it mean to have a “maturing” economy? In fully developed economies, GDP growth and growth in electricity demand have typically been 2 percent per year, and sometimes less, since the 1990s. The slower growth rate in electricity demand can also be attributed, to some extent, to the shrinking of electricity-intensive industries and growth in less-energy-intensive services and industries.

That is not to say that Mauritius will not again experience periods of intense growth in either GDP or electricity demand, but the growth rates seen in the late 1980s and throughout the 1990s are unlikely to be sustained over long periods of time in the future. The International Energy Agency's "World Energy Outlook 2000" has electricity generation growing at an average annual rate of 2.7 percent globally and 4.5 percent in developing countries, with slightly higher values for India and China, through 2030.

2.4 The Importance of Electricity Today

The challenge of yesterday for CEB was to provide sufficient power to supply the electricity needs of a rapidly growing country. Sustained growth in electricity demand of more than 10 percent per year put tremendous pressure on the electricity sector and public finances. The absence of a long-term electricity plan meant that CEB moved away from a least-cost expansion plan, often having to take more expensive, short-term measures to prevent power shortages, including continuing to run older, less efficient, equipment.

The challenge for tomorrow is for CEB to more efficiently deliver electricity services for the three very good reasons below.

Electricity fuels our daily lives. Mauritians rely on electricity to run their appliances, equipment and industrial plants; light their homes, neighbourhoods, and businesses; and air condition their living and working spaces. Twenty years ago the average home had few electric appliances. Today the average home has most of the basic kitchen appliances, one or more televisions, a VCR, and perhaps a computer, DVD player, dishwasher, and other items. Likewise, the typical office is now equipped with computers, photocopiers, and other electricity-using equipment.

Electricity drives the national economy. Electricity is a significant input into the production of other goods and services. The manufacturing, tourism, wholesale and retail trade, and construction sectors comprise almost 45 percent of the national economy. These sectors are facing tough competition globally and must control costs and increase efficiency and productivity to maintain their competitive edge.

Access to reliable, fairly priced electricity is also important for attracting and developing the information and communications technology sector in Mauritius. Technology firms depend on a continuous, quality supply of electricity.

The electric sector itself is a major source of economic activity. CEB is one of the premier companies in Mauritius. With annual revenues nearing the Rs 5 billion mark, CEB is an economic force in itself. CEB employs about 1,700 people and contributes to the support of approximately 750 previous employees who are now pensioners. In 2001, CEB placed orders totalling Rs 1,186 million on local firms; in 2002 that figure was Rs 1,496 million. Whether it be ordering work boots from local suppliers for our line crews and power station staff or having local manufacturers make the thousands of concrete poles we require each year, CEB is undisputedly contributing to income creation in the national economy.

In addition to these orders, CEB made purchases of energy from independent power producers (IPPs) in 2002 totalling Rs 1,415 million. These IPPs employ about 140 persons in the power stations associated with their sugar operations.

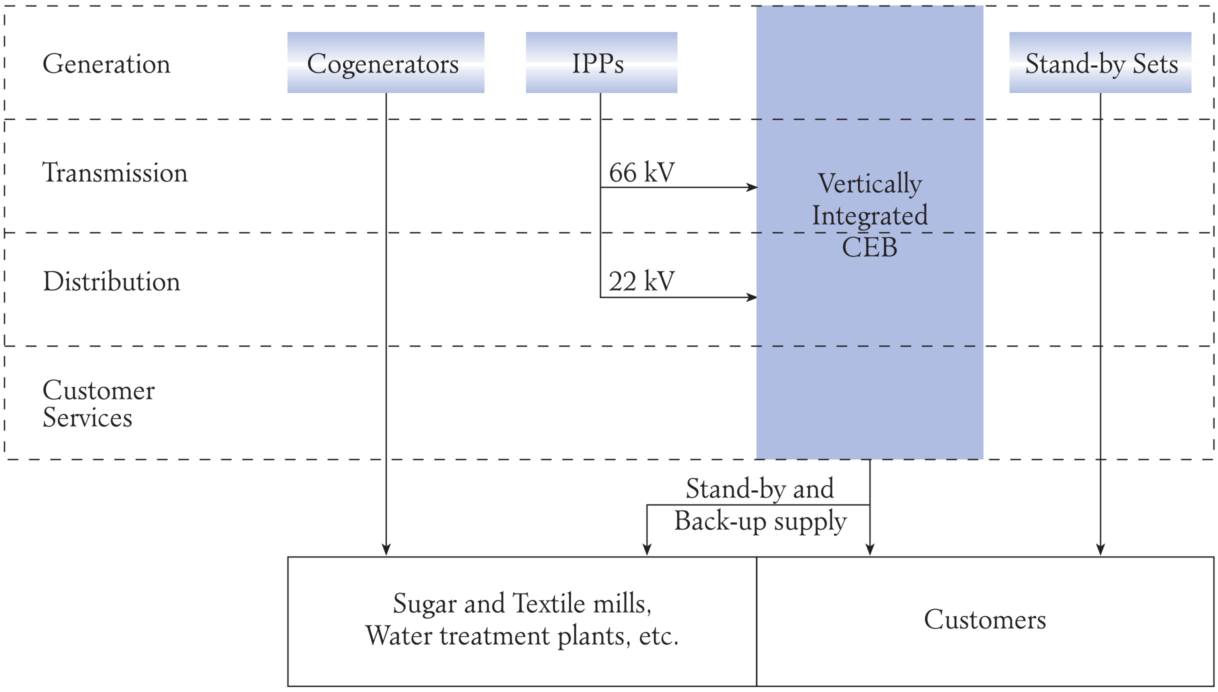
Aside from its employment benefits and economic spin-offs, electricity is a prime contributor to national development, and that development expertise is also being extended to other parts of the southern African region.

2.5 Electric Sector Reform

The Government of Mauritius is making a major policy change in the electricity sector. In 2000, Government commissioned a consortium of consultants to carry out an in-depth analysis of the electric sector and to formulate a plan for sector restructuring.

Government, after watching the extent of reforms elsewhere, has wisely recognised that Mauritius is neither ready for, nor in need of, large-scale electricity reform. In general, reforms elsewhere were intended to reduce costs to customers by making the sector more competitive. Vertically integrated electricity monopolies have typically been separated into generation, transmission, and distribution entities. Of these, typically only generation and distribution have been privatised and competition induced by dividing these entities into multiple companies. To function properly, competitive markets require many buyers and sellers. On an island the size of Mauritius—and even moreso in the case of Rodrigues—there are no economies of scale to be gained by such division. Government has, therefore, opted to corporatise CEB as a vertically integrated company and to retain CEB in Government ownership. Early next year, the required legislation will be enacted to provide the legal basis for these reforms.

Figure 2-2. Electricity Industry Structure in Mauritius



Government will introduce an independent Regulatory Authority to oversee sector development. Draft legislation is in place to establish the framework for regulation of public utilities including the Central Electricity Board, Central Water Authority, and Wastewater Management Authority. The regulator will be an independent agency of the Government, operating under its own Act. The primary responsibilities of the regulator as they pertain to CEB will be to ensure that our tariffs are fair, just, and reasonable, and that we provide a safe, adequate, and secure service to our customers.

Experience elsewhere has proven that electricity regulation, firstly, must be truly independent, and secondly, should emulate market principles as much as reasonably possible. This means Government no longer picks the winners, either in terms of new suppliers of generation or in terms of customer affairs. Modern economics applied by the regulator in a balanced manner will compel the electric sector to be more efficient.

Even though CEB operates today as a vertically integrated utility—which means that responsibility for the full range of electricity services, including generation, transmission, distribution, and customer services lies with the utility—Figure 2-2 shows that there are already other players in the electric sector in Mauritius. There are opportunities to introduce more competition in the development and operation of new sources of electricity supply, however, and a notable feature of Government's reform process is the move towards a more competitive electricity generation sector, with increased private sector participation.

Mauritius has had private power generators since electricity was first available on the island. Since the 1990s, this private sector participation has been formalised through policy directives, such as the Bagasse Energy Development Program which gave rise to an increased number of seasonal IPPs at sugar estates scattered around Mauritius and, since the late 1990s, through the signing of power purchase agreements with FUEL Steam and Power Generation Co., Consolidated Energy Ltd., and Compagnie Thermique de Belle Vue. The result is that today virtually all bagasse from sugar processing on the island is burned for electricity generation and cogeneration purposes.

Hand in hand with more private sector development of new generation, CEB will still retain the ability to implement our own generation and to redevelop or introduce efficiency improvements at our existing facilities, should this prove to be more cost effective for electricity consumers. At the same time, we have been doing our part to create an atmosphere conducive to private sector investment by, for example, introducing a transparent and competitive Request for Proposals process for acquiring new power generation resources.

In committing to give the private sector an important role to play in the development of electricity facilities, Government frees up precious public funds for needed improvements in social services such as education, health care, sanitation, etc., Government is, however, taking a cautious approach to sector reform by maintaining vital infrastructure, such as the electricity network, in the hands of CEB. Development, expansion, and operation of the transmission and distribution network will remain solidly in CEB's hands. What we will do is ensure equal access to the network to all generators in Mauritius and, as capacity and contractual constraints are gradually lessened, move to a practice of least-cost dispatch based on the marginal cost of generation. This will produce more transparent and cost-effective operations for the benefit of all electricity customers and suppliers.

ENERGY FACT

Mauritius currently has a single coal handling facility located at Mer Rouge and operated by Coal Terminal Management Company. In 2002, 312,030 tonnes of coal were imported into Mauritius. Of this amount, 286,886 tonnes—or 92%—were used by independent power producers for generating electricity. The volume of coal imported is expected to increase by a further 25% when the St. Aubin Power Plant comes into service in 2005.

2.6 Towards a Sustainable Electricity Future

2.6.1 Physical Development and the Role of Government

Mauritius will need more energy-related infrastructure to enable the desired economic growth that will maintain its position as an economic leader in the region. For their parts, CEB and the private sector will invest in power plant and electricity delivery upgrades and in new energy production facilities. This will require better physical infrastructure at the national level, such as road networks and port facilities for fuel handling.

The Halcrow Group undertook a review of the National Physical Development Plan for the Ministry of Housing and Lands and issued a final report in April 2003. The resulting National Development Strategy identifies certain planning policies that pertain to electric infrastructure planning, including:

- Policy E1 aims at identifying sites for new power stations, recognising that land for potential power stations is constrained by such factors as the need to import fuel and to be reasonably close to major demand centres. Policy E1 also suggests that suitable buffer areas of up to 1 km from sensitive land uses be established.

- Policy E2 covers the need for service corridors and rights of way for power cable networks that must be considered during the planning stage for major development projects. CEB's high voltage lines generally need to cross third-party land, and obtaining the necessary rights of way is becoming increasingly difficult.

- Policy I5 encourages industry to reduce pollution to internationally acceptable standards and goes on to state that it is desirable to concentrate or cluster polluting industries, on the basis that pollution can be managed more readily if emanating from a single source. Above all, industry is encouraged to reduce air, noise, and water pollution.

- Policy I7 covers "bad neighbour" industries, such as power generation. Where a "bad neighbour" industry exists adjacent to residential or commercial areas, Policy I7 encourages the cleaning up or relocation of such industry if there are opportunities for redevelopment, with reduction of pollution encouraged over relocation.

In addition to the social programs that are the purview of Government, policy makers need to free up some public funds to provide institutional arrangements, incentives, or subsidies for the development of clean, renewable technologies. This type of public policy mechanism has been instrumental in advancing the installation of renewable technologies in European countries.

Finally, permitting and other necessary regulations can be put in place which provide for the import into Mauritius of only products and appliances that meet a specific standard of energy efficiency. Tax incentives and other mechanisms could also be introduced to stimulate a more competitive market for energy-efficient products.

2.6.2 Demand-Side Management

Energy saving activities that reduce demand—and, therefore, defer the need for new supply—are the most cost effective means to a sustainable energy future. Low or subsidised electricity rates, however, provide a poor price signal for customers to either conserve electricity or invest in energy efficiency. In the coming months, CEB will release a long-term tariff strategy that will give customers the right signals for energy-saving activity while giving due consideration to poverty alleviation and equity among customers.

At CEB, we believe there is a significant opportunity for energy savings through conservation and increased energy efficiency. We recognise that strong utility involvement is needed to encourage the attitudinal and behavioural changes that lead customers to use energy wisely and we are committed to continuing with customer forums and community information programs which encourage energy awareness. In future plans, our goal is to show how at least 10 percent of total electricity demand growth will be served through conservation and energy efficiency.

2.6.3 Environmental Sustainability

Over the past decade, emissions of greenhouse gases (GHG) and their link to global climate change have emerged as a significant international environmental issue. In May 2001, Mauritius became a signatory to the Kyoto Protocol and there are many challenges associated with this commitment including, for example, identifying and implementing measures that foster economically efficient means of achieving GHG emission reductions while ensuring a fair distribution of the burden across economic sectors.

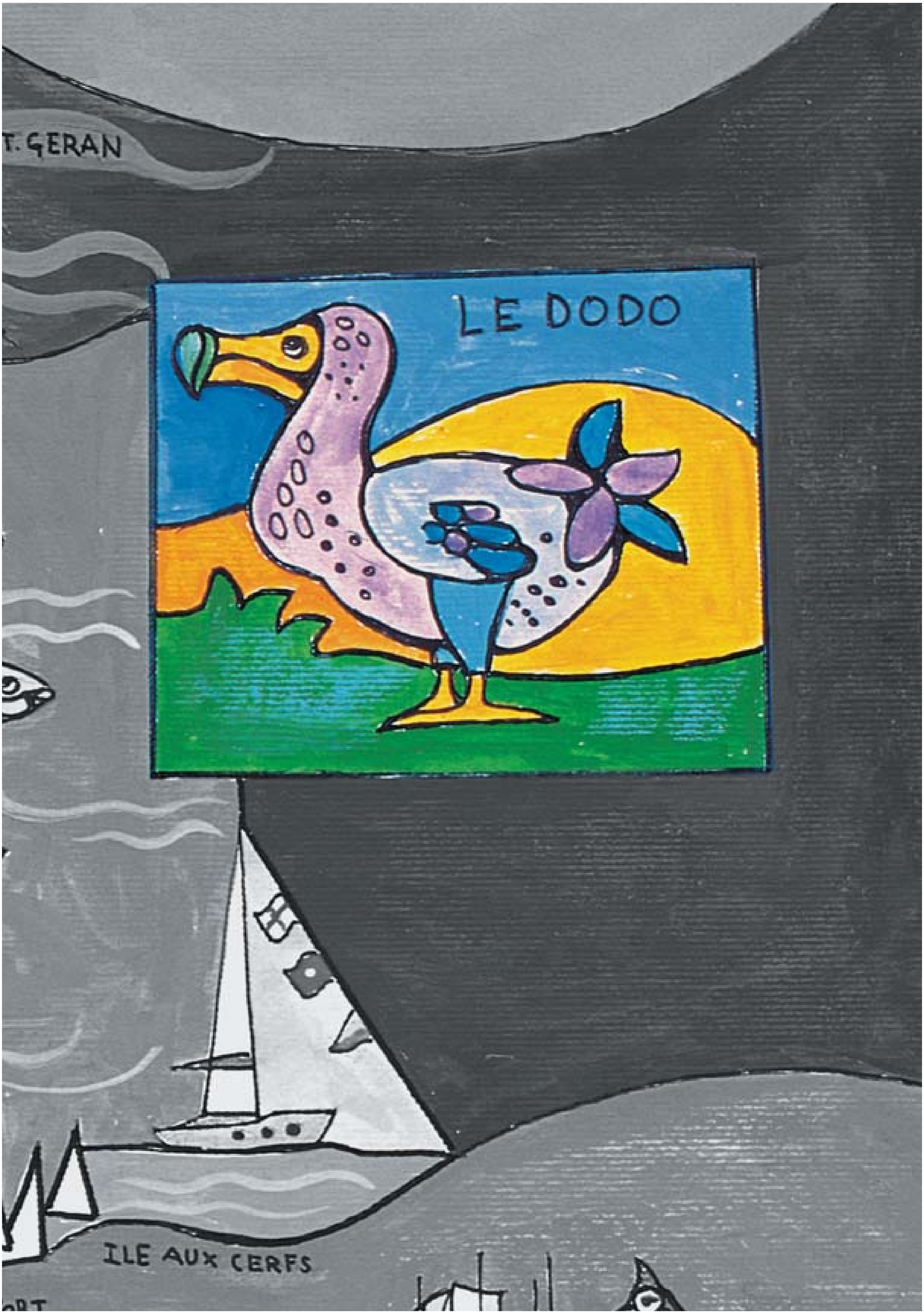
Currently, some 20 percent to 25 percent of electricity generated in Mauritius is from renewable sources of energy, notably hydro and bagasse. While this is an admirable achievement, supplies of both of these types of energy are limited, which means that GHG emissions in Mauritius will increase as we use more fossil fuels to generate electricity. We are all challenged to develop strategies to reduce and mitigate GHG emissions while continuing to contribute to a growing economy.

For our part at CEB, we plan to phase out less efficient generating units and have already set efficiency standards for new generating units to be constructed in Mauritius. This will improve our emissions per unit energy generated even when using fossil fuels. We will also continue to monitor technological advancements in renewable energy supply resources and incorporate these into ongoing planning and generation acquisition processes as they become technically and commercially viable.

2.7 In Summary

CEB has much to commemorate in its 50th Anniversary year as a fundamental enabler of economic development in Mauritius. But the challenge goes on. Mauritius faces a rapidly changing and vulnerable electricity future. The country does not benefit from an abundance of natural energy resources and so depends heavily on imported fossil fuels for electricity generation. Yet a reliable and competitively priced supply of electricity is fundamental to the nation's economy and the electric sector itself provides thousands of jobs which—directly and indirectly—support the quality of life in Mauritius.

We hope the perspectives provided in this chapter provide the rationale and motivation for all our stakeholders—customers, employees, suppliers, business partners, and government—to work with us in moving along the path outlined in this Integrated Electricity Plan to a more economical and sustainable electricity future.



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Chapter 3

Demand Supply Outlook

3.1 Introduction

The demand-supply outlook describes the difference between the demand for electricity and CEB's ability to meet that demand using the existing system of supply resources. The demand-supply outlook thus shows the net requirement for new electricity supply, taking into consideration the need to have adequate reserve margins.

The demand-supply outlook is presented in the four following sections:

- Section 3.2 presents a picture of our current outlook for electricity demand;
- Section 3.3 provides an overview of the existing system of supply resources;
- Section 3.4 discusses the planning criteria and reserve margins that need to be factored into the demand-supply balance; and
- Section 3.5 uses this information to then identify the need for additional electricity supplies to be further addressed by this IEP.

3.2 Demand Outlook

Figures 3-1 and 3-2 show the forecasts for energy generation and peak capacity requirements, respectively, with historic data also shown from 1989 through 2002. In addition to a probable forecast, low and high forecasts are shown in each Figure.

Figure 3-1 shows that under the probable forecast, energy generation requirements will increase from 1,715 GWh in 2002 to 2,727 GWh in 2012. This is equivalent to an average cumulative annual growth rate of 4.8% over the ten-year planning horizon. The high-growth scenario is equivalent to an average cumulative annual growth rate of 6.5% while the low-growth scenario is equivalent to an average cumulative annual growth rate of 3.6% over ten years. By comparison, energy generation requirements grew from 1989 through 2002 at an average cumulative annual rate of 8.6%.

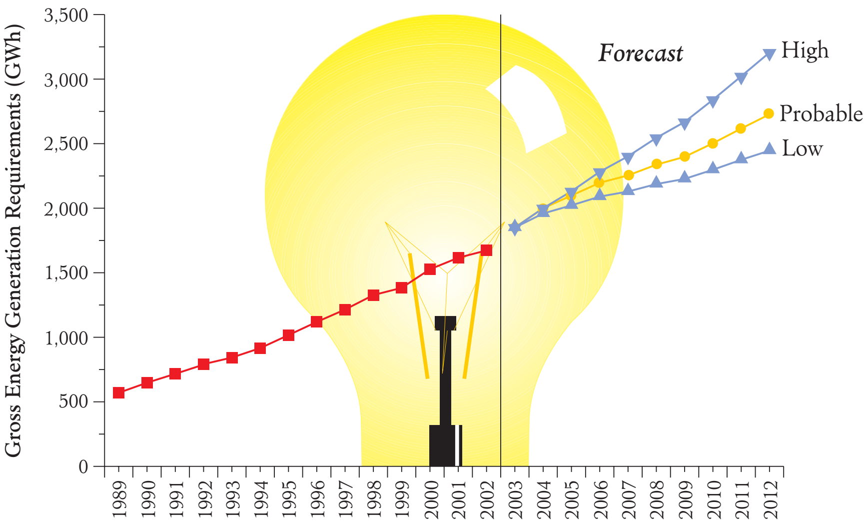
Figure 3-2 shows that under the probable forecast, capacity requirements to meet peak demand will grow from 319 MW in 2002 to 484 MW in 2012. This represents an average increase of 17 MW per year over the next ten years, or an average cumulative annual increase 4.3%. By comparison, peak demand grew from 1989 through 2002 at an average cumulative annual rate of 7.4%.

3.3 Capability of the CEB System

3.3.1 Overview

Figure 3-3 indicates the locations of CEB and IPP generating stations and the layout of the major transmission system. The new St. Aubin Power Project which is scheduled to come into service in the latter half of 2005 is considered as a committed resource and is also shown on Figure 3-3.

Figure 3-1. Forecast of Gross Energy Generation Requirements



CENTRAL ELECTRICITY BOARD

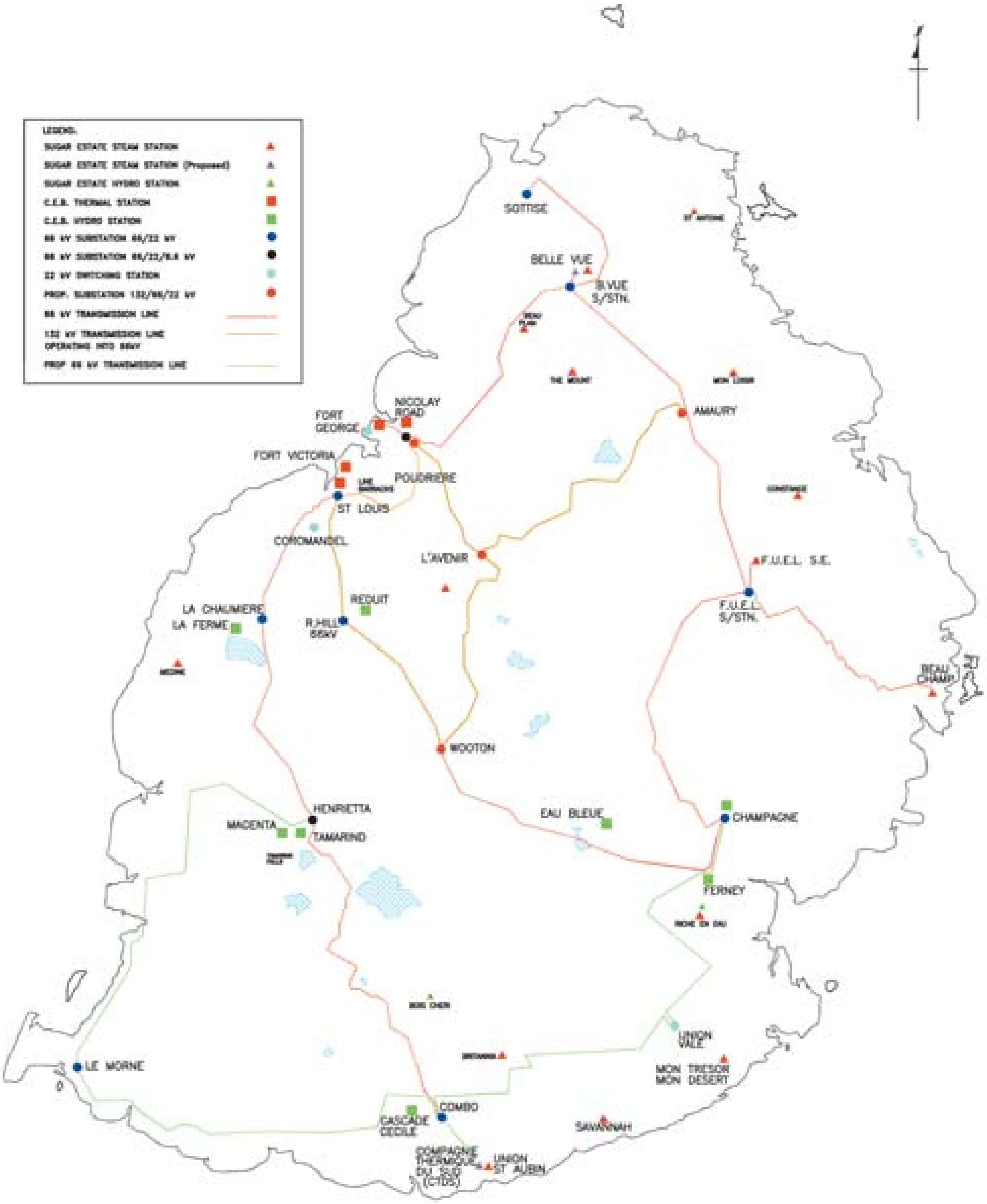
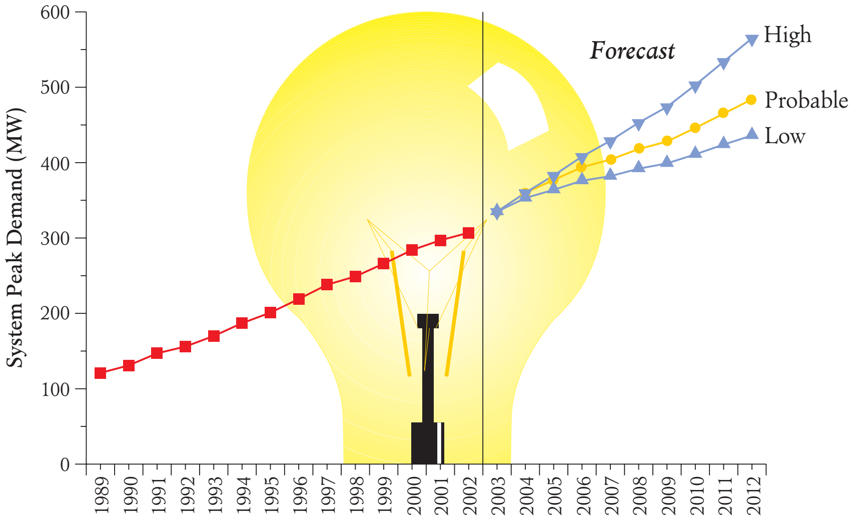


Figure 3-3. Mauritius Generating Stations and Transmission System

Figure 3-2. Forecast of Peak Capacity Requirements



3.3.2 Generation Capability

The effective capacity and annual energy capability of existing and committed generation resources as at the end of 2005, and prior to any planned unit retirements, are shown in Table 3-1. Currently about 75 percent of existing generating capacity is in CEB ownership; the remainder is held by IPPs in the sugar industry.

CEB Generation

CEB's four thermal power stations are located at three sites in the Port Louis area. Fort George is the largest of the stations. The five slow-speed diesel engines there have a total effective capacity of 135 MW and are designed for base load duty. St. Louis and Fort Victoria power stations are located at Plaine Lauzun. Both stations house medium-speed diesel engines and operate in general only between 07.00 hrs and 21.00 hrs daily. St. Louis has six Pielstick units with a total effective capacity of 48 MW. Fort Victoria has two stations; the older station houses seven Mirrlees engines with a total

Table 3-1. Capability of Existing and Committed Generation Resources by 2005

	Effective Capacity (MW) Crop Season	Effective Capacity (MW) Intercrop Season	Annual Energy Capability[1] (GWh)
Existing Hydro			
CEB[2]	27	37	85
IPPs	0.3	0.3	0.4
Subtotal	**27.3**	**37.3**	**85.4**
Existing Thermal			
CEB[3]	302	302	1,405
IPPs	117	111	810
Subtotal	**419**	**413**	**2,215**
Committed New Resources			
IPPs[4]	30	30	200
Subtotal	**30**	**30**	**200**
TOTAL	**476.3**	**480.3**	**2,500.4**

1 Annual energy capability based on 85% loading of available effective capacity.
2 Total installed capacity at CEB's hydro stations is 53 MW. For planning purposes, the effective capacity is reduced to reflect average, seasonal water conditions. Annual energy capability shown is for average year precipitation levels.
3 Limitation on energy capability of CEB thermal plant used for planning purposes as follows: Fort Victoria operation between 07.00 hrs to 21.00 hrs daily; Nicolay operation subject to an economic limit of 65 GWh per year.
4 Binding power purchase agreement in place with Compagnie Thermique du Sud for the St. Aubin power station to come into service by October 2005.

effective capacity of 24 MW and the newer station houses two MAN units with a total effective capacity of 18 MW. At Nicolay power station there are three open cycle combustion turbines with a total effective capacity of 77 MW. These units run on kerosene and are designed to operate to serve peak loads and emergencies.

The seven Mirrlees engines at Fort Victoria have clocked an average of approximately 65,000 running hours. They are the oldest and least efficient of CEB's thermal generating units and have reached the end of their technically and economically efficient lives. Moreover, in certain wind regimes, these units cannot be run as the air emissions trouble neighbouring inhabitants. We plan, therefore, to retire these units at the earliest possible date following the addition of replacement capacity. Currently this retirement is scheduled for 2006.

The six Pielstick units at St. Louis have a nameplate capacity of 12 MW each, but have been downrated to 8 MW in recognition of their age and long running hours—now an average of approximately 125,000 hours. The units have been well maintained and remain in good working order despite their age. They are nearing the end of their serviceable lives and CEB plans to progressively retire these units, one per year, starting in 2008.

CEB operates eight hydroelectric stations having a total installed capacity of 53 MW. The full installed capacity can only be exploited in wet periods with heavy rainfall. As shown in Table 3-1, for planning purposes we assume 37 MW are available in the January to June period and 27 MW in the July to December period. Three dams—Diamamouve, Tamarind Falls and Eau Bleue—provide storage for the Champagne, Tamarind, Magenta, and Le Val hydro power stations. The remaining stations at Ferney, Réduit, Cascade Cécile, and La Ferme are run-of-river stations.

These hydro stations make a small but very significant contribution to electricity generation in Mauritius. Champagne and Tamarind/Magenta are generally used for peaking purposes. The run-of-river plants operate as base load when there is sufficient water. Some of our hydro stations must run each day to provide minimum water flows to downstream users for irrigation purposes.

The amount of energy we are able to generate from our hydroelectric stations varies dramatically over the year. From January through June we may be able to generate anywhere between about 5 GWh and 20 GWh per month; during July and August we may be able to generate between 5 GWh and 10 GWh per month; and from September through December, we typically generate 5 GWh or less per month. In an "average" year we generate about 85 GWh from hydro. With the Midlands Dam and the La Nicolière diversion in place, our energy potential was reduced by about 12 GWh this year.

IPP Generation

CEB has three IPPs that operate under long-term, take-or-pay power purchase agreements. They provide electricity year-round using a combination of coal and, during the crop season, bagasse. These three IPPs are Consolidated Energy Ltd., FUEL Steam and Power Generation Co. Ltd., and Compagnie Thermique de Belle Vue Ltée. In total, they provide an effective capacity of 111 MW during the intercrop season and 78 MW during the crop season. Since these IPPs must supply steam and electricity to adjacent sugar mills, their output to CEB is reduced during the crop season when the sugar mills are operating.

CEB also has power purchase agreements with seven IPPs that produce electricity from bagasse during the crop season only. The capacity from these seasonal IPPs is 39 MW and is vital to CEB as it offsets the crop-season reduction in capacity from the three year-round IPPs. In 2002, CEB and the seasonal IPPs renegotiated their power purchase agreements. A modification to the price indexation formula has produced and will continue to produce considerable cost savings for CEB each year. At the same time, some operational procedures which had been practised by tacit agreement were formalised in the contracts. Over the five or six years that most of these seasonal IPPs have been operating under contract, they have successfully improved their operational efficiency, with the result that they are able to deliver more electricity to CEB from their supplies of bagasse.

Following from our December 2002 Request for Proposals, we recently reached agreement with a new IPP, Compagnie Thermique du Sud, for the supply of electricity from a 30 MW coal-fired steam plant to be located next to the St. Aubin sugar factory. CEB and CTDS signed a power purchase agreement on 15 October 2003. Under the terms of this agreement, Compagnie Thermique du Sud will be fully operational no later than October 2005. We consider this IPP to be a committed resource and the capacity and energy from the plant is shown in Table 3-1 as well as in our demand-supply balance from 2005.

Figure 3-4. Summer Demand Profile, Week of January 13, 2003

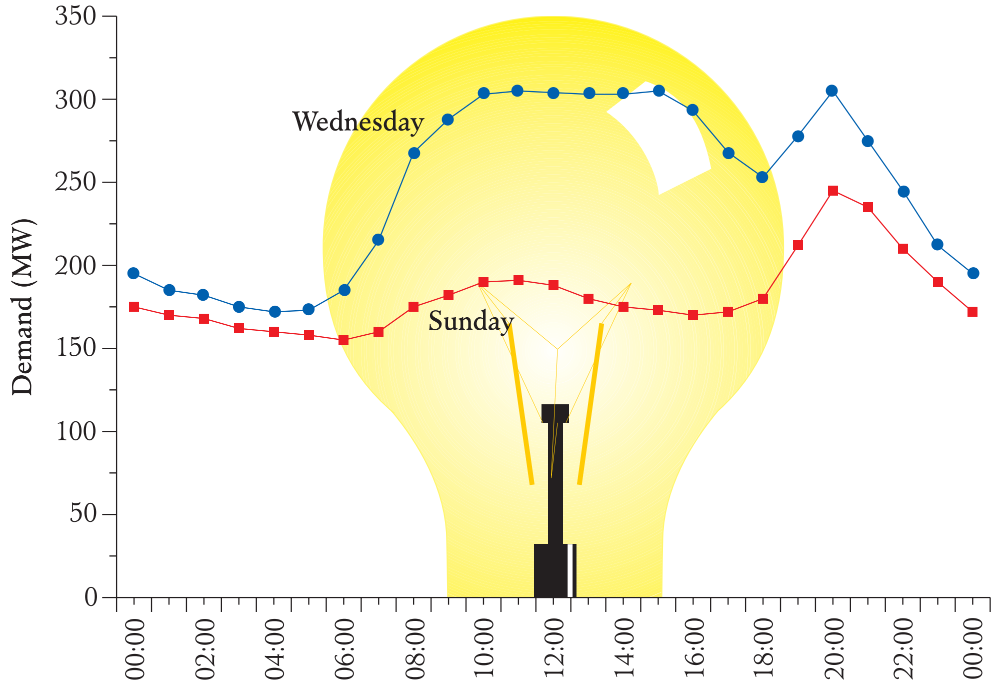
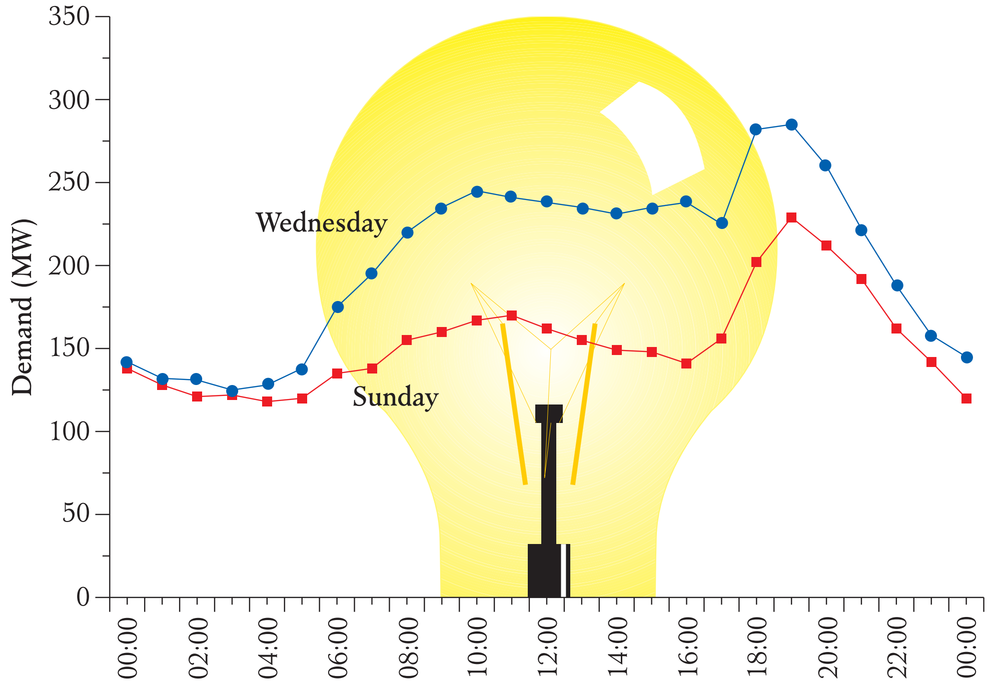


Figure 3-5. Winter Demand Profile, Week of July 21, 2003



3.3.3 Daily Demand Profile

Our daily demand profile in Mauritius has two distinct characteristics: a sharp peak of high demand for a short duration in the early evening, followed by a valley of low demand in the late evening and overnight period. The profile varies with time of the day, day of the week, and season of the year. Actual daily demand curves are shown in Figure 3-4 for a typical summer weekday and summer Sunday, and in Figure 3-5 for a typical winter weekday and winter Sunday.

Comparing these profiles one can see, first, that demand is higher overall in the summer than in the winter. Our summer peak has historically occurred in November or December; recently it has also occurred in April or May. The general profile, whether summer or winter, shows a demand of around 100 MW to 150 MW (winter) and 150 MW to 200 MW (summer) for about eight hours in the late evening and overnight. Demand then rises over about four hours to reach 250 MW (winter) and 300 MW (summer), where it remains for about seven hours during the day. Demand then often drops off for an hour or so before rising to the daily peak which is now routinely exceeding 300 MW for a duration of approximately two hours. After the evening peak, demand drops off sharply.

Electricity cannot be stored on any commercial scale. That means CEB must have the capability to supply the exact amount of electricity our customers demand at the very time they demand it. This fact, given the variable nature of our demand profile, imposes two significant constraints on our system capacity: (i) the need to add capacity just to meet a growing peak load of short duration; and (ii) the underutilisation of that capacity at other times.

- *High demand for an evening peak of short duration*. To meet the evening peak we often have to run every generating unit available on our system at maximum output. And, because the peak demand is growing at a faster rate than overnight demand, we must continue to add new capacity—in both generation and in our network—simply to meet the peak. This capacity, which sits idle for most of the time, is thus very expensive.

- *Insufficient demand in late evening and overnight periods*. Because the overnight demand level is low, we must turn off generating units where the technology allows this type of operation. Some generating units, such as the slow-speed diesel engines at Fort George, are not designed for this type of operation and therefore must be backed down to run at low output levels. We also ask our IPPs to back down their generation at night. Such operations cause difficulties: for CEB in meeting our minimum guaranteed energy purchase obligations from IPPs, and for the IPPs in maintaining production levels in their sugar factories. For both CEB and the IPPs, operating generating units at low loads is less efficient and therefore more costly.

The uneven shape of the daily demand profile means CEB must plan carefully the mix of generation capacity and system expansion for efficient use of our invested capital and investments yet to be made. Demand-side management, discussed in the next Chapter, is a possible means of easing some of these constraints.

3.3.4 Transmission and Distribution Capability

The CEB transmission network has a number of specific features that are significant in terms of the relationship between the location of generation sources and the locations of demand, or load centers. Major generation sources are concentrated in the Port Louis area. The majority of today's demand is concentrated in:

- The Port-Louis area, where it is supplied through the St. Louis, Fort George, and Nicolay substations;

- The area of Beau Bassin to Curepipe, where it is supplied through the Rose Hill, La Chaumière, Wooton, and Henrietta substations; and

- The North and northeastern areas, which are supplied through the Belle Vue and FUEL substations.

Because of this relationship between the concentration of supply and location of demand, CEB's 66 kV transmission network was facing significant limitations in the mid-1990s in its ability to efficiently transmit power in sufficient quantities to the bulk supply points (BSPs). At peak times, some of the transmission lines were loaded to full capacity, resulting in "system congestion" in much the same way as a road network becomes congested with traffic. The heavy loading on the transmission system also made it difficult for CEB to coordinate routine maintenance of the network, since there were only limited, short periods of time when circuits along the lines could be taken out of service.

With the implementation of the first phase of a transmission development plan in 2002, the 66 kV grid has been relieved of congestion problems and can now be more readily programmed for maintenance purposes. This phase comprised the construction of 37 km of new 132 kV lines, the replacement of 23 km of existing 66 kV lines by lines with a design rating of 132 kV, and the construction of two new switching stations. The 132 kV lines are currently operating at 66 kV and will be converted to operation at 132 kV in the future as demand patterns warrant.

The transmission system currently comprises eleven major 66 kV-to-22 kV substations and 215 km of 66 kV lines.

Electricity is distributed at medium voltage (MV) mainly through 22 kV and 6.6 kV overhead lines totalling around 2,200 circuit kilometres. The 22 kV overhead network consists of aluminum alloy conductors, with line technology conforming to British Standard BS 1320; however, increasing use is being made of insulated twisted conductors to replace some spans of bare conductor along sections with trees or near to buildings and other structures. CEB owns and maintains some 4,200 medium-voltage-to-low-voltage transformers on the network. Spurs supplying the transformers are tapped from the main lines through individual or grouped fuses.

Electricity is also distributed through underground feeders which now total some 336 circuit kilometres, mostly in urban areas such as Port Louis, Curepipe, Vacoas, Quatre Bornes, and Rose Hill. On these underground feeders, transformers are connected via one or more switch-fused disconnectors on ring main units.

3.4 Planning Criteria

3.4.1 Generation Planning Criteria

CEB has developed this IEP in a manner consistent with established energy and capacity reserve criteria suited to small island nations. These are static, deterministic criteria and, because Mauritius is an island without interconnection to sources of supply from neighbouring jurisdictions, are higher than the reserves that would need to be held in other countries.

In future, CEB will employ a probabilistic approach in its planning, based on the probability and the cost of having unserved demand. For many utilities, a standard measure of reliability for planning is to provide enough generating capacity so that only one day of capacity shortage results every ten years. Using this type of approach in the future will allow us to better optimise our generation plans on the basis of equipment performance characteristics and economics.

Spinning Reserves

Since there is no economically viable way to store electricity in large quantities, some generation capacity must be held in reserve and at the ready (i.e., the generators must be “spinning” though not actually producing power) to exactly match the generation to any instantaneous rise or fall in demand at all times of the day and night. Spinning reserve also makes an essential contribution to the maintenance of the real-time stability of the electric system overall. CEB usually keeps a spinning reserve approximately equal to 10 percent of demand. At peak times, for example, this spinning reserve must be equivalent to 30 MW of capacity—which is about the size of one generating unit at the Fort George power station.

System Reserves

CEB has planned its power generation requirements so that sufficient power generating capacity is available to meet peak demand under an N-2 criterion. That means we must have sufficient generating capacity assuming the largest generating unit in the system is unavailable due to regularly scheduled maintenance and, at the same time, the next largest generating unit unexpectedly fails, or vice versa.

Generally the combination of spinning reserves and system reserves means that CEB plans to have reserve margins in the range of 20 percent to 25 percent of total effective generating capacity.

3.4.2 Transmission Planning Criteria

The key task of transmission planning is to provide adequate network capacity to handle energy flows from the generation plants to the bulk supply points. The distribution network then distributes the energy from the bulk supply points to the end customer. The key consideration in transmission planning is to maintain system reliability and quality of power supply. The need for future reinforcements of the bulk transmission system and the nature of these reinforcements are influenced by several factors such as:

- Power transfer capacity requirements;
- Location and size of new generation resources;
- Expected retirement of existing generation elements; and
- Economic benefits of reducing transmission losses.

Figure 3-6. Energy Balance with Existing and Committed Resources

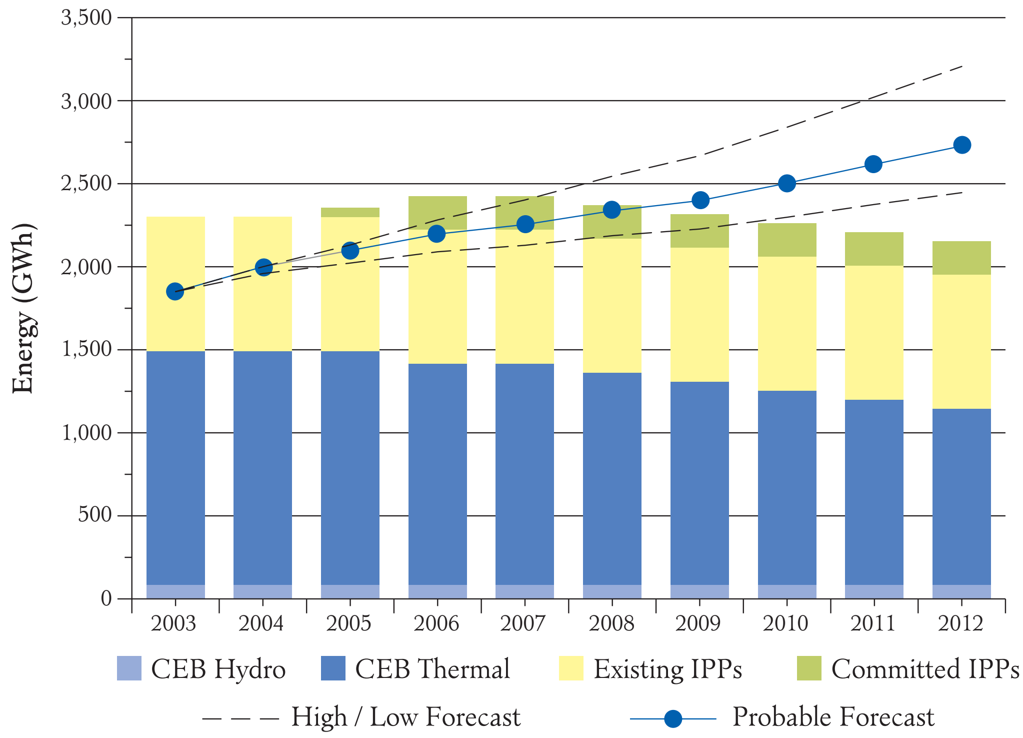
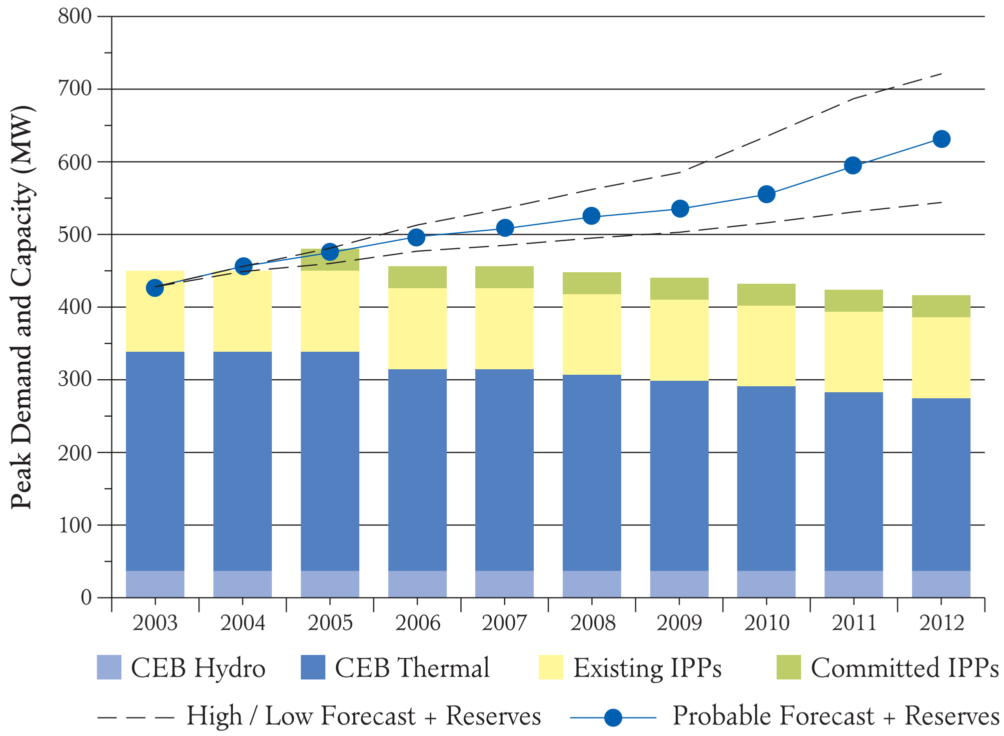


Figure 3-7. Effective Capacity Balance with Existing and Committed Resources



The electrical system is planned and designed to meet an appropriate level of system reliability. This includes certain standards of steady-state and dynamic performance under a variety of single or multiple contingencies, such as the loss of a major system component.

N-1 Minimum Standard Security Criterion

In planning and designing our transmission system, we apply the N-1 minimum standard security criterion. That means, the transmission system must remain intact and capable of transmitting the system peak demand to the 22 kV busbars when any one circuit and/or one 66 kV-to-22 kV transformer is out of service due to a fault or for maintenance.

We plan the minimum carrying capacity of the transmission network such that, for the secured event of a fault outage of any of: (i) a single transmission circuit, and (ii) a power transformer, there shall not be any the following:

- Loss of supply capacity;
- Unacceptable overloading of any primary transmission equipment;
- Unacceptable voltage conditions; or
- System instability.

3.4.3 Distribution Planning Criteria

The distribution network must be designed so that voltage at the customers' premises remains within statutorily prescribed limits under both normal and emergency conditions. CEB has adopted voltage regulation performance in the range ± 6 percent, to give a margin within the statutory requirement to maintain voltages at the nominal level of 230 V for single-phase and 400 V for three-phase service. CEB further provides back-up supply for almost all feeders and for 22 kV spur lines with loads above 100 Amps. We design the system so that the maximum number of switching operations which may be carried out to reconfigure the network in the event of an outage is limited to six.

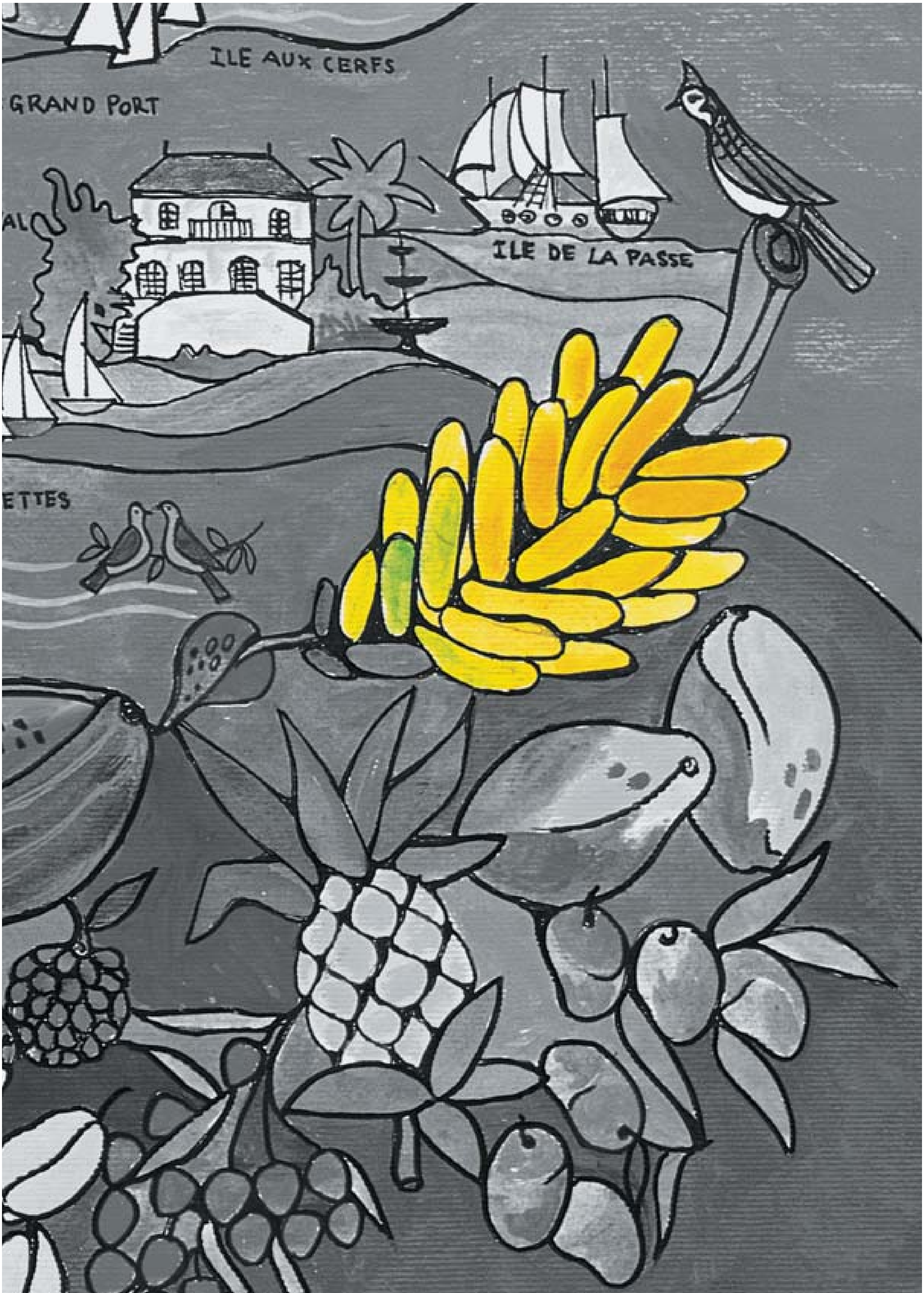
3.5 Need for New Electricity Supplies

At CEB, we are actively taking decisions on whether and how much to invest in maintaining output from aging infrastructure as well as on investment in new generating assets to meet demand. Some of our generating assets are reaching an age where maintenance and replacement costs will need to be increasingly scrutinised and decisions taken on closure, repowering, site redevelopment, or other alternatives.

Figures 3-6 and 3-7 show the gap between the energy and peak demand forecasts, respectively, and the supply capability of existing and committed resources less planned unit retirements. We see from Figure 3-6 that new resources are needed to meet the projected energy demand in 2008 if we are to avoid extensive use of higher-cost generating units. CEB assigns an energy capability to each generating unit based on its economic operating conditions, and this is reflected in Figure 3-6. For example, the gas turbines at Nicolay are a useful and economic generating resource in the overall system context at utilisation rates no greater than 10 percent to 15 percent; therefore the contribution to the energy balance from Nicolay is limited to 65 GWh for planning purposes. More energy can be produced from Nicolay, as it was in the mid- to late 1990s, but this energy is expensive.

The peak demand forecasts in Figure 3-7 include an allowance for spinning and system reserve margins as discussed in Section 3.4.1. Figure 3-7 shows that new generating capacity is needed to meet peak demand in 2006 to maintain adequate reserve margins and allow us to retire the Mirrlees units at Fort Victoria. Typically the time required for new generating plant to come on line—if planning, licensing, and construction go smoothly—is three to five years. Therefore we must act quickly now to meet our needs for 2006. Our plan for doing this is described in Chapter 5.

In the meantime, until sufficient new capacity comes on line, CEB will experience capacity constraints. We will need to make more extensive use of our gas turbines and continue to rely heavily on the aging and inefficient plant at Fort Victoria. Along with our IPPs, we must do our utmost to maximise the unit availability in all our generating stations in 2004 and 2005. Once sufficient new capacity is available on the system, our older, inefficient units will be retired. We do not plan to dismantle all the units immediately thereafter, but will keep some of them in reserve for national emergency purposes.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Chapter 4

Demand Forecast

4.1 Introduction

The primary purpose of a demand forecast is to address the key questions of "why, when, where, and how much" electricity will be required in the future. The forecast needs to reflect not only near-term changes and developments that influence demand, but also factors that may have major implications on demand for electricity over the longer term.

The demand forecast is a key input to all CEB's planning activities. It is important therefore, that forecasts of future demand be as accurate as possible and be updated regularly. The extent to which we can successfully forecast energy and peak demand requirements is instrumental in meeting our obligation as electricity supplier to Mauritius and in understanding the nature and timing of capital expenditures we will need to make to expand and enhance our system. The extent to which we can successfully forecast our sales provides the foundation for our revenue projections and, thereby, the extent to which we can pursue business strategies and projects. Because we expect the assumptions underlying the forecast to change over time, we will update our demand forecast on an annual basis and make any necessary updates to the IEP accordingly.

This chapter presents our forecast of electricity requirements and outlines the assumptions, information, and process used to prepare the 2003 to 2012 forecast of energy and peak demand. The chapter has seven main sections which follow this introduction:

- **Section 4.2 – Forecast of Electricity Requirements** presents the energy and peak demand forecasts in summary form for readers who want to see the overall forecasts but are not interested in sectoral detail.

- **Section 4.3 – Socio-Economic Context and Drivers of Demand** describes some of the leading economic and customer-based assumptions used to develop the forecast.

- **Sections 4.4, 4.5, and 4.6 – Residential Sales Forecast, Commercial Sales Forecast, and Industrial and Other Sales Forecasts,** respectively, contain the sectoral energy sales forecasts and the assumptions used in preparing these forecasts.

- **Section 4.7 – Forecasting Process and Methodology** describes the approach used in developing the probable, high demand growth, and low demand growth forecasts for both energy and peak demand.

- **Section 4.8 – Demand-Side Management** discusses the present status of CEB's demand-side management programs and the most promising activities to which we propose to dedicate more attention in the coming years.

4.2 Forecast of Electricity Requirements

4.2.1 Electricity Sales and Gross Generation Requirements

Total energy sales to CEB's customers in Mauritius are projected to increase from 1,492 GWh in 2002 to 2,436 GWh by 2012. This is an average annual growth rate of 5.0% over the next ten years. The residential sector will account for 768 GWh (or 32 percent) of 2012 sales; the commercial sector for 816 GWh (or 33 percent); and the industrial and other sectors for the remaining 852 GWh (or 35 percent.) Table 4-1 shows the probable forecast of sales by customer segment and this information is presented graphically in Figure 4-1.

Gross generation requirements to meet the probable sales forecast are projected to increase from 1,715 GWh in 2002 to 2,727 GWh in 2012, as shown in Table 4-2.

4.2.2 Peak Demand and Capacity Requirements

System capacity requirements to provide for peak demand are projected to rise from 319 MW in 2002 to 484 MW in 2012, as shown in Table 4-2. This represents an average annual increase of 17 MW, or 4.3%, over the planning horizon.

Table 4-1. Probable Sales Forecast by Customer Segment

	RESIDENTIAL		COMMERCIAL		INDUSTRIAL AND OTHER	
YEAR	GWh	Growth Rate (%)	GWh	Growth Rate (%)	GWh	Growth Rate (%)
2002	521	–	420	–	551	–
2007	650	4.5	597	7.3	743	6.2
2012	768	3.4	816	6.5	852	2.8

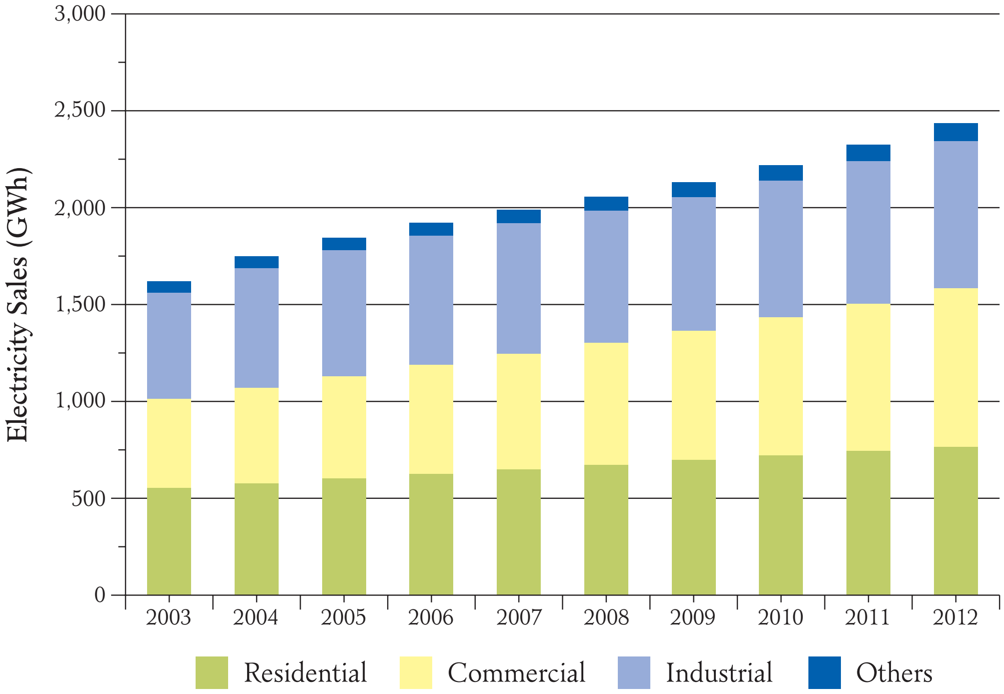
Note: Growth rates shown are average cumulative annual growth over the next 5 and following 5 years.

Table 4-2. Summary of Probable Forecast Elements

	SALES		GROSS GENERATION REQUIREMENTS		SYSTEM CAPACITY REQUIREMENTS	
YEAR	GWh	Growth Rate (%)	GWh	Growth Rate (%)	MW	Growth Rate (%)
2002	1,492	–	1,715	–	319	–
2007	1,990	5.9	2,254	5.6	404	4.8
2012	2,436	4.1	2,727	3.9	484	3.7

Note: Growth rates shown are average cumulative annual growth over the next 5 and following 5 years.

Figure 4-1. Probable Forecast of Electricity Sales by Customer Segment



4.3 Socio-Economic Context and Drivers of Demand

Significant changes are taking place in Mauritius which in turn are affecting both the way electricity is consumed and the geographical location where it will be required.

- Diversification and consolidation in the sugar sector is releasing a significant amount of land now under sugar cane cultivation for housing and other developments such as business parks and integrated resort schemes.

- The textile sector is adapting to international challenges by placing emphasis on efficiency of operations. Centralisation on larger factories is evidence of this quest for efficiency. Trading protocols such as the African Growth and Opportunity Act (AGOA) are introducing our country to a new breed of textile manufacturing plant—the spinning mill—that will consume significant amounts of energy on a 24-hour basis. Spinning mill projects are expected to have a lifetime of between five and fifteen years.

- The tourism sector is now focusing almost exclusively on development at the high end of the market, placing demand for large sites for hotels and integrated resort schemes on coastal areas which were previously neither developed nor electrified. Eco-tourism, on the other hand, is planned primarily for inland areas and is not expected to be as energy intensive.

- The information and communication technology (ICT) and financial services sectors are expected to grow rapidly and to give rise to load centres that will consist of new styles of building development outside townships, in locations presently undeveloped. The electricity consumed by these buildings is expected to be over longer hours than is the pattern in current office buildings and complexes.

- A rapidly growing stock of vehicles is putting our roads and transportation infrastructure under stress. Government has identified Light Railway Transit (LRT) as part of the solution to traffic congestion. The LRT will run on electricity and is expected to come into operation in 2009/10. The energy intensity of the system will depend on the hours of operation and its dispersion over the island. In parallel with the LRT system, priority development of commercial hubs is expected to occur around the LRT stations and car park sites, all of which will require additional street lighting.

- The local style of living is undergoing a transformation, with a pronounced split of the extended family structure and the tendency for more people to opt for community living in apartments in urban areas. The number of second homes is increasing.

- The facilities and amenities gap between urban and rural areas is gradually decreasing, and will be reduced even more rapidly if the proposed National Development Strategy of achieving critical mass through clustering of settlements and employment-generating activities in the conurbation, the countryside, and on the coast is successful in the long-term. Rural growth zones, where a range of mixed use is envisaged, have been identified for Bel Air Rivière Sèche, Centre de Flacq, Bon Accueil, Pamplemousses, Triolet, Goodlands, Rivière du Rempart, Bambous, Rose Belle and Chemin Grenier.

4.4 Residential Sales Forecast

Residential sales are forecast to grow from the figure of 521 GWh recorded in 2002 to 650 GWh in 2007 to 768 GWh in 2012. These figures represent average annual growth rates of 4.5% over the next five years and 3.4% over the following five years. This is in contrast to the annual growth rate which averaged 6.6% through the 1990s.

The two main drivers of the residential sales forecast are the forecast of number of residential accounts and the forecast specific use rate, that is, the yearly consumption per residential account.

Number of Residential Accounts

There will be sustained requirements for more housing due to an increasing population, the splitting of the extended family structure, acquisition of secondary housing by more and more people, and the import of foreign labour to work in priority economic sectors, such as in textile factories and in the ICT field. At the same time, more people—residents and non-residents alike—will opt to live in apartments. The construction and occupancy of a large number of apartment projects is a positive indication that the market exists for such a living style. These factors taken together are expected to contribute to an annual increase of about 7,000 new housing units over the planning horizon.

Although there is a large number of morcellement projects being implemented, it remains to be verified what percentage of the plots of land sold will be developed in the short-term; for many people, buying a plot of land is simply regarded as a long-term investment.

ENERGY FACT

The average household in Mauritius used about 1,175 kWh of electricity in 1992 and today uses about 1,770 kWh per year.

Residential Use Rate

The average Mauritian household electrical load has been growing steadily over the years due to a general increase in living standards and disposable income as well as the increasing availability and affordability of electrical appliances on the market. Over the decade from 1992 to 2002, the average yearly increase in specific consumption was 60 kWh, or about 4.2%. In 1992, the average Mauritian household used about 1,175 kWh of energy per year. Today the average household uses about 1,770 kWh of energy each year. But usage varies widely among residential customers. About 15 percent of households consume less than 600 kWh of energy each year and about 15 percent consume more than 2,400 kWh of energy each year.

Appliances such as air conditioners, dishwashers, home cinema, and home office equipment are gaining in popularity in middle income households. Other common domestic appliances such as televisions and refrigerators are being replaced by larger units. Many medium and high income households are purchasing duplicate appliances.

In summary, over the next ten years the combined effect of the increase in the number of residential accounts and the trend of increasing penetration of household appliances will tend to be offset by improved energy efficiency of major appliances and the fact that there will be a smaller number of people per household. Thus the overall growth in residential sales is expected to be fairly constant at approximately 24 GWh per year. The growth in use rate, however, will slow from about 3.5% in 2003/04 to 1% in 2011/12. The effects of advances in energy-efficient building technology on residential use patterns are expected to take longer before their impact is felt.

ENERGY FACT

The typical large office building (18 storeys) in Port Louis consumes about 4.6 GWh of electricity per year, approximately equal to the consumption of 3,000 households.

4.5 Commercial Sales Forecast

Sales to commercial customers are forecast to grow from the figure of 420 GWh recorded in 2002 to 597 GWh in 2007 and to 816 GWh in 2012. These figures represent average annual growth rates of 7.3% over the next five years and 6.5% over the following five years. Commercial sales are expected to account for the largest growth in CEB's overall sales in the coming years, as they have done in the past decade.

The commercial sector comprises a very diverse group of customers such as finance, tourism, utilities, transportation, wholesale and retail trade, recreation, food and beverage supply, health care, education, and public administration. New and expanded services supported by consumer spending will contribute to growth in this sector.

We are presently witnessing the construction of a large number of high-rise office and commercial buildings. Such an increase in the amount of floor stock is a clear indication that the commercial customer base will sustain significant growth, at least up to the medium-term.

This sector is service oriented and efficiency driven. Increasing adoption of ICT to improve customer relationships and electricity-using technologies to enhance productivity and competitiveness are expected. The tendency for increasing use of electricity, primarily for lighting, air-conditioning, refrigeration, and electronic and office equipment, will be sustained.

4.6 Industrial and Other Sales Forecasts

Sales to industrial and other customers are forecast to grow from the figure of 551 GWh recorded in 2002 to 852 GWh in 2012. This represents an average annual growth rate overall across these customer segments of about 4.5% over the next ten years, down from the average annual growth rate of about 7% observed over the past ten years. The 2012 sales figures are broken down as follows: 760 GWh to industrial customers, 51 GWh to street lighting, and 41 GWh to irrigation customers. Discussion of each of these customer segments is provided below.

Industry

Industrial consumption has contributed to a significant share of our total sales volume in the past, but growth in industrial consumption will be outpaced by residential and commercial consumption in the future. In the past, the ratio of commercial to industrial projects was 4:1; today the ratio is 5:1 and this pattern is expected to persist.

Globalisation, erosion of preferential trade agreements, limits on primary resource availability and a relatively expensive labour force are constraining our manufacturing sector. Competitiveness and quality of products will be the key factors that will determine the survival of this sector, but at the same time, new trade agreements should create new opportunities, particularly in the textile sector. Local and foreign investors are expected to use Mauritius as platform from which to enter as yet untapped markets on the African continent.

Although Mauritius is still regarded as an economy in development, our industry is not expected to duplicate the growth that the industrialised nations' economies have had in the past. This can be explained by a few fundamental differences. Firstly, we do not have an abundance of raw materials. Secondly, fewer and fewer people will be content to work in factories, preferring the services and knowledge-based sectors. Thirdly, emphasis is placed today on sustainable development in an interconnected world. Industry is expected to shift to more value-added production, to adopt production processes that make more efficient use of primary resources. This type of industry tends to be less electricity intensive.

Industrial sales are expected to increase from 499 GWh in 2002 to 760 GWh in 2012, representing an average annual growth rate of 4.3%.

Street and Outdoor Lighting

Requirements for street lighting will increase steadily over time due to:

- increasing kilometers of lighted highway;
- addition of lighting along existing roads which are presently not lit;
- increasing numbers of traffic lights; and
- increasing numbers of billboards and signboards with overnight lighting.

At the same time, inefficient fluorescent tubes will be replaced by long-life and efficient sodium lamps of higher wattage.

Outdoor lighting will also proliferate due to an increasing number of high-rise buildings with ground-level and decorative lighting and recreational facilities that require overnight lighting.

Street and outdoor lighting sales are expected to increase from 22 GWh in 2002 to 51 GWh in 2012, representing an average annual growth rate of 8.8%.

At the present time, all traffic signals in Mauritius use incandescent or halogen light bulbs to illuminate the traffic signal head. Despite many technical and economic advantages, the penetration of more efficient Light Emitting Diodes (LED) as a substitute for the incandescent bulb is expected to take place slowly and not until the medium term due to their substantially higher initial cost. As the demand for LED traffic signals increases worldwide, prices are expected to fall and this will promote their adoption into the local market.

Irrigation

As more agricultural land is released for development, the remaining land under cultivation will be optimised for more efficient irrigation and water use. Electricity will continue to be required to power pumping plants for irrigation and sprinkling of sugar cane fields, vegetable and fruit plantations, as well as other crop-raising activities. Pumping loads will, therefore, continue to make up the primary electricity demand from irrigation customers. Sales to irrigation customers are expected to grow by a modest 1 GWh per year, or from 27 GWh in 2002 to 41 GWh in 2012, representing an average annual growth rate of 4.3%.

4.7 Forecasting Process and Methodology

4.7.1 Energy Forecast

The demand forecast for energy was prepared using a bottom-up approach, starting from a forecast of energy sales on a sector-by-sector basis. To the sales forecast, the energy consumed by the system was added to obtain the gross energy generation needs; i.e.,

Gross Energy Generation Requirements =
Energy Sales + Network Losses +
Power Station Auxiliary Consumption

Energy Sales

For the short-term, that is 2003 to 2004, seasonal indices were used to forecast the energy requirement by quarter. Adjustments were made in recognition of public policy incentives for sectoral growth and major infrastructure development, such as spinning mills and integrated resort schemes. Low, probable, and high energy consumption scenarios were established based on the confidence of major projects being completed by 2004. The advantage of this approach for the immediate short term is that it offers sufficient accuracy for short-term financial planning.

For the long-term, that is 2010 to 2012, a growth rate method was used. Growth rates for customer number and specific consumption were predicted for the main customer categories of residential, commercial, industrial, irrigation and street lighting; i.e.,

Forecast Energy Sales =
Forecast Customer Number x
Forecast Specific Consumption

Low, probable and high scenarios were established using three scenarios for growth rates. This methodology was adopted over one based on a relationship with GDP, since economic growth in Mauritius is still developmental and heavily influenced by public policy. A relationship derived from past GDP-Sales relationships was not expected to hold true for the future.

For the medium-term, that is 2005 to 2009, a smoothing function was applied to link the short-term and the long-term results in each scenario.

Network Losses

The network loss, which is the percentage difference between total energy sent out from the power stations and total energy sales, was predicted for each year over the planning period using back analysis and extrapolation of historic system loss performance. Only a single scenario for line losses was used.

Power Station Auxiliary Consumption

Power stations themselves consume electricity. The internal consumption for each power station assumed to be in operation—except existing IPP stations whose output is measured net of auxiliary consumption—over the planning horizon was predicted based upon the most likely plant operating scenario and experience with each type of station.

DEMAND-SITE MANAGEMENT OBJECTIVES

- *Improve productivity and utilisation of existing assets*
- *Promote energy efficiency*
- *Avoid environmentally and financially expensive investment in supply capacity*
- *Encourage off-peak consumption*

4.7.2 Peak Demand Forecast

The forecast of capacity requirements to meet peak demand, for low, probable, and high scenarios, was derived using an empirical relationship with total energy sent out for the respective cases; i.e.,

$$P = a + bE + cE^{1/2}$$

where P = peak power sent out for the year (MW);
E = total energy sent out during the year (GWh);
a, b, and c are regression coefficients derived from historical data.

These results were checked against an extrapolation of representative quarterly 2002 load-duration curves, in which the future load-duration curves were assumed to remain of the same shape for the same season. The forecast energy sent out was fitted to the quarterly load-duration curves to derive the expected peak demand for future years. Both this methodology and the empirical relationship yielded similar results.

4.8 Demand-Side Management

4.8.1 Rationale

Utility planning in its early days consisted simply of forecasting increasing demand for electricity and then constructing new sources of supply, such as power stations and transmission lines, to meet that demand. Since this entrenched supply-side approach has proven to be not only costly to the environment and to electricity consumers, but also unsustainable, integrated planning now includes explicit consideration of demand-side approaches. Electricity consumers alongside utilities now participate in meeting their electricity needs by managing both the level and timing of their demand—that is demand-side management (DSM.)

The main benefit of DSM from a utility's perspective is that existing electricity infrastructure is more efficiently and productively used and, thereby, expenditures on new sources of electricity supply—including generating facilities, power purchases, and transmission and distribution capacity additions—can be deferred. From a customer's perspective, using energy wisely means electricity bills can be lower. For everyone, burning less fossil fuel to produce electricity conserves non-renewable resources and improves our environment.

People will argue and debate over fossil fuel prices and the number of years before oil, coal, and gas reserves are depleted. Even the experts do not agree on the gap between global supply and worldwide demand for these energy resources. No matter what view one takes on that subject, what we believe is that, for Mauritius, the greatest room for improvement in our energy future lies with demand. Clearly, the least expensive way to meet growing demand is conservation. Whether in our industries, businesses, or homes, we must strive to rein in our energy consumption if we are to achieve a stable and sustainable energy future.

From 1992 to 2002, CEB added additional generating plant capacity equivalent to about 30 MW every two years. As the next Chapter will show, we anticipate that figure is likely to be on the order of 30 MW each year between 2006 and 2012. If, through effective DSM, we can curtail the system peak demand by some 30 MW, it may be possible for us to defer the installation of an equivalent-sized generating plant midway during that period. For that reason, CEB is committed to implementing a modest DSM program in the context of our integrated planning process. There is, however, no guarantee that a DSM program can avoid or delay the need to construct additional capacity. Nevertheless, we are certain that such a program will produce benefits in the long run, both for us and for our customers.

4.8.2 CEB's Plan for Improved Asset Utilisation and DSM

At CEB, we are reviewing our own practices and procedures for meeting the country's ever-increasing demand for electricity. Developing and publishing this IEP is just the first step and its development is already changing the way many of our activities are carried out. A case in point is our effort to enhance the carrying capability of our network and reduce network losses, rather than simply concentrating on network expansion. This is being done through targeted projects such as the one described below, and through diversification of our points of supply, as discussed in Chapter 6 of this IEP.

But DSM cannot be only CEB's concern. If our customers do not participate actively, then our efforts will fail. We will endeavour to garner our customers' active participation using a combination of mechanisms and programs outlined later in this Section.

Reduction of Technical Losses in CEB's Network

Losses in power distribution systems can be classified into technical and non-technical losses. Whether considered technical or non-technical, reducing losses is important to CEB. For every 1% reduction in losses, we gain an additional 17 GWh of electricity which, if sold at today's average selling price, is equivalent to revenue of Rs 50 million.

CEB customarily reports only the overall system losses which, being based on the difference between the total energy exported to the grid from the various power stations and the total energy sales to our customers, includes both technical and non-technical losses. Historically, CEB has been reporting a gradual decrease in overall system losses. The decrease was rapid from 1990 to 1994, when losses were reduced from 13.8% to 11.6%, respectively. The decrease has slowed somewhat, but has continued so that in 2002, losses were on the order of 10.8%.

Losses occur throughout the entire power system, from the generator through to the customer's meter; however, we are focusing our attention at this time on the distribution network, where a larger proportion of losses generally occur. We have just begun to implement a three-phase program to first determine and then manage losses. In this program, being implemented jointly by the Distribution and the Corporate Planning & Research Departments, we will:

- Determine technical losses on the distribution network through a controlled measurement program on typical distribution network segments and through an audit of customer service activities such as metering, billing, and collection;

- Identify loss reduction projects and set targets for loss reductions based on the findings of the measurement program; and

- Manage the implementation of those loss reduction projects.

In the meantime, for planning purposes in this IEP, we are targeting to achieve an overall system loss level of approximately 8% by 2012. This is probably the practical limit for our electric system in Mauritius.

Tariffs

We are currently assessing the tariff incentives necessary to encourage customers to shift part of their usual peak time consumption to off-peak hours while maintaining the same levels of comfort and energy service.

Time-of-use tariffs are particularly suitable DSM options for a utility such as CEB, where our demand profile is characterised by a sharp evening peak. Charging higher rates at certain times of the day gives customers a more accurate picture of the different costs of electricity at different times of the day, particularly at peak times when more expensive generating capacity must be fired up for only an hour or two each day to meet a sharp rise in demand of relatively short duration. Customers can then adjust their usage pattern, if they so wish.

ENERGY FACT

A high-efficiency motor is more expensive to buy. But consider this... An electric motor operating in a Mauritian factory can consume electricity equivalent to its purchase cost within the first 600 hours of operation—a mere four weeks of continuous use. Every year, the running cost of the motor will be from three to twelve times its purchase cost. Over its working life—say, an average of thirteen years—it may consume over 150 times its purchase cost in energy. Clearly, the lowest overall cost will not be achieved unless both purchase and running costs are considered together. The bottom line: Energy efficiency pays for itself.

CEB already has time-of-use tariffs for certain commercial and industrial customers; however, the majority of our commercial and industrial customers are not able to take advantage of the tariffs for reasons including:

- The existing tariff definitions disqualify most small and medium customers; and
- The existing tariff structure presents incentives that make the time-differentiated pricing attractive only to those customers that have relatively high demand and operate on a 24-hour basis.

We are revising our tariff structure and pricing to remove these and other barriers to more widespread availability of tariff incentives. We want to be able to offer time-of-use tariffs to a broader customer group; however, it is uncertain what effects time-of-use pricing will have on demand patterns. Short-term estimates from pilot studies are necessary to examine the effects, costs, and benefits.

As a practical matter, time-of-use pricing is permitted only where electronic meters such as the type CEB has been installing since 1992 are in place. Presently, 95% of the meters we install each year are of the electronic type. Nevertheless, to offer at least all medium and large commercial and industrial customers the choice of a time-of-use tariff, we must replace some 12,000 electromechanical meters currently in service with electronic ones. This replacement can take place only gradually because the level of investment required is of the order of Rs 180 million, excluding administrative and labour costs.

We propose to introduce time-of-use pricing for residential customers on a pilot basis. We recognise that shifting part of their demand from peak to off-peak hours may be impossible or impractical for some households and we do not wish to impose a higher peak-time price on those customers who truly cannot alter their consumption.

For customers to benefit from tariff incentives such as time-of-use pricing, it may be necessary for them to invest in control technologies, such as timers and switches. These expenses are generally more than offset by reduced energy bills.

End-Use Energy Efficiency Programs

Being energy efficient means each of us reduces the amount of electricity we use in our homes and businesses. In doing so, we lower our energy bills and reduce the need for more and bigger power plants.

We will begin to assist our customers become more energy efficient by first disseminating information and then by promoting substitute appliances and equipment that produce equal levels of service with less electricity. Examples include energy-saving appliances and lighting, high-efficiency ventilating and air conditioning systems, efficient building design and advanced electric motors and drive systems.

As part of our effort to develop market intelligence and to influence energy-efficient behaviour, we will, in conjunction with other institutions and Government, identify appropriate building standards as well as barriers to energy efficiency which limit markets for energy-efficient products and services or prevent them from functioning effectively.

Designing energy efficiency into new construction can be a large source of energy savings that comes at little or no extra cost. With the level of new construction activity presently going on in Mauritius, all project developers should be incorporating energy efficiency into their buildings and complexes. This should encompass at a minimum lighting, ventilating, and air conditioning systems. Architectural design should consider making the best use of daylighting, and building material design can specify insulation, cladding, and double glazing on windows.

In order for us to advise residential customers on how to use electricity judiciously and to guide them on how best to participate in DSM, we must understand the end-use penetration and utilisation of household electrical appliances by various householders. We are preparing to release a survey to 4 percent of our residential customer base to help us gather such information. Some of the survey questions pertain to penetration—that is, the number and types—of appliances in households and the pattern of use. General questions include level of household income, type of residence and whether primary or secondary, and geographic location. We will use the survey to determine the scope to shift the timing of appliance use.

We will also use the survey as a means for customers to express their awareness of the benefits of energy-saving lighting and their willingness to purchase energy-saving light bulbs. This information will allow us to better prepare our sensitisation campaign and to determine the need for Government's assistance with fiscal incentives to promote penetration of high quality energy-saving lighting in the marketplace.

Peak Sharing with Private Stand-by Sets

Many businesses and industries are now routinely purchasing stand-by generating sets for their own use. This is evident from the statistics on new generating set purchases shown in Table 4-3. At CEB, we are interested in assessing the use and monitoring the penetration of these stand-by sets for the following reasons:

Table 4-3. Purchases of Diesel Generating Sets ≥ 500 kVA

YEAR	UNITS PURCHASED
1995	14
1996	15
1997	17
1998	17
1999	20
2000	30
2001	29
2002	13

Source: Central Statistical Office.

- The participation of private owners of large stand-by generating sets represents a potential DSM option to be investigated, particularly for peak sharing as defined below.
- We need to know how much our customers are willing to invest—and therefore the value they place—in securing their electricity supply to help us better understand the costs to the economy of power outages.
- From a system safety point of view, due to the potential for backfeed to the electricity grid, we need to record in a systematic manner the location of stand-by sets installed by customers on their premises.

"Peak sharing" is an attempt to reduce the demand on our system at peak times through a cooperative effort with our customers. The customer directly assists CEB by generating electricity for its own consumption during times of peak demand on the CEB system, which may or may not be the times of peak electricity use by the customer. Customers would operate their generating sets when directed to do so by CEB.

Peak sharing on a wide scale will only be beneficial to CEB if it effectively protects the reliability of the power supply, efficiently uses generation and transmission systems, and delays construction and maintenance costs of additional electricity infrastructure. From the customer's perspective, peak sharing will only be beneficial if it provides immediate energy cost savings and payback on generator sets. This means the benefits to the customer will depend on our tariff structure and rates, in combination with any incentive we may offer for this peak sharing arrangement.

We will investigate the extent to which benefits may result in a win-win situation. In cases where peak sharing as a DSM option is found to be viable, qualifying criteria and terms for a Peak Sharing Agreement will be defined and customer-partners identified. Qualifying criteria will include, among other things, the following:

- The customer's existing load and the demand in the immediate geographic vicinity;
- Capacity and reliability of the stand-by set;
- The cost of installing intelligent, two-way controls on the equipment and network infrastructure;
- Requirements to maintain security of the CEB network; and
- Environmental constraints, such as noise nuisance and air emissions.

Chapter 5
Generation Plan

5.1 Introduction

To capture competitive market forces in planning for new generation, a utility should start with communicating its optimal plan and the decision process it will use to acquire new generation. This is what we are doing in this IEP and in this Chapter in particular.

In this Chapter, we:

- Discuss the relationship between utility and non-utility generation in Section 5.2;
- Identify the different types of resource options that are most suitable to meeting our requirements in Section 5.3;
- Lay out our capacity expansion plan, showing the timing and approximate size of planned additional generation in Section 5.4; and
- Include in Section 5.5 our Generation Resource Acquisition Policy that outlines why, when, and how we will acquire new generating plant.

5.2 The Role of Independent Power Producers

Electricity generation in Mauritius, as in many other countries, is provided by both utility (i.e., CEB) and non-utility (i.e., IPP) sources. CEB held a monopoly position in generation from its inception 50 years ago until the emergence in the late 1990s of a significant number of IPPs. All current IPPs are affiliated with the sugar sector. The participation of non-utility generators in Mauritius was, in fact, introduced to both support the sugar sector and provide for the full and efficient use of bagasse as a local, renewable biomass fuel for energy generation.

St. Antoine was the first sugar factory to sell excess electricity generated from bagasse to CEB in 1957. Other sugar factories began to do the same, selling to CEB electricity which was surplus to the needs of the factory. This electricity was only intermittently available, and was referred to as *énergie à bien plaire*. Médine Sugar Estates was the first sugar factory to export electricity to CEB under contract, starting in 1979, although it had been selling excess energy to CEB prior to signing the contract. FUEL Steam and Power Generation Co. signed a power purchase agreement with CEB in 1983, although it too had been selling excess energy to CEB prior to that time. The Bagasse Energy Development Programme of 1991 gave a further boost to the sugar industry and provided the necessary incentives to the sugar factories to improve the efficiency of their operations and to encourage the production of electricity using bagasse.

CEB currently has power purchase agreements with three IPPs operating dual-fired coal/bagasse plants and producing electricity on a year-round basis. We also have power purchase agreements with seven IPPs operating bagasse-fired plants and producing electricity in the crop season only; depending on actual harvest conditions that is nominally July through November. As more and more sugar-producing activities are centralised, and in an effort to promote the most efficient use of bagasse for energy production, these seasonal power plants will ultimately be converted into year-round electricity production facilities.

The emergence of these IPPs has been of tremendous assistance to CEB in meeting the rapidly increasing demand for electricity that has prevailed since the mid-1980s. Without these IPPs, CEB would have had serious difficulty—and imposed a high financial burden on Government—raising the capital needed to provide this generating capacity on its own. The dispersed location of the IPPs has also relieved pressure on the transmission system in the Port Louis vicinity, where CEB's thermal power stations are located, and has improved the utilisation of the transmission and distribution system around the island.

The continued viability of the electric sector depends, in part, on continuing to attract private capital to provide new electricity infrastructure. We expect IPPs to be our key partners in the future and to acquire all the new power generation that comes from IPPs through a competitive Request for Proposals process. This we will do in line with our Generation Resource Acquisition Policy included in Section 5.5 because we realise that to successfully attract private investment in power generation, we need to have predictability, transparency, and clarity in our decision-making and operations processes. At the same time, we need to make these processes as cost effective as possible to lower our customers' energy costs.

5.3 Generation Resource Options

5.3.1 Current Generation Fuel Mix

Power generation in Mauritius is based on a diversity of fuels, as shown in Figure 5-1 for the Year 2000. The generation fuel mix of the member countries of the Organisation for Economic Cooperation and Development (OECD) is also shown for the same year, for comparison. The generation fuel mix in Mauritius has been evolving with time, with the biggest changes being the substitution of coal for diesel oil in recent years and the increasing contribution of bagasse. This evolution in the relative amounts of fuels used for generation is shown in Figure 5-2.

> ***ENERGY FACT***
> *CEB spent Rs 574 million on the purchase of 115,515 tonnes of fuel oil for its Fort George power station in 2002. Over the course of the year, the price for this fuel increased from U.S.$ 129 per tonne to U.S.$ 183 per tonne. CEB has borne these costs without passing on the price increases to consumers.*

5.3.2 Conventional Generation Technologies

The conventional generation technologies best suited to Mauritius include internal combustion engines, coal-fired steam plant or dual-fired steam plant using bagasse and a complementary fuel such as coal, and combustion turbines. While hydro is also a conventional generation technology, it is also a renewable energy source and will be discussed in that context.

Conventional generation technologies may also be used in a cogeneration setting. Cogeneration is the production and use of electricity and steam (or heat) in a single installation. Cogeneration plants are generally sited at industrial facilities where the electricity produced is also used on site to reduce the energy costs associated with the industrial facility. All of the current IPPs operate cogeneration facilities, providing steam and electricity to their associated sugar mills.

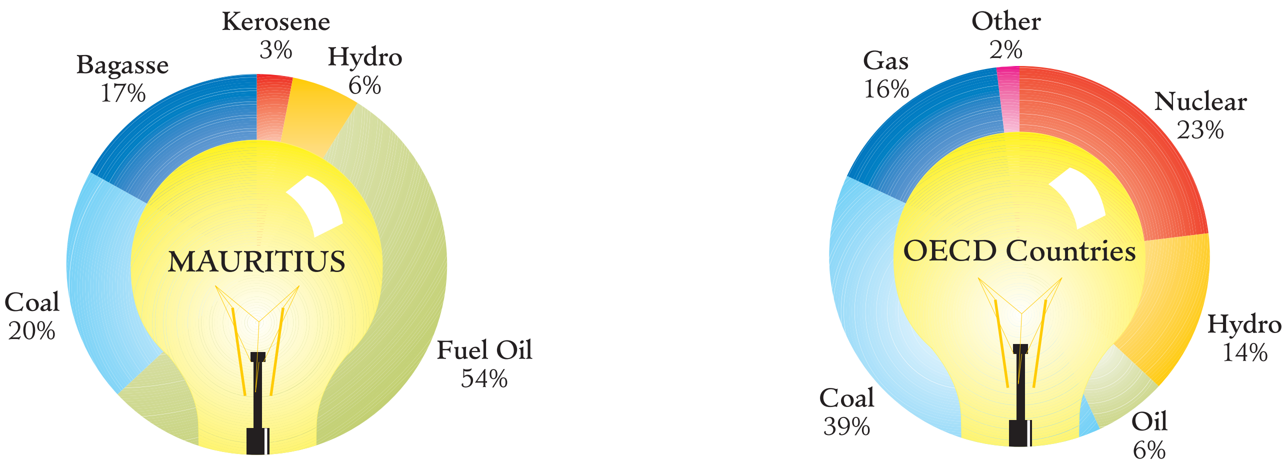
Internal Combustion Engines

Internal combustion engines running on heavy fuel oil have a long history and good track record of high availability and reliability in island-based systems. The units may be slow-speed or medium-speed, the former running at speeds in the range of 100 rpm to 250 rpm, and the latter running at speeds in the range of 400 rpm to 700 rpm.

Medium-speed diesel engines are in widespread use in sizes as small as 1 MW and up to 25 MW or more. These units offer relatively low capital investment and shorter construction periods, but have marginally higher operations and maintenance costs due to the need for regular replacement of components and parts stemming from the faster operation speeds. This technology is well-suited to semi-base load operations as the engines may be easily started and stopped daily as required.

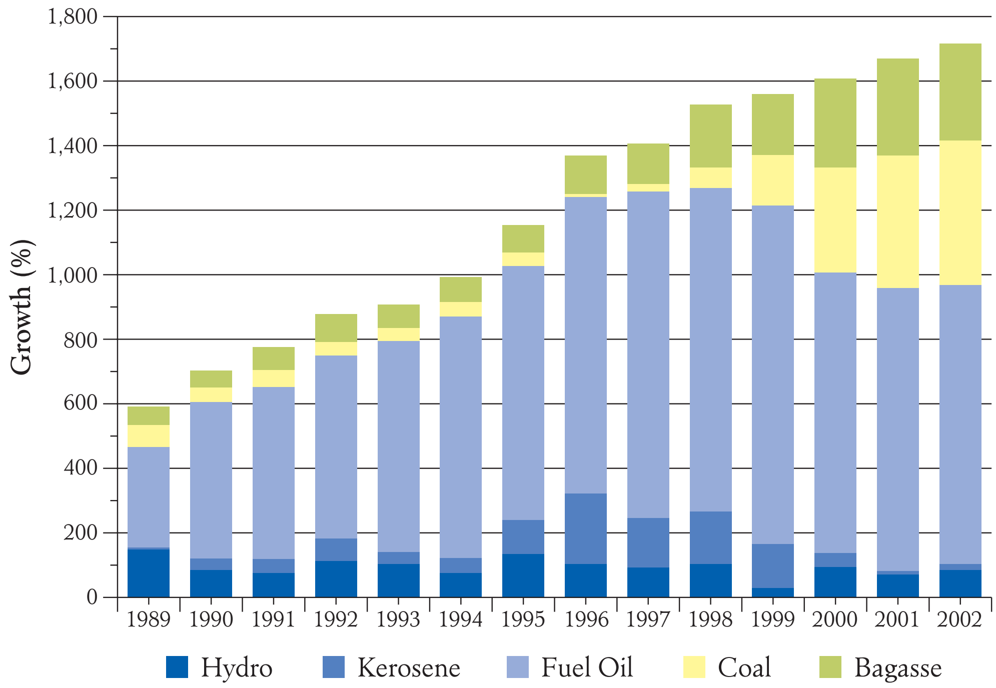
Slow-speed diesel engines are found in the range of 8 MW to 80 MW. They require higher capital investment and are less flexible in operation; that is, they are not amenable to daily starting and stopping.

Figure 5-1. Generation Fuel Mix for the Year 2000



Source: OECD, 2002, "OECD in Figures: Statistics on the Member Countries."; CEB

Figure 5-2. Generation Fuel Mix, 1989 to 2002



On the other hand, they require less maintenance than medium-speed engines and offer better reliability and fuel efficiency. Thus their overall operations and maintenance costs are lower.

Internal combustion engines typically emit more oxides of nitrogen (NO_x) than other types of fossil fuel generation and, depending on the composition of the fuel, can also have significant sulphur dioxide (SO_2) emissions. Some form of fuel pretreatment and emissions controls are generally required to meet prevailing environmental standards.

CEB is in the process of carrying out a feasibility assessment of the extension of the St. Louis power station, contemplating the addition of three new medium-speed diesel engines each with capacity in the 10 MW to 12 MW range. The primary benefits associated with this project are that it would minimise the overall environmental impacts associated with operation of the entire St. Louis power station; add modern, more efficient generating technology to replace aging generating units; and take fullest advantage of a site and existing infrastructure already used for power generation. As mentioned for this type of technology, the unit operations would be flexible and therefore able to more closely match the needs of our variable demand profile.

An Environmental Impact Assessment study has been completed for the project and we expect to have a full feasibility study completed before the middle of 2004. Should the project prove to be feasible, it could be implemented for an earliest in-service date of October 2005, or could be scheduled as required to meet CEB's needs between 2006 and 2008.

Coal-Fired and Dual-Fired Steam Plant

Our three, year-round IPPs use dual-fired steam plant technology, with unit sizes ranging from 18 MW to 35 MW. Bagasse and coal are complementary fuels in this type of plant, since both can be fed into a boiler using the same chain-grate system. When bagasse is not available, or in short supply, electricity production is maintained using coal. A coal-fired steam plant can be economical in the 30 MW to 50 MW size range, though this type of technology is most economic in sizes which are too large for Mauritius.

This plant technology typically has high capital costs but lower fuel costs and is therefore economical at high capacity utilisation factors. Plants of this type generally require a 24-month construction and commissioning period.

Coal used in Mauritius is imported from South Africa or Mozambique and is of generally low sulphur content, which means emissions of SO_2 can be maintained within environmental limits. One of the greatest criticisms of coal-fired generation is that it is the largest emitter of carbon dioxide, the reference greenhouse gas, of all the conventional generation technologies. This impact can be moderated in terms of CO_2 emissions over all units of electricity generated when coal is used in a dual-fired plant in conjunction with bagasse, which is considered to be carbon neutral.

Dust from coal handling and combustion and ash disposal are other important considerations associated with this technology. Coal ash is of two types: fly ash which has other potential secondary uses, such as in the production of cement; and bottom ash. Secondary uses of bottom ash are not as easily identifiable, as the properties of bottom ash vary dramatically according to the chemical composition of the coal. In many jurisdictions, where an environmentally sound disposal option is not available, bottom ash may only be disposed of in sanitary landfills. Combustion of bagasse produces more fly ash than bottom ash. This fly ash can be mixed with sugar cane residue and applied as fertiliser.

Coal plants are generally fitted with electrostatic precipitators to minimise emissions of dust and other particulate matter.

Combustion Turbines

Combustion turbines are derivatives of jet engines developed for commercial aircraft. They may be open cycle or closed cycle turbines and can run on a variety of fuels.

Combined cycle gas turbines have accounted for a high proportion of newly installed generation worldwide since the 1990s in recognition of their low capital cost, short construction periods, high efficiency, and low environmental emissions. This highly efficient form of power generation integrates the operation of a high efficiency gas turbine with a steam turbine and can therefore be used in cogeneration projects. Unfortunately, Mauritius does not have the supplies of natural gas or the infrastructure to support this technology in its most economical form.

Open cycle combustion turbines are economical solutions for peaking plant in Mauritius. These units have the ability to be started and fully operational in minutes. They have some of the same advantages as combined cycle gas turbines, namely lower capital cost per kilowatt installed, short construction times, and low air emissions. Because in Mauritius these units must run on expensive fuels such as kerosene and gas oil, they are economic only up to capacity utilisation factors of 10 percent to 15 percent. Combustion turbines are available in many sizes, of which the viable capacities for Mauritius would be in the range of 30 MW to 50 MW.

5.3.3 Renewable and Alternative Generation Technologies

Renewable sources of energy are those that depend on natural systems such as the flow of water, the sun, wind, tides and waves, the earth's internal heat, and biomass. Because they have the ability to renew themselves, they are not finite in quantity and are considered to be inexhaustible. This is in contrast to non-renewable sources of energy, such as fossil fuels, which are exhaustible and finite, and generally produce greater environmental impacts when they are combusted for power generation. On the down side, many renewable energy resources are intermittent in nature. For example, the wind may not be blowing coincident with the time of peak demand and drought conditions may lead to insufficient water to run hydro plant.

The renewable generation technologies best suited to Mauritius include wind, hydro, solar, and biomass. Wind and solar power are coming within the range of cost effectiveness for consideration as a supply option in certain applications. We will be maintaining a watching brief on further developments in these technologies with a view to supporting their future implementation in Mauritius. As the economics of these technologies improve, we will begin to include them formally in our ongoing planning process.

Other renewable technologies, such as fuel cells and wave or tidal power are still not sufficiently proven for commercial application at any scale. We will continue to monitor these technologies as their costs could decrease as the technology evolves and some of these technologies may be suitable for special, small-scale applications. A rationalisation of our tariff structure and pricing may open the way for development of more "green" power. The fact that subsidies exist in our current tariffs means that some consumers do not see the true costs of producing and delivering electricity. This acts as a structural barrier to investment in renewable technologies, which remain at the present time more expensive than conventional generation technologies.

Wind

The wind has been harnessed to do useful work, such as pumping water and grinding grain, for millennia. Today's wind turbines can generate over 1 MW of power per turbine, but sizes vary, starting at just a few tens of kilowatts. Wind generation is enjoying wide application in Europe, thanks in part to public policy incentives but also because costs have come down dramatically as the technology has advanced. Germany now leads the world in wind generation, with 12,000 MW of installed capacity. Denmark and Spain also have a large base of installed wind capacity. More work needs to be done to estimate the potential for wind development in Mauritius, but we are probably ready for at least a demonstration project, if not a full commercial application of wind power.

The key advantages of wind generation include no harmful air emissions and the price of the fuel which, of course, is free. Factors to be considered for wind as a viable generation option in Mauritius include:

- Managing the structures in cyclonic conditions. Wind turbines now come with collapsible masts that enable the structure to lay flat on the ground in case of storms, but this manoeuvre must be done manually, which means that the turbines could be damaged before they can be taken down. Wind turbines typically have two blades that automatically rotate into the wind, and thereby avoid damage if wind speeds exceed the design limits.

- Availability of land. Wind turbines do take up space, although with high ground clearance to the blades, the surrounding land can be used for other purposes, such as agriculture. Wind farms are now being constructed offshore, to ease land use constraints.

- Variable output. Even in areas with favourable wind regimes, wind power is still intermittent and cannot be considered as reliable as other forms of generation.

- Grid interconnection. Wind turbines with intermittent operation can cause disturbances on the electricity grid due to initial high reactive power intake at synchronisation. This situation is generally manageable using capacitor banks, if required. The location of wind farms may require long lines to a point of interconnection.

- Visual impact. Individual opinions vary as to whether a wind farm is unsightly or attractive.

Hydro

With the completion in 1983 of the Diamamouve Dam to provide water storage for our Champagne hydroelectric station, the hydro potential in Mauritius has been reached. There are now more and more competing uses for the water which we use to generate electricity. In fact, with the construction of the Midlands Dam, some water which would have otherwise flowed into our reservoir and been converted to energy has now been diverted to other uses. Our hydroelectricity production at Champagne in 2003 has been reduced as a result. When considered in combination with the lack of available natural sites with favourable topography for hydro developments, we do not believe new medium-sized hydro is a promising generation option.

There is a possibility of installing a small generator at Midlands Dam, with a capacity of about 1 MW. We will monitor the feasibility and proceed with a project if it can be economically justified.

Microturbines are gaining in popularity, requiring only a small streamflow or head drop to produce a few tens or hundreds of kilowatts of electricity. We do not yet know the full potential for micro-scale hydro development in Mauritius, but this technology is likely best suited to use in off-grid applications directly at consumers' premises.

The high head drop and small storage at our Tamarind Falls facility have the potential for development of a pumped storage scheme. However, as long as we have to import fossil fuels to generate the electricity needed to pump the water back into the reservoir for re-use, such a scheme is not likely to be economically justified.

While we may have exhausted our hydro potential in Mauritius, we are nonetheless pleased that we are making best use of the water we do have, when it is available.

Solar

Solar power is somewhat different from the other renewable technologies discussed here in that it is best suited to off-grid applications; that is, solar power is attractive as a distributed resource connected directly to the end use. For example, solar panels on a residential roof or a school or library could provide energy for lighting or water heating in the building. Solar panels can be used in a small installation for water pumping or to power a street light in a remote setting.

Like wind, solar power has low environmental impacts other than visual ones, and the power generated is intermittent. The most promising solar technology is photovoltaics, in which solar panels convert solar radiation into electricity. Solar systems can vary in output from a few hundred watts to a few megawatts. There is still some controversy over the holistic practicality of solar power, as the manufacture of solar panels is in itself a complex and energy-intensive process.

Electricity production from solar resources is a function of the radiative properties of the sun and is influenced by microclimatic factors. Clouds and shade limit the amount of power that can be produced. Therefore, some locations in Mauritius will be better suited to solar power installations than others. Before making any firm plans for the implementation of solar technology on a localised scale, we need to better understand the availability of the resource over the island and the most promising applications. Given the current high price of solar systems, we are unlikely to be making any demonstration program commitments in the near future. Large-scale applications of solar technology with an associated distribution network are not well suited to Mauritius, where electricity is already available everywhere. At any scale, a large surface area is required for the collector panels. Moreover, the technology remains expensive—at about four to five times the cost of power from conventional sources, it is still far from being commercially attractive.

Individual customers, however, may find a small solar installation on their premises to be attractive.

Biomass

Biomass consists of organic matter. The traditional form of biomass energy is wood; however, in Mauritius we are more familiar with bagasse, the fibrous matter that remains after sugar cane is crushed and the juices extracted.

The attractiveness in burning bagasse to produce electricity is that it is carbon neutral and therefore does not contribute to the greenhouse effect, and that it is an indigenous fuel that can be replenished each year. Thus, the more bagasse we burn, and the more efficiently we convert it to electricity, the less fuel we have to import. The combustion of bagasse does produce air emissions and significant quantities of ash which must be disposed of. Sugar cane must be transported by agricultural vehicles or lorries, which have their own atmospheric emissions, from plantations to a sugar mill/power plant for use. On the other hand, if it were not used for generating electricity, the bagasse would have to be burned anyway, or otherwise disposed of. The fact that bagasse is only available during the cane harvesting season means that a power station using bagasse must also use a complementary fuel to produce firm power on a year-round basis.

The chief attribute of bagasse that distinguishes it from most other forms of renewable energy is that it is a fuel that is in private ownership, unlike the wind, sun, and water which are public goods and freely available. To CEB, therefore, it is a fuel with a price attached.

When we think of biomass in Mauritius, the first thing that comes to mind is bagasse. However, biogas and organic wastes are also considered as part of biomass. The Ministry of Local Government and Rodrigues is currently investigating the feasibility of generating electricity from methane gas at Mare Chicose landfill. If not used to produce electricity, this biogas must otherwise be flared. The electricity-generating potential from this installation would be small, of the order of 1 MW to 2 MW, and limited in duration to about five to ten years, depending on the actual gas production and collection at the landfill. CEB would be ready to accept this generation onto our 22 kV network.

The Ministry of Local Government and Rodrigues is also considering the feasibility of building a new waste-to-energy facility comprised of one or more landfills and/or an incinerator. Such a project is capital intensive and may not be practical for Mauritius in the short term, in the absence of rigorous recycling and composting initiatives. CEB is working jointly with Government in considering project siting and the appropriate pricing for electricity produced by such a facility, which is expected to be of a size of 10 MW to 12 MW.

Fuel Cells

Fuel cell technology is still under development. It remains expensive and not yet readily available, but does hold the promise of being a major source of energy in the future. Fuel cells do not burn fuel—typically hydrogen—to produce electricity, they convert it chemically in much the same way as a battery does, and their only by-products are water and heat. A limiting factor in the adoption of fuel cell technology at any scale, even in the larger markets of North America and Europe where some bus transportation is already powered by fuel cells, is the need for hydrogen infrastructure. We do not expect to see implementation of fuel cell technology in Mauritius in the near term.

Tidal and Wave

For islands such as Mauritius and Rodrigues, marine-based energy technologies would seem to have enormous appeal; however these technologies are still at the development stage. Their costs, capability, and impacts are still not well understood. The technologies currently being investigated, with demonstration projects installed in Europe, Canada, and the U.S., convert the energy in tides and waves to electricity. Harnessing thermal gradients in marine waters is also an area of study.

Implementation of such a project in Mauritius would have to consider the balance between impacts in and around our lagoons, grid interconnections, and, of course, cost relative to other renewable or conventional generation technologies. CEB is unlikely to invest in this technology over the planning horizon.

5.4 Generation Capacity Expansion Plan

The use of an integrated planning process creates a more favourable and transparent environment for the acquisition of new generation capacity on a competitive basis. It specifically addresses the question of when a utility needs a new generating resource. It recognises that new generating resources must be acquired to maintain reliability in meeting forecast demand but may also be added at other times to lower overall costs. That is, even in the case of excess capacity, a utility could lower its overall costs by acquiring a new resource that is less expensive than current operating costs. This means that when considering a generation addition, we must not simply compare the cost of the next planned or last installed unit as an "avoided cost," but must also compare the cost of the resources displaced by the new option.

A special case is the addition of a peaking resource, that is, a generating unit that can come on and off line on short notice to serve load for a short period of time and in emergencies. It may not be economic for an IPP to build and operate a peaking-only plant since the prices to fully defray the cost of developing this capacity would be too high. The responsibility of adding generating units specifically to meet peak demand, then, may continue to rest with CEB.

WHEN IS NEW GENERATION REQUIRED?

In an economically efficient environment, generating capacity is added if it reduces the overall system costs, or if it provides an increase in system reliability (which can be measured by the difference between generating capacity and demand) sufficient to recover the cost of building the capacity. Investment in new capacity which will be used only during peak demand periods ("peaking" units) is difficult to recover.

Our plan for generation capacity expansion is presented in Table 5-1 and shown graphically in terms of total new capacity in Figure 5-3. The numbers in Table 5-1 are indicative and are based on both the size of our projected needs and the reasonable size of suitable candidate plant currently available in the marketplace. When considering these numbers, 32 MW may be interpreted to mean capacity additions in the range of, say, 30 MW to 40 MW and is not necessarily limited to a single unit.

For example, extension of CEB's St. Louis power station could be a candidate plant for addition in 2006. The project currently under assessment consists of the addition of three units of size 10 MW to 12 MW. That means we will be looking to add at least another 28 MW to 34 MW from other sources which could, in turn, be comprised of one or more units. This would be spelled out as part of a Request for Proposals.

What is certain, however, is that at least a part of the new capacity added in the period 2006 to 2008 must be capable of two-shift operation; that is, able to be started up and shut down on a daily basis. Until our night time demand grows to become more in line with our base load capability, this flexibility in operations will be imperative.

The probable generation expansion plan outlined in Table 5-1 and illustrated in Figure 5-3 can easily be modified in the event of a different demand future:

- If demand growth slows, half of the additional capacity proposed in the probable case for 2006 could be deferred to come into operation in 2007 and the addition proposed for 2008 could be deferred to come into operation in 2009. Alternatively, CEB could retire early some of the capacity scheduled for retirement in 2008 and beyond.
- If demand growth accelerates, the resource scheduled for 2008 could be advanced for addition in 2007. We feel this flexibility is achievable and realistic given the requirement that some of the capacity to be added in the near term must be capable of two-shift or peaking operation. The logical technologies for this type of operation are also the quickest to put into service. Sufficient time would then be available to solicit an additional tranche of generation for 2008.

Table 5-1. Planned Capacity Additions, 2006 to 2012

	NEW CAPACITY ADDITIONS (MW)		
YEAR	Probable	Low Demand	High Demand
2006	64	32	64
2007	0	32	32
2008	32	0	32
2009	0	32	32
2010	32	0	50
2011	50	32	50
2012	50	0	50
TOTAL	228	128	310

5.5 Generation Resource Acquisition Policy

5.5.1 Preamble

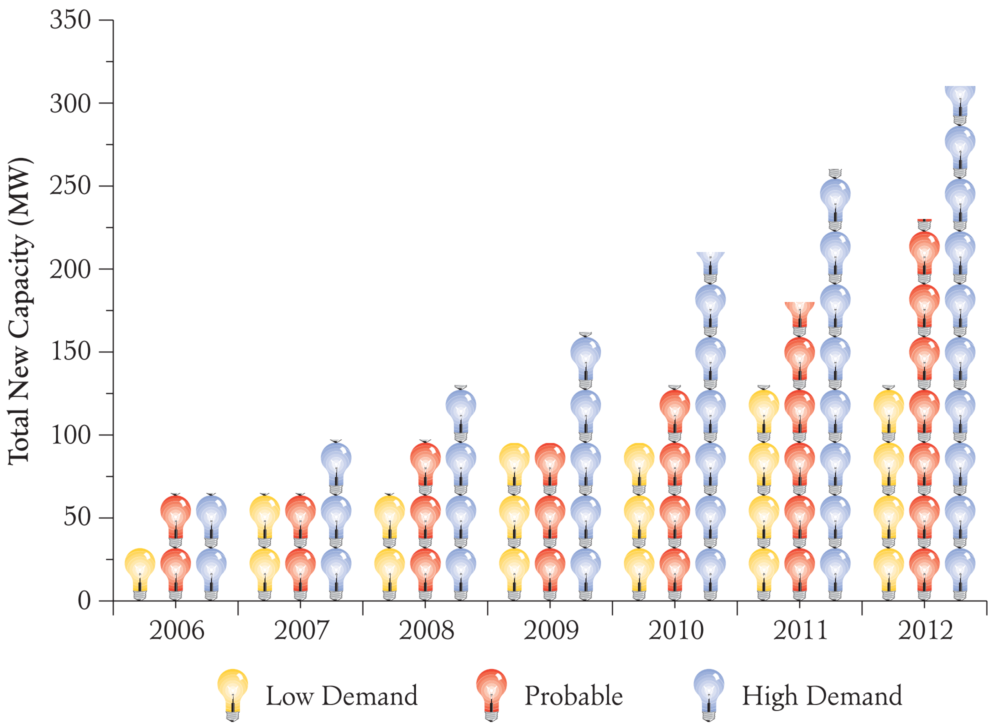
CEB will continue to rely on the private sector and IPP projects for new supply of energy and capacity, limiting our own role to undertaking efficiency improvements at existing facilities—but not at any cost. We must ensure that future power purchase agreements give CEB greater flexibility to operate the electric system in a least-cost, efficient manner, and allocate risk appropriately. We will, therefore, evaluate both build and buy alternatives for new generation to find the best solutions for Mauritius.

There are three main objectives for an IPP program in Mauritius:

- Attract outside capital to meet growing electricity needs without imposing strains on internal financial capabilities;
- Reduce electricity costs through competitive pressures; and
- Assign risks in an efficient manner.

IPPs and CEB now contribute approximately equal proportions of the energy generated in Mauritius. With more and more independent power suppliers in the system, we must ensure that each generator begins to share the responsibility for reliability and security of supply. New suppliers must be aware of our needs and expectations for power generation. For that reason, we are publishing our Generation Resource Acquisition Policy in this IEP. We feel that by making clear our plans and acquisition policy, IPPs will be able to offer better responses to our future requests for proposals for new electricity supply. We will continue to use a competitive bidding process for new supply and will endeavour to

Figure 5-3. Generation Capacity Expansion Plan, 2006 to 2012



open the field to as many potential suppliers as possible. The greater the number of bids, the more efficient the competition and the greater confidence CEB can have in selection of the preferred bidder.

CEB's Generation Resource Acquisition Policy is illustrated in Figure 5-4 and explained below. This type of policy has been used effectively in other jurisdictions like Mauritius, where a government-owned utility is attempting to procure more resources from the private sector in line with a policy to introduce competition and efficiency into the sector.

5.5.2 Why and How Will CEB Add New Generation Resources?

CEB must, over time, add new generating resources to ensure that electricity requirements in Mauritius are reliably met ("needs-based" additions.) CEB may also add generating resources in advance of need if there is an opportunity to reduce the expected cost of meeting future electricity requirements ("opportunity-based" additions.) At the present time, CEB's generation planning is done on a deterministic basis which assumes that all energy demand will be served and there will be sufficient capacity among the generation resources to meet the daily peak load. The following factors, therefore, influence the need for new resource additions:

- The forecast of electricity demand;
- The expected contribution from existing CEB and IPP resources;
- The incremental costs of existing resources, particularly fuel prices;
- The anticipated cost of new resources; and
- CEB capital expenditure considerations.

Needs-Based Additions

All-source requests for proposals are CEB's currently preferred method of acquiring new resources to meet the forecast of electricity demand because:

- Public policy is to solicit the participation of private investors in developing infrastructure projects and in developing a competitive market for power generation;

- Competitive bidding assures the most economic result for electricity consumers; and

- CEB is currently constrained by its debt level and is, therefore, focusing capital expenditures on network infrastructure and customer services functions.

Nevertheless, CEB has opportunities to add its own generating resources, for example, by adding new engines at existing power stations; by decommissioning old units at existing power stations and replacing these with new units; and/or by developing generating stations at new sites. The costs of these alternatives must be carefully weighed against CEB's capital raising and allocation constraints as well as the likely costs of generating resources supplied by the private sector.

CEB's self-build options will not be bid into an all-source RFP but their costs and benefits will be weighed as part of the decision-making process prior to releasing any RFP. Furthermore, these options will be used as benchmarks to determine the relative attractiveness of any option.

Opportunity-Based Additions

Other generation resources can be acquired if they present attractive opportunities. These can generally be described in terms of four groups of resources, each described below.

Lost Opportunity Resources. CEB will consider acquiring new resources in advance of need if such resources have a low cost and may not be available when CEB expects to acquire new resources on the basis of need. Examples include projects where electricity is generated using biogas from solid waste landfills.

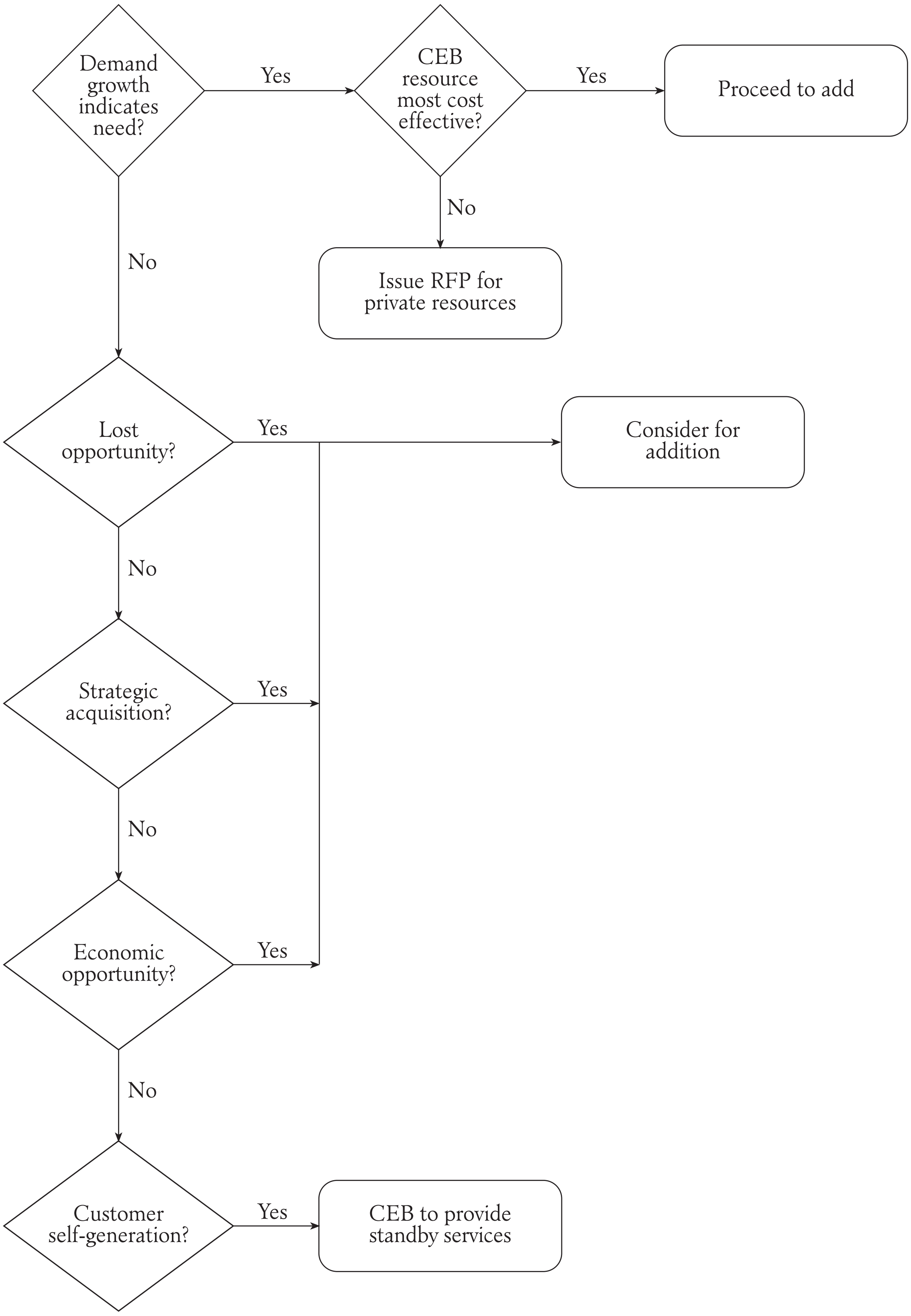
Strategic Resources. CEB is investigating the feasibility of implementing demand-side management and energy efficiency programs, which can defer the need for new generation resources, as well as renewable energy technologies to diversify fuel risk and address environmental and locational risks.

- DSM programs require investment by CEB—and also, usually, by customers—which may be costly today but may defer the need for the addition of expensive generating resources, such as units which are added simply to serve peak demand.

- Energy produced by wind and micro-hydro turbines is becoming more and more economic as the technologies develop. Studies are required to prove that Mauritius has the appropriate wind and hydrologic regimes before these options can be seriously considered.

- Solar technologies are also developing rapidly, but remain expensive and best suited to off-grid

Figure 5-4. Why and How CEB Will Add New Generation Resources



applications, such as in rural areas which are not connected to the main electricity grid, or for domestic applications, such as lighting and hot water heating.

Economic Opportunity Resources. Private sector developments that represent economic opportunities for CEB will be considered if they:

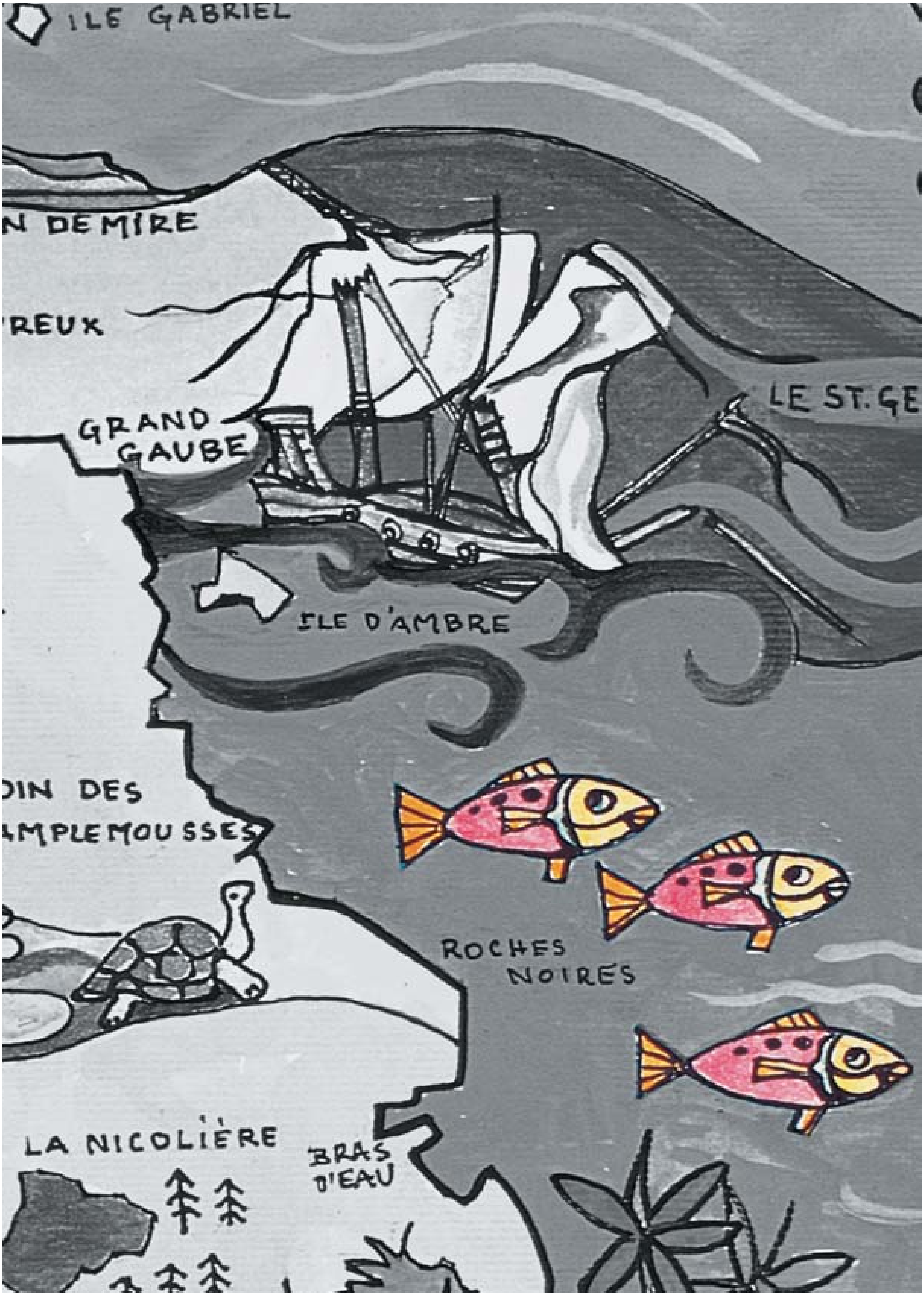
- Are cost effective in meeting local or regional electric system reinforcement requirements;
- Provide sufficient social and environmental benefits; or
- Present CEB with profitable business diversification prospects.

Customer Self-Generation Resources. Some existing CEB customers have the ability to generate electricity for their own use or for supply to other customers. For example, IPPs in the sugar sector sell electricity to CEB and provide steam and electricity to adjacent sugar milling operations. Some IPPs have expressed interest in supplying electricity to new developments on or adjacent to their properties. CEB will consider supporting more of such initiatives in the future by supplying back-up and standby services if sufficient benefits to all CEB customers can be demonstrated. Tariffs for these types of services are currently under development. Many customers, particularly hotels, have their own generating sets. Generally, they still prefer to purchase electricity from CEB as it is less expensive than operating and maintaining their own generating sets.

5.5.3 Comparing New Generation Resource Alternatives

Some form of decision analysis technique is required to evaluate competing generation resources. CEB prefers to use a multi-criteria analysis to identify the trade-offs involved in selecting one project, resource, or resource type over another. This type of analysis is also useful for identifying where additional information may better inform the decision. Identifying key trade-offs may also indicate areas where reconfiguring an alternative may improve its attractiveness. This information may be sought by way of clarification in an evaluation in progress or may be used to improve future acquisition processes.

The criteria to be used in any resource acquisition process may vary, depending on the nature of the resource (e.g., needs- or opportunity-based) and the economic, demographic, financial, and technical conditions prevailing at the time of the proposed acquisition. The evaluation will generally comprise both monetary and non-monetary criteria. For example, in evaluating the proposals received under the December 2002 RFP, CEB considered criteria including financial cost, impacts on and benefits to the CEB system, potential benefits to the country, and other qualitative factors. As CEB endeavours to improve its financial situation and the strength and reliability of its electricity network and customer services in the face of electric sector reforms, these criteria are likely to remain important in RFPs issued in the near future, but may be modified as necessary for any RFP process.


ILE GABRIEL
N DEMIRE
REUX
GRAND GAUBE
LE ST. GE
ILE D'AMBRE
DIN DES AMPLEMOUSSES
ROCHES NOIRES
LA NICOLIÈRE
BRAS D'EAU

Chapter 6

Transmission and Distribution Plan

6.1 Introduction

The purpose of the transmission system is to transmit electricity at higher voltages from the sources of generation to bulk supply points (BSPs). From these BSPs, the distribution system carries the electricity at lower voltages to our customers' premises. The key objective in transmission and distribution planning, therefore, is to maintain reliability in this electricity network so that we are able to assure power quality and to deliver electricity in the quantity our customers demand at the time when they need it.

This chapter is divided into the following sections:

- Section 6.2 describes how we model our network to determine future needs and facilitate long-term planning. It goes on to discuss important transmission network elements and options and presents our rationale on the question of overhead versus underground networks.
- Section 6.3 provides a review of the present conditions of transmission line loading and 66 kV busbar voltage at various bulk supply points and describes the projects we have planned for targeted actions in the short term.
- Section 6.4 discusses our plans for the optimal expansion of the transmission network over the longer term.
- Sections 6.5 and 6.6 discuss the short-term and long-term plans, respectively, for the distribution network.

6.2 Determining Future Transmission Needs

6.2.1 System Modeling

At CEB, we analyse our transmission network using the software program ERACS to model load flows in the lines, using actual system data taken from records for peak demand. To calibrate and verify our results, we compare the results of the load flow studies to the SCADA readings measured by our automated data acquisition system on the day of the recorded peak.

With our model calibrated in this way, we can then extrapolate the peak demand at each bulk supply point to reflect projected future loadings, allowing for the addition of new, and any retirements of existing, generation units. As system constraints are exposed, we then identify projects and investments needed to expand and enhance the network to maintain reliability and security of supply.

6.2.2 Transmission Options

Several types of transmission resources can be used to reinforce the transmission system. These include new transmission lines; upgrading or otherwise improving the capacity of existing lines; improving the carrying capacity of the system using capacitors, voltage support, or other control equipment; or other actions. We base our selection of the transmission resource option for any given circumstance on the size and location of generation resources relative to demand centres as well as the specific needs of the transmission network itself.

All customers require both active and reactive power. While active power can only be produced by the alternators in power stations, reactive power can be generated by either those same alternators or by using reactive power compensation equipment such as capacitor banks, synchronous condensers, or static voltage compensators. So while CEB supplies both active and reactive power, we strive to avoid having excess reactive power flow in the transmission network as this can cause unnecessary line losses and voltage drops. Reactive power compensation planning has a major role to play in maintaining the quality of electricity supply. By including this option in our integrated planning process we avoid excessive reactive power flow in the transmission network, thus regulating voltage deviation and the mismatch between active and reactive power demand and supply. For example, our system studies confirm that, to improve the voltage and power factor profile of the transmission system, additional reactive power compensation will required at Union Vale, Henrietta and La Chaumière. We will begin this system optimisation, including existing capacitor banks, starting in 2004.

6.2.3 Overhead and Underground Lines

Given that Mauritius lies within the tropical cyclone belt, people often ask why we do not put all of our network underground to limit damage. The answer is fairly straightforward. For practical and economic considerations, CEB's transmission lines are all overhead. Transmission line towers are designed to withstand tropical cyclones with wind speeds of 275 km/hour in addition to other standard planning criteria. Overhead transmission lines follow the shortest route which takes them from generating sources over mountains and across sugar cane fields and forests to bulk supply points. Undergrounding these lines would entail increasing the length of the lines by as much as 40 percent, with attendant increases in direct costs as well as increased outage time for repairs.

CEB distributes electricity through both overhead and underground lines. Because of the high costs associated with having an underground system, lines are placed underground mostly in urban areas such as Port Louis, Curepipe, Vacoas, Quatre Bornes, and Rose Hill, or where access to an overhead network would be impractical.

As circumstances warrant, and subject to the cost effectiveness in both installation and maintenance, more and more lines are being routed underground. For example, all large residential developments will be required to provide sites for compact substations and underground sleeves to route distribution cables.

6.3 The Transmission Network, 2003 through 2005

6.3.1 Overview

Figure 6-1 is a schematic diagram of the transmission network as it would currently function in the inter-crop season—that is from approximately January through June-and prior to the commissioning of Dumas substation, which is expected in December 2003. In the inter-crop season when the sugar estates are not exporting electricity to CEB, there is less generation into the 22 kV network and load flow in the 66 kV transmission system is, therefore, at its maximum. Items depicted in red lines on Figure 6-1 denote the potential problem areas which we are addressing with a series of projects described here.

Our analysis showed that under the forecast peak demand for 2003, congestion could arise on the Nicolay-St. Louis and St. Louis-Chaumière 66 kV lines, and the 66 kV-to-22 kV transformers at Nicolay, Rose Hill, Belle Vue and FUEL substations could reach their maximum security loading. The loss of one transmission circuit or transformer on these parts of the system would expose a large number of customers to the risk of power outage. To avoid this situation, CEB is commissioning the Dumas and Sottise substations, adding transformer capacity at the Rose Hill substation, and installing capacitor banks at the Henrietta substation. With these measures and associated 22 kV network reconfiguration, we will be able to meet peak demand conditions with adequate security in 2003.

From this starting point for planning the 2004 network, we find that busbar voltage in the southern part of the network could reach the lower level of acceptability and we are making investments in projects to alleviate this potential problem as well as to provide for a back-up supply to Combo substation. We are preparing for further projects to be completed in 2005 at the Henrietta and Le Morne substations to ensure the security and quality of supply of these regions. Our committed investments for transmission expansion in 2003 to 2005 are described in the following subsections.

6.3.2 Dumas 66 kV Substation

With the addition of the fourth and fifth generating units at Fort George power station, both the three-phase and single-phase fault current capacity of Nicolay substation have been exceeded. To limit the fault current, the 66 kV busbars of Fort George and Nicolay substations have been split. The commissioning of Dumas substation, which is planned for December 2003, will alleviate these system constraints.

6.3.3 Champagne to Union Vale 66 kV Line and Union Vale 66 kV-to-22 kV Substation

In order to secure the 66 kV supply of Combo Substation, a new 66 kV line with a length of 35 km is being constructed between Combo and Champagne substations. The project has been divided into two stages. The first stage will complete the line between Champagne and Union Vale substations and the second stage will complete the line between Union Vale and Combo Substations. The first stage is now approximately 90 percent complete and commissioning at 22 kV is expected by the end of 2003.

Union Vale substation will enhance network development to provide improved service in the

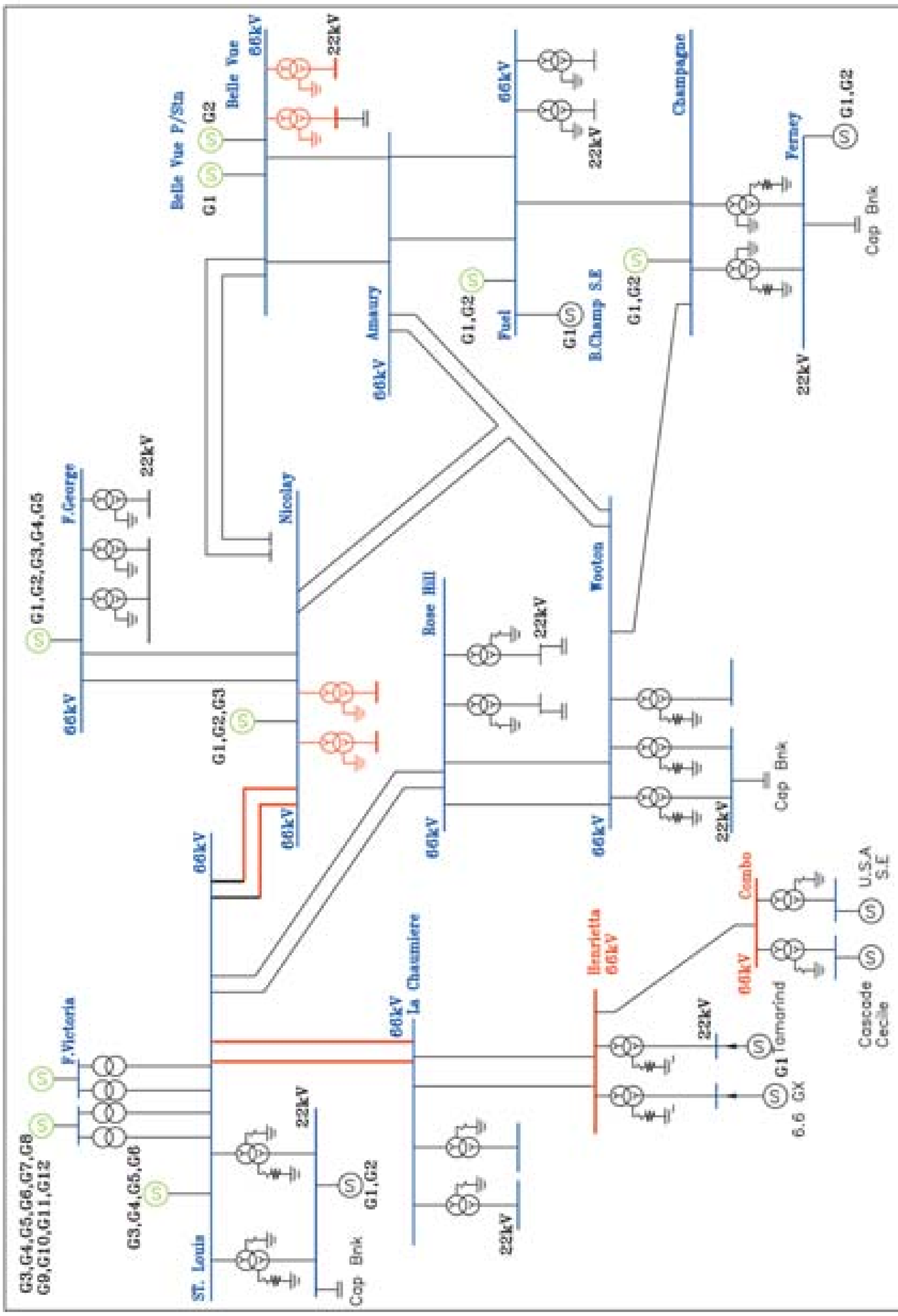


Figure 6-1. Schematic Diagram of Existing Transmission Network, November 2003

southeastern part of the island beyond 2012. We will be converting the existing 22 kV switching station at Union Vale into a major 66 kV-to-22 kV substation. Equipment has been ordered and design works are in progress to meet an expected commissioning date at the end of 2004.

6.3.4 66 kV-to-22 kV Substation at Sottise

This project will provide an additional bulk supply point to relieve congestion of the existing 22 kV feeders in the North and improve reliability and quality of supply to the north-northwestern part of the island. To date, construction of approximately 9 km of single-circuit 66 kV line has been completed from Belle Vue substation and is now operating at 22 kV. The 66 kV-to-22 kV substation and outgoing 22 kV feeders are under construction. Commissioning is expected by early December 2003.

6.3.5 Henrietta to Le Morne 66 kV Line

This project will not only allow for the rapid growth related to tourism in the south of the island, but will also avert voltage fluctuations which occur from time to time in the region. As an additional benefit, transmission line losses will be reduced.

As a first stage, a 66 kV transmission line, 27 km in length, will be constructed from Henrietta substation to a new 66 kV-to-22 kV major substation at Le Morne. The line will be operated at 22 kV pending construction of the substation. As a second stage, another 66 kV line, 20 km in length, will be constructed between Combo and Le Morne substations.

6.3.6 66 kV-to-22 kV Substation at Amaury

Amaury station has been commissioned to date as a switching station. We plan to upgrade this switching station into a bulk supply point in 2004. This new 66 kV-to-22 kV substation will provide supply to the northeastern part of the island, decreasing the lengths and loadings of existing feeders and reducing network losses. This additional bulk supply point will also relieve the 66 kV-to-22 kV transformers which are nearing saturation at FUEL and Belle Vue substations.

6.4 The Transmission Network, 2006 through 2012

Our long-term analysis covering the period up to 2012 leads to the development of projects aimed at optimal network expansion. Future system loadings are based on the demand forecast presented in Chapter 4 and on the sizes of new and retired generation capacity identified in Chapter 5.

Since we cannot know with certainty either the locations of future generating stations or the ultimate location of demand on our network, we have based our long-term plan on the goal of minimising transmission system losses. While we cannot effectively control the location of demand centres, we can attempt—to a certain extent—to influence the location of generation injection points. For that reason, we have identified the most favourable locations for new generation and these are presented in Table 6-1. This will be of interest to all potential suppliers of power generation.

Table 6-1. Location of Favourable Generation Injection Points

Period	Substation
2006 to 2008	• Le Morne • Henrietta • La Chaumière • Union Vale • Combo • Saint Louis
2008 to 2010	• Wooton • Henrietta • Saint Louis • Union Vale
2010 to 2012	• Rose Hill • Sottise • Amaury • Union Vale

What do we mean when we say these locations are favourable? Simply that they help us optimise our network by either minimising line losses or avoiding or deferring the need to make capital investments in infrastructure enhancement. For example, if new generation is injected at either Le Morne, Henrietta, or La Chaumière substations in 2006/07, we could avoid the need to construct a 66 kV line extension between Wooton and Henrietta substations. If all new generating plants are sited according to the locations shown in Table 6-1, our transmission system would function more efficiently, with improved load flows and reduced technical losses. More importantly, this development configuration could defer to beyond 2012 the need to convert and upgrade the operation of our network from 66 kV to 132 kV.

Regardless of the location of new generation supplies, we have identified the following sites for development of bulk supply points:

- Beau Champ,
- Petite Rivière (La Tour Koenig),
- Riche Terre,
- Phoenix,
- Château D'Eau, and
- Goodlands.

To facilitate optimum development of existing and new bulk supply points, we will install a minimum of two transformers, each with a unit capacity of 30 MVA or 45 MVA, at each BSP depending on the rate of increase of demand at specific locations. Figure 6-2 shows the evolution of the transmission network with planned new bulk supply points up to 2012.

6.5 The Distribution Network, 2003 through 2005

6.5.1 Overview

CEB's distribution network is fed via eleven 66 kV-to-22 kV substations located around the island, as illustrated in Figure 3-3. Power is distributed through radial type feeders. Each feeder is normally secured by either a second feeder between two different substations or by a second feeder from the same substation.

The long-term transmission plan described in the preceding Section provides a solid base for planning distribution in the sense that proposing the location of new and the optimum loading of existing bulk supply points ensures sufficient BSP capacity is planned to keep distribution feeders to reasonable lengths and loadings. The distribution plan further ensures that distribution infrastructure is in place to coincide with the future upgrading and development of new BSPs. To that end, the distribution system projects described in the following subsections will be implemented in the near term.

6.5.2 Port Louis Area

The industrial zone at La Tour Koenig/Petite Rivière has been identified for development of new spinning mills. As a first phase to supply this additional development, CEB is proposing to construct in 2004 a switching station to be fed by the new 22 kV Koenig feeder from St. Louis. As a second phase, and when required for additional development in the area, the switching station will be developed into a bulk supply point.

No additional medium-voltage-to-low-voltage (MV/LV) substations will be connected to the 6.6 kV network in Port Louis. Rather, the 22 kV network will be extended to serve the needs of additional customers.

The load on the Line Barracks and Poudrière substations is low, and we will be recovering two transformers for replacement of older transformers in service elsewhere on the network.

The Nicolay substation is designed to have three 66 kV-to-22 kV transformers. In order to provide space for the required extension of the 22 kV switchboard, the existing 6.6 kV substation will be recovered and additional 6.6 kV-to-0.415 kV substations will be converted. The recovered 6.6 kV panels from Nicolay and Line Barracks substations will be used to replace older 6.6 kV panels still in service elsewhere on the network.

The suburban and industrial area north of Port Louis is developing rapidly and the load on the Riche Terre feeder cannot be shifted to or shared with adjacent feeders. A switching station is to be erected at Riche Terre at the earliest possible date to facilitate switching operations and to accommodate the new feeders from Nicolay and Fort George.

6.5.3 The North

Back-up 66 kV supply is planned for the Sottise substation in light of development of a new industrial zone at Goodlands. In 2004, the first phase of works consists of erecting a 66 kV line from Amaury to the Goodlands area. This line would operate at 22 kV in the near term. In the second phase, this line will be upgraded to 66 kV and extended to Sottise substation by 2005. Depending on load growth in the Goodlands area, a new bulk supply point may be required.

6.5.4 The South and Southwest

To serve the proposed integrated resort scheme at Bel Ombre and other developments in the southern coastal area, construction of a 66 kV line (operating at 22kV) between Henrietta and Combo via Le Morne and another 22 kV line between Combo and Bel Ombre will be completed by 2004. The line will operate initially at 22 kV and be upgraded to 66 kV in 2005.

6.5.5 The East

To serve the proposed integrated resort scheme and development at Beau Champ and to better serve demand growth in the northeast, a 66 kV-to-22 kV

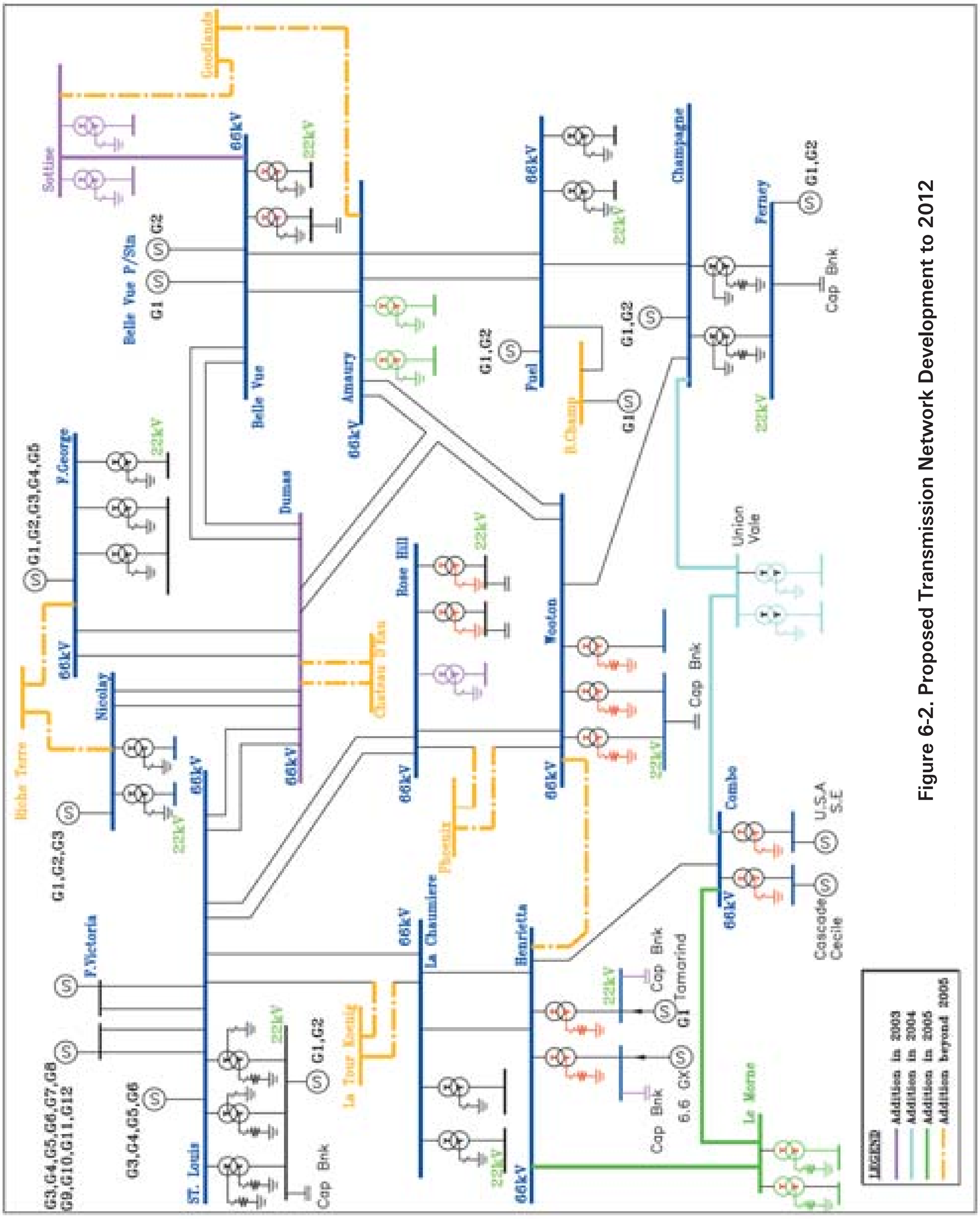


Figure 6-2. Proposed Transmission Network Development to 2012

substation will be constructed at Beau Champ in 2005/06. This means the power supplied to CEB by Consolidated Energy Co. Ltd. will no longer be injected to the 66 kV busbar at the FUEL substation, but to the new 66 kV-to-22 kV substation at Beau Champ itself. This will have the added benefit of reducing line losses.

6.5.6 The Centre

In areas such as Curepipe, Vacoas, Quatre Bornes, and Rose Hill, where new customers require connection to the 6.6 kV network, several 6.6 kV transformers will be converted to 22 kV in order to keep an acceptable load level on both the distribution feeders and the 22 kV-to-6.6 kV transformers.

6.6 The Distribution Network, 2006 through 2012

6.6.1 System Reinforcement

The commissioning of additional bulk supply points at Sottise, Amaury, Union Vale, Le Morne, Beau Champ, Riche Terre, and La Tour Koenig means that the operating scheme of the distribution network will need to be modified. CEB's long-term plan is to add new feeders and other reinforcement projects to limit the feeder loading in normal operating conditions and/or provide the necessary security of supply.

Certain feeders will still be heavily loaded, however, because of high-consumption customers at the ends of lines. Examples include the feeder from Belle Vue or Amaury serving Novel Textiles; the Pointe D'Esny feeder from Ferney power station; the new St. Jean feeder from Rose-Hill to St. Jean substation; and the La Vigie feeder at Wooton serving Nouvelle France load.

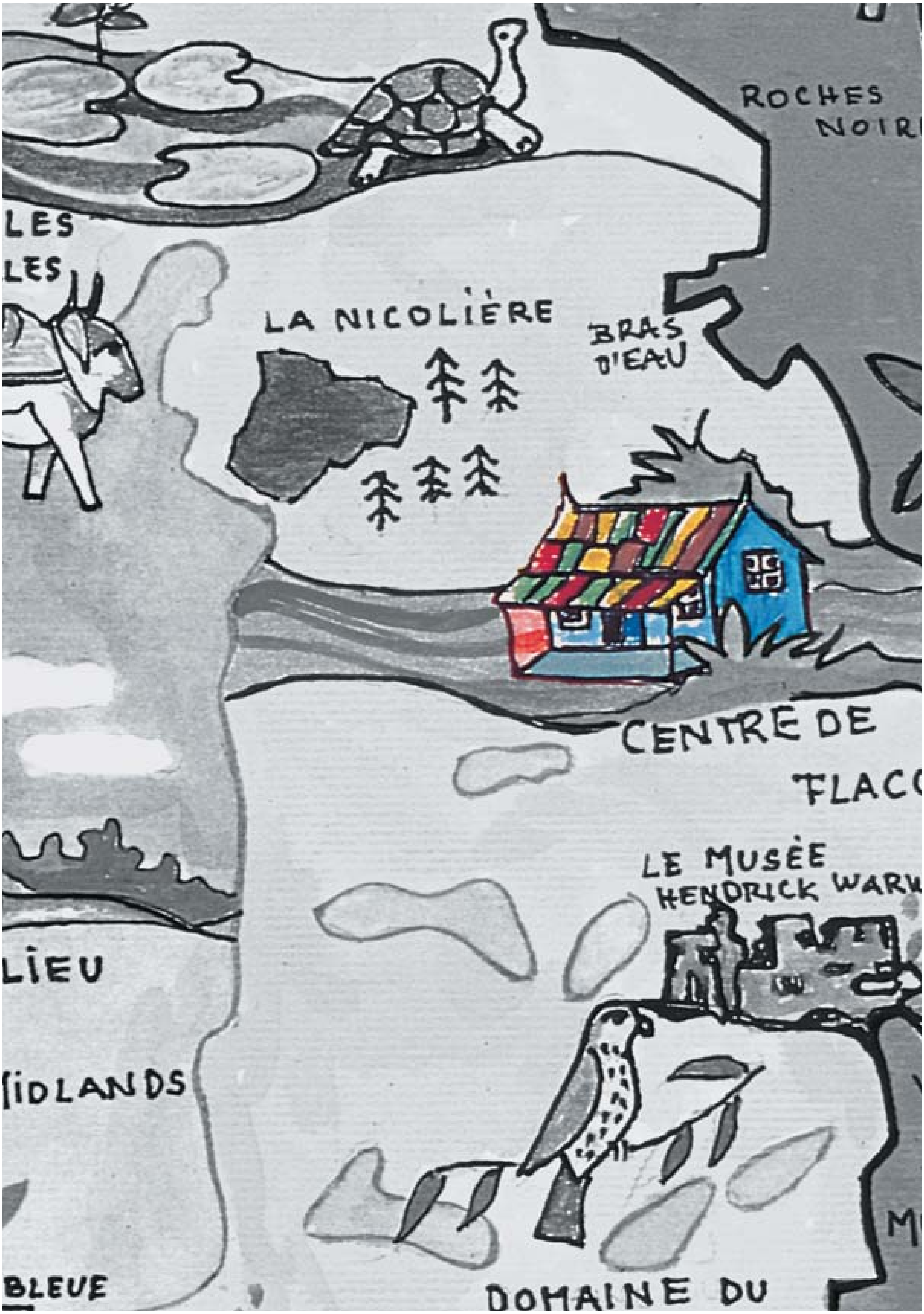
Although the project has not yet been precisely defined, CEB is considering the addition of a bulk supply point at Château D'Eau to supply the central Port Louis area. This BSP could also be used as back-up for the southern part of the city, for the Poudrière area, and for the Fort George-Caudan cables.

6.6.2 Line Loss Reduction

As discussed in Section 6.4, the addition of new generation sources at various points around the transmission system will decrease line losses in the network. Under our proposed long-term transmission and distribution plan, and with a change in the system operating schemes, loading levels on heavily loaded feeders will be reduced and this will also decrease line losses in the network. The commissioning of Sottise, Le Morne and Beau Champ substations and the reorganisation of their associated feeders is anticipated to reduce losses substantially.

Implementation of the following enhancements and standards in project conception and design could reduce network losses to a level of approximately 9 percent of the energy sent out from generating stations towards the end of the planning horizon, compared to the 2002 level of 10.8 percent:

- Developing the new bulk supply points;
- Avoiding distribution feeders for bulk power transfer between a 66 kV-to-22 kV injection point and a 22 kV switching station, where the switching station is not slated for additional upgrading to a bulk supply point;
- Limiting feeder loading under normal conditions to 50 percent of the nominal current;
- Constructing all new 22 kV lines with 150 mm^2 all-aluminum alloy conductor,
- Equipping 66 kV-to-22 kV substations with at least two transformers of 36/45 MVA; and
- Adopting a minimum of 4 low voltage feeders per MV/LV substation, with each low voltage feeder having at least size 70 mm^2 aluminum conductor.


ROCHES
NOIR
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LA NICOLIÈRE
BRAS
D'EAU
CENTRE DE
FLAC
LE MUSÉE
HENDRICK WARW
LIEU
IDLANDS
BLEUE
DOMAINE DU

Chapter 7
Rodrigues

7.1 Introduction

The island of Rodrigues has no electricity interconnection with Mauritius. CEB is the sole producer and distributor of electricity for the island.

Although lagging somewhat behind Mauritius in terms of economic development, Rodrigues is expected to quickly catch up. The island has been targeted for significant development in the short term, with aid and incentives that will promote more rapid economic growth and, as a consequence, encourage electricity consumption. As a complement to the recent setting up of the Regional Assembly to administer the island, the time is right to give separate and focused attention to an electricity plan for Rodrigues.

This chapter contains the following Sections:

- Section 7.2 presents the electricity demand outlook, starting with a discussion of the nine dominant socio-economic sectors and then presenting a ten-year forecast of energy generation and peak capacity requirements;
- Section 7.3 summarises the status and capability of electricity generation and distribution on the island; and
- Section 7.4 defines the plans for future development of electricity supplies.

7.2 Demand for Electricity

7.2.1 Socio-Economic Context

The inhabitants of Rodrigues live in a predominantly rural environment, are largely self-sustaining, and, up to now, have generally been somewhat immune to world economic influences. This situation is rapidly changing. As the island becomes more well-known as a result of tourism, and as living standards increase as a result of targeted development programs by the Government of Mauritius and international agencies, Rodriguans are coming more and more under the same influences as people in Mauritius and elsewhere. Developments in the economic sectors discussed below will have their influence on electricity consumption, either in quantity demanded, in time of use, or both.

Residential Development

Recent land parceling projects are an indication of the expected sustained population growth. Construction of about 600 houses annually is expected over the coming years, with a direct impact on the contribution of the residential sector to the peak demand. Penetration of computers and air conditioners in Rodriguan households has begun and will grow over time.

Access to Water and the Desalination Project

Presently, the restricted supply of water is one of the main factors limiting the economic development of Rodrigues Island. In the residential sector, low water pressure in pipes combined with an irregular supply makes it unattractive for people to buy appliances, such as electric showers and washing machines, that run on water. In the industrial and services sectors, activities that require significant amounts of water are unlikely to be undertaken unless the investors provide their own water supplies, which is a costly disincentive. Therefore, unless viable surface reservoirs are constructed or desalination plants set up on a sufficiently large scale, the economic growth of Rodrigues is expected to continue to be curtailed.

Given the relatively long lead time required to construct and fill a surface reservoir, the Rodrigues Regional Assembly believes desalination plants represent the solution to restricted water supplies for the short to medium term. The proposal currently being entertained by the Regional Assembly is to install two desalination plants at Mourouk, with each plant producing 2,000 m^3 of water per day.

When commissioned, expected to be in about two years' time, the plants will run on a 24-hour basis. The plants will constitute the largest single electricity consumer in Rodrigues, with an estimated daily energy consumption of about 16,000 kWh added to about 1,100 kWh for pumping the plant output uphill to water storage and distribution facilities. The operating schedule for the desalination plants may be flexible, thereby reducing the pressure on the evening system peak load. However, the plant operations may exacerbate the morning peak.

Tourism

Tourism holds the promise to become the most important sector in the island's economy, and will witness rapid development with the advent of the desalination plants. Not less than six hotel projects are expected over the coming four to five years. With a view to promoting proximity tourism, the hotels will not have more than 60 rooms and the expected load requirement is 250 kVA per hotel.

Statistics show that some 40,000 visitors come to Rodrigues yearly. By year 2005, this number is expected to reach 100,000. With Plaine Corail Airport becoming an international airport, with direct links to other Indian Ocean islands, tourist arrivals will be more or less steady throughout the year; that is, there will be no distinct peak and off-peak seasons.

The tourism industry itself can be expected to generate other supporting activities and economic spin-offs.

Education

In the wake of education reforms, three state secondary schools have already been constructed and two more are scheduled for construction. These facilities will contribute principally to the morning load. Some facilities, however, will have computer labs and libraries that will remain open for extended hours as a community service.

Health Services

Dialysis equipment was installed at Queen Elizabeth Hospital last year and, although health services in Rodrigues are constantly being improved, there is no plan to install further energy-intensive equipment in the near future.

Industry

Industrial development has not progressed significantly despite the fact that Government has provided incentives to potential investors to set up factories on the island. A notable exception is the building industry which is at present facing difficulty in keeping up with demand for vibrated concrete blocks and cement. As witnessed recently during the extension of the Plaine Corail Airport and the refurbishment of main roads, the demand on existing stone crushers for aggregates and blocks exceeded the supply capacity, often at the expense of house construction needs. Such a situation may arise again with the forthcoming construction of hotels planned for the island.

Fishing

This industry, while important to the local economy, does not have a significant, direct impact on the electricity requirements of the island.

Sports, Leisure, and Recreation

The number, nature, and size of sports and recreation facilities will remain in proportion to the size of the population, that is, relatively small. Most developments are expected to be in the Port Mathurin area, including proposals to construct a commercial complex at the waterfront and an international standard swimming pool.

Street Lighting

The road network on the island is gradually being improved with more and more kilometers of roadway having street lighting. We expect increasing requests for street lamps all over the island. The option of installing solar street lighting units has proved to be costly both at the initial investment stage and for repairs. Of ten units installed on a pilot basis, only four remain in service. Future street lighting is assumed to be dependent on supplies from CEB.

Table 7-1. Growth in Customer Numbers

	1992		2002		Average Annual Growth Rate 1992-2002 (%)
	No. Customers	% of Total	No. Customers	% of Total	
Residential	6,419	91	8,968	89	3.4
Commercial	600	8	977	10	5.0
Industrial	77	1	126	1	5.0
Total*	**7,097**		**10,135**		

Note: Total also includes street lighting and irrigation customers.

Table 7-2. Growth in Specific Electricity Consumption

	Specific Consumption (kWh/customer/yr)		Average Annual Growth Rate 1992 - 2002
	1992	2002	(%)
Residential	662	1,269	6.7
Commercial	2,696	5,315	7.0
Industrial	8,146	9,670	1.7

7.2.2 Customer Base and Consumption Patterns

Growth in Customer Numbers

Residential customers represent the dominant customer segment in Rodrigues and presently account for about 89 percent of the total customer base, as can be seen in Table 7-1. The average cumulative annual growth rate in customer numbers over the period 1992 to 2002 has been higher for the commercial and industrial sectors than the residential sector, but it will be many years before the residential sector ceases to dominate electricity demand.

Specific Consumption

Specific consumption, or use rate, is the amount of energy consumed by a customer in a given year. Residential and commercial customers have nearly doubled their use rate over the past decade, as can be seen from Table 7-2, whereas the specific consumption of industrial customers has grown only slightly. In 1990, 68 percent of households, for a total of 5,334 residential customers, had electricity supply and consumed an average of 550 kWh of electricity per year. Two years later, in 1992, our residential customer base numbered 6,419 and these households consumed an average of 662 kWh of electricity per year. A decade later, in 2002, our residential customer base increased to 8,968, and these households consumed an average of 1,269 kWh per year. By the end of the forecast period, we anticipate the residential use rate will reach 2,200 kWh per year.

Energy Sales by Customer Category

The growth in energy sales shown in Table 7-3 is a combination of both increasing numbers of customers and increasing use rate. The commercial customer segment has accounted for an increasing proportion of sales over the last decade, whereas the residential segment has maintained a relatively constant proportion of total sales. Sales to industrial customers as a proportion of total sales fell after 1992, but have remained fairly constant, at about 7 percent of total sales in recent years.

We expect the commercial segment to continue to account for a larger share of total sales as the services sector grows in Rodrigues. At the same time, we expect to see the residential share drop slightly. This trend has already been experienced to date in 2003.

Demand Profile

Unlike Mauritius where demand in summer is 20 percent to 30 percent higher than demand in winter, the daily demand profile in Rodrigues does not differ much with the seasons. The typical daily demand profile, as shown in Figure 7-1 for two Wednesdays in 2002, is characterised by both a morning peak and an evening peak. The morning peak typically occurs at 10.00 hrs and the evening peak typically occurs at 18.00 hrs in winter and at 19.00 hrs in summer.

For the past ten years, the yearly system peak demand has occurred invariably on 31 December, and this peak is typically of the order of 300 kW higher than the next highest monthly peak in the same year.

Table 7-3. Energy Sales by Customer Segment

	1992		2002		Average Annual Growth Rate 1992-2002
	Sales (MWh)	% of Total*	Sales (MWh)	% of Total*	(%)
Residential	3,393	62	11,411	63	11.1
Commercial	1,618	25	5,230	29	12.4
Industrial	802	13	1,238	7	4.4

* Figures given for % of Total may not add to 100%, as figures shown do not include sales to street lighting and irrigation customers.

Figure 7-1. Typical Daily Demand Profile for Rodrigues

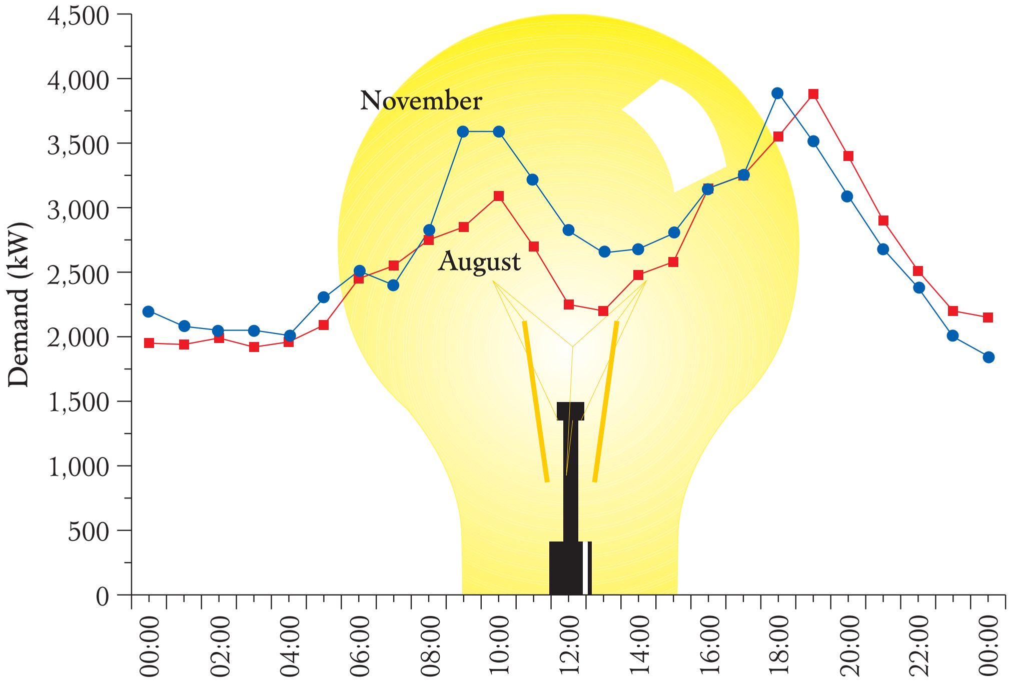


Table 7-4. Summary of Forecast Elements With Desalination Project

YEAR	SALES GWh	SALES Growth Rate (%)	GROSS GENERATION REQUIREMENTS GWh	GROSS GENERATION REQUIREMENTS Growth Rate (%)	SYSTEM CAPACITY REQUIREMENTS kW	SYSTEM CAPACITY REQUIREMENTS Growth Rate (%)
2002	18.2	–	22.6	–	4,400	–
2007	33.8	13.2	40.7	12.5	7,195	10.3
2012	41.8	4.3	49.6	4.0	8,525	3.5

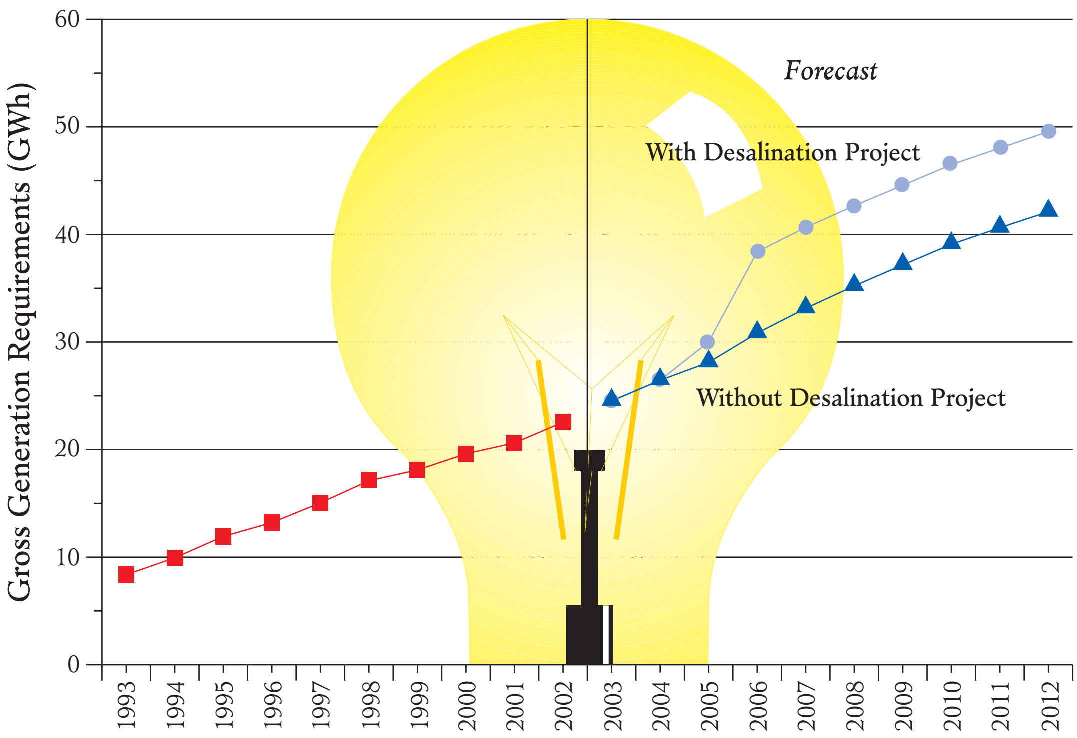
Note: Growth rates shown are average cumulative annual growth over the next 5 and following 5 years.

Table 7-5. Summary of Forecast Elements Without Desalination Project

YEAR	SALES GWh	SALES Growth Rate (%)	GROSS GENERATION REQUIREMENTS GWh	GROSS GENERATION REQUIREMENTS Growth Rate (%)	SYSTEM CAPACITY REQUIREMENTS kW	SYSTEM CAPACITY REQUIREMENTS Growth Rate (%)
2002	18.2	–	22.6	–	4,400	–
2007	27.5	8.6	33.1	7.9	6,045	6.6
2012	35.6	5.3	42.2	5.0	7,425	4.2

Note: Growth rates shown are average cumulative annual growth over the next 5 and following 5 years.

Figure 7-2. Forecast of Gross Energy Generation Requirements



7.2.3 Demand Forecast

Figures 7-2 and 7-3 show the forecasts for energy generation and peak capacity requirements in Rodrigues, respectively, with historic data also shown from 1993 through 2002. In each Figure, two forecasts are shown: one forecast with the desalination project and one forecast without the project. Table 7-4 summarizes the forecast elements with the desalination project and Table 7-5 summarizes the forecast elements without the project.

Figure 7-2 shows that without the desalination project, energy generation requirements are projected to increase from 22.6 GWh in 2002 to 42.2 GWh in 2012. This is equivalent to an average cumulative annual growth rate of 6.4% over the ten-year planning horizon. By comparison, energy generation requirements grew from 1993 through 2002 at an average cumulative annual rate of 11.6%. With the desalination project, energy generation requirements are projected to increase to 49.6 GWh in 2012. This is equivalent to an average cumulative annual growth rate of 8.2% over ten years.

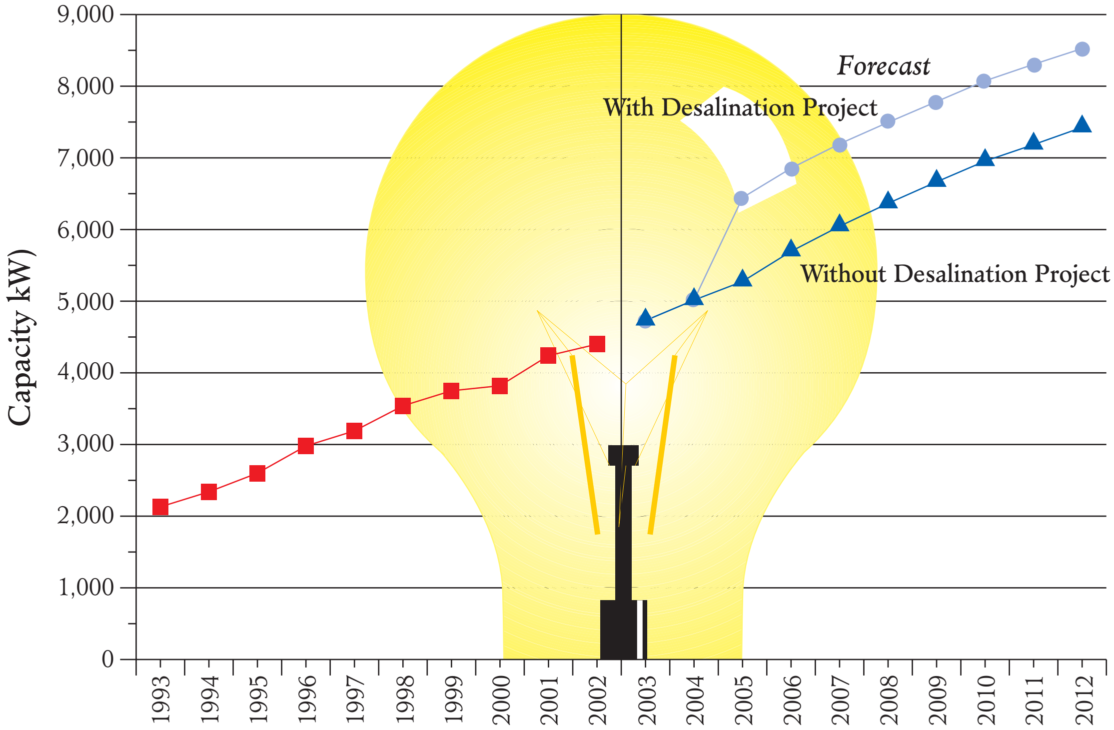
Figure 7-3 shows that without the desalination project, capacity requirements to meet peak demand are projected to grow from 4,400 kW in 2002 to 7,425 kW in 2012. This represents an average increase of about 302 kW per year over the next ten years, or an average cumulative annual increase 5.4%. By comparison, peak power generated grew from 1993 through 2002 at an average of 252 kW per year, or an average cumulative annual increase of 8.4%. With the desalination project, capacity requirements are projected to grow to 8,525 kW in 2012. In general, the desalination project adds about 1,100 kW to the forecast of peak capacity requirements without the project.

7.2.4 Demand-Side Management

The village of Roche Bon Dieu, in eastern Rodrigues, is participating in a pilot project to assess the potential benefits of switching to energy-saving household lighting. This project of the Rodrigues Council of Social Services is being funded by the United Nations Development Programme Global Environmental Facility through a small projects grant.

In the first phase of the pilot project, energy-saving light bulbs were installed in 25 village homes in February 2003. We are providing consumption data to the pilot project to assess the impact on customers'

Figure 7-3. Forecast of Peak Capacity Requirements



consumption and electricity bills. Should the pilot project prove successful, a second phase will be introduced to expand the initiative to more villages. Ultimately the objective is to have good quality energy-saving light bulbs installed island-wide. Preliminary estimates are that this measure could reduce the need for energy generation by one million kWh each year.

7.2.5 Demand Forecasting Process and Methodology

Energy

A similar bottom-up approach as used for Mauritius and described in Chapter 4 has been used in developing the energy forecast for Rodrigues. That is, starting from a forecast of energy sales, then adding the energy consumed by the system, we obtained the forecast of gross energy generation requirements.

Energy Sales

In Rodrigues, energy sales are closely related to the demographic expansion of the island, since the residential market segment represents the largest fraction of sales and has been the fastest growing segment in Rodrigues. A major part of the commercial energy sales is in turn linked to population increase. Industry on the other hand is not expected to grow significantly. Therefore, the basic sales forecast was developed based on a regression of historic sales over population. Some adjustments were necessary, however, to take cognisance of the planned hotel projects and the desalination plants.

Because of the uncertainty of the timing of the desalination project and its major impact on any demand forecast, two energy scenarios were established: one with the desalination project coming into service at the end of 2005, and the other without the project.

Network Losses

Network losses in Rodrigues are expected to remain relatively stable at 10.8 % over the planning horizon.

Power Station Auxiliary Consumption

Power station auxiliary consumption was estimated for the existing Port Mathurin power plant using historic data and applied to future requirements, taking into account that the older units at Port

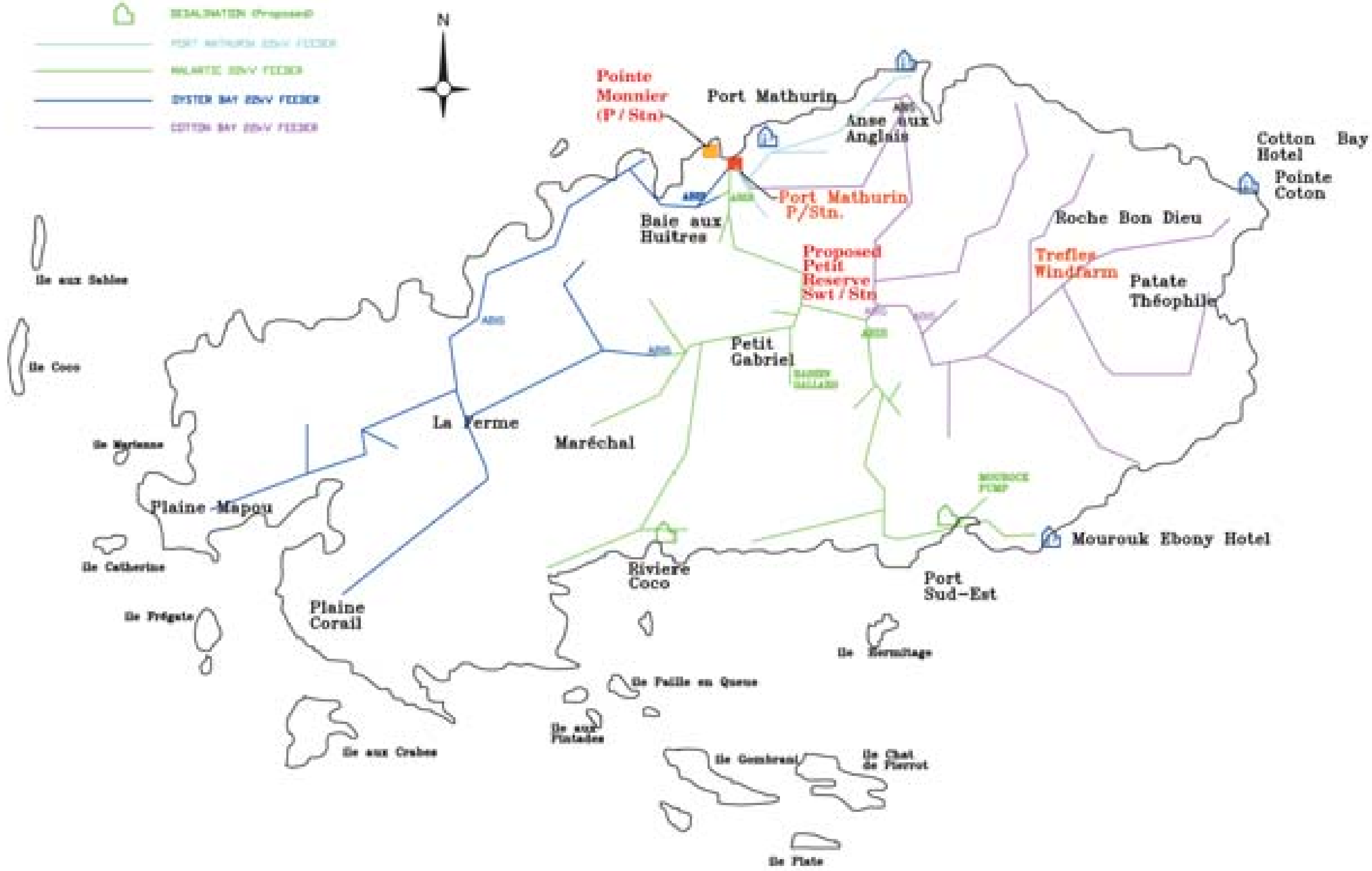


Figure 7-4. Rodrigues: 22 kV Network & Power Stations

Mathurin power station will be gradually phased out. The wind farm at Trèfles was not assigned any auxiliary consumption.

Peak Demand Forecast

The capacity requirement for peak demand was derived separately for the thermal plants and the wind farm. For the thermal plants, the peak power requirement was derived from the energy forecast using the energy-peak power relationship described in Section 4.7.2, but using different coefficients from those determined for Mauritius.

For the wind farm, an average firm capacity of 75 kW was estimated to be available at any given time over the planning period. This availability was estimated from historic data when wind turbines were operational at the site in the late 1980s.

One scenario was established for peak demand with the desalination plants and a second scenario without the project.

7.3 Supply of Electricity - Current Status

7.3.1 Power Generation

Figure 7-4 indicates the locations of existing and future generating stations and the layout of the distribution system. At the present time, electricity is generated at a single location, namely the Port Mathurin power station. Total installed capacity there is 6 MW, comprised of six 500 kW MWM Deutz units and three 1 MW MAN units. The effective capacity of the power station is 5.4 MW when all units are available. The Deutz units run on light fuel oil and are used for peaking duty. The MAN units run on heavy fuel oil and are used for base load duty.

The combination of rapidly increasing demand and aging generating units has made the need for new generation particularly urgent. Construction of a new power station is now underway at Pointe Monnier. Until the new units are commissioned, all existing units at Port Mathurin are required to run daily and be at full availability. The unplanned outage of one unit can lead to load shedding if a unit breakdown occurs in a period of high demand.

The site of the new power station at Pointe Monnier lies at the eastern end of a 65,000 m^2 area of land reclaimed in 1990/91 for industrial development. The site is being prepared for the first phase of development, which consists of the installation of two 1.9 MW internal combustion engines that will run on heavy fuel oil. The contract for supply of the engines was awarded to Burmeister & Wain Scandinavian Contractor of Denmark in 2002. Site and civil works are just getting underway, and the power station is expected to come into service at the end of 2004.

Phase 1 development includes a power house, workshops, office building, and appurtenances such as fuel storage tanks, a fuel pipeline from Port Mathurin, electrical transformers, and switchgear. To limit noise impacts in the area, the new station will have an acoustically designed power house with silenced combustion air intakes, silenced ventilation air intakes and outlets, and a silenced exhaust stack approximately 30 metres high. Phase 1 development is expected to cost Rs 300 million.

There is space at the Pointe Monnier site for two additional phases of future development and expansion, with each phase comprising the addition of two engines similar to Phase 1. This means the Pointe Monnier site will serve the needs of Rodrigues for power generation to well beyond 2012.

A feasibility study and Environmental Impact Assessment were completed earlier this year for a new wind farm site at Trèfles. Three Vergnet 60 kW wind turbines will be installed at this site. The project, expected to cost about Rs 13 million, marks the beginning of a renewable energy strategy for the island.

Concrete foundations for the wind turbines have already been cast. The masts and generators are on site and erection works will begin in November. The units are expected to be commissioned in mid-December 2003 and will be fully operable via remote control from the Port Mathurin power station.

7.3.2 Distribution Network

The distribution network begins at Port Mathurin power station, from where we distribute electricity through four feeders, shown in Figure 7-4, operating at a voltage of 22 kV. The shortest feeder is 5 km long and serves the Port Mathurin area. The other three feeders average 25 km in length and provide electricity service to all parts of the island. Each of the four feeders is secured by another feeder line to provide security in the event of faults which may occur for various reasons on the primary distribution network.

The 22 kV network comprises a total of some 130 km of overhead lines with mainly 50 mm^2 aluminum alloy conductors. There are presently about 115 distribution transformers having a total capacity of 20,500 kVA. All are protected with both individual and group fuses.

The low voltage network is comprised of twisted insulated cables, which make it highly reliable compared to a network comprised of bare conductors. Moreover, this type of construction reduces the time taken for reinstatement works after a cyclonic event. Following the intensive electrification program on the island, the low voltage network has grown to 350 km.

The system power factor is 0.95, and this high power factor can be attributed to the relatively low level of industrial activity that would otherwise contribute to larger reactive power consumption. The average yearly losses over the last ten years have been estimated at 10.8 percent, which is acceptable for such a lightly loaded system with long line lengths. This figure can be partly attributed to losses occurring in the large number of transformers with low load factors as well as over the relatively long, overhead radial feeders. We expect the value of line losses to go up with increasing demand; however, with the implementation of the switching station at Petit Réserve, feeder lengths and loadings will be reduced. Overall, then, we expect line losses to remain at about 10.8 percent of power station output to the network.

Some undergrounding of the network has taken place in Rodrigues. Of the 90-plot morcellement at Roche Bon Dieu, 15 houses constructed to date have had supply through underground service cables. Service cables will be laid for the remaining plots as houses are constructed. Undergrounding of service cables has also been effected at another morcellement at Songes, where houses have been constructed to date on 17 of 78 plots.

7.4 Future Development of Electricity Supplies

7.4.1 Power Generation

Because of the significant impact of the proposed seawater desalination project on the electricity generation requirements for Rodrigues, we have developed two capacity expansion plans: one with the desalination project and one without. The lead time associated with construction and commissioning of the desalination plants is similar to that associated with the addition of another generating unit. Therefore, we will know to proceed with the appropriate generation expansion scenario as soon as the desalination project proceeds to implementation.

Regardless of the timing of the desalination project implementation, CEB is planning for the retirement from active duty of the six 500 kW engines at Port Mathurin power station. These units will be retained for emergency purposes only.

Figures 7-5 and 7-6 present the capacity balance with and without the desalination project, respectively, and incorporate the generation capacity expansion plan for each case. With or without the desalination project, we plan to proceed to Phase 2 development at Pointe Monnier immediately after Phase 1 development is completed, adding the first of two 1.9 MW units to come into service in December 2005 or January 2006 (for graphical purposes, this addition is shown in Figures 7-5 and 7-6 as coming in 2006.) The wind farm at Trèfles is assumed to provide a minimum available capacity of 75 kW to the electric system starting in 2004. The peak demand forecasts in Figures 7-5 and 7-6 include an allowance for spinning and system reserves. For Rodrigues, the system reserve assumes the largest generating unit in the system is unavailable due to regularly scheduled maintenance.

Assuming the desalination project proceeds to come into service in or around January 2006, we will add the second 1.9 MW unit of Phase 2 at Pointe Monnier approximately 12 months after the first unit of Phase 2; that is, in December 2006/January 2007. We will retire three of the 500 kW engines at Port Mathurin after the Phase 1 expansion at Pointe Monnier is completed, as illustrated in Figure 7-5, and the remaining three 500 kW engines after the Phase 2 expansion at Pointe Monnier is completed. To continue to meet projected demand growth, another 1.9 MW unit is scheduled to come into service in December 2009/January 2010. These additions plus the 75 kW contribution from the wind farm will bring the effective generating capacity in Rodrigues to 12,425 kW, which will be sufficient to meet projected peak demand beyond the end of the planning horizon in 2012. This capacity will also provide sufficient energy capability to meet projected sales.

If the desalination project is deferred beyond our planning horizon, we will retire two of the 500 kW engines at Port Mathurin in 2005, as illustrated in Figure 7-6, and the remaining four units when the first unit of Phase 2 development at Pointe Monnier comes into service in December 2005/January 2006. The second unit of Phase 2 development at Pointe Monnier will be scheduled to come into service approximately 24 months after the first unit of Phase 2; that is, by December 2007/January 2008. These additions plus the 75 kW contribution from the wind

Figure 7-5. Rodrigues Capacity Balance With Desalination Project in Early 2006

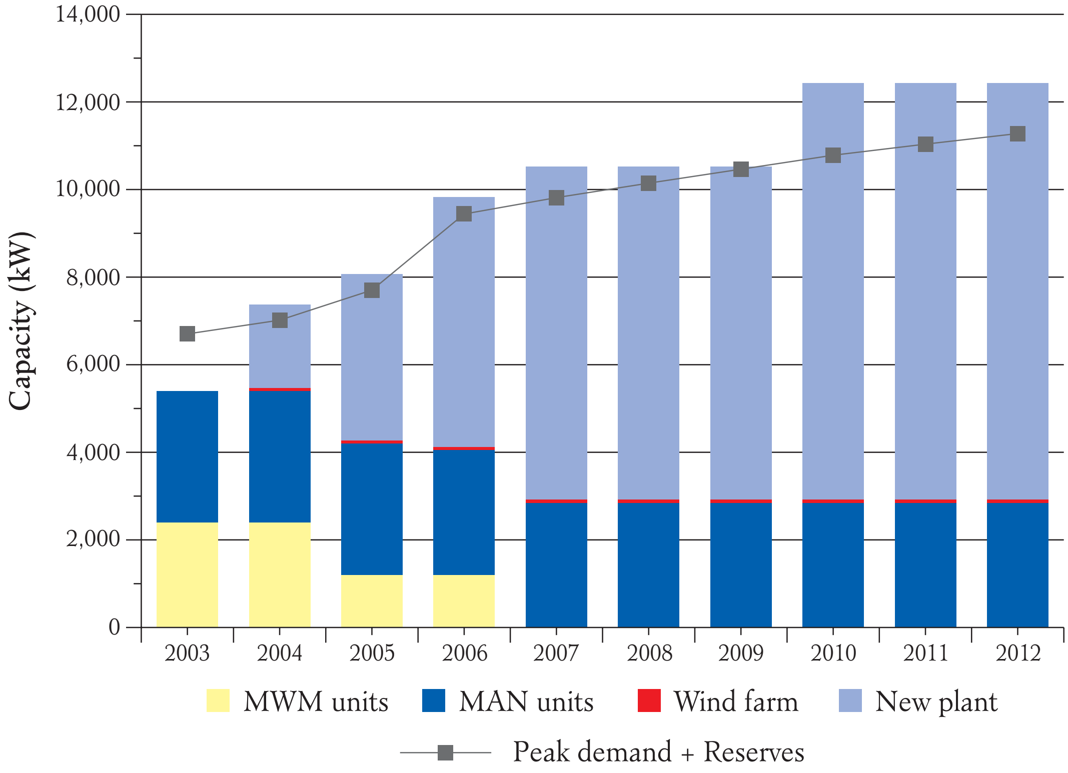
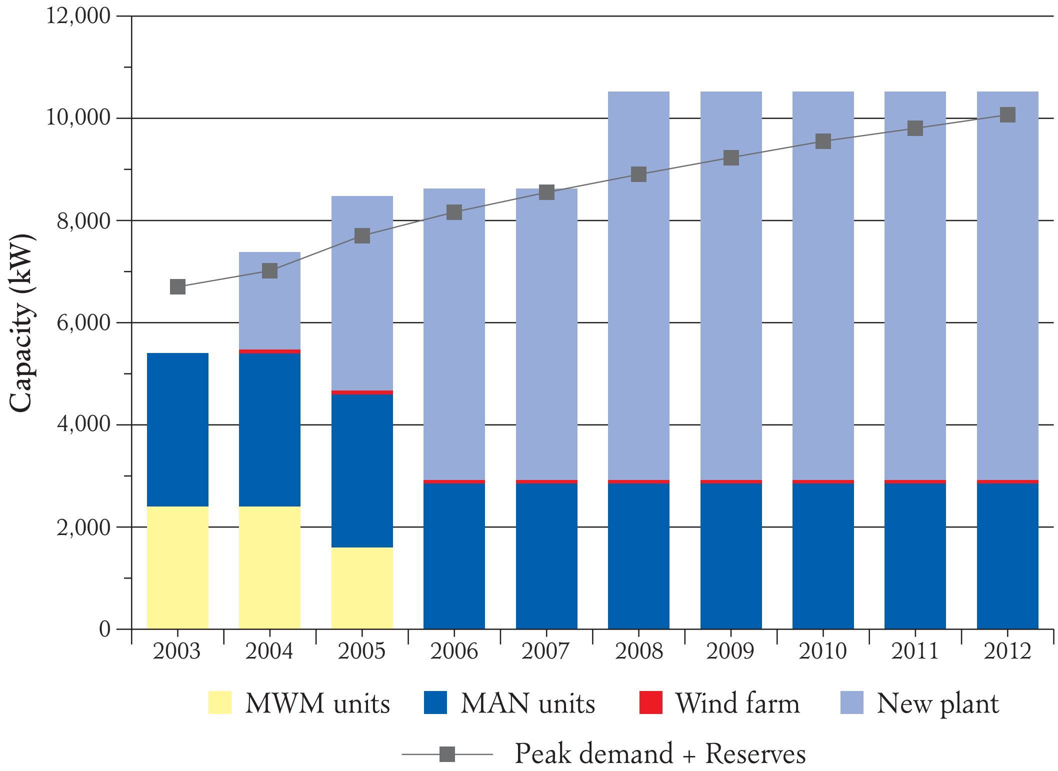


Figure 7-6. Rodrigues Capacity Balance Without Desalination Project



farm will bring the effective generating capacity in Rodrigues to 10,525 kW, which will be sufficient to meet the projected peak demand and energy sales to the end of the planning horizon in 2012.

7.4.2 Distribution Network

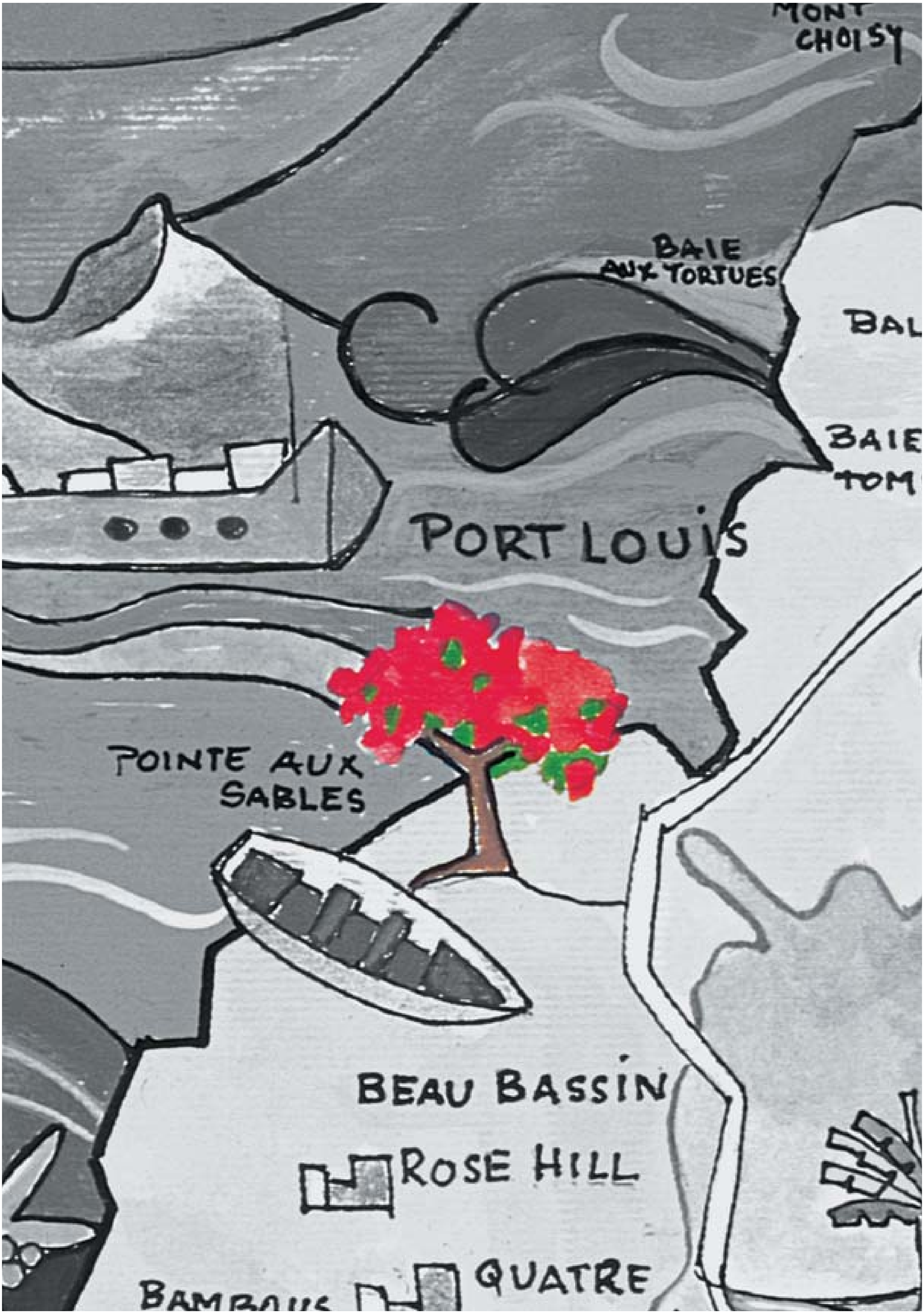
With the existing network design making use of 50 mm^2 aluminum conductors, our lines in Rodrigues are expected to have sufficient spare capacity to provide for the needs of the island over the planning horizon.

A key focus for the distribution network strengthening will be to interconnect the two power stations at Port Mathurin and Pointe Monnier. Two interconnectors, each 1.1 km in length, will be put in place to transfer bulk power from the new power station at Pointe Monnier to the existing Port Mathurin substation. Two circuits of 240 mm^2 armoured aluminum cables will be placed underground. This is a security measure so that, in case of an outage in one circuit, the other circuit will be able to transfer the total power generated. Distribution will then continue from Port Mathurin substation, making use of the existing network infrastructure.

To provide a reliable supply to strategic centres such as the Plaine Corail Airport and Queen Elizabeth Hospital, a second source of supply will be put in place. This will enable quick restoration of supply in the event of a fault.

The wind farm at Trèfles will inject power into the grid in the eastern part of the island, thereby relieving part of the power transfer and current flow from Port Mathurin station. This will help to reduce losses in this part of the network.

The existing feeders, at approximately 25 km, are long. Despite having back-up lines for each of the feeders, the long lengths of the feeder means that when a problem does arise, many customers along the entire length are affected. In order to improve our service delivery reliability, to minimise outage time, and to reduce line losses, we plan to begin reducing the length of the radial feeders, splitting them into shorter radial feeders. We plan to start by erecting a new feeder from Port Mathurin to a proposed switching station near Petit Réserve which will split Cotton Bay, Malartic, and Oyster Bay feeders into lines averaging 7 km each. The first phase—erection of the switching station—is planned for 2004; the new feeder from Port Mathurin station to Petit Réserve is scheduled for 2005.


MONT CHOISY
BAIE AUX TORTUES
BAIE TOM
PORT LOUIS
POINTE AUX SABLES
BEAU BASSIN
ROSE HILL
QUATRE

Chapter 8
10-Year Outlook

8.1 Introduction

The 10-Year Outlook is our perspective on the major generation, transmission, and distribution projects and the other planning activities needed over the long term to meet the forecasted demand for electricity and to ensure a secure supply of electricity for Mauritius. Any long-term plan has to contend with a strong element of unpredictability. The 10-Year Outlook is, therefore, a snapshot in time and not an unqualified prediction of what CEB will do over the next few years. If conditions change, we will modify our plans accordingly. We must remain flexible to adapt to developments that cannot be foreseen as well as changing circumstances, including customer demand. Nevertheless, due to the relatively long lead times for major projects—from project inception to feasibility studies to project implementation—we must have a long-term outlook to ensure project completion according to a schedule and thus meet our obligation as electricity provider.

This Plan will result in long-term, substantial financial commitments from CEB and other suppliers in the electricity industry. We estimate the needed expansion identified in this IEP will require investment on the order of Rs 7 billion in generation and Rs 5 billion in transmission and distribution. Funds to meet these commitments will need to be sourced. We need this 10-Year Outlook, therefore, to plan sufficient time to obtain affordable funding on the best possible terms. Future capital allocation and investment decisions on the part of CEB, IPPs, and other suppliers, are made in anticipation of the successful and economic recovery of these investments. Sustainable cost recovery of investment is, therefore, also something we must plan for.

This 10-Year Outlook has been based on the best information available and is current up to October 2003. Elements of the Plan will be implemented as described herein, but are subject to change as new information becomes available or as circumstances change.

This Chapter provides a summary of our long-term outlook broken down in terms of demand, generation, transmission, and distribution.

8.2 Demand and Demand-Side Management

The foundation of this Integrated Electricity Plan—the demand outlook—is also one of the main sources of uncertainty. We have endeavoured to bound that uncertainty by preparing a high demand and a low demand scenario in addition to a probable forecast. However, since we cannot know for sure how our customers' needs for electricity will grow, we will continue to monitor changes in demand, update the demand forecast annually, and update this IEP as required.

Given the variable daily and seasonal demand profile and its effect on system capacity requirements, we will develop specific demand-side management initiatives within the next few years aimed at moderating the growth rate of the peak demand. We will start with pilot projects and use the findings therefrom to assess the potential benefits of initiating larger-scale demand-side management programs. This will alow us to estimate and then monitor the impacts—on customers' electricity bills and on CEB's business, for example—of the demand-side management initiative.

We plan to gradually rationalise our tariffs to meet various objectives:

- Ensure all our customers are treated equitably, reducing improper cross- or intra-class subsidies and instituting lifeline provisions for qualifying customers.
- Price electricity wisely, with incentives to foster energy efficiency and conservation and deter the wasteful use of electricity.
- Allow recovery of investments made to expand and develop the electric system. In other words, price electricity based on prudently incurred costs and ensure that the electric sector is kept financially viable.
- Encourage sustainable, national economic growth through the efficient allocation of resources. When electricity is underpriced and undervalued, this acts as a structural barrier to the introduction of more sustainable, renewable energy technologies which remain somewhat more expensive than conventional technologies.

- Achieve simplicity and stability in electricity pricing. Due to inflation, the relative devaluation of our currency, and other such externalities, the costs associated with our business will continue to change over time and the prices at which electricity is sold cannot remain fixed for too long. Nevertheless, we recognise that electricity prices should not be changed too frequently.

We have already begun a 3-step process to restructure CEB's tariffs:

1. *Establish the Tariff Structure*. We have completed the design of the desired structure for future tariffs. This consists of setting out the customer categories (e.g., residential, general service, stand-by supply, etc.) and types of tariffs available within each category (e.g., block rates, time-of-use rates, etc.)

2. *Determine the Tariff Pricing*. This step will establish the optimal price for each tariff that is fair to CEB's customers (i.e., provides the lowest possible prices, eliminates improper inter- and intra-class subsidies, and provides appropriate price signals for intelligent electricity consumption) and at the same time is in the interests of CEB (i.e., provides an adequate return on investment and operating costs.)

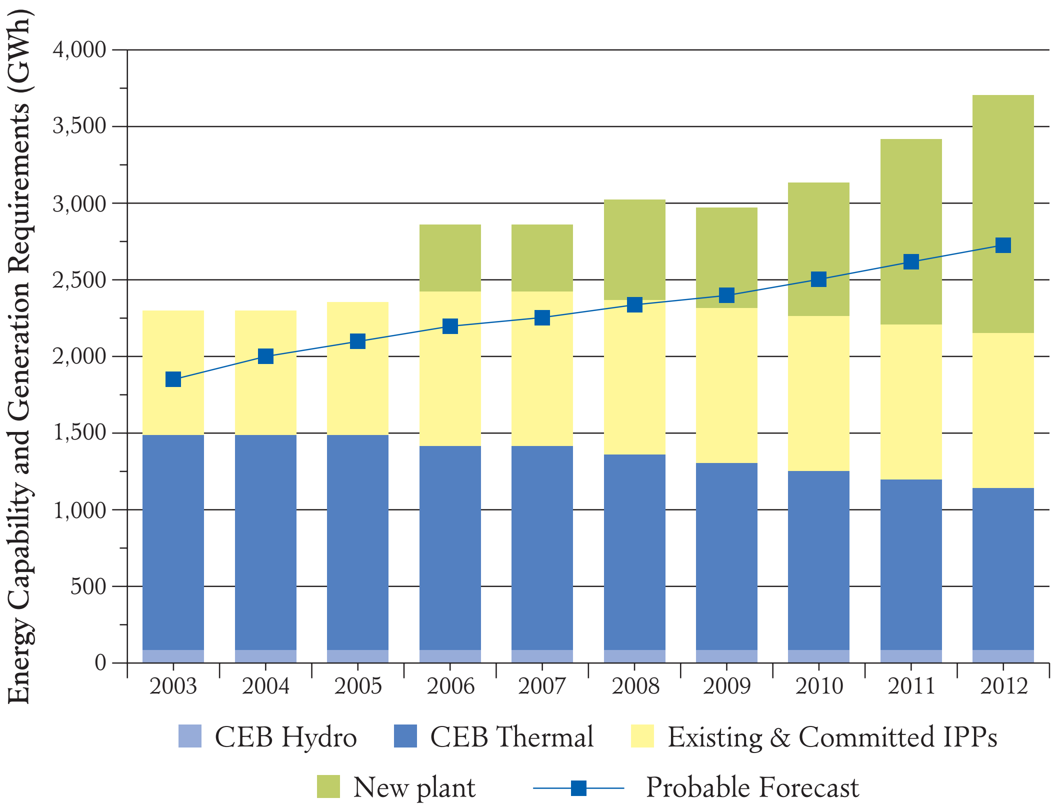
3. *Develop a Tariff Strategy*. We will outline a strategy to migrate from our existing tariffs and tariff structure to the revised structure and optimal pricing. We will plan for this to be a gradual transition, taking place over a period of about five years.

8.3 Generation

Based on the forecast of probable demand and our supply of existing and committed generation resources, the next capacity resource additions are needed in 2006. Further additions will be needed after 2006 to the end of the planning horizon. To meet a 2006 in-service date, immediate actions are required and are outlined in Chapter 9.

Figures 8-1 and 8-2 show as "New Plant" the planned generation resource additions for Mauritius that make up the 10-Year Outlook in terms of their contributions to the energy and capacity balances, respectively. Our generation needs can be described

Figure 8-1. Energy Balance: 10-Year Outlook for New Generation Resources



as capacity driven, since the planned additions are required primarily to meet projected peak demand plus required reserve margins. The new plant will provide sufficient energy capability to meet our projected gross generation requirements.

The capacity balance and planned generation additions for Rodrigues are presented in Figures 7-5 and 7-6.

While this Integrated Electricity Plan and the energy and capacity balances shown in Figures 8-1 and 8-2 provide our perspective on the timing and size of new generation resources, they do not presuppose individual generation projects. The generation technology and location of new generating facilities will be addressed as part of our future generation resource acquisition processes in which considerable weight will be given to minimising future costs and building a sustainable energy future. Acquisitions from the private sector will come through comprehensive, competitive requests for proposals that will spell out any particulars regarding generation size, type, location, and evaluation criteria.

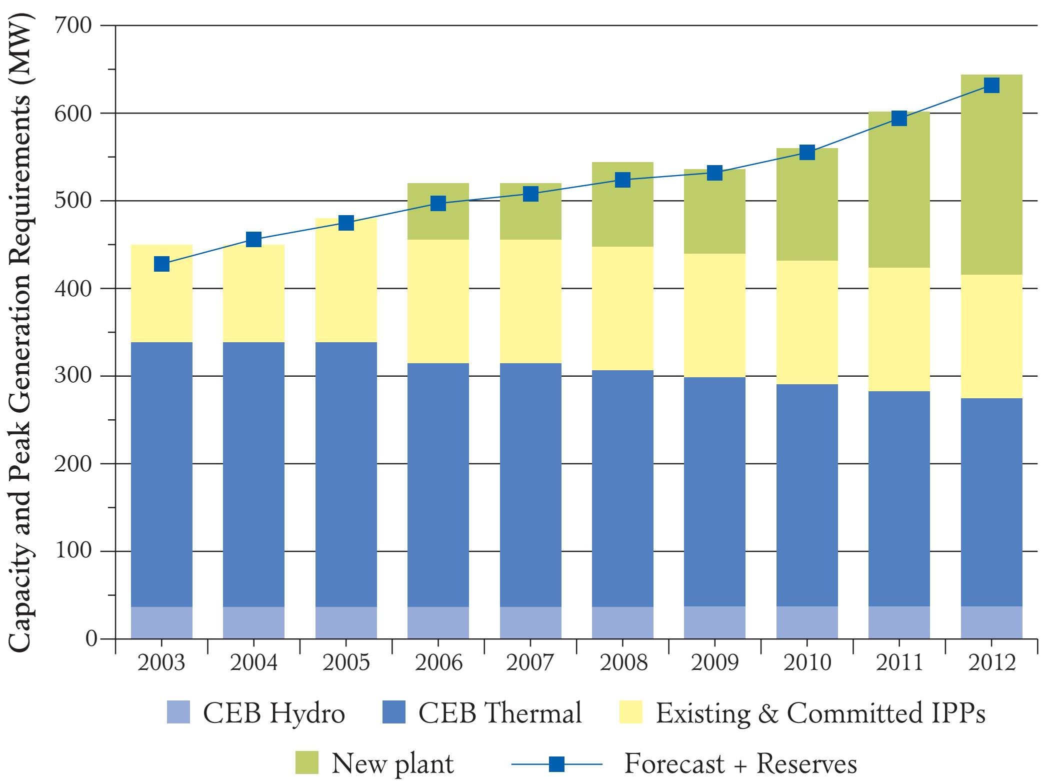
In line with our generation Resource Acquisition Policy presented in Chapter 5, acquisition of private sector generation does not preclude CEB from exercising our own viable options to repower and redevelop existing power stations if these options will produce benefits for electricity consumers in Mauritius and can be feasibly undertaken within our capital structure.

There is increasing public interest in the development of new, "green" resources in Mauritius and a potential need to mitigate greenhouse gas emissions associated with fossil-fuel-fired generation. Therefore, we will investigate the addition of new green resources and/or demand-side management with the goal of meeting ten per cent of demand growth from such resources over the long term. The costs of wind, solar, fuel cell, and marine-based generation will likely continue to decrease as the technologies evolve and we will give due consideration to adding such renewables, based on their competitive commercial value to CEB and to our customers. We will continue to watch for specialty, small-scale applications for such technologies.

8.4 Transmission

The 10-Year Outlook anticipates that the transmission network, which has been recently commissioned from a

Figure 8-2. Capacity Balance: 10-Year Outlook for New Generation Resources



66 kV ring into a 66 kV grid, will have sufficient capacity to transmit the projected peak demand growth through the end of the planning horizon. Portions of the 66 kV network have been constructed at 132 kV but are currently energised at 66 kV. We will monitor developments over the coming years and allow for the gradual uprating to 132 kV operation over time, as warranted by load flow requirements. Operation at 132 kV may be necessary at or shortly after the end of the planning horizon 2012. Therefore, in our ongoing planning activities we are continuing to examine scenarios and develop plans to energise the already upgraded transmission lines to 132 kV. In keeping with our ultimate network design, any upgrading to 132 kV will be implemented to form part of a 132 kV ring that will overlay and support the 66 kV network. This 132 kV ring network is expected to be in place before 2015.

The major planned transmission activities of the Ten-Year Outlook comprise:

- Upgrading of existing major 66 kV-to-22 kV substations in 2004 and 2005 and implementation of new major substations, phased to coincide with growth of the load centres.

- Reducing line losses through the installation of new and optimisation of existing capacitor banks.

- Phased upgrading of the SCADA system at the System Control Centre. This will include developing new teleprotection capability starting in December 2003. We will begin to incorporate geographical information on our transmission and distribution networks into the database of the new enterprise-wide information system to be implemented in 2004. This will allow geographical real-time information on the operating states of the power system to be displayed in the control room, thereby allowing us to more effectively coordinate the works carried out by our field personnel.

- Addition of new bulk supply points: at Goodlands to supply the northeastern part of the island; at Petite Rivière to supply the western coast; at Riche Terre to supply the industrial zone; at Château D'Eau to supply the neighbouring land developments and northern part of Port Louis; and at Phoenix to supply the industrial zone and central region. The implementation schedule of certain of these capital projects depends on the realisation of specific private land development projects. Developers of these private projects will provide part of the funding necessary for transmission infrastructure enhancements.

8.5 Distribution

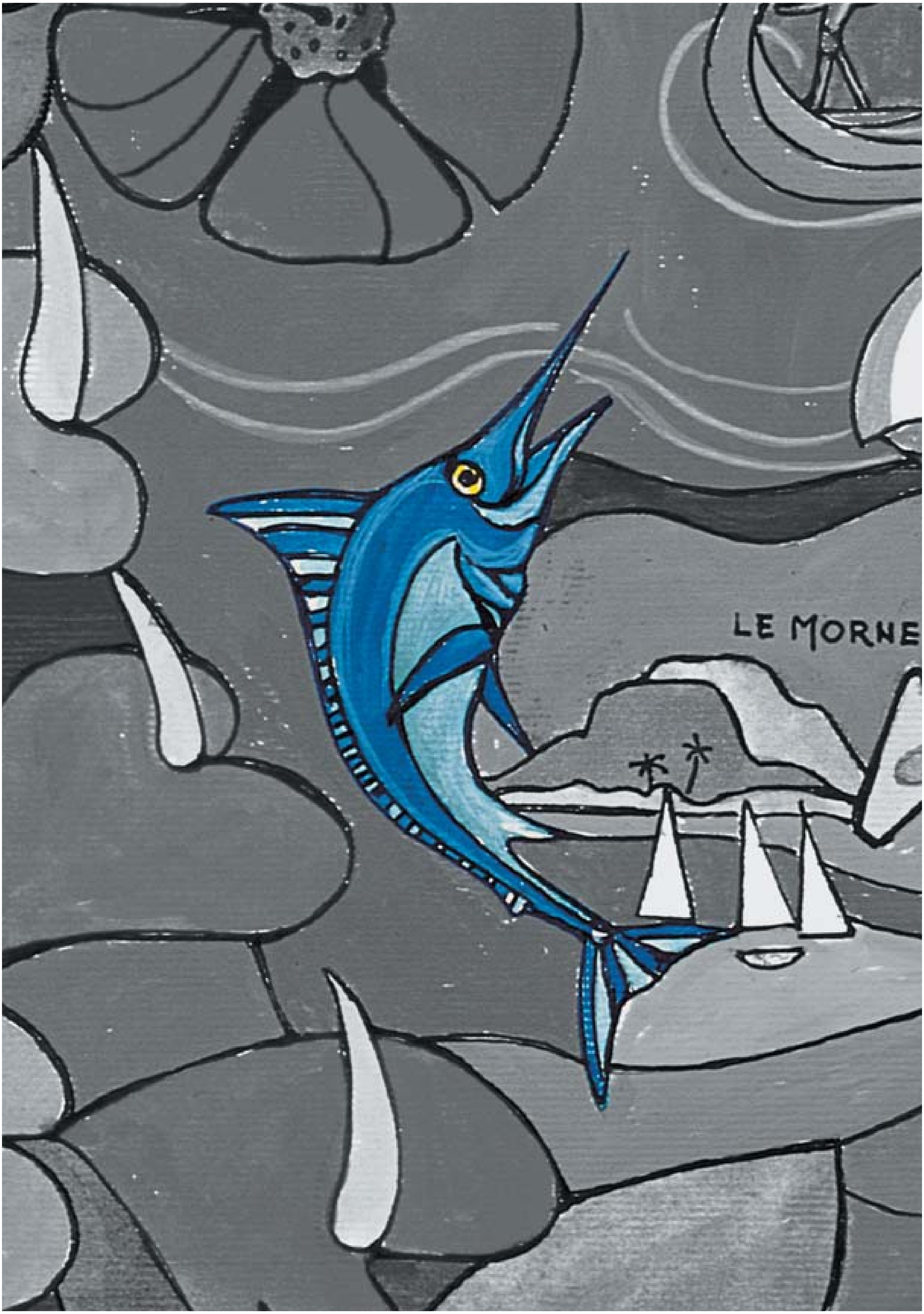
We plan to continue to meet forecasted load growth by the gradual refurbishment of existing medium voltage feeders in the distribution system and the construction of new 22 kV feeders originating at the bulk supply points. Planning of these feeders must remain flexible to the needs of new land developments and their associated loads. Therefore, we will continuously monitor both the network loading and changes in demand and, as required, strengthen the critically loaded portions of the distribution system.

In an effort to improve our operational effectiveness, we will be gradually automating the procedures required to re-energise the medium voltage network. These procedures are now undertaken manually. To proceed with the automation, we will first review our power system design principles, upgrade our protection system, and then install the necessary communications for remote control capability. We plan to introduce a pilot project for sensitive installations to evaluate the operational benefits and, at the same time, train field personnel.

In Rodrigues, the principal long-term development will consist of continued meshing of the distribution network and erection of a switching station at Petit Réserve along with the associated interconnector from Port Mathurin Power Station. We anticipate new hotel developments and the proposed desalination plants will be located in coastal areas at the ends of feeders. We will monitor these developments and strengthen or modify feeders as these loads appear.

Planned distribution activities for the Ten-Year Outlook comprise:

- Upgrading of switching stations to bulk supply points at La Tour Koenig, Riche Terre, Phoenix, and Goodlands.
- Constructing new substations at Le Morne, Beau Champ, and Château D'Eau, and reconstructing existing 22 kV substations at Nicolay, St. Louis, Rose Hill, and Wooton.
- Converting 6.6 kV transformers and feeders to 22 kV to keep loads on 6.6 kV feeders in Rose Hill, Beau Bassin, Quatre Bornes, Vacoas, and Curepipe areas to acceptable levels.
- Phasing out the 6.6 kV in Port Louis by 2010.
- Using a series of strategies to reduce distribution system losses.
- Introducing an automated meter reading system to large customers.


LE MORNE

CENTRAL ELECTRICITY BOARD

Chapter 9
Action Plan

9.1 The Way Forward

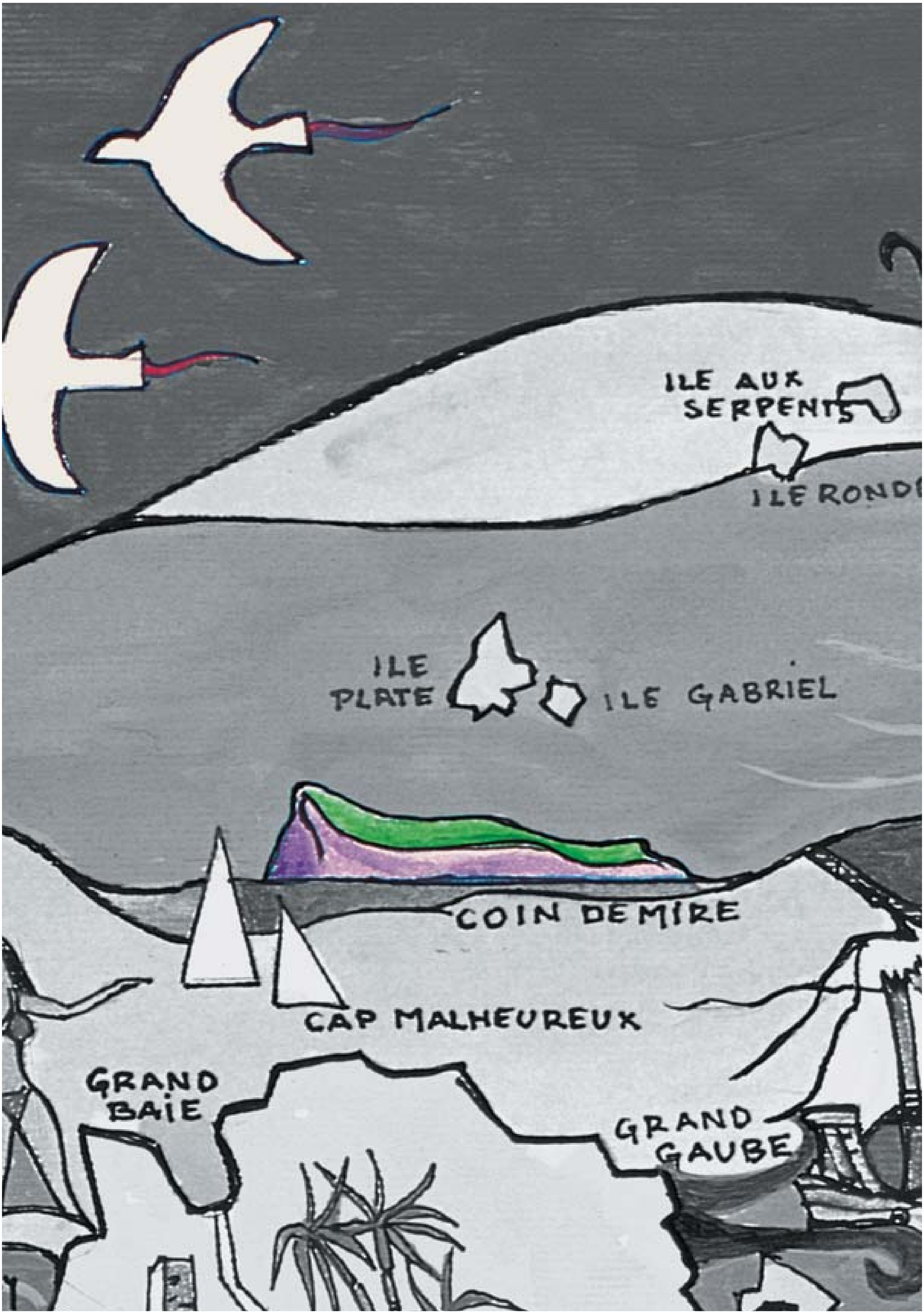
Mauritius needs new electricity resources in the near term. The Action Plan describes the actions CEB must take in the short term to acquire, implement, or maintain the availability of those new resources, projects, and programs identified in the 10-Year Outlook and to help us prepare to respond to risks and uncertainties. The Action Plan is, therefore, our blueprint identifying the way forward. It forms part of CEB's business and operational planning, with the Action Plan items appearing in our work plans and annual budgets. The Action Plan is based on current information and will be updated as needed on an ongoing basis.

Table 9-1. CEB's Action Plan, 2003 to 2005

ITEM	DESCRIPTION
Demand	
Demand-side Management	Launch pilot project in each customer segment for time-of-use pricing. Continue research on electricity substitution and self-generation by large customers.
Energy Efficiency Planning	Conduct sensitisation campaigns to motivate energy efficiency, conservation, and shifting demand from peak to off-peak hours. Continue to work with UNDP and stakeholders on energy efficient building design. Collaborate with other institutions to identify market barriers to energy efficiency and measures to overcome.
Domestic Energy Savings	Continue to support Rodrigues pilot project for energy efficient lighting, extending project reach, if cost effective. Promote use of good quality energy saving lamps.
Tariff Strategy	Continue with development of 5-year tariff strategy for release in mid-2004. Develop wheeling and stand-by supply tariffs based on Cost of Supply methodology.
Network Losses	Proceed with loss measurement program. Identify and implement viable loss reduction projects.
Planning and Forecasting Activities	Monitor changes in demand growth, including potential large new loads, and develop strategies to meet deviations from forecast assumptions.

ITEM	DESCRIPTION
Generation	
New Resources	Issue a Request for Proposals in December 2003 for 60 MW to 70 MW of new generating capacity fired by bagasse and a complementary fuel. First 30 MW to 40 MW to be developed for the earliest in-service date in 2006 and the second 30 MW to 40 MW for January 2008.
St. Louis Power Station	Continue with feasibility assessment for the addition of 30 MW to 40 MW of heavy fuel oil-fired units. Apply for Environmental Impact Assessment licence by November 2003.
Existing IPPs	Continue with implementation of messaging system between System Control Centre and IPP control rooms.
Fort Victoria Power Station	Develop a retirement strategy for Mirrlees units and spare holdings.
Port Mathurin Power Station	Develop a retirement strategy for MWM units and spare holdings.
Pointe Monnier Power Station	Continue Phase 1 development for late 2004 in-service date. Prepare for Phase 2 development, with next new unit for late 2005 in-service date.
Renewable Technologies	Commission wind farm at Trèfles for supply to Rodrigues grid starting in December 2003. Continue to collect information, monitor technological advancements, and provide annual updates of technology information summaries. Support information exchange and establish demonstration projects, if cost-effective.
Greenhouse Gas	Continue to monitor policy developments and offset opportunities locally and internationally.
Transmission	
Transmission Backbone	Commission Champagne-Union Vale 66 kV line by end of 2004 and Combo-Le Morne and Henrietta-Le Morne 66 kV lines in second half of 2005. Achieve security of supply by closing the ring Champagne-Union Vale-Combo in mid-2005. Begin to commission back-up 66 kV Amaury-Sottise line. Continue to monitor transmission system performance reliability requirements, investigating possible need to upgrade sections of line from 66 kV to 132 kV operation.
Transformers	Increase power transformer capacity of Rose Hill and Combo substations in second half of 2004. Add 66 kV-to-22 kV transformer at Nicolay by end 2005.

ITEM	DESCRIPTION
Transmission (cont'd)	
Capacitors	Install capacitor banks at Henrietta and La Chaumière substations by mid-2004.
Substations and Bulk Supply Points	Commission Dumas and Sottise substations in December 2003; Amaury and Union Vale in 2004; and Le Morne in late 2005. Prepare to commission Beau Champ substation in 2006.
Communication and Protection	Implement fibre optic cables for data communications in place of microwave. Establish links between 66 kV substations for teleprotection relaying. Introduce unit protection for the short transmission lines between Dumas, Fort George, and Nicolay substations by end 2003 and between St. Louis, Rose Hill, and Wooton substations in 2004.
Rights of Way	Identify property, servitudes, and rights of way needs to ensure availability for future substation and network development.
Distribution	
Major Substations	Commission new 22 kV switchboard at Rose Hill-Ebène and St. Louis, with additional feeders, in 2004. Complete replacement of 22 kV switchboard at Nicolay substation, with extension for new feeder, in 2005. Reconstruct Wooton 22 kV substation with new feeders in 2005.
Switching Stations (identified for upgrading to BSPs)	Commission switching stations, feeders, and network reconfiguration at Pailles, La Tour Koenig, and Riche Terre in 2004 and prepare for commissioning at Phoenix in 2006.
Network Reinforcement and Refurbishment	Continue implementation of various projects, including undergrounding, upgrading from 6.6 kV to 22 kV, adding new feeders, and back-up supplies.
Automated Meter Reading	Introduce AMR systems for 2,000 largest customers, starting 3-year phased program in 2004.
Rodrigues	Commission two underground circuits linking Pointe Monnier power station to Port Mathurin power station by late 2004. Commission Petit Réserve switching station in 2004 with new interconnector to Port Mathurin power station in 2005.


ILE AUX SERPENTS
ILE RONDE
ILE PLATE
ILE GABRIEL
COIN DE MIRE
CAP MALHEUREUX
GRAND BAIE
GRAND GAUBE

Glossary

Air emissions. The chemical compounds released to the atmosphere from the burning of fossil fuels. The most common emissions associated with electricity generation include oxides of nitrogen (NO_x); sulfur dioxide (SO_2), carbon monoxide (CO), and carbon dioxide (CO_2). The latter is also a "Greenhouse gas."

Base Load. A minimum amount of electric power sustained over a given period of time, usually assumed to be 24 hours per day. A base load generating unit is one which is generally designed for continuous operation at or near full capacity. CEB considers its base load power stations to be those that operate around the clock to meet all or part of the base load, namely Fort George and the IPP power stations year-round and the sugar estates during the crop season.

British Standard BS 1320. The standard to which CEB constructs its distribution network. Key features include:

- conductors in horizontal configuration,
- conductors fixed to horizontal wooden cross-arms via three pin-type insulators, as regard alignment poles,
- self-supporting poles for alignment poles, stayed for angle-poles and end-poles.

Bulk Supply Point (BSP). The major substations which receive energy from the transmission network and then distribute the energy, thus representing the source of supply to the distribution network.

Busbar. The common connection point of two or more transmission circuits.

Capacity. The amount of electric power delivered or required for which a generator, turbine, transformer, transmission circuit, station, or system is rated by the manufacturer. Also, the maximum load that a generating unit, generating station, or other electrical apparatus can carry under specified conditions for a given period of time without exceeding approved limits of temperature and stress. The unit of measurement is the Watt (W).

Carbon dioxide (CO_2). A naturally occurring gas, also a by-product of burning fossil fuels and biomass, and of land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore is given a Global Warming Potential of 1.

Demand. The amount of electric energy required at any specific point or points on a system. The primary source of demand originates at the energy consuming equipment or appliance of the consumer. Often used interchangeably with "Load"; however, demand is generally associated with customers' requirements whereas load is generally associated with the technical impacts and requirements of the electric system.

Demand centre (also referred to as "Load centre"). The geographic location of concentrated demand. We often refer to, for example, industrial zones or municipalities as demand centres.

Demand Forecast. An estimate of the level of energy or capacity that is likely to be needed at some time in the future. See also "Load forecast".

Demand-side Management (DSM). Methods of managing electrical resources that affect a customer's end use, rather than the supply, of electricity. Demand-side management includes, but is not limited to, energy-efficient lighting and load control apparatus.

Dispatching. The operation and control of an integrated electric system specifically pertaining to the scheduling and assignment of unit loading to individual generating stations, to maintain the most reliable and economical supply.

Distribution. Distribution of electricity is the process of transforming high-voltage electricity to lower voltages and then physically delivering it to households, industrial facilities, commercial establishments, government and other offices, and other end users. CEB's primary distribution system operates at voltages of 22 kV and 6.6 kV while the low-voltage supply at the terminals of the end consumers is at 230 Volts, single phase, and 400 Volts, three phase, with a tolerance of ±6%.

Fault outage. An unplanned loss of supply to customers due to a network fault.

Firm Power. The power capacity that is available around the clock.

Forced Outage Rate. The fraction of time for which a generating unit is required but cannot be in service due to an unplanned event, such as an equipment breakdown.

Frequency Regulation. The maintenance, by the System Control Centre, of the system frequency within the range of ±1.5% of the nominal value of 50 Hertz.

Generation. The process of producing electric energy from other forms of energy. Also, the amount of electric energy produced, expressed in Watt-hours (Wh).

Generation resource or generating plant. A facility with prime movers, electric generators, and auxiliary equipment for converting mechanical and chemical energy into electrical energy. A generating plant may contain more than one type of prime mover.

Gigawatt (GW). One million kilowatts.

Gigawatt-hour (GWh). One million kilowatt-hours.

Greenhouse effect. Greenhouse gases effectively absorb infrared radiation emitted by the Earth's surface, by the atmosphere itself due to the same gases, and by clouds. Atmospheric radiation is emitted in all directions, including downward to the Earth's surface. Thus greenhouse gases trap heat within the surface-troposphere system. This is called the "natural" greenhouse effect.

Greenhouse gas (GHG). Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. However, there are a number of human-made greenhouse gases in the atmosphere, such as halocarbons and other chlorine and bromine containing substances.

Grid. The layout of the electrical transmission system or a synchronized transmission network.

Independent power producer (IPP). An independent (i.e., not affiliated with CEB) generator of electricity for sale to CEB.

Kilowatt (kW). A unit of electric power equal to one thousand Watts.

Kilowatt-hour (kWh). The most commonly used unit of electric energy. One kWh is equivalent to one kW of power used for one hour. Customers' electricity bills show energy consumption in terms of kWh.

Load. The amount of electric power delivered or required at any specific point or points on a system. The requirement originates at the energy-consuming equipment of the consumer.

Load centre (see "Demand centre").

Load-duration curve. A graph of system load, expressed in MW, versus hours. The value of the x-axis being the number of hours the load is at or exceeds the corresponding y-axis value.

Load factor. The ratio of the units of electricity generated by a generating unit to that theoretically possible if the unit were operated at full rated load.

Load Flow. The voltage, current, power, and power factor or reactive power at various points in an electric network under existing or contemplated conditions of normal operation.

Load forecast. Predicted demand for electric power. A load forecast may be short-term (e.g., 15 minutes) for system operation purposes, long-term (e.g, 5 years to 20 years) for generation planning purposes, or for any range in between. Load forecasts may cover peak demand (kW), energy (kWh), reactive power (kVAR), and/or load profile. Forecasts may be made up of total system load, transmission load, substation/feeder load, individual customers' loads, and/or appliance loads. See also "Demand forecast".

Load management. The management of load patterns in order to better utilise the facilities of the system. Generally, load management attempts to curtail load or shift load from peak use periods to other periods of the day or year.

Load profile. Graphical depiction of the quantity of electricity demanded over a specified time period.

Load research. The systematic gathering, recording, and analysing of data describing customers' patterns of energy usage.

Loss of load probability. The probability that an outage in an electric system will occur in any particular time interval resulting in customer demand (or load) not being met.

Marginal cost. The cost to the utility of providing the next (marginal) kilowatt-hour of electricity, irrespective of sunk (or fixed) costs.

Megawatt (MW). A unit of electric power equal to one thousand kilowatts.

Megawatt-hour (MWh). A unit of electric energy equivalent to one megawatt of power used for one hour. One MWh is equal to one thousand kWh.

Net generation. Gross generation of a generating unit or group of units in a power station less the electric energy consumed within the generating station.

Operating reserves. The generating capacity held in reserve to allow an electric system to continue operating to fully meet demand and to allow for variations in load and for frequency regulation.

Peak demand. The maximum instantaneous capacity or electric power demanded by customers and imposed on the electric power system. Peak demand is usually reported as the highest total demand point reached in a calendar year.

Power station. An installation comprising one or more generating units owned and/or controlled by a single entity.

Reactive power. The component of power which is interchanged between the source and reactive elements to establish electrostatic and magnetic fields. The energy associated with this component is zero. Reactive power is required to meet the reactive needs of the transmission system and reactive loads such as motor drives, fluorescent lighting, and other end uses. The unit of reactive power is the VAR and the consumption of reactive power is the VARh, similar to the unit of active power which is the kW and its consumption the kWh.

Reactive power compensation. The injection of reactive power into the network to provide voltage support and control as well as to increase the power transfer capability of the transmission system.

Power transfer capability. The maximum power that a transmission circuit linking two stations can carry for a given period of time without exceeding approved limits of temperature, stress, and design operating conditions (e.g., sag, ground clearance.)

Primary transmission equipment. Any equipment installed on CEB's transmission system to enable bulk transfer of power. This include transmission circuits, busbars, and switchgear.

Reliability. Electric system reliability has two components: adequacy and security. Adequacy is the ability of the electric system to supply customers at all times, taking into account scheduled and unscheduled outages of system facilities. Security is the ability of the electric system to withstand sudden disturbances, such as electric short circuits or unanticipated loss of system facilities.

Reserve margin. Electric power systems need to have excess capacity to assure reliability in meeting demand in the event that a power plant breaks down or a transmission line shorts out. The amount of excess generation capacity needed for such reliability is often referred to as a reserve margin. The trend in countries and jurisdictions with interconnections to other sources of supply has seen generation reserve margins falling to levels as low as 15 percent, although in Australia and the Asia-Pacific region, margins are still maintained at or above 20 percent. For Mauritius, our plan is to keep reserves at a level between 20 percent and 25 percent.

SCADA. Supervisory Control and Data Acquisition. This is the computerised system which monitors the status of the electric network, generating stations, and power flows and remotely controls the switchgear at substations.

Secured event. A contingency which would be considered for the purposes of assessing system security. Under a secured event, the transmission system security criteria must not be breached.

Spinning Reserve. Fast-response capability held on partly loaded, synchronized generators to compensate for any sudden change in demand, network frequency, or generator outage. CEB usually takes 10 percent of peak demand as spinning reserve.

Substation. The purpose of a substation is to transform electrical energy at different voltages levels for distributing power to regional centres such as villages, industries, and commercial centres. Sub-stations are normally sited near densely populated areas and various switchgear combinations and layouts are employed in substation design. In Mauritius a typical substation will transform 66 kV power to 22 kV or 22 kV power to 6.6 kV for distribution purposes.

System Control Centre. Refers to CEB's operating unit responsible for centralised dispatch of generating units and grid operation within the network.

System instability. Refers to:

(a) Poor electric system damping and pole slipping, where one or more synchronous generating units loses synchronism with the remainder of the system; and/or

(b) Voltage collapse, where progressive, fast or slow, voltage decrease or increase develops leading to partial or total system blackout.

System protection. The complete protective scheme, inclusive of sensors, relays, and protective devices, designed to operate switchgear in order to isolate faulty parts of the power system such that the remainder of the system remains intact and functional.

Transmission. The process of conducting the flow of electricity at high voltages from the points of generation to the location of groups of electricity users, such as residential neighbourhoods, industrial parks, and commercial centres. Transmission voltage in Mauritius is 66 kV.

Transmission capacity. The rated power-carrying capacity of the transmission network.

Transmission circuit. The portion of the transmission system between two or more circuit breakers, but excluding busbars and generating circuits.

Transmission system. The system consisting of high-voltage (66 kV) network owned or operated by CEB and used for the transmission of electricity from generating sources to substations or to other generating sources, or between substations.

Unserved energy. The amount of energy demanded that cannot be supplied with available capacity.

*VAR. (*See *"Reactive power".)*

Value of unserved energy. The total monetary value per kilowatt-hour that consumers place on an outage or insufficient energy availability.

Variable operating costs. Operating costs that depend directly on the level of electricity produced from a power plant.

Voltage control. The regulation of transmission voltage by adjusting generator reactive output and transformer taps, and by switching capacitors and inductors on the transmission and distribution systems.

Watt. A unit of power, named after James Watt, a Scottish engineer, which is the rate of energy transfer equivalent to one ampere of current flowing due to a voltage difference of one volt at unity power factor. One watt is equivalent to approximately 1/746 horse-power, or one Joule per second.

Watt-hour (Wh). One watt of power used for one hour.