How to Achieve Security in Electricity Supply?

Through diversification of energy sources, utility aims to mitigate risks of supply. By blending the energy portfolio with different sources of inputs, the objective of securing supply shall certainly be met.

CEB, by sharing this objective, will endeavour to broaden, as economical as possible, its power generation mix!
Chapter 5: Power Generation Plan 2013-2022

Integrated Electricity Plan 2013–2022

POWER GENERATION PLAN 2013–2022

Chapter 5

To enable countries to develop to their full potential, new power plants need to be constructed at the right time so as to meet rising electricity demand. Achieving and maintaining a reliable electricity supply is a key target for any power utility. The reliability of each generating unit largely influences the overall system’s reliability. In fact, system reliability is achieved when the available generation capacity is able to meet demand effectively at all times, even under conditions of scheduled maintenances* and forced outages*.

Capacity planning is essentially carried out for the long term, mainly because of the technical and economic lifetime of power plants. Basically, the aims of generation planning are to identify the optimal time when new capacity should be added, to determine the magnitude of new capacity and to recommend the right technology including potential siting of the new capacity.

In the following sections, the CEB’s generation plan for the period 2013–2022 is elaborated. The elaboration starts with a brief examination of the 2003–2012 generation expansion plan, proposed in the last IEP, and its achievements focussing specifically on major projects that were implemented. The second, and last, part of the discussion details the revised generation expansion plan based on the demand forecast presented in the previous Chapter.

5.1 FLASHBACK ON INTEGRATED ELECTRICITY PLAN (IEP) 2003-2012

In the IEP 2003–2012, CEB drew up its tactical plan to ensure continuous power supply to its customers. A number of important power expansion projects were implemented as a result. The main topics pertaining to generation planning covered in the IEP 2003–2012 were:

- The relationship between utility and non-utility generation;
- The different resource options available and suitable to meet demand;
- The timing for, and appropriate size of, planned addition;
- The Generation Planning Acquisition Policy, which addressed the why, when and how new generating plant could be acquired; and
- The possibility to promote renewable energy technologies.

5.1.1 Targeted Capacity Addition

In support to the Sugar Sector Reform and with the objective of optimizing the use of indigenous energy sources – ‘bagasse’ for energy production – CEB, in-keeping with the policy of Government, set the target to accommodate the next power plant, which would operate using cogeneration (coal-‘bagasse’) technology. Based on the demand forecast presented in the IEP 2003-2012, it was thus decided that a generating unit of 32 MW would be commissioned, as and when the need for additional capacity would be required.

5.1.2 Actual Plant Commissioning

During the period of the last IEP, the following new generation projects were commissioned:

‘Compagnie Thermique Du Sud’ (CTDS)

In order to prevent potential negative impact on our country’s electricity generation capacity, CEB was called upon to launch a Request-For-Proposal (RFP) in 2003 for a 30 MW capacity plant on a fast track. Following the RFP and the ensuing negotiations, the CTDS, a pure coal-based power plant, was commissioned in 2005. This capacity addition was not in line with the target set. The reason for the deviation, however, was due to delays associated with the Sugar Sector Reform.

Saint-Louis Re-development

Based on the analysis of load duration curves* and demand pattern of forthcoming infrastructural projects,
it was resolved that a new semi-base plant capacity would be required by 2006. In this respect, CEB initiated the re-development of the Saint-Louis Power Station, whereby three medium speed diesel engines of 13.8 MW each were commissioned in 2006. This project was again a necessary diversion from the strategy to optimize ‘bagasse’ for electricity generation for the reason stated above.

‘Compagnie Thermique de Savannah’ (CTSav)
With the on-going centralization of the Sugar Sector, most of the Continuous Power Producers (CPPs) – small-sized less efficient power plants – were required to stop operations. In order to optimize the use of the ‘bagasse’ for electricity production of those closing CPPs, it was decided that more efficient IPPs be set up. Hence, under a directive from the Government, CEB launched an RFP for a 60 to 70 MW coal—’bagasse’ power plant. Hence, in 2007, the CTSav Power Station was commissioned, with a net export capacity of 74 MW on coal mode, and 65.5 MW on ‘bagasse’ mode.

5.1.3 Limitations of Coal—’Bagasse’ Power Plant
The previous IEP outlined the numerous advantages that IPPs had brought to our country’s electricity generation capacity. Apart from supporting the CEB in meeting the fast-growing demand, their geographical dispersion had also helped to reduce pressure on the transmission system and improve lines’ losses. But, on the other hand, the low-efficiency spreader-stoker technology of the IPPs has been impacting negatively on the country, both financially and environmentally.

5.1.4 Least-Cost Expansion Plan
A pre-feasibility study on the addition of new generation capacity in the long term concluded that pulverized coal technology would be the least-cost capacity expansion for Mauritius. The main advantage of pulverized-coal technology over spreader-stoker technology is its high efficiency (32% as compared to 25%).

Following a consultancy study on the siting of power station in 2001, the Pointes-Aux-Caves site was earmarked for the setting up of a coal power plant using pulverized-coal technology. In this respect, an IPP proposal, more precisely the CT Power, was received from the Government for consideration. Despite the execution by signature of a Power Purchase Agreement (PPA) with the CT Power on the 23rd of December 2008, the development of the project was delayed as the EIA license was not yet granted.

As an alternative to the delayed CT Power project and to ensure the least-cost expansion within a tight schedule, CEB opted for the re-development of the Fort Victoria Power Station. The latter’s re-development plan was already worked out some years back. The CEB proceeded on a fast track with a two-phase implementation. The first phase was completed in 2010 with the commissioning of two 15 MW medium-speed diesel engines. The second phase, which consisted of a further addition of 60 MW medium-speed diesel engines, was commissioned in 2012. The coming into operation of the new engines enabled the retirement of the old, less efficient, FIAT and Mirrles engines and shall contribute in meeting demand until 2014.

5.1.5 Development in Renewable Energy (RE)
When the last IEP was published, there was little advancement in renewable energy in Mauritius, as the cost of investment was extremely high and fossil fuels, such as HFO and coal, provided relatively cheaper options for generating electricity. At that time, the share of renewable energy (consisting of only ‘bagasse’ and hydro) in the energy mix was around 23%. Discussion was also centred on the advantages and limitations of integrating renewable energy in the power system.

During the term of the IEP 2003-2012, around the year 2006, renewable energy was seriously contemplated by the Authorities. Government’s expectations on renewable energy were eventually crystallized in the Maurice Ile Durable (MID) concept. The goal of the MID is to make Mauritius a model for sustainable development and to enable people to satisfy their basic needs and enjoy a better quality of life without compromising the well-being of future generations. Energy is one of the major components among the ‘5Es’ of the MID. The MID framework basically operates on the taxation of fossil fuels to subsidize renewable energy projects and finances sustainable development projects.

Further to the above, the need to promote the development of renewable energy was additionally addressed in Government’s Long-Term Energy Strategy (LTES) 2009-2025 for Mauritius. The long-term energy strategy document is actually a white paper for the development of the energy sector up to the year 2025.

* See glossary
In line with Government’s objective to promote sustainable development in the context of the Maurice Ile Durable vision, the LTES 2009-2025 lays emphasis on the development of renewable energy, the reduction of our dependence on imported fossil fuel and the promotion of energy efficiency.

To enable and facilitate the development of renewable energy projects, as laid down in the LTES, the Negotiating Panel of the CEB was entrusted with the responsibility of considering large-scale renewable energy projects. So far, the panel has negotiated Energy Supply and Purchase Agreement (ESPA)* for the projects listed in Table 5.1 above.

**Assumptions**

The above-targeted energy mix is based on the assumptions that the coal and waste energy projects, approved by the Government, would be operational by 2013. New and more affordable Photovoltaic (PV)* technology would be also available. The targets were subject to revision in response to changes in technology and outcomes of local energy resources assessment and affordability.

**Status of Current RE Projects**

In order to meet the above targets for renewable energy, the Ministry of Energy and Public Utilities (MEPU) is currently in the process of developing a Renewable Energy Master Plan*. The plan will provide a roadmap to reach the targets set. Meanwhile, the CEB, in line with the Government policy to promote the use of local energy resources, has already embarked on a number of renewable energy projects, as listed in Table 5.3 on the next page.

As a key facilitator, CEB will also actively participate in RE projects initiated under the MEPU’s Energy Strategy Action Plan (ESAP) 2011-2025, which comprises the development of a Wind Atlas, study to increase energy production from ‘bagasse’, study to use cane residues for electricity production and the setting up of a pilot plant for handling and feeding cane residues.

In addition to the above, CEB will also actively participate in RE projects initiated under the MEPU’s Energy Strategy Action Plan (ESAP) 2011-2025, which comprises the development of a Wind Atlas, study to increase energy production from ‘bagasse’, study to use cane residues for electricity production and the setting up of a pilot plant for handling and feeding cane residues.

### Targets for Renewable Energy

In the LTES, the targets for renewable energy were defined. Table 5.2 below shows the current status for 2010 and the progressive transition to meet the target of 35% of renewable energy capacity by the year 2025.

#### TABLE 5.2: Percentage Share of Energy Sources

<table>
<thead>
<tr>
<th>Fuel source</th>
<th>PERCENTAGE OF TOTAL ELECTRICITY GENERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010</td>
</tr>
<tr>
<td><strong>Renewable</strong></td>
<td></td>
</tr>
<tr>
<td>‘Bagasse’</td>
<td>16%</td>
</tr>
<tr>
<td>Hydro</td>
<td>4%</td>
</tr>
<tr>
<td>Waste to Energy</td>
<td>0%</td>
</tr>
<tr>
<td>Wind</td>
<td>0%</td>
</tr>
<tr>
<td>Solar PV</td>
<td>0%</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td>20%</td>
</tr>
<tr>
<td><strong>Non-Renewable</strong></td>
<td></td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>37%</td>
</tr>
<tr>
<td>Coal</td>
<td>43%</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td>80%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100%</td>
</tr>
</tbody>
</table>


* See glossary
5.1.6 Distributed Generations (DGs)*

Distributed generation has recently become a reality in Mauritius with the setting up of the Small-Scale Distributed Generation (SSDG)\(^*\) Project. The possibility to broaden the scope of distributed generations in Mauritius is currently being studied, so as to enable connection of Medium-Scale Distributed Generation (MSDG). Related information on the SSDG and MSDG Schemes is available on the CEB website [www.ceb.intnet.mu](http://www.ceb.intnet.mu).

Small-scale distributed generation (SSDG)

CEB, in collaboration with the MEPU, launched the SSDG project in December 2010. In this project, Small Independent Power Producers (SIPPs)* are given the opportunity to produce their own electricity from renewable sources (PV, wind or hydro) and export any surplus to the grid.

The main objective of the SSDG project is to promote distributed generation of electricity from renewable energy technologies. The SSDG project helps to reduce the use of fossil fuels for electricity generation, mitigate emission of Greenhouse Gases and decrease line losses on the Low Voltage (LV)* network. The implementation of the SSDG has required the development of a Grid Code to allow the integration of photovoltaic, wind turbine and small hydro technologies* within the grid. The Grid Code defines all the requirements relevant to the performance, operation, testing, safety and maintenance of Distributed Generation connected to CEB’s low voltage network. It also defines the rights, responsibilities and conduct of all parties involved in the process. Furthermore, the Grid Code describes the Feed-In Tariffs (FITs)* that are payable to SIPPs for the energy exported to the grid.

The first phase of the SSDG Project was opened for a total capacity of 2 MW, which was extended to 3 MW in December 2011. Out of the total capacity of 3 MW, initially 100 kW was reserved for Rodrigues. This 100 kW was subsequently increased to 200 kW.

For the 2.8 MW capacity allocated for Mauritius, 341 applications were retained out of 403 received. So far, 77 SSDGs representing a total capacity of about 714 kW have already been commissioned. For the allocated 200 kW capacity for Rodrigues, 55 applications were received. Under the first-come-first-serve

### Table 5.3: Status of Renewable Energy Projects

<table>
<thead>
<tr>
<th>Projects</th>
<th>Capacity (MW)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicolière Feeder Canal Hydro Plant</td>
<td>0.35</td>
<td>Hydro plant was commissioned in September 2010.</td>
</tr>
<tr>
<td>Midland Dam Hydro Plant</td>
<td>0.35</td>
<td>Project is currently under implementation. Commissioning is expected by the end of 2012.</td>
</tr>
<tr>
<td>Identify potential sites for mini- and micro-hydro plants</td>
<td>–</td>
<td>An RFP to seek consultancy services is expected to be launched early 2013.</td>
</tr>
<tr>
<td>Bagatelle Dam Mini-Hydro Project</td>
<td></td>
<td>Preliminary discussions have already started with the CWA and the WRU.</td>
</tr>
<tr>
<td>Setting of 1 to 2 MW Solar PV Farms</td>
<td>10</td>
<td>Project currently under evaluation. Solar PV farms are expected to be commissioned by 2014.</td>
</tr>
<tr>
<td>Development of a Grid Code, FIT* and Model ESPA for MSDG* projects</td>
<td>–</td>
<td>The World Bank, under the MEPU’s ESAP 2011–2025, had provided CEB with a grant to undertake this consultancy exercise so as to define the framework to integrate renewable energy systems above 50 kW to the grid.</td>
</tr>
<tr>
<td>Bigara Wind Farm</td>
<td>1.1</td>
<td>Since the DCA did not give its clearance, the project was subsequently shelved in 2011.</td>
</tr>
<tr>
<td>Aerowatt Wind Farm (Revised)</td>
<td>9</td>
<td>CEB recently resumed negotiations with the promoter, but for a reduced capacity of 9 MW. Negotiation on the ESPA is in progress.</td>
</tr>
<tr>
<td>Wind measurement at potential sites</td>
<td>–</td>
<td>CEB is in the process of identifying potential sites for the setting up of small wind farms similar to Rodrigues. Wind measurement masts will be installed and a feasibility study to assess sites’ wind potential will be carried out.</td>
</tr>
<tr>
<td>Solar PV Farm</td>
<td>15</td>
<td>A project proposal is under consideration.</td>
</tr>
</tbody>
</table>

* See glossary
principle, 35 applications had been retained and are currently being processed.

Another scheme, under the SSDG project, for a capacity of 2 MW has been made available for Public, Educational, Charitable and Religious (PECR) institutions. For this category, 97 applications had been received for a total capacity of about 1.2 MW. The tariff applicable for this scheme, irrespective of the renewable energy technology used, is the CEB’s Marginal Cost of Production.

Once the cumulated capacities of 5 MW SSDG are effectively connected to the CEB’s network, a study will be carried out to assess the impact of the connected SSDGs on the low voltage network. The results of the impact assessment will determine whether the low voltage network will be able to accommodate the connection of additional SSDG(s). However, connection of additional SSDG(s) will not necessarily be under the same terms and conditions of the current SSDG Schemes.

Medium-Scale Distributed Generation (MSDG)*
After the launching of the SSDG project, interests were shown by larger electricity consumers and promoters to set up renewable energy systems of capacity higher than 50 kW. Such type of RE installation will fall under the Medium-Scale Distributed Generation (MSDG) Scheme.

As in the case of the SSDG scheme, implementation of the MSDGs project will also require the development of an appropriate Grid Code and the applicable Feed-In Tariff. Normally, MSDGs will be connected mainly at Medium Voltage (MV) level. The maximum number of projects which the grid can safely accommodate will depend on the grid’s absorption capacity*. The MSDG will generally cover projects of capacity above 50 kW but lower than 4 MW.

5.2 THE 2013–2022 GENERATION EXPANSION PLAN
Based on the 10-Years load forecast, as described at length in the previous chapter, the total annual energy requirement from power stations will be around 2673 GWh in 2013 and will increase steadily to reach 3519 GWh by 2022. The resultant peak power demand is forecasted to grow at a steady rate of 2.9 % per annum. In relation to the load forecast, CEB is anticipat-
The Pielstick engines have exceeded, by far, their normal operating life. These engines not only run inefficiently, but are also becoming problematic for the CEB in terms of environmental compliance. To remain in accordance with environmental norms, CEB is envisaging their retirement in the near future.

In respect to the retirement of the Pielstick engines, a re-development plan of the Saint-Louis Power Station was initiated and has been already completed. CEB is currently seeking to obtain the necessary EIA license for the project. According to the present generation expansion plan, the development of the project will not be contemplated during the course of this IEP.

As regards to the Wartsila engines, commissioned in 2006, they contribute to about 6 to 8% of the national electricity requirements. These engines are all medium-speed type and operate as semi-base-load generators; that is, they start their operation at seven o’clock in the morning and stop at 21:00 hours.

Fort Victoria Power Station

Since 2009, the Fort Victoria Power Station had undergone two phases of re-development. In fact, the re-development plan of the Fort Victoria Power Station was prepared back in 2004, but it was deferred as there were other power projects in the pipeline. Subsequently, due to delays in other power plant projects, the Fort Victoria re-development project was revived again on a fast-track basis so as to meet the increasing demand of the country.

In the past, the Fort Victoria Power Station had 8 Mirrlees engines providing a total output of 42 MW. Since these engines were running inefficiently and had reached the end of their useful life, which were causing adverse effect on the environment (noise and air pollution), they were retired in 2008 as part of the first phase of the re-development. The Phase-One of the re-development included the commissioning of two new Wartsila units of 15 MW each.

The second phase of the re-development was initiated in 2011, whereby four Wartsila units of 15 MW each were commissioned in 2012. In addition to the six Wartsila units, there are also two MAN engines of 8.5 MW each. All these engines are medium-speed type and contribute to meet the semi-base load.

The newly-commissioned Wartsila engines have a useful life of 25 to 30 years; this means that they can safely supply electricity to the grid until 2040, assuming no major breakdowns occur.

Today, the Fort Victoria Power Station provides a total capacity of 107 MW to the CEB’s grid and is expected to have an annual plant load factor of around 35%.
Nicolay Power Station
Nicolay Power Station is the only CEB’s power plant operating on kerosene. It consists of three open-cycle gas turbines with a total effective capacity of 75 MW. The plant is primarily used as a peak-lopping facility. The Nicolay Power Station has the highest running costs and, therefore, generally has a low annual plant load factor of around 3%.

Since these gas turbines have the highest marginal costs* of production, they are dispatched only in exceptional cases, such as unscheduled outages* and/ or planned maintenance* of IPPs and partial/general blackouts.

Hydro Power Plants
CEB has currently nine hydroelectric power stations in operation, with a total effective capacity of 55.8 MW. They account for approximately 9% of the island’s total effective capacity. In a good season (rainy), these stations can meet 10% to 12% of the electricity demand in Mauritius, while in a less favourable season (drought), such as in 1999, the energy produced can be as low as 2%.

CEB recently commissioned a small hydro plant having a capacity of 350 kW at the La Nicolière Feeder Canal. As at to date, this plant has generated some 1.7 GWh of electricity. Another similar project at the Midlands Dam has been planned for commissioning early 2013.

According to a recent study, the hydro potential in Mauritius has almost already reached its limit. However, it is believed that there is still room for the development of mini- and micro-hydro plants and enhancement of existing dams’ capacities. These potential hydro developments are also part of the Government’s ESAP 2011-2025. CEB has already embarked on such a project; whereby the water storage capacity of the Sans Souci Dam will be increased by some 30%. This development, accompanied with the impounding of waters at River Canard, although modestly, will contribute to increase electricity generation from hydro.

The Phase-One of the project, which involves increasing the Dam capacity from 240 metres to 243 metres, will be completed in 2014. Furthermore, CEB has recently initiated a project to identify potential sites for the installation of mini- and micro-hydro plants. The study will be completed in 2013.

5.2.2 Independent Power Producers (IPPs)
CEB is currently managing Power Purchase Agreements (PPAs)* with 5 Independent Power Producers (IPPs), which operate on firm-power basis. CEB also manages an ESPA Contract with the Sotravic Landfill Gas Energy Ltd.

The largest of the IPPs is the ‘Compagnie Thermique de Savannah’ (CTSav), which was commissioned in 2007. Its net total export capacity is 74 MW. All the IPPs, with the exception of ‘Compagnie Thermique Du Sud’ (CTDS), operate on ‘bagasse’ in the crop season and coal during inter-crop season. In the ‘bagasse’ mode of operation, the IPPs export less power to the CEB’s grid, as some of the produced steam is sent to the nearby sugar factories for sugarcane production processes.

In 2011, IPPs produced 55%, equivalent to 1337 GWh, of the total electricity consumption in Mauritius. Among the IPPs, three, namely CTBV, FSPG and CEL, have ‘take-or-pay’ contracts with the CEB. The ‘take-or-pay’ principle means that the CEB shall pay for the contractual energy amount even if the energy is not dispatched, while the power plant is available. The PPAs of these IPPs include the purchase of energy on the single-part tariff model. For the other two IPPs (CTDS and CTSav), CEB negotiated for the two-part tariff model, which treats Capacity and Energy Charges* as two different cost elements.

Some additional useful information on power generation assets is provided in Appendix B1.

5.2.3 Generation Planning Methodology
The present generation planning methodology adopts a deterministic approach. A demand-supply balance matrix*, which forms the basis to determine the need for capacity addition, takes into consideration:

1. The updated effective capacities* of existing plants; and

2. The ‘N minus 2’ criterion, that is, one of the largest generators is assumed to be on maintenance, while the second largest generator is assumed to be on breakdown.

In the demand-supply matrix, the peak demand forecast is inflated by 10% to cater for spinning reserve*.

* See glossary
Then, the Reserve Capacity Margin (RCM)*, which determines the need for capacity addition in a particular year, is calculated as per the formula below:

\[
\frac{\sum_{i}^{n} \text{Effective Capacity}}{(\text{Forecasted Peak Power} + 10\% \text{ Spinning Reserve})} - (\text{Capacity Out})_{\text{Max}} - (\text{Capacity Out})_{\text{Bdown}} - 1
\]

where,
- \( n \) is the total number of generating units connected to the grid;
- \((\text{Capacity Out})_{\text{Max}}\) is the maximum capacity that is assumed to be unavailable due to maintenance;
- \((\text{Capacity Out})_{\text{Bdown}}\) is the largest generating unit assumed to be unavailable due to breakdown.

If the RCM is below a threshold value (say, −5%), it triggers the addition of new plant(s) in the system.

The methodology to determine the least-cost expansion plan depends on:

1. An in-depth analysis of the historical load duration curves, which dictate the technology to be adopted for future expansion; and
2. The Screening curve* analysis, which provides a way to trade-off different technologies, in terms of investment costs and operating costs.

More information on the capacity planning methodology is provided in Appendix B2.

5.2.4 Committed Additions and Retirements

Based on the present generation plan, the following will be required in the short term.

Generation Plant Addition

1. The next major capacity addition is a 100 MW coal plant (CT Power), which will be located in the West at Pointes-aux-Caves. The target implementation date has been set for 2015/2016.
2. Commissioning of the Midlands Dam hydro project, which has a capacity of 350 kW, early 2013.
3. The Curepipe Point (Plaine Sophie) Wind Farm project is expected to be connected to the grid by the end of 2014. This project will be the first big Wind Farm of the island, with a total installed capacity of 29.4 MW.
4. CEB has also embarked on a 10 MW Solar Photovoltaic Project, which will be interconnected on the medium-voltage network. At best, the project will consist of 5 Solar PV Farms of 2 MW each. They are expected to be commissioned by the end of 2014.
5. A 15 MW Solar PV Farm project is also under consideration.

As a pertinent information, it is worth pointing out that only the first above-mentioned generation project fall under the system’s ‘needs-based additions’, while the next four renewable energy projects fall under what is referred as the ‘opportunity-based additions.’

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* See glossary
Generation Plant Retirements
With the commissioning of new generation plants and in meeting the objective of the least-cost expansion, CEB will progressively retire the old, and less efficient, Pielstick engines at the Saint-Louis Power Station.

5.2.5 Demand-Supply Balance
Figure 5.2 shows the matching of electricity demand with generation capacity for the planning period 2013–2022.

5.2.6 Planned Capacity Additions (2013–2022)
Following an assessment of new capacity requirements and the evaluation of alternatives, new capacity additions, as shown in Table 5.4, have been planned for the coming years.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>CAPACITY (MW)</th>
<th>POWER PLANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>50</td>
<td>CT Power</td>
</tr>
<tr>
<td>2016</td>
<td>50</td>
<td>CT Power</td>
</tr>
<tr>
<td>2017</td>
<td>50</td>
<td>New</td>
</tr>
<tr>
<td>2021</td>
<td>50</td>
<td>New</td>
</tr>
</tbody>
</table>

5.2.7 Energy Generation Forecast Methodology
Energy generation forecast is mainly carried out for budgetary purposes. It is used to prepare budget estimates for the procurement of fuels and other inputs. It also serves to determine the allocation of the amount of energy that will be purchased from the IPPs.

To estimate the energy that will be generated, the energy sales forecast is adjusted by a factor, which represents the network losses* and the energy used-on-works*. Figure 5.3 below illustrates the energy losses that are incurred from the point of generation up to customers’ premises and the energy consumed by auxiliaries* (energy used-on-works).

From the energy sales estimates, the Gross Energy Generation is calculated as follows:

\[
\text{Gross Energy Generation} = \text{Energy Sales} + \text{Used-on-Works} + \text{Network losses}
\]

The allocation of energy to each power plant is subsequently made on the basis of recent trends of the load duration curve. For a better understanding, a brief on the methodology used to estimate the energy generation is given in Appendix B3.

5.2.8 Evolution of Generation Mix
In the early 2000, CEB produced most of its electricity using heavy fuel oil. As from 2005, with the commissioning of CTDS and CTSav, the share of coal in the energy mix started to increase. The share of renewable energy (hydro and ‘bagasse’) has remained almost constant over the past decade.

* See glossary
Figure 5.4 illustrates the evolution of fuel mix from 2002 to 2011.

5.2.9 Generation System Costs
From an economic point of view, it is ideal to expand a power generating plant by adding generating units, which require low capital investment and have low operating costs. In reality, this is hardly possible. When assessing the economics of power generation technologies, two key cost elements are considered:

(a) Capital Investment Costs (expressed in MUR/kW) of different available technologies. The Capital Investment Cost is the capital outlay necessary to build the power plant;
(b) Power Generation Costs (expressed in MUR/kWh), which represent the total cost of generating electricity, using specific technology. Power generation costs consist of costs associated with the initial capital investment in a power plant (fixed investment charges), fuel costs, operation and maintenance costs and taxes and insurances.

A break-down of the general categories of costs for power generation technologies is presented in Figure 5.5 below. The dashed line indicates that the fixed investment charges are a function of the capital investment costs.
Generation Costs - CEB’s Plants

The average cost of generation of CEB plants is calculated using the weighted mean of units generated for a particular year. In general, CEB generates some 40% of its electricity from HFO and about 1% from kerosene. Hence, despite gas turbines having a high running cost, the average cost of CEB’s generation is close to the cost of generation from HFO engines. The unit cost of generation for CEB’s power plants consists of costs of fuel oil, lubricating oil, labour, maintenance, depreciation, administrative, overheads and finance costs.

Generation Costs - IPP Plants

Usually, IPPs’ costs of generation are lower than CEB’s generation costs for the following reasons:

(1) IPPs operate on coal which is a cheaper fuel than HFO; and
(2) Capacity Utilization Factor (CUF)* of IPPs is above 80% as they operate mostly as base plants.

The price (tariff) of electricity purchased from an IPP is normally agreed at the PPA negotiation stage. The agreed tariff, in most cases, includes an indexation mechanism based on:

- Actual cost of fuel on the world market;
- Inflation rate;
- Exchange rate; and
- Interest rate.

System Average Cost of Generation

Since both, IPPs and CEB power plants, are solicited to meet the daily demand, their combined costs of generation are used to determine the system generation cost. The variation in the system generation cost is a function of the hourly demand profile. During the night, the generation cost is at its lowest level because only the most efficient power plants are in operation. But at peak times, the system cost is relatively higher as high running cost engines have to be operated to meet short duration system demand. The average system cost of generation also depends on:

- Seasonality;
- Days of the week;
- Maintenance of plants; and
- Breakdown of plants.

Given the influence of these factors, the system generation cost, as such, varies continuously under different scenarios.

Cost of Generation of Renewable Energy

Save for the hidden cost to the environment, which is normally not included in the cost of operations of fossil-fuels-based generation, the cost of generation of renewable energy technology is comparatively higher than that of conventional sources of power generation. The main reasons for the high costs are the relatively significant initial investment and the very low capacity utilization factor of renewable energy projects. Given these constraints, the financial risks are indeed much higher in RE projects.

However, current trends show a gradual decrease in the cost of generation of renewable technologies. Two possible reasons may explain the decreasing costs:

(1) Competition among suppliers of renewable technologies on the world market; and
(2) New improved products with higher efficiencies being offered.

While there is growing pressure to increase the use of RE technology, their high investment costs continue to inhibit their fast penetration. In our context, with the current Government declared policy and the setting up of the MID fund, it is believed that renewable technologies will make promising progress in the coming years.

However, as things stand today, it seems that renewable energy generation will continue to be more expensive compared to oil- or coal-based electricity generation in the medium term, unless the environmental costs* associated with fossil-fuels-based generation are quantified and factored into the average system generation cost of conventional technologies. Estimating environmental costs is in fact highly challenging in practice.

Besides not having the necessary resources and being an electricity producer, it is not appropriate for the CEB to determine the environmental costs associated with its electricity production activities. The Ministry Of Environment and Sustainable Development (MOESD), which possesses the necessary environmental accounting tools and competences, is more
apt to determine the environmental costs of electricity generation from fossil fuels.

In similar vein, to ensure completeness in costs analysis and accounting, while the MOESD shall endeavour in determining the environmental costs of conventional electricity generating engines, it requires that the opportunity cost* of the massive investments made in the fossil-fuels-based technologies, which are required to back-up the operations of the RE technologies, be assessed equitably.

5.2.10 MID Contribution

In embracing the least-cost policy*, given the current state-of-affairs, renewable technologies being intermittent in nature will always be the second best alternative for the CEB. As mentioned above, the cost of generating energy from renewable sources is comparatively higher than the existing firm-power generating engines. Economically speaking, the higher cost of electricity produced from renewable energy sources should normally be translated into higher cost of electricity, unless it is subsidized.

In order to promote the integration of more renewable energy technologies in the energy mix, the support of Government is strongly required so as to cover the extra costs incurred in the purchase of the higher-cost cleaner energy. As such, financing from the MID fund is more than desirable in order to promote the adoption of renewable technologies.

CEB can only afford to pay the average system cost of generation and the MID fund to cover the additional costs implied in the tariff(s) of renewable energy generation.

The graph in Figure 5.6 below depicts a case, where the MID contributions have facilitated the implementation of renewable energy projects and enabled the CEB to purchase the electricity generated.

5.2.11 Consultancy Supports in Relation to Generation Capacity Expansion

In order to fulfil its mission of securing the future electricity supply of the country, CEB will continue to solicit, where necessary, the supports of reputable consultancy firms and international agencies. Already a few studies, as listed hereunder, will be carried out with the help of international experts this year:

- Pre-feasibility study for the use of Liquefied Natural Gas (LNG)* as an alternative to heavy fuel oil. LNG is an interesting option to enable the diversification of the country’s energy sources.
- Development of mini- and micro-hydro projects. This study will have as main objective to identify potential sites across the island, where mini- and micro-hydro generators can be installed.

The development of nuclear power for civil purposes appears to be gaining acceptance worldwide. As implausible as it may appear, nuclear technology is a generation option to substitute fossil-fuels-based generation in Mauritius. **As a matter of preparedness**, through the MEPU, CEB will initiate the process to seek technical assistance from the IAEA for preliminary research on future nuclear technology. In this regard, during the planning period, with the assistance of the IAEA, a roadmap for the possible implementation of this option will be defined so as to ascertain its economic viability. It is worth highlighting that this preparatory process in itself may cover a period of at least 10 to 15 years.

* See glossary