# Quantification of the Power System Energy Losses in South Pacific Utilities

## Solomon Islands Electricity Authority, Solomon Islands

Submitted to

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# 1. Executive Summary

KEMA at the request of the Pacific Power Association (PPA) conducted an energy efficiency study titled: "Quantification of Energy Efficiency in the Utilities in South Pacific Utilities" for 10 Southern Pacific Island Utilities. This report summarizes study results for the Solomon Islands Electricity Authority (SIEA) Honiara power system.

Project objectives and deliverables:

1. Quantification of energy losses in the power system.
2. Preparation of an Electrical Data Handbook containing electrical characteristics of the power system high voltage equipment.
3. Preparation of a digital circuit model of the power system using EASY POWER, an established commercial package.
4. Preparation of a prioritized replacement list of power system equipment to reduce technical losses.
5. Identification of sources of non-technical losses.
6. Recommendations for strategies on reducing technical and non-technical losses.

## 1.1 Quantification of System Losses

Losses throughout the SIEA system consist of power station losses and distribution system losses. Both loss categories are quantified.

- Station Losses: power plant auxiliary loads.
- Distribution System Losses: these losses can be divided into technical and non-technical parts as well as unbilled usage.
  - Technical losses: summation of transformer core losses, transformer copper losses, distribution feeder losses, secondary wire losses and losses of any other equipment in the system, like reactors and capacitor banks. Technical losses will become higher as power factors drop below unity.

– Non-technical losses: inaccurate meters, meter tampering or by-passing, theft, meter reading errors, irregularities with prepaid meters, administrative failures, wrong multiplying factors, others.

– Unbilled usages: energy consumption that is not billed should be considered a financial loss for the company rather than a non-technical loss.

As part of the study on supply side energy efficiency KEMA also analyzed generation efficiency.

## 1.2 SIEA's System Energy Losses

KEMA's analysis of the SIEA power system determined that total losses are 22.91% of annual generation, which is a very high percentage. These losses consist of:

- 2.89% in power station auxiliaries (station losses).
- 5.85% in technical losses.
- 17.05% in non-technical losses.

Non-technical losses may include unbilled usage, which typically consists of a utility's own building usage, energy used by pumps for the water and sewer systems, street lights, etc. Energy usage for these applications is typically estimated and subsidized by the government. Considering no unbilled usage information was provided for the SIEA system, and unbilled usage was assumed to be zero.

### 1.2.1 Generation Losses

Station losses are the difference between total energy produced by the generating units and total energy entering into the transmission and distribution delivery system and, as previously mentioned, were estimated as 2.89%. KEMA was able to estimate the station losses from the data provided.

### 1.2.2 Transmission and Distribution Losses

The SIEA Honiara Transmission and Distribution system consists of a 33kV transmission system that serves several 33-11kV distribution substations, which in turn serve the 11kV feeders. There are two main power stations: Honiara Power Station and Lungga Power Station.

The 11kV feeders in Honiara are comprised of both overhead and underground conductors connecting Ring Main Units (RMU) as well as pole-top transformers that serve the secondary loads. The primary system losses were estimated from the power flow study and metering data that was combined with calculations in Excel spreadsheets for transformer losses and LV system losses.

### 1.2.3 Non-technical Losses

The non-technical losses at SIEA are 17.05%, which is very high. Based on KEMA's experience a good value would be below 4 percent for a system such as SIEA. Activities such as electricity theft, meter tampering, and meter by-passing may be contributing to the high level of non-technical losses on the Honiara power system.

Therefore, an analysis of non-technical losses should be a major focus for loss improvement. KEMA offers suggestions in this regard described in the following sections.

#### 1.2.3.1 Metering

KEMA found no significant metering issues or irregularities, but does not have good data on the condition of the meter population.

## 1.3 Recommendations

### 1.3.1 Generation Losses

The loss component due to power station usage (2.89%) is in the normal range, but there may still be options for improvement. An energy efficiency audit could reveal possibilities for energy savings.

### 1.3.2 Transmission and Distribution Losses

The 33kV transmission circuits in Honiara are comprised of overhead and underground circuits, which are listed in the data handbook. Three of the 5 transmission circuits connect Lungga Power Station, Honiara Power Station, and Ranadi Substation in a loop configuration, with radial 33kV lines serving Honiara East and White River Substations.

The Honiara distribution system is comprised of overhead and underground 11 kV circuits, which are listed in the data handbook. The substation cable tails are all underground cables and are listed below:

- 95 mm$^2$ XLPE 3-conductor Al cable (Feeders 1,2 and 4)
- 70 mm$^2$ PILC 3-conductor Cu cable (Feeders 3,5,6 and 12)
- 70 mm$^2$ XLPE 3-conductor Al cable (Feeders EH-1, R-1 and WR-1)
- 150 mm$^2$ XLPE 3-conductor Cu cable (Feeder 11)

These conductors were adequately sized for load-serving purposes and do not require replacement to serve the existing load. As long as future load growth does not create a risk of the distribution feeder conductors being loaded beyond their thermal limits, KEMA does not recommend changing feeder conductors just for the purpose of reducing losses. Should system load or patterns require an increase in conductor size, then consideration should be given to losses in the choice of new conductors.

## 1.3.3 Non-technical

SIEA's non-technical losses of 17.05% are extremely high. This suggests that undesirable activities such as electricity theft, meter tampering, and meter by-passing (all examples of non-technical losses) are a serious problem on the SIEA system.

### 1.3.3.1 Metering

Since the non-technical losses are high, KEMA recommends that a program focused on discovering theft, meter tampering, and other causes of non-technical losses should be implemented immediately.

A Customer Information System should be implemented to aggregate the customer meter readings, and calculate the loading for each distribution transformer. This is a very valuable tool for planning and for identifying when customer metering irregularities occur.

See section 6 for more details regarding metering issues and recommendations.

#### 1.3.3.2 Other Losses

As non-technical losses on the Honiara system are so high, theft could be a greater issue than currently recognized by the SIEA. Possible causes of theft should be investigated thoroughly.

It was brought to KEMA's attention that there are known non-payment issues with the Solomon Island Water Authority. Energy usage for the water and sewer pump systems is already being monitored. This should be considered a financial loss, and not a non-technical loss.

## 1.4 Prioritized list of equipment for replacement

Based on KEMA's review of the SIEA electric system, the following list of equipment is recommended for replacement.

1. Generators. Two of the nine diesel units owned by SIEA in the Honiara system were not operable at the time of KEMA's site visit. The current Honiara electric system only has an adequate resource reserve margin for the worst n-1 scenario, but cannot meet an n-2 reliability criterion. Based on improved generation efficiency and fuel savings, SIEA should consider replacing one of the retired decommissioned units at Honiara Power Station. The new generating unit should have a capacity of 1500 kW and, if used for base-load at highest efficiency (assumed to be 4 kWh / Liter), the average system fuel efficiency is expected to go up to 3.84 kWh / Liter, which means that the yearly savings on SIEA fuel cost would exceed the annual carrying costs of the new generator (see Section 3.1.2). This generator replacement would also improve system reliability (see Section 3.1.1).

2. Metering. Old meters should be tested at regular intervals and replaced when found to be inaccurate.

# 2. Project Approach

In January 2011, KEMA launched 10 studies on behalf of the Pacific Power Association (PPA) to quantify power system energy losses by utility across the South Pacific region. The purpose of these studies is to review the power system energy losses in each utility's existing generation facilities, transmission and distribution networks, and billing procedures and to identify where losses occur in the system and to quantify those losses. Finally, these studies will supply recommendations to minimize energy losses and prioritize which assets will reduce losses most through upgrades or replacement for each utility.

Within weeks of contract award, KEMA submitted data requests to the appropriate utilities and proposed project execution methodologies to PPA for approval to gain an understanding of each utility's systems prior to conducting site visits.

## 2.1 Data Collection

Prior to visiting of the city of Honiara for data collection and technical assessments of the power system, KEMA sent data request documents on February 23, 2011 regarding information needed to create a power system model using EasyPower®, so that the data definitions used in the data request were consistent with the simulation software and to ensure the accuracy of the study results.

Subsequently, KEMA visited Honiara from April 5th to April 8th 2011 to collect data, interview key SIEA personnel, and assess the power system.

During the visit much relevant data was gathered and SIEA personnel were very helpful and provided information regarding billing, generation, and loss statistics. Plant generator schedules, equipment nameplate information and other relevant data were all readily accessible.

After the on-site visit some clarifications were requested by e-mail and additional generation, load, and loss information was promptly received.

## 2.2 Utility Operations

The SIEA system peak load condition for 2010 on the Honiara system was 13,780 kW. The total connected distribution transformer capacity on the SIEA system was 29,770 kVA. The power system consists of:

- Honiara Power Station houses three (3) diesel generators. Data for these units is given in the Data Handbook. The generator capabilities are summarized as follows:

- Lungga Power Station houses six (6) diesel generators. Data for these units is given in the Data Handbook. The generator capabilities are summarized as follows:

- A 33kV transmission system comprised of five (5) feeders connecting the Lungga and Honiara Power Stations to the Honiara East, Ranadi, and White River Substations. Four of the five transmission circuits are underground cables.

- An 11kV distribution system comprised of eleven (11) feeders. There are six (6) feeders emerging from Honiara Power Station, two (2) from Lungga Power Station, and one (1) each from East Honiara, Ranadi, and White River Substations.

- At the end of February 2010, there were 10,411 customers served by the Honiara system. Of these, 6,184 were metered using conventional energy meters, and 4,227 prepaid for their usage using Cashpower metering devices. By the end of November 2010, more customers were using the prepaid metering program as opposed to the conventional metering services (6,500 Cashpower customers vs. 4,000 kWh customers).

With a peak load of 13,780 kW and 25,710 kW of available generation, the SIEA system had a reserve margin of 34% in 2010. The n-1 availability criterion (loss of the largest unit) reserve margin was 3.5%, and would have to shed load for an n-2 generating unit condition at peak loads.

## 2.3 Identifying and Quantifying Losses

Electric power is generated in power stations and delivered through the transmission and distribution systems to the customer. Energy losses occur in each part of the power system until reaching the customer's meter. Power system energy losses are divided into categories based on where the losses happen and the cause as indicated below:

1. Power station losses – energy consumed by the equipment in support of power generation, also called power station auxiliary load or power station own usage.

2. System losses – losses incurred by moving power through the transmission and distribution systems, including transformers, over-head line conductors, areal cables or underground cables, and LV secondary service wires.

Losses in category 2 consist of both Technical Losses and Non-technical Losses. Technical losses are the losses that can be estimated as a result of electric current passing through the power system equipment. In contrast to technical losses, there are non-technical losses, which are not directly caused by power system equipment. Causes of non-technical losses can include inadequate or inaccurate meters, theft, meter tampering or by-passing, meter-reading errors, irregularities with prepaid meters, administrative failures, and wrong multiplying factors.

There is another category of losses due to energy usage that is not accounted for and subsequently not billed for. The unbilled usage results in a financial loss to the utility and should not be included as part of non-technical loss. Examples of unbilled usages that KEMA found in some cases include street lighting, own building usage, and electric power used for supplying other utilities such as water and sewage.

Furthermore, financial losses may present due to a non-optimized efficiency of the generation system and individual generating units. Improvement of the generation efficiency will lead to fuel savings.

In this study, KEMA estimated power station losses and distribution system losses. Where information was not sufficient, assumptions were made to facilitate the estimation. KEMA created a Power flow model in EasyPower to represent the SIEA power system of Honiara. Power flow studies were performed for the peak load condition. Peak system losses in kW, including primary feeder losses and power transformer copper losses, were estimated based on the results from the power flow study. An Excel spreadsheet was created to estimate the peak kW losses that were not calculated in power flow study, such as power transformer core losses, distribution transformer losses, and LV service wire losses. These kW losses were converted to annual kWh energy losses by utilizing the estimated Loss Factor. Unbilled usage was estimated for all the causes identified.

The total system energy losses are equal to the total annual energy produced by the power stations less the station own use and annual energy sold. Non-technical losses were then derived by comparing the total system losses and the sum of the technical losses and unbilled usage.

# 3. Generation

At the time of KEMA's visit to the island of Guadalcanal, the 2 main power stations, Honiara and Lungga Power Stations together contained a total of nine (9) diesel generators. Units 1 and 2 at Honiara Power Station were not available for service at the time of KEMA's visit.

## 3.1 Equipment

Honiara and Lungga Power Stations generator units specifications, as listed in the SIEA Data Handbook, are aggregated in Table 1.

**Table 1 – Honiara and Lungga Generator Units**

| Location | Unit ID | Make | Rated | | | |
|---|---|---|---|---|---|---|
| | | | kV | MVA | Pf | MW |
| Honiara | H1* | Perkins | 0.415 | 1.88 | 0.8 | 1.5 |
| | H2* | Perkins | 0.415 | 1.88 | 0.8 | 1.5 |
| | H3 | Perkins | 0.415 | 1.88 | 0.8 | 1.5 |
| Lungga | L5 | Mirlees | 11 | 1.91 | 0.8 | 1.53 |
| | L6 | Mirlees | 11 | 3.55 | 0.8 | 2.84 |
| | L7 | Wärtsilä | 11 | 5.3 | 0.8 | 4.24 |
| | L8 | Wärtsilä | 11 | 5.25 | 0.8 | 4.2 |
| | L9 | Mitsubishi | 11 | 5.25 | 0.8 | 4.2 |
| | L10 | Niigata | 11 | 5.25 | 0.8 | 4.2 |

* Units were out-of-service at the time of KEMA's visit.

The following pictures illustrate the condition of the generator units during the time of KEMA's visit in April 2011.

**Figure 1 – Honiara Unit 1**

**Figure 2 – Honiara Unit 2**

**Figure 3 – Honiara Unit 3**

**Figure 4 – Lungga Unit 5**

**Figure 4 – Lungga Unit 6**

**Figure 6 – Lungga Unit 7**

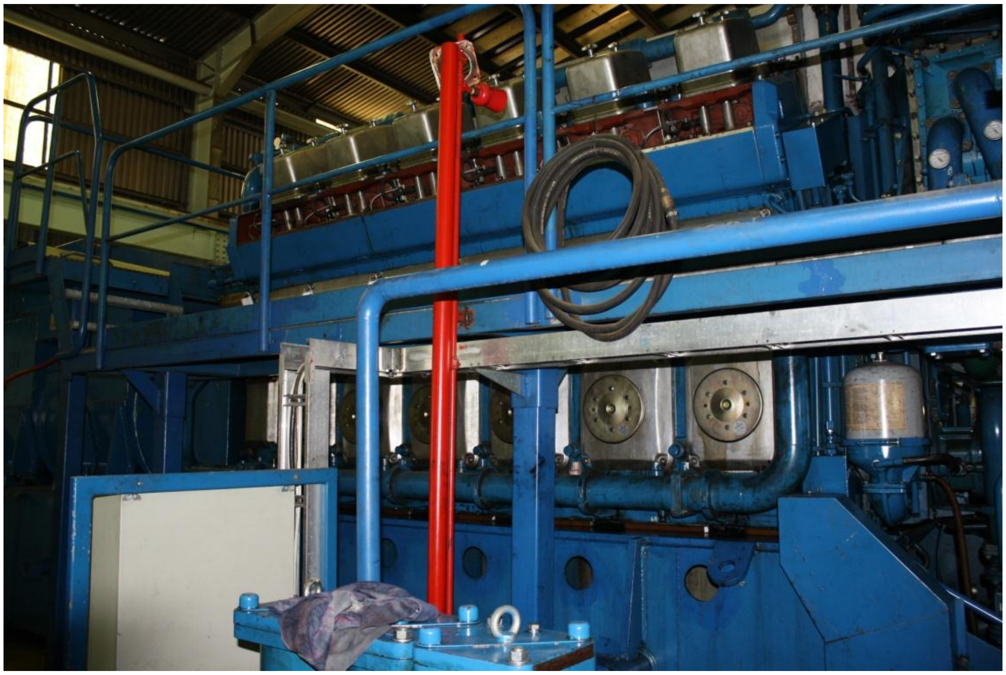


**Figure 7 – Lungga Unit 8**

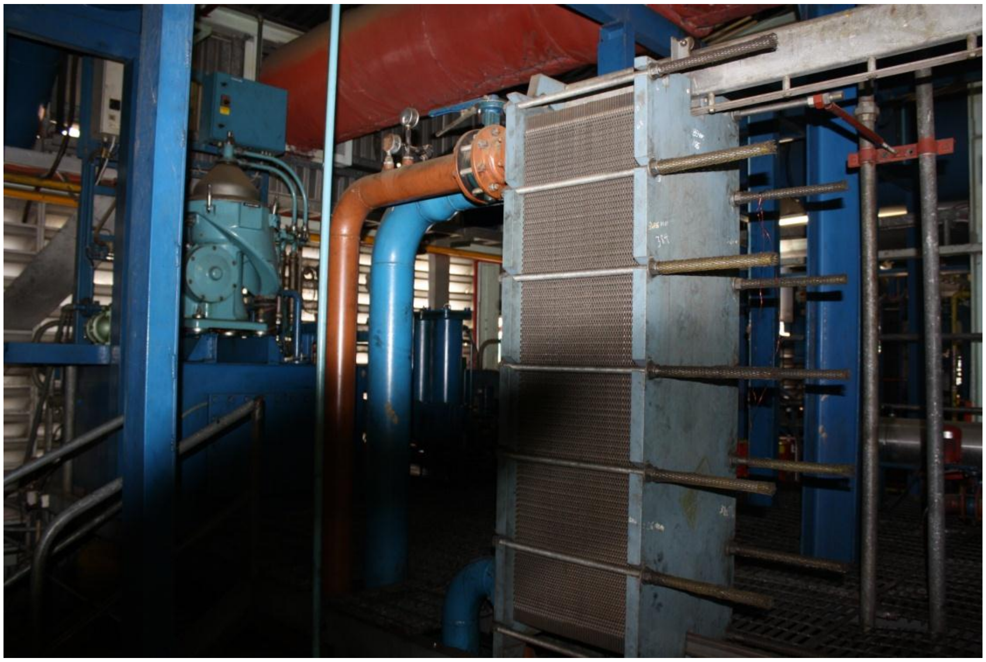


**Figure 8 – Lungga Unit 9**

**Figure 9 – Lungga Unit 10**

As provided in the SIEA Data Handbook, the Honiara station transformer equipment consists of the following:

- Three (3) 11/33 kV step up transformers connecting the Lungga Power Station to the distribution network,
- Five (5) 33/11 kV step down transformers throughout the system stations linking the secondary distribution network. Two (2) are at Honiara Power Station, and one (1) each at the Ranadi, East Honiara, and White River substations.
- Ten (10) 11/.415 kV step down transformers feeding the stations auxiliaries: four (4) at the Lungga Power Station, three (3) at the Honiara Power Station, one (1) each at Ranadi, Honiara East, and White River substations
- One (1) 11/.415 kV earthing transformer at the Honiara Power Station.

### 3.1.1 Reliability Criteria

The reserve margins were evaluated based on the capacity available for dispatch at the time of KEMA's visit and the latest recorded peak demand, which was 15.31 MW in November 2010.

The n-1 reserve margin was calculated assuming the contingency of the largest generator; the L7 Unit at Lungga Power Station, which is rated at 4.24 MW. This event would diminish the capacity available for dispatch to 18.47 MW, leaving a reserve margin of 3.16 MW, or a 20.91%.

The n-2 criterion was calculated assuming the contingency of the aforementioned L7 unit, and any one of the 4.2 MW units (L8, L9, or L10) at the Lungga Power Station. This event would diminish the capacity available for dispatch to 14.27 MW, which would not be sufficient to serve the peak load of 15.31 MW and the system would experience a generation deficiency of 1.04 MW.

The calculated capacity reserve margins are shown in Table 2.

**Table 2 – Current Reliability Criteria***

| Scenario | Capacity Reserve Margin |
|---|---|
| **n-1** | 20.91% |
| **n-2** | -6.53% |

* These criteria are calculated disregarding the generation capacities of units H1 and H2.

This situation can be mitigated by replacing one of the decommissioned 1500 kW units (H1 or H2) at the Honiara Power Station. This would be sufficient to meet the peak demand under the n-2 reliability criterion. The improvement in reserve margins with the addition of a 1500 kW unit are illustrated in Table 3.

**Table 3 – Reliability Criteria with Additional 1500 kW Unit***

| Scenario | Capacity Margin |
|---|---|
| **n-1** | 30.71% |
| **n-2** | 3.27% |

* These criteria are calculated without the contribution of units H1 and H2.

Beyond meeting the capacity reserve margins for the n-2 reliability criterion, replacing generator H1 or H2 at the Honiara Power Station is expected to have a beneficial impact on the overall system fuel efficiency.

### 3.1.2 Net Present Value (NPV) Calculations

Using 2010 production and fuel efficiency data as the base case, KEMA estimated the financial benefit associated with the introduction of a new 1500 kW unit. The following assumptions were made based on system average figures and realistic estimates:

1. The new generator unit will replace unit H1 at Honiara Power Station,
2. The new generator unit has a utilization factor of 35% throughout the year, producing 4,599 MWh / year,
3. The new generator is dispatched strategically to have a fuel efficiency of 4 kWh / Liter,
4. The existing generators are dispatched in such a way as to maintain their current fuel efficiency rates,
5. The long term average price forecast for diesel fuel was assumed to be $1.75/liter.
6. The power produced by the new generator will completely displace the contribution from H2 because it is out-of-service. It will also completely displace the contribution from H3 and a portion of L9 because, of the remaining existing units, these are the least fuel efficient,
7. The new unit has a financial life of 20 years.
8. The new unit can be dispatched as a base-load generator to serve the same loads as Lungga Power Station.

Table 4 illustrates the current fuel efficiency figures for 2010; this is the base case scenario and was calculated using data provided by SIEA.

**Table 4 - System Production and Efficiency for 2010**

| Station | Unit ID | Fuel Used (Liters) | Production (kWh) | Fuel Efficiency (kWh / Liter) |
|---|---|---|---|---|
| Honiara | H1 | 0 | 0 | - |
| | H2 | 43,378 | 166,850 | 3.85 |
| | H3 | 103,398 | 345,780 | 3.34 |
| Lungga | L5 | 206,023 | 765,400 | 3.72 |
| | L6 | 1,146,420 | 4,246,012 | 3.70 |
| | L7 | 6,479,679 | 24,583,840 | 3.79 |
| | L8 | 1,894,693 | 7,297,490 | 3.85 |
| | L9 | 4,062,409 | 14,689,178 | 3.62 |
| | L10 | 5,993,987 | 22,427,430 | 3.74 |
| **Total** | | **19,929,987** | **74,521,980** | **3.74** |

With replacement of H1, part of the energy produced by the new generating unit completely replaces the output of units H2 and H3 at Honiara Power Station. The rest of H1 output displaces the energy produced by unit L9 at Lungga Power Station by roughly 4 GWh per year. Table 5 shows the expected effect adding the new generator unit will have on the other generator units' production forecast, with the greatest impacts on existing units highlighted in red.

### Table 5 - Production and Efficiency with Replacement of 1500 kW Generator

| Station | Unit ID | Fuel Used (Liters) | Production (kWh) | Fuel Efficiency (kWh / Liter) |
|---|---|---|---|---|
| Honiara | NEW | 1,149,750 | 4,599,000 | 4.00 |
| | H2 | 0 | 0 | - |
| | H3 | 0 | 0 | - |
| Lungga | L5 | 206,023 | 765,400 | 3.72 |
| | L6 | 1,146,420 | 4,246,012 | 3.70 |
| | L7 | 6,479,679 | 24,583,840 | 3.79 |
| | L8 | 1,894,693 | 7,297,490 | 3.85 |
| | L9 | 2,928,952 | 10,602,808 | 3.62 |
| | L10 | 5,583,749 | 22,427,430 | 3.74 |
| **Total** | | **19,389,266** | **74,521,980** | **3.84** |

The addition of the new generator is expected to increase the average system fuel efficiency from 3.74 kWh / Liter to 3.84 kWh / Liter saving roughly 500,000 liters of diesel per year under the stated assumptions.

Table 6 illustrates the economic assumptions made for the calculation of the Net Present Value (NPV) of installing a new generator. The assumed Diesel cost per liter represents the average fuel price forecast over the lifetime of the new generator. The inflation, cost of capital and financial lifetime assumptions made by KEMA are based on typical values.

### Table 6 – Economic Assumption

| Economic Inputs | |
|---|---|
| **Inflation** | **3.00%** |
| **Cost of Capital** | **8.00%** |
| **Financial Life** | **20 Years** |
| **Price of Diesel** | **$1.75 / Liter** |

Table 7 shows the results of the NPV calculations with and without the new 1500 kW generator unit.

**Table 7 - NPV of New Generator Unit**

| Scenario | Adding 1 Generator | No Change |
|---|---|---|
| **Generator Installation Cost** | | |
| Installation cost | 1400 $/kW | 1400 $/kW |
| Unit Capacity | 1500 kW | 0 kW |
| Capital Cost | $2,100,000 | $0 |
| Annual Payment | $213,889 /Year | $0 /Year |
| **NPV of Capital Cost** | **$2,692,820** | **$0** |
| **Additional Generator Maintenance** | | |
| Annual Cost | $12,000 /Year | $0 /Year |
| **NPV of Generator Maintenance** | **$151,077** | **$0** |
| **Fuel Cost** | | |
| Fuel Efficiency | 3.84 kW/Liter | 3.74 kW/Liter |
| Production | 74,521,980 kWh/Year | 74,521,980 kWh/Year |
| Fuel Usage | 19,389,266 Liters/Year | 19,929,987 Liters/Year |
| Annual Cost | $33,931,216 /Year | $34,877,477 /Year |
| **NPV of Fuel Expenditures** | **$427,186,037** | **$439,099,239** |
| **Total Annual Cost** | $34,157,105 / Year | $34,877,477 / Year |
| **Total Annual Savings** | $720,372 / Year | $0 / Year |
| **NPV of Total Expenditures** | **$430,029,934** | **$439,099,239** |

Therefore, the proposed unit is projected to result in a $720,372 net savings annually to SEIA. Although the economic and reliability analysis is based on a new 1500 kW unit, it is possible that larger generator sizes may be even more cost effective. SIEA should consider appropriate options in this regard.

The NPV comparison in Table 7 shows that investing in a new 1500 kW generator unit is economically justified.

As stated earlier in the list of technical assumptions, the new generator is assumed to be able to serve the same loads as the ones served by the Lungga Power Station; and effectively be dispatched as a base-load generator.  According to the data provided by SIEA, the existing units at Honiara Power Station seemed to be dispatched for short periods of time to meet peak demands. However, the new unit for H1 should be specified as a base-load generator.

## 3.2 Analysis of Losses

This section addresses the fuel efficiency of the generator units and station auxiliary losses (own usage).

***Fuel Efficiency***

Monthly fuel usage statistics for 2010 were provided to KEMA in an Excel spreadsheet and were used to calculate the efficiency of the generators that were in operation during that time, as well as the system average on Honiara system. This is summarized in Table 4.

Well-maintained and properly dispatched diesel engine fuel efficiency should be around 4 kWh per liter. These fuel efficiency figures indicate that there are likely to be possibilities for improvement in SIEA Honiara generator dispatch and engine maintenance programs. Generating units typically have the best fuel efficiency when running around their rated power output.

***Station Losses***

As already mentioned, the station losses were estimated as 2.89%. Station losses are the difference between total energy produced by the generating units and total energy entering into the transmission and distribution system. This value for station losses is in the normal range, but options for reducing these losses should be investigated.

## 3.3 Findings

KEMA's review of the SIEA generator fuel efficiency and station losses on the Honiara system have revealed some areas for improvement, as listed below:

- Investigate ways to improve diesel engine operation to improve generator fuel efficiency. Areas for improvement include engine maintenance practices and generator dispatch procedures.

- Purchase one new diesel generator unit to replace one of the aging Honiara 1500 kW Units 1 or 2, which were under repair or out of service at the time of KEMA's visit. Replacing one unit would improve the n-1 capacity reserve margin, and is necessary to maintain an acceptable resource reserve margin of roughly 3%. As discussed in section 3.2, unit replacement will result in improved fuel efficiency and economic savings.

# 4. Transmission and Distribution

During KEMA's site visit to the island of Guadalcanal in the Solomon Islands, the SIEA provided a one-line diagram of the Honiara 33 kV transmission and 11 kV distribution systems. Also provided was a copy of the "SIEA Transmission and Distribution Network Data Book 2010", which included data that was used in the EasyPower model such as conductor types, line section lengths, and distribution transformer locations and sizes. KEMA used this data to prepare the EasyPower model which was then used to evaluate system losses.

The SIEA also provided monthly and total generation and sales figures for the Honiara system for 2010 which were also used in the evaluation of system losses.

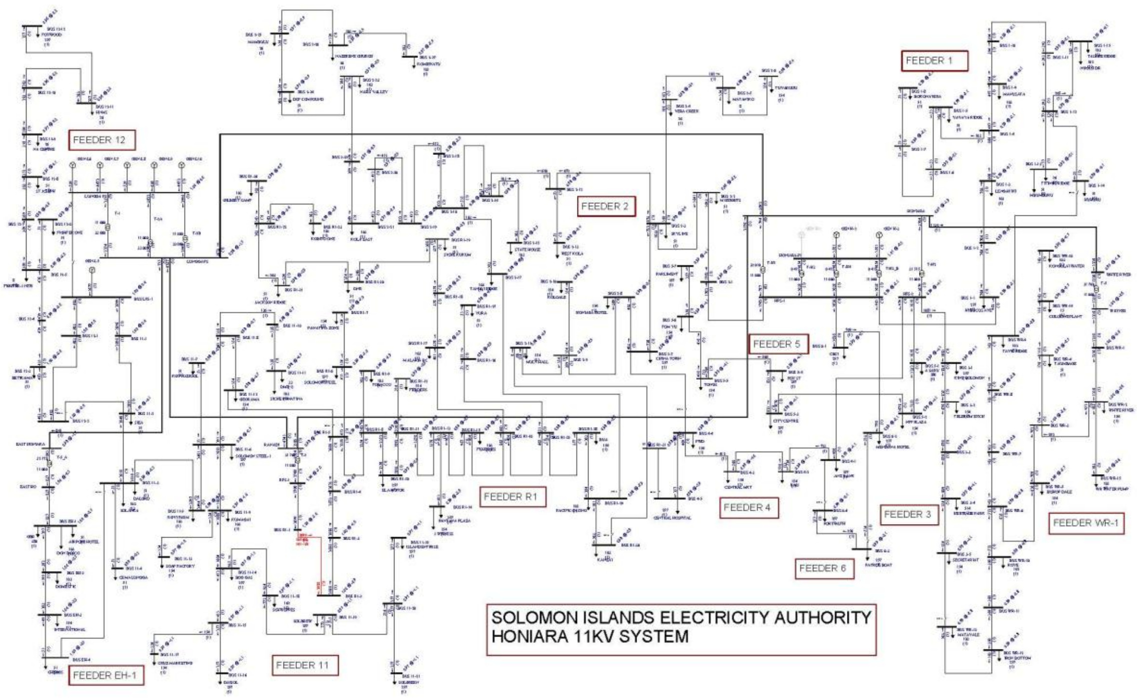
The distribution system consists of a mixture of 11 kV overhead and underground conductors that serve Ring Main Units (RMU) and pole-mounted transformers. The substation getaway conductors are all underground cables and are listed below:

- 95 $mm^2$ XLPE 3-conductor Al cable (Feeders 1,2 and 4)
- 70 $mm^2$ PILC 3-conductor Cu cable (Feeders 3,5,6 and 12)
- 70 $mm^2$ XLPE 3-conductor Al cable (Feeders EH-1, R-1 and WR-1)
- 150 $mm^2$ XLPE 3-conductor Cu cable (Feeder 11)

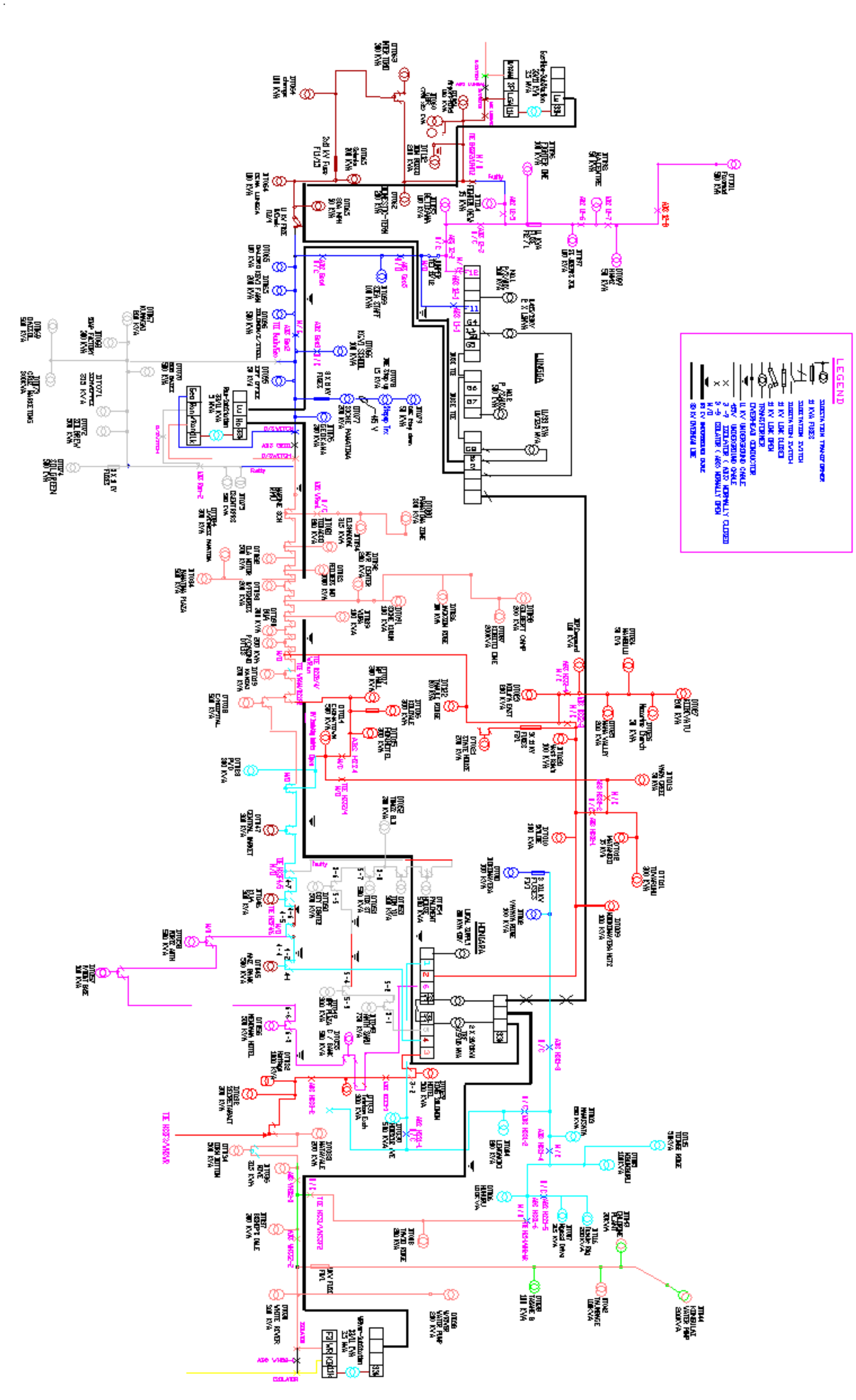
The 33kV transmission circuits on the island of Guadalcanal are comprised of overhead and underground circuits, which are listed in the data handbook. Three of the 5 transmission circuits connect Lungga Power Station, Honiara Power Station, and Ranadi Substation in a loop configuration, with radial 33kV lines serving Honiara East and White River Substations.

A one line diagram of the EasyPower model is provided in figure 11. A larger version of this diagram, along with an Excel spreadsheet file of the loss calculations, are included with the data handbook in the Appendices.

## Figure 10 – Honiara System One-Line Diagram from EasyPower Model



## Figure 11 - Honiara System One-Line Diagram from SIEA

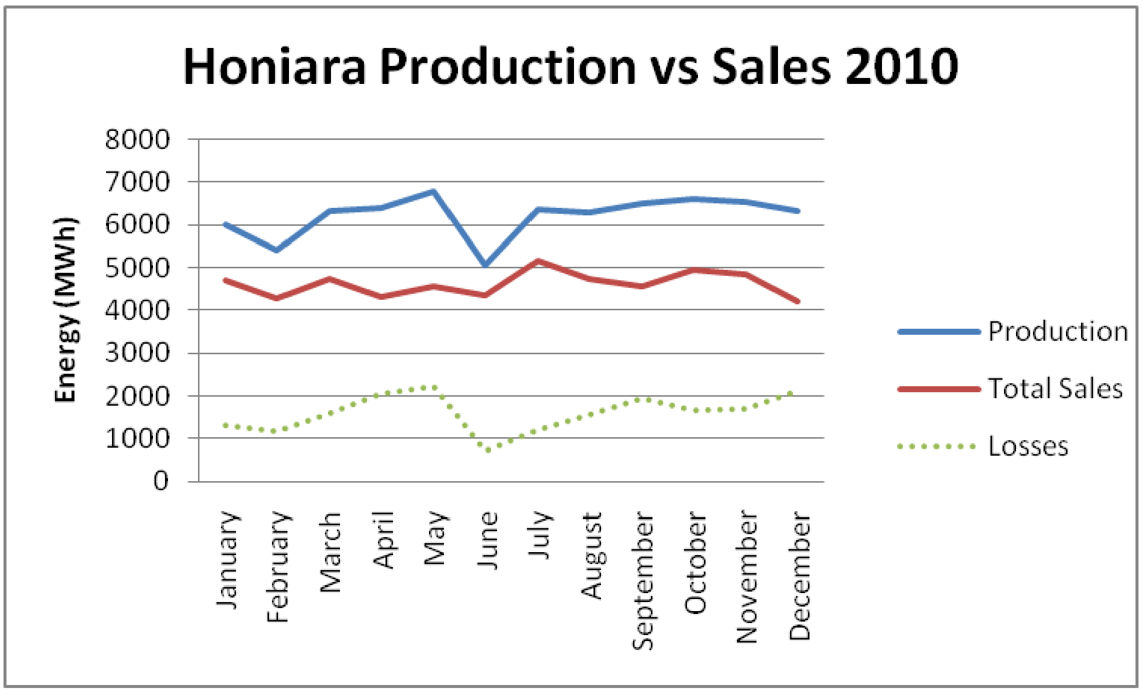


The following SIEA 2010 Honiara power system statistics are relevant to the loss study:

- There were 128 distribution transformers with total connected capacity of 29,770 kVA.
- The Honiara system peak load was 13,780 kW.
- There were 10,411 customers on the SIEA Honiara system.
- The SIEA Honiara distribution system contains no switched reactors or shunt capacitors.

The SIEA provided KEMA with monthly data for gross energy generated and the energy billed on the Honiara system for 2010. These are shown graphically in Figure 13.

**Figure 12 – 2010 Monthly Energy Generated and Sold**




The difference between energy billed and energy generated represents the total of all station losses and transmission and distribution system losses on the Honiara system. It is unclear why the level of losses dropped significantly in June.

## 4.1 Equipment

The SIEA Honiara 33 kV transmission system and 11 kV distribution system equipment is discussed in the following sections.

### 4.1.1 Transmission System

The SIEA Honiara 33 kV transmission system consists of the following circuits:

- TL-1 is an overhead line comprised of Dog ACSR conductor that connects Lungga Power Station with Honiara Power Station.
- TL-2 is an underground circuit with 70 mm$^2$ Al XLPE Cable that connects Lungga Power Station with Ranadi Substation.
- TL-3 completes the 33 kV loop by connecting Ranadi Substation with Honiara Power Station through a 70 mm$^2$ Al XLPE underground cable.
- TL-4 is an underground circuit comprised of 50 mm$^2$ Al XLPE cable that feeds Honiara East Substation from Lungga Power Station.
- TL-5 is an underground circuit comprised of 50 mm$^2$ Al XLPE cable that feeds White River Substation from Honiara Power Station.

Complete Transmission Line data for Honiara is given in the SIEA Draft Data Handbook (2010).

### 4.1.2 Distribution System

The SIEA 11 kV distribution system on the island of Guadalcanal consists of 11 distribution feeders. The substation getaway conductors are all underground cables and are listed below:

- 95 mm$^2$ XLPE 3-conductor Al cable (Feeders 1,2 and 4)
- 70 mm$^2$ PILC 3-conductor Cu cable (Feeders 3,5,6 and 12)
- 70 mm$^2$ XLPE 3-conductor Al cable (Feeders EH-1, R-1 and WR-1)
- 150 mm$^2$ XLPE 3-conductor Cu cable (Feeder 11)

As of 2010, the SIEA Honiara power system had 113 three-phase distribution transformers installed along the 11 kV distribution feeders with a total installed capacity of 29,770 kVA (this excludes station service transformers).

### 4.1.3 LV Wires

The secondary system consists of wires connecting from the low voltage (LV) side of distribution transformers to the customer meter. Since no information in regards to the secondary system was provided, KEMA made assumptions about typical secondary wire configurations in order to estimate the secondary wire losses.

## 4.2 Analysis of Losses

To quantify losses through the distribution system and service wires, the following assumptions were made:

1. The total energy generated and energy sold over the past one year (01/2010-12/2010) was used for the study.
2. Loads were distributed based on the distribution transformer locations.
3. Loads were allocated proportionally to the kVA capacity of each distribution transformer.
4. Actual voltage drops through primary feeders were calculated in power flow study with model in Easy Power. However, voltage drops through feeders were not considered in loss estimations for distribution transformers and secondary services wires.
5. Typical value for transformer no-load losses and load losses from literature[1] were used to estimate distribution transformer losses.
6. A typical value for transformer no-load losses from literature[2] was used to estimate power transformer losses.

[1] EN 50464-1, 2007 Three-phase oil-immersed distribution transformers 50 Hz, from 50 kVA to 2500 kVA with highest voltage for equipment not exceeding 36 kV - Part 1: General requirements, data for three-phase transformers.

7. Secondary wire losses were estimated based on average customer consumption for all customers combined.

8. Typical secondary service wire type, size and configuration were assumed, no information was provided.

SIEA has provided one-line diagram of Honiara interconnected system. Detail information about feeder segment distance, conductor type and size, and kVA capacity of distribution transformers are provided in the draft SIEA Transmission and Distribution Network Data Book dated November 2010.

KEMA developed a power flow model in Easy Power for Honiara network based on the one line diagram and data provided in the data book. Assumptions are taken for feeder sections where size or length information are missing from the data book. There are a number of distribution transformers of which kVA sizes are not consistent between the one line diagram and the data book, sizes as marked on one line diagram are used in the power flow model as well as in the loss estimation. Power flow model assumption details are provided in Appendix A. This distribution system model includes two power stations: Honiara power station and Lungga power station, and 33kV to 11kV distribution system. Distribution transformers were represented as spot loads with a constant kVA load equal to the transformer capacity and load power factor of 0.9. Easy Power provides a feature that allows the user to scale loads to a specific value when the power flow is performed.

Power flow through the 33kV lines between the two power stations is affected by the operation and maintenance outage schedule of the power stations. According to SIEA's monthly statistics for 2010, Honiara power station had no power output for 3 out of 12 months of the year. In the power flow study for the peak load condition, generator dispatches were assumed based on the 2010 generation production statistics provided. Therefore, for the loss analysis, two (2) separate power flow cases were developed. One case had power output from both Honiara and Lungga power stations, while the other case had power output from Lungga power station only. The power flow study results for both cases are shown in Table 8.

**Table 8 - Power Flow Summary**

[2] Typical Load and No-Load Losses Related to Sizing MVA, Figure from Areva Transformer Handbook (2008)

| Scenario | Time Duration (% of the year) | Total feeder and power transformer losses* (kW) | Power transformer losses only* (kW) |
|---|---|---|---|
| **Lungga Online and Honiara Online** | 9 months (75%) | 288.3 | 39 |
| **Lungga Online and Honiara Offline** | 3 months (25%) | 394.2 | 66.9 |

*For transformers, power flow analysis only calculates load loss.

To estimate annual system losses, peak kW losses were calculated for both power dispatch scenarios and a weighted average was determined according to the percentage of time during the year each scenario occurred in 2010.

Losses in kW through the primary feeders and power transformers were calculated in the power flow study at the system peak demand. System load is allocated proportionally to distribution transformers by their connected KVA capacities allocated to each feeder. The KEMA power flow study corresponded with a 13,780 kW peak load condition for 2010 by applying a system Utilization Factor of 51.43% to all loads. The total connected capacity used was 29,770 kVA.

For the SIEA power system in Honiara, electric power is supplied from two generation stations. In 2010, the annual generation production was 74,521,980 kWh and power stations auxiliary usage was 2,152,593 kWh. Energy sent out to the distribution system after power station's own usage was measured as 72,369,387 kWh. In 2010, system peak demand was 13,780 kW. Honiara interconnected system has load factor estimated as 60% and loss factor estimated as 41%. The technical losses in kW were converted into kWh energy losses and the results are presented in the next section.

Distribution transformer losses were estimated with typical loss data. Secondary wire losses were estimated with typical configuration and average customer consumption for all customers. Secondary system consists of wires connecting from the low voltage (LV) side of distribution transformer to the customer meter. The only information KEMA got about the secondary system was that the secondary lines are Aluminum bundle conductors of sizes from 25 to 95 $mm^2$. KEMA took assumption of typical secondary wire configuration to estimate secondary losses. It is assumed that the typical secondary system wires are in tree structure, with the 3-phase LV cable as the Secondary Line (SL) and single phase wires as Service Drops (SD) tapping along the Secondary Line in equal distance and extending to each customer meter. All customers were considered and assumed to be mixed along the SL.

- Service Line (SL) is also referred as LV feeder or secondary feeder (in contrast to 11kV feeder as primary feeder). Service Line connects from LV side of the distribution transformer with service drops tapping along it. Assuming that in average there are 2 SL per distribution transformer with average length of 500 meter per SL. Typical SL cable is size 25 to 95 $mm^2$ Aluminum 3-phase bundled cables. Average Ohm/km resistance of 25 and 95 $mm^2$ Aluminum cable is used as typical SL resistance for SL loss estimation. SIEA should collect data for the actual SL type and size to develop typical value based on that.

- Service Drops (SD) are tapped from SL and extended to customer meter. It was brought to KEMA's attention by the PPA that it is common practice to use 10$mm^2$ twisted copper conductors for single phase SD, therefore this conductor type was assumed for loss estimation, along with an average length of 20 meter.

## 4.3 Findings

The total system losses are equal to the total energy that entered into the distribution system out of power stations less the total energy sold and the energy unaccounted for. It was brought to KEMA's attention by the PPA that street lighting is metered. However, SIEA did not state whether this energy was billed or not, therefore unbilled usage was estimated as zero. A summary of estimated losses is provided in Table 9.

**Table 9 - Loss Estimation**

| System Data | Energy (kWh) | % of generation | % of system consumption |
|---|---|---|---|
| annual generation | 74,521,980 | | |
| annual station auxiliary | 2,152,593 | 2.89% | |
| annual system consumption | 72,369,387 | 97.11% | |
| annual energy sold | 55,303,389 | 74.21% | 76.42% |
| system loss including unbilled usage | 17,065,998 | 22.90% | 23.58% |
| unbilled usage: street light | 0 | 0.00% | 0.00% |
| technical loss | 4,358,255 | 5.85% | 6.02% |
| non-technical loss | 12,707,743 | 17.05% | 17.56% |

The SIEA Honiara system had technical losses for 2010 estimated at 5.85%, while non-technical losses were estimated at 17.05% of total annual generation. Discussion of both components is provided in Section 5.

# 5. Non-Technical Losses

In the category of non-technical losses one can identify different loss causes, such as meter inaccuracy, administrative and/or billing failures, electricity theft, meter tampering, meter by-passing, and others. Sometimes non-reimbursed power deliveries (for example for street lighting or water company activities) are also considered to be non-technical losses. Those power deliveries however – if they are not accounted for or not paid for – are a financial loss for the company and not a non-technical system loss.

As summarized under Section 4.3, the non-technical losses were extremely high (17.05% of generation). This indicates that there may be causes of non-technical losses, such as theft, meter by-passing, inaccurate or unmetered usage. Therefore, KEMA recommends that SIEA investigate possible causes of non-technical losses more vigorously.

Estimating street lighting usage would provide SIEA with additional financial information for future decision-making and cost recovery methods.

KEMA also recommends that SIEA take steps to obtain, monitor and record distribution transformer load data to develop an asset assessment data base, either through software which takes into account the customer meters on each of the transformers or through physically measuring the load by installing demand type meters on the secondary side of each of the transformers.

These meters can be installed while using current transformers (CT's) mounted on the pole or on the pad mounted transformers. If customers are equipped with new digital meters and can be linked in a database or in the CIS to the distribution transformers, it may not be necessary to install these meters at the distribution transformers.

## 5.1 Sources of Non-technical Losses

Possible non-technical loss sources include:

- Not accounting for all energy used by SIEA offices, stores, or workshops,
- Identifying energy theft is left to meter readers or line men, which are part of the community and may not be open to bringing situations to management's attention,
- Meters are not tested and not working properly,
- Meters are old and not working properly,

- No regular procedure to check meter multipliers,
- Organizationally, no one person who is responsible for loss reduction.

SIEA must focus its attention to the reduction of the losses; auditing and assignment of a Revenue Assurance Officer can contribute to reducing non-technical losses.

### 5.1.1 Metering Issue Losses

KEMA noticed no irregularities as far as metering issues. The generation data provided by the SIEA clearly covered the same time period as the monthly meter reading data so that energy generated in a full month matches with the energy sold, including the energy prepaid for the month prior. This significantly improves the accuracy of the loss calculation.

Location of the customer meters should be tied to transformers which are connected, preferably through a Geographical Information System (GIS) in CIS (Customer Information System). Every year analyses should be performed to see which transformers can be replaced for proper loss reduction or because of overloading and general maintenance.

#### 5.1.1.1 Aged Meters

KEMA was not provided with data on the condition of the meter population. KEMA recommends that SIEA implements an energy meter assessment study to identify and replace faulty devices. This program should be conducted periodically throughout the system to ensure accurate readings. Considering the large population of prepayment meters on the system, special attention should be given to the Cashpower devices to ensure no electricity is dispensed once the paid period has expired.

#### 5.1.1.2 Meter Tampering and Bypassing

Energy theft is a serious problem on the Honiara system. Meter readers should be trained to look for unusual meters that have had their seals removed or provide other clues that they have been tampered with and report those to management immediately. Cases of meter tampering should be investigated immediately (with assistance of local police, if necessary, to ensure employee safety) and corrective actions should be taken to reduce incidents of energy theft to a minimum.

#### 5.1.1.3 Inaccurate Meter Reading

Inaccurate meter reading will lead to irregular monthly figures for power usage. Although SIEA has a Customer Information System that raises red flags when irregularities occur, and it relies on the administrative personnel to notice irregularities. Most of the time inaccurate readings can be corrected by the next meter reading. SIEA should consider training its staff to be more vigilant of these occurrences.

### 5.1.2 Billing Losses

SIEA did not explicitly make KEMA aware of any billing losses; however, the non-technical losses are extremely high, therefore the billing process should be reviewed.

### 5.1.3 Billing Collection Losses

SIEA should audit its meter population to ensure that they are all registered either in the Cashpower, or conventional kWh billing systems, and that a single customer can be held accountable for the energy spent at any given location. This effort will require collaboration between the finance and GIS teams to ensure proper meter assignment.

Billing collection losses and bad debt are not to be counted to system losses. Any billing losses or bad debt amounts that are written off are actually financial losses and not system losses. SIEA should work with SIWA to resolve the issue of past revenue losses, and mitigate future non-payment.

### 5.1.4 Loss through Theft

As already mentioned SIEA non-technical losses are high. Therefore, KEMA recommends that SIEA implement a program of training meter readers to look for instances of theft; particularly in densely populated areas, where meter-tampering is typically more common.

### 5.1.5 Administrative Failures

The occurrence of administrative failures (in the process from meter reading to billing) was not identified as a problem for the SIEA system. However, since non-technical losses were so high, an audit of the administrative department may reveal some discrepancies.

### 5.1.6 Line Throw-ups

No line throw-ups were identified during KEMA's visit.

## 5.2 Analysis of Losses

When analyzing non-technical losses it can be noticed that the loss calculations show a very high percentage of non-technical losses (17.05%).

## 5.3 Findings and Related Observations

The loss calculations show a high percentage of non-technical losses (17.05%). The meter population appeared to be in fairly good condition and line throw-ups were not seen during KEMA's visit, so based on data made available to KEMA it's unclear why non-technical losses are at such a high level. Since no indication was given during the site visit as to the possible causes, it can only be assumed that these losses include a mixture of meter errors, theft and a possibly billing and collection errors.

The findings on non-technical losses can be summarized as follows:

- No information was provided on the condition of the distribution energy meters.

- Additional metering should be added to monitor sewage and water pumps, as well as street lighting to better quantify these categories of losses.

- The extent of energy theft, meter tampering, and meter by-passing cannot be documented with the data that SIEA was able to provide. However, since non-technical losses are high, line patrols and meter inspections should be performed on a regular periodic basis to help to identify the presence and extent of such problems.

- Instances of administrative failures in the process from meter reading to billing were not reported to KEMA. However, insufficient data was provided to review the revenue collection process. An audit of the billing and collection procedures should be conducted by a third party to ensure an unbiased evaluation of the administrative process.

# 6. Findings and Recommendations

This chapter provides a compilation of findings and recommendations for the SIEA system on the Honiara system.

## 6.1 Generation

From the data provided, the fuel efficiency for Lungga and Honiara Power Stations averaged 3.74 kWh/liter for 2010. This figure is somewhat on the low side and it may be possible to further improve it by changing the way the units are dispatched and by keeping the units in optimal operating condition. KEMA recommends that the SIEA consider looking at opportunities for improving its economic dispatch of generation resources.

The Honiara power station own usage for SIEA was 2.89% of production, which is a reasonable figure. A good figure for auxiliary consumption is typically below 4%, and this figure is below that threshold. Therefore, KEMA has no recommendations in regards to power station usage, other than to say that coolers and other auxiliary loads that comprise power station usage should be well-maintained according to manufacturer recommendations. Furthermore it is recommended to conduct an energy audit in order to identify possible efficiency improvements.

There were two generating units that were out-of-service and obviously not being maintained at the time of KEMA's visit of the Honiara power station. SIEA has sufficient generating capacity to meet its peak demand under an n-1 reliability criterion, but not n-2. Therefore, KEMA recommends that SIEA replace one of the decommissioned 1500 kW diesel generators at the Honiara Power Station to improve dispatch capability, reduce production costs and enhance system reliability. The annual cost calculations in section 3.1 show that there would be immediate pay-back in the form of net annual savings.

## 6.2 Transmission and Distribution

The technical losses on the SIEA distribution system are 5.85%, which is relatively good. A good figure (e.g., "best in class") is typically less than 5%.

Technical losses include primary line losses, distribution transformer losses, LV secondary wire losses, and other non-conventional sources such as bad connectors and hot spots. Therefore, KEMA recommends that SIEA perform infrared inspection of key connections and facilities throughout its system to determine if such hot spots do indeed exist.

To improve the loss estimation, KEMA recommends continuing meter monitoring and meter calibration, as well as maintaining historical data. KEMA also recommends keeping record of all power equipment from manufacture including equipment specifications, name plate information and test data.

## 6.3 Non-Technical Losses

The non-technical losses on the SIEA distribution system are 17.05%, which is extremely high. A good value for non-technical losses would be below 5%. There are a few step KEMA recommends SIEA takes to identify and mitigate these losses.

The meter population may be aging; therefore, an asset assessment program focusing on identifying and replacing old or inaccurate meters is recommended.

Additional metering should be added to monitor the water and sewage pump usage to enhance detection and categorization of losses.

Theft, meter tampering, and meter by-passing are assumed to be serious issues for the SIEA system. KEMA recommends patrolling the lines, and inspecting energy meters on a periodic basis to determine the extent of such problems. Meter readers should be trained to detect meters that have been tampered with, or other illegal activities. Local police should be present when dealing whenever such a situation occurs to ensure a safe and fair resolution.

Administrative failures in the process from meter reading to billing may be a significant cause of inaccuracies in the account billing process. However, insufficient data was provided to truly assess this aspect of the revenue collection process. An audit of the administrative and meter reading processes should be conducted by a third party to ensure an unbiased evaluation of the situation, and identify potential discrepancies in numbers, inefficient procedures, or suspicious behavior.

# 7. Suggested Equipment Replacement

During KEMA's site visit to the island of Guadalcanal, the SIEA system generation and distribution equipment was reviewed. KEMA gathered data to complete the loss analysis and develop a list of SIEA equipment, including observations on the condition of the facilities. Upon completion of the loss analysis, KEMA compiled a list of equipment proposed for achieving energy loss savings for SIEA's system on the Honiara system.

Two of the nine units owned by SIEA in the Honiara power station were out of service during the time of KEMA's visit. KEMA recommends that SIEA consider installing a new, high-efficiency diesel unit, rated 1500 kW to replace Honiara Unit 1. KEMA's cost analysis indicates this would be economically beneficial. It would also provide enough additional generating capacity to serve the peak load under an n-2 generator outage condition. The new H1 unit should be specified as a base-load generator.

Because of the high non-technical losses (17.05%), KEMA recommends a thorough assessment of the energy meter population to identify and replace faulty or inadequate devices.

# A. Data Handbook

The following data for the Solomon Island Electricity Authority (SIEA) Honiara power system on Guadalcanal Island should be appended to the existing SIEA data handbook. Data that was missing or assumed are noted accordingly with a green highlight.

## A.1 Generation

Data for the Solomon Island Electricity Authority (SIEA) Honiara power system generators is listed below.

**Table 1 - SIEA Honiara Generator Data**

| Bus Name | Unit Designation | Base Voltage (kV) | Base MVA | PMax (MW) | Speed (rpm) | Poles | Type | Xd | X''d | Xo | Unit Status* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HONIARA-PS | GEN H-1 | 0.415 | 1.88 | 1.5 | Unknown | 4 | HS Diesel | 1.96 | 0.12 | 0.02 | 0 |
| HONIARA-PS | GEN H-2 | 0.415 | 1.88 | 1.5 | Unknown | 4 | HS Diesel | 1.96 | 0.12 | 0.02 | 0 |
| HONIARA-PS | GEN H-3 | 0.415 | 1.88 | 1.5 | Unknown | 4 | HS Diesel | 1.96 | 0.12 | 0.02 | 1 |
| BUS LPS-1 | GEN L-5 | 11 | 1.91 | 1.53 | 1000 | 12 | MS Diesel | 1.9 | 0.215 | 0.025 | 1 |
| LUNGGA PS | GEN L-6 | 11 | 3.55 | 2.84 | 900 | 6 | MS Diesel | 2.0 | 0.16 | 0.025 | 1 |
| LUNGGA PS | GEN L-7 | 11 | 5.3 | 4.24 | 750 | 8 | MS Diesel | 1.74 | 0.181 | 0.104 | 1 |
| LUNGGA PS | GEN L-8 | 11 | 5.25 | 4.2 | 750 | 8 | MS Diesel | 1.69 | 0.186 | 0.107 | 1 |
| LUNGGA PS | GEN L-9 | 11 | 5.25 | 4.2 | 750 | 8 | MS Diesel | 1.69 | 0.21 | 0.107 | 1 |
| LUNGGA PS | GEN L-10 | 11 | 5.25 | 4.2 | 600 | 10 | MS Diesel | 1.57 | 0.299 | 0.107 | 1 |

Notes:
*Unit Status: 0 = unavailable, 1 = available for service.

## A.2 Transmission System Data

Data for the Solomon Island Electricity Authority (SIEA) Honiara transmission system is listed below. Data items provided include power transformer data, and transmission line cable and conductor data.

**Table 1 - Power Transformers**

| No. | From Bus | To Bus | kVA | Voltage (kV) | | Impedance p.u.* | | In-Service Year | Status** |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Primary | Secondary | Resistance | Reactance | | |
| T-1 | LUNGGA PS | BUS LPS-1 | 6400/8000 | 33 | 11 | | 0.0941 | Unknown | 1 |
| T-2 | LUNGGA PS | BUS LPS-2 | 1000/12500 | 33 | 11 | | 0.0938 | Unknown | 1 |
| T-3 | LUNGGA PS | BUS LPS-2 | 1000/12500 | 33 | 11 | | 0.1134 | Unknown | 1 |
| T-4 | HONIARA PS | BUS HPS-1 | 7500/9375 | 33 | 11 | | 0.09 | Unknown | 1 |
| T-5 | HONIARA PS | BUS HPS-2 | 7500/9375 | 33 | 11 | | 0.0923 | Unknown | 1 |
| T-6 | BUS HPS-1 | BUS HPS-3 | 2000/2300 | 11 | 0.415 | | 0.0669 | Unknown | 1 |
| T-7 | BUS HPS-1 | BUS HPS-3 | 2000/2300 | 11 | 0.415 | | 0.0669 | Unknown | 1 |
| T-8 | BUS HPS-1 | BUS HPS-3 | 2000/2300 | 11 | 0.415 | | 0.0669 | Unknown | 1 |

Note:
* pu impedance based on the transformer base MVA
** Status of transformer: 1= On-line, 2=Off-line

**Table 2 - Transmission Line/Cable Data**

| Record No. | From Bus | To Bus | Nominal Voltage (kV) | Circuit No. | Length (km) |
|---|---|---|---|---|---|
| 1 | LUNGGA PS | HONIARA PS | 33 | TL-1 | 9.63 |
| 2 | LUNGGA PS | RANADI | 33 | TL-2 | 3.29 |
| 3 | RANADI | HONIARA PS | 33 | TL-3 | 5.86 |
| 4 | LUNGGA PS | HONIARA EAST | 33 | TL-4 | 4.19 |
| 5 | HONIARA PS | WHITE RIVER | 33 | TL-5 | 4.51 |

**Table 3 - Transmission Line/Cable Conductor Data**

| Record No. | From | To | Conductor Type | Config. Type | Current Rating (AMPs) | MVA Rating | Length (km) |
|---|---|---|---|---|---|---|---|
| 1 | LUNGGA PS | HONIARA PS | ACSR Dog | OH | 319 | 18.2 | 9.63 |
| 2 | LUNGGA PS | RANADI | 70 $mm^2$ AL | UG | 183 | 11.6 | 3.29 |
| 3 | RANADI | HONIARA PS | 70 $mm^2$ AL | UG | 183 | 11.6 | 5.86 |
| 4 | LUNGGA PS | HONIARA EAST | 50 $mm^2$ AL | UG | 151 | 8.6 | 4.19 |
| 5 | HONIARA PS | WHITE RIVER | 50 $mm^2$ AL | UG | 151 | 8.6 | 4.51 |

## A.3 Distribution System Data

Data for the Solomon Island Electricity Authority (SIEA) power system for the Honiara Island distribution system is listed below.
Data items include distribution feeders and distribution transformers.

**Table 5 - Distribution Feeders**

| Feeder | Substation | Total feeder Length (mi) | Connected KVA |
|---|---|---|---|
| F1 | Honiara | 4,690 | 1,865 |
| F2 | Honiara | 10,070 | 3,365 |
| F3 | Honiara | 1,190 | 2,300 |
| F4 | Honiara | 2,420 | 1,900 |
| F5 | Honiara | 1,170 | 3,150 |
| F6 | Honiara | 1,070 | 2,000 |
| F11 | Lungga | 8,800 | 5,580 |
| F12 | Lungga | 8,480 | 915 |
| EH-1 | East Honiara | 2,680 | 2,300 |
| R-1 | Ranadi | 9,680 | 4,915 |
| WR-1 | White River | 6,280 | 2,745 |
| **HONIARA TOTALS** | | **56,530** | **31,035** |

**Table 6 - Distribution Feeder Data**

| Feeder-Section No. | From Bus | To Bus | Conductor | Type | Distance (meters) | Current Rating (Amps) | MVA Rating |
|---|---|---|---|---|---|---|---|
| 1-1 | HPS-1 | BUS 1-1 | 95 $mm^2$ AL XLPE | UG | 430 | 221 | 4.2 |
| 1-2 | BUS 1-1 | BUS 1-2 | ACSR Apple | OH | 280 | 185 | 3.5 |
| 1-3 | BUS 1-2 | BUS 1-3 | HDC 7/1.0 | OH | 250 | 69 | 1.3 |
| 1-4 | BUS 1-3 | BUS 1-4 | HDC 7/1.0 | OH | 150 | 69 | 1.3 |
| 1-5 | BUS 1-4 | BUS 1-5 | HDC 7/1.0 | OH | 620 | 69 | 1.3 |
| 1-6 | BUS 1-5 | BUS 1-6 | ACSR Apple | OH | 550 | 185 | 3.5 |
| 1-7 | BUS 1-6 | BUS 1-7 | ACSR Cherry | OH | 220 | 321 | 6.1 |
| 1-8 | BUS 1-7 | BUS 1-8 | ACSR Apple | OH | 140 | 185 | 3.5 |
| 1-9 | BUS 1-4 | BUS 1-9 | HDC 7/1.0 | OH | 320 | 69 | 1.3 |
| 1-10 | BUS 1-9 | BUS 1-10 | HDC 7/1.0 | OH | 150 | 69 | 1.3 |
| 1-11 | BUS 1-10 | BUS 1-11 | ACSR Apple | OH | 330 | 185 | 3.5 |
| 1-12 | BUS 1-11 | BUS 1-12 | ACSR Cherry | OH | 60 | 321 | 6.1 |
| 1-13 | BUS 1-12 | BUS 1-13 | ACSR Cherry | OH | 50 | 321 | 6.1 |
| 1-14 | BUS 1-12 | BUS 1-14 | ACSR Apple | OH | 590 | 185 | 3.5 |
| 1-15 | BUS 1-12 | BUS 1-15 | ACSR Cherry | OH | 50 | 321 | 6.1 |
| F1-WR TIE | BUS 1-14 | BUS WR-9 | ACSR Cherry | OH | 500 | | |
| **FEEDER 1 TOTALS** | | | | | **4,690** | | |
| 2-1 | HPS-1 | BUS 2-1 | 95 $mm^2$ AL XLPE | UG | 20 | 221 | 4.2 |
| 2-2 | BUS 2-1 | BUS 2-2 | ACSR Cherry | OH | 860 | 321 | 6.1 |
| 2-3 | BUS 2-2 | BUS 2-3 | ACSR Cherry | OH | 430 | 321 | 6.1 |
| 2-4 | BUS 2-3 | BUS 2-4 | HDC 7/1.0 | OH | 150 | 69 | 1.3 |
| 2-5 | BUS 2-4 | BUS 2-5 | HDC 7/1.0 | OH | 430 | 69 | 1.3 |
| 2-6 | BUS 2-5 | BUS 2-6 | HDC 7/1.0 | OH | 490 | 69 | 1.3 |
| 2-7 | BUS 2-3 | BUS 2-7 | HDC 7/1.0 | OH | 780 | 69 | 1.3 |
| 2-8 | BUS 2-7 | BUS 2-8 | ACSR Cherry | OH | 230 | 321 | 6.1 |
| 2-9 | BUS 2-8 | BUS 2-9 | ACSR Cherry | OH | 270 | 321 | 6.1 |
| 2-10 | BUS 2-9 | BUS 2-10 | ACSR Apple | OH | 240 | 185 | 3.5 |
| 2-11 | BUS 2-9 | BUS 2-11 | HDC 7/1.0 | OH | 250 | 69 | 1.3 |
| 2-12 | BUS 2-3 | BUS 2-12 | ACSR Cherry | OH | 460 | 321 | 6.1 |
| 2-13 | BUS 2-12 | BUS 2-13 | ACSR Cherry | OH | 140 | 321 | 6.1 |
| 2-14 | BUS 2-12 | BUS 2-14 | ACSR Apple | OH | 930 | 185 | 3.5 |
| 2-15 | BUS 2-14 | BUS 2-15 | ACSR Cherry | OH | 410 | 321 | 6.1 |
| 2-16 | BUS 2-14 | BUS 2-16 | ACSR Cherry | OH | 180 | 321 | 6.1 |

| Feeder-Section No. | From Bus | To Bus | Conductor | Type | Distance (meters) | Current Rating (Amps) | MVA Rating |
|---|---|---|---|---|---|---|---|
| 2-17 | BUS 2-16 | BUS 2-17 | ACSR Cherry | OH | 160 | 321 | 6.1 |
| 2-18 | BUS 2-16 | BUS 2-18 | ACSR Cherry | OH | 110 | 321 | 6.1 |
| 2-19 | BUS 2-18 | BUS 2-19 | ACSR Apple | OH | 320 | 185 | 3.5 |
| 2-20 | BUS 2-19 | BUS 2-20 | ACSR Quince | OH | 160 | 76 | 1.5 |
| 2-21 | BUS 2-20 | BUS 2-21 | ACSR Apple | OH | 40 | 185 | 3.5 |
| 2-22 | BUS 2-21 | BUS 2-22 | ACSR Cherry | OH | 160 | 321 | 6.1 |
| 2-23 | BUS 2-22 | BUS 2-23 | ACSR Apple | OH | 400 | 185 | 3.5 |
| 2-24 | BUS 2-23 | BUS 2-24 | ACSR Cherry | OH | 330 | 321 | 6.1 |
| 2-25 | BUS 2-24 | BUS 2-25 | ACSR Cherry | OH | 120 | 321 | 6.1 |
| 2-26 | BUS 2-25 | BUS 2-26 | ACSR Apple | OH | 580 | 185 | 3.5 |
| 2-27 | BUS 2-26 | BUS 2-27 | ACSR Apple | OH | 380 | 185 | 3.5 |
| 2-28 | BUS 2-7 | BUS 2-28 | HDC 7/1.0 | OH | 540 | 69 | 1.3 |
| F2-R1 TIE | BUS 2-17 | BUS R1-29 | ACSR Cherry | OH | 500 | | |
| **FEEDER 2 TOTALS** | | | | | **10,070** | | |
| F2-F4 TIE | BUS R1-31 | BUS 4-5 | 95 $mm^2$ AL XLPE | UG | 300 | | |
| 3-1 | HPS-2 | BUS 3-1 | 70 $mm^2$ CU PILC | UG | 140 | 173 | 3.3 |
| 3-2 | BUS 3-1 | BUS 3-2 | 70 $mm^2$ CU PILC | UG | 180 | 173 | 3.3 |
| 3-3 | BUS 3-2 | BUS 3-3 | ACSR Apple | OH | 160 | 185 | 3.3 |
| 3-4 | BUS 3-3 | BUS 3-4 | HDC 7/1.0 | OH | 120 | 69 | 1.3 |
| 3-5 | BUS 3-4 | BUS 3-5 | ACSR Cherry | OH | 90 | 321 | 6.1 |
| F3-WR TIE | BUS 3-5 | BUS WR-13 | ACSR Cherry | OH | 200 | | |
| **FEEDER 3 TOTALS** | | | | | **1,190** | | |
| 4-1 | HPS-2 | BUS 4-1 | 95 $mm^2$ AL XLPE | UG | 620 | | |
| 4-2 | BUS 4-1 | BUS 4-2 | 95 $mm^2$ AL XLPE | UG | 300 | | |
| 4-3 | BUS 4-2 | BUS 4-3 | HDC 7/1.0 | OH | 380 | | |
| 4-4 | BUS 4-3 | BUS 4-4 | HDC 7/1.0 | OH | 640 | | |
| 4-5 | BUS 4-4 | BUS 4-5 | 95 $mm^2$ AL XLPE | UG | 480 | | |
| **FEEDER 4 TOTALS** | | | | | **2,420** | | |
| 5-1 | HPS-2 | BUS 5-1 | 70 $mm^2$ CU PILC | UG | 210 | | |
| 5-2 | BUS 5-1 | BUS 5-2 | 70 $mm^2$ CU PILC | UG | 140 | | |
| 5-3 | BUS 5-2 | BUS 5-3 | 70 $mm^2$ CU PILC | UG | 220 | | |
| 5-4 | BUS 5-3 | BUS 5-4 | 70 $mm^2$ CU PILC | UG | 100 | | |
| 5-5 | BUS 5-4 | BUS 5-5 | 70 $mm^2$ CU PILC | UG | 60 | | |
| 5-6 | BUS 5-5 | BUS 5-6 | 70 $mm^2$ CU PILC | UG | 180 | | |

| Feeder-Section No. | From Bus | To Bus | Conductor | Type | Distance (meters) | Current Rating (Amps) | MVA Rating |
|---|---|---|---|---|---|---|---|
| 5-7 | BUS 5-6 | BUS 5-7 | 70 $mm^2$ CU PILC | UG | 260 | | |
| **FEEDER 5 TOTALS** | | | | | **1,170** | | |
| 6-1 | HPS-1 | BUS 6-1 | 70 $mm^2$ CU PILC | UG | 40 | | |
| 6-2 | BUS 6-1 | BUS 6-2 | 70 $mm^2$ CU PILC | UG | 250 | | |
| 6-3 | BUS 6-2 | BUS 6-3 | 70 $mm^2$ CU PILC | UG | 300 | | |
| 6-4 | BUS 6-3 | BUS 6-4 | 70 $mm^2$ CU PILC | UG | 180 | | |
| F6-F4 TIE | BUS 6-4 | BUS 4-1 | 70 mm2 CU PILC | UG | 300 | | |
| **FEEDER 6 TOTALS** | | | | | **1,070** | | |
| 11-1 | LPS-1 | BUS 11-1 | 150 $mm^2$ CU XLPE | UG | 20 | | |
| 11-2 | BUS 11-1 | BUS 11-2 | ACSR Cherry | OH | 230 | | |
| 11-3 | BUS 11-2 | BUS 11-3 | ACSR Cherry | OH | 830 | | |
| 11-4 | BUS 11-3 | BUS 11-4 | ACSR Cherry | OH | 520 | | |
| 11-5 | BUS 11-3 | BUS 11-5 | ACSR Cherry | OH | 550 | | |
| 11-6 | BUS 11-5 | BUS 11-6 | ACSR Cherry | OH | 590 | | |
| 11-7 | BUS 11-6 | BUS 11-7 | HDC 7/1.0 | OH | 310 | | |
| 11-8 | BUS 11-6 | BUS 11-8 | ACSR Cherry | OH | 1,040 | | |
| 11-9 | BUS 11-6 | BUS 11-9 | ACSR Cherry | OH | 1,370 | | |
| 11-10 | BUS 11-8 | BUS 11-10 | ACSR Apple | OH | 320 | | |
| 11-11 | BUS 11-10 | BUS 11-11 | HDC 7/1.0 | OH | 220 | | |
| 11-12 | BUS 11-8 | BUS 11-12 | ACSR Cherry | OH | 130 | | |
| 11-13 | BUS 11-9 | BUS 11-13 | ACSR Cherry | OH | 250 | | |
| 11-14 | BUS 11-9 | BUS 11-14 | ACSR Cherry | OH | 290 | | |
| 11-15 | BUS 11-14 | BUS 11-15 | ACSR Apple | OH | 250 | | |
| 11-16 | BUS 11-15 | BUS 11-16 | ACSR Apple | OH | 120 | | |
| 11-17 | BUS 11-15 | BUS 11-17 | ACSR Cherry | OH | 270 | | |
| 11-18 | BUS 11-14 | BUS 11-18 | ACSR Cherry | OH | 300 | | |
| 11-19 | BUS 11-18 | BUS 11-19 | ACSR Cherry | OH | 150 | | |
| 11-20 | BUS 11-19 | BUW 11-20 | ACSR Cherry | OH | 150 | | |
| 11-21 | BUS 11-20 | BUS 11-21 | ACSR Apple | OH | 110 | | |
| 11-22 | BUS 11-21 | BUS 11-22 | ACSR Apple | OH | 270 | | |
| F11-12 TIE | BUS 11-2 | BUS 12-2 | ACSR Cherry | OH | 10 | | |
| F11-EH TIE | BUS 11-3 | BUS EH-4 | 95 $mm^2$ AL XLPE | UG | 500 | | |
| **FEEDER 11 TOTALS** | | | | | **8,800** | | |

| Feeder-Section No. | From Bus | To Bus | Conductor | Type | Distance (meters) | Current Rating (Amps) | MVA Rating |
|---|---|---|---|---|---|---|---|
| 12-1 | LPS-1 | BUS 12-1 | 70 $mm^2$ CU PILC | UG | 20 | | |
| 12-2 | BUS 12-1 | BUS 12-2 | ACSR Cherry | OH | 110 | | |
| 12-3 | BUS 12-2 | BUS 12-3 | ACSR Apple | OH | 490 | | |
| 12-4 | BUS 12-3 | BUS 12-4 | ACSR Cherry | OH | 3,600 | | |
| 12-5 | BUS 12-4 | BUS 12-5 | ACSR Apple | OH | 570 | | |
| 12-6 | BUS 12-5 | BUS 12-6 | ACSR Apple | OH | 270 | | |
| 12-7 | BUS 12-5 | BUS 12-7 | ACSR Apple | OH | 110 | | |
| 12-8 | BUS 12-7 | BUS 12-8 | HDC 7/1.0 | OH | 1,690 | | |
| 12-9 | BUS 12-8 | BUS 12-9 | HDC 7/1.0 | OH | 730 | | |
| 12-10 | BUS 12-9 | BUS 12-10 | HDC 7/1.0 | OH | 480 | | |
| 12-11 | BUS 12-10 | BUS 12-11 | ACSR Apple | OH | 410 | | |
| **FEEDER 12 TOTALS** | | | | | **8,480** | | |
| EH-1 | EHSS-1 | BUS EH-1 | 70 $mm^2$ AL XLPE | UG | 20 | | |
| EH-2 | BUS EH-1 | BUS EH-2 | 95 $mm^2$ AL XLPE | UG | 1,130 | | |
| EH-3 | BUS EH-2 | BUS EH-3 | 95 $mm^2$ AL XLPE | UG | 1,030 | | |
| EH-4 | BUS EH-3 | BUS EH-4 | 95 $mm^2$ AL XLPE | UG | 500 | | |
| **FEEDER EH TOTALS** | | | | | **2,680** | | |
| R1-1 | RANADI | BUS R1-1 | 70 $mm^2$ AL XLPE | UG | 20 | | |
| R1-2 | BUS R1-1 | BUS R1-2 | HDC 7/1.0 | OH | 60 | | |
| R1-3 | BUS R1-2 | BUS R1-3 | ACSR Cherry | OH | 70 | | |
| R1-4 | BUS R1-3 | BUS R1-4 | 95 $mm^2$ AL XLPE | UG | 500 | | |
| R1-5 | BUS R1-4 | BUS R1-5 | ACSR Cherry | OH | 200 | | |
| R1-6 | BUS R1-5 | BUS R1-6 | ACSR Apple | OH | 1,000 | | |
| R1-7 | BUS R1-6 | BUS R1-7 | ACSR Cherry | OH | 270 | | |
| R1-8 | BUS R1-5 | BUS R1-8 | 95 $mm^2$ AL XLPE | UG | 160 | | |
| R1-9 | BUS R1-8 | BUS R1-9 | 25 $mm^2$ AL XLPE | UG | 40 | | |
| R1-10 | BUS R1-8 | BUS R1-10 | 95 $mm^2$ AL XLPE | UG | 110 | | |
| R1-11 | BUS R1-10 | BUS R1-11 | 95 $mm^2$ AL XLPE | UG | 140 | | |
| R1-12 | BUS R1-11 | BUS R1-12 | 25 $mm^2$ AL XLPE | UG | 40 | | |
| R1-13 | BUS R1-11 | BUS R1-13 | 95 $mm^2$ AL XLPE | UG | 240 | | |
| R1-14 | BUS R1-13 | BUS R1-14 | 25 $mm^2$ AL XLPE | UG | 130 | | |
| R1-15 | BUS R1-13 | BUS R1-15 | 95 $mm^2$ AL XLPE | UG | 380 | | |
| R1-16 | BUS R1-15 | BUS R1-16 | 95 $mm^2$ AL XLPE | UG | 300 | | |
| R1-17 | BUS R1-16 | BUS R1-17 | 95 $mm^2$ AL XLPE | UG | 30 | | |

| Feeder-Section No. | From Bus | To Bus | Conductor | Type | Distance (meters) | Current Rating (Amps) | MVA Rating |
|---|---|---|---|---|---|---|---|
| R1-18 | BUS R1-17 | BUS R1-18 | ACSR Apple | OH | 50 | | |
| R1-19 | BUS R1-18 | BUS R1-19 | ACSR Apple | OH | 410 | | |
| R1-20 | BUS R1-19 | BUS R1-20 | ACSR Apple | OH | 210 | | |
| R1-21 | BUS R1-20 | BUS R1-21 | ACSR Quince | OH | 530 | | |
| R1-22 | BUS R1-21 | BUS R1-22 | ACSR Apple | OH | 950 | | |
| R1-23 | BUS R1-22 | BUS R1-23 | 25 $mm^2$ AL XLPE | UG | 390 | | |
| R1-24 | BUS R1-23 | BUS R1-24 | 25 $mm^2$ AL XLPE | UG | 650 | | |
| R1-25 | BUS R1-16 | BUS R1-25 | 95 $mm^2$ AL XLPE | UG | 240 | | |
| R1-26 | BUS R1-25 | BUS R1-26 | 95 $mm^2$ AL XLPE | UG | 100 | | |
| R1-27 | BUS R1-26 | BUS R1-27 | ACSR Apple | OH | 340 | | |
| R1-28 | BUS R1-27 | BUS R1-28 | 95 $mm^2$ AL XLPE | UG | 600 | | |
| R1-29 | BUS R1-28 | BUS R1-29 | 95 $mm^2$ AL XLPE | UG | 290 | | |
| R1-30 | BUS R1-29 | BUS R1-30 | 95 $mm^2$ AL XLPE | UG | 430 | | |
| R1-11 TIE | BUS 11-12 | BUS R1-5 | 95 $mm^2$ AL XLPE | UG | 500 | | |
| R1-F2 TIE | BUS R1-30 | BUS R1-31 | 95 $mm^2$ AL XLPE | UG | 300 | | |
| **FEEDER R1 TOTALS** | | | | | **9,680** | | |
| WR-1 | W RIVER | BUS WR-1 | 70 $mm^2$ AL XLPE | UG | 20 | | |
| WR-2 | BUS WR-1 | BUS WR-2 | ACSR Cherry | OH | 500 | | |
| WR-3 | BUS WR-2 | BUS WR-3 | ACSR Cherry | OH | 240 | | |
| WR-4 | BUS WR-3 | BUS WR-4 | ACSR Apple | OH | 1,880 | | |
| WR-5 | BUS WR-3 | BUS WR-5 | ACSR Cherry | OH | 850 | | |
| WR-6 | BUS WR-5 | BUS WR-6 | ACSR Cherry | OH | 960 | | |
| WR-7 | BUS WR-6 | BUS WR-7 | ACSR Cherry | OH | 300 | | |
| WR-8 | BUS WR-6 | BUS WR-8 | ACSR Apple | OH | 120 | | |
| WR-9 | BUS WR-8 | BUS WR-9 | ACSR Cherry | OH | 70 | | |
| WR-10 | BUS WR-6 | BUS WR-10 | ACSR Cherry | OH | 290 | | |
| WR-11 | BUS WR-10 | BUS WR-11 | ACSR Cherry | OH | 220 | | |
| WR-12 | BUS WR-11 | BUS WR-12 | 25 $mm^2$ AL XLPE | UG | 170 | | |
| WR-13 | BUS WR-12 | BUS WR-13 | HDC 7/1.0 | OH | 90 | | |
| WR-14 | BUS WR-4 | BUS WR-14 | ACSR Apple | OH | 50 | | |
| WR-15 | BUS WR-2 | BUS WR-15 | ACSR Apple | OH | 320 | | |
| WR-16 | BUS WR-14 | BUS WR-16 | ACSR Apple | OH | 200 | | |
| **FEEDER WR TOTALS** | | | | | **6,280** | | |

## Table 7 - Three-phase Distribution Transformers

| NO. | LOCATION | FEEDER | KVA | BUS NO. | Primary (KV) | Secondary (Volts) | Total |
|---|---|---|---|---|---|---|---|
| DT001 | BOKONAVERA | F-1 | 100 | BUS 1-8 | 11 | 415 | 100 |
| DT002 | VAVAYA RIDGE | F-1 | 100 | BUS 1-5 | 11 | 415 | 100 |
| DT003 | MANUSATA | F-1 | 200 | BUS 1-9 | 11 | 415 | 200 |
| DT004 | LENGAKIKI | F-1 | 200 | BUS 1-3 | 11 | 415 | 200 |
| DT005 | MBUMBURU | F-1 | 100 | BUS 1-13 | 11 | 415 | 100 |
| DT006 | HUHURU | F-1 | 100 | BUS 1-14 | 11 | 415 | 100 |
| DT007 | NGOSSI DR | F-1 | 315 | BUS 1-15 | 11 | 415 | 315 |
| DT115 | TITINGE RIDGE-1 | F-1 | 50 | BUS 1-13 | 11 | 415 | 50 |
| DT116 | TASAHE RIDGE | F-1 | 200 | BUS 1-15 | 11 | 415 | 200 |
| DT030 | HIBISCUS AVE | F-1 | 500 | BUS 1-1 | 11 | 415 | 500 |
| | **FEEDER 1 TOTALS** | | **1,865** | **9** | | | **1,865** |
| DT009 | M HEIGHTS | F-2 | 100 | BUS 2-2 | 11 | 415 | 100 |
| DT010 | SKYLINE | F-2 | 100 | BUS 2-3 | 11 | 415 | 100 |
| DT011 | TUVARUHU | F-2 | 300 | BUS 2-6 | 11 | 415 | 300 |
| DT012 | MATANIKO | F-2 | 15 | BUS 2-5 | 11 | 415 | 15 |
| DT013 | VARA CREEK | F-2 | 50 | BUS 2-4 | 11 | 415 | 50 |
| DT014 | CHINATOWN | F-2 | 500 | BUS 2-7 | 11 | 415 | 500 |
| DT015 | HONIARA HOTEL | F-2 | 300 | BUS 2-8 | 11 | 415 | 300 |
| DT016 | KOLOALE | F-2 | 300 | BUS 2-10 | 11 | 415 | 300 |
| DT017 | MULT HALL | F-2 | 300 | BUS 2-11 | 11 | 415 | 300 |
| DT124 | DCP COMPOUND | F-2 | 100 | BUS 2-24 | 11 | 415 | 100 |
| DT020 | WEST KOLA | F-2 | 200 | BUS 2-13 | 11 | 415 | 200 |
| DT021 | STATE HOUSE | F-2 | 200 | BUS 2-15 | 11 | 415 | 200 |
| DT022 | ? | ? | 0 | ? | 11 | 415 | 0 |
| DT023 | KOLA EAST | F-2 | 200 | BUS 2-21 | 11 | 415 | 200 |
| DT024 | MAMBULU | F-2 | 50 | BUS 2-25 | 11 | 415 | 50 |
| DT025 | NAHA VALLEY | F-2 | 200 | BUS 2-23 | 11 | 415 | 200 |
| DT026 | NAZERINE CHURCH | F-2 | 50 | BUS 2-26 | 11 | 415 | 50 |
| DT027 | KOMBIVATU | F-2 | 200 | BUS 2-27 | 11 | 415 | 200 |
| DT122 | TANULI RIDGE | F-2 | 200 | BUS 2-17 | 11 | 415 | 200 |
| DT123 | ? | ? | 0 | ? | 11 | 415 | 0 |
| | **FEEDER 2 TOTALS** | | **3,365** | **18** | | | **3,365** |
| DT029 | KING SOLOMON | F-3 | 500 | BUS 3-1 | 11 | 415 | 500 |
| DT031 | TELEKOM EXCH | F-3 | 500 | BUS 3-2 | 11 | 415 | 500 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **DT032** | HERITAGE PARK | F-3 | 1000 | BUS 3-4 | 11 | 415 | 1000 |
| **DT032A** | SECRETARIAT | F-3 | 300 | BUS 3-5 | 11 | 415 | 300 |
| | **FEEDER 3 TOTALS** | | **2,300** | **4** | | | **2,300** |
| **DT008** | TAVIO RIDGE | WR-1 | 200 | BUS WR-9 | 11 | 415 | 200 |
| **DT033** | KUKUTU | WR-1 | 100 | BUS WR-13 | 11 | 415 | 100 |
| **DT034** | IRON BOTTOM | WR-1 | 500 | BUS WR-12 | 11 | 415 | 500 |
| **DT036** | ROVE | WR-1 | 315 | BUS WR-10 | 11 | 415 | 315 |
| **DT037** | BISHOP DALE | WR-1 | 300 | BUS WR-5 | 11 | 415 | 300 |
| **DT038** | WHITE RIVER | WR-1 | 300 | BUS WR-2 | 11 | 415 | 300 |
| **DT038A** | WR WATER PUMP | WR-1 | 200 | BUS WR-15 | 11 | 415 | 200 |
| **DT038B** | TASAHE B | WR-1 | 0 | DISCONNECT ED | 11 | 415 | 0 |
| **DT041** | IRON BOTTOM | WR-1 | 500 | BUS WR-12 | 11 | 415 | 500 |
| **DT042** | TAUMBAGE | WR-1 | 100 | BUS WR-4 | 11 | 415 | 100 |
| **DT043** | CHLORINE PLANT | WR-1 | 30 | BUS WR-14 | 11 | 415 | 30 |
| **DT044** | KONGULAI WATER | WR-1 | 200 | BUS WR-16 | 11 | 415 | 200 |
| | **FEEDER WR TOTALS** | | **2,745** | **12** | | | **2,745** |
| **DT018** | CENTRAL HOSPITAL | F-4 | 500 | BUS 4-5 | 11 | 415 | 500 |
| **DT028** | PWD | F-4 | 300 | BUS 4-4 | 11 | 415 | 300 |
| **DT045** | ANZ BANK | F-4 | 500 | BUS 4-1 | 11 | 415 | 500 |
| **DT046** | KAU | F-4 | 300 | BUS 4-2 | 11 | 415 | 300 |
| **DT047** | CENTRAL MKT | F-4 | 300 | BUS 4-3 | 11 | 415 | 300 |
| | **FEEDER 4 TOTALS** | | **1,900** | **5** | | | **1,900** |
| **DT048** | A SARU | F-5 | 750 | BUS 5-1 | 11 | 415 | 750 |
| **DT049** | NPF PLAZA | F-5 | 300 | BUS 5-2 | 11 | 415 | 300 |
| **DT050** | CITY CENTRE | F-5 | 500 | BUS 5-3 | 11 | 415 | 500 |
| **DT051** | FOX ST | F-5 | 500 | BUS 5-4 | 11 | 415 | 500 |
| **DT052** | TONGS BLDG | F-5 | 300 | BUS 5-5 | 11 | 415 | 300 |
| **DT053** | TOM YU | F-5 | 300 | BUS 5-6 | 11 | 415 | 300 |
| **DT054** | PARLIAMENT | F-5 | 500 | BUS 5-7 | 11 | 415 | 500 |
| | **FEEDER 5 TOTALS** | | **3,150** | **7** | | | **3,150** |
| **DT055** | CBSI | F-6 | 500 | BUS 6-1 | 11 | 415 | 500 |
| **DT056** | MENDANA HOTEL | F-6 | 500 | BUS 6-2 | 11 | 415 | 500 |
| **DT057** | PATROL BOAT | F-6 | 500 | BUS 6-3 | 11 | 415 | 500 |
| **DT058** | PORT AUTHORITY | F-6 | 500 | BUS 6-4 | 11 | 415 | 500 |
| | **FEEDER 6 TOTALS** | | **2,000** | **4** | | | **2,000** |
| **DT060** | GBR-1 | EH-1 | 750 | BUS EH-1 | 11 | 415 | 750 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DT060A | GBR-2 | EH-1 | 750 | BUS EH-1 | 11 | 415 | 750 |
| DT061 | AIRPORT HOTEL | EH-1 | 100 | BUS EH-1 | 11 | 415 | 100 |
| DT062 | DOMESTIC | EH-1 | 200 | BUS EH-2 | 11 | 415 | 20 |
| DT063 | INTERNATIONAL | EH-1 | 300 | BUS EH-3 | 11 | 415 | 300 |
| DT064 | CHENGS | EH-1 | 100 | BUS EH-4 | 11 | 415 | 100 |
| DT112 | DON BOSCO | EH-1 | 200 | BUS EH-1 | 11 | 415 | 200 |
| | **FEEDER EH TOTALS** | | **2,300** | **7** | | | **2,300** |
| DT059 | SIEA | F-11 | 100 | BUS 11-2 | 11 | 415 | 100 |
| DT064A | CEMA LUNGGA | F-11 | 100 | BUS 11-4 | 11 | 415 | 100 |
| DT065 | SOLANKA | F-11 | 200 | BUS 11-3 | 11 | 415 | 200 |
| DT065A | KGVI FARM | F-11 | 200 | BUS 11-5 | 11 | 415 | 200 |
| DT065B | DALGRO-1 | F-11 | 100 | BUS 11-3 | 11 | 415 | 100 |
| DT065C | DALGRO-2 | F-11 | 50 | BUS 11-3 | 11 | 415 | 50 |
| DT066 | KGVI SCHOOL | F-11 | 100 | BUS 11-7 | 11 | 415 | 100 |
| DT067 | KUMAGAI | F-11 | 200 | BUS 11-9 | 11 | 415 | 200 |
| DT068 | SOAP FACTORY | F-11 | 300 | BUS 11-13 | 11 | 415 | 300 |
| DT069 | DAISOL | F-11 | 500 | BUS 11-16 | 11 | 415 | 500 |
| DT070 | BOG GAS | F-11 | 500 | BUS 11-14 | 11 | 415 | 500 |
| DT071 | SCHWEPPES | F-11 | 315 | BUS 11-18 | 11 | 415 | 315 |
| DT072 | SOLBREW | F-11 | 500 | BUS 11-19 | 11 | 415 | 500 |
| DT073 | CRUZ MARKETING | F-11 | 300 | BUS 11-17 | 11 | 415 | 300 |
| DT074 | SOLGREEN | F-11 | 500 | BUS 11-21 | 11 | 415 | 500 |
| DT075 | ISLAND ENTPRSE | F-11 | 300 | BUS 11-22 | 11 | 415 | 300 |
| DT075A | ISLAND ENT-2 | F-11 | 200 | BUS 11-22 | 11 | 415 | 200 |
| DT076 | GEOKAMA | F-11 | 300 | BUS 11-12 | 11 | 415 | 300 |
| DT077 | SICHE PANATINA | F-11 | 200 | BUS 11-11 | 11 | 415 | 200 |
| DT078 | DME STEP-UP | F-11 | 15 | BUS 11-11 | 11 | 415 | 15 |
| DT079 | DME STEP-DOWN | F-11 | 50 | BUS 11-11 | 11 | 415 | 50 |
| DT095A | SIFF OFFICE | F-11 | 50 | BUS 11-6 | 11 | 415 | 50 |
| DT096 | SOLOMON STEEL | F-11 | 500 | BUS 11-6 | 11 | 415 | 500 |
| | **FEEDER 11 TOTALS** | | **5,580** | **23** | | | **5,580** |
| DT019 | KANZAI | R-1 | 200 | BUS R1-30 | 11 | 415 | 200 |
| DT080 | PANATINA ZONE | R-1 | 300 | BUS R1-7 | 11 | 415 | 300 |
| DT081 | TOBACCO | R-1 | 200 | BUS R1-10 | 11 | 415 | 500 |
| DT082 | ELA MOTOR | R-1 | 500 | BUS R1-10 | 11 | 415 | 500 |
| DT083 | FIELDERS | R-1 | 1000 | BUS R1-12 | 11 | 415 | 1000 |
| DT084 | PANATINA PLAZA | R-1 | 500 | BUS R1-14 | 11 | 415 | 500 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DT084A | J WITNESS | R-1 | 300 | BUS R1-14 | 11 | 415 | 300 |
| DT086 | JACKSON RIDGE | R-1 | 100 | BUS R1-21 | 11 | 415 | 100 |
| DT087 | KOBITO ONE | R-1 | 200 | BUS R1-23 | 11 | 415 | 200 |
| DT088 | GILBERT CAMP | R-1 | 200 | BUS R1-24 | 11 | 415 | 200 |
| DT089 | VURA 1 | R-1 | 100 | BUS R1-27 | 11 | 415 | 100 |
| DT090 | BUA | R-1 | 300 | BUS R1-28 | 11 | 415 | 300 |
| DT091 | SICHE KUKUM | R-1 | 100 | BUS R1-19 | 11 | 415 | 100 |
| DT092 | MALARIA RC | R-1 | 200 | BUS R1-17 | 11 | 415 | 200 |
| DT093 | FISHERIES | R-1 | 200 | BUS R1-15 | 11 | 415 | 200 |
| DT094 | SOLOMON STEEL | R-1 | 315 | BUS R1-6 | 11 | 415 | 315 |
| DT113 | PACIFIC CASINO | R-1 | 200 | BUS R1-29 | 11 | 415 | 200 |
| | **FEEDER R TOTALS** | | **4,915** | **17** | | | **4,915** |
| DT095 | BETIKAMA | F-12 | 100 | BUS 12-3 | 11 | 415 | 100 |
| DT096A | FIGHTER ONE | F-12 | 100 | BUS 12-6 | 11 | 415 | 100 |
| DT097 | ST JOSEPH | F-12 | 100 | BUS 12-8 | 11 | 415 | 100 |
| DT098 | NA CENTRE | F-12 | 50 | BUS 12-9 | 11 | 415 | 50 |
| DT099 | HNMS | F-12 | 50 | BUS 12-11 | 11 | 415 | 50 |
| DT101 | FOXWOOD | F-12 | 500 | BUS 12-12 | 11 | 415 | 500 |
| DT114 | FIGHTER 1 NEW | F-12 | 15 | BUS 12-5 | 11 | 415 | 15 |
| | **FEEDER 12 TOTALS** | | **915** | **7** | | | **915** |
| | **HONIARA SYSTEM TOTALS** | | **31,035** | **113** | | | **31,035** |

# B. Power Flow Model Assumptions

SIEA provided KEMA with a copy of its “SIEA Transmission and Distribution Network Data Book” dated November 2010 (draft C). Data on some feeder ties and normally-open points is missing from SIEA’s 2010 data book. Assumptions made by KEMA in developing the Honiara network model are listed below:

**Exhibit A-2: Feeder Conductor Assumptions**

| Reason | Conductor Characteristics Assumptions |
|---|---|
| There is no data for a tie between feeder EH-1 and feeder 11. | 500 meters 95 mm2 AL XLPE from Chengs (BUS EH-4) to CEMA Lungga (BUS 11-4). |
| There is no data for a tie between feeder R-1 and feeder 11. | 100 meters 95 mm2 AL XLPE from Geokama (BUS 11-12) to Marine School RDU (BUS R1-5). |
| There is no data for a tie between feeder R-1 and feeder 2. | 500 meters ACSR Cherry from Tanuli Ridge (BUS 2-17) to Pacific Casino (BUS R1-29). |
| There is no data for a tie between feeder 4 and feeder 6. | 300 meters 70 mm2 CU PILC from ANZ Bank (BUS 4-1) to Ports Authority (BUS 6-4). |
| There is no data for a tie between feeder 3 and feeder WR-1. | 200 meters ACSR Cherry from Secretariat (BUS 3-5) to Kukutu/Matavale (BUS WR-13). |
| No data was provided for the tie between feeder 1 and feeder WR-1. | 200 meters ACSR Cherry from Tavio Ridge (BUS WR-9) to Huhuru (BUS 1-14). |

Some distribution transformer sizes in SIEA’s 2010 data book do not match the sizes provided in the one-line diagram. Transformer assumptions made by KEMA in developing the Honiara network model are listed in Exhibit A-3.

**Exhibit A-3: Distribution Transformer Assumptions**

| Transformer | Reason | kVA Rating Assumption |
|---|---|---|
| DT004 (BUS 1-3) Lengakiki | The one-line diagram says transformer size is 200KVA, while data book says 100KVA. | 200 kVA |
| DT020 (BUS 2-13) West Kola | The one-line diagram says transformer size is 100KVA, while data book says 200KVA. | 100 kVA |
| DT031 (BUS 3-2) Telekom Exchange | The one-line diagram says transformer size is 300KVA, while data book says 500KVA. | 300 kVA |
| DT033 (BUS WR-13) Kukutu | The one-line diagram says transformer size is 100KVA, while data book says 200KVA. | 100 kVA |
| DT038 Tasahe B | The one-line diagram says transformer size is 100kVA, while data book says disconnected. | DISCONNECTED |
| DT041 (BUS WR-12) Iron Bottom Sound | The one-line diagram says transformer size is 500kVA, while data book has no record of this unit. | 500 kVA |
| DT045 (BUS 4-1) ANZ Bank | The one-line diagram says transformer size is 500kVA, while data book says 300KVA. | 500 kVA |
| DT047 (BUS 4-3) Central Market | The one-line diagram says transformer size is 300kVA, while data book says 200KVA. | 300 kVA |
| DT060A (BUS EH-1) GBR-2 | The one-line diagram says transformer size is 750kVA, while data book says 750KVA. | 750 kVA |
| DT072 (BUS 11-19) Solbrew | The one-line diagram says transformer size is 500kVA, while data book says 300KVA. | 500 kVA |

One feeder section WRan/1 (2) as the second feeder section leading out of transformer T-2 at Randi substation is HDB 7/1.00 conductor as indicated in the SIEA 2010 draft data book. The conductor is of much smaller capacity compared to the neighboring section using ACSR/GZ Cherry 6/4.75. A power flow study at peak demand indicates current rating violation through this feeder section. Since the size of this feeder section is much smaller than the neighboring sections, SIEA should consider reconductoring as HDC 7/3.5, which has a rating close to the neighboring sections to relieve the flow violation.

# C. One-Line Diagrams

**Exhibit A-4: SIEA Honiara System One-Line Diagram from EasyPower Model**

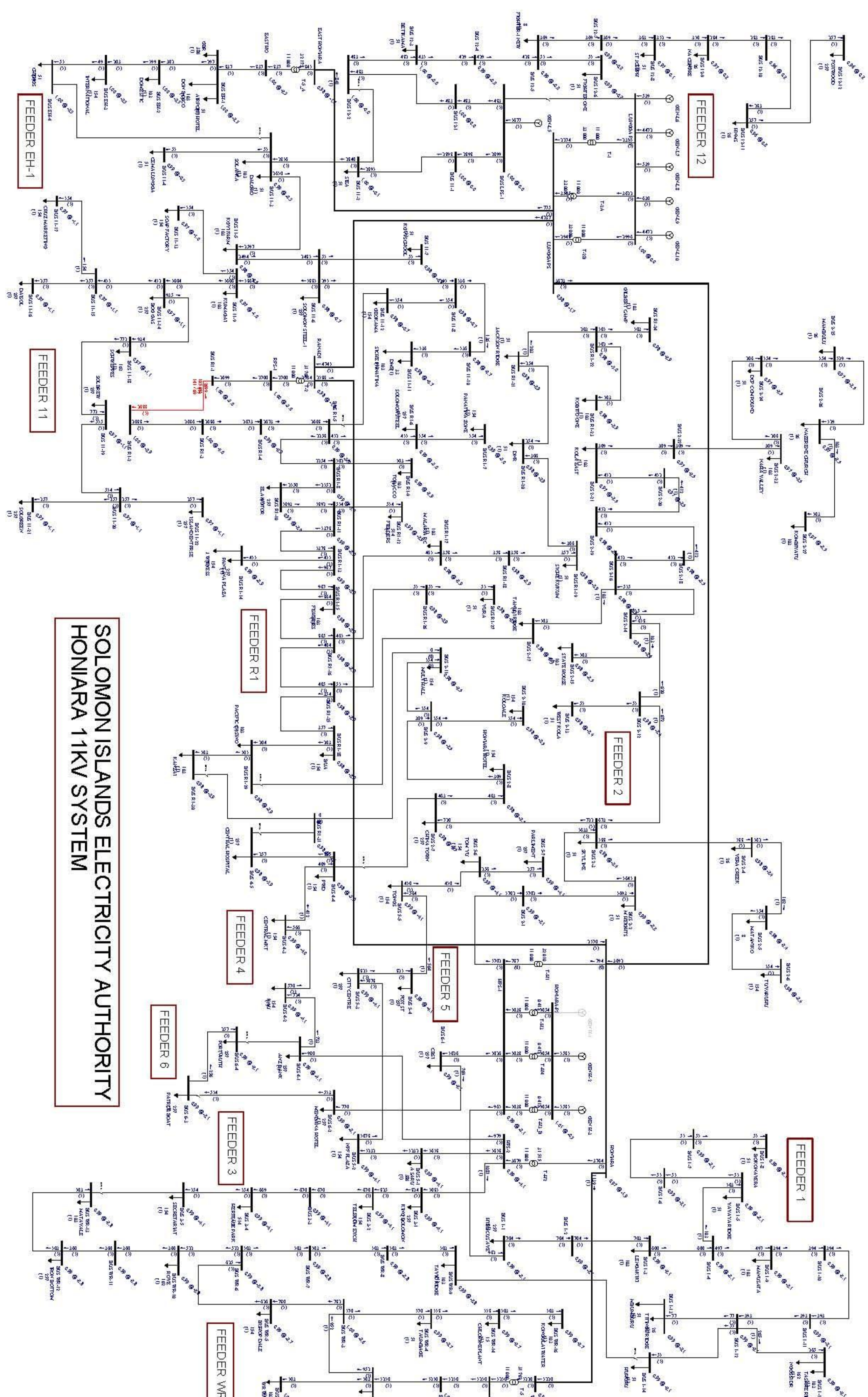
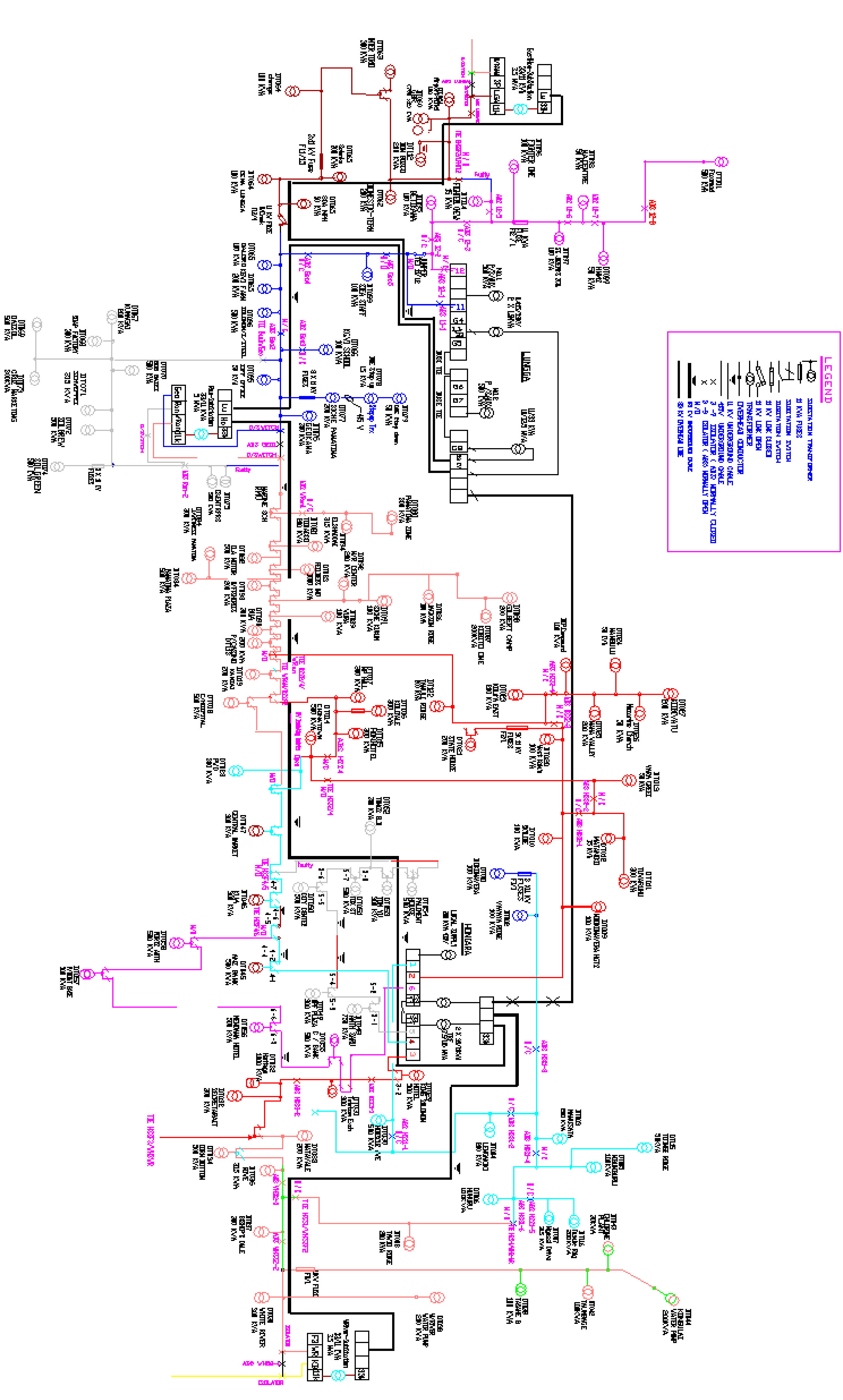


**Exhibit A-5: Honiara System One-Line Diagram from SIEA**



# D. Technical Loss Calculations

SIEA Loss Worksheet.xlsx (See attached file)