Quantification of Energy Efficiency in the Utilities of the U.S. Affiliate States (Excluding US Virgin Islands)

American Samoa Power Authority (ASPA)

Ordered by the Pacific Power Association

Prepared by KEMA Inc

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1. Executive Summary

1.1 Introduction

KEMA was asked by the Pacific Power Association (PPA) to conduct an energy efficiency study titled: "Quantification of Energy Efficiency in the Utilities of the U.S. Affiliate States (excluding US Virgin Islands)" for 10 Northern Pacific Island Utilities in the year 2010. During this year however, it has been decided to postpone the study for ASPA to the year 2011, because many important parts of ASPA's power system were seriously damaged and/or destroyed during the natural disaster that hit American Samoa in September 2009 and in 2010 ASPA was still working on restoration of the power system, including the erection of a new power station at Satala. In July 2010 the study for ASPA has commenced and at that time the new power plant at Satala was close to becoming operational. Until that time rental power units have been supplying power to mainly the Eastern part of the ASPA system, while on the other half of the island the Tafuna power station remained operational. For this reason it has been decided not to perform an assessment on fuel efficiency of the ASPA generating units and not to quantify power station losses, as this has been done for the other 9 Northern Pacific Island Utilities. This way the study for ASPA has been focused on the transmission and distribution systems.

This report covers the study results for ASPA, American Samoa.

Project objectives and deliverables:

- Quantify energy losses in the transmission and distribution systems.
- Prepare an Electrical Data Handbook containing electrical characteristics for high voltage equipment in the transmission and distribution system.
- Review and update the already existing digital circuit model of the ASPA power system which was provided to KEMA in an older version of ETAP, an established commercial package.
- Prepare a prioritized replacement list of power system equipment to reduce technical losses.
- Identify sources of non-technical losses.
- Recommend strategies for reducing technical and non-technical losses.

1.2 Quantification of Losses

Losses in the transmission and distribution systems are the company's System Losses which is the difference between the energy entering from the power stations into the transmission and distribution systems and the total energy sold.

The System Losses consist of the following loss categories:

- Technical losses: Summation of transformer core losses, transformer copper losses, transmission line losses, primary distribution feeder losses, and secondary wire losses. 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 and possible other non-technical loss causes.

Unbilled Usages: Energy consumptions that are not billed should be accounted for and billed, or in case these consumptions are not billed they should be considered a financial loss rather than a non-technical loss. Unbilled usage could for example be for street lighting and water and sewerage distribution equipment (pumps). In the case of ASPA we have not identified usages that are not accounted for. Street lights are accounted for and billed, while usage of water and sewerage pumps is recovered by a water pumping charge that is added on the customer bills for water usage.

ASPA is also American Samoa's water production and distribution company, as well as the island's sewerage and solid waste company. Furthermore ASPA is also involved in fuel trading.

1.3 Major findings and recommendations

KEMA's analysis of ASPA's power system determined total System Losses of 10.09% of annual energy production, consisting of:

- 6.03% in technical losses.
- 4.07% in non-technical loss.

As clarified in Chapter 4.1 under paragraph 1 the losses have been quantified making use of figures that KEMA obtained for the month of May 2010. According to ASPA information system losses in 2010 were somewhat lower, namely 9.3%. According to ASPA statistics losses in 2008 and 2007 were again somewhat lower, namely 9.1% and 9.0%. As explained in Chapter 4.1 there may be a certain inaccuracy involved in the quantification of losses based on the figures of May 2010.

Statistics also show that the consumption in May 2010 was around 9% lower than in 2008.

Recommendations:

(Chapter 6 and the Appendices contain more detailed information.)

1. Use the appropriate size of the distribution transformers and optimize the sizes so that no-load losses are reduced.

2. Use an infrared camera to scan the power system equipment at least annually to find hot spots. These usually occur at connector points. Repair as necessary.

3. Require large industrial and commercial customers to maintain power factor requirements above 85%. Install capacitors to other parts of the distribution system to maintain an overall power factor of the feeders and overall distribution system of above 95%

C. Metering, Billing, and Collection

1. Resolving the current problems with prepaid meters as mentioned in chapter 2.2, which have caused non-technical losses, should be continued and finalized as soon as possible.

2. In order to have a closer match between energy sold and energy entering into the distribution system, it would be better to perform the monthly meter reading every month in just a few days around the last day of the month. This way the energy sold is (almost) covering the same monthly period as the monthly generation statistics. This way – particularly when looking at a period of one year – the measured losses will have a higher accuracy.

3. The condition of the rather old meter population is not really known. Regularly old meters are taken out of the system in order to verify accuracy of this old meter population. Some 80 old meters are tested weekly. Records should be maintained of meter types and/or certain manufacturing years of meter types, which show a bad accuracy when tested. This way a dedicated meter replacement program can be developed, in conjunction with the program for introducing more prepaid meters.

4. Meter tampering and meter bypassing are phenomena that monthly occur. Records should be maintained of customers that have been identified for tampering and/or bypassing in order to regularly monitor the status of these customers' meters. This should also be done for customers with prepaid meters where tampering and/or bypassing has been identified.

5. Train a customer service staff member to audit metering and billing processes (including quality checks of billing system data such as multiplier factors, tariff categories applied to customers, functioning of red flags in the case of irregularities and non-technical loss causes found by meter readers, such as meter tampering or by-passing.

Assign a senior staff member to be Revenue Assurance Officer, responsible for Loss Reduction Strategies, and who plans and initiates loss reduction programs, keeps records of progress, and reports to the General Manager. Further details on this recommendation are given in Chapter 6.2.3.

2. Project Approach

In February 2010, KEMA launched 10 studies on behalf of the Pacific Power Association (PPA) to quantify power system energy losses by utilities across the North Pacific region. The purpose of these studies is to review the power system and quantify the 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.

As mentioned in Chapter 1 the study for ASPA was postponed until June 2011, only focusing on energy losses in the T&D systems.

2.1 Data Collection

Prior to visiting ASPA in American Samoa for data collection and technical assessments of the power system, KEMA has sent data request documents to ASPA. The major Data Request document contained a list of all data needed for the study, while an additional Excel document was sent for entering all required data of equipment and system components. These data needed to be collected to create a power system model in the grid calculation program EasyPower. ASPA indicated however that its power system was modeled in ETAP although in an older version of this software and still with the old Satala power generation units that have been replaced by 11 new generating units with a total capacity of 18 MW. KEMA has replaced the old Satala power station in the ETAP model by the newly built power station with its new generating units.

KEMA visited ASPA in American Samoa in the week of June 6, 2011, for data collection, interviews and an assessment of the power system.

During the visit much relevant data has been gathered, although not all data was readily available. Personnel at ASPA was helpful with supplying additional data after the visit as requested.

For the quantification of losses study we had to make assumptions, based on our experience, in certain areas such as low voltage secondary wires/service lines.

2.2 The ASPA Power System

ASPA currently has a maximum load of around 24.8 MW. For the coming years no substantial demand growth is expected.

The power system consists of:

- two power stations in Tafuna and Satala. The two power stations have a 34.5 kV interconnection for power transmission, which was out of service at the time of KEMA's visit. Both power stations are serving their half of the island's consumption. On each side the peak is not higher than some 13 MW.

  The **Tafuna** power station has 4 Deutz diesels each 4.75 MW and 2 Caterpillars each 1.5 MW (based on nameplate ratings), all fueled with diesel nr. 2. The Deutz generating units have been de-rated to respectively 4.3, 4,2, 4.1, 4.1 MW and both Caterpillars to 0.8 MW each, which makes the total available capacity 18.3 MW.

  During KEMA's visit to American Samoa two of the Deutz engines were out of service for building in new controllers. During this period rental power was temporarily available (9 units of 0.9 MW each).

  The **Satala** power station that has been destroyed during the tsunami in September 2009 has been rebuilt and is now consisting of 11 containerized high-speed Caterpillar units with a total capacity of 18 MW. The new Caterpillars are fueled with ultra low sulfur diesel. During the construction of the new power station rental power has been installed with a total capacity of 27 MW.

  By April 2012 a **1.5 MW solar power** station will be installed near the Tafuna airport. The solar power will be stepped up to a 13.2 kV voltage level and will feed in at feeder nr. 7 and nr 9. No storage will be installed, so solar power will only be available at daylight. The intermittent character of the solar power supply should be controlled by fast response of the diesel engines in the Tafuna power station. It is recommended to perform a dynamic study on integration of renewable into the grid, in case installation of more intermittent renewable energy resources will be considered, with which measures for anticipating on a higher percentage of intermittent renewable energy sources can be determined.

  Although fuel efficiency and power station own usage is not part of the study for ASPA, we have identified in data provided that before the natural disaster in 2009 fuel efficiency was almost 4 kWh/liter and power station own usage was around 3.6%. Compared with similar island systems these figures are reasonably well. With the new power station in Satala KEMA expects that these figures could even be improved.

- a **34.5 kV transmission** system consisting of an underground cable (9.5 miles long) between the power stations in Satala and Tafuna, with transformers 34.5/13.2 kV on both sides of the line, each 5 MVA.
- **13.2 kV distribution** systems going out from both power plants. In total there are eight 13.2 kV feeders (feeder 1 and feeders 3 through 9) and additionally there are two short feeder lines (‘Starkist’ and ‘Samoa packing’) dedicated to a number of industrial clients. During KEMA’s visit a new feeder (feeder 10) was under construction. This new feeder will take over a part of the load of feeder 9. Only feeder 9 has a capacitor bank with a rating of 600 kVAr. As an average the system’s power factor is 0.9. Feeders are partly overhead lines and partly underground cables, such as Feeders 1, 3, 5 and 8 and the SP and SK feeders..

  KEMA received an overview of the numbers and ratings of distribution transformers per feeder. The total installed power of ASPA’s distribution transformers is 71,790 kVA, which is relatively high compared with the maximum load of 24.8 MW (27.5 MVA at power factor of 0.9).

- For the **low voltage systems** assumptions have been made on the typical secondary configurations. Service wires are at an average of 60 to 70 ft, while most of them are # 2, sometimes 4 or 6. In residential areas we see mostly 3 to 4 spans per transformer. The spans are reaching to the meter houses, from where he customers have their own service line behind the meter. Low voltage is usually 120/208 V, sometimes other voltages are delivered making use of one-phase transformer combinations.

- ASPA has **11,961 customers** for electricity, of which 2,276 customers have pre-paid (or “debit”) meters. Next to the 2276 prepaid ("debit") meters of Landis & Gyr ASPA has installed electronic meters (30%) of Elster and 125 Itron meters for remote customers for remote reading with a handheld device. The electromechanical meters are from Westinghouse and GE.

  ASPA is experiencing problems with the prepaid meters. Currently entry pads are being replaced and because of problems with tokens that clients can re-enter. Another problem occurs if the voltage falls under 114 V or goes over 126 V. In those cases the display disappears and the client is disconnected. This happens only incidentally and solutions for the voltage problems are looked after.

  Meter reading is spread out each month in the period between the 1st and the 14th. The Starkist and Samoa packing processors are read at the end of the month.

All meters are tested before installation. Old meters are tested if irregularities are found by meter readers or in case of customer complaints. Sometimes some 80 to 90 meters per week have to be tested. Meter accuracy is first tested before repair. Next to irregularities reported by meter readers the billing system raises red flags at irregular usage. Also prepaid meters are checked because of by-passing or tampering. In May 2011 ASPA found 7 illegal prepaid meters and monthly ASPA goes out for checking 100 to 200 meters because of red flags and irregularities. If bills are not paid after 30 days, the customers are disconnected. Reconnection fee is $ 25.

2.3 Identifying and Quantifying Losses

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

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

System losses – losses occurred along power transferring through the transmission and distribution systems, such as transformers, overhead line conductors, aerial cables or underground cables and service wires. At the metering point also losses may occur because of the accuracy margin of the meters.

System Losses 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 equipments. In contrast to technical losses, there are non-technical losses, which are not directly caused by power system equipments. Causes of non-technical losses can be: theft, inadequate or inaccurate meters, meter tampering or by-passing, meter-reading errors, irregularities with prepaid meters, administrative failures, wrong multiplying factors, etc.

There is another category of loss due to energy usage that is not accounted for and subsequently not billed for. The unbilled usage results in 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 islands are: street lighting, utility's own building usage, electric power used for supplying other utilities such as water and sewage.

Furthermore, financial losses may be 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 transmission and distribution system losses. Where information was not sufficient, assumptions were made to facilitate the estimation. KEMA updated ASPA's power flow model in ETAP to represent the power system in American Samoa. The power flow study was performed to calculate system kW losses through primary feeders at peak demand. Furthermore an Excel spreadsheet was created to estimate kW losses that are not calculated in the power flow study, such as losses of distribution transformers and service wires. These kW losses were converted to kWh energy losses on annual basis by utilizing the estimated Loss Factor.

The total system energy loss was calculated as the difference between total annual generation after station's own usage and annual energy sold. Non-technical loss was then derived by comparing the total system loss and the sum of the estimations for technical losses.

3. Grid Model and Calculation of Technical Losses

3.1 Estimates and Assumptions for Missing Data

In order to quantify losses, the following assumptions have been made:

1. The power output for the one month of May, 2010 is used as average monthly output and used to estimate annual energy production and consumption. This way most recent data as provided to KEMA has been used. It must be noted that while the generated units are exactly measured from May 1 to June 1, the sold units are monthly measured during meter reading periods from the 1st to the 14th of the month. This way there an inaccuracy occurs when defining the losses over this period. If the figures are taken for a whole year this inaccuracy can be considered to be lower.

2. The typical value of no load loss and total loss for transformers from literature[1] is used for power transformer core loss estimation.

3. The secondary service wire type and size were assumed, based on information provided by ASPA and common practices. Furthermore assumptions were made for average wire lengths and general structures to estimate the secondary losses. The secondary loss consumption is estimated based on the assumed average customer consumption.

4. The effect of voltage drops through feeders is not considered in loss estimations except in the power flow study in ETAP.

3.2 ETAP Model

ASPA provided its power system model in ETAP. In this power flow model, there are 2 power plants interconnected by a 34.5 kV transmission line. KEMA replaced the generators in Satala power station by 11 new generators total 18 MW capacity to represent the generators that are currently operating in the Satala power station.

KEMA performed a power flow study for peak demand condition. ASPA indicated that the power transformers at both terminal of the 34.5kV interconnection line are out of service.

[1] Electric Power Distribution System Engineering, by Turan Gonen

Therefore, both power stations serve the feeders connected their 13.2 kV buses and there is no power flow through the 34.5kV line. To represent the system peak load of 24.75 MW, a Diversity Factor[2] of 76% is applied to all loads in the model. Since power station's own loads do not cause system losses, those loads are not included in the peak demand to determine the Diversity Factor.

At the next page the ASPA system one line diagram is shown. Please note that in ETAP the system model is nested, which means that details of each feeder is in a subnet, showing in a separate window. The feeder tabs in the one line diagram are just visual indicators, not the actual ones.

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[2] Diversity Factor defined in ETAP, and used to scale loads.

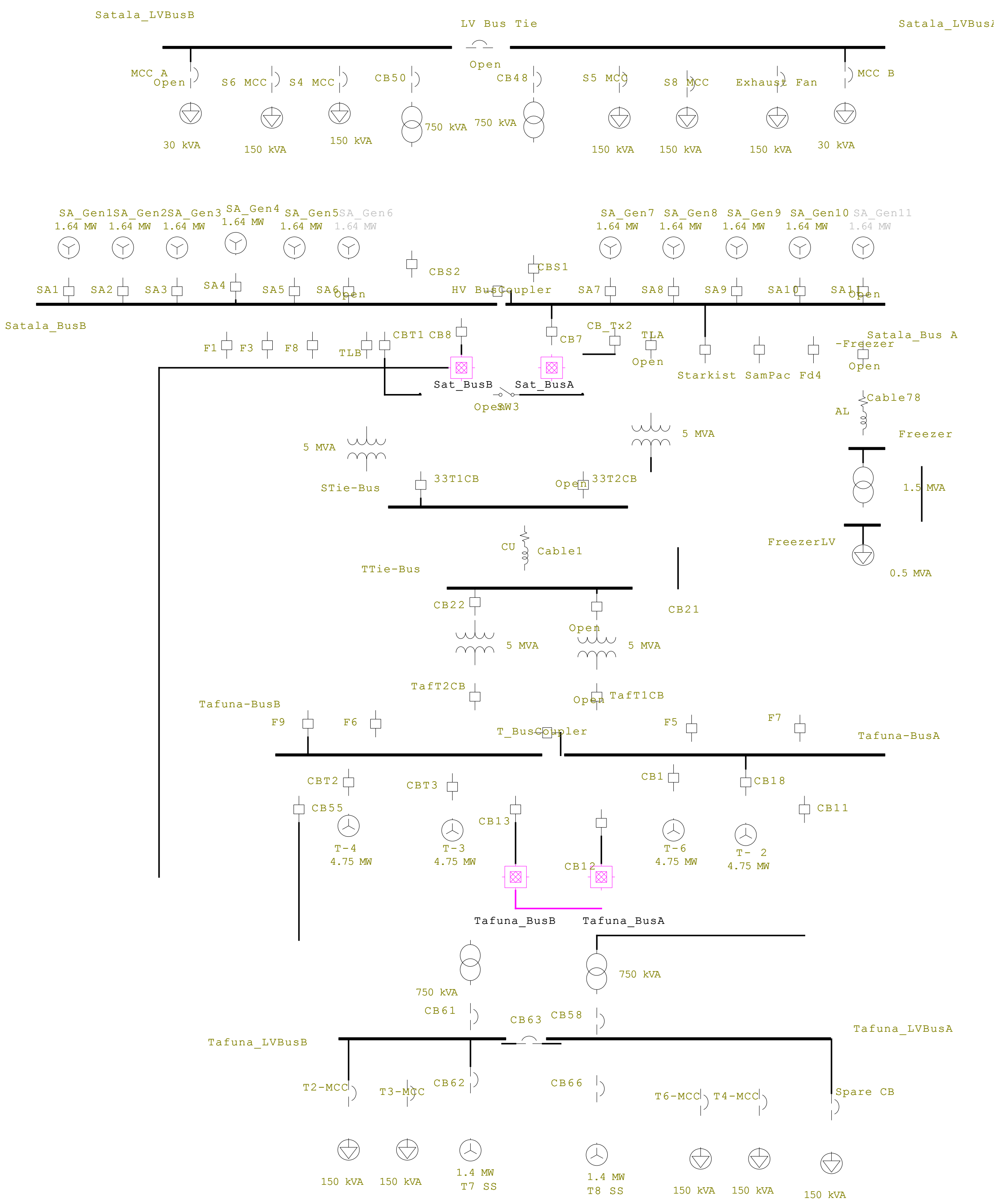

Exhibit 1: ASPA one line diagram

3.3 System Loss Estimation

System losses include technical losses and non-technical losses.

Technical losses are estimated as the sum of losses in several grid parts: transmission lines, primary feeders, power transformers, distribution transformers, and secondary wires. Except losses through transmission lines and primary feeders, as well as power transformer copper losses, all other losses have been calculated in Excel sheets. Where information was not fully sufficient, assumptions were made to facilitate the estimation, and could result in a margin of difference from the actual loss value.

Non-technical losses have been calculated as the difference between total system losses and technical losses. The total system losses are the total energy entering into the system out of power plants subtracted by total energy sold and the energy unaccounted for. ASPA serves street lights and provides water and sewer service. Street lights are accounted for and billed. Energy consumption for water and sewage services are billed to the water department. A summary of the loss estimation is provided in the following exhibit.

Exhibit 1: Loss Estimation

Based on 2010 figures	MWh	% of generation	% of energy entering into the T&D system
Annual generation	159,113,294		
Annual station auxiliary	479,892	0.30%	
Annual energy entering into the T&D system	158,633,402	99.70%	
Annual energy sold	142,573,920	89.61%	89.88%
System loss	16,059,482	10.09%	10.12%
Unbilled usage (street light)	0	0.00%	0.00%
Technical loss	9,589,915	6.03%	6.05%
Non technical loss	6,469,567	4.07%	4.08%

4. Electrical Data Handbook

As part of the project's scope of work KEMA has prepared an Electrical Data Handbook which contains the electrical characteristics of the ASPA power system high voltage equipment.

The Electrical Data Handbook has been attached to this report as Appendix 2.

5. Analysis of technical and non-technical losses

5.1 Technical Losses

Technical losses are 6.04% of the total energy entering the T&D system out of the power stations. Exhibit 3 shows a breakdown of technical losses for the different technical loss causes.

Exhibit 3: Technical Losses

Type of Losses	Sub Total MWh	% of total technical losses
Dist Transformer Core	2,053	21.41%
Dist Transformer Cu	560	5.84%
Secondary wires	5,273	54.99%
Feeder Wires	1,703	17.76%
Power Transformer Cu	0	0
Power Transformer core	0	0
Total =	9,590	100.00%
Core Losses Alone	2,053	

No losses have been calculated for the power transformers 34.5/13.2 kV since the 34.5 kV transmission line has not been in service during the period considered for calculating technical losses. As this occurs in many cases technical losses are relatively high in the low voltage system (in ASPA's case 54.99%) while distribution transformer core losses are causing 21.41% of the technical losses. The relatively low copper losses indicate that the distribution transformers are oversized to a certain degree.

In general 6.03% of technical losses is a relatively good figure. In Chapter 6 it will be indicated what potential may be available for further reduction of technical losses.

5.2 Non-Technical Losses

Non-technical losses are 4.08% of the total energy entering into the T&D system. Inaccuracy of meters will be partly causing the non-technical losses, as well as problems that occur with the prepaid meters as already mentioned. Next to that theft, meter tampering, by-passing are contributing to non-technical losses.

For determining the non-technical losses KEMA has deducted the calculated technical losses from the total losses that are given by the ASPA statistics (energy entering into the system minus the total energy sold). The total of energy entering into the system is every time measured over a month period from the 1st day of the month until the 1st day of the next month. Energy sold however is taken from the meter readings which are done every month in the period from the 1st until the 14th. Furthermore the energy sold via the prepaid meters is based on prepayments by the customers and not actually on the exact usage of these prepaying customers during a month. In fact an exact measurement of system losses will only be possible if all customer usages are measured from the 1st of the month to the 1st of the next month, which in fact will only be possible once an Automated Metering Infrastructure (AMI) has been installed.

Based on ASPA's yearly statistics we have seen that system losses are varying around 9%, sometimes somewhat higher, sometimes somewhat lower. Our calculations for 2010 are based on May 2010 data, extrapolated into annual statistics. This may have caused that losses are some 1% higher than measured in previous years.

6. Findings and Recommendations

6.1 Technical Losses

The technical losses in the ASPA distribution system are with 6.04% at a reasonable level. During the period as observed by KEMA the transmission system between the two power stations has not been into service, which means that each power station has served its part of the island. Under the current load conditions the transmission line should only be energized in case of shortage of production capacity in one of the power stations, although the ASPA grid will be more stable in case both power stations are interconnected, which will become of increasing importance if more intermittent renewables will be connected to the grid. Without the transmission line energized both power stations can however operate under the n-1 condition, supposed all generators are operable. There will be cases when the transmission line needs to be put into service, in case for example one generator in Tafuna is under maintenance and another generator trips. In case the transmission line has to carry – for example – 4 MW to support one power station by the other one, the additional losses in the transmission line and power transformers at both terminals would be 45.6 MWh on a monthly basis and would increase technical losses from 6.04% to 6.37%. However, this is a rather hypothetical scenario, since n-2 at the Tafuna station is an emergency situation and would not continue for a long time. Therefore the 6.37% annual technical loss value for this scenario is accurate by itself, but misleading because transmission of 4 MW is only a forced and relatively short-term amount of power flow in an N-2 scenario. Normal dispatch with the 34.5kV line would be smaller, assuming the Tafuna units are of comparable kWh/Gal efficiency.

During KEMA's visit in June 2011 a new feeder line was under construction. This new feeder, called Feeder 10, leaves the Tafuna power station and will take over a part of the load of Feeder 9, which is ASPA's most heavily loaded feeder with more than 3,800 customers. At a certain point Feeder 9 will get its new ending point while the remainder of this feeder will be connected to Feeder 10. It is expected that by taking over a part of the load of feeder 9 by feeder 10 the overall feeder line losses will become slightly lower.

Since the total installed capacity of distribution transformers is more than 70 MVA, while the ASPA peak load is around 24.8 MVA, it can be concluded that ASPA's distribution transformer capacity is oversized. This means that not only capital costs are higher but that all distribution transformers together also create a relatively high amount of core losses, and on the other hand relatively low copper losses. For future expansions and or replacements these aspects should be evaluated in a cost/benefit analysis, while at the same time the transformer specifications for new transformers should include valuation figures for copper and core losses in order to evaluate the transformers' total lifecycle costs. This way a cheaper transformer (mostly having higher losses) may have higher lifecycle costs than a more expensive transformer that has lower losses.

Furthermore it would be worthwhile to measure the power factor in longer and higher loaded feeders. Once the power factor values are known it can be determined whether investing in capacitor banks could be beneficial because of lower losses. Furthermore ASPA should require large industrial and commercial customers with power factor below 85% to maintain power factor requirements above 85%.

A final recommendation is to regularly check electrical connections in 13.2 kV lines and connections with switchgear and transformers as well as connections in the LV system. This could be done with an infrared camera. It is KEMA's experience that these types of connections to switchgear and transformer bushings can become hot spots after being in service for years, which cause higher technical losses.

6.2 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.

During the site visit we noticed that:

- All meters are read monthly between the 1st and 14th day of the month, which means that there is an inaccuracy in the monthly statistics of energy consumed compared with the energy entering into the system as read between the 1st of the month and the 1s of the next month;
- Meters in the power stations and at the outgoing feeders are not revenue class meters;
- The determination of usage with prepaid meters is inaccurate as long as the problems with entry pads which need to be replaced and with problems with tokens that clients can re-enter have not been resolved.
- In May 2011 ASPA found 7 illegal prepaid meters and monthly ASPA goes out for checking 100 to 200 meters because of red flags and irregularities. Some 80 meters are tested weekly because of irregularities found.
- Irregularities are found by meter readers, while the CIS/billing system raises a red flag when irregular usage is found.

- There is still a large amount of aged meters (Westinghouse and GE) which may have a bad accuracy.
- Theft, meter tampering, meter by-passing are phenomena that occur in American Samoa, given the relatively high amount of irregularities that are found monthly.

As KEMA found in its loss calculations as summarized under Section 3.3 the non-technical losses appear to be 4.07%. Reduction of non-technical losses should be pursued in order to reach a level of not higher than 2%.

6.2.1 Sources of Non-technical Losses

6.2.1.1 Metering Issue Losses

In order to have a better match between energy sold and energy entering into the distribution system, it would be better to perform the monthly meter reading every month around the last day of this month. This way the energy sold is (almost) covering the same monthly period as the monthly generation statistics. This way – particularly when looking at a period of one year – the measured losses will have a higher accuracy.

6.2.1.2 Aged Meters

The condition of the rather old meter population is not really known. Regularly old meters are taken out of the system in order to verify accuracy of this old meter population. Some 80 old meters are tested weekly. Records should be maintained of meter types and/or certain manufacturing years of meter types, which show a bad accuracy when tested. This way a dedicated meter replacement program can be developed, in conjunction with the program for introducing more prepaid meters.

6.2.1.3 Meter Tampering and Meter Bypassing

Meter tampering and meter bypassing are phenomena that monthly occur. Records should be maintained of customers that have been identified for tampering and/or bypassing in order to regularly monitor the status of these customers' meters. This should also be done for customers with prepaid meters where tampering and/or bypassing has been identified.

6.2.1.4 Inaccurate Meter Reading

Inaccurate meter reading has not reported by ASPA as being a real issue.

6.2.1.5 Billing Collection Losses

Billing collection losses and bad debt are not to be counted to system losses. Any billing losses or bad debt amounts that have to be written off, are financial losses and not system losses.

6.2.1.6 Administrative Failures

The occurrence of administrative failures (in the process from meter reading to billing) has not been identified.

6.2.1.7 Line Throw-ups

No line throw-ups have ever been identified. What is line throw-ups.

6.2.2 Analysis of Non-Technical Losses

When analyzing non-technical losses it can be noticed that the loss calculations show a percentage of non-technical losses of (4.08%).

Non-technical loss causes that can occur are inaccurate meters and furthermore the overall non-technical loss figure is also being influenced by the fact that there is a discrepancy between the recording periods of “energy sold” and “energy entering into the feeders”.

Furthermore some 100 to 200 irregularities are found monthly including irregularities by meter tampering and bypassing (theft). Irregularities with prepaid meters also contribute to non-technical losses.

At different utilities we have seen that verification of the quality of billing system data, such as multiplying factors for larger customers, also reveals errors that contribute to non-technical losses. Periodical verification of the billing system data may also bring some opportunities for reducing non-technical losses.

6.2.3 Recommendations

In larger utilities with too high amounts of non-technical losses, one of the main areas in aligning a utilities’ operation to Revenue Assurance is to implement a Revenue Assurance Process making use of an advanced Revenue Intelligence System. For conducting most efficient fraud prevention/detection and revenue operation audits with limited resources, an advanced Revenue Intelligence system is very helpful. Such a system can detect potential fraud based on information from multiple sources using advanced detection rules. It will vastly increase the hit rate and support a range of revenue assurance activities. These changes/processes should include:

- Implementation of a formal Revenue Assurance Process including an overall Audit Process.
- Implementation of Revenue Intelligence software to support Revenue Assurance oriented operations

However, for a **small utility like ASPA** with non-technical losses at 4.07% - which is too high but not exceptionally high, implementation of a Revenue Assurance Department and implementation of Revenue Intelligence software requires a large investment and may have a large organizational impact.

A more pragmatic approach can be developed to locate non-technical losses and increase the effectiveness of revenue-protection operations.

ASPA is recommended to consider the following:

1. Assign a senior staff member to be Revenue Assurance Officer, responsible for Loss Reduction Strategies, and who plans and initiates loss reduction programs, keeps records of progress, and reports to the General Manager.

2. Develop a program for checking old meters.

3. Train meter readers to identify tampering, by-passing, broken seals, hook ups.

4. Train a customer service staff member to audit metering and billing processes (including quality checks of billing system data such as multiplying factors, tariff categories applied to customers, functioning of red flags in the case of irregularities) and non-technical loss causes found by meter readers, such as meter tampering or by-passing.

5. Select targets for inspection, also focusing on commercial customers. When selecting targets for inspection, the potential of the estimated amount of revenue recovery should be a major selection factor. When selecting accounts with highest revenues the recovery potential and hit rates will be the most efficient, particularly when only limited resources will be available.

6. Make operations less predictable. ASPA's own experience may possibly show that there are sophisticated fraud activities that take advantage of known patterns of Revenue Assurance operations. This should be countered with less predictable operations (e.g. occasional night inspections, computer-generated random daily target lists, and so on). This will help to identify these fraudsters and increase the deterrent effect.

7. Prevent repeat fraud activities. Once a fraud is found, measures should be implemented to ensure it will not occur again.

8. KEMA has no reason to assume that any internal collusion activities occur at ASPA. In general we see that an important aspect of effective revenue protection operation is to prevent and curb potential internal collusion. Internal collusion seriously undermines the effectiveness of any revenue assurance process. One possible solution is to bring in non-local inspection teams to conduct critical revenue-protection operations, such as large account audits under the direct control of the utility's top management.

9. Employ right tactics for each group of customers. It is a fact that different types of customers have different needs for electricity, different usage patterns and different payment capabilities. A successful revenue assurance strategy should take this into account to develop corresponding tactics for each group of customers. In general, customers should be grouped based on their usage patterns and payment capabilities. Establishing typical usage patterns and payment capabilities for each group is a very important task of Revenue Assurance. Results should then be used as the basis for employing right tactics for each group of customers.

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7. Suggested Equipment Replacement

The analysis of technical and non-technical losses at ASPA's T&D system has not revealed that immediate replacement of certain components of the system would bring substantial loss reductions which go along with favorable pay back times due to the benefits that the replacement would bring.

Further investigations on the power factor in different network parts could reveal the justification of investing in capacitor banks. In order to identify such situations power factor measurements should be carried out in suspected network parts.

We would also advise to invest in an infrared camera with supporting software ($ 30k to $ 40k) in order to identify hot spots in the system that are causes for high technical losses in for example bad connections and bushings.

For future expansion and/or replacement of distribution transformers it is advised to choose appropriate transformer ratings with which losses will be lower than in the current situation with an oversized transformer population.

ASPA is already working on resolving the problems with prepaid meters that undoubtedly have contributed to higher non-technical losses.

ASPA should continue with checking the old population of electromechanical meters and should develop a meter replacement program.

Appendices

Appendix 1: Data Request

Appendix 2: Data Handbook

Appendix 3: Loss Reduction Worksheet