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POWER QUALITY MANAGEMENT PLAN 2011

DOCUMENT NUMBER: NW-#30060260

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0		Original Issue	Prepared by	AJF
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1	14 April 2011	After comments received by consultants	Prepared by	GJM
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			Approved by	MJIG

1. PURPOSE

The purpose of this document is to describe, for Power Quality (PQ)

- Aurora's approach to PQ management, as reflected through its legislative and regulatory obligations;
- The key projects and programs underpinning its activities for the period 2011/12 -2016/17; and
- Forecast capex and opex, including the basis upon which these forecasts are derived.

2. SCOPE

This document outlines the implementation and management of the PQ Strategy and associated Program of Work from 2011/12-2016/17.

Power Quality is defined by a set of parameters that describe how suitable the supply is to Aurora's customers. Specifically:

- Steady State voltage;
- Voltage Sags & Swells;
- Harmonics, Flicker & distortion;
- Voltage Unbalance and
- Power factor

are the parameters used by Aurora to describe PQ. Reliability of supply is excluded.

The PQ thread manages the specific PQ issues, and relies on other threads to consider and maintain the general network PQ through their asset management and augmentation practices. The PQ thread works with the Development thread where issues relate to load constraints, and the Metering thread for the implementation of PQ metering.

3. BACKGROUND (SET THE SCENE)

3.1 Tasmanian Electricity Code

The Tasmanian Electricity Code (TEC) outlines Aurora Energy's PQ responsibilities and obligations. It covers of all the PQ parameters in Chapter 8. The TEC refers to the Australian Standards where necessary. In conjunction with the TEC, the National Electricity Rules (NER) will be followed.

While the TEC does not refer to PQ, the parameters are defined in the following chapters

- 8.6.3 Power Factor
- 8.6.4 Voltage
- 8.6.5 Harmonics
- 8.6.7 Negative Sequence Voltage
- 8.6.9 Voltage Fluctuations

These parameters define the minimum standards of PQ Aurora aims to deliver, and the TEC is used as the threshold to trigger augmentation.

Section 8.6.11 Interruptions to supply, known as the reliability standards are not considered PQ and are not addressed in the management of PQ.

Sections 8.6.5 Harmonics & 8.6.9 Voltage Fluctuations call on AS/NZ 61000.3.6 and AS/NZ 61000.3.7 respectively, and these standards dictate the permissible levels of harmonics and voltage fluctuations. These levels together with additional distorting loads influence the type and size of allowable connections and can drive augmentation to increase fault levels to manage existing PQ.

3.2 National Electricity Rules

Schedules S5.1.5 and S5.1.6 define the Voltage Fluctuations and Voltage Harmonic limits and duplicate the TEC 8.6.5 and TEC 8.6.7 and as such there is no additional requirements from the NER.

4. TREATMENT TRADE-OFFS

4.1 Inspection and monitoring

All PQ improvement work is based on actual inspection monitoring at the location of the reported issues, providing an accurate measurement of the issue to direct the solutions if needed. Under this process, the exact cause of the issue is detected and ensures the appropriate solution is undertaken.

The monitoring process requires further improvement by increasing the coverage of the network and allowing proactive management.

CablePI has provided a valuable monitoring tool and identified a number of issues that would have been otherwise unreported by Aurora's customers.

4.2 Planned vs Reactive Renewals

At present all renewals are reactive to issues identified through the reactive PQ management process. The PQ monitoring program will lead to proactive management by monitoring the network for issues and allow a planned response. However for this to

occur there needs to be a critical mass of PQ meters providing coverage over the entire network. With the proposed present PQ monitoring program this is not expected to occur in the next five years.

4.3 Non-network solutions

PQ management will benefit from the Non-network solutions particularly in the introduction of Demand Management initiatives planned as part of the Demand Management Plan.

PQ issues are generally resolved by augmenting the network with either a transformer or low voltage circuit upgrade. The time frames dictated for resolution of issues does not provide opportunities to deploy non-network solutions.

As the strategy of proactive management is implemented these opportunities will become available.

5. REACTIVE PQ MANAGEMENT

5.1 Process

Reactive PQ management is managing a customer's issue after it has presented itself. Aurora's commitment to improving PQ and customer service drives the process, reinforced by the requirements in the TEC. The two main drivers from the TEC are to resolve the issue in a *timely* manner and to the required *standard*. Appendix A shows the current process that is used to manage the reactive PQ management.

5.2 Customers Complaints

PQ issues present in an electricity network can result in different issues that our customers will notice and alert Aurora. Common complaints feature "power surges"; usually symptoms of poor voltage supply. Other issues include clocks running fast (due to voltage notching), damage to motive loads or equipment that will reset or is inoperable.

Call centre staff are trained to recognise these issues and a fault crew will visit the site to verify the issue and check for unsafe conditions. Once an issue has been established the complaint will be forwarded to the PQ Investigation stage.

5.3 PQ Investigation (AIQMO):

In the current pricing determination (2008-2012), this OPEX work program (category code: AIQMO) is the main conduit to assess PQ issues within the network. It is primarily a reactive process where the customer initiates contacts with Aurora about a PQ issue. It should be noted during the 2012 – 2017 period Aurora will begin to promote the proactive management of power quality as detailed in section 7 of this plan.

This program involves a field officer visiting the site, inspecting the network and connections, assessing the load of the circuits, installing PQ logging equipment at the customer point of connection and transformer terminals. The PQ logging equipment is installed for several days then analysed to determine the issues. Additional logging in different locations may then be required to find the source of the issue.

Once the cause of the PQ issue is identified the appropriate corrective measure is determined and implemented. The work programs to rectify the PQ issues are discussed in section 11. The driver for this work is for TEC compliance, ensuring that the technical requirements are adhered to and in a timely manner.

5.4 Install new overhead transformers for voltage improvement (PQTXV) & augment overhead circuits for voltage problems (PQLVV)

There are two main work programs that look after the upgrade of the network due to voltage issues. They are broadly defined by installing a transformer OR upgrading the low voltage circuit.

The work program "Install new overhead transformers for voltage improvement" (category code: PQTXV) primary focus is to install a transformer and associated works to rectify a PQ issue. Where as, "Augment overhead circuits for voltage problems" (category code: PQLVV) primary focus is the upgrade of the low voltage reticulation to rectify a PQ issue.

These two work programs are primarily generated from supply quality PQ complaint process (covered under AIQMO). Regional/Local Area Managers also generate this category of work on as need basis. Both methods are a *reactive* trigger to solve the PQ issue. A small number of jobs for PQTXV and PQLVV are identified prior to the beginning of the financial year's program of work. These are entered as confirmed work and are deemed *proactive* type jobs.

Based on historical spend over the past three years (FY 2006/07, 2007/08, 2008/09), it has shown a variable capital expenditure with no clear trend showing an increase or decrease. This is in the table below:

	FY 2006-07	FY 2007-08	FY 2008-09
PQLVV	**$ 363,372**	**$ 569,922**	**$ 402,897**
PQTXV	**$1,201,180**	**$1,300,655**	**$2,277,242**

6. ASSESS NEW CONNECTIONS

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6.1 New Supply Process

The New Supply Process captures all new connections to the system, and identifies loads that have the potential for creating disturbances. Each identified load is assessed against the PQ parameters defined in the TEC for compliance. This process ensures that all potentially distorting loads will not cause PQ issues.

6.2 Flicker and Harmonic Allocation

For larger distorting loads the methodologies defined in AS/NZS 6100 0.3.6 *Limits – Assessment of emission limits for distorting loads in MV and HV power systems* and

AS/NZS 61000.3.7 *Limits – Assessment of emission limits for fluctuating loads in MV and HV power systems* for allocating voltage flicker and harmonics are used. The implementation of methodologies is undertaken using AS/NZ Hand Book 264 (HB264).

This process involves determining planning levels at feeder levels and allocating a portion of the planning level to the new loads.

7. PROACTIVE PQ MANAGEMENT

A key strategic initiative of the PQ Strategy is to move to the proactive management of PQ. Reactive management is the only option available to Aurora at present, as there is little or no PQ monitoring within the network. There are several issues that proactive management can resolve.

To enable proactive management the following conditions need to be met

- A comprehensive PQ metering program covering the bulk of installations
- PQ analysis to identify issues
- A range of tools to address the issues

This initiative began this regulatory period through the introduction of the PQ monitoring program.

7.1 Reactive Process Issues

The present reactive process will continue to *maintain* PQ only by responding to customer issues once the issue has become severe enough to result in a complaint. This results in the need for a timely resolution to the issue involving:

- An immediate Field crew visit (safety check)
- Installation of temporary PQ meters and subsequent investigation within 21 days. Involves two more site visits
- A fast resolution to the issues, potentially with a capital improvement, that impacts the work planning during the year.

7.2 Proactive Management Benefits

By moving to Proactive management several benefits can be achieved.

7.2.1 Improved Customer Service

Proactive PQ management aims to address issues *before* they become severe enough to cause a complaint from customers. By achieving this customers will receive an increased quality of supply and improves customer service through a reduction in complaints.

7.2.2 Reduced Operating costs

By utilising PQ monitoring devices in the network, Field crew visits and PQ investigation visits won't be necessary, reducing these operating costs significantly.

There are also network over-heads associated with managing the reactive process that are expected to reduce.

7.2.3 More options to improve supply

Under the reactive process the time frames to implement the solutions are internally set to six weeks, due to an improved customer service driver. This time frame is quite onerous on Network Services especially when lengthy designs are needed. The result is that only local network augmentation options are considered.

With more time to further investigate other options including detecting the source of the disturbances or non-network alternatives, capital efficiency may be obtained.

7.3 Benefit realisation

A key requirement to realising the benefits is a comprehensive monitoring program to identify the issues proactively. While this monitoring program has already begun to be rolled out, it will need to cover a critical mass of the network to allow the proactive process to override the reactive process and deliver the benefits described above. With the proposed PQ program the required coverage will take around five years. Therefore there is no OPEX reduction forecast in the coming regulatory control period.

8. PQ MONITORING PROGRAM

The PQ monitoring program is designed to monitor network PQ performance and ultimately identify PQ issues necessary for proactive management. The PQ monitoring program is focused explicitly on delivering PQ outcomes and excludes any activities related to consumption metering for revenue purposes.

8.1 PQ Metering programs

The data collected by the PQ meters will be in a varying form and complexity. It is intended the installation of these meters will drive AIQMO down over time and proactively aid PQTXV and PQLVV categories of work. The OPEX associated with this category is the costs for the communications to meters.

In order to change from a reactive strategy (pricing determination 2008 - 2012) to a more proactive strategy, more PQ data is required. By obtaining PQ data at the start and end of LV feeders in the first instance, will enable a more proactive management of the system. This will aid in identifying issues before they arise and improved management of customer expectations.

Appendix A shows the existing and proposed processes for PQ management.

8.1.1 Specialised PQ meter on bus of substation

To complement the previous installation of the smart type feeder PQ meters, specialised PQ meters will be installed on substation bus bars or bus sections (if the bus is run normally opened). These meters will be the highest of class of metering and provide the required standard of metering to deliver Aurora's obligations with the Australian Standards defined in the TEC. These specialised meters will be able to capture RMS (Root Mean Square) and waveform graphical information and short and long term flicker, which have not, in the past, been captured on an ongoing basis. These meters will aid, not only in PQ investigations (such as motor starts, transients and harmonics), but protection events will see a huge benefit from these meters – able to pin point and help with identifying protection issues.

8.1.2 Smart PQ meter at the start and end of LV feeder

A smart type PQ meter will be installed at the start and the end of every LV feeder connected to transformers equal and greater to 100kVA. The PQ meter at the start of the LV feeder will identify any issues with the transformer (tap setting, loading) it is connected to. Whereas, the PQ meter at the end of the LV feeder primarily identifies any issues associated with the LV feeder (conductor size, voltage drop).

Regular collection of the recorded PQ data from these meters will drive the PQ strategy to proactively monitor the network and issue upgrades. The three proposed methods of collecting PQ data are:

- PQ Investigator (meter reader) to attend on site and conduct a manual download
- Connect the PQ meter to a modem and communicate via the NextG network
- Meters to be connected up in a smart grid environment, for example, Silver Springs

Currently, the manual download via a PQ Investigator will be the method of collecting this data, until smart grid strategies are fully implemented.

To drive efficiency and reduce costs, this program will be completed in conjunction with the meter non-demand replacement program. The PQMET program will influence the location of the meter replacements to maximise the benefits to both parties.

This project is to be delivered by the Metering thread and no PQ funding has been forecast for this project.

8.1.3 Ground mounted Substations

Ground Mounted substations require attention regarding PQ due to the comparatively higher number of customers connected to these substations. By measuring the PQ performance of sites with suspected issues, augmentation can be planned with greater certainty and allow greater time to consider non-network alternatives. The PQ meters replace the existing Maximum Demand meter and provide a greater level of detail for load management purposes.

All new padmounts substations are now commissioned with a PQ meter. These meters will be capturing PQ data continually, and can be downloaded manually on an as needs basis.

8.1.4 Overhead transformers

Similar to ground mounted substations, larger Overhead substations supply a large volume of customers and can result in expensive augmentation projects to resolve PQ issues. By measuring the actual performance of transformers with potential issues, augmentation can be planned with greater certainty and allow greater time to consider non-network alternatives.

This project will be trialled during the coming regulatory period. Ten sites will be selected for the trial concentrating on transformers 100kVA and greater. This trial will enable future deployment of such a PQ metering methodology when needed in a required and timely manner.

8.1.5 Replacement loggers

In order to continue with the reactive PQ Investigations under the AIQMO program, PQ loggers are required to carry out the data logging. These only have a limited life and the ongoing update and replacement is required in order to maintain the high levels of data logging and to comply with Australian metering standards.

8.1.6 Long Term National PQ Survey

The 'Long Term National PQ Survey' is a program Aurora has been associated with for many years. Aurora provides varied PQ data from different sites and voltages from across Tasmania. This data is compared with other distribution businesses involved in the survey and a detail report of the state of the network is provided. The survey allows Aurora to compare its PQ performance against other distribution businesses and determine any trends in network PQ performance.

Aurora is intending to use the Survey and its metrics for the internal analysis of the large volume of PQ data to be gathered from the PQ monitoring program.

9. NEW TECHNOLOGY SOLUTIONS

New concepts will be trialled, developed and then implemented into the distribution network. Two targeted areas are low voltage regulators and new automatic voltage regulators.

The aim of low voltage regulation is to target specific areas with poor voltage level issues by regulating the voltage to within standards. This targets non-complaint LV installations where the cost of a full HV upgrade is cost prohibitive.

The aim of the installation of new automatic voltage regulators (under the category code: PQRIV) is to replace the existing AVR in ground-mounted regulators. The main drivers are for greater PQ data collection and improved tap control due to the increasing penetration of embedded generation onto the distribution network. The reverse power flow through the regulator will be a result of embedded generation and suitable equipment must be in place to cater for it.

10. POWER QUALITY WORK PROGRAMS

The work programs proposed in the 2012/13 – 2016/17 regulatory control period are detailed below.

10.1 Reactive PQ Management Programs

The Reactive PQ Programs

- PQHVV- Augment OH HV- Voltage Regulation Improvement
- PQLVV- Augment OH LV- LV Ccts for Voltage Problems
- PQTXV- New OH Transformers for Voltage Improvement
- AIQMO- Power Quality Investigations (OPEX)

represent the work programs associated with the Reactive PQ Management Process. The forecast methodology for these work programs can be found in NW-#30132733-Power Quality Process Category Analysis.

10.1.1 PQLVV

This program aims to address PQ issues that arise in the LV network. The issues are identified through the reactive process and may involve re-balancing of the LV network, adjusting transformer tap settings or augmenting the LV circuit. This program continues at average (based on the previous 5 years historical volumes) levels from the present regulatory period and predicts 41 individual augmentation projects annually. This program was costed by Network Services with the forecast volumes provided.

10.1.2 PQTXV

This program aims to address the PQ issues that arise at the MV-LV transformation level. The issues are identified through the reactive PQ process and generally address undersized transformers affecting steady state voltage under peak load conditions. PQTXV work may also involve augmentation of the LV network. This program continues at average levels from the present regulatory period and predicts 67 individual augmentation projects annually. This program was costed by Network Services with the forecast volumes provided.

10.1.3 AIQMO

This program represents the operating cost to investigate power quality complaints raised by Aurora customers.

The forecast is for 650 investigations per year. This project is costed on a per unit basis by Network Services and provides a unit rate for budgeting purposes.

10.1.4 PQHVV

This program aims to address PQ issues that arise within the HV network. These are generally steady state voltage issues that are the result of incremental load growth on rural feeders with smaller size conductor. This program augments conductors identified through the reactive process and increases fault levels to reduce customer complaints from substandard voltage. As the issues addressed under this program affect the HV network, the benefits address larger numbers of customers. As this program is reactive, the forecast is based on a volume forecast. This program has been allocated $150k nominally per annum to augment 1.5km of small size conductor based on continuing the existing the program at the present rate. This program was costed by Network Services with the forecast volumes provided.

10.1.5 PQRIV

This program aims to address the PQ issues that arise in the HV network and result in the installation of HV voltage regulators. In some cases the installation of HV regulators offers a cost saving over HV augmentation. Aurora has installed a total of four HV regulators since 2008 to address HV steady state voltage issues. Aurora anticipates three more regulators to address steady state voltage issues, based on a slight reduction in volumes from the present regulatory period. This program was costed by Network Services with the forecast volumes provided.

10.2 PQ Metering Programs

10.2.1 PQMET

The PQ Metering program consists of the following projects:

- Install PQ Meters – Ground Mounted Substations
- Install PQ Meters – OH Transformers (trial)
- Specialised PQ Metering at MV Bus

- Purchase replacement loggers for voltage monitoring

Each project forecast can found here: NW-#30168190-PQMET - Forecast Numbers (PD2012)

The Project *Install PQ Meters – Ground Mounted Substations* will retrofit PQ meters with communications in ground-mounted substations in place of analogue maximum demand meters. This project is underway in the present regulatory period and will continue into the next. The sites are chosen on a strategic basis to maximise the benefit to other threads.

The Project *Install PQ Meters – OH Transformers (trial)* will trial the PQ monitoring in large OH transformers. The trial project will look at different aspects of hardware, installation, information gathered and location of sites.

The *Specialised PQ Metering at MV Bus* project will install higher quality PQ logging equipment at the bulk supply substation bus. These devices are required to provide information on the harder to detect PQ parameters such as harmonics and flicker. Aurora intends to rollout these meters to all major substations within the next regulatory control period.

The *Purchase replacement loggers for voltage monitoring* updates the older PQ logging equipment used as part of the PQ investigation process. Newer equipment provides additional functionality for the faster identification of PQ issues. This program was costed by Network Services with the forecast volumes provided.

10.2.2 PQCOM

This operation program allows for the modem communication costs associated with remotely gathering the information required under the PQ metering program. This program forecast is based on actual proposed meter installations in line with the proposed PQ Metering program. The forecast can be found here: NW-#30133592-PQ Projected Modem Operating Costs (PD4)

10.2.3 National PQ survey

The National Long Term Power Quality Survey (LTNPQS) is a nationwide survey sponsored by the Energy Networks Association (ENA) Reliability and Power Quality Committee (R&PQC) and collated by the University of Wollongong. This survey provides a valuable insight into the status of Aurora's PQ, comparisons against national performance and trends. Aurora is able to use this information at a high level for strategic development and planning. The survey has been a key input into the development of the PQ monitoring program.

10.3 New technology

10.3.1 PQRIV

Low Voltage Regulators - Development and Trial

Aurora intends to trial the use of Low Voltage regulators on the network as a tool to defer network augmentation. Initial research shows the devices can be effective but

further development and trials are necessary. Aurora intends to trial 10 devices commencing in 2012/13 and trial these for up-to three years, then following the successful trial continue the rollout to other areas.

10.3.2 Install AVR Ground Mounted Regulators with SCADA Comms

This program aims to upgrade the Automatic Voltage Regulators (AVRs) in ground mounted three phase voltage regulators with modern electronic relay units. These devices provide additional voltage regulation functionality such as line drop compensation to provide better voltage regulation as well as the SCADA remote control, monitor and event logging.

10.4 Other PQ Programs

10.4.1 PQHVV – Consultant reviews

A category of work for consultant reviews has been included to aid in specific jobs for PQ related works.

Generally the work consultants are engaged for is around specific issues involving complex harmonic or flicker problems, or when particular customer equipment is impacting customers in the network and a third party opinion is required.

11. SUMMARY OF PROPOSED EXPENDITURE

11.1 Introduction

This section contains a summary of the forecast expenditure to complete the PQ Program

11.2 CAPEX

Table 11.2 shows the CAPEX.

	2012/13	2013/14	2014/15	2015/16	2016/17
Augment OH LV Circuits (PQLVV) (D Type)	$625k	$590k	$590k	$590k	$585k
Install Substation - New OH Transformer for voltage improvement (PQTXV) (D Type)	$2,115k	$2,150k	$2,150k	$2,150k	$2,140k
Augment OH HV Circuits (PQHVV)	$160k	$160k	$160k	$160k	$160k
National PQ Survey	$40k	$40k	$40k	$40k	$40k
Reviews & Studies by Consultants	$20k	$20k	$20k	$20k	$20k
Install PQ Meters - Ground	$135k	$135k	$135k	$135k	

Mounted Substations substation					
Install PQ Meters - OH Transformers (Trial)				$65k	
Purchase - Replacement Loggers for Voltage Monitoring (Including Complaints)	$7.5k	$7.5k	$7.5k	$7.5k	$7.5k
Specialised PQ Metering at MV Bus	$175k	$175k	$175k	$175k	$175k
Install AVR Ground Mounted Regulators with SCADA Comms	$135k	$135k			
Install Voltage Regulator(s)	$135k	$135k	$135k		
Low Voltage Regulators - Development and Trial	$400k	$400k			$400k
Total CAPEX	$3,947.5k	$3,947.5k	$3,412.5k	$3,342.5k	$3,527.5k

Table 11.2: PQ CAPEX for 2012 – 2017

11.3 OPEX

Table 12.3 shows the OPEX.

	2012/13	2013/14	2014/15	2015/16	2016/17
AIQMO Scope PQ Investigations	$708k	$700k	$700k	$700k	$690k
Install PQ Meters - Communications Costs	$4k	$6k	$8k	$9k	$10k
Total OPEX	$712k	$706k	$708k	$709k	$700k

Table 12.3: PQ OPEX for 2012 – 2017

11.4 Comparison with Historical Spend

The overall PQ capital forecast is a decrease on the 09/10 financial year Program of Work.

The forecasted funds allocated to the Reactive management for PQ continues at the present levels, with no increase in volumes of work anticipated. The past work on improving the PQ in the HV network has decreased as the issues have been addressed. The forecasted number of new voltage regulators needed due to PQ issues has also decreased.

The continued implementation of the PQ monitoring program will see a resulting increase in CAPEX directed to the program, and a minor operating expense for communication costs. This program will identify new issues that will need to be resolved in the medium term (i.e. beyond the next regulatory control period)

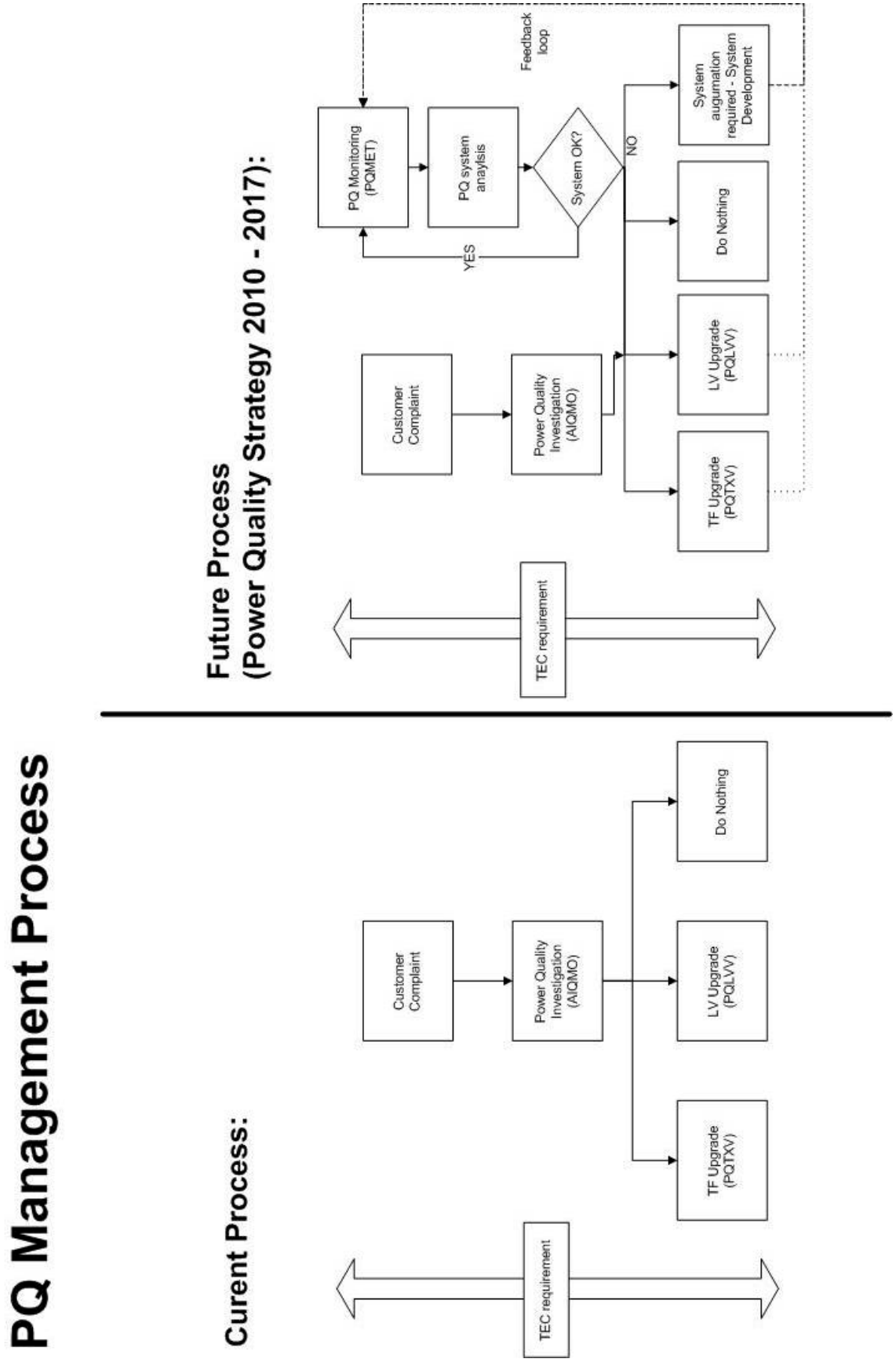
11.5 CAPEX/OPEX trade off

As the PQ monitoring program increases coverage of the state, the OPEX spend on reactive PQ investigations will decrease. However this will rely on an almost complete coverage of the state to capture the ~700 complaints annually before a complaint is raised. Aurora does not expect to gain this coverage in the next five years, and therefore has not forecast a reduction in investigation OPEX.

12. REFERENCES

- Tasmanian Electricity Code Chapter 8
- National Electricity Rules
- AS/NZS 61000 series
- Aurora Energy Steady State Voltage Standard

- Appendix A


PQ Management Process
Curent Process:
Customer Complaint
Power Quality Investigation (AIQMO)
Do Nothing
LV Upgrade (PQLVV)
TF Upgrade (PQTXV)
TEC requirement
Future Process
(Power Quality Strategy 2010 - 2017):
Feedback loop
PQ Monitoring (PQMET)
PQ system anaylsis
System OK?
YES
NO
System augumation required - System Development
Do Nothing
LV Upgrade (PQLVV)
TF Upgrade (PQTXV)
Customer Complaint
Power Quality Investigation (AIQMO)
TEC requirement