

Augex Power Quality - Investment Case

Overview

Power quality is the variance of voltage magnitude and waveform from the standards that customers expect.

We have a mostly reactive power quality program, responding to customer complaints. Typical power quality complaints include:

- Steady state over- and under-voltage
- Temporary voltage sags and swells
- Voltage unbalance
- Excessive harmonics or interference
- Rapid voltage changes

These power quality issues can cause customers to experience appliance malfunction or failure, and prevent solar PV inverters from operating.

Forecasting Approach

Historic data was used to forecast the total number of complaints, as well as the total number of valid complaints. We found there is one complaint for every two MWs of consumer solar PV added to the network. Of those complaints, 84% are considered a valid complaint. A typical intervention to solve a valid complaint is to perform a tap-change on the distribution transformer, at a cost of approx. \$1,500. With embedded solar PV forecast to increase by 1,000MW by 2030, without preventative measures we can anticipate a proportional increase in complaints as shown below.

There is an opportunity to pro-actively identify power quality issues using power quality monitoring equipment installed on the network, as well as utilising smart meter data. This is not included in this investment case, as it forms part of **10.05 Future Network Business Case Overview**.

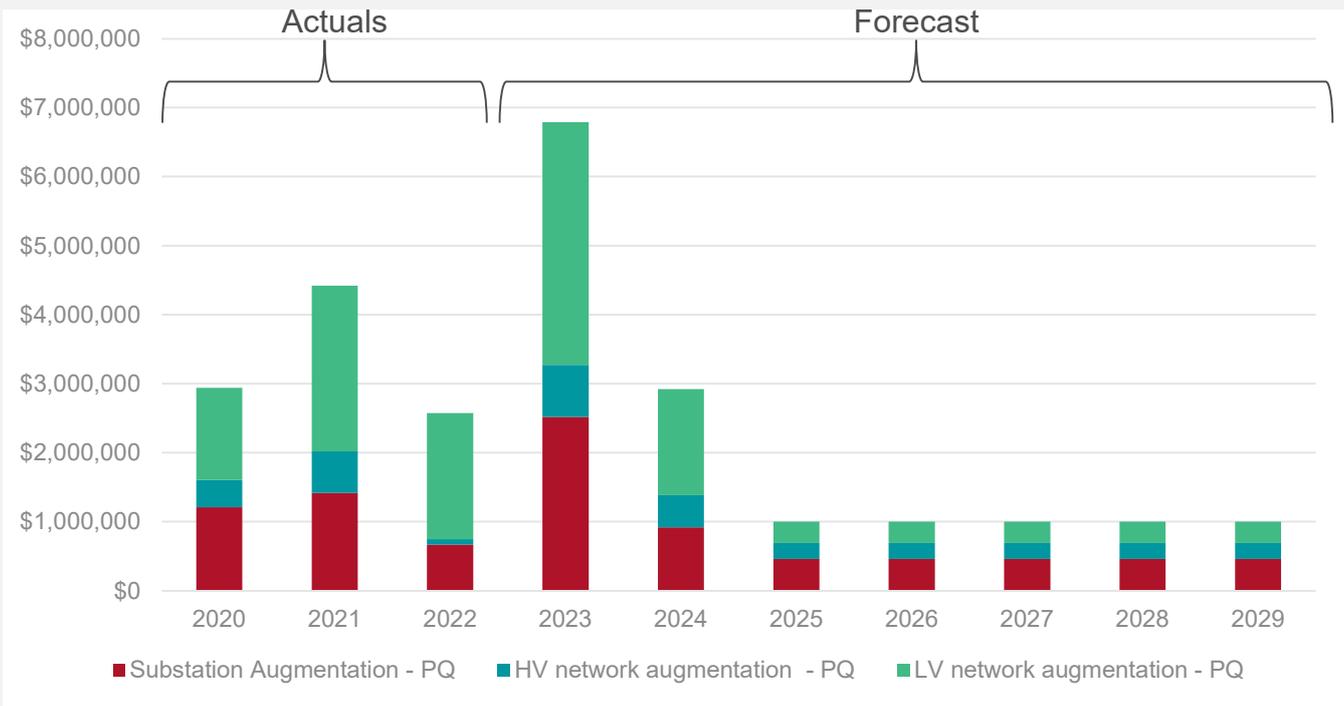


Investment Options

A typical opex intervention involves performing a tap change on the distribution transformer. In cases where a capex solution is required, augmentation of the distribution substation, or the HV or LV network are typical solutions. The average cost for these interventions is shown below.

Category	Project Cost
HV Augmentation - Average	\$53,512
HV Augmentation - Conductor	\$48,120
HV Augmentation - Substation	\$61,092
LV Augmentation – Average	\$44,111
LV Augmentation – Conductor	\$44,663
LV Augmentation - Substation	\$50,110
Substation Augmentation - Average	\$34,211

Forecast Power Quality augmentation expenditure for the 2024-29 period is \$5.0m, averaging \$1.0M per annum. The actual/forecast for 2019-24 is \$13.8M.



Note: All values are in middle of the year 2023-24 real dollar terms.

Data source: Actuals: Internal delivery reports, Forecasts: Internal analysis aligned to the 'Forecasting approach'

The table below shows the drivers of power quality investment following an internal challenge across capex programs. Only demand-driven constraints are included in the forecast for 2024-29. The DER-driven constraints will be funded under 10.05 Future Network Business Case and reported in RIN category Export Services from next period.

Investment	% Demand	% DER
HV network augmentation - PQ ESS_20	50%	50%
LV network augmentation - PQ ESS_21	20%	80%
Substation Augmentation - PQ ESS_35	50%	50%

We are confident that our approach delivers an efficient and prudent level of investment because:

- **Clear, prudent drivers from Asset Management Objectives for Quality and Compliance (as detailed in 10.01 Strategic Asset Management Plan):** Deliver the sustained network performance our customers expect, Maintain compliance with our network-related obligations.
- **Aligned** to the Power Quality network strategy objective Achieve and maintain compliance with PQ standards (see below).
- **Review and moderation:** Our forecasts have been aligned to meet the expectations of our customers.

The major benefits expected from these investments are:

- **Improved safety:** These investments include responding to complaints reported as 'shocks & tingles'.
- **Reduced customer losses:** Over- and under- voltage can lead to degradation or failure of customer equipment.
- **Improved service to customers:** Will result in fewer unplanned failures, including solar PV inverters not operating when voltages exceed bounds. Addressing concerns raised by customers in relation to power quality.

Forecast Power Quality augmentation expenditure for the 2024-29 period is \$5.0m. The reduction from 2019-24 actual/forecast of \$13.8M is primarily due to:

- Expenditure allocation for DER-driven issues to be covered in Future Network Business Case with forecast volume of complaints expected to increase due to more solar PV being installed.
- Demand driven complaints are expected to remain steady in the short term.

Network Strategy – Power Quality: Summary

Essential Energy's Power Quality (PQ) strategy sets strategic direction for the business on asset management targets and initiatives to ensure that its supply power quality obligations are met in a manner which balances cost, risk and performance.

Context

Power quality is the measure of the variance of voltage supply from specified characteristics in terms of waveform and magnitude.

PQ issues are identified when supply conditions occur outside of the established PQ supply standard causing customer equipment to malfunction or fail.

Over the past five years PQ issues have been dominated by the increased uptake of DER, particularly rooftop PV, which has led to,

- **sustained overvoltage issues** and deteriorating load factor due to widening LV voltage range and shift in peak demand voltage.
- **Inadequate management of bi-directional power flow** due to limited capability of the distribution network and voltage regulating schemes (particularly in overhead network areas with longer LV circuit lengths).

Other PQ issues include,

- **Harmonics:** Increased use of inverter coupled devices for both load and generation inject harmonics into the power system and affect the voltage waveform.
- **Lack of action** in truly moving towards the 230V LV standard established nationally in 2000.
- **Unbalance:** Risk of unbalance between the voltage phases, as single-phase loads or PV are inherently difficult to connect evenly across each phase.

Analysis of PQ complaints has shown a correlation between the increasing count of solar PV approvals and subsequent overvoltage PQ complaints, specifically in locations with high solar penetration. These locations also coincide with areas where distribution tap changes have occurred to solve the capacity constraint.

Line of Sight

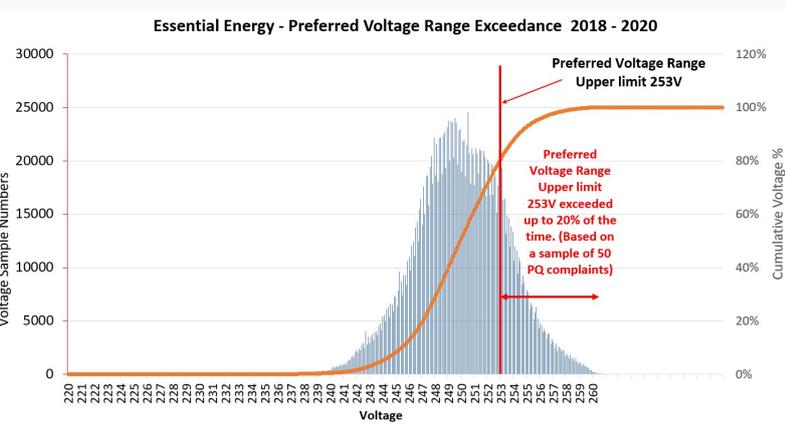
The Power Quality Strategy is an enabler for Essential Energy's Corporate Strategy, **Pillar 1 - Strengthen the core business**, **Pillar 2 - Realise the full value of our network resources**, and **Pillar 3 - Maximise the value of being connected to the grid**. The Asset Management Objectives (AMO) related to the strategy are AMO-03, AMO-06, AMO-08, AMO-09 and AMO-14. Subsequent Network Targets (NT) PQ1, PQ2 and PQ3 have been developed to align with the AMOs

PQ1	PQ2	PQ3
Achieve and maintain compliance with Power Quality standards	Maximise value from PQ issue resolution through increased visibility	Improve our customers PQ complaint resolution experience

Performance and Targets

	Current Performance	Target Performance (Baseline 2020)
PQ1	<ul style="list-style-type: none"> ▪ Overvoltage comprises the largest share of PQ issues (~64%, ~724 complaints p.a.), with voltages exceeding 253V up to 20% of the time at customer MSBs and on the EE LV network. ▪ Network performance on remaining PQ metrics is generally compliant with supply standards. ▪ PQ performance has limited reporting view across the network due to lack of visibility and is identified on a case-by-case basis (based on customer complaints). 	<ul style="list-style-type: none"> ▪ Medium Term: 10% reduction in customer complaints from sustained overvoltage potentially delivering improvement in Customer Value of approx. \$111K p.a. ▪ Long Term: 100% compliance with the expected PQ standard. 20% reduction in the number of customer complaints from sustained overvoltage potentially delivering improvement in Customer Value of approx. \$222K p.a.
PQ2	<ul style="list-style-type: none"> ▪ Piecemeal approach to assessing and responding to overvoltage complaints; reactive tap changes favoured due to cost effectiveness. ▪ Proactive solution to persistent PQ issues usually selected by holistic network / feeder review (scheduled completion cycle no longer than 5 years). ▪ Lack of formalised systems and workflow management tools to monitor and track performance against PQ standards (no centralised E2E system for PQ issue Vs PQ compliance). 	<ul style="list-style-type: none"> ▪ Short Term: 100% of PQ hotspot areas identified and prioritised using voltage data from smart metering & heatmaps ▪ Medium term: 10% reduction in customer complaints resulting in a 10% improvement in Operating cost potentially saving approx. \$192K p.a. ▪ Long term: 20% reduction in the number of customer PQ complaints resulting in a 20% improvement in Operating cost potentially saving approx. \$384K p.a.
PQ3	<ul style="list-style-type: none"> ▪ Lack of E2E support system to track issues from initiation to resolution. ▪ Duration for PQ issue resolution >270 days for ~7% of customer complaints, with inconsistent duration of time spent on PQ resolution steps. 	<ul style="list-style-type: none"> ▪ Medium term: 100% Visibility of all PQ issue resolution performance through a centralised E2E system. ▪ Medium term: 95% of the PQ complaints are resolved within a duration of 270 days. ▪ Long term: 97% of the PQ complaints are resolved within a duration of 270 days.

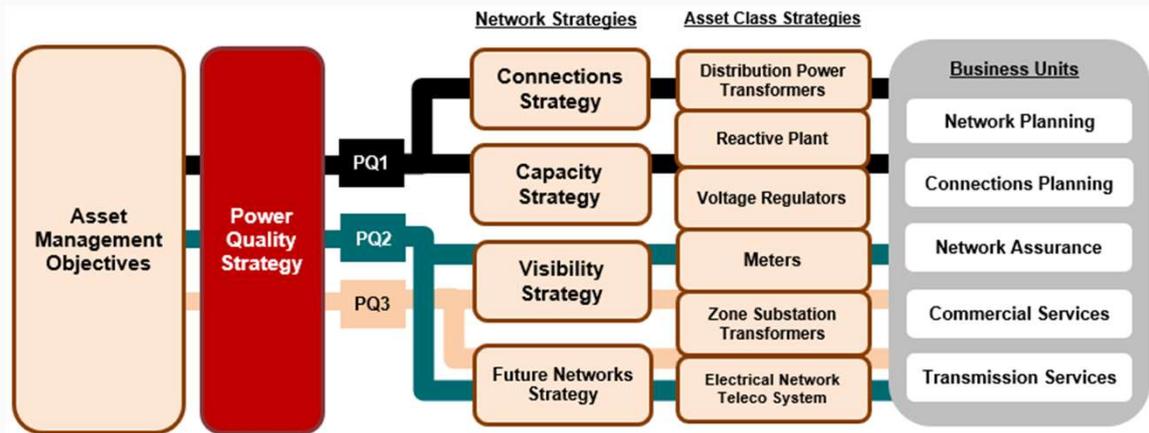
Primary PQ Issue - Overvoltage



DEPOT	COUNT	%
ORANGE	125	5.6%
TAREE	110	5.0%
LISMORE	70	3.2%
BATHURST	67	3.0%
PT MACQUARIE	67	3.0%
BALLINA	62	2.8%
PARKES	58	2.6%
DUBBO	56	2.5%
GRAFTON	55	2.5%
QUEANBEYAN	53	2.4%
GRIFFITH	47	2.1%
LEETON	46	2.1%
MACLEAN	45	2.0%
TWEED HEADS	44	2.0%
KEMPSEY	42	1.9%

Implementation

The figure to the right outlines the paths of implementation for each strategic direction. Some aspects of the implementation for each will reside within other network strategies where Power Quality is an additional lens to place over existing direction. Through these other network strategies all asset classes will be impacted by direction from the Power Quality Strategy. Business units involved in implementing the strategic direction have been shown at the right of the figure.



Summary

The strategic directions to achieve each of the Network Targets are to:

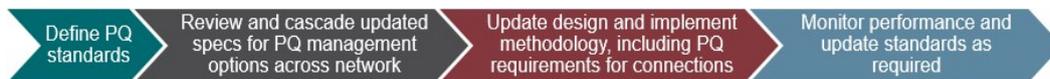
PQ1

Achieve and maintain compliance with Power Quality standards

This Network Target aims to:

- Achieve and maintain compliance with Power Quality standards including relevant regulations and policies, while ensuring appropriate value add commercial trade-off,
- Assist with setting up the associated network configuration and organisational processes with adjacent network strategies and stakeholders for execution.

Specifications for power quality are dictated by the NER and NSWIR (service and reliability standards), AS/NZS standards (technical guidelines), EE's electricity supply standard 8026 and connection agreements with customers

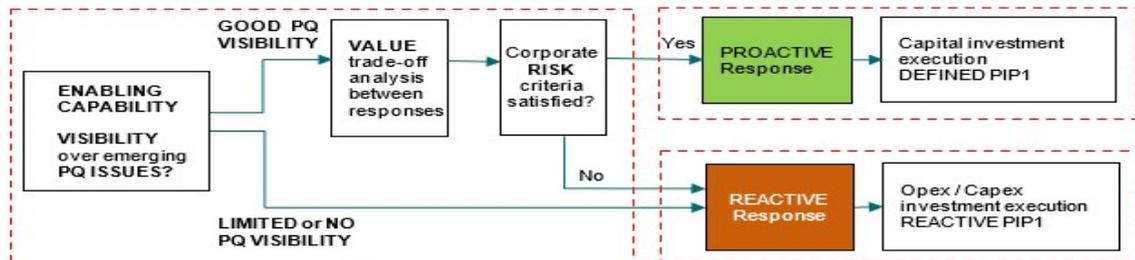


PQ2

Maximise value from PQ issue resolution through increased visibility

This Network Target aims to:

- Maximise the value from PQ issue resolution by assessing the risk and value trade-offs,
- Ensure responses to PQ issues are provided appropriate prioritisation consistent with Essential Energy's value and risk framework.



PQ3

Improve our customers PQ complaint resolution experience

This Network Target aims to:

- Assist with improving the PQ issue response time frame by refining the workflow management tool/monitoring systems, organisational processes, and accountabilities by creating a complete E2E process to monitor and track PQ issue resolution times to ensure timely response to customer complaints.
- Establish PQ resolution KPIs that align with corporate goals to ensure accountability during the resolution process.
- Ensure responses to PQ issues are provided appropriate prioritisation consistent with Essential Energy's value and risk framework that will improve the customers PQ experience.