



Electricity Network Operation Standards

October 2011



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Document and Amendment History

Issue No.	Date	Approved By	Summary of Changes
1	July 2004	M – NCP&S	Replaces previous document <i>ES2 – Electricity Supply Standards – December 1998</i> Amended by CIA 1288 - November 2004 Amended by CIA 1288A - February 2006
2	June 2006	M – NR&P	Replaces previous document ENOS- July 2004
3	June 2009	EM – SP	Replaces previous document ENOS – June 2006
4	October 2011	EM - SP	Replaces previous document ENOS – June 2009 Adoption of nominal 230V range

SCOPE

This publication describes Ausgrid's objectives for its electricity *network's* impact on the characteristics of electricity supplied by *retailers* to their *customers* through its electricity *Network*.

ISSUE

This is the fourth edition of this publication.

WARNING

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All correspondence should be directed to the:

Executive General Manager
System Planning & Regulation
Ausgrid
GPO Box 4009
SYDNEY NSW 2001

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1 Introduction

Ausgrid operates an extensive electricity *network* which brings the electricity supplied by your *retailer* to your home or business.

Our aim in this document is to:

- provide tips on how you can protect your electrical installations and your electrical equipment and appliances connected to our electricity *network* from the potential problems that unprotected equipment can suffer because of variations to electricity supplied through our *network*, and
- help you understand the operating environment of our *network*, and explain why the electricity supplied through it has particular characteristics.

We set out Ausgrid's objectives for the impact that our *network* has on the characteristics of the electricity supplied through it by your *retailer*.

1.1 Definitions

Terms relating to the reliability and quality of electrical supply that are not in common use are defined in the glossary (see Section 7) and defined terms appear in *Italics* in the text.

1.2 How to use this Guide

This guide is in two parts. Part A is designed for the general reader. Part B is for use by specialists, and contains technical material in technical language.



PART A

FOR THE GENERAL READER

2 Electrical Equipment and your Electricity Supply

Ausgrid is committed to bringing you a safe and reliable electricity service and maintaining a high quality power supply to *customers*.

All electricity *networks* experience interruptions to supply, most often when power lines are brought down by storms, bushfires and accidents. It is also normal for power supply to fluctuate.

Electricity users can take steps to minimise the possible effects of supply variations.

Ausgrid wants to alert its *customers* to the fact that some electrical equipment on the market does not have adequate tolerance to supply variations. Many businesses, and a growing number of private users, now have a range of data processing, control and instrumentation equipment that is highly sensitive to variations in the electricity supply. While most electrical products have been designed to withstand some variation in supply, very few are designed to withstand the range of voltage fluctuations that are a common feature of distributed electricity.

When buying electrical equipment it is always important to check that it is able to tolerate variations in electricity supply and seek independent advice whether you need additional protection. This can be done by increasing the capacity of your electrical installation to withstand voltage disturbances, or through additional protective devices on the particular piece of equipment, or both.

Resetting digital clocks and timers can be a source of frustration. A flashing alarm clock usually represents a momentary interruption or a *network* switching event that results in a reduction in the voltage supply for less than a few milliseconds (called a voltage 'dip') rather than a *sustained interruption*. By buying appliances with an in-built battery backup, *customers* can avoid the need to reset digital clocks and timers when these very short duration events occur.

Customers who need to establish whether they have sufficient protective measures in place or assess all the risks of loss or damage arising out of different supply conditions must seek their own independent expert advice. Commercial and industrial users must seek expert advice, particularly because they will generally need to consider additional methods to protect data or sensitive equipment against particular supply conditions. There are specialist consultants in the field of equipment installation, control and protection and power conditioning. Ausgrid can provide guidance on supply quality issues.

The Energy Networks Association (ENA) publication *Customer Guide to Electricity Supply* provides comprehensive information that will assist you to understand the causes of supply variability, the risks to particular equipment and available protective measures.

The table below contains some examples of protective measures commonly employed to avoid or guard against typical variations in supply conditions which either arise from the *network* or are generated by a *customer's* equipment or installation. The list is not exhaustive – it is offered for interest's sake and you should not use it as a substitute for the ENA publication or independent expert advice if you need to buy or install protection equipment.

Table 1: Examples of Protective Measures

Condition	Protective Measures
Voltage too low	Use equipment designed to operate on low voltage as well as normal voltage. Switch off major equipment and restart it when supply is restored.
<i>Brownout</i> (For example, half voltage)	Use either: <ul style="list-style-type: none"> • equipment designed to operate down to half voltage to minimise impact of <i>brownouts</i>; or • undervoltage relay and circuit breaker to interrupt power supply; • uninterruptible power supply (UPS) for critical equipment such as computers. Switch off major equipment and restart it when supply is restored.
Voltage dips	Use either: <ul style="list-style-type: none"> • equipment designed to tolerate and ride through voltage dips; • UPS for critical equipment; or • equipment with battery back-up.
Rapid voltage transients (eg, flicker)	Use a line filter or, in extreme cases, a UPS.
Lightning <i>surges</i>	Use: <ul style="list-style-type: none"> • <i>surge</i> diverters on switchboards; • small <i>surge</i> diverters in equipment; and/or • power boards or plug-in devices with <i>surge</i> protection for small equipment. Note: These measures are normally only appropriate in lightning prone locations or where critical equipment is used.
<i>Surges</i> generated by <i>customers'</i> equipment	Use: <ul style="list-style-type: none"> • a plug-in <i>surge</i> diverter at source appliance and/or at critical equipment; or • UPS for critical equipment.
Harmonic distortion	Use a power conditioning device, eg, line filter or UPS for critical equipment.
Interruptions for a few seconds	Use either: <ul style="list-style-type: none"> • equipment designed to tolerate or ride through short interruptions; • UPS for critical equipment; • equipment with battery back-up; or • undervoltage relay to switch off equipment prone to damage.
Interruptions longer than a few seconds	Use UPS or equipment with battery back up.
Voltage unbalance	Use phase-failure relay on equipment prone to damage. The relay will interrupt power supply to avoid damage. <i>Customers</i> must ensure their load is balanced

Note:

- Some protective devices can be obtained from hardware stores, electrical supply outlets or specialist suppliers.
- Good quality equipment and appliances will have a number of these protective measures incorporated in their design or 'built in'.
- If a protective device requires installation, the law requires that a qualified electrician must install it.

3 Obligations to other Customers and the Network

Under their *Contract* with Ausgrid, *customers* are required to comply with the requirements of the Service and Installation Rules of NSW and any other reasonable requirements imposed by Ausgrid. Consistent with those Rules and its rights under the *Contract*, Ausgrid requires the *customer* to ensure that:

- their electrical installation does not adversely affect Ausgrid's network or the *customers'* installations; and
- that any audible or electronic noise generated by their electrical installation does not breach relevant laws or adversely affect others.

If disturbances on the network are caused by more than one customer, Ausgrid will establish overall limits for the interference by each customer, and customers who exceed their limits are required to rectify the situation.

4 Ausgrid's Reliability Objectives

4.1 Ausgrid's Standards for Network Reliability

Ausgrid's objective is to achieve the best possible overall reliability of our electricity network, given the condition and utilisation of existing network assets and the funding available to maintain and augment the electricity network. In addition Ausgrid also aims to use all reasonable and practicable efforts to ensure that in any financial year, it meets the targets set by the Minister for Energy in respect of reliability standards and individual feeder standards.

In stating the above objectives, Ausgrid excludes the following types of interruptions:

- momentary interruptions (interruptions of one minute or less);
- interruptions occurring on major event days, including major natural or third party events (such as storms, bushfires etc.);
- transmission system outages;
- load shedding due to insufficient generation to meet system load;
- automatic load shedding controlled by under frequency relays following an occurrence of a power system under frequency condition;
- faults in a *customer's* premises or equipment;
- compliance with directions from grid system operators or emergency services;
- planned interruptions; or
- interruptions agreed to by the *customer*.

Customers must plan around the possibility that the electricity supply may not be available at all times and that interruptions could occur without notice, or with notice in accordance with the *Contract*.

Customers who may suffer loss or damage if a supply interruption occurs are responsible for installing and maintaining sufficient back-up power supplies if they wish or need to mitigate such loss or damage. This particularly applies to *customers* with time-critical activities or equipment, eg. hospitals, or *customers* who need to maintain accurate time or have electronic devices which maintain settings and information in volatile memory.

If there is electronic data important to a *customer*, particularly business data, then the *customer* is responsible for backing up that data to non-volatile storage in accordance with prudent business practice and at least on a daily basis.

4.2 Ausgrid's Reliability Reports for Network Performance

Ausgrid's reliability reports utilise the definitions of normalised interruptions contained in the paper *National Regulatory Reporting for Electricity Distribution and Retailing Businesses*, March 2002, published by the ACCC, and includes all recorded interruptions on the network. The definitions have been amended by the Design, Reliability and Performance Licence Conditions imposed on Distribution Network Service Providers by the Minister for Energy on 1 August 2005 and revised on 1 December 2007. The Licence Conditions are available on the IPART website www.ipart.nsw.gov.au.

4.3 Ausgrid's Customer Service Standards for Network Performance

At Ausgrid, we are committed to providing the best possible service to our 1.6 million *customers* across Sydney, the Central Coast and the Hunter.

If an interruption to your electricity supply does occur we try to minimise the inconvenience to homes and businesses. Our frontline staff are on call 24 hours to respond to emergencies or outages as they occur.

New customer service standards have been established by the NSW Government setting out the level of service that Ausgrid and other electricity businesses are expected to meet.

If we do not meet our customer service standards, you may be entitled to claim a payment of \$80 from us. You may be entitled to this payment if you experience too many interruptions in one year or an interruption that lasts too long. A maximum of \$320 can be claimed per premises in any one financial year.

Any electricity account holder who is connected to Ausgrid's electricity distribution network in Sydney, the Central Coast and the Hunter Region, may apply for a payment under the customer service standards, regardless of their choice of energy *retailer*.

Further information regarding customer service standards is available from Ausgrid's website or local Ausgrid customer service office.



PART B

FOR SPECIALISTS

5 Steady State Supply Voltage

5.1 Voltage Range for Electricity supplied through the Network

Supply voltage is the voltage, from phase to neutral or phase to phase, for electricity that is supplied at a *customer's point of supply*. Maintaining this steady state *supply voltage* is important to ensure appropriately designed equipment does not malfunction and is not damaged.

When Ausgrid identifies or is notified that the steady state *supply voltage* is outside the specified target range, Ausgrid will take reasonable steps to modify the *network* to ensure that the voltage will be maintained at the required level and achieve Ausgrid's steady state voltage supply objective.

5.1.1 Low Voltage Network

Ausgrid's objective for the operation of its *network* is to maintain a target steady state phase to neutral *supply voltage* (measured as a ten-minute average) within the range of 216 V to 253 V at *customers' points of supply* under normal operating conditions. This range is the nominal voltage range of 230V in the relevant Australian Standard AS 60038 *Standard Voltages*, with a tolerance of +10%/- 6% to allow for voltage regulation on the mains between distribution substations and *customers' points of supply*.

It should be noted that due to system operational constraints and physical *network* limitations, it may not be possible to maintain the target steady state *supply voltage* range for all of the time at a given customer point of supply. However, Ausgrid aims to maintain supply within the target steady state supply voltage range for at least 98% of the time when measured over a period of one week.

Where the above target steady state *supply voltage* range cannot be maintained, particularly under abnormal *network* arrangements such as may occur during maintenance, Ausgrid's objective is to maintain a steady state voltage within the range 207 V to 262 V at all times. This range excludes situations arising from faults or voltage interruptions.

Following an Energy Networks Association review in 2011, Ausgrid commenced migration from a nominal voltage of 240 V to 230 V. Over time, the normal average Ausgrid network voltage will be reduced from around 250V to around 240V.

5.1.2 High Voltage Network

Ausgrid's high voltage distribution *network* operates at several voltage ranges. Accordingly, high voltage *customers* must obtain from Ausgrid *network*, the *network* operating objective for *supply voltage* applicable to their location, particularly before proceeding with any project expenditure or commitments.

6 Fluctuations and Distortions in Supply Characteristics

The types of fluctuations, disturbances and distortions in the characteristics of electricity supplied from an electricity network can be divided into three areas:

- (a) **Frequency departures** – where the frequency falls outside the normal range.
- (b) **Voltage disturbances** – where voltage shape is maintained but the voltage magnitude falls outside the normal range,
- (c) **Distortion disturbances** – where the voltage shape is non-uniform or distorted (non sinusoidal).

Each is discussed in this section.

6.1 Frequency Departures

Ausgrid does not control the frequency on the electricity supplied through its electricity network, as this standard is set during the electricity generation process. The Australian Energy Market Operator (AEMO), which replaced the National Electricity Market Management Co Pty Limited (NEMMCO) in July 2009, establishes standards and regulates the frequency of supply on the national grid. If Ausgrid becomes aware of frequency excursions in excess of AEMO's standards, Ausgrid will endeavor to bring these to AEMO's attention.

6.2 Voltage Disturbances

A voltage disturbance is where the voltage shape is maintained but the voltage magnitude is outside the steady state *supply voltage* range described in Section 5.1. Voltage disturbances can be categorised as

- Short duration variations - includes short duration interruptions, sags (dips) and swells of up to one minute;
- Long duration variations -includes *sustained interruptions* (covered in Section 2), under-voltage and over-voltages of duration greater than one minute;
- Voltage unbalance – where the magnitude of the three phase voltages is not equal.

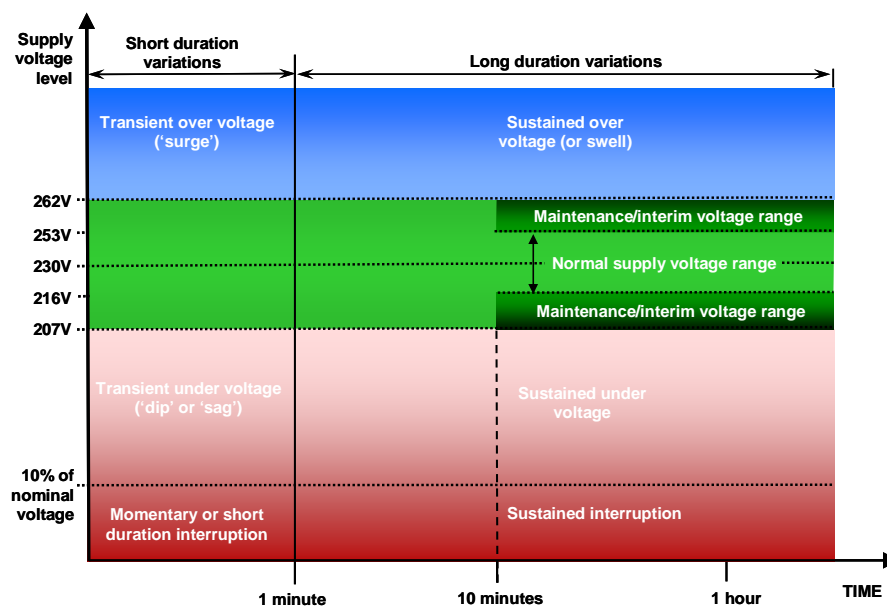
Voltage disturbances such as voltage unbalance, under and over-voltage are described in the ENA publication *Customer Guide to Electricity Supply*. The publication also includes objectives of electricity *network* businesses (including Ausgrid) in relation to these disturbances and action *customers* can take to minimise any impact of these disturbances.

Customers are responsible for minimising voltage unbalance caused by their installation, and ensuring their installation complies with relevant rules, particularly the Service and Installation Rules of NSW.

6.2.1 Voltage Sags (Dips)

A voltage sag (dip) is a short duration reduction in *supply voltage* for less than one minute but generally lasting less than one second. A short duration interruption is a drop in *supply voltage* to a level of less than or equal to 10% of steady state *supply voltage* for up to one minute in duration. Refer to Figure 1.

Figure 1: Supply voltage fluctuations (not to scale)



Voltage sags and short duration interruptions are one of the main issues of concern to industry. This is because equipment and digital systems are often unable to withstand the reduction in *supply voltage* even though the reduction may be small or the duration of the disturbance typically less than a few seconds.

The ENA publication *Customer Guide to Electricity Supply* contains information on the typical voltage sags experienced on Australian electricity networks and how customers can mitigate the risks of equipment maloperation because of sags.

6.3 Distortion Disturbances

Under normal conditions, the voltage delivered by the network has a sinusoidal shape. Distortion disturbances are where the voltage shape is non-uniform or non-sinusoidal. They can be broken into three categories:

- Transients – very short term events (with a duration of less than 1/10 second);
- Waveform distortion (including harmonics);
- Voltage differences between Neutral and Earth.

Ausgrid's objective with regard to distortion disturbances is to manage the *network* planning, maintenance and construction process so as to comply with the latest edition of the National Electricity Rules (NER), the Standards Australia handbook for power quality HB264, and relevant Energy Networks Association guidelines. This handbook and guidelines, including associated planning levels, will be utilised where applicable and any other occurrences outside this will be treated on a case by case basis by Ausgrid.

6.3.1 Transients

Voltage transients are usually large but very short term changes (lasting less than about 1/10 second) to the voltage shape and can be caused by events such as lightning, switching operations on the *network* or switching within *customers'* equipment. Care should be taken by *customers* when switching highly reactive loads within an installation as these are a major contributor to voltage transients. Transients can damage electronic components, if they are not adequately protected. Additional information on switching transients and lightning can be obtained from the ENA publications.

Ausgrid's objective is to limit *network* switching transients to less than two times the normal *supply voltage*. When notified that a *customer's* equipment is adversely affected by voltage transients Ausgrid will take reasonable steps within its power to:

- (a) investigate and test for the distortion;
- (b) require an affecting *customer* to rectify the situation;
- (c) correct, where practicable, distortion of the voltage at the *customer's* connection point, where it is outside the limits set by the AS/NZS 61000.3 series of standards. Note that the standards allow for differences between urban and rural networks.

Refer to the ENA publication and Section 2 of this document for protective measures that may assist *customers* in minimising any impact of these disturbances.

6.3.2 Waveform Distortion (including Harmonic Distortion)

Voltage waveform distortion including harmonic distortion results from the operation of appliances or equipment that draw non-sinusoidal currents from the *network*. Harmonic distortion can cause the *supply voltage* to depart from a sine wave in a repetitive manner. Maintaining waveform distortion within acceptable limits is important because it can otherwise cause interference and damage to sensitive *customer* and *network* equipment. This form of distortion can also cause light flicker, incorrect operation of ripple control devices (used for off peak electric hot water) and computers, audible noise in television, radio and audio equipment and vibration in induction motors. *Customers* with sensitive equipment may need to install devices to protect it, eg an appropriately designed uninterruptible power supply.

Note: Signals injected into the *network* by distributors to control off peak loads are designed as higher level harmonics and should not normally cause interference.

When notified that a *customer's* equipment is adversely affected by voltage waveform distortion, Ausgrid's objective is to take reasonable steps within its power to:

- (a) investigate and test for the distortion;
- (b) use reasonable and practical efforts to minimise interference to radio and television reception emanating from components of Ausgrid's *network* and abide by rulings of the Australian Communications Authority to correct problems associated with the generation of electromagnetic noise;
- (c) ensure that the mains signaling voltage does not exceed 20 Volts;
- (d) require an affecting *customer* to rectify the situation;
- (e) to correct, where practicable, distortion of the voltage at the *customer's point of supply*, where it is outside the limits set by the AS/NZS 61000.3 series of standards or the limits set by relevant IEC Standards.

Additional information on harmonics and noise can be obtained from the ENA publications including action *customers* can take to minimise any impact of these disturbances.

6.3.3 Voltage and Current Differences between Neutral and Earth

Although neutral conductors are nominally at earth voltage, minor voltage differences may occur between neutral and earth. The voltage differences may be steady state, temporary or transient, or combinations of these components. Maintaining the voltage difference between neutral and earth within limits specified is important to minimise voltage imbalance in multi phase systems. Exceeding these limits may affect the operation of sensitive three phase motors, generate waveform distortion and cause the *network* to operate irregularly, affecting *network* reliability.

A direct current component in the neutral conductor has the effect of offsetting the sinusoidal waveform and can be caused by equipment that has different operating characteristics in each half of the voltage cycle. Maintaining the direct currents in the neutral to acceptable limits is important because such current can cause corrosion of the *network* and a *customer's* earthing system, possibly leading to unsafe operating conditions. *Customers* with equipment that causes DC current flow may need to install isolation transformers and should seek advice accordingly.

Ausgrid's objective for its *network* is to limit both alternating and direct voltage differences between neutral and earth to less than 10 Volts steady state (ten-minute average) at the *point of supply*.

During electrical faults, ground voltage levels at or near points where the current flows to earth may elevate. These elevated voltages generally diminish rapidly, as the distance increases from the earthing point or earth grid. The variation of the fault condition voltage with distance from the earthing location is described in terms of ground voltages or 'step and touch' voltages. Maintaining ground fault voltages within appropriate limits is important to reduce the risk of electric shock and damage to electrical equipment. Particular care must be taken in relation to any electrical installation in the vicinity of swimming pools, including domestic pools, and other wet areas.

Ausgrid's objective for its network is not to exceed the applicable levels outlined in the Energy Supply Association of Australia (ESAA) publications *EC5 Guide to Protective Earthing* and *C(b)1 - Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines*. To achieve this Ausgrid will design its earthing systems to comply with the general requirements of these publications and with the Energy Supply Association of Australia /Telstra *Earth Mat Rise Code* and *Guide to Overhead Construction*.

7 Glossary

Contract	Ausgrid's <i>Standard Form Customer Connection Contract</i> .
Customer	The <i>customer</i> of a <i>retailer</i> under a retail supply contract, where the <i>retailer</i> supplies electricity to the <i>customer</i> through Ausgrid's <i>network</i> .
Network	Ausgrid's electricity supply network.
Point of supply	The boundary point between Ausgrid's electricity <i>network</i> and the customer's electrical installation.
Power system	The integrated assets of the national grid associated with the generation, transmission and distribution of electricity.
Retailer	A person who holds a retail supplier's licence permitting it to supply electricity to <i>customers</i> on certain conditions.
Supply voltage	The voltage, from phase to neutral or phase to phase, at the <i>point of supply</i> .
Surge	An increase in voltage of short duration. The term tends to be loosely applied to all voltage increases.
Sustained interruption	A reduction in the steady state <i>supply voltage</i> to less than 10%, for greater than one minute duration.

The following publication issued by the ENA provides additional definitions and information essential for understanding this document and is also available on our website www.ausgrid.com.au:

- Customer Guide to Electricity Supply

8 Status of the Document

This document is the *Electricity Network Operation Standards* publication referred to in Ausgrid's Standard Form Customer Connection Contract (*Contract*).

It is intended for use only by *customers* who are connected to Ausgrid's electricity network and should be read in conjunction with the following publication issued by ENA (Energy Networks Association), which provides definitions and information essential for understanding this document:

- Customer Guide to Electricity Supply.

The latest edition of this document is available on our website www.ausgrid.com.au.

Assumptions

In stating its objectives for its *network*, Ausgrid does not include:

- interference originating from a *customer's* installation that adversely affects the installation and equipment of that *customer* or other *customers*; and
- events or incidents associated with generation or the transmission grid.

Limitations

Although Ausgrid intends to use all reasonable efforts to address departures from the objectives specified in this standard, there could be circumstances which affect Ausgrid's ability to meet them. Accordingly:

- each objective must be read subject to the limit of liability specified in the *Contract*; and
- this document and the ENA publication referred to above do not constitute a representation or warranty by Ausgrid that the electricity supplied by *retailers* to *customers* through its *network* will be of a particular quality, or that it will be available at all times.