



**TITLE:**

**Annual Reliability and Power Quality Report – 1 July 2010 - 30 June 2011**

**PREPARED BY:**

**Network Performance Branch**

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**23 September 2011**

Network Performance Branch, Networks Division

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# Document Control

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## Executive Summary

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This Annual Reliability and Power Quality Report allows the Government, the community and other stakeholders to see how Western Power's electricity network is performing with respect to obligations under Schedule 1 of the *Electricity Industry (Network Quality and Reliability of Supply) Code 2005* (the Code).

The reliability performance of the Western Power Network in 2010/11 compared to the previous year has improved.

There were a number of Western Power activities throughout the reporting period which delivered this reliability improvement to customers. These initiatives and activities included deployment of specific auto-reclosers and load break switching equipment; continuation of the State Underground Power Program targeted infrastructure rebuilds and augmentation; and routine and targeted maintenance programs.

The reliability improvement this year was also attributed by the reduction in the impact of interruptions caused by environmental factors such as inclement weather, flora and fauna. These influences, however, caused adverse affects on the reliability of supply within the rural areas, as such programs will continue to be implemented to address the reliability of supply in these areas.

The Power Quality compliance level of 8% Total Harmonic Distortion ("THD") was met for all sites 100% of the time.

The total number of customer interruptions lasting greater than 12 hours improved by 48%, subsequently there was a reduction in the number of customer claims for extended outages.

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# 1 Purpose

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The purpose of the Annual Reliability and Power Quality Report (this report) is to present the performance of the Western Power Network in accordance with Schedule 1 of the *Electricity Industry (Network Quality and Reliability of Supply) Code 2005* (the Code), for the reporting period 1 July 2010 to 30 June 2011.

The Code, established by the Minister for Energy under the *Electricity Industry Act 2004* sets out quality standards to network operators in relation to voltage fluctuations, harmonics, planned or significant interruptions. Section 27 of the Code states that a transmitter and distributor must publish a report setting out the information described in Schedule 1 of the Code (Schedule 1).

Western Power's commitment is to work with the Office of Energy and the Economic Regulation Authority (Authority) to ensure that the data presented in this report interprets the Code requirements correctly.

Caution should be taken when comparing the figures stated in this report with other reliability performance reporting publications produced by Western Power. For example Western Power is required to report on industry standard definitions, subsequent performance and its network reliability to the Authority, different from the measures defined in the Code<sup>1</sup>.

## 1.1 Definitions

Terminology used in this report is in accordance with definitions presented in Item 1 to Item 3 of Schedule 1.

For the purposes of this report, the discrete area *all other areas of the State* as stated in Items 2 (c) and 3 (c) of Schedule 1, will be referred to as Rural areas and will be specific to the Western Power Network.

In reference to Item 11 of Schedule 1:

- 'SAIDI' (System Average Interruption Duration Index) refers to item 11(d)
- 'SAIFI' (System Average Frequency Interruption Duration Index) refers to item 11(b)
- 'CAIDI' (Customer Average Interruption Duration Index) refers to item 11(a)
- 'ASAI' (Average Service Availability Index) refers to item 11(c)

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<sup>1</sup> Specifically, section 12 of the Code

## 2 How to read this report

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This report has been laid out in the various sections as below:

For contextual purposes:

Section 3 provides geographic details of the Western Power Network; and

Section 4 provides an overview of the actual performance of the Western Power Network and the influencing factors that impacted the performance.

For response to Code purposes:

Section 5 addresses Item 5 of Schedule 1; reporting on the number of customers that experienced power interruptions exceeding 12 hours at least once during the 12 months to 30 June 2011.

Section 6 addresses Items 6, 7 and 8 of Schedule 1; summarising the complaints which have been received, logged and subsequently actioned.

Section 7 addresses Item 9 of Schedule 1; which is the response to payment for failure to give required notice of planned interruption and payment for supply interruption exceeding 12 hours, (Section 18 and 19 respectively of the Code).

Section 8 addresses Items 11, 12 and 13 of Schedule 1; providing data which is inclusive of all protection device trips on the network greater than or equal to one minute that resulted in loss of power to customers.

Section 9 addresses Items 14 and 15 of Schedule 1; and articulates the customer percentiles of average length of interruption, total length of interruption and number of interruptions for the 12 months to 30 June 2011.

Section 10 addresses Item 4 of Schedule 1 which outlines the power quality performance of the Western Power Network in accordance with the Code.

### 3 Network Topology

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Western Power operates and maintains the transmission and distribution electricity grid within the South West Interconnected System (SWIS) known as the Western Power Network.

The Western Power Network comprises of approximately 1,100 feeders and circuits incorporating 96,000 kilometres of conductor, 787,000 power poles and towers, 13,500 distribution substations, to provide electricity supply to approximately one million customers and 230,375 streetlights.

The Western Power Network covers a geographic area from Kalbarri down to Albany, and from Perth through to the Goldfields (Figure 1).



Figure 1: Map of Western Power's Network (grey)

## 4 Overview

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The 2010/11 performance of the Western Power Network, compared to the previous year improved.

There were a number of activities during the year that delivered improvements in the reliability of supply to customers, namely:

- Increasing the operating / switching flexibility of the Western Power Network through deployment of 3-phase telemetered auto-reclosers and load break switches.  
Auto-reclosers are a fault interrupting device used to restore supply; limit the impact the duration of an interruption; and attempt to reduce the area and number of customers affected. A load break switch installed within the network provides greater flexibility / interconnection between feeders to facilitate restoration and thus minimise the duration of an interruption;
- Installation of interconnections, replacing overhead powerlines with underground reticulation and the augmentation/upgrading of distribution feeders. These specific activities focusing on the infrastructure which contribute largely to the system SAIDI. This strategy will improve the reliability of supply within specific locations and sections of the network through the reduction of faults caused by equipment failure and wildlife (birds and animals) interacting with the network;
- The State Underground Power Program  
This is a partnership, with a shared funding arrangement, between Western Power, the State Government and local Government Authorities. This program selects areas and implements the replacement of the overhead distribution network with underground reticulation. Underground power is more secure in severe weather conditions; reduces safety hazards caused by fallen powerlines; eliminates vegetation around overhead powerlines; and minimises car accidents involving network infrastructure (eg poles)
- Routine and targeted asset maintenance programs, which include the replacement of under performing assets, deteriorating assets and defective assets, such as poles, conductors and substations.

There was a reduction of interruptions caused by environmental factors predominantly outside of Western Power's control, such as inclement weather, flora and fauna. However these factors still had an adverse affect on the reliability of supply within the Rural areas:

- The most significant weather event occurred on the 29 January 2011 where a storm, consisting of lightning and strong winds, caused extensive damage to the network in the Wheatbelt and Midwest Regions. Approximately 71,000 customers were affected on the day, with winds gusting up to 126 kph.
- Another significant weather event occurred on the 28 February 2011 where an afternoon sea breeze in combination with hot, moist and volatile air produced severe thunderstorm activity and strong wind gusts in some parts of Perth. Approximately 59,000

customers were affected on the day, predominantly in the Northern suburbs, Perth Hills area and South East regions.

- Additionally, localised bushfires occurred during strong winds in the outer Perth Metropolitan area on the 6 February 2011, causing significant damage to some parts of Western Powers Network. Approximately 13,000 customers were affected for up to 3 days.

## 5 Interruptions exceeding 12 hours

This section is a response to Item 5 of Schedule 1 of the Code.

Code extract:

*“The number of premises of small use customers the supply of electricity to which has been interrupted –*

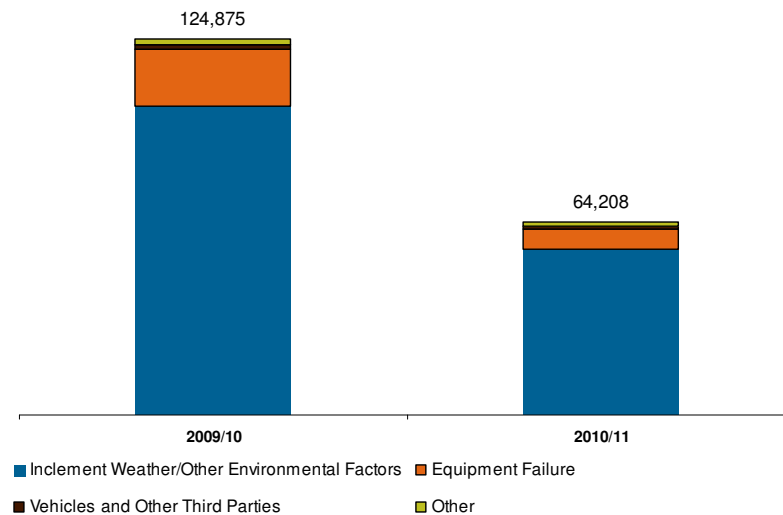
- a) For more than 12 hours continuously: or*
- b) More than the permitted number of times, as that expression is defined in section 12(1)”*

### 5.1 Response

Western Power Network connections (customers) = 999,372

- 54,414 customer premises experienced one interruption that exceeded 12 hours
- 9,794 customer premises that experienced more than one interruption that exceeded 12 hours

Figure 2 shows the total number of customer interruptions lasting greater than 12 hours by fault cause.



**Figure 2: Customer Interruptions lasting greater than 12 hours by Fault Cause**

- The interruptions for 2010/11 were predominately due to events beyond Western Power’s control such as storm and lightning activity on the 29 January 2011 and 28 February 2011 (see section 4)
- In comparison to last year fewer equipment failures occurred during hot weather conditions
- 1,118 incidents occurred where customers experienced interruptions that exceeded 12 hours. Refer to Appendix B for a complete list of customer interruptions.

**Table 1: Customers that have been interrupted more than the number of times expressed in section 12(1) of the Code**

	2009/10	2010/11
Urban area (including Perth CBD) customers that have been interrupted more than 9 times	12,616	6,813
Rural area customers that have been interrupted more than 16 times	1,513	435

Urban area customers experiencing more than 9 interruptions for the 12 months to 30 June 2011 were predominantly within the outer suburbs of the North East and South East parts of the Perth Metropolitan region. Rural area customers experiencing more than 16 interruptions for the 12 months to 30 June 2011 were predominantly within the Mid West and Wheatbelt regions.

Western Power constantly monitors areas where customers experience recurring interruptions and undertakes remedial action where required.

## 6 Customer Complaints

This section is a response to Items 6, 7 and 8 of Schedule 1.

Code extract:

*“The total number of complaints received”*

*“The number of complaints received from customers in each of the discrete areas”*

*“The total amount spent by the transmitter or distributor in addressing complaints, other than by way of payment under sections 18 and 19”*

### 6.1 Response

- The total number of complaints received were investigated as to whether a provision of Part 2 (or an instrument under 14(3)) has been met or complied with is shown in Table 2
- Table 2 also provides a breakdown in each of the discrete areas of the complaints received
- The total amount spent during the 12 months to 30 June 2011 addressing complaints (including materials and labour on the network for both CAPEX and OPEX) was \$6.86 million compared to \$7.80 million in the previous 12 months

**Table 2: Complaints received in 2009/10 and 2010/11 - total and by discrete area as per Items 6 and 7 of Schedule 1.**

	# Complaints	
	2009/10	2010/11
Perth CBD	53	69
Urban areas other than Perth CBD	1,655	1,674
Rural areas	317	415
Isolated systems	43	36
<b>Total</b>	<b>2,068</b>	<b>2,194</b>

Following investigations of each customer complaint the findings were communicated to the customers. Where significant infrastructure investment was required to address the issue, works were planned, scoped and the applicable corrective action undertaken.

## 7 Payments to Customers

This section is a response to Item 9 of Schedule 1.

Code extract:

*“The number and total amount of payments made by the transmitter or distributor under each of sections 18 and 19”*

### 7.1 Planned Interruptions

Historically, planned power supply interruptions have been a frequent source of customer complaints. Significant changes to the planned outage notification process have meant that customers are provided with a minimum of six business days notification instead of the legislated 72 hours. Greater notification is provided to country customers. A dedicated team now exists to assist customers with any concerns they may have and as more Project Managers utilise the new centralised notification system, it is projected that the number of complaints and service standard payments will significantly decrease.

As well as improving the customer experience, these changes have also delivered in excess of \$2 million in business benefits.

Table 3 below, shows a considerable increase in service payments to customers for lack of or insufficient notification of a planned outage. Western Power believes this can be attributed to an 18 percent increase in planned outages for customer funded, maintenance and reinforcement works in the 2010/11 financial year. Further to this, increased public awareness of planned outage service payments has resulted from a spike in the number of media reports about these interruptions from one in 2009/10 to 17 in the 2010/11 financial year. Annual advertising in the Synergy Life magazine to all customers connected to the Western Power Network has also assisted in educating our customers about the availability of the service standard payment.

### 7.2 Extended Outage Payment Scheme

The majority of extended outage (interruption) incidents were due to events beyond Western Power’s control such as storm and lightning activity. In particular, these weather events occurred on the 29 January 2011 and the 28 February 2011 (see section 4).

Figure 2 shows the decrease in interruptions exceeding 12 hours by cause. There were fewer equipment failures and more favourable weather conditions (in comparison to last year).

**Table 3: Payments in 2009/10 and 2010/11 as per Items 9 of Schedule 1**

	2009/10		2010/11	
	Number	Value	Number	Value
Payments for failure to give required notice of a planned interruption	573	\$28,650	1,158	\$57,900
Payments for supply interruptions exceeding 12 hours	34,151	\$2,732,080	24,170	\$1,933,600

## 8 Discrete Areas 4 year average

This section is a response to Items 11, 12 and 13 of Schedule 1.

Code extract:

*“For each discrete area –*

- a) The average length of interruption of supply to customer premises expressed in minutes*
- b) The average number of interruptions of supply to customer premises*
- c) The average percentage of time that electricity has been supplied to customer premises; and*
- d) The average length of all interruptions of supply to customer premises expressed in minutes.”*

*“The information published for each paragraph of item 11 in respect of each of the 3 years ending 30 June preceding the year to which the report relates.”*

*“For each paragraph of item 11, the average of the 4 amounts under that paragraph in respect of the years comprising –*

- a) The year to which the report relates; and*
- b) The 3 years referred to in item 12.”*

### 8.1 Response - Perth CBD

The SAIDI, CAIDI and SAIFI performance did not improve for the 12 months to 30 June 2011 due to interruptions attributed to faults and overloading of specific low voltage (LV) cables. The length of these interruptions was affected further as a result of resource management practices where worker fatigue is managed during long interruption periods.

Some augmentation works and redistribution of loads have been undertaken to reduce the possibility of similar interruptions occurring in the future.

**Table 4: Perth CBD area reliability**

KPI	Units	Financial Year Ending 30 June				4 Year Average
		2007/08	2008/09	2009/10	2010/11	
SAIDI	Minutes	57	46	11	42	39
SAIFI		0.25	0.30	0.29	0.37	0.30
CAIDI	Minutes	223	152	36	112	131
ASAI	%	99.989	99.991	99.998	99.992	99.993

## 8.2 Response - Urban areas other than Perth CBD

SAIDI and CAIDI improved in urban areas during the 12 months to 30 June 2011.

However, power line upgrades have contributed to a reduction in the impact of unplanned interruptions caused by equipment failure. Also, automated switchgear has reduced customer impact due to interruptions such as storms and other environmental events.

There was also a reduction in the impact of inclement weather and localised storm activity.

**Table 5: Urban areas (other than the Perth CBD) reliability**

KPI	Units	Financial Year Ending 30 June				4 Year Average
		2007/08	2008/09	2009/10	2010/11	
SAIDI	Minutes	269	329	471	296	341
SAIFI		2.91	2.70	2.72	2.31	2.66
CAIDI	Minutes	92	122	173	128	129
ASAI	%	99.949	99.937	99.910	99.944	99.935

## 8.3 Response – isolated networks (Ravensthorpe)

The figures in Table 6 contain improvements for customers in the town of Ravensthorpe that were “islanded” from the Western Power Network from 17 December 2009 to 2 February 2011, and then from 10 June 2011 to cater for peak winter load.

The reliability of Ravensthorpe when islanded, improved when compared to the previous financial year. There were no interruptions due to lightning activity in this time period. The interruptions whilst Ravensthorpe was islanded during the last financial year were predominately due to car vs pole incidents and planned interruptions.

The town of Ravensthorpe was reconnected to the grid in February 2011 with a “bridging solution”. This enables the remote start up of a local power station in the event of Western Power Network unavailability and during peak energy demands within that area.

Ravensthorpe is currently scheduled to be fully reconnected to Western Powers Network by September 2011.

**Table 6: Isolated Networks (Ravensthorpe)**

KPI	Units	Financial Year Ending 30 June				4 Year Average
		2007/08	2008/09	2009/10	2010/11	
SAIDI	Minutes	N/A		888	404	N/A
SAIFI				2.47	3.90	
CAIDI	Minutes			360	104	
ASAI	%			99.831	99.923	

## 8.4 Response – Rural areas

The SAIDI, CAIDI and SAIFI performance was poorer for Rural areas during the 12 months to 30 June 2011. The primary reason of this increase was the storm activities experienced on the 29 January 2011 (see Section 4 for details).

Automated switchgear has reduced the impact of the interruptions on customers by reducing the restoration time.

**Table 7: Rural areas reliability**

KPI	Units	Financial Year Ending 30 June				4 Year Average
		2007/08	2008/09	2009/10	2010/11	
SAIDI	Minutes	599	735	818	956	777
SAIFI		4.68	5.07	5.43	4.43	4.90
CAIDI	Minutes	128	145	151	216	160
ASAI	%	99.886	99.860	99.844	98.818	99.602

## 9 Percentile values

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This section is a response to Items 14 and 15 of Schedule 1.

Code extract:

*“For customer premises in each discrete area, an estimate of the 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup>, 90<sup>th</sup>, 95<sup>th</sup>, 98<sup>th</sup> and 100<sup>th</sup> percentile values of –*

- a) The average length of interruption referred to in item 11(a)*
- b) The number of interruptions; and*
- c) The total length of interruptions.”*

*“For each category of information in item 14 (a), (b) and (c), a graph showing the distribution of customer premises across the range of that category”*

Percentiles are selected over the customer premise count for each discrete area.

For an example on how to interpret the tables and figures below, please see Table 9 and Figure 4. It shows that in 12 months to 30 June 2011, 50 percent of customers in urban areas had no more than 2 interruptions.

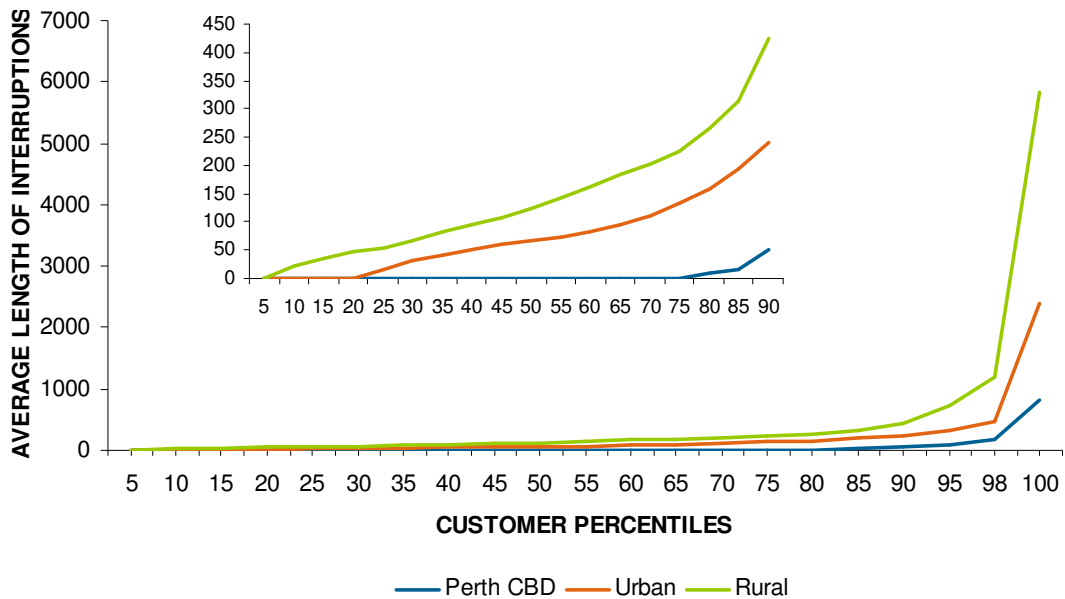
## 9.1 Response - Average length of interruption

Table 8 outlines the average length of interruptions to customers based on the prescribed percentiles for 12 months to 30 June 2011:

- The 100th percentile figure for Rural is due to storm activity on the 29 January 2011
- The 100th percentile figure for Urban and Perth CBD are predominantly due to storm activity on the 28 February 2011. Refer to Section 4 for details of these storms.
- 90% of the customers in the CBD is experiencing longer average length of interruption by an extra 32 minutes compared to last year
- 90% of the customers in the Urban region is experiencing shorter average length of interruption by 118 minutes compared to last year
- 90% of the customers in Rural region is experiencing longer average length of interruption by extra 99 minutes compared to last year

**Table 8: Average length of interruption (minutes) percentile figures as per Item 14(a) of Schedule 1**

	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>	98 <sup>th</sup>	100 <sup>th</sup>
Perth CBD	0	0	0	51	101	176	820
Urban	15	65	132	242	327	465	2406
Rural	54	124	224	424	727	1207	5831



**Figure 3: Average length of interruption percentile distribution as per Item 15 of Schedule 1**

## 9.2 Response - Number of interruptions

Table 9 outlines the number of interruptions to customers based on the prescribed percentiles for 12 months to 30 June 2011.

- Approximately 76% of CBD customers experienced no interruptions
- Approximately 99% of Urban area customers experienced 9 or fewer interruptions
- Approximately 99% of Rural area customers experienced 16 or fewer interruptions
- 90% of the customers in CBD are experiencing the same number of interruption as last year
- 90% of the customers in Urban region is experiencing the one less number of interruption as last year
- 90% of the customers in Rural region is experiencing the same number of interruption as last year

Areas of Western Powers network which have a high frequency of interruptions are monitored and targeted for applicable remedial activities.

**Table 9: Number of interruptions percentile figures as per Item 14(b) of Schedule 1**

	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>	98 <sup>th</sup>	100 <sup>th</sup>
Perth CBD	0	0	0	1	2	2	6
Urban	1	2	3	4	5	7	32
Rural	1	3	5	8	9	12	24

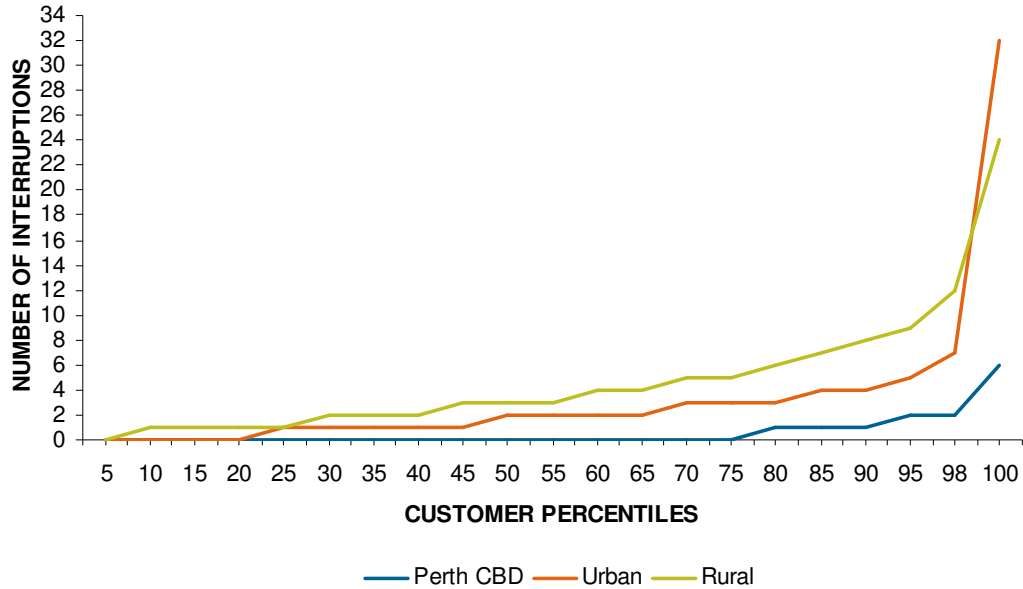


Figure 4: Number of interruptions percentile distribution as per Item 15 of Schedule 1

### 9.3 Response - Total length of all interruptions

For 12 months to 30 June 2011:

- Approximately 88% of Perth CBD customers experienced total interruption minutes of less than 30 minutes
- Approximately 44% of Urban area customers experienced total interruption minutes of less than 160 minutes
- Approximately 55% of Rural area customers experienced total interruption minutes of less than 290 minutes
- 90% of the customers in CBD is experiencing longer total length of interruption by extra 38 minutes compared to last year
- 90% of the customers in Urban region is experiencing shorter total length of interruption by 478 minutes compared to last year
- 90% of the customers in Rural region is experiencing a small increase in total length of interruption by extra 4 minutes compared to last year

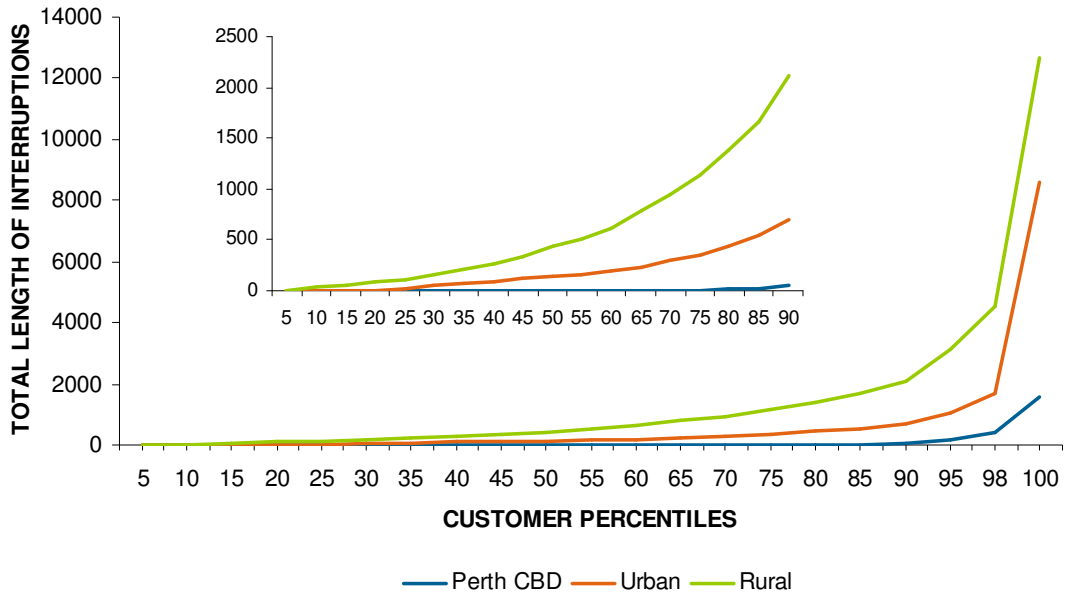
The 100th percentile figure for Urban and Perth CBD is predominantly due to extended interruptions attributed to storm activity experienced on the 28 February.

The 100th percentile figure for Rural is predominantly due to extended interruptions attributed to the storm activity experienced on the 29 January.

Refer to Section 4 for details of these storms.

**Table 10: Total length of interruptions (minutes) percentile figures as per Item 14(c) of Schedule 1**

	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>	98 <sup>th</sup>	100 <sup>th</sup>
Perth CBD	0	0	4	59	148	397	1567
Urban	25	141	357	692	1021	1707	8574
Rural	113	429	1135	2113	3159	4542	12643



**Figure 5: Total length of interruptions percentile distribution as per Item 15 of Schedule 1**

## 10 Power Quality

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This section is a response to Item 4 of Schedule 1.

Code extract:

*“In respect of each failure by the transmitter or distributor to comply with a provision of this Code or an instrument under Section 14(3) (as identified by monitoring records or under section 24 or following a complaint) –*

- a) The total number of breaches of each provision; and*
- b) The remedial action taken in each case*

### 10.1 Response

Permanent Power Quality (PQ) meters have been deployed in different parts of the LV distribution network to monitor the quality of customers' supply. This section of the report is in relation to the compliance of the LV distribution network<sup>2</sup>, which in turn is reflective of the high voltage distribution network.

The program of installing permanent PQ meters continues with an additional 12 devices deployed for the 12 months to 30 June 2011. This brings the total number of PQ meters operating on the network to 96.

The compliance level of 8% Total Harmonic Distortion (“THD”) was met for all sites 100% of the time.

See Appendix A for details pertaining to power quality compliance.

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<sup>2</sup> As no code non-compliance or complaints have been received in regards to harmonic or flicker on the transmission network, there are no breaches to report.

## Appendix A. Power Quality Compliance

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### A.1 Harmonics Compliance

Harmonic voltage distortion is caused by particular types of equipment that are connected to the network. Harmonic voltage distortion can impose extra strain on the network and other equipment connected to it. The voltage distortion levels arising from harmonics in the network are to be contained within the compatibility levels given in Part 2 Section 7 of the Code. Western Power's Technical Rules provide the requirements that must be met by equipment connecting to the distribution and transmission networks.

To assist the management of harmonics on the distribution network, Western Power has developed tools based on requirements specified in applicable standards<sup>3</sup>. These tools are used for new commercial and industrial loads to assign the allowable level of voltage harmonics emitted in the network when connected.

Figures 6 and 7 are representative of the THD present at the customer and distribution transformer sites respectively. The median THD recorded by the permanent PQ meters is approximately 2.5% for the customer sites and 2.0% for the transformer sites. The compliance level of 8% THD was met for all sites 100% of the time. The Western Power planning level of 6.5% was met 99.97% of the time for customer sites and 99.98% of the time for transformer sites. Investigations have identified that a very small number of customer loads were the source of harmonic distortion, contributing to exceeding the Western Power planning level. However, this is a local issue and not adversely impacting customers living in close proximity. Because of this, no further action is required.

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<sup>3</sup> Australian Standard AS61000 series and the methodologies stated PQ Handbook HB264

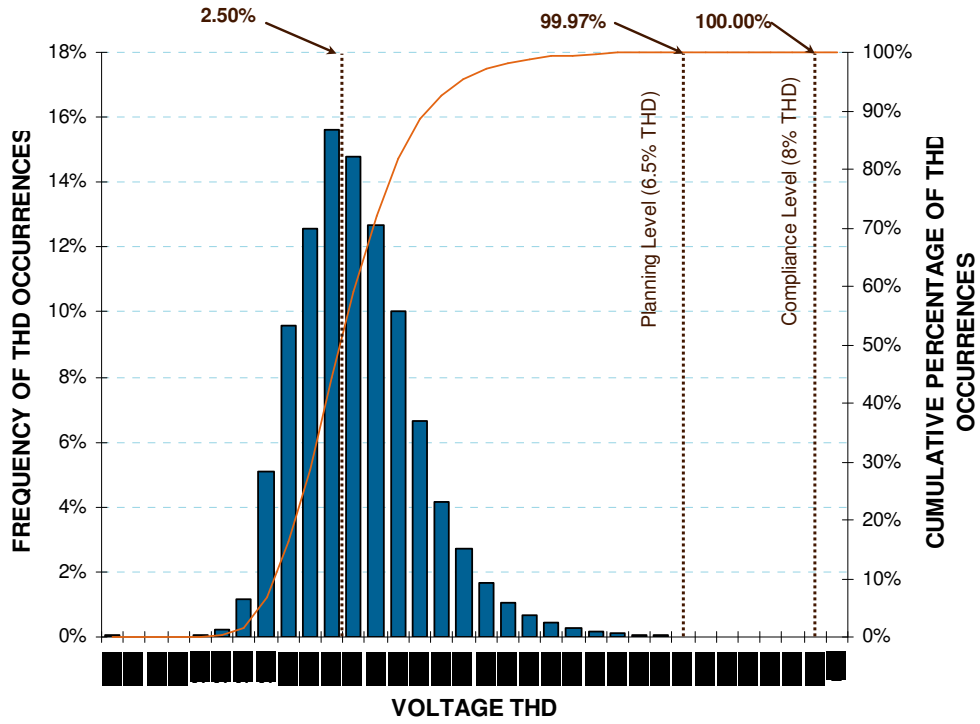


Figure 6: Percentage of THD for aggregate of 40 customer permanent PQ meters recording sites

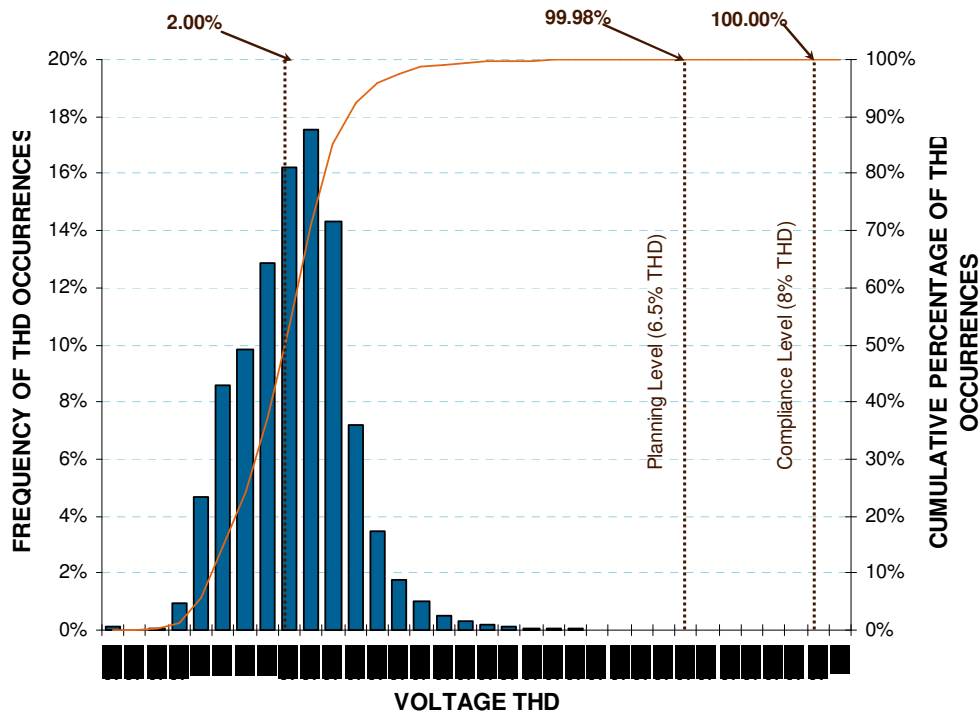


Figure 7: Percentage of THD for aggregate of 56 transformer permanent PQ meters recording sites

## A.2 Voltage Variation Compliance

Voltages must be maintained within  $\pm 6\%$  of the of the nominal supply voltage according to the *Electricity Act 1945* Section 25(1)(d) (“the Act”). The nominal voltage for the purposes of the Act and the Code is 240 V single-phase and 415 V three-phase. According to Western Power’s Technical Rules the steady state voltage must be within the following limits:

- $\pm 6\%$  of the nominal voltage during normal conditions
- $\pm 8\%$  of the nominal voltage during maintenance conditions
- $\pm 10\%$  of the nominal voltage during emergency conditions

Figures 8 and 9 represent the frequency of variations in voltage levels for customer and transformer sites as recorded by the permanent PQ meters.

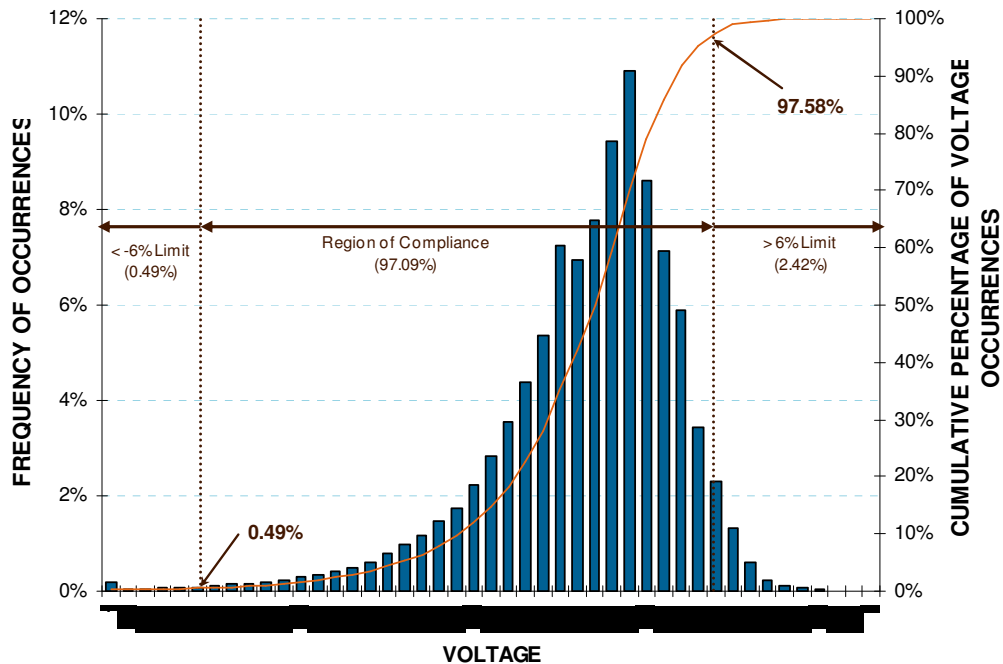


Figure 8: Voltage distribution for aggregate of 40 permanent PQ meters at customer sites

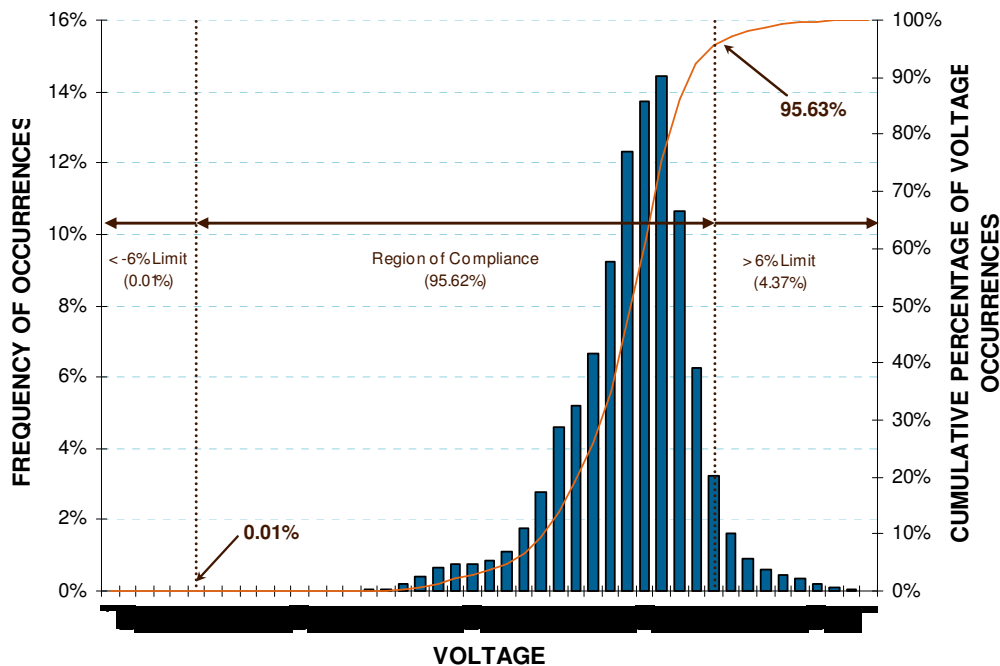


Figure 9: Voltage distribution for aggregate of 56 permanent PQ meters at transformer sites

Figures 8 and 9 showed that the voltage levels were maintained within the required limits for 97.09% of the time at customer sites, and 95.62% of the time at transformer sites.

The voltage lower limit (240V -6%) was not met for 0.49% and 0.01% of the time of customer and transformer sites respectively of the time recorded. These recordings can be mostly attributed to short term peak loads.

The voltage upper limit (240V +6%) was exceeded at many customer and transformer sites for 2.42% and 4.37% of the time respectively. The contributing factors to exceeding the high voltage limit occurring at the LV side of a distribution transformer are:

- variations in the setpoint voltage of the Automatic Voltage Regulator (AVR) of the power transformer at the zone substation
- voltage variances of  $\pm 1.5\%$  about the setpoint before the AVR responds to restore voltage levels within the tolerance range of  $\pm 1.5\%$
- periods of very light loads on the network
- the increasing penetration of photovoltaic solar systems that cause voltage rise on the network

The locations represented by the permanent PQ meters have a median voltage of approximately 250V for the transformer sites and 248V for customer sites. This illustrates that the distribution network generally complies with the Code under 'normal operating' conditions.

Given the global market of equipment and appliances, and the greater penetration of customer renewable energy systems, a national consistency in the management of voltages within the distribution network and within the customer's installation is necessary. In addition there are some inconsistencies across jurisdictions on declared voltage levels and the corresponding ranges. In the interest of national consistency in managing the voltage levels within the network, and within the customer's installation, the Energy Networks Association ("ENA") and Standards Australia are developing standards and overall strategies for determining compliance.

Western Power is involved in this work and subsequently will leverage off the outcomes to develop similar strategies and implementation plans over the next five years.

### A.3 Voltage Unbalance Compliance

Power is distributed to customers by way of 3 phase electricity, in which each phase's voltage is displaced by  $120^\circ$  and of equal magnitudes. In this situation the supply is considered to be a "balanced" supply. Phase unbalance is caused by significantly differing loads across each phase which result in unequal voltage levels and possibly phase displacements. Such situations can have a detrimental effect particularly on equipment that required all three phases to operate.

The Code does not specify voltage unbalance requirements but they are stated in the Technical Rules in terms of ratio of "negative phase" sequence to "positive phase" sequence. The requirement for LV ratios is to be less than 2%.

All measurements were recorded as positive and negative sequence components by the permanent PQ meters and the unbalance results calculated.

Figure 10 and Figure 11 depict the occurrences of voltage unbalance between 0 and 3% for customer and transformer permanent PQ meter sites. These figures show that the voltage unbalance is well within the limit for 99.29% of the time for customer sites and 99.60% for transformer sites. A number of sites have slightly exceeded the limit for short periods. For the affected transformer sites this has been mainly due to long HV distribution circuits supplying the respective transformer. Customer sites which are affected are more determined by the customer's own loading on each phase with a small contribution from the networks imbalance seen at the transformer sites.

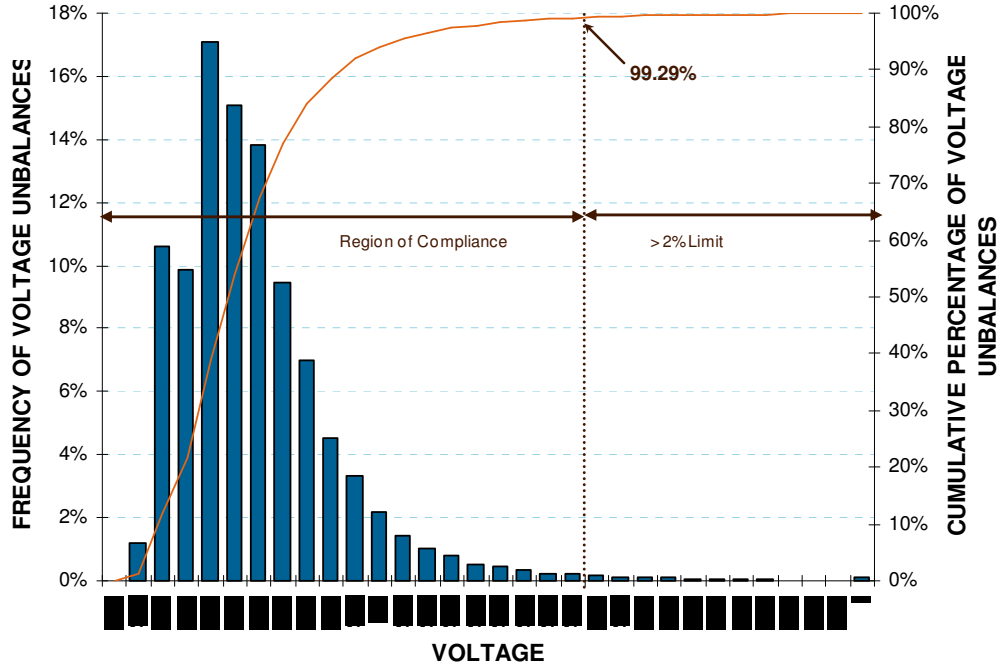


Figure 10: Voltage unbalance for aggregated recordings for 40 permanent PQ meter customer sites

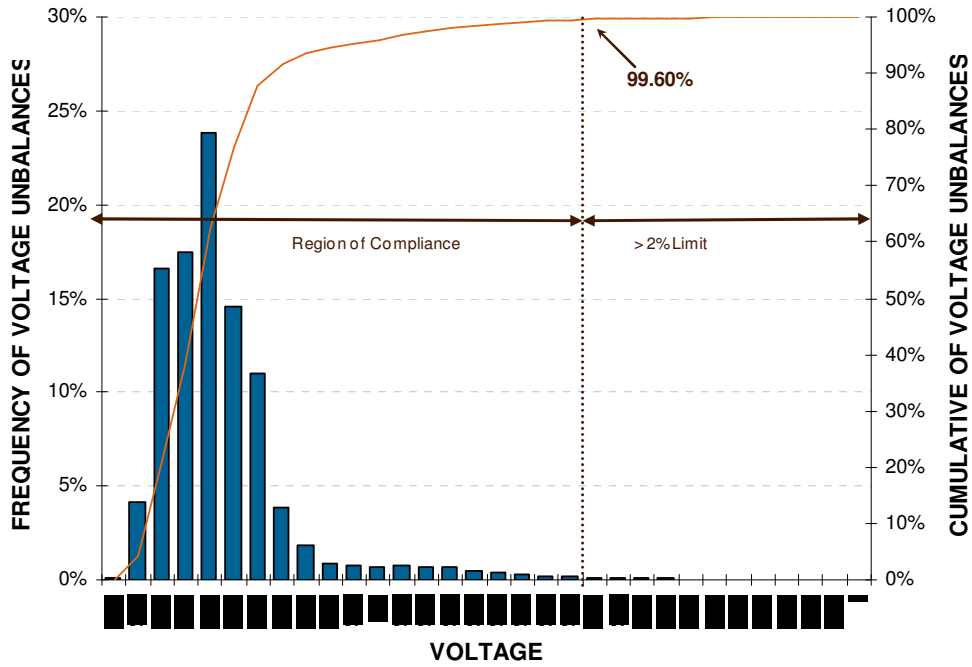


Figure 11: Voltage unbalance for aggregated recordings for 56 permanent PQ meter transformer sites

## A.4 Summary

The non-compliances reported in preceding sections are of relatively short duration in respect to the entire measurement period. Overall, there has been no significant change in non-compliance levels since the last report. As a result, no further action is required.

## Appendix B. List of Customer Interruptions Greater than 12 Hours

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
1	19.5	19.52	2
2	16.95	64.22	8
3	14.85	14.85	12
4	23.38	23.38	3
5	19.6	19.6	93
6	12.66	12.66	104
7	14.18	14.18	485
8	50.94	50.94	1
9	27.68	27.68	1
10	20.34	20.34	1
11	12.94	12.94	1
12	12.83	12.83	1
13	17.61	17.61	1
14	14.42	14.42	1
15	12.61	12.61	1
16	16.86	16.86	1
17	22.46	22.46	3
18	15.65	15.65	4
19	18.55	18.55	6
20	12.63	12.63	4
21	17.93	17.93	3
22	13.22	13.22	19
23	17.32	17.32	4
24	12.65	12.65	1
25	16.13	16.13	221
26	17.45	17.45	162
27	15.23	15.23	1
28	33.59	33.59	35
29	14.17	14.17	69
30	27.4	27.4	15
31	20.83	20.83	39
32	13.63	14.93	44
33	18.08	18.08	6
34	17.92	17.92	1
35	16.76	25.88	6
36	17.92	17.92	1
37	17.71	17.71	6
38	15.25	15.25	1
39	18.17	18.17	1
40	17.65	17.65	1
41	14.79	14.79	1
42	18.26	18.26	2
43	17.98	17.98	1
44	13.66	13.66	1
45	20.62	20.62	1
46	14.15	14.15	1
47	14.82	14.82	75
48	18.35	18.35	1
49	15.89	16.49	354
50	15.58	15.58	1
51	13.54	13.54	35
52	14.88	14.88	64

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
53	13.25	13.25	1
54	13.67	13.67	1
55	15.7	15.7	117
56	12.64	12.64	29
57	15.14	15.14	123
58	13.63	13.63	1
59	17.46	17.46	1
60	12.26	12.26	15
61	12.79	12.79	1
62	14.1	14.1	1
63	12.8	12.8	4
64	12.88	12.88	1
65	18.09	18.09	1
66	14.37	14.37	1
67	16.51	19.57	36
68	14.29	14.29	1
69	14.17	14.17	1
70	14.66	14.66	1
71	17.84	17.84	46
72	18.11	18.11	1
73	12.92	12.92	1
74	13.2	13.2	1
75	14.05	14.05	9
76	19.35	19.35	1
77	17.85	21.5	35
78	14.54	14.54	1
79	18.12	18.12	9
80	15.32	15.32	1
81	13.91	13.91	1
82	97.57	97.57	1
83	15.27	15.27	1
84	12.74	12.74	1
85	13.25	13.25	10
86	12.18	12.18	54
87	14.67	14.67	1
88	12.33	12.33	1
89	22.6	22.6	40
90	13.68	13.68	5
91	18.7	18.7	12
92	12.29	12.29	1
93	70.76	70.76	1
94	87.54	87.54	1
95	12.41	12.41	42
96	13.82	13.82	1
97	61.52	61.52	1
98	16.27	16.27	42
99	14.88	14.88	1
100	17.12	17.12	1
101	22.84	22.84	1
102	23.81	23.81	1
103	17.89	17.89	5
104	21.89	21.89	1
105	14.27	14.27	1
106	19.17	19.17	1
107	16.89	16.89	1
108	18	18	62
109	22.79	22.79	2
110	12.78	12.78	2
111	15.8	15.8	27
112	12.77	14.56	24

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
113	13.2	13.2	119
114	13.47	14.45	36
115	15.88	15.88	34
116	12.05	17.13	21
117	21.98	21.98	11
118	19.12	19.12	1
119	17.58	17.58	1
120	13	14.38	15
121	25.23	25.23	1
122	18.37	18.37	5
123	21.81	21.81	1
124	15.8	15.8	1
125	12.79	12.79	1
126	16.16	16.16	26
127	17.64	17.64	1
128	41.32	41.32	1
129	14.76	14.76	12
130	13.85	13.85	1
131	15.89	15.89	24
132	13.66	13.66	1
133	15.35	15.35	1
134	16.52	16.52	1
135	15.19	15.19	39
136	13.99	13.99	1
137	15.83	15.88	10
138	16.62	16.62	1
139	44.68	44.68	1
140	12.9	12.9	1
141	13.11	13.11	5
142	79.46	79.46	1
143	15.38	15.38	8
144	16.01	16.01	11
145	27.9	27.9	1
146	17.04	17.04	1
147	14.04	14.04	1
148	19.32	19.32	36
149	73.85	73.85	2
150	24.13	24.13	2
151	12.77	12.77	76
152	17.65	17.65	10
153	21.45	21.45	7
154	16.17	19.82	17
155	15.08	15.08	11
156	25.17	25.17	1
157	12.67	12.67	85
158	12.28	12.28	339
159	14.52	14.52	1
160	16.6	16.6	1
161	15	15	72
162	17.48	17.48	5
163	13.9	13.9	13
164	29.38	29.38	37
165	14.59	14.59	8
166	41.92	41.92	1
167	13.56	13.56	14
168	17.44	17.44	1
169	17.44	17.44	1
170	12.09	12.09	17
171	24.45	24.45	1
172	12.18	12.18	102

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
173	17.78	17.78	5
174	13.97	13.97	41
175	14.11	19.69	39
176	16.62	16.62	49
177	18.77	18.77	4
178	14.13	14.13	15
179	18.31	18.31	8
180	23.58	23.58	1
181	12.54	12.54	1
182	16.33	16.33	22
183	19.16	19.16	18
184	12.68	12.68	15
185	20.46	20.46	1
186	12.59	12.59	1
187	22.88	22.88	1
188	15.11	15.11	1
189	15.07	15.07	1
190	13.06	13.06	1
191	15.53	16.78	50
192	28.63	28.63	1
193	18.03	18.03	1
194	18.3	18.3	2
195	27.66	27.66	1
196	12.44	12.44	6
197	18.38	18.38	1
198	17.65	17.65	1
199	15.58	15.58	1
200	13.3	13.3	1
201	19.82	19.82	1
202	17.33	17.33	1
203	21.11	21.11	9
204	24.07	24.07	9
205	20.42	20.42	1
206	17.15	17.15	71
207	19.86	19.86	1
208	14.12	14.12	1
209	18.38	18.38	1
210	15.94	15.94	1
211	16.72	16.72	1
212	12.71	12.71	1
213	14.33	14.33	84
214	17.18	17.18	1
215	13.36	13.36	1
216	14.81	14.81	1
217	20.99	20.99	1
218	16.71	16.71	1
219	12.51	12.51	22
220	19.51	19.51	2
221	12.43	12.43	1
222	13.09	13.09	1
223	16.69	16.69	1
224	44.85	47.57	2
225	16.82	16.82	17
226	12.32	12.32	1
227	15.78	24.38	12
228	18.72	18.72	7
229	14.84	14.84	1
230	13.28	13.28	1
231	14.17	21.25	40
232	12.1	15.29	40

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
233	29.87	29.87	5
234	26.15	26.15	1
235	17.4	17.4	24
236	15.81	15.81	14
237	13.01	13.01	18
238	24.2	24.2	1
239	16.84	16.84	1
240	15.75	15.75	1
241	12.07	12.07	18
242	12.33	12.33	1
243	12.9	12.9	10
244	13.47	13.47	1
245	12.58	12.58	1
246	17.22	17.22	1
247	13.33	13.33	1
248	12.79	12.79	31
249	16.89	16.89	25
250	15.96	15.96	1
251	15.51	15.51	11
252	17.4	17.4	77
253	13.41	13.41	47
254	14	14	124
255	13.11	13.11	93
256	12.72	12.73	16
257	12.41	12.41	2
258	17.45	17.45	54
259	13.1	13.1	12
260	15.57	15.57	25
261	16	16	1
262	19.13	19.13	74
263	12.28	12.28	1
264	14.69	14.69	1
265	12.52	12.52	66
266	12.68	12.68	123
267	14.07	14.07	94
268	15.18	15.18	15
269	12.8	12.8	3
270	13.75	13.75	27
271	12.52	12.52	3
272	14.73	14.73	1
273	23.38	23.38	4
274	18.79	18.79	3
275	16	16	13
276	18.42	18.42	24
277	13.03	13.03	102
278	12.08	12.08	6
279	21.33	23.88	3
280	16.94	16.94	1
281	21.99	21.99	20
282	16.99	16.99	1
283	14.76	14.76	1
284	15.81	15.81	4
285	18.23	18.23	30
286	16.03	26.28	294
287	25.18	25.18	5
288	25.58	25.58	5
289	22.9	22.9	92
290	24.47	24.47	11
291	17.39	17.39	2
292	17.61	17.61	1

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
293	20.09	20.09	9
294	15.24	15.24	1
295	18.5	18.5	3
296	15.57	15.57	1
297	15.83	15.83	1
298	42.8	42.8	1
299	17.33	17.33	1
300	15.85	15.85	1
301	14.38	14.38	1
302	16.66	16.66	1
303	13.02	13.02	1
304	15.01	15.01	3
305	34.86	34.86	1
306	15.59	15.59	126
307	16.69	16.69	1
308	20.9	20.9	2
309	12.85	12.85	1
310	17.42	47.32	77
311	23.73	23.73	1
312	13.26	13.26	113
313	14.46	14.46	1
314	15.1	15.1	37
315	13.49	14.59	21
316	16.4	16.4	11
317	12.01	12.01	1
318	14.95	15.38	67
319	12.35	12.35	80
320	12.08	12.08	103
321	14.31	14.31	1
322	17.34	18.86	55
323	19.67	19.67	1
324	12.31	12.31	121
325	20.24	20.24	43
326	16.63	16.63	1
327	28.79	28.79	48
328	45.89	70.76	35
329	18.79	18.79	7
330	23.02	23.02	1
331	20.92	20.92	1
332	25.99	25.99	12
333	23.13	23.13	185
334	15.24	15.24	24
335	14.64	14.64	1
336	19.97	19.97	1
337	13.29	13.29	19
338	22.66	22.66	1
339	13.68	13.68	1
340	19.29	19.29	1
341	23.22	23.22	16
342	18.64	18.64	1
343	21.78	21.78	1
344	18.39	18.39	1
345	18.29	18.29	1
346	18.28	18.28	1
347	21.11	21.11	1
348	15.62	15.62	1
349	13.22	15.42	58
350	19.33	19.33	1
351	17.72	17.72	2
352	14.55	14.55	1

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
353	17.12	17.12	74
354	15.19	15.19	272
355	15.51	15.51	138
356	13.44	13.44	1
357	12.36	12.36	1
358	12.49	12.49	1,124
359	37.97	37.97	1
360	30.51	30.51	65
361	35.41	35.41	11
362	24.83	24.83	1
363	24.4	24.4	48
364	29.92	29.92	1
365	32.28	76.16	12
366	29.71	29.71	1
367	33.17	33.17	1
368	28.98	28.98	48
369	26.76	26.76	22
370	19.61	19.81	319
371	24.33	24.33	1
372	12.6	12.6	99
373	26.6	144.13	44
374	27.44	27.44	1
375	21.47	21.47	567
376	119.23	119.23	25
377	69.15	69.15	18
378	26.46	26.46	23
379	98.24	98.24	66
380	122.88	122.88	50
381	27.87	52.63	840
382	100.24	100.33	62
383	27.45	27.45	452
384	24.06	24.06	684
385	26.72	26.72	1,231
386	17.23	28.74	1,477
387	19.55	21.85	627
388	21.97	50.82	37
389	99.02	99.02	1
390	75.16	75.16	1
391	45.11	45.11	12
392	75.05	75.05	1
393	68.7	94.43	26
394	24.01	43.91	1,056
395	98.42	98.42	1
396	42.31	42.31	16
397	16.81	51.09	928
398	69.95	69.95	33
399	43.44	43.44	1,196
400	25.21	25.21	2
401	20.74	20.74	74
402	48.09	48.09	13
403	18.5	19.43	77
404	33	68.75	31
405	25.21	25.21	69
406	16.57	16.57	1
407	18.35	18.35	92
408	27.03	27.03	178
409	25.24	25.24	24
410	20.68	20.68	1
411	20.98	20.98	44
412	20.29	20.29	1

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
413	22.26	122.8	2,772
414	25.64	25.64	1
415	24.26	24.26	1
416	18.2	18.23	1,559
417	21.67	21.67	1
418	24.86	24.86	1
419	47.17	47.17	2
420	12.37	12.37	1
421	15.3	15.3	1
422	15.65	15.65	18
423	18.4	18.4	229
424	12.08	14.2	82
425	14.86	14.86	1
426	69.37	69.37	1
427	17.14	17.14	1
428	12.99	12.99	1
429	22.75	22.75	7
430	16.33	16.33	3
431	12.12	12.12	2
432	41.44	41.44	1
433	21.19	21.19	1
434	93.51	93.51	1
435	13.71	13.71	9
436	20.7	20.7	1
437	21.59	21.59	1
438	61.93	61.93	1
439	41.01	41.01	125
440	64.97	64.97	15
441	65.3	65.3	1
442	21.14	21.14	1
443	36.76	36.76	1
444	14.11	14.11	1
445	40.49	40.49	25
446	60.55	60.55	1
447	39.91	39.91	1
448	40.98	40.98	1
449	15.06	15.06	1
450	13.76	13.76	1
451	12.06	12.06	1
452	36.8	36.8	1
453	18.59	18.59	1
454	12.39	12.39	3
455	13.08	13.08	4
456	19	19	1
457	13.7	13.7	1
458	41.44	41.44	17
459	12.39	12.39	97
460	56.32	56.32	1
461	37.51	37.51	19
462	47.45	47.45	1
463	31.24	31.24	1
464	27.69	27.69	10
465	31.05	31.05	1
466	30.93	30.93	1
467	26.5	26.5	1
468	25.89	25.89	1
469	52.85	52.85	37
470	34.06	34.06	42
471	21.02	21.02	15
472	31.04	31.04	76

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
473	32.67	32.67	7
474	45.31	45.31	1
475	49.07	49.07	3
476	47.05	98.24	212
477	29.38	91.6	545
478	21.14	21.14	100
479	21.11	21.11	54
480	22.62	22.62	1
481	71.7	121.03	67
482	24.92	24.92	1
483	24.91	24.91	1
484	21.78	21.78	248
485	24.44	24.44	55
486	20.18	20.18	47
487	20.76	20.76	1
488	65.32	65.32	1
489	14.1	14.1	102
490	48.23	48.23	1
491	18.06	18.06	1
492	19.03	19.03	1
493	18.25	18.25	1
494	13.7	13.7	78
495	42.72	42.72	4
496	28.17	117.93	219
497	19.24	19.24	1
498	95.04	95.04	53
499	16.79	16.79	1
500	14.68	14.68	125
501	35.5	35.5	1
502	14.51	14.51	1
503	68.38	68.38	1
504	13.44	13.44	1
505	117.88	117.88	2
506	32.1	32.1	11
507	61.38	61.38	56
508	54.36	54.36	1
509	56.97	56.97	1
510	21.6	21.6	73
511	15.69	15.69	1
512	56.24	56.24	18
513	19.45	19.45	1
514	23.11	23.11	1
515	16.85	16.85	1
516	20.18	20.18	1
517	15.91	15.91	1
518	23.73	23.73	1
519	25.1	25.1	1
520	65.28	65.28	1
521	15.04	15.04	1
522	13.9	13.9	1
523	20.2	20.2	11
524	15.75	15.75	1
525	15.62	15.62	1
526	13.29	13.29	1
527	23.39	23.39	1
528	21.3	21.3	1
529	20.3	20.3	1
530	17.44	17.44	1
531	16.91	16.91	1
532	18.72	18.72	13

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
533	20.35	20.35	33
534	12.49	12.49	1
535	40.78	40.78	1
536	17.83	17.84	33
537	13.7	13.7	1
538	16.73	16.73	1
539	42.65	42.65	64
540	14.1	14.1	1
541	96.03	96.03	1
542	30.2	30.2	4
543	119.57	119.57	1
544	27.87	27.87	1
545	69.37	146.66	51
546	69.48	69.48	1
547	49.92	49.92	1
548	29.12	29.12	1
549	96.74	96.74	35
550	141.29	141.29	4
551	27.77	27.77	37
552	23.29	23.29	1
553	24.16	24.16	1
554	24.56	24.56	1
555	164.55	164.55	1
556	16.72	21.33	22
557	21.77	21.77	45
558	15.87	15.87	1
559	28.94	28.94	1
560	14.9	15.68	24
561	120.21	120.21	1
562	31.4	31.4	1
563	27	27	1
564	29.48	29.48	45
565	25.42	25.42	26
566	51.25	51.25	67
567	166.25	166.25	1
568	26.59	26.59	1
569	121.02	121.02	53
570	44.72	44.72	3
571	144.73	144.73	7
572	165.4	165.4	4
573	28.33	28.33	42
574	22.44	22.44	5
575	120.41	120.41	23
576	169.27	169.27	27
577	16.21	16.21	1
578	70.49	70.49	1
579	164.47	164.47	31
580	123.47	123.47	1
581	22.35	22.35	1
582	13.11	20.57	664
583	66.4	66.4	1
584	13.41	13.41	1
585	125.87	125.87	1
586	37.42	37.42	1
587	82.82	82.82	1
588	166.07	166.07	1
589	26.66	26.66	1
590	29.06	29.06	1
591	24.47	24.47	23
592	27.43	27.43	1

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
593	22.7	22.7	1
594	20.34	20.34	14
595	15.31	15.31	1
596	14.91	14.91	1
597	26.89	26.89	1
598	21.69	21.69	1
599	12.91	12.91	2
600	17.04	17.04	1
601	14.69	14.69	25
602	16.49	16.49	1
603	14.31	14.31	6
604	25.97	25.97	1
605	168.77	168.77	18
606	46.45	46.45	1
607	53.31	53.31	1
608	143.18	143.18	7
609	49.31	49.31	1
610	23.35	23.35	4
611	49.32	49.32	1
612	27.48	27.48	31
613	14.11	14.11	1
614	13.98	13.98	16
615	13.71	13.71	233
616	55.75	55.75	1
617	46.55	46.55	1
618	25.06	25.06	1
619	33.22	33.22	1
620	14.05	14.05	1
621	28.69	28.69	1
622	21.18	21.18	1
623	14.46	14.46	32
624	26.54	26.54	52
625	21.87	21.87	1
626	14.67	18.55	706
627	44.58	44.58	12
628	22.79	41.79	1,601
629	76.65	76.65	3
630	24.78	24.78	1
631	12.05	12.1	463
632	26.18	26.22	15
633	15.67	15.67	1
634	22.22	22.22	1
635	16.38	16.38	1
636	17.38	17.38	39
637	12.02	12.02	1
638	12.04	12.04	10
639	46.53	46.53	1
640	12.11	12.11	193
641	20.61	20.61	6
642	17.49	17.49	3
643	12.44	12.44	11
644	26.46	26.46	1
645	21.79	21.79	3
646	15.89	15.89	1
647	12.02	12.02	1
648	18.98	18.98	1
649	21.85	21.85	1
650	36.75	36.75	2
651	19.35	19.35	4
652	44.9	44.9	12

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
653	18.99	18.99	15
654	24.73	24.73	11
655	18.24	18.24	1
656	16.86	16.86	12
657	22.87	22.87	4
658	20.12	20.12	14
659	20.27	23.64	59
660	17.79	17.79	1
661	18.34	18.34	3
662	25.17	25.17	1
663	44.82	45.05	77
664	14.87	14.87	14
665	20.17	20.17	1
666	17.98	23.28	4
667	24.25	24.25	25
668	42.05	42.05	1
669	19.49	19.49	1
670	12.95	13.34	221
671	16.01	16.01	1
672	40.8	40.8	1
673	16.56	16.56	7
674	21.4	21.4	22
675	18.89	18.89	2
676	14.24	14.24	1
677	12.3	12.3	5
678	19.16	19.16	1
679	19.58	19.58	20
680	19.02	19.02	16
681	20.38	20.38	25
682	20.17	20.17	1
683	16.38	16.38	1
684	12.5	12.5	62
685	13.5	13.5	1
686	19.25	19.25	1
687	12.16	12.16	122
688	13.78	13.78	28
689	14.61	14.61	1
690	12.73	12.73	1
691	20.56	20.56	1
692	13.86	13.86	1
693	13.5	13.5	16
694	35.97	35.97	1
695	17.07	17.07	1
696	14.33	14.33	14
697	12.11	12.11	1
698	25.6	25.6	2
699	23.31	23.31	1
700	20.56	20.56	1
701	21.35	21.35	1
702	19.98	20.27	27
703	18.55	18.55	1
704	16.15	16.15	1
705	16.73	16.73	1
706	18.43	18.43	1
707	18.77	18.77	7
708	43.03	43.03	11
709	44.92	44.92	4
710	29.77	29.77	10
711	44.38	44.38	436
712	29.52	29.52	8

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
713	18.7	18.7	2
714	20.43	20.43	1
715	15.29	15.29	2
716	36.99	55.92	16
717	14.64	14.64	1
718	29.22	29.22	2
719	25.05	25.05	6
720	23.07	23.07	1
721	19.08	19.08	15
722	19.03	22.12	5
723	18.62	18.62	5
724	13.94	13.94	63
725	17.41	17.41	26
726	21.28	21.28	1
727	28.43	28.43	35
728	27.01	27.01	20
729	23.79	23.79	1
730	13.74	13.74	4
731	16.93	16.93	1
732	68.84	68.84	1
733	22.29	22.29	1
734	16.47	16.47	1
735	19.79	46.48	53
736	20.8	20.8	1
737	16.52	16.52	812
738	18.4	18.4	1
739	12.23	12.23	17
740	29.7	29.7	1
741	20.38	20.38	1
742	37.63	37.63	12
743	22.7	28.32	40
744	43.1	43.1	1
745	19.13	19.13	1
746	71.5	71.5	1
747	20.8	20.8	1
748	18.7	18.7	1
749	30.78	30.78	20
750	26.88	26.88	1
751	19.97	24.89	64
752	26.35	26.35	1
753	18.89	18.89	1
754	62.01	62.01	1
755	19	19	1
756	21.73	21.73	1
757	18.32	18.32	1
758	17.1	38.58	27
759	20.63	20.63	1
760	23.25	25.4	32
761	14.58	14.58	4
762	16.65	16.65	1
763	19.93	19.93	1
764	17.08	17.08	1
765	59.34	59.34	1
766	13.6	13.6	1
767	12.96	12.96	1
768	13.32	13.32	1
769	14.37	14.37	1
770	16.28	16.28	1
771	14.16	14.16	1
772	27.95	27.95	1

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
773	45.64	45.64	1
774	45.38	45.38	1
775	25.17	25.17	1
776	22.01	22.01	1
777	26.62	26.62	5
778	21.55	21.55	1
779	30.46	30.46	1
780	49.48	49.48	13
781	12.42	31.44	3,029
782	22.83	23.31	978
783	27.1	31.45	991
784	19.22	26.93	3,121
785	21.76	47.91	39
786	21.56	53.23	368
787	13.85	13.85	1
788	22.91	22.91	1
789	23.77	48.3	1,729
790	28.98	29.01	581
791	22.62	22.62	174
792	27.37	49.7	1,793
793	23.55	23.55	1
794	20.15	20.23	1,032
795	23.26	50.11	356
796	39.77	40.75	607
797	26.8	44.78	1,031
798	13.71	48.97	698
799	51.15	51.15	1
800	30.64	30.64	623
801	14.95	14.95	11
802	16.02	16.02	1
803	14.54	14.54	1
804	14.55	14.55	265
805	17.09	18.21	1,628
806	20.55	20.55	53
807	12.99	23.33	200
808	53.95	53.95	1
809	19.04	19.04	5
810	22.8	22.8	77
811	24.55	24.55	1
812	16.87	16.87	124
813	21.33	21.33	1
814	24.49	24.49	1
815	13.58	13.59	500
816	18.23	18.23	104
817	43.48	43.48	1
818	20.1	20.1	97
819	14.72	14.72	1
820	18.07	18.07	1
821	18.56	18.56	1
822	17.23	17.23	1
823	16.53	16.53	71
824	12.47	12.47	182
825	20.24	20.24	1
826	14.08	14.08	95
827	20.64	20.64	1
828	20.13	20.13	1
829	20.17	20.17	4
830	13.15	16.82	734
831	13.81	13.81	1
832	19.66	19.66	24

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
833	17.88	17.88	1
834	18.87	19.47	53
835	13.91	13.91	1
836	17.79	17.79	118
837	29.33	29.33	156
838	17.51	17.51	34
839	21.47	28.35	216
840	40.73	40.73	1
841	16.03	16.03	39
842	14.25	14.25	1
843	14.8	14.8	8
844	14.88	14.88	1
845	25.85	25.85	64
846	15.69	15.69	7
847	12.87	12.87	1
848	17.9	17.9	1
849	30.96	30.96	1
850	12.83	12.83	4
851	19.86	19.86	251
852	35.66	35.66	108
853	48.03	48.03	1
854	19.63	19.63	88
855	45.96	45.96	1
856	22.36	22.36	1
857	17.51	17.51	2
858	23.58	23.58	3
859	12	12	1
860	21.75	21.75	12
861	23.09	23.09	27
862	30.68	30.68	1
863	23.73	23.73	7
864	18.75	18.75	1
865	25.39	25.39	1
866	36.71	36.71	1
867	24.47	24.47	1
868	59.08	59.08	35
869	17.07	17.07	1
870	23.31	23.31	1
871	43.65	43.65	2
872	27.24	27.24	93
873	40.47	40.47	275
874	18.37	18.37	134
875	28.97	28.97	4
876	28.83	28.83	51
877	40.31	40.31	148
878	15.68	15.68	1
879	45.01	45.01	4
880	48.26	48.26	2
881	18.12	18.12	1
882	14.33	15.74	5
883	46.09	46.09	22
884	54.67	54.67	29
885	24.96	24.96	51
886	45.63	45.63	21
887	12.67	12.67	1
888	14.92	14.92	1
889	35.29	35.29	1
890	38.42	38.42	1
891	54.67	54.7	32
892	50.68	50.68	36

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
893	43.59	43.59	23
894	14.56	14.56	1
895	22.38	22.38	52
896	36.87	36.87	23
897	20.67	20.67	44
898	14.12	14.12	136
899	15.84	15.84	1
900	16.99	16.99	38
901	25.53	25.53	14
902	22.95	22.95	1
903	22.62	22.62	5
904	25.42	25.42	1
905	76.13	76.13	2
906	69.6	69.6	17
907	18.7	18.7	1
908	18.11	18.11	1
909	15.72	15.72	1
910	20.26	20.26	1
911	16.06	16.06	1
912	15.34	15.34	1
913	18.22	18.22	1
914	12.48	12.48	1
915	23.1	23.1	1
916	13.46	13.46	1
917	59.28	59.28	24
918	14.59	14.59	52
919	16.91	16.91	1
920	12.23	12.23	53
921	91.73	91.73	1
922	26.71	26.71	1
923	13.95	13.95	1
924	14.37	14.37	1
925	19.2	19.2	1
926	19.36	19.36	1
927	18.87	18.87	1
928	13.06	13.06	1
929	23.72	23.72	3
930	17.05	17.05	16
931	12.07	12.07	78
932	17.51	17.51	87
933	19.2	19.2	73
934	20.63	20.63	1
935	40.59	40.59	180
936	15.38	15.38	5
937	50.91	50.91	1
938	19.06	19.06	1
939	13.21	13.21	16
940	12.29	12.29	52
941	12.99	88.46	23
942	18.65	18.65	1
943	13.59	13.59	1
944	13.4	13.4	1
945	20.51	20.51	24
946	17.85	17.85	1
947	17.83	17.83	1
948	21.58	21.58	4
949	21.72	21.72	27
950	15.93	15.93	1
951	19.9	19.9	1
952	18.67	18.67	15

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
953	15.95	15.95	1
954	15.96	15.96	1
955	45.68	45.68	6
956	18.07	18.07	2
957	16.05	16.05	12
958	21.77	21.77	4
959	15.52	15.52	15
960	12.5	12.5	1
961	25.59	25.59	1
962	14.64	14.64	1
963	12.56	14.91	25
964	14.76	14.76	1
965	14.05	18.74	645
966	15.02	15.02	1
967	13.84	13.84	1
968	15.81	15.81	10
969	12.7	12.7	14
970	16.32	16.32	1
971	18.73	18.73	1
972	28.55	28.55	1
973	15.88	15.88	1
974	16.96	16.96	1
975	12.55	12.55	1
976	12.53	12.53	1
977	26.15	26.15	1
978	25.29	25.29	1
979	17.02	17.02	1
980	17.66	17.66	1
981	18.11	18.11	29
982	16.32	16.32	7
983	15.69	15.69	1
984	32.37	32.37	1
985	16.21	16.21	12
986	14.28	14.28	1
987	16.49	16.49	5
988	19.6	19.6	1
989	22.42	22.42	4
990	21.78	21.78	1
991	13.45	13.45	1
992	26.88	26.88	1
993	12.98	12.98	39
994	23.47	23.47	9
995	16.32	16.32	178
996	14.98	14.98	1
997	13.85	13.85	1
998	20.09	20.09	2
999	13.88	13.88	1
1,000	17.74	17.74	1
1,001	15.96	15.96	186
1,002	32.04	32.04	1
1,003	14.65	14.65	1
1,004	13.39	13.39	1
1,005	15.45	15.45	1
1,006	14.92	14.92	1
1,007	128.14	128.14	1
1,008	15.73	15.73	1
1,009	44.95	44.95	1
1,010	22.23	22.23	49
1,011	16.39	16.39	1
1,012	12.32	12.32	1

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
1,013	15.74	15.74	1
1,014	12.49	12.49	1
1,015	20.49	20.49	1
1,016	17.39	17.39	1
1,017	44.23	44.23	134
1,018	14.2	14.22	218
1,019	13.83	13.83	71
1,020	12.48	12.48	1
1,021	15.19	15.19	1
1,022	13.54	13.54	1
1,023	15.5	15.5	30
1,024	14.23	14.23	2
1,025	21.19	21.19	1
1,026	13.82	13.82	6
1,027	16.89	16.89	1
1,028	14	14	1
1,029	20.01	20.01	1
1,030	13.34	13.34	28
1,031	13.87	13.87	1
1,032	12.03	12.03	1
1,033	12.85	12.85	11
1,034	13.41	13.41	10
1,035	22.59	22.59	1
1,036	12.24	12.24	3
1,037	12.09	12.09	8
1,038	20.51	20.51	1
1,039	12.08	12.08	1
1,040	12.08	12.08	20
1,041	22.78	22.78	2
1,042	20.32	20.32	1
1,043	27.59	27.59	26
1,044	16.79	16.79	14
1,045	21.64	21.64	3
1,046	23.21	23.21	5
1,047	13.15	13.15	411
1,048	21.96	21.96	1
1,049	22.04	22.04	50
1,050	16.71	16.71	2
1,051	26.49	26.87	66
1,052	23.39	23.39	37
1,053	13.43	13.43	1
1,054	19.08	19.08	1
1,055	12.03	12.03	1
1,056	12.43	12.43	1
1,057	12.47	12.47	1
1,058	17.01	17.01	1
1,059	12.12	13	4
1,060	13.69	13.69	2
1,061	36.2	36.2	96
1,062	12.16	12.16	1
1,063	14.31	14.31	1
1,064	14.31	14.31	113
1,065	13.58	13.58	11
1,066	14.55	14.55	1
1,067	14.85	14.85	71
1,068	20.71	20.71	1
1,069	18.06	22.46	55
1,070	16.47	16.47	1
1,071	14.51	14.51	1
1,072	16.38	16.38	1

Interruption	First Restoration (hours) after 12 hours	Final Restoration (hours)	Customers Affected
1,073	23.27	23.27	1
1,074	15.95	15.95	1
1,075	15.12	15.12	1
1,076	12.46	12.46	50
1,077	25.19	25.2	12
1,078	18	18	1
1,079	16.65	16.65	15
1,080	12.56	12.56	1
1,081	12.02	12.02	61
1,082	12.02	12.02	1
1,083	13.87	13.87	18
1,084	21.75	21.75	1
1,085	14.4	14.4	239
1,086	25.93	25.93	1
1,087	15.79	15.79	7
1,088	16.83	16.83	1
1,089	21.07	21.07	1
1,090	18.84	18.84	1
1,091	17.8	17.8	1
1,092	15.02	15.02	1
1,093	12.3	12.3	1
1,094	17.42	17.42	78
1,095	13.28	13.28	1
1,096	13.27	13.27	1
1,097	12.65	12.65	81
1,098	17.63	17.63	5
1,099	16.96	16.96	1
1,100	14.85	14.85	17
1,101	14.63	14.63	22
1,102	12.77	12.77	43
1,103	13.29	13.29	1
1,104	12.26	26.58	1,062
1,105	14.49	14.49	1
1,106	14.25	28.53	32
1,107	26.54	26.54	1
1,108	24.58	24.58	17
1,109	19.07	19.07	1
1,110	24.68	24.68	3
1,111	12.74	12.74	4
1,112	18.67	18.67	1
1,113	18.44	18.44	21
1,114	14.49	14.49	1
1,115	15.04	15.04	8
1,116	13.32	13.32	15
1,117	21.62	21.62	1
1,118	21.16	21.16	79