PACIFICORP
A MIDAMERICAN ENERGY HOLDINGS COMPANY

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May 1, 2006

VIA ELECTRONIC FILING

Ms. Carole J. Washburn
Executive Secretary
Washington Utilities & Transportation Commission
1300 S. Evergreen Park Drive, SW
Olympia, WA 98504-7250

Re: Compliance Filing in Docket No. UE-051090
Mid-American Energy Acquisition Commitments

Pursuant to WAC 480-09-340 and RCW 80.28.050 and -060, PacifiCorp (d.b.a., Pacific Power & Light Company) submits for filing an original and two (2) copies of the compliance filing made for the above docket.

The purpose of this filing is to submit to the Commission for approval PacifiCorp's proposed momentary average interruption frequency index (MAIFI) plan as identified in Wa 28, identified in Order 08 of Docket UE-051090.

Background

In December, 2004, PacifiCorp filed with the Washington Utilities and Transportation Commission (WUTC) a proposal to extend is Service Standards Program, in Docket UE-042131. At that time the Company proposed to eliminate Performance Standard 4, which committed to improve its Momentary Average Interruption Frequency Index ("MAIFI") by 5%. Subsequent to the completion of the ScottishPower merger it was determined that the Company did not have widespread System Control and Data Acquisition (SCADA) system for creating information that leads to the calculation for a MAIFI measure. While the Company was not prepared to delineate an improvement target that it could not measure, the Company asserted its interest in continuing to evaluate operational and customer data to continue to improve its system reliability. During the Mid-American acquisition of PacifiCorp, at the time of the "most favored state" process, the WUTC identified its interest in selecting particular commitment identified previously in working the Idaho regulatory staff. This commitment, in UE-051090 on March 9, 2006, reads:

- Wa 28, which commits PacifiCorp to file with the Commission a proposed plan to develop and implement an acceptable alternative to the formed Network Performance Standard related to Momentary Average Interruption Frequency Index ("MAIFI").

Summary
The Company provides the attached MAIFI proposal document to comply with UE-051090, Order 08, Wa 28.

It is respectfully requested that all formal correspondence and Staff requests regarding this filing be addressed to the following:

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Please direct any informal questions to Heide Caswell at 503-813-6216.

Sincerely,

Andrea Kelly /sa

Andrea Kelly
Vice President, Regulation

Enclosures
cc: Graciela Etchart

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PACIFICORP ASSET MANAGEMENT
MAIFIE REPORTING
MEASUREMENT REPORT
April 28, 2006

CONTENTS

1.0 Executive Summary (WASHINGTON Only) 2
2.0 Background 3
3.0 Processes 4
3.1 Pre-CADOPS Environment: 4
3.2 Post-CADOPS Implementation, Prior To April 1, 2006: 5
3.3 Post-CADOPS Implementation, After April 1, 2006: 6
3.4 Post-CADOPS /Post-EMS/SCADA Environment: 7
4.0 MAIFI Calculations 8
5.0 Recommendations 9
Appendix A: Lightning Flash Density Map for PacifiCorp service Territory 10
Appendix B: Vegetation Greenness Map of the United States 11
Appendix C: Washington State SCADA Overview 12
Appendix D: Washington SCADA, Tabular By Operating Area 13
Appendix E –Washington Circuit Characteristics Maps 14
Appendix F –Momentary Reliability from IEEE P1366-2003 17

1.0 EXECUTIVE SUMMARY (WASHINGTON ONLY)

In December, 2004, PacifiCorp filed with the Washington Utilities and Transportation Commission (WUTC) a proposal to extend is Service Standards Program, in Docket UE-042131. At that time the Company proposed eliminating its plans for improving momentary interruptions due to the incomplete development of its System Control and Data Acquisition (SCADA) system. Nonetheless, the Company committed to continue to evaluate operational and customer data to continue to improve the system reliability as related to momentary interruptions. During the Mid-American acquisition of PacifiCorp, at the time of the "most favored state" process, the WUTC identified its interest in selecting particular commitment identified previously in working the Idaho regulatory staff. This commitment, in UE-051090 on March 9, 2006, reads:

- Wa 28, which commits PacifiCorp to file with the Commission a proposed plan to develop and implement an acceptable alternative to the formed Network Performance Standard related to Momentary Average Interruption Frequency Index ("MAIFI").

At the time of the merger between PacifiCorp and ScottishPower, the Company committed to the Performance Standards Program, and in performance standard 4 (PS4), committed it would improve momentary average interruption frequency index (MAIFI) by 5% within the 5 year period after the merger's approval. As the Company continued to unfold methods for measuring and managing reliability improvements it became clear that a highly scientific and widespread measure for MAIFI was not reasonable, due to the incomplete penetration of SCADA. These two factors result in the ability to approximate a true momentary frequency index, but the precision and consistency of that measure was not high. As a result, the Company continued to use its historical surrogate for evaluating MAIFI, which relied on manual breaker counters, and determined that in the ensuing 5 years it had delivered the necessary improvement of 5%. However, it needed to rethink its approach to develop a more scientific and sustainable MAIFI measure. As a result, the methodology documented here was devised. This document identifies the process, calculations, controls and future plans for momentary outage reporting, effective April 1, 2006.

The merger between PacifiCorp and ScottishPower and the introduction of CADOPS (Computer Aided Distribution Operations System, an automated outage management system), and Prosper/US (which is a company-developed system for archiving and reporting outage information), throughout PacifiCorp have been shown to significantly increase the accuracy and consistency of sustained outage reporting. With CADOPS implementation, (in March, 2002) the legacy systems which captured momentary information, however incorrectly, were disabled from automatically generating these statistics. In the interim, a limited amount of SCADA-outfitted substations have been reporting momentary outage information into the CADOPS system. These outage events have been archived into Prosper/US. Momentary indices have been the result of this small subset of momentary outages divided by the total customers for each state, which previously under-calculated momentary metrics. This report describes the going-forward data collection methodology, utilizing PacifiCorp's extensive SCADA system, beginning at April 1, 2006. Additionally, it describes the method to calculate MAIFI and $MAIFI_E$.

2.0 BACKGROUND

Upon the completion of the ScottishPower merger, the Company immediately instigated plans to simultaneously improve and monitor network reliability performance. This was accomplished through a series of improvement programs such as the deployment of the Network Initiatives Program, as well as implementation of outage management software.

The effect of the Network Initiatives Program, as well as other delivery system improvements, can be evidenced by evaluating performance up to the point that CADOPS was implemented, and has been previously demonstrated in each state's reported momentary outage metrics. The system improvements that delivered the reduction in historic MAIFI included the continued expansion of the underground network, improved vegetation management programs, continued fuse coordination techniques, optimization of reclosers and greater usage of reclosers and SmartLinks.

The Company used substation breaker operations counts to infer a momentary interruption. It calculated that for every time a substation breaker operated when not associated with a switching or maintenance operation, a momentary interruption had occurred. Every customer served from that substation breaker was considered to have experienced a momentary customer interruption. The total number of momentary customer interruptions was divided by all customers to arrive at MAIFI. This was divided by 3 to arrive at a MAIFIe result. The factor of 3 was selected because the Company's convention was to have 3 operations prior to lockout. This method did not account for breaker operations that resulted in lockout, for those operations that successfully cleared a fault prior to the third reclose operation, nor for short-duration loss of supply events. Regardless, using the breaker-operation method consistently from 1995 through 2002 demonstrated that the Company had achieved its merger commitment 5% improvement goal (in Performance Standard 3).

However, after CADOPS, the reported MAIFI indices in each state have substantially declined, in large part due to the methods used to calculate a MAIFI metric. Upon implementation of CADOPS, a substantial number of momentary events were not transmitted into Prosper/US, which led to an understatement of the Company's momentary indices.

Commencing on April 1, 2006 the Company proposes that it will use its existing SCADA system in concert with its Dispatch Log Application to calculate momentary indices for the customers served by SCADA detected circuits, will explicitly report MAIFI and $MAIFI_E$ metrics and will contain this data within its routinely provided reliability reports[1]. After deployment of its EMS/SCADA project the same fundamental calculations will be performed within the PI historian, the database into which the EMS/SCADA system will feed, and again will derive momentary metrics, consistent with IEEE standards.

[1] Since WAC 480-100-393 and 480-100-398 do not require metrics regarding momentary outages, this data will not be provided in PacifiCorp's Annual Reliability Report. Rather, this data will be provided in data supporting its Performance Standards Program, filed in UE04-2131, for which the Company routinely reports reliability information.

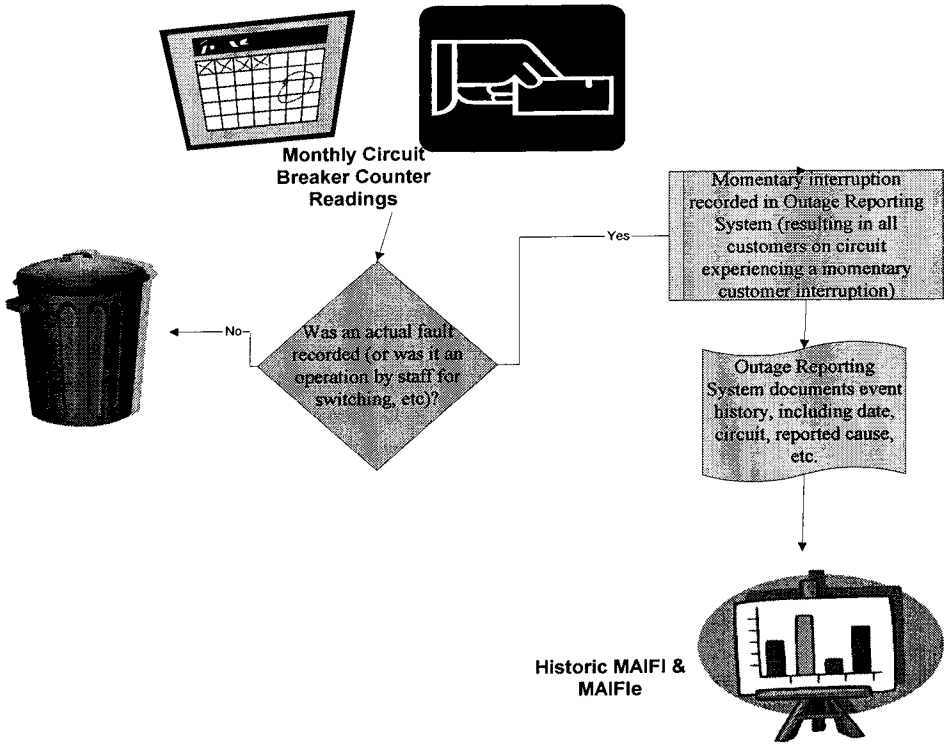
3.0 PROCESSES

3.1 PRE-CADOPS ENVIRONMENT:

Prior to CADOPS, PacifiCorp measured momentary events based upon circuit breaker operations, measured by mechanical counters located at substations. It assumed that every time a breaker operated, except when associated to routine maintenance or with a temporary switching operation, a momentary interruption occurred. This data was collected by monthly capture of these breaker counter readings, performed concurrent with substation inspections. These readings were entered into the outage reporting system via an assumption that for each of these events during the period, each customer connected to the circuit experienced a momentary customer interruption. The momentary average interruption frequency index, or MAIFI, was calculated by dividing the sum of momentary customer interruptions by all customers served within the given area (i.e. the number of customers served within a state). To calculate a momentary event index, it divided the MAIFI index by a factor of 3 (based upon the Company's conventional settings for reclosures prior to lock-out). These interruptions were stored as ORS (Outage Reporting System) entries within the outage management system.

The effect of this approach was to overstate momentary interruptions since many of them result in a sustained interruption (and these can not be differentiated). Potentially, also momentary events may be incorrect since in many cases only one operation of a breaker may be required to clear a fault.

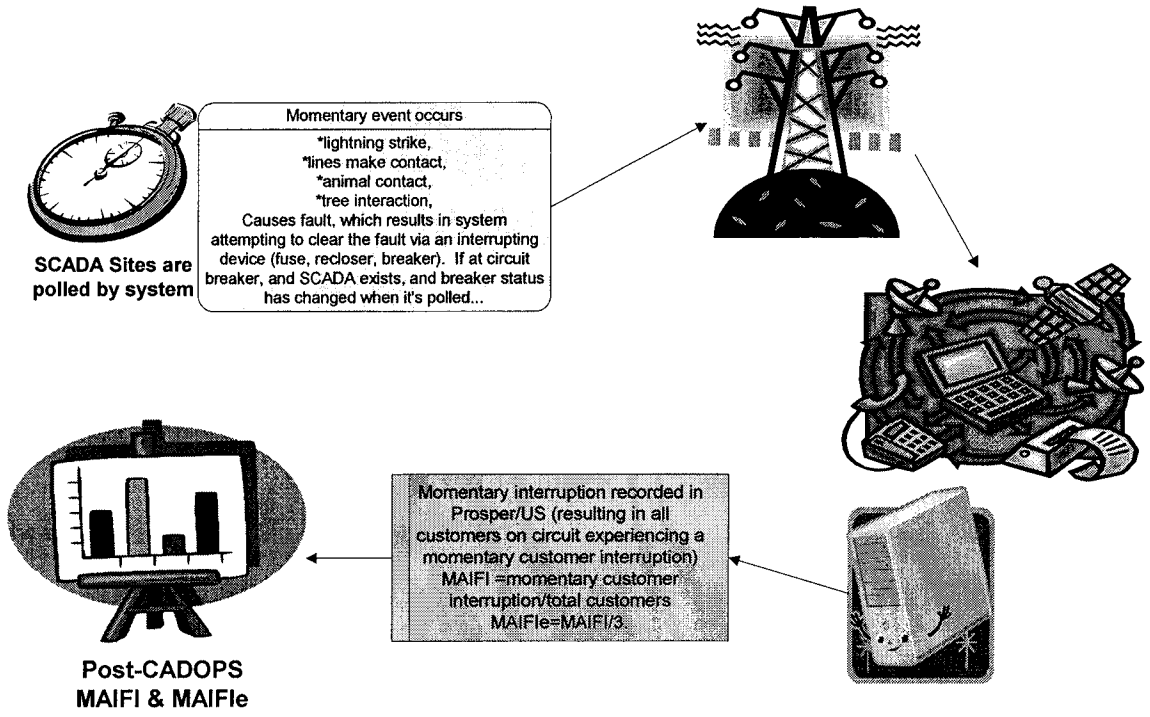
Figure 1: Pre-CADOPS Method for Calculating MAIFI & MAIFIe



3.2 POST-CADOPS IMPLEMENTATION, PRIOR TO APRIL 1, 2006:

At the time of CADOPS implementation, and in preparation for a more long-range momentary outage management data capture strategy, the Company severed the ties that fed breaker-initiated momentary events into the Outage Reporting System. Instead, it determined that utilizing information initiated by SCADA-collected data would be a more accurate measure of momentary interruptions. As such, these outages were reported into Prosper/US, but resulted in understated momentary indices since the system reports were dividing the interruptions (of which only a small percentage were being reported) by all customers served by the Company.

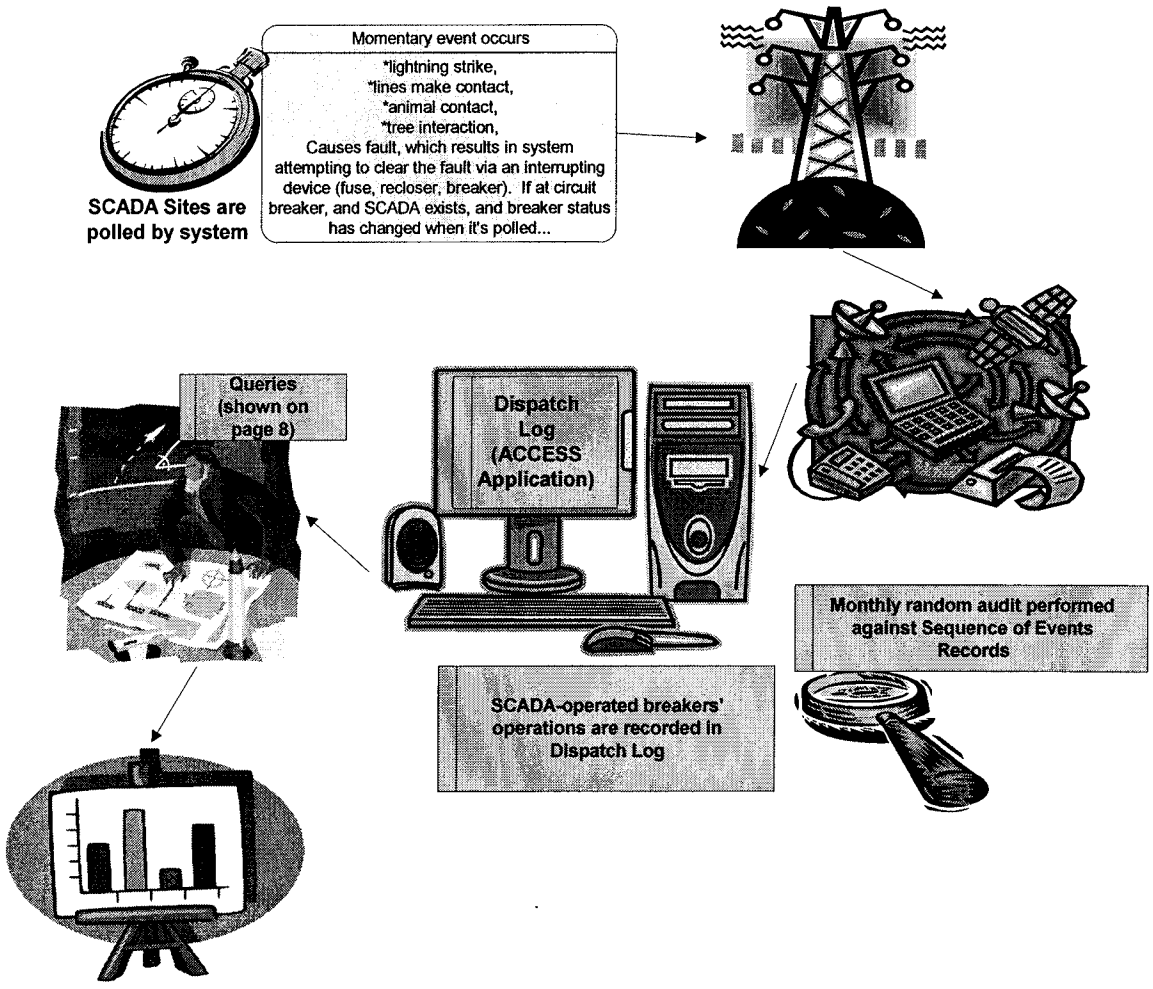
Figure 2: Post CADOPS, Prior to April 1, 2006 Method for Calculating MAIFI & MAIFIe



3.3 POST-CADOPS IMPLEMENTATION, AFTER APRIL 1, 2006:

As stated previously, at the time of CADOPS implementation much in regards to momentary outage data collection changed. One system that was implemented prior to that time is called the Dispatcher Log. This system is an ACCESS database application, and is used to record breaker operations that occur on SCADA operated devices. The data collected within this ACCESS application is all actions that occurred on them, such as tagged-out status, operated (and time, date, number of operations, lock-out status and cause of operation and includes loss of upstream supply). On a monthly basis, a random audit will be prepared, comparing Dispatch Log entries against Sequence of Events Records for SCADA-operated breakers. This dataset will serve as the interim data source until the EMS/SCADA Project is released[2]. Upon implementation of this methodology, the Company will deliver momentary indices consistent with IEEE P1366 standards, where SCADA breakers are present.

Figure 3: Post CADOPS, Post-April 1, 2006 Method for Calculating MAIFI and MAIFIe

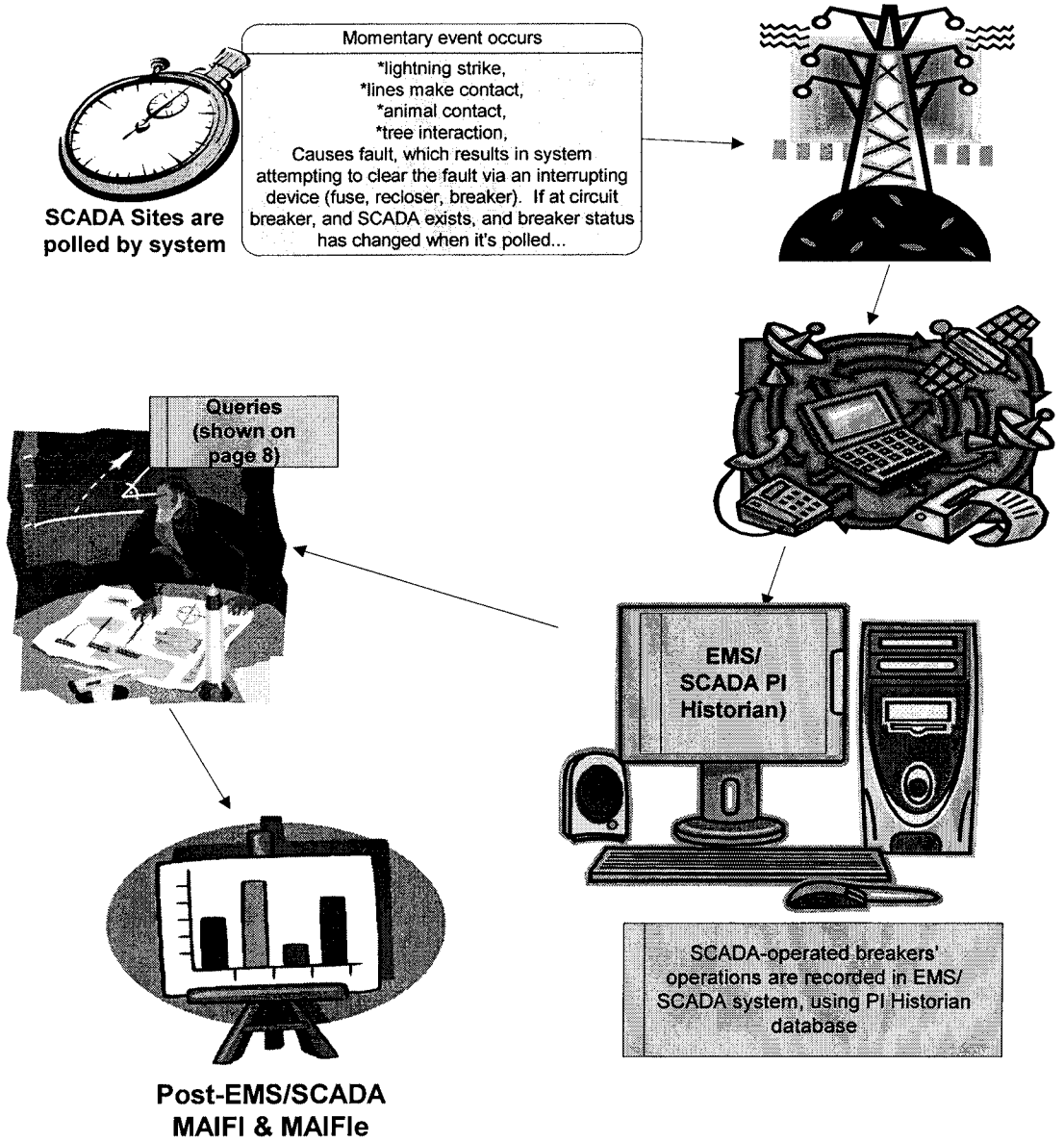


[2] EMS/SCADA is targeted for late 2005 deployment.

3.4 POST-CADOPS /POST-EMS/SCADA ENVIRONMENT:

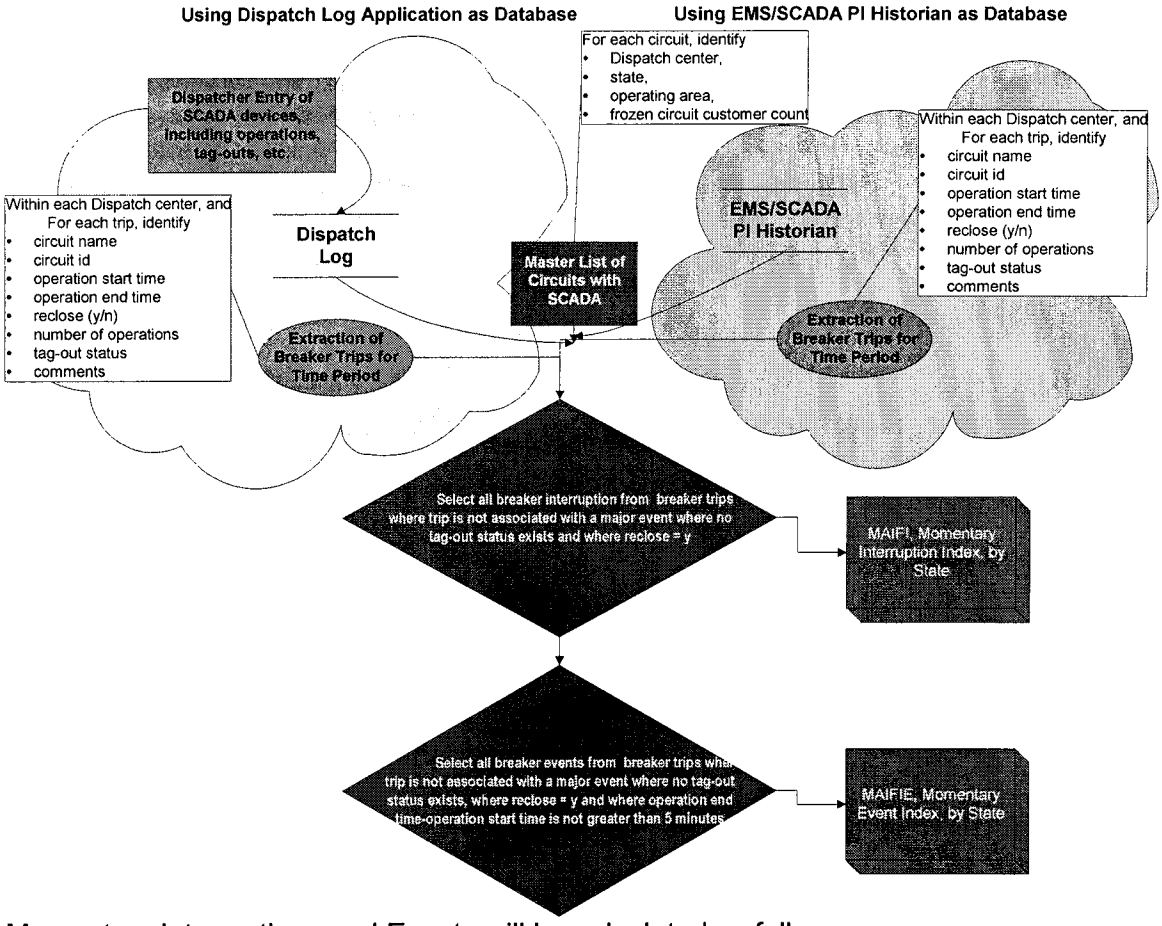
Upon completion of the EMS/SCADA Project the Company will have a single, comprehensive data source for evaluation of all types of momentary outage operations which requires no human intervention for collecting momentary incidents. After EMS/SCADA deployment, rather than querying the Dispatch Log ACCESS database, queries within EMS/SCADA's PI historian database will be conducted which is fed directly from EMS/SCADA. As previously identified, this method will derive momentary indices consistent with IEEE P1366 standards.

Figure 4: Post-CADOPS, Post EMS/SCADA Method Calculating MAIFI and MAIFIe



4.0 MAIFI CALCULATIONS

Figure 5: Calculation Flow Process using Dispatch Log & PI Historian



Momentary Interruptions and Events will be calculated as follows:
Definitions

- ✓ SCADA breaker *interruption* is the individual operation of a breaker that does not result in a lockout event, and is not associated with a pre-arranged tagging-out event.
- ✓ SCADA breaker *event* is the individual sequence of a breaker operation that does not result in a lockout event, and for which the next operation in the sequence must be within 5 minutes of the end of the prior operation. It also is not associated with a pre-arranged tagging-out event.

Calculation

- ✓ For each state,
  Momentary Interruption = ($\sum$ (SCADA breaker operation)*(SCADA breaker customer count))/($\sum$(SCADA breaker customer count)
  Momentary Event = ($\sum$ (SCADA breaker event)*(SCADA breaker customer count))/($\sum$(SCADA breaker customer count)

Assumptions

- ✓ Fundamentally, momentary outages are promulgated via vegetation[3], lightning[4] or animals within the vicinity of the overhead distribution system.
- ✓ Downline reclosers[5] have a negligible effect on momentary events experienced by customers either upstream or downstream of the recloser.

5.0 RECOMMENDATIONS

It is recommended that PacifiCorp migrate its momentary outage measurement to leverage its extensive SCADA system and derive IEEE standard-compliant momentary indices. It is proposed that the methodology described previously for using the Dispatch Log ACCESS application for calculating momentary interruption and event indices be employed until the implementation of EMS/SCADA. Thereafter, similar queries and calculations will be used within EMS/SCADA's PI historian database. In areas where SCADA equipment does not exist, continued use of breaker operations data (derived from mechanical counters) and customer complaint information should be relied upon to determine if any particular area may be experiencing momentary outage performance that is unacceptable.

[3] Vegetation panels are shown in Appendix B to demonstrate the relative predictability of this type of exposure to the overhead system.
[4] Lightning flash densitites are depicted on Appendix A across PacifiCorp's service territory.
[5] Hydraulic and electronic reclosers are delineated in Appendix C.

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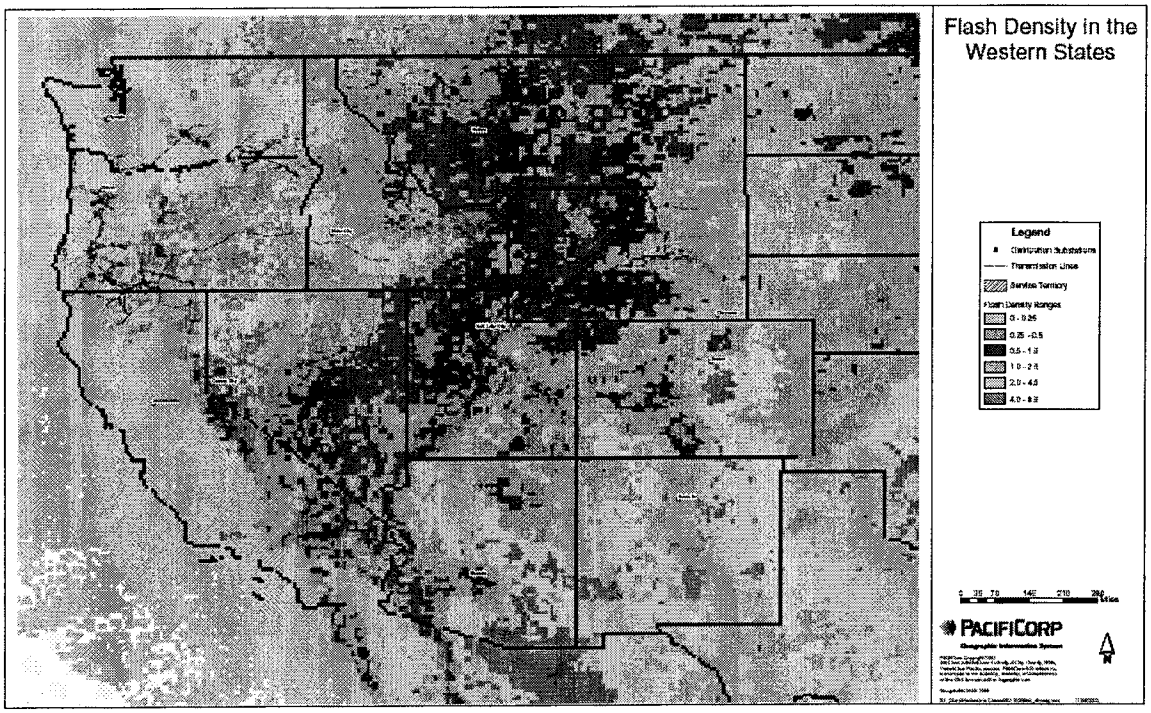
APPENDIX A: LIGHTNING FLASH DENSITY MAP FOR PACIFICORP SERVICE TERRITORY



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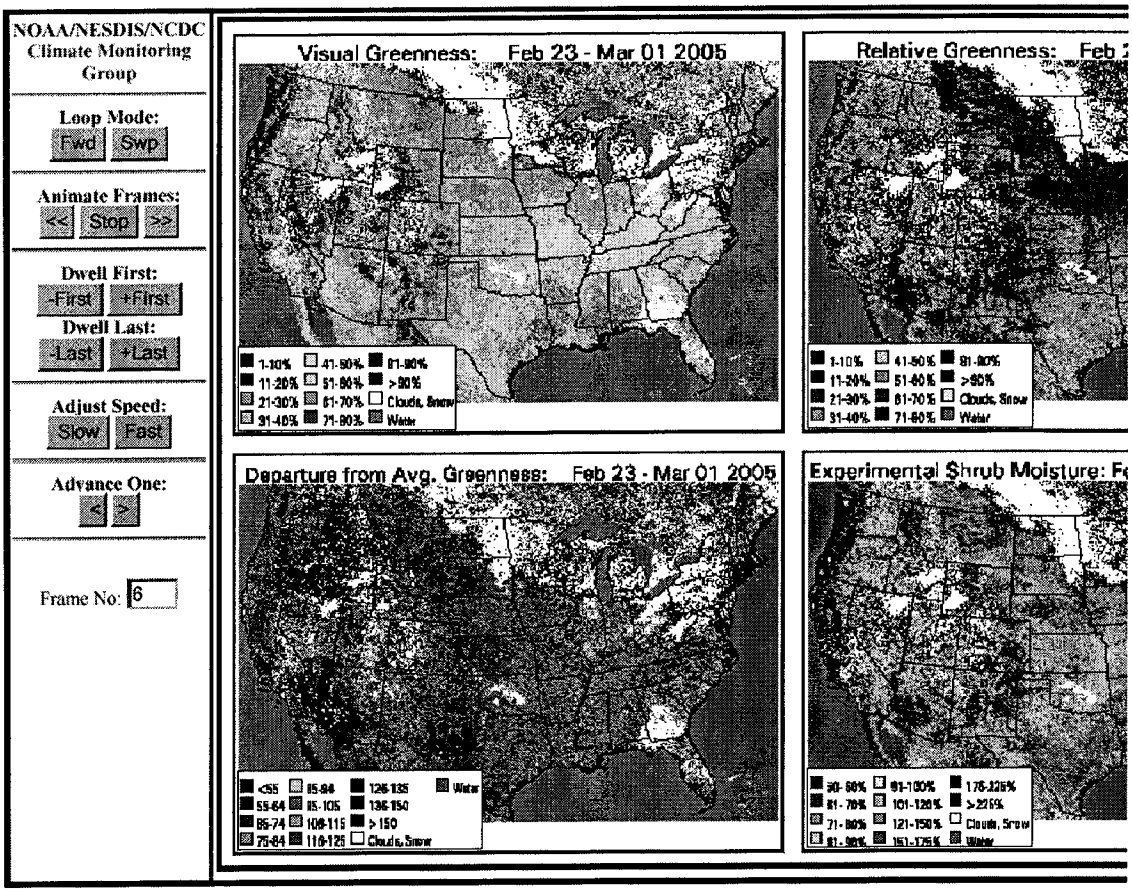
APPENDIX B: VEGETATION GREENNESS MAP OF THE UNITED STATES

NCDC / Monitor / Greenness / Search / Help

USFS/NIFC Vegetation Greenness Maps



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APPENDIX C: WASHINGTON STATE SCADA OVERVIEW

Washington State SCADA Distribution Lines with Line Reclosers

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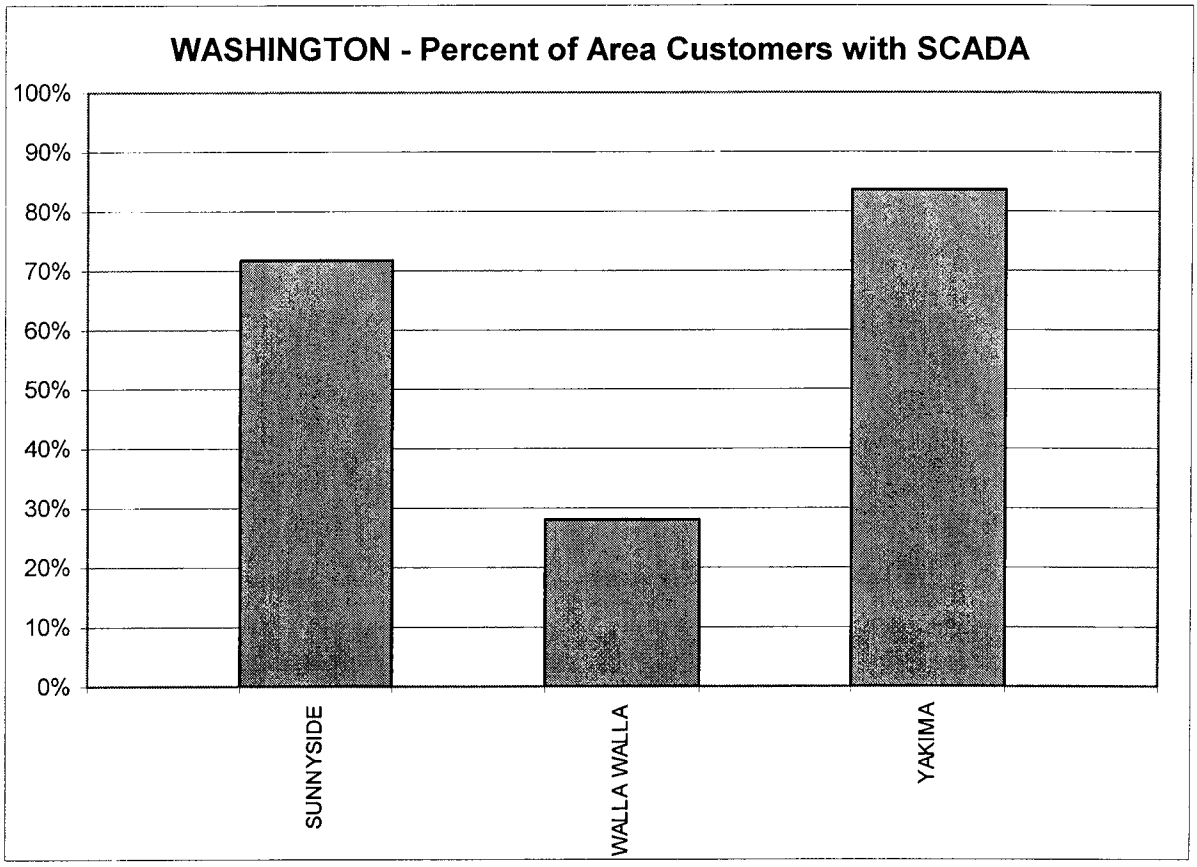
APPENDIX D: WASHINGTON SCADA, TABULAR BY OPERATING AREA



OP AREA		Total	% of Area Customers with SCADA
SUNNYSIDE	Customers with SCADA	16,185	72%
	Customers without SCADA	6,352	
WALLA WALLA	Customers with SCADA	7,575	28%
	Customers without SCADA	19,377	
YAKIMA	Customers with SCADA	63,679	84%
	Customers without SCADA	12,450	
Total Sum of Customers with SCADA		87,439	70%
Total Sum of Customers without SCADA		38,179	30%

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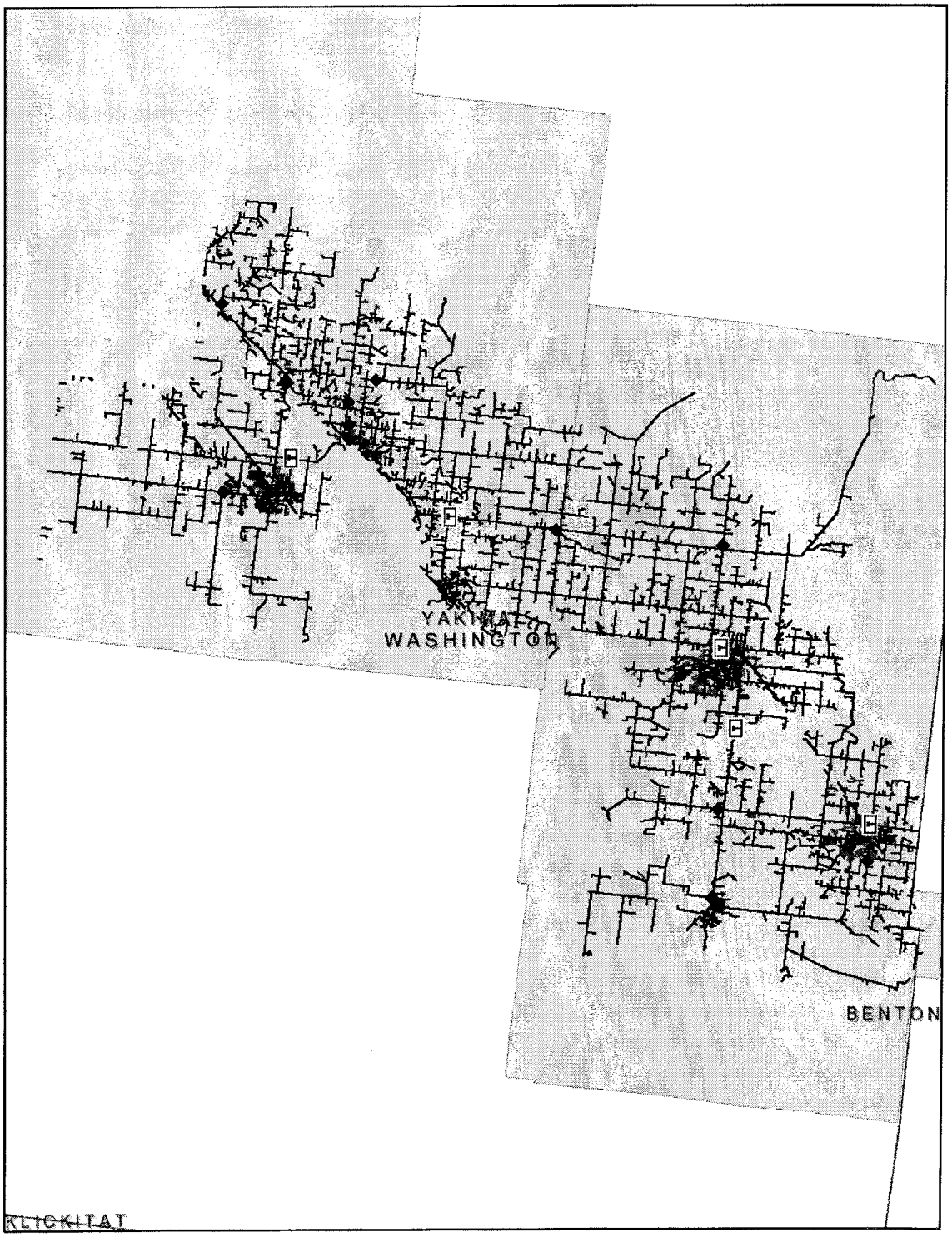
APPENDIX E –WASHINGTON CIRCUIT CHARACTERISTICS MAPS

Sunnyside



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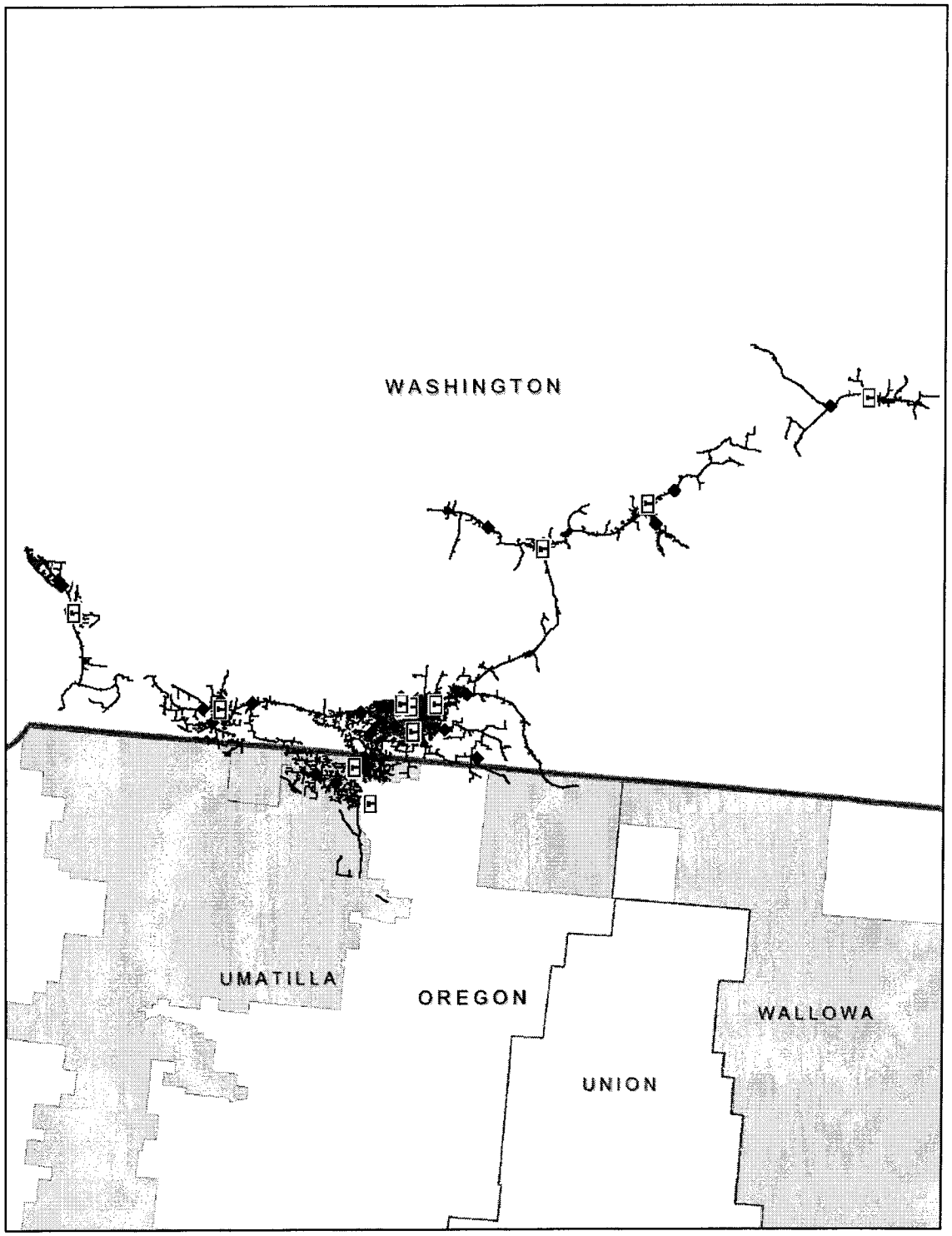
Walla Walla



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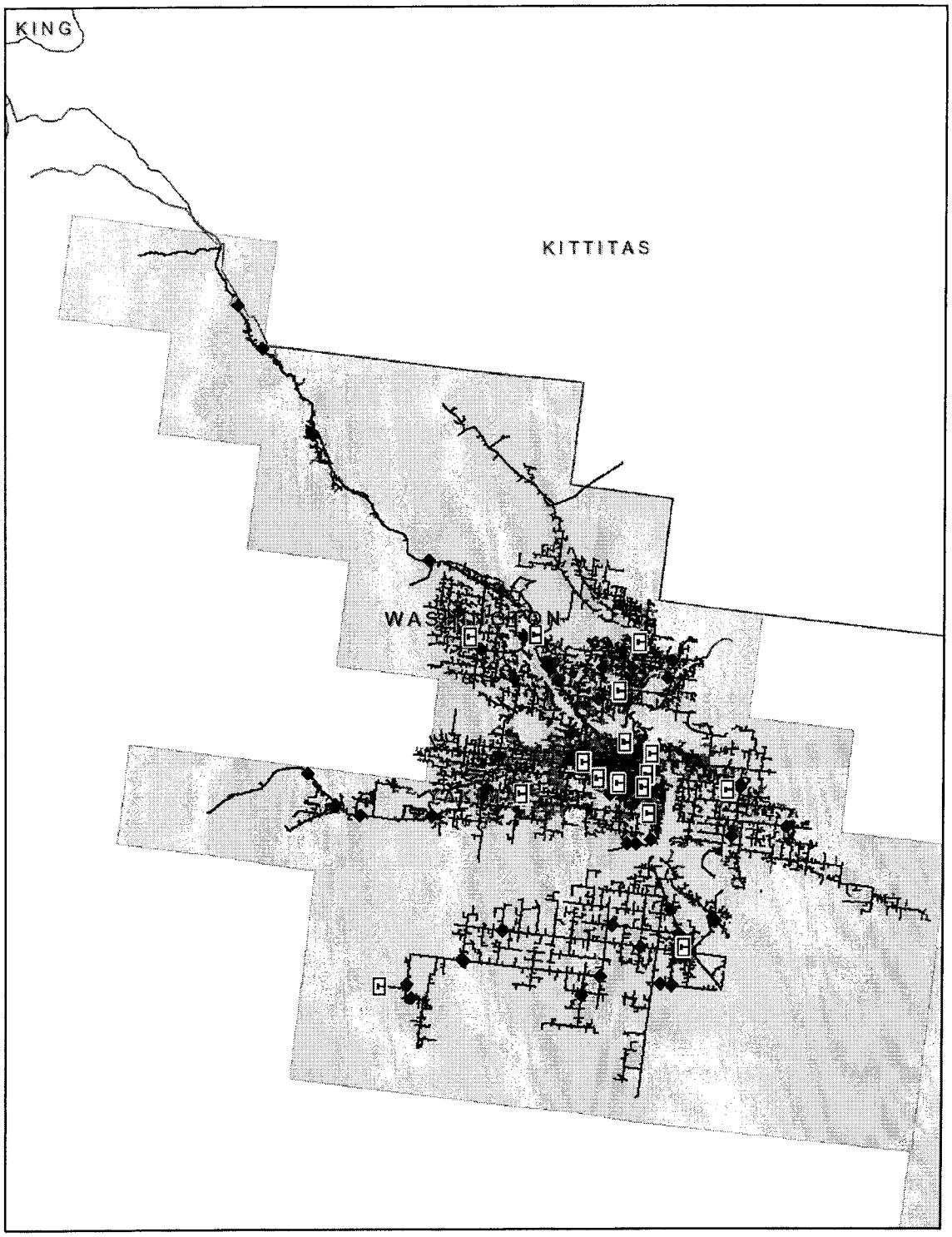
Yakima



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APPENDIX F –MOMENTARY RELIABILITY FROM IEEE P1366-2003

3. Definitions

Definitions are given here to aid the user in understanding the factors that affect index calculation. Many of these definitions were taken directly from *The Authoritative Dictionary of IEEE Standards Terms*, 7th Edition [B9][3]. If there is a conflict between the definitions in this document and the dictionary, the definitions in this document take precedence. Others are given because they have a new interpretation within this document or have not been previously defined.

3.1 connected load: Connected transformer kVA, peak load, or metered demand (to be clearly specified when reporting) on the circuit or portion of circuit that is interrupted. When reporting, the report should state whether it is based on an annual peak or on a reporting period peak.

3.2 customer: A metered electrical service point for which an active bill account is established at a specific location (e.g., premise).

3.3 customer count: The number of customers either served or interrupted depending on usage.

3.4 distribution system: That portion of an electric system that delivers electric energy from transformation points on the transmission system to the customer.

NOTE—The distribution system is generally considered to be anything from the distribution substation fence to the customer meter. Often the initial overcurrent protection and voltage regulators are within the substation fence and are considered to be part of the distribution system.

3.5 forced outage: The state of a component when it is not available to perform its intended function due to an unplanned event directly associated with that component.

3.6 interrupting device: An interrupting device is a device whose purpose is to interrupt the flow of power, usually in response to a fault. Restoration of service or disconnection of loads can be accomplished by manual, automatic, or motor-operated methods. Examples include transmission circuit breakers, feeder circuit breakers, line reclosers, line fuses, sectionalizers, motor-operated switches or others.

3.7 interruption: The loss of service to one or more customers connected to the distribution portion of the system. It is the result of one or more component outages, depending on system configuration. *See also:* outage.

3.8 interruption duration: The time period from the initiation of an interruption to a customer until service has been restored to that customer. The process of restoration may require restoring service to small sections of the system (see 5.3.2) until service has been restored to all customers. Each of these individual steps should be tracked collecting the start time, end time and number of customers interrupted for each step.

3.9 interruptions caused by events outside of the distribution system: Outages that occur on generation, transmission, substations, or customer facilities that result in the interruption of service to one or more customers. While generally a small portion of the number of interruption events, these interruptions can affect a large number of customers and last for an exceedingly long duration.

3.10 lockout: Refers to the final operation of a recloser or circuit breaker in an attempt to isolate a persistent fault, or to the state where all automatic reclosing has stopped. The current-carrying contacts of the overcurrent protecting device are locked open under these conditions.

3.11 loss of service: A complete loss of voltage on at least one normally energized conductor to one or more customers. This does not include any of the power quality issues such as sags, swells, impulses, or harmonics.

[3]The numbers in brackets correspond to those of the bibliography in Annex D.

3.12 major event: Designates an event that exceeds reasonable design and or operational limits of the electric power system. A Major Event includes at least one Major Event Day (MED).

3.13 major event day: A day in which the daily system SAIDI exceeds a threshold value, T_{MED}. For the purposes of calculating daily system SAIDI, any interruption that spans multiple calendar days is assigned to the day on which the interruption began. Statistically, days having a daily system SAIDI greater than T_{MED} are days on which the energy delivery system experienced stresses beyond that normally expected (such as severe weather). Activities that occur on major event days should be separately analyzed and reported. (See 4.5.)

3.14 momentary interruption: A single operation of an interrupting device that results in a voltage zero. For example, two circuit breaker or recloser operations (each operation being an open followed by a close) that momentarily interrupts service to one or more customers is defined as two momentary interruptions.

3.15 momentary interruption event: An interruption of duration limited to the period required to restore service by an interrupting device.

NOTE—Such switching operations must be completed within a specified time of 5 min or less. This definition includes all reclosing operations that occur within five minutes of the first interruption. For example, if a recloser or circuit breaker operates two, three, or four times and then holds (within 5 min of the first operation), those momentary interruptions shall be considered one momentary interruption event.

3.16 outage (electric power systems): The state of a component when it is not available to perform its intended function due to some event directly associated with that component.

NOTE—

(1) An outage may or may not cause an interruption of service to customers, depending on system configuration.

(2) This definition derives from transmission and distribution applications and does not apply to generation outages.

3.17 planned interruption: A loss of electric power that results when a component is deliberately taken out of service at a selected time, usually for the purposes of construction, preventative maintenance, or repair.

NOTE—

(1) This derives from transmission and distribution applications and does not apply to generation interruptions.

(2) The key test to determine if an interruption should be classified as a planned or unplanned interruption is as follows: if it is possible to defer the interruption, the interruption is a planned interruption; otherwise, the interruption is an unplanned interruption.

3.18 planned outage: The state of a component when it is not available to perform its intended function due to a planned event directly associated with that component.

3.19 reporting period: The time period from which interruption data is to be included in reliability index calculations. The beginning and end dates and times should be clearly indicated. All events that begin within the indicated time period should be included. A consistent reporting period should be used when comparing the performance of different distribution systems (typically one calendar year) or when comparing the performance of a single distribution system over an extended period of time. The reporting period is assumed to be one year unless otherwise stated.

3.20 step restoration: A process of restoring interrupted customers downstream from the interrupting device/component in stages over time.

3.21 sustained interruption: Any interruption not classified as a part of a momentary event. That is, any interruption that lasts more than 5 minutes.

3.22 total number of customers served: The average number of customers served during the reporting period. If a different customer total is used, it must be clearly defined within the report.

3.23 unplanned interruption: An interruption caused by an unplanned outage.

4. Reliability indices

4.1 Basic factors

These basic factors specify the data needed to calculate the indices.

i denotes an interruption event

r_i = Restoration Time for each Interruption Event

CI = Customers Interrupted

CMI = Customer Minutes Interrupted

E = Events

T = Total

IM_i = Number of Momentary Interruptions

IM_E = Number of Momentary Interruption Events

N_i = Number of Interrupted Customers for each Sustained Interruption event during the Reporting Period

N_{mi} = Number of Interrupted Customers for each Momentary Interruption event during the Reporting Period

N_T = Total Number of Customers Served for the Area

L_i = Connected kVA Load Interrupted for each Interruption Event

L_T = Total connected kVA Load Served

CN = Total Number of Customers who have Experienced a Sustained Interruption during the Reporting Period

$CNT_{(k>x)}$ = Total Number of Customers who have Experienced more than x Sustained Interruptions and Momentary Interruption Events during the Reporting Period

k = Number of Interruptions Experienced by an Individual Customer in the Reporting Period

T_{MED} = Major event day identification threshold value.

4.2 Sustained interruption indices

4.2.1 System average interruption frequency index (SAIFI)

The system average interruption frequency index indicates how often the average customer experiences a sustained interruption over a predefined period of time. Mathematically, this is given in Equation (1).

4.3 Load based indices

4.3.1 Average system interruption frequency index (ASIFI)

The calculation of this index is based on load rather than customers affected. ASIFI is sometimes used to measure distribution performance in areas that serve relatively few customers having relatively large concentrations of load, predominantly industrial/commercial customers. Theoretically, in a system with homogeneous load distribution, ASIFI would be the same as SAIFI. Mathematically, this is given in Equation (15).

$$ASIFI = \frac{\sum \text{Total Connected kVA of Load Interrupted}}{\text{Total Connected kVA Served}} \quad (15)$$

To calculate the index, use Equation (16).

$$ASIFI = \frac{\sum L_i}{L_T} \quad (16)$$

4.3.2 Average system interruption duration index (ASIDI)

The calculation of this index is based on load rather than customers affected. Its use, limitations, and philosophy are stated in the ASIFI definition in 4.3.1. Mathematically, this is given in Equation (17).

$$ASIDI = \frac{\sum \text{Connected kVA Duration of Load Interrupted}}{\text{Total Connected kVA Served}} \quad (17)$$

To calculate the index, use Equation (18).

$$ASIDI = \frac{\sum r_i L_i}{L_T} \quad (18)$$

4.4 Other indices (momentary)

4.4.1 Momentary average interruption frequency index (MAIFI)

This index indicates the average frequency of momentary interruptions. Mathematically, this is given in Equation (19).

$$MAIFI = \frac{\sum \text{Total Number of Customer Momentary Interruptions}}{\text{Total Number of Customers Served}} \quad (19)$$

To calculate the index, use Equation (20).

$$MAIFI = \frac{\sum IM_i N_{mi}}{N_T} \quad (20)$$

4.4.2 Momentary average interruption event frequency index ($MAIFI_E$)

This index indicates the average frequency of momentary interruption events. This index does not include the events immediately preceding a lockout. Mathematically, this is given in Equation (21).

$$MAIFI_E = \frac{\sum \text{Total Number of Customer Momentary Interruption Events}}{\text{Total Number of Customers Served}} \quad (21)$$

To calculate the index, use Equation (22).

$$MAIFI_E = \frac{\sum IM_E \times N_{mi}}{N_T} \quad (22)$$

4.4.3 Customers experiencing multiple sustained interruption and momentary interruption events ($CEMSMI_n$)

This index is the ratio of individual customers experiencing more than n of both sustained interruptions and momentary interruption events to the total customers served. Its purpose is to help identify customer issues that cannot be observed by using averages. Mathematically, this is given in Equation (23).

$$CEMSMI_n = \frac{\text{Total Number of Customers Experiencing More Than } n \text{ Interruptions}}{\text{Total Number of Customers Served}} \quad (23)$$

To calculate the index, use Equation (24).

$$CEMSMI_n = \frac{CNT_{(k>n)}}{N_T} \quad (24)$$

4.5 Major event day classification

The following process ("Beta Method") is used to identify MEDs. Its purpose is to allow major events to be studied separately from daily operation, and in the process, to better reveal trends in daily operation that would be hidden by the large statistical effect of major events. This approach supersedes previous major event definitions (see Annex A for sample definitions). For more technical detail on derivation of the methodology refer to Annex B.

A major event day is a day in which the daily system SAIDI exceeds a threshold value, T_{MED}. The SAIDI index is used as the basis of this definition since it leads to consistent results regardless of utility size and because SAIDI is a good indicator of operational and design stress. Even though SAIDI is used to determine the major event days, all indices should be calculated based on removal of the identified days.

In calculating daily system SAIDI, any interruption that spans multiple days is accrued to the day on which the interruption begins.

The major event day identification threshold value, T_{MED}, is calculated at the end of each reporting period (typically one year) for use during the next reporting period as follows:

$$CTAIDI = \frac{(8.17 \times 200) + (71.3 \times 600) + (20.3 \times 25) + (267.2 \times 60) + (120 \times 700) + (10 \times 1500) + (40 \times 300)}{1800} = 95.68 \text{ min} \quad (32)$$

$$CAIDI = \frac{200 + 600 + 25 + 60 + 700 + 1500 + 300}{1800} = 1.76 \quad (33)$$

$$ASAI = \frac{8760 \times 3000 - (8.17 \times 200 + 600 \times 71.3 + 20.3 \times 25 + 267.2 \times 60 + 120 \times 700 + 10 \times 300 + 10 \times 1500 + 40 \times 1800)60}{8760 \times 2000} = 0.999836 \quad (34)$$

$$ASIFI = \frac{800 + 1600 + 75 + 500 + 2100 + 3000 + 200}{4000} = 2.12 \quad (35)$$

$$ASIDI = \frac{(800 \times 8.17) + (1800 \times 71.3) + (75 \times 20.3) + (500 \times 267.2) + (2100 \times 7500) + 3000(45) + 200 \times 40}{4000} = 444.69 \quad (36)$$

$CTAIDI_p$, $CAIFI_p$, $CEMI_n$, and $CEMSMI_n$ require detailed interruption information for each customer. The database should be searched for all customers who have experienced more than n interruptions that last longer than five minutes. Assume n is chosen to be 5. In Table 5, customer Willis, J. experienced seven interruptions in one year and it is plausible that other customers also experienced more than five interruptions, both momentary and sustained.

For this example, assume arbitrary values of 350 for $CN(k > n)$, and 750 for $CNT_i(k > n)$. The number of interrupting device operations is given in Table 6 and is used to calculate $MAIFI_e$ and $MAIFI_{ge}$. Assume the number of customers downstream of the recloser equals 750. These numbers would be known in a real system.

$$CEMI_5 = \frac{350}{2000} = 0.175 \quad (37)$$

$$MAIFI_e = \frac{8 \times 2000 + 12 \times 750}{2000} = 12.5 \quad (38)$$

$$MAIFI_{ge} = \frac{5 \times 2000 + 6 \times 750}{2000} = 7.25 \quad (39)$$

$$CEMSMI_5 = \frac{750}{2000} = 0.375 \quad (40)$$

Using the above sample system should help define the methodology and approach to obtaining data from the information systems and using it to calculate the indices.

5.3 Examples

The following subclause illustrates two concepts: momentary interruptions and step restoration through the use of examples.

5.3.1 Momentary interruption example

To better illustrate the concepts of momentary interruptions and sustained interruptions and the associated indices, consider Figure 1 and Equation 41, Equation 42, and Equation 43. Figure 1 illustrates a circuit composed of a circuit breaker (B), a recloser (R), and a sectionalizer (S).

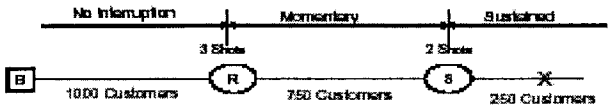

Figure 1—Sample system 2

For this scenario, 750 customers would experience a momentary interruption and 250 customers would experience a sustained interruption. Calculations for SAIFI, MAIFI, and MAIFIE on a feeder basis are shown in Equations 41–43 below. Notice that the numerator of MAIFI is multiplied by 2 because the recloser took two shots, however, MAIFIE is multiplied by 1 because it only counts the fact that a series of momentary events occurred.

$$SAIFI = \frac{250}{2000} = 0.125 \quad (41)$$

$$MAIFI = \frac{2 \times 750}{2000} = 0.75 \quad (42)$$

$$MAIFI_E = \frac{1 \times 750}{2000} = 0.375 \quad (43)$$

5.3.2 Step restoration examples

The following case illustrates the step restoration process. A feeder serving 1000 customers experiences a sustained interruption. Multiple restoration steps are required to restore service to all customers. Table 7 shows the times of each step, a description and associated customers interruptions and minutes they were affected in a time line format.

Table 7—Example 1 for a feeder serving 1000 customers with sustained interruption

Relative Time	Description	Customer Interruptions	Duration (min)	CMI
00:00	1000 customers interrupted.			
00:45	500 customers restored, 500 still out of service.	500	45	22 500
01:00	Additional 300 customers restored, 200 still out of service.	300	60	18 000
01:10	Feeder trips again, 800 previously restored customers are interrupted again. (200 remained out and were not restored at this time.)			
01:30	800 customers restored again.	800	20	16 000
02:00	Final 200 customers restored. Event ends.	200	120	24 000
Totals		1800	N/A	80 500
Example SAIFI = 1800/1000 = 1.8 interruptions Example CAIDI = 80 500/1800 = 44.7 min Example SAIDI = 80 500/2000 = 40.5 min.				

