ELECTRIC DISTRIBUTION SYSTEM RISK ASSESSMENT USING ACTUAL UTILITY RELIABILITY DATA

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ABSTRACT

This thesis describes the research conducted on the use of historical performance data in assessing the financial risk for a power distribution utility in a performance based regulation (PBR) regime. The historical utility data used in this research are taken from the Canadian Electrical Association (CEA) annual reports. The individual utility data in these reports are confidential and only provided to the participating utilities. Thirteen utilities that participate in the CEA data reporting activity agreed to provide their individual utility data for the research described in this thesis. These utilities are anonymous and are referred to by numerical designations in accordance with the CEA protocol. This research could not have been conducted without the support of these utilities.

The objectives of the research described in this thesis are to examine and analyze the variations in the annual performance indices of the thirteen participating utilities and the aggregated systems including the overall indices and the cause code contributions, and to examine the possible utilization of historic utility reliability indices to create suitable reward/penalty structures in a PBR protocol. The potential financial risk and actual financial payment analyses for these selected utilities are conducted using their historical performance data imposed on a number of possible reward/penalty structures developed in this thesis. An approach to recognize adverse utility performance in the form of Major Outage Years (MOY) is developed and the influence of the MOY performance in PBR decision making is examined.

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ACRONYMS

HLI	Hierarchical Level I
HLII	Hierarchical Level II
HLIII	Hierarchical Level III
SAIFI	System Average Interruption Frequency Index
SAIFI	System Average Interruption Frequency Index
SAIDI	System Average Interruption Duration Index
CAIFI	Customer Average Interruption Frequency Index
CAIDI	Customer Average Interruption Duration Index
ASAI	Average Service Availability Index
ENS	Energy Not Supplied
AENS	Average Energy Not Supplied
PBR	Performance Based Regulation
CEA	Canadian Electrical Association
MOY	Major Outage Year
IOR	Index of Reliability
ASUI	Average Service Unavailability Index
EENS	Expected Energy Not Supplied
FMEA	Failure Mode and Effect Analysis
RBTS	Roy Billinton Test System
Ave.	Average
S.D.	Standard Deviation
Unkn	Unknown
Sch.O	Scheduled Outage
Los.S	Loss of Supply
De.E	Defective Equipment
Tr.C	Tree Contact
Lightn	Lightning
Ad.W	Adverse Weather
Ad.En	Adverse Environment
Hu.E	Human Element
For.I	Foreign Interference
ERP	Expected Reward/penalty Payment
R/PS	Reward/Penalty Structure
MED	Major Event Day

CHAPTER 1

INTRODUCTION

1.1 Electric Power System

The function of an electric power system is to generate electrical energy as economically as possible and to transfer this energy over transmission line and distribution networks with maximum efficiency for delivery to consumers at acceptable voltages, frequency and reliability [1]. An electric power system consists of three principal segments: the generating stations, the transmission system, and the distribution systems.

Generating plants produce electrical energy from other forms of energy such as fossil fuels, nuclear fuels or water flow. Generation substations connect generating plants to transmission lines through step-up transformers that increase the generation voltage to transmission levels [2]. Transmission systems transport electricity over long distances from generating facilities to transmission or distribution substations. Most transmission lines are overhead but there is a growing trend towards the use of underground transmission cables. Distribution systems deliver power from bulk power systems to retail customers. Distribution substations receive power from the transmission system and step down the transmission voltages using power transformers to supply the primary distribution systems.

1.2 Power System Reliability

Power systems have evolved over decades. Their primary emphasis has been on providing a reliable and economic supply of electrical energy to their customers. Overinvestment can lead to excessive operating costs, which impact the tariff structure and lead to high customer costs. Underinvestment results in decreases in the reliability of customer service. The resulting economic and reliability impacts can lead to difficult managerial decisions in both the planning and operating phases [3].

Many design, planning and operating criteria and techniques have been developed to resolve and satisfy the dilemma between the economic and reliability constraints. The criteria and techniques used in early practical applications were all deterministically based. System behavior, however, is stochastic in nature and deterministic techniques can not respond to this condition. Probabilistic technique have been developed which recognize not only the severity of an event but also the likelihood or probability of its occurrence. Enhancements in computing facilities and improvements in evaluation techniques have resulted in the development of a wide range of probabilistic methodologies for power system reliability evaluation [3].

Power system reliability evaluation, both deterministic and probabilistic, can be divided into the two aspects of system adequacy and system security. This relationship is shown in Figure 1.1 [3].

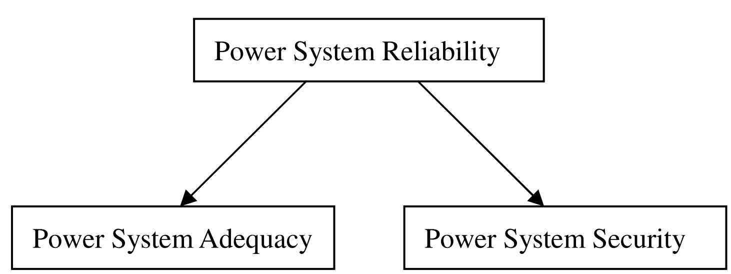


Figure1.1 Subdivision of system reliability

System adequacy is generally considered to relate to the existence of sufficient facilities within the system to satisfy the consumer demand. These facilities include those necessary to generate sufficient electrical energy and the associated transmission and distribution networks required to transport the energy to the actual consumer load points [3].

System security is related to the ability of the system to respond to disturbances arising within the system without causing widespread cascading events. Security is therefore associated with the response of the system to whatever disturbances the system is subjected to. These disturbances are considered to include conditions causing local and widespread effects and the loss of major generation and transmission facilities [3].

Considerable effort has been devoted to reliability assessment of power systems. Most of the relevant publications are documented in the comprehensive bibliographies published since 1971 [4-10].

1.3 Power System Functional Zones and Hierarchical Levels

Power system reliability assessment can be conducted in the three basic functional zones of generation, transmission and distribution. Hierarchical levels (HL) can be created by combining the three functional zones. This is illustrated in Figure 1.2.

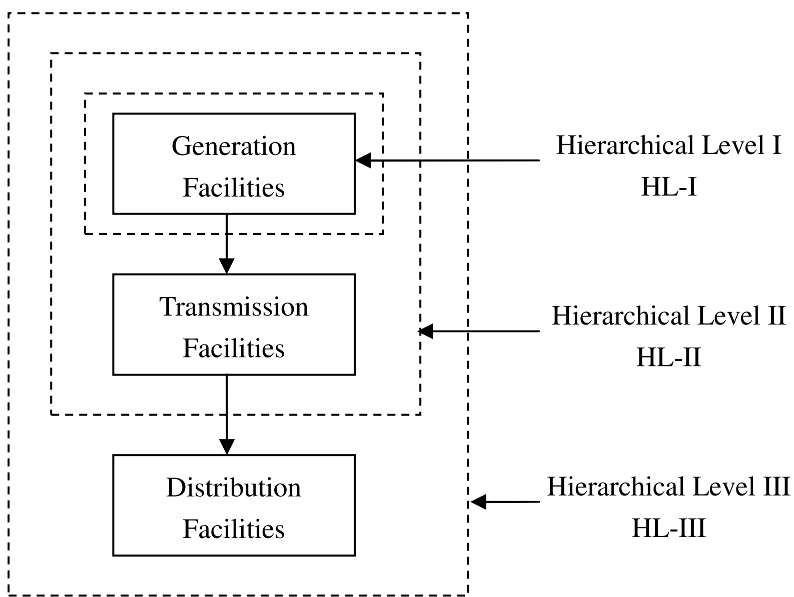


Figure1.2 Hierarchical levels in a power system

Reliability assessment at hierarchical level I (HLI) deals with the generating system. In an HLI study, the system generation is examined to determine its ability to meet the total system load requirement, considering random failures and preventive maintenance of the generating units. The transmission network and the distribution facilities are not included in assessments at this level.

Both the generation and transmission facilities are included in a hierarchical level II (HLII) study. Reliability assessment at HLII is concerned with the ability of the system to deliver energy to the bulk supply points. HLII analysis is more complicated than that at HLI and includes overload effects, redispatch of generation, and consideration of independent, dependent and common-cause outages.

Hierarchical level III (HLIII) assessment refers to the complete system including distribution and the overall system ability to satisfy the capacity and energy demands of individual consumers. Although HLI and HLII analyses are regular performed, HLIII studies are usually impractical because actual power systems are very large and complex and it is very difficult to evaluate the entire system using a single and direct technique such of those applied at HLI or HLII. Distribution systems are usually assessed separately and combined with HLII parameters if necessary.

1.4 Distribution System Reliability

Historically, distribution systems have received considerably less attention regarding reliability modeling and evaluation than that devoted to generating systems [3]. A distribution system has a relatively low cost and distribution outages have a much more localized effect than events on the generation system, where inadequacy could have widespread economic consequences for society [3].

Analysis of customer failure statistics show that distribution systems make the greatest individual contribution to the unavailability of customer supply. A customer connected to an unreliable distribution system could receive poor energy supply even though the generation and transmission system are highly reliable. This fact clearly illustrates the importance and necessity of conducting reliability evaluation in the area of distribution systems.

Reliability assessment of a distribution system is concerned with the performance at the customer load points. Quantitative assessment techniques in this area originated in 1964 [11]. The paper entitled “Power System Reliability: I- Measures of reliability and Methods of Calculation” written by D.P. Caver, F.E Montmeat, and A.D. Patton introduced the concept of failure bunching in parallel facilities due to storm associated failures, and outages as a result of component overloading in parallel systems. This paper introduced procedures for calculating failure frequency and average outage duration in addition to the probability of failure. This work was extended in two papers by R. Billinton and M.S. Grover which presented a consistent set of equations for series/parallel system reduction including adverse weather and permanent, temporary, maintenance and overload outage modes [12] [13]. The concept of utilizing minimal cuts in complex configurations is illustrated in [13].

The basic parameters used to evaluate the reliability of a distribution system can be categorized as load point indices and system indices [3]. The basic load point indices are the load point failure rate, the average outage time and the average annual outage time. The set of system reliability indices includes the System Average Interruption Frequency Index (SAIFI), the System Average Interruption Duration Index (SAIDI), the Customer Average Interruption Frequency Index (CAIFI), the Customer Average Duration Frequency Index (CAIDI), the Average Service Availability Index (ASAI) and energy oriented indices such as the Energy Not Supplied (ENS) and the Average Energy Not Supplied (AENS).

The load point and system reliability indices are normally determined on an annual basis. Because of the stochastic nature of a power system, the indices for any particular year are random values and are functions of the component failures rates, repair times, and restoration times within the year. A complete representation of these indices involves a knowledge of the underlying probability distributions. It is relatively easy to compute the average values as the associated analytical techniques are highly developed for both radial and meshed distribution systems. Other applications such as performance based regulation studies, and reliability cost/worth analysis may require the development of the distributions associated with the annual reliability indices [3].

1.5 Performance Based Regulation (PBR)

Historically, many electric power systems were single integrated utilities that owned and operated the facilities in the three functional zones of generation, transmission and distribution. The rates charged by an electric utility are based on the cost of generating and delivering electricity. In return for fulfilling their obligation to serve customers in an exclusive service territory, utilities are guaranteed a reasonable return on their investments. In this paradigm, reliability is usually not specifically regulated. Utilities have tended to design their systems to conservative design standards, and aggressively tackle reliability problems knowing that the attendant costs can be recovered [14].

In a deregulated environment, customers are no longer captive and can shop around for different electric energy providers. The demand for electricity is very sensitive to price, and therefore the lowest cost provider will usually prevail. This has put immense pressure on electric utilities to reduce costs. Deregulated utilities can reduce costs by deferring capital projects, reducing in-house expertise, and increasing maintenance intervals. As a direct consequence, the reliability of these systems may deteriorate [14]. Since most systems have been designed and maintained to high standards, this deterioration may not manifest itself immediately. System reliability may seem fine for several years, but could then begin to rapidly deteriorate. When the reliability problems become evident, utilities often lack the necessary resources to address the problem. Regulatory agencies are well aware that deregulation could have a negative impact on system reliability. In reality, customers are connected to a unique distribution system that largely determines the reliability that they receive. These customers are captive, and cannot switch distribution systems if the reliability becomes unacceptable. Regulatory authorities are therefore moving to performance based regulation to provide appropriate balances between reliability and cost.

Performance Based Regulation (PBR) is a term used to describe the application of a set of incentive-based tools which can be applied to the determination of fair and reasonable rates. These flexible rate setting tools can reduce the regulatory burden and at the same time protect the interest of the ratepayers. A PBR approach provides the opportunity to deal with changing circumstances and has the potential to provide flexibility for both the utility and the regulator, while providing a utility with direct incentives for improving economic efficiency.

A PBR works as a contract that rewards a utility for providing good reliability and/or penalizes a utility for providing poor reliability. This can either be at a system level or applied to individual customers. Either way, PBR introduces an element of financial risk that did not previously exist. In order to effectively manage this risk, utilities need the ability to determine the uncertainty associated with system performance [14-18].

1.6 Canadian Electricity Association

The Canadian Electricity Association (CEA) maintains a comprehensive database of component and system outage data on behalf of the reporting utilities. Canadian electric power companies have always been conscious of the need to measure their performance in regard to serving their customers. The CEA has been actively involved in assessing service continuity for over forty years. This activity is now an integral element in the CEA protocols on component and system outage data evaluation [15]. The Service Continuity Report on Distribution System Performance in Electrical Utilities is published annually and presents the results of consecutive surveys on the performance of the participating utility distribution systems. The annual reports [19] show the service continuity performance of the individual participating utilities and the aggregate performance of Canadian utilities. The individual utility performance indices are confidential and only provided to the participating utilities. A composite report is also published that contains only the aggregated Canadian data. This report does not provide any specific utility data and is therefore not confidential. Thirteen utilities agreed to provide the individual utility data for the research described in this thesis. These data are taken from the CEA annual reports [19] and are shown in subsequent chapters in this thesis. In accordance with the CEA protocol, the utilities are anonymous and are referred to by numerical designations. The data includes the performance statistics and the interruption cause contributions for the individual utilities and for the aggregated Canadian entity.

1.7 Research Objectives and Outline of the Thesis

This research is focused on the analysis of the reliability performance of a group of actual utilities using their historical data. Considerable work has been done on distribution risk assessment at the University of Saskatchewan. Relatively recent work has been focused on using simulation methods to determine system reliability indices and their associated index probability distributions [16, 17, 18]. In the research described in this thesis, the concept of using index probability distributions is extended by using actual historical distributions based on data provided by the participating utilities.

The objectives of the research work reported in this thesis are:

1) To examine and analyze the variations in the annual performance indices of the thirteen participating utilities and the aggregated systems created by pooling selected utility groups. The analysis is focused on the overall utility statistics and the cause codes contributing to the overall values.

2) To examine the possible utilization of historic utility performance data in the creation of suitable reward/penalty structures in a PBR protocol.

3) To develop an approach to recognize adverse utility performance in the form of Major Outage Years (MOY) and to examine the influence of the MOY performance in PBR decision making.

This thesis is structured in seven chapters. This chapter briefly presents some general comments on electrical power systems and power system reliability evaluation. It also provides a very brief introduction to power system deregulation and performance based regulation. The research objectives and the thesis outline are presented in this chapter.

Chapter 2 provides a brief introduction to electric power distribution systems and the basic distribution system reliability indices. The basic differences between predictive assessment and historical performance are explained. The analytical and simulation methods for predictive assessment are introduced in this chapter. The CEA indices and cause code definitions are also given and an example of CEA data using an aggregated system designated as Canada is presented.

Chapter 3 is focused on an interruption cause code analysis of sixteen systems including seven urban utilities, six integrated utilities, three pooled systems and the overall Canada system data..

Chapter 4 presents the reliability index probability distributions for two selected utilities.

Similar information on the other individual utilities and the pooled utilities are provided in Appendix [1] and [2]. The concepts associated with reward/penalty structures in a PBR framework are examined together with the financial risks faced by the two selected utilities.

Chapter 5 presents a method to classify the major outage years (MOY) in the past performance of a utility. The MOY associated with each cause code are also considered.

Chapter 6 compares the financial risk for the two selected utilities associated with the year 2004 including and excluding the cause code component designated as Loss of Supply, and including and excluding the utility MOY.

Chapter 7 presents a summary of the research work reported in this thesis together with some concluding remarks.

Chapter 4, 5 and 6 are focused on the data for the two selected utilities. The Appendices contain similar study information on the remaining eleven utilities and the pooled systems.

CHAPTER 2

DISTRIBUTION SYSTEM RELIABILITY

2.1 Power Distribution System

A power distribution system is the segment of the overall power system that links the bulk electricity system to the consumer service points. It contains: sub-transmission circuits, distribution substations, primary feeder circuits, distribution transformers, secondary circuits and service lines. Figure 2.1 shows a simplified drawing of a distribution system in an overall electric power system.

Distribution substations convert energy to lower primary system voltages for local distribution and usually provide facilities for voltage regulation of the primary voltage. Primary feeder circuits usually operate in the range of 11kV to 33kV and supply the load in well defined geographical areas. Distribution transformers are often installed on poles or on pads or near the consumer sites and transform the primary voltage to the secondary voltage. Secondary circuits carry energy from the distribution transformers at service voltage. Service lines deliver energy from secondary circuits to consumer premises at the required voltage level.

2.2 Basic Distribution System Configurations

Radial distribution systems: A radial system is connected to only one source of supply and is exposed to many interruption possibilities. The most important of which are those due to overhead line or underground cable failures or transformer failures. Each event may be accompanied by a long interruption. Radial feeders tend to have lower reliability than feeders with alternate supply capability [20]. Feeders and transformers have finite failure

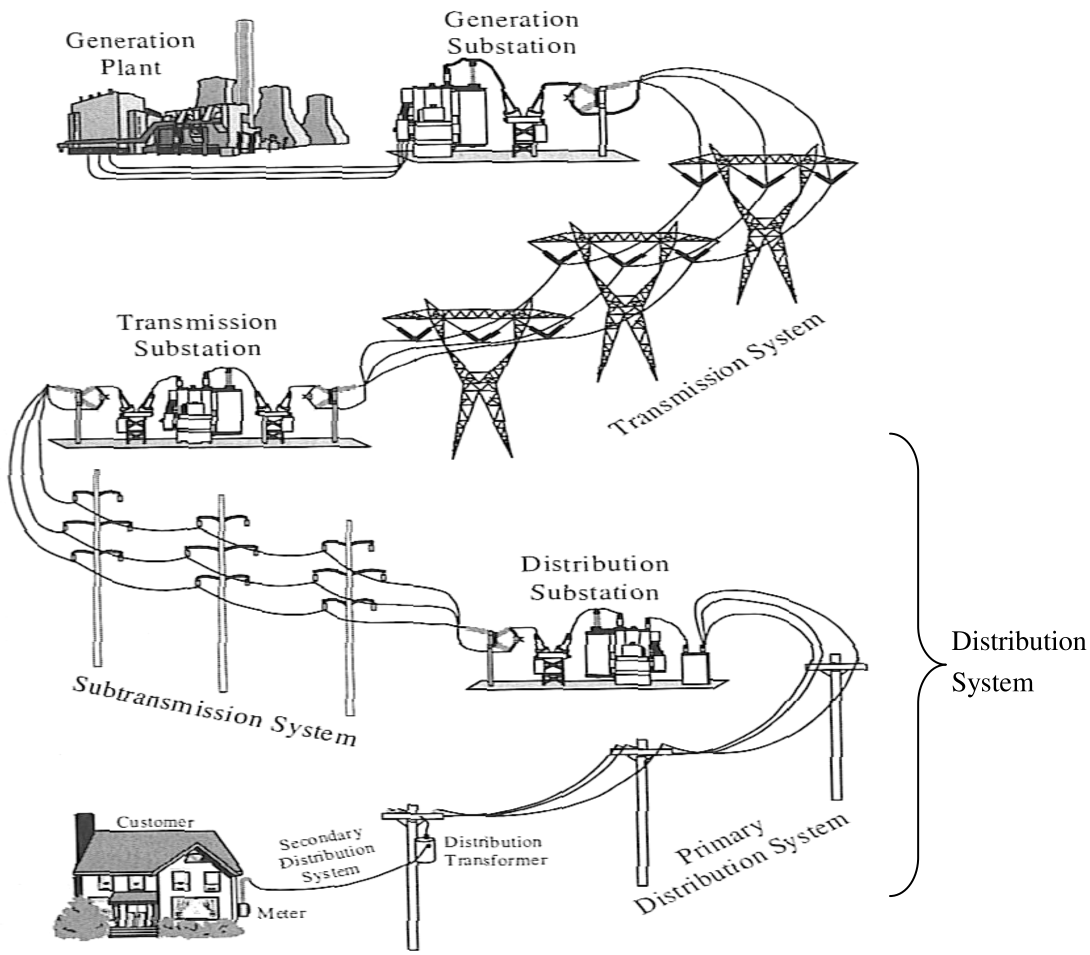


Figure 2.1 An overall electric power system and its subsystems

rates and interruptions are expected and statistically predictable. Feeder breaker reclosing action or temporary faults are likely to affect sensitive loads. Purely radial feeders with no alternate supply capability are usually used for small loads or rural systems. Figure 2.2 shows an example of a small radial feeder.

Primary loop: A big improvement over a radial system is obtained by providing a primary loop, which can provide power from two sources. This is also called an open ring system.

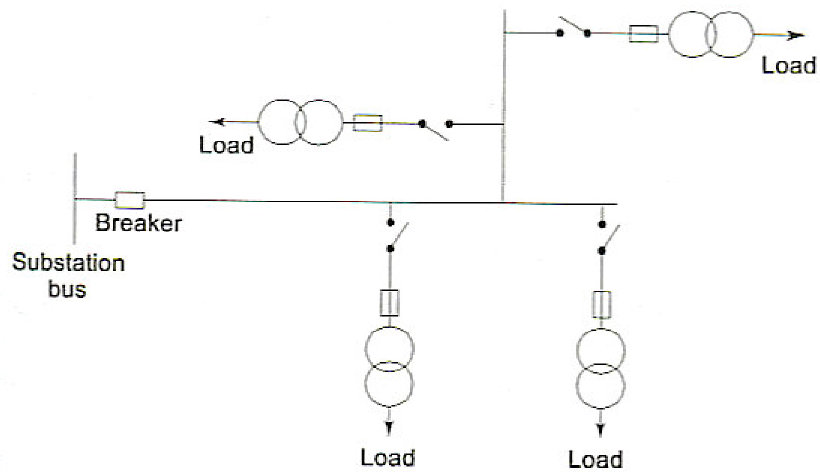


Figure.2.2 A radial distribution system

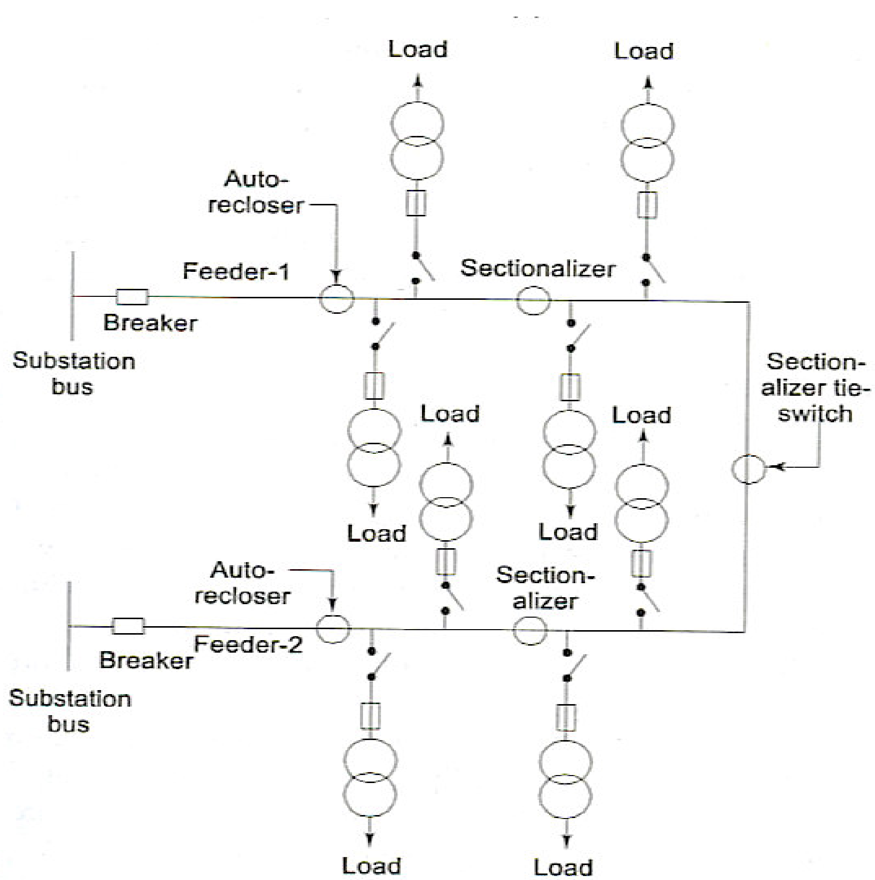


Figure 2.3 A primary loop distribution system

A simple example of an open ring system is shown in Figure 2.3. Normal power flow to the consumer is by way of a single path at any one time from either side of the loop. The loop is normally operated with the sectionalizer switch open. Any section of the feeder can be isolated and switching action performed to restore service. Sensitive loads can be affected by reclosing under temporary fault conditions.

2.3 Distribution System Reliability Indices

The reliability of a distribution system can be described using two sets of reliability parameters. These are the individual load point reliability indices and the overall system reliability indices [3].

2.3.1 Load Point Indices

There are three basic load point reliability indices used to characterize the continuity of power supply to an individual load point. They are the load point failure rate (λ), the average outage time (r) and the annual unavailability or the average annual outage time (U).

The load point failure rate indicates the number of failures that a load point experiences during a period of time, usually a year. The average outage time is the average outage duration at a load point due to a load point failure. The average annual outage time at a load point can be estimated from the product of the failure rate and average outage time. This is the total duration in a year that power supply to the load points is unavailable. The three annual predictive indices are expected values and not deterministic parameters. They are therefore long run average values and have underlying probability distributions.

2.3.2 System Reliability Indices

The three primary load point indices introduced above are very important from a customer standpoint. The system performance can also be assessed on an overall system basis. These indices [3] reflect the adequacy of overall system supply and indicate the system behavior and response. The system basic indices are defined as follows:

(1) System Average Interruption Frequency Index (SAIFI)

This index is defined as the average number of interruptions per customer serviced per year.

$$SAIFI = \frac{Total\ Number\ of\ Customer\ Interruption}{Total\ Number\ of\ Customers\ Served} = \frac{\Sigma(\lambda_i \cdot N_i)}{\Sigma N_i} \qquad (2.1)$$

where, λ_i is the failure rate and N_i is the number of customers at load points i.

(2) System Average Interruption Duration Index (SAIDI)

This index is defined as the average interruption duration per customer served per year.

$$SAIDI = \frac{Sum\ of\ Customer\ Interruption\ Durations}{Total\ Number\ of\ Customers} = \frac{\Sigma(U_i \cdot N_i)}{\Sigma N_i} \qquad (2.2)$$

where U_i is the annual outage time and N_i is the number of customers at load point i.

(3) Customer Average Interruption Duration Index (CAIDI)

This index is defined as the average interruption duration for customer interrupted during a year.

$$CAIDI = \frac{Sum\ of\ Customer\ Interruption\ Durations}{Total\ Number\ of\ Customers\ Interruptions} = \frac{\Sigma(U_i \cdot N_i)}{\Sigma(\lambda_i \cdot N_i)} \qquad (2.3)$$

where λ_i is the failure rate, U_i is the annual outage time and N_i is the number of customers at load point i.

(4) Index of Reliability (IOR) or Average Service Available Index(ASAI)

$$\text{IOR} = \text{ASAI} = \frac{8760 Hours/year - SAIDI}{8760 Hours/year} \quad (2.4)$$

(5) Average Service Unavailable Index(ASUI)

$$\text{ASUI} = 1\text{-ASAI} = \frac{SAIDI}{8760 Hours/year} \quad (2.5)$$

(6) Expected Energy not supplied index (EENS)

$$\text{EENS} = \Sigma L_i \cdot U_i \quad (2.6)$$

Where L_i and U_i respectively are the average connected load and the average annual outage time at load point i.

(7) Average Energy not supplied index (AENS)

$$\text{AENS} = \frac{Total\ Energy\ not\ Supplied}{Total\ Number\ of\ Customers\ Served} = \frac{\Sigma L_i \cdot U_i}{\Sigma N_i} \quad (2.7)$$

where N_i, L_i and U_i are defined as above.

The first five indices are customer-oriented indices and the last two are load and energy-oriented indices. These indices can be used not only to assess the past performance of a distribution system but also to predict the future system performance.

Table 2.1 shows the overall Canadian distribution system reliability performance indices for 2002, 2003 and 2004 [19]. Reference 19 also contains pooled reliability data for urban utilities and integrated utilities consisting of urban and rural systems. The data for 2003 are shown in Table 2.2.

Table 2.1 Overall Canadian system reliability performance indices for 2002, 2003, 2004

Index	Year		
	2002	2003	2004
SAIFI(interr./yr)	2.33	2.67	1.98
SAIDI(hr/yr)	4.06	10.65	3.95
CAIDI (hr/interr.)	1.74	3.99	1.99
IOR(ASAI)	0.999536	0.998784	0.999549
ASUI	0.000464	0.001216	0.000451

Table 2.2 Reliability performance indices of urban utilities and integrated utilities in 2003

Index	Urban Utilities	Integrated Utilities	Canada
SAIFI(interr./yr)	2.21	2.80	2.67
SAIDI(hr/yr)	7.51	10.36	10.65
CAIDI(hr/interr.)	3.40	3.70	3.99
IOR(ASAI)	0.999143	0.998817	0.998784
ASUI	0.000857	0.001183	0.001216

2.4 Prediction and Performance Assessment

Techniques have been developed [3] to assess the expected future performance of a distribution system. This task is designated as predictive reliability evaluation and can provide relevant information associated with future system operation. This activity is normally performed in the system planning stage. Predictive reliability indices reflect the ability of the system to perform its intended function.

Past performance assessment involves observing, recording and analyzing historical component failures, repair and restoration times, load point interruptions and their duration, number of customers affected, etc [3]. The resulting information can be used to improve the performance of existing systems by changing the maintenance schedules, modifying protection schemes, providing spares or improving component quality, etc. As noted in Chapter 1, the Canadian Electricity Association (CEA) reporting systems contain and compile reliability data collected by many Canadian electric power utilities. Annual reports on the performance of these systems are published each year. The Annual Service Continuity Report on Distribution System Performance in Electrical Utilities published by CEA is a valuable and informative reference on customer service reliability. [19]

The information provided by both predictive and past performance analysis are useful to utilities, regulators and customers. The research in this thesis is focused on utility past performance analysis. The reliability indices of existing systems can be used as reference indicators in selecting appropriate values in the reliability assessment of a proposed system. In a PBR regime, this information can also prove valuable in reducing the potential financial risk to the distribution utility [21].

2.5 Analytical and Simulation Methods

The predictive reliability assessment techniques in power distribution systems can be divided into the two basic approaches of analytical methods and simulation techniques. The following is a brief introduction to these methods.

2.5.1 Analytical Methods

Analytical methods represent a distribution system by mathematical models and use failure mode and effect analysis (FMEA) to obtain the expected load point values [3]. Analytical techniques for distribution system reliability evaluation are highly developed. Reference 22 introduces and illustrates many general analytical techniques. These techniques are applied to power system reliability assessment in [3]. An analytical technique to evaluate the probability distributions associated with relevant reliability indices was developed by

Billinton and Goel [23]. The analytical method was the most popular approach in the early years and is still used in a wide range of practical applications. Quantitive analytical methods that have been developed and applied include using Markov processes [12], minimal cuts [13], frequency and duration concepts and approximate method etc [3]. A number of programs based on the analytical method have been developed at the University of Saskatchewan to assess distribution system reliability [24]. Analytical models can become quite complicated, however, when the system has complex configurations and complicated operating procedures. Simulation techniques can prove advantageous in these cases. The reliability indices obtained using a basic analytical technique are average or expected values and contain no information in the distribution of the indices.

A direct analytical approach can be used to obtain the average reliability indices at the different load points and for the overall distribution system. The three basic load point reliability indices i.e. the failure rate, the average outage time and the average annual outage time can be obtained as follows.

$$\lambda_i = \sum_j \lambda_j \tag{2.8}$$

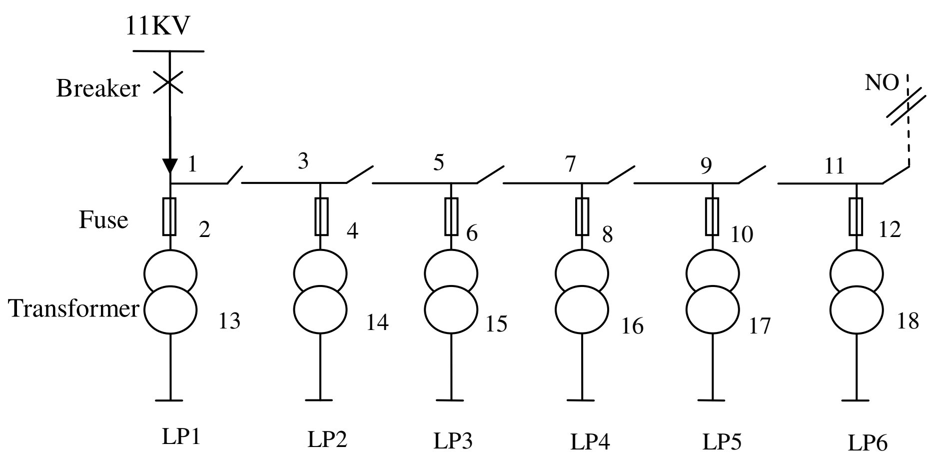
$$U_i = \sum_j \lambda_j \cdot r_j \tag{2.9}$$

$$r_i = \frac{U_i}{\lambda_i} \tag{2.10}$$

Where λ_j, r_j are the failure rate, repair time of event j respectively and U_i is the annual outage time at load point i.

2.5.2 An Example Utilizing the Analytical Method

Figure 2.4 shows a simple distribution circuit designated as Feeder 1 at Bus 6 in the Roy Billinton Test System (RBTS) [25] [26]. The system data is shown in Table 2.3 and 2.4 where λ is the failure rate, *r* is the repair time, *s* is the switching time and *rl* is the replacement time. The fuses are considered to be 100% reliable. The load point indices are calculated using Equation (2.8) to (2.10) as shown in Table 2.5, and the results are presented in Table 2.6. The overall feeder or system indices are calculated using Equations (2.1) to (2.7) and these results are shown in Table 2.7.



Note: LP is Load Point

Figure 2.4 Feeder 1 at Bus 6 in the RBTS

Table 2.3 Main section data, Line: λ=0.065 (f/ km. yr)

Main Section	Length (km)	λ (f/yr)	r (hr/f)	s (hr/f)
1	0.75	0.04875	5	1
3	0.60	0.03900	5	1
5	0.75	0.04875	5	1
7	0.75	0.04875	5	1
9	0.60	0.03900	5	1
11	0.80	0.05200	5	1

Table 2.4 Lateral section and transformer data

Lateral Section	Length (km)	λ (f/yr)	r (hr/f)	s (hr/f)	Transformer	λ (f/yr)	rl (hr/f)
2	0.60	0.03900	5	1	13	0.015	10
4	0.80	0.05200	5	1	14	0.015	10
6	0.75	0.04875	5	1	15	0.015	10
8	0.60	0.03900	5	1	16	0.015	10
10	0.75	0.04875	5	1	17	0.015	10
12	0.60	0.03900	5	1	18	0.015	10

Table 2.5 Load point index calculation

	Load point 1			Load point 2			Load point 3		
Comp failure	λ (f/yr)	r (hr/f)	U (hr/yr)	λ (f/yr)	r (hr/f)	U (hr/yr)	λ (f/yr)	r (hr/f)	U (hr/yr)
1	0.04875	5	0.24375	0.04875	1	0.04875	0.04875	1	0.04875
3	0.03900	1	0.03900	0.03900	5	0.19500	0.03900	1	0.03900
5	0.04875	1	0.04875	0.04875	1	0.04875	0.04875	5	0.24375
7	0.04875	1	0.04875	0.04875	1	0.04875	0.04875	1	0.04875
9	0.03900	1	0.03900	0.03900	1	0.03900	0.03900	1	0.03900
11	0.05200	1	0.05200	0.05200	1	0.05200	0.05200	1	0.05200
2	0.03900	5	0.19500	--	--	--	--	--	--
4	--	--	--	0.05200	5	0.26	--	--	--
6	--	--	--	--	--	--	0.04875	5	0.24375
8	--	--	--	--	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--
13	0.015	10	0.15	--	--	--	--	--	--
14	--	--	--	0.015	10	0.15	--	--	--
15	--	--	--	--	--	--	0.015	10	0.15
16	--	--	--	--	--	--	--	--	--
17	--	--	--	--	--	--	--	--	--
18	--	--	--	--	--	--	--	--	--
Total	**0.33025**	**2.472**	**0.81625**	**0.34325**	**2.454**	**0.84225**	**0.34000**	**2.544**	**0.86500**

In Table 2.5, r is used to designate the restoration time.

The indices for Load points 4, 5, 6 are obtained in a similar manner to that shown in Table 2.5.

Table 2.6 Load point reliability indices

Load point	λ (f/yr)	r (hr/f)	U (hr/yr)	Num. Cus
1	0.33025	2.47	0.81625	138
2	0.34325	2.45	0.84225	126
3	0.34000	2.54	0.86500	138
4	0.33025	2.47	0.81625	126
5	0.34000	2.43	0.82600	118
6	0.33025	2.51	0.82925	118

Table 2.7 System (Feeder 1) indices

System (Feeder 1)	
SAIFI	0.33566
SAIDI	0.83286
CAIDI	2.48125
ASAI(IOR)	0.9999
ASUI	9.5E-05

2.5.3 Simulation Methods

The reliability indices obtained in Section 2.5.2 are average values. These indices are very important but have limitations regarding the uncertainty of the system behavior. Simulation method can be used to overcome this deficiency. Monte Carlo simulation can provide information related to the probability distributions of the reliability indices in addition to their average values. Considerable research in this area has been conducted at the University of Saskatchewan, not only at HLI and HLII but also on distribution systems. [15-17]. A software named 'SMdisrel' has been developed at the University of Saskatchewan to conduct comprehensive analyses of radial distribution systems. This program was utilized to determine the distribution system reliability indices and their probability distributions shown in Figure 2.5 [21]. This figure shows the probability distribution associated with the SAIFI and SAIDI indices for the four feeders connected at Bus 6 in the RBTS.

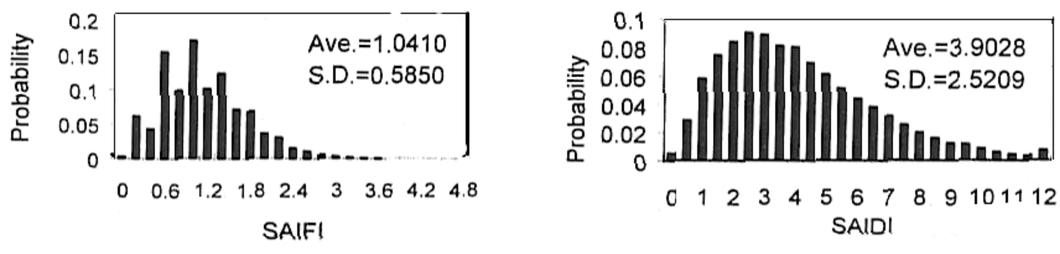


Figure 2.5 SAIFI and SAIDI probability distributions for Bus 6, RBTS [21]

Figure 2.5 shows the average value of each reliability index and also the likelihood that certain values occur in the future. Probability distributions obtained using a simulation method can provide considerable additional information and prove useful in assessing future risks.

Simulation methods use a random number generator and the probability distributions of the component failure and restoration processes to generate a history of component up and down times. The system reliability indices and their distributions are obtained from the generated system history. The index probability distributions reflect the future reliability performance of the system.

After the system has been constructed and placed in operation, it begins to form its actual reliability based on real life conditions encountered over time. The system reliability may be quite different from that predicted in the planning stage. Most utilities collect system reliability data such as customer interruptions, annual outage times and calculate the SAIFI and SAIDI on an annual basis. These actual yearly data can be used to create index distributions and compared with those produced using the simulation method. The amount of collected data is far less than that generated in a simulation method. The distributions created from actual historical data reflect the actual existing system performance and therefore are very valuable. This thesis is focused on analyzing system reliability index distributions based on actual utility data. These distributions are then used to predict the potential utility financial risk in a performance based regulation regime.

2.6 Canadian Service Continuity Data

This section provides a brief introduction to actual utility service continuity data by presenting the SAIFI and SAIDI indices for the aggregated pool of utilities reporting to the CEA. This pool is designated as the Canada data in this thesis. Table 2.8 and Figure 2.6 show the SAIFI and SAIDI annual indices for the period 1991 to 2004.

Table 2.8 Annual Canadian Reliability Data

	Canada	
Year	SAIFI	SAIDI
1991	3.55	4.24
1992	3.06	3.34
1993	2.97	3.36
1994	2.55	3.39
1995	2.8	3.06
1996	2.39	2.86
1997	2.35	3.7
1998	*2.40* (3.58)	*3.32* (30.31)
1999	2.59	4.31
2000	2.26	3.23
2001	2.41	3.67
2002	2.33	4.06
2003	*2.37* (2.67)	*5.11* (10.65)
2004	1.98	3.95
Ave.	*2.572*	*3.686*
S.D.	*0.401*	*0.599*

*Comment: 1. the data underlined exclude the effect of "IceStorm 98" and the significant events in 2003

2. S.D represents the standard deviation

The CEA annual service continuity report contains detailed data on the participating utilities and on Canada as a whole. These data include the cause code contributions in addition to the calculated SAIFI, SAIDI, CAIDI and IOR indices. The cause code contributions are discussed in Chapter 3.

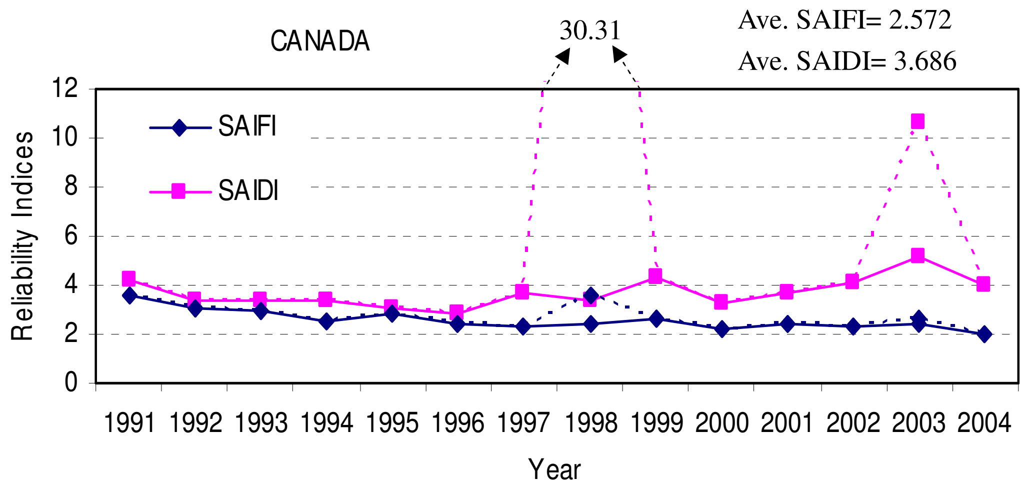


Figure 2.6 Annual SAIFI and SAIDI of Canada from 1991-2004

*Note: ---- denotes including "IceStorm 98" and 2003 Significant Events.

Figure 2.7 shows the SAIFI and SAIDI distributions of the pooled Canada system based on the data in Table 2.8 (from 1991-2004). This figure also excludes IceStorm 98 and the 2003 significant events. Further discussions of index distribution are given in Chapter 4.

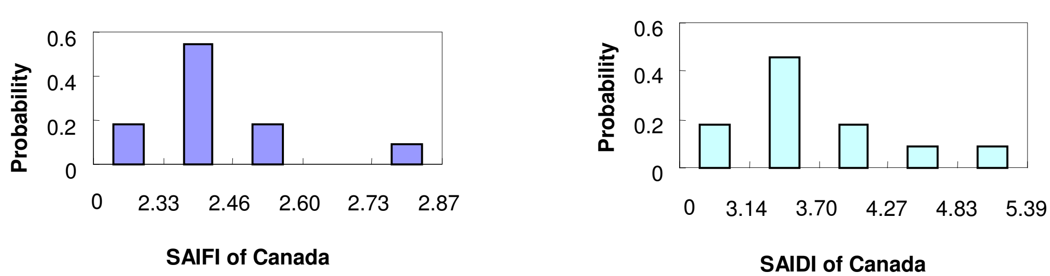


Figure 2.7 SAIFI and SAIDI probability distributions for Canada

2.7 Summary

Power distribution systems are briefly introduced in this chapter and two basic distribution configurations, radial and primary loop systems are presented. The basic distribution system reliability indices used in practice are also illustrated. The concept of predictive assessment and performance based assessment is introduced. Two methods for predictive assessment, the analytical and simulation methods are illustrated by simple examples. Both the simulation and analytical techniques to assess distribution system reliability are used in practice. Both techniques provide valuable information on the expected performance of distribution systems. This chapter illustrates the additional information on the annual variability of the predicted indices that can be obtained using a sequential simulation approach. In the next chapter, the interruption cause contributions for thirteen utilities are analyzed and discussed using their annual performance data presented in CEA reports.

CHAPTER 3

INTERRUPTION CAUSE ANALYSIS BASED ON ACTUAL DATA

3.1 Introduction

The Canadian Electricity Association has a long history of assessing customer service reliability levels through the production of its annual Service Continuity Report. The individual utility data in these reports are confidential to the participating utilities.

Thirteen utilities agreed to provide their data in an investigation of the causes contributing to the present levels of service reliability in their jurisdictions. This chapter examines the annual variations of the cause code contributions and the residual uncertainty in the annual variation in the standard reliability indices. Service continuity indices are being increasingly used by regulators in performance based regulation (PBR) protocols and an examination of the random variations in service continuity levels should prove useful in assessing the financial risk faced by an electric power utility under a PBR regime.

3.2 CEA Interruption Cause Code Definition

The system reliability characteristics of individual utilities differ due to the diversities in service areas, load densities, system topologies, weather environments and service standards, etc. Urban systems usually have short supply feeders, underground circuits, and alternate power supplies. Their reliability indices are therefore generally better than those of rural or integrated urban/rural systems [27].

An examination of the contributions to the service continuity indices from various system factors provides considerable insight into how the performance can be improved. The CEA reporting system divides the customer outages into ten cause codes. Their definitions are as follows [19]. The abbreviate names for the cause codes are shown in the brackets and are used later in the figures in this chapter.

0 – Unknown/Other (Unkn)

Customer interruptions with no apparent cause or reason which could have contributed to the outage

1 – Scheduled Outage (Sch.O)

Customer interruptions due to the disconnection at a selected time for the purpose of construction or preventive maintenance

2 – Loss of Supply (Los.S)

Customer interruptions due to problems in the bulk electricity supply system such as underfrequency load shedding, transmission system transients, or system frequency excursions.

3 – Tree Contacts (Tr.C)

Customer interruptions caused by faults due to trees or tree limbs contacting energized circuits.

4 – Lightning (Lightn)

Customer interruptions due to lightning striking the Distribution System, resulting in an insulation breakdown and/or flashovers

5 – Defective Equipment (De.E)

Customer interruptions resulting from equipment failures due to deterioration from age, incorrect maintenance, or imminent failures detected by maintenance

6 – Adverse Weather (Ad.W)

Customer interruptions resulting from rain, ice storms, snow, winds, extreme ambient temperatures, freezing fog, or frost and other extreme conditions

7 - Adverse Environment (Ad.En)

Customer interruptions due to equipment being subjected to an abnormal environment such as salt spray, industrial contamination, humidity, corrosion, vibration, fire or flooding

8 – Human Element (Hu.E)

Customer interruption due to the interface of the utility staff with the system such as incorrect records, incorrect use of equipment, incorrect construction or installation, incorrect protection setting, switching errors, commissioning errors, deliberate damage, or sabotage.

9 – Foreign Interference (For.I)

Customer interruption beyond the control of the utility such as birds, animals, vehicles, diggings, vandalism, sabotage and foreign object

3.3 Analysis of Interruption Causes

The data from the thirteen utilities are used in this analysis. Utility 1-1 to Utility 1-7 are urban utilities. This group is collectively designated as Region 1; Utility 2-1 to 2-6 are integrated (urban/rural) utilities and collectively designated as Region 2. The pooled systems designated as Regions 1 and 2 and Canada are also analyzed in this chapter.

Section 3.2 shows the ten cause codes used in the CEA protocol. The individual utility and pooled system results for the period 1995-2003 are shown graphically in the following section. These graphs present the total annual index, the total index minus the Loss of the Supply component and three other major cause codes contributing to the annual indices. Smaller cause code contributors are grouped in a Remaining category. In some cases, the data for certain early years are not available and therefore the graphs cover a reduced time period. The graphs show the total annual index minus the Loss of Supply component (noted as Ex.loss) as this component could be considered to be outside the control of a distribution company and therefore excluded from further consideration in a PBR analysis. This is discussed further later in this thesis.

3.3.1 Urban utilities: Utilities 1-1 to 1-7

Utility 1-1 is a small urban utility with a relatively low load density and a low circuit ratio. Circuit ratio refers to the ratio of the overhead line length and underground cable lengths. The major cause codes in the SAIFI graph shown in Figure 2.1 are Defective Equipment and Adverse Weather. Loss of Supply has a significant impact on the total indices in the first four years especially in 1996, where it accounts for 63% of the total SAIFI but it has little influence on the SAIFI in subsequent years. Defective Equipment also makes a major contribution to the total indices, particularly in the early years.

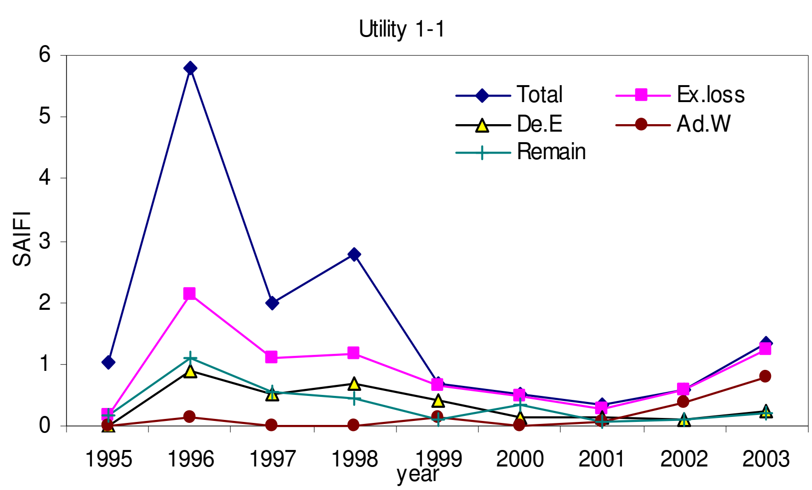


Figure 3.1 Major cause contributions to the SAIFI for Utility 1-1

The SAIDI graph of Utility 1-1 is presented in Figure 3.2 and shows that Loss of Supply makes a large contribution to SAIDI in the period 1996-1998 (over 50% of the total). The Loss of Supply contribution is particularly large in 1997. Defective Equipment and Adverse Weather are two other major contributors to SAIDI as shown in Figure 3.2.

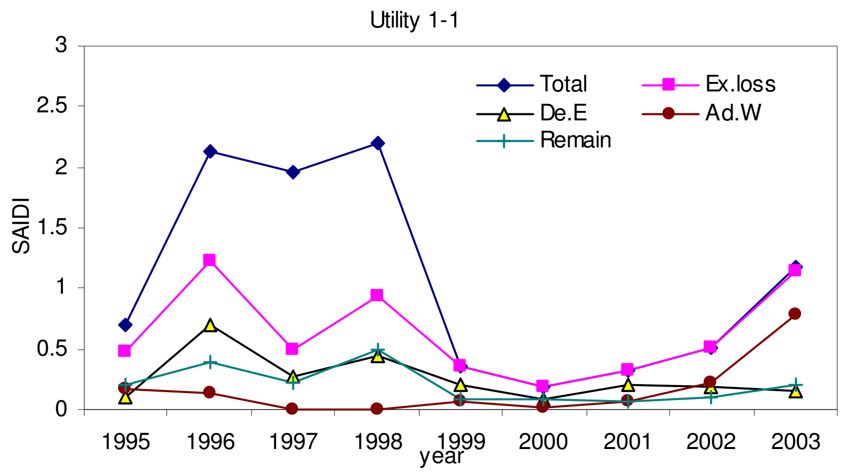


Figure 3.2 Major cause contributions to the SAIDI for Utility 1-1

Utility 1-2 is a small urban utility with a high load density and low circuit ratio. It can be seen in Figure 3.3 and 3.4 that Loss of Supply has almost no influence on the total SAIFI and SAIDI. Foreign Interference has an observable effect on both indices which can be seen from the graphs. The Unknown component has a recognizable effect on SAIFI in some years. Adverse Weather is a relatively minimal component of SAIFI but has a significant influence on the SAIDI. Defective Equipment also makes a big contribution to the SAIDI.

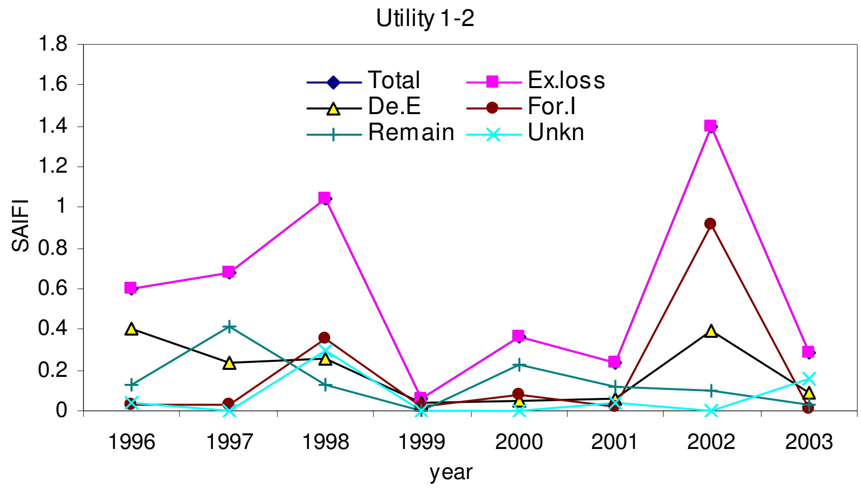


Figure 3.3 Major cause contributions to the SAIFI for Utility 1-2

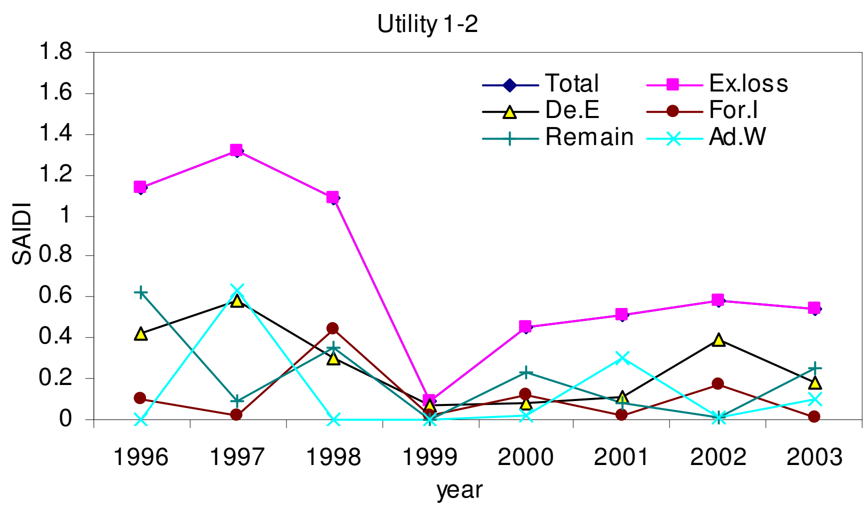


Figure 3.4 Major cause contributions to the SAIDI for Utility 1-2

Figure 3.5 and 3.6 show the major cause contributions for Utility 1-3, which is a small urban utility with a low circuit ratio and relatively high load density. It can be seen that Loss of Supply makes a significant contribution to the annual indices in 1995, 1998, 1999 and 2002. It accounts for 40% of the total index in some years and greatly impacts the overall SAIFI and SAIDI profiles. Defective Equipment creates major fluctuations in SAIDI in many years. Its influence on SAIFI is notable but less than that on SAIDI. Lightning and Foreign Interference are the other major contributors to the annual indices and to their variability. The contribution of Adverse Weather is generally low for Utility 1-3, other than in 1996.

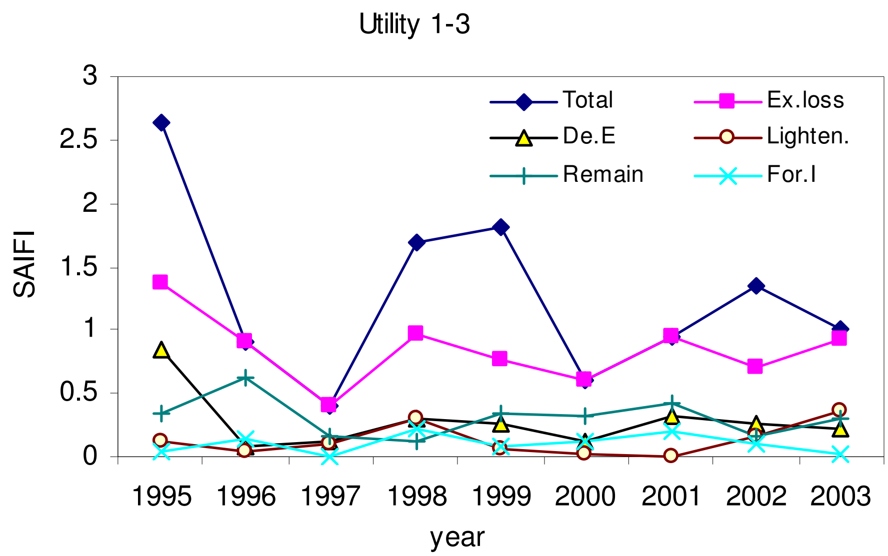


Figure 3.5 Major cause contributions to the SAIFI for Utility 1-3

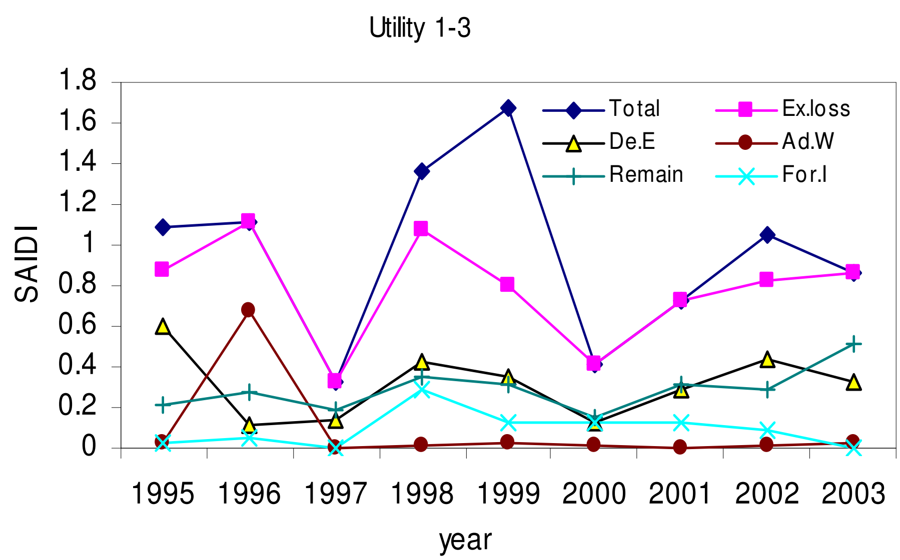


Figure 3.6 Major cause contributions to the SAIDI for Utility 1-3

Utility 1-4 is an urban utility with a large service area and high load density. It also has a low circuit ratio. It can be seen from Figures 3.7 and 3.8 that the contribution of Loss of Supply and Defective Equipment remain relatively constant over the nine years. Foreign

Interference has a relatively higher contribution to SAIFI than to SAIDI. Adverse Weather has much more influence on SAIDI than on SAIFI especially in 1996 and 2002. The Defective Equipment and Remaining cause contributions are relatively constant.

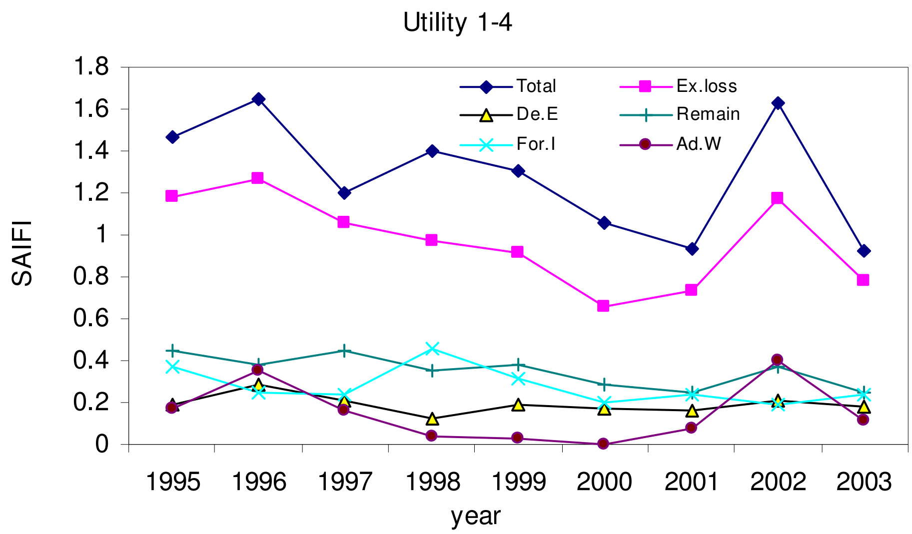


Figure 3.7 Major cause contributions to the SAIFI for Utility 1-4

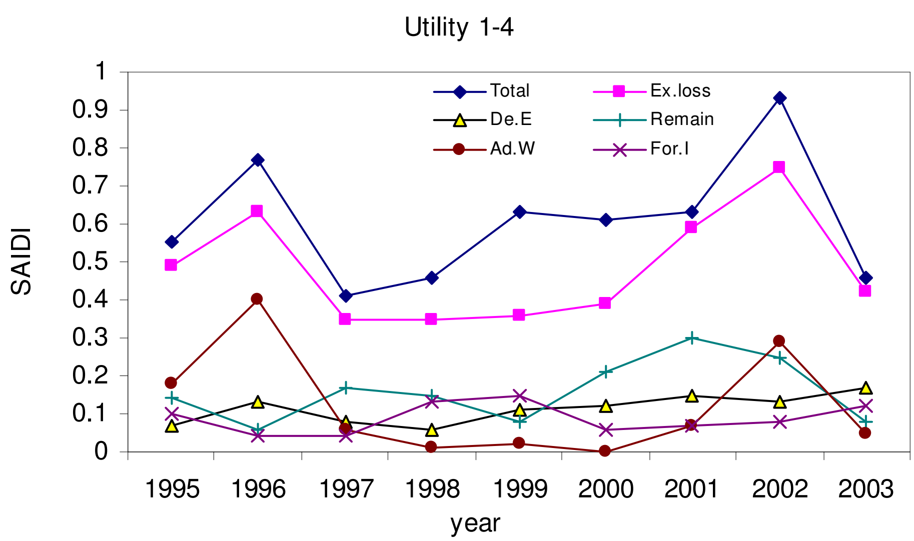


Figure 3.8 Major cause contributions to the SAIDI for Utility 1-4

Utility 1-5 is a small urban utility with a relatively high load density and low circuit ratio. The data available from CEA for this utility is from 1999 to 2003 as shown in Figure 3.9

and 3.10. It can be seen from the graphs that Loss of Supply has a significant impact on SAIFI and SAIDI in 2003 when the utility suffered from the "August 14 blackout". Lightning occurred more frequently in 1999 and 2000 but it has relatively little influence on SAIDI (not shown in the SAIDI graph), and the Remaining contribution is generally constant.

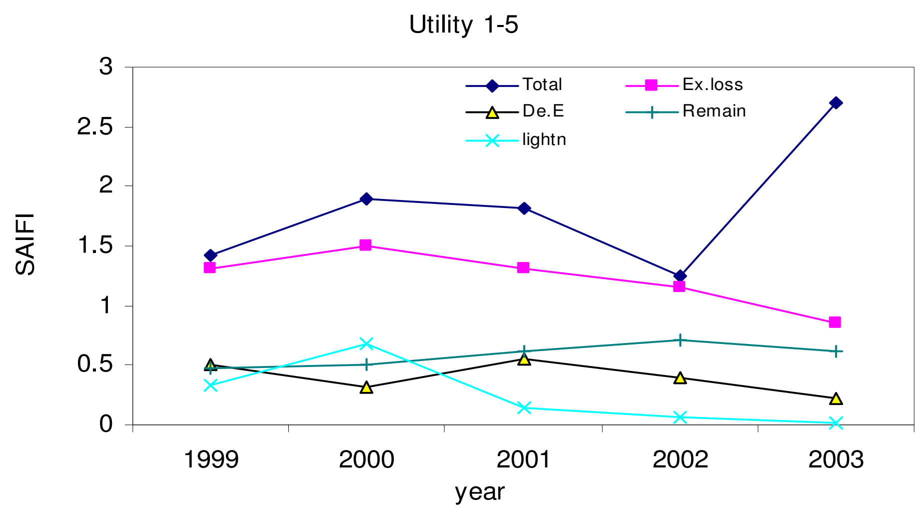


Figure 3.9 Major cause contributions to the SAIFI for Utility 1-5

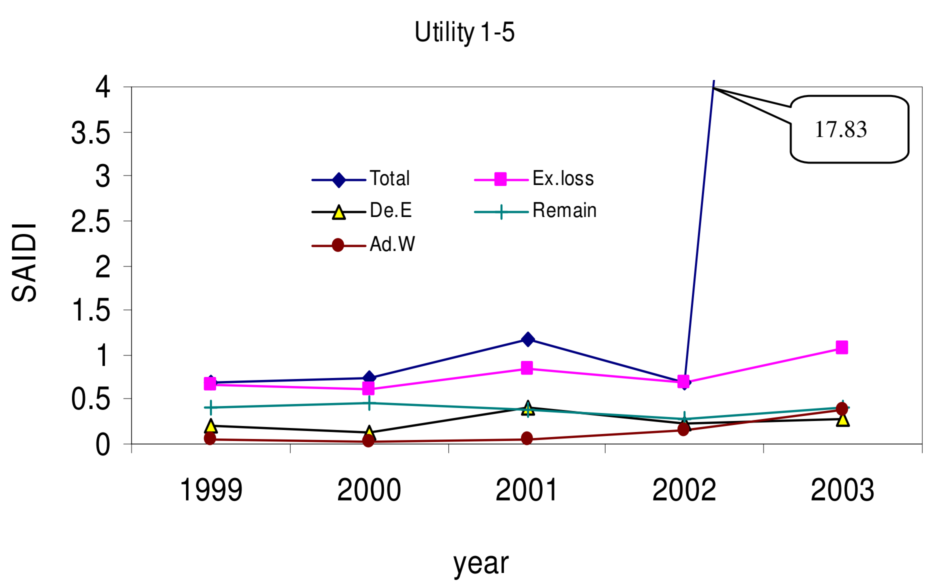


Figure 3.10 Major cause contributions to the SAIDI for Utility 1-5

Utility 1-6 is a large urban utility with a relatively high load density. The graphs shown in Figures 3.11 and 3.12 show that Loss of Supply has a similar impact in 2003 to that for Utility 1-5. Adverse Weather had a significant effect in 1998 due to the enormous ice storm in eastern Canada but has very little influence in the other years. Scheduled Outage was also a major contributor in 1998.

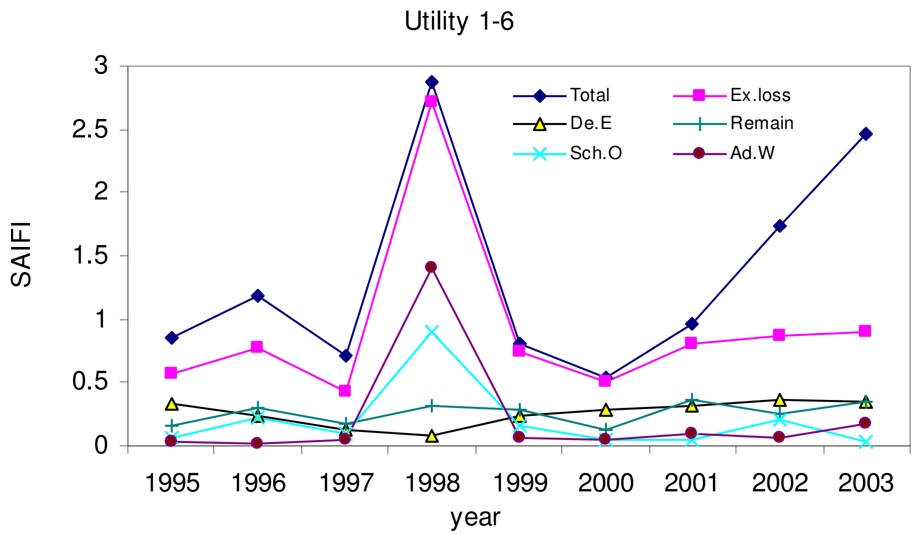


Figure 3.11 Major cause contributions to the SAIFI for Utility 1-6

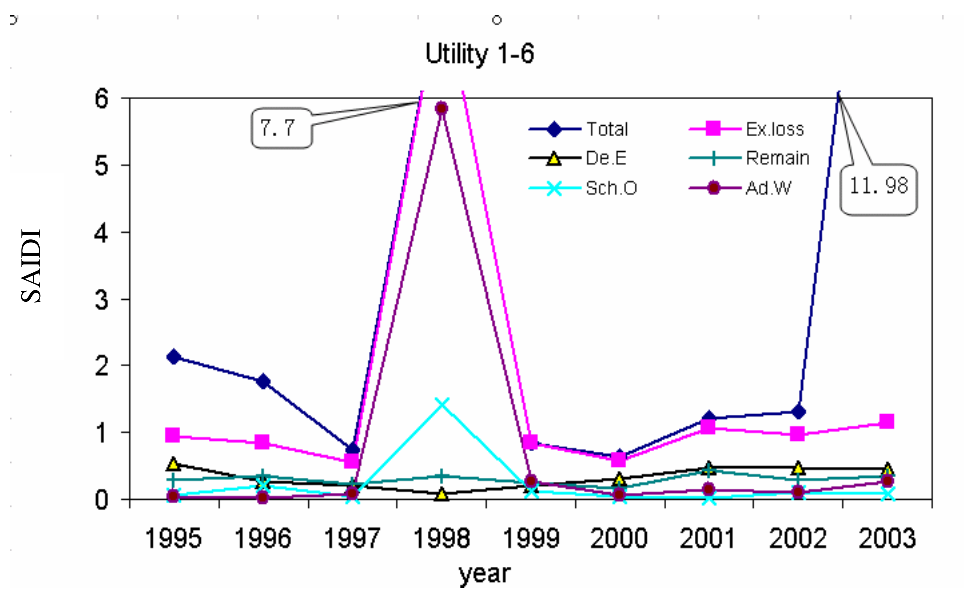


Figure 3.12 Major cause contributions to the SAIDI for Utility 1-6

Figures 3.13 and 3.14 show the annual SAIFI and SAIDI of Utility 1-7. This utility is a medium sized urban utility with a relatively high load density and low circuit ratio. The figures show that the indices appear to be gradually increasing during this period. Loss of Supply makes a large contribution in 2003 especially to SAIDI. Adverse Weather has a large effect on both SAIFI and SAIDI in the later years. Defective Equipment is a major contributor that appears to have decreased over the last four years.

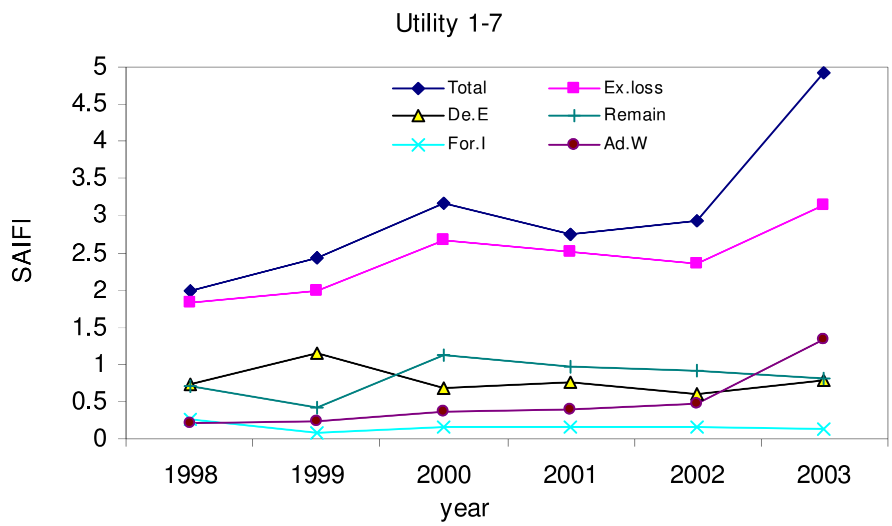


Figure 3.13 Major cause contributions to the SAIFI for Utility 1-7

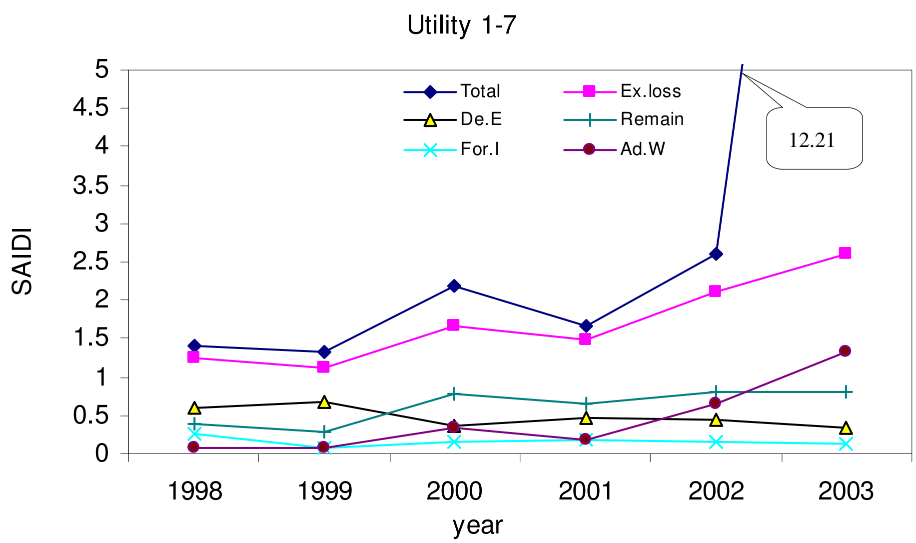


Figure 3.14 Major cause contributions to the SAIDI for Utility 1-7

3.3.2 Integrated utilities: Utilities 2-1 to 2-6

Utility 2-1 is an integrated system with a high circuit ratio and low load density. It can be seen from Figure 3.15 and 3.16 that Loss of Supply has a larger contribution to SAIFI than to SAIDI. Scheduled Outages make a noticeable but relatively constant contribution to SAIDI. Adverse Weather has a significant influence on SAIDI and as can be seen from the sudden increases in 2002 and 2003 creates a major fluctuation in the Total SAIDI index.

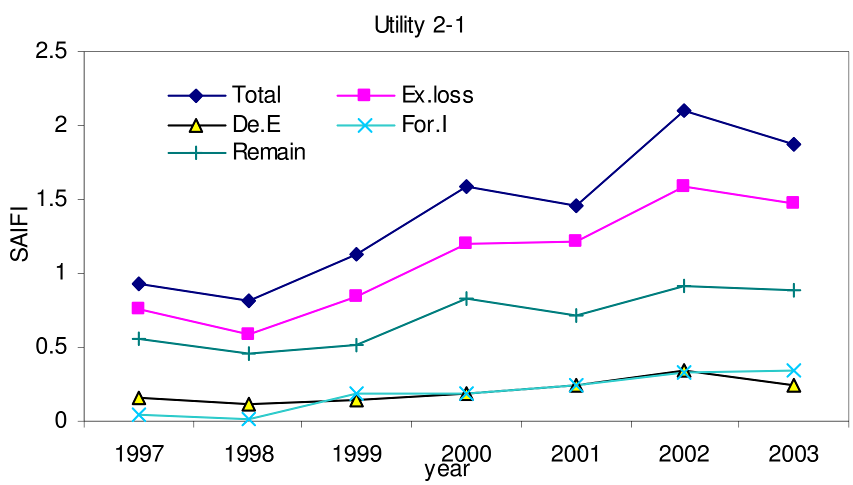


Figure 3.15 Major cause contributions to the SAIFI for Utility 2-1

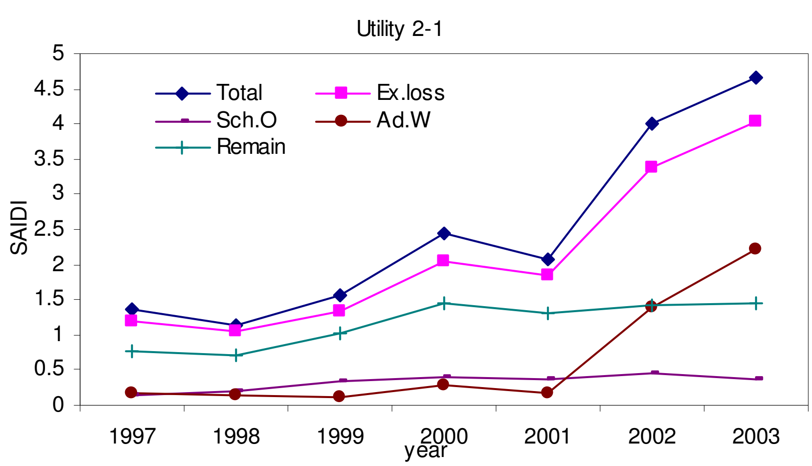


Figure 3.16 Major cause contributions to the SAIFI for Utility 2-1

Utility 2-2 is an integrated system with low load density and a relatively high circuit ratio.

Its performance is shown in Figures 3.17 and 3.18. The Loss of Supply components are very large for this utility. The average percentage contribution due to Loss of Supply is 76% of the Total SAIFI. The other cause codes are relatively small and constant over the years. The contribution of Loss of Supply to the SAIDI is also significant but less than it is to the SAIFI. Adverse Weather also makes a noticeable contribution to the fluctuations in SAIDI. Tree Contact is another important contribution to SAIDI for this utility.

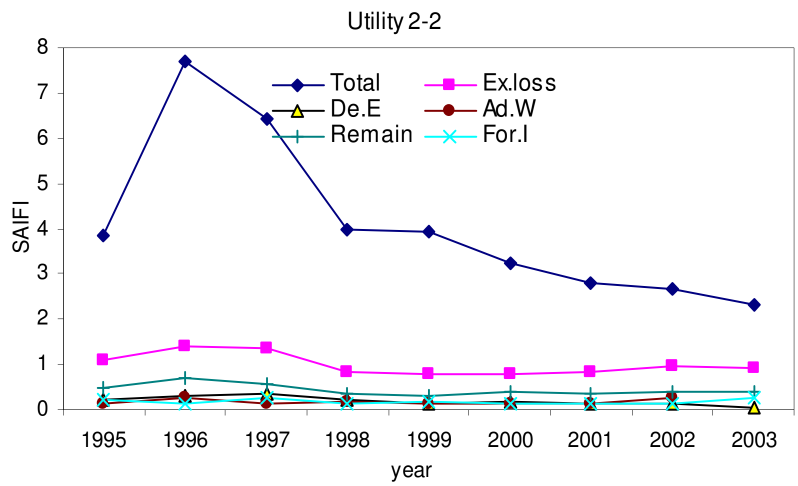


Figure 3.17 Major cause contributions to the SAIFI for Utility 2-2

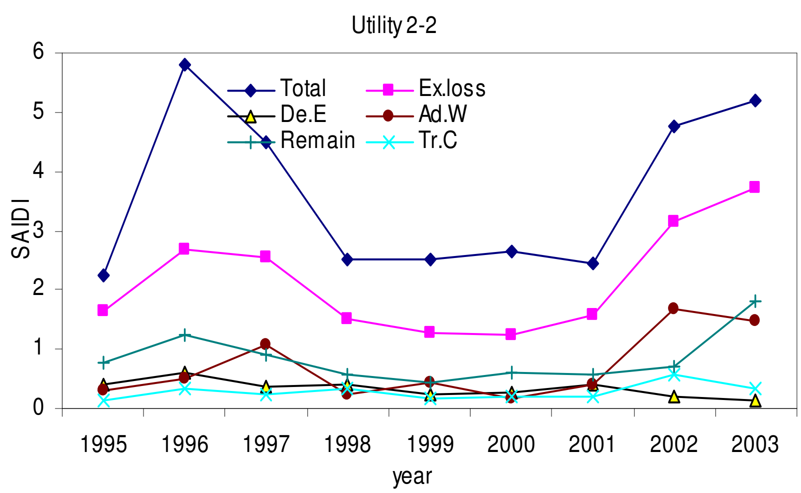


Figure 3.18 Major cause contributions to the SAIDI for Utility 2-2

Utility 2-3 is an integrated utility with a relatively high circuit ratio and relatively low load density. The major contributions are shown in Figures 3.19 and 3.20. It can be seen that Loss of Supply has minimal effect on both the SAIFI and SAIDI indices in the first six years but makes relatively large contributions in subsequent years. Lightning makes a noticeable contribution to the variability of the Total SAIFI. Scheduled Outages make significant contributions to both SAIFI and SAIDI for this utility. The contributions due to Defective Equipment and the Remaining causes are relatively constant. Adverse Weather has more influence on SAIDI than on SAIFI and contributes to the variability of the total index.

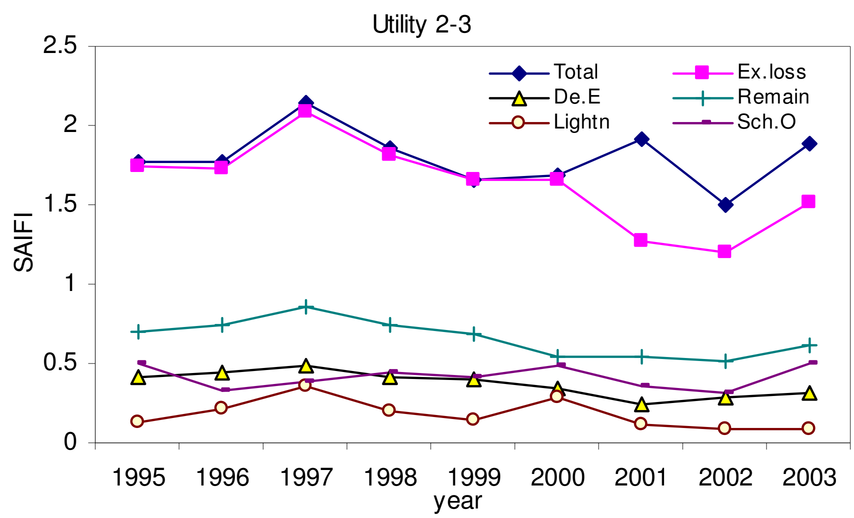


Figure 3.19 Major cause contributions to the SAIFI for Utility 2-3

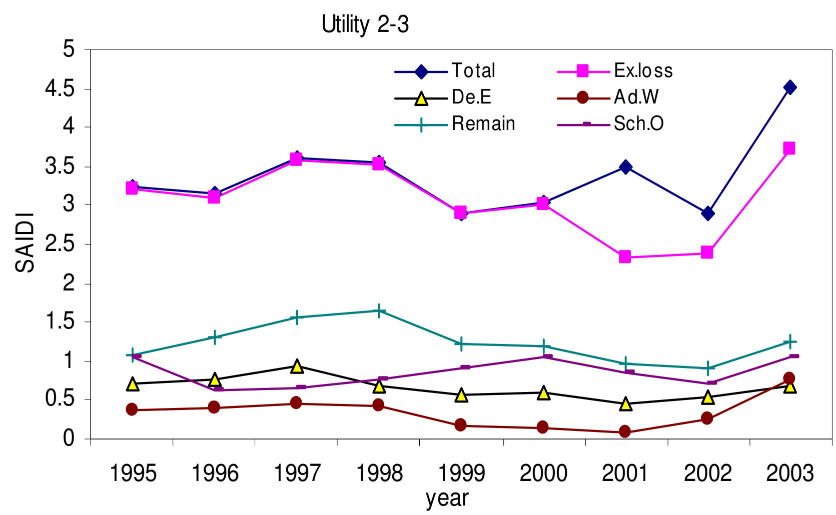


Figure 3.19 Major cause contributions to the SAIDI for Utility 2-3

Utility 2-4 is an integrated system with a relatively high load density and very high circuit ratio. It can be seen that Loss of Supply is a major contributor to SAIFI except in 1998. Scheduled Outages and Adverse Weather are two other important contributors to the overall indices.

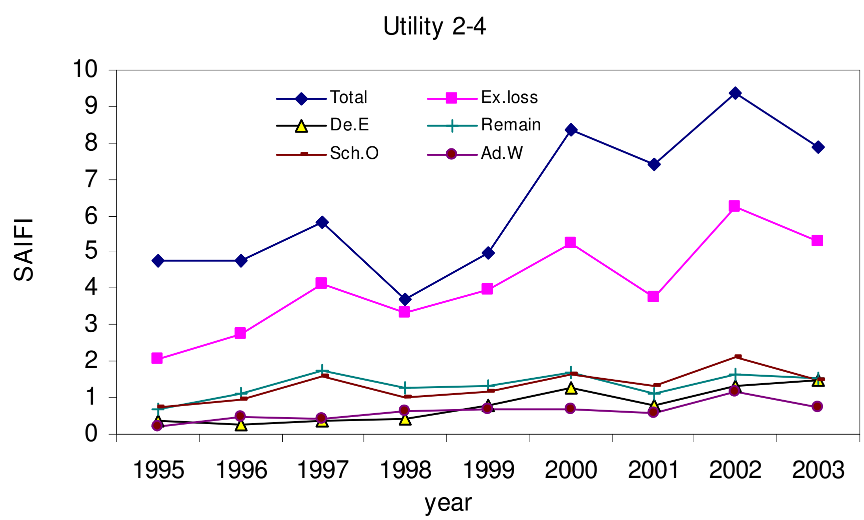


Figure 3.21 Major cause contributions to the SAIFI for Utility 2-4

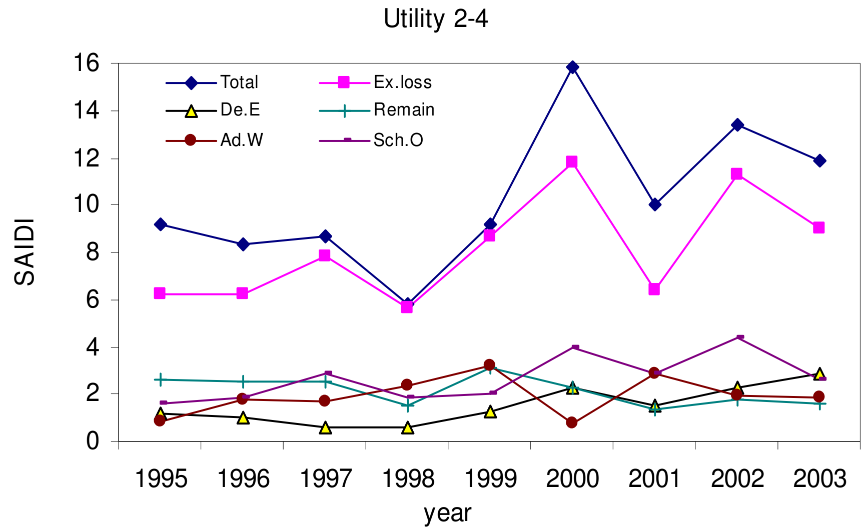


Figure 3.22 Major cause contributions to the SAIDI for Utility 2-4

Utility 2-5 is an integrated system with low load density and high circuit ratio and its cause contributions are shown in Figures 3.23 and 3.24. It can be seen that the Loss of Supply has a significant impact on both SAIFI and SAIDI indices. Scheduled Outages and Adverse Weather are also important contributors and Adverse Weather has a major impact on SAIDI in 1999. The Defective Equipment contribution remains relatively constant over the period.

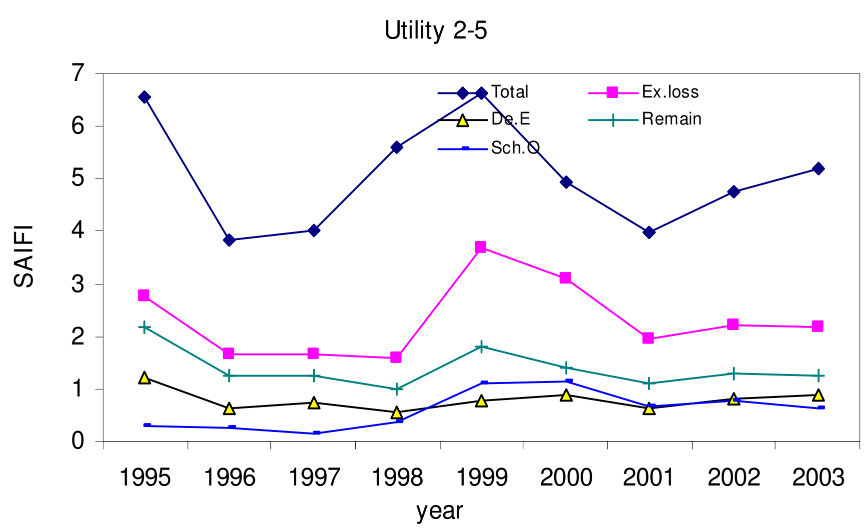


Figure 3.23 Major cause contributions to the SAIFI of Utility 2-5

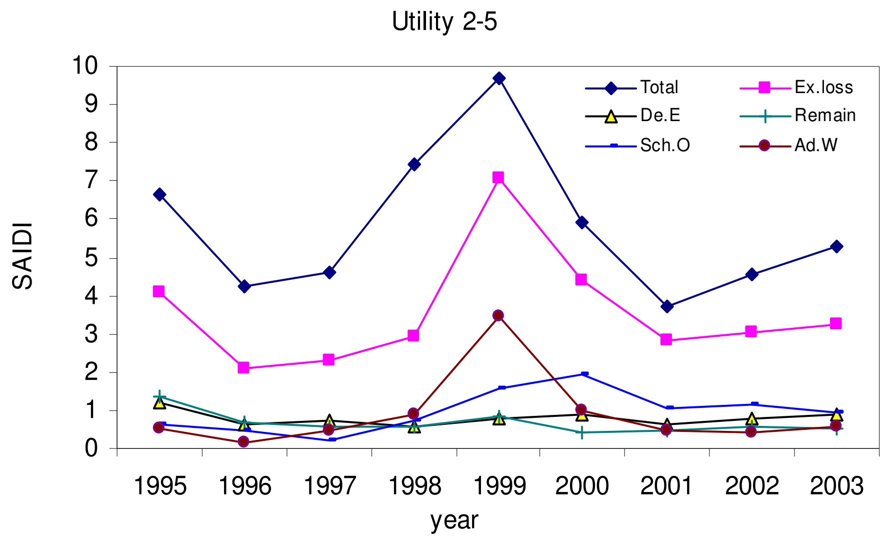


Figure 3.24 Major cause contributions to the SAIDI for Utility 2-5

Utility 2-6 is a large integrated system with a low load density and a relatively high circuit ratio. It can be seen from Figures 3.25 and 3.26 that Loss of Supply makes a very small contribution to the SAIFI and SAIDI indices for this utility. Defective Equipment makes a large contribution to both the annual indices and their variabilities. Lightning is another contributor that has a noticeable influence on the Total indices. Scheduled Outages also make a large contribution that is relatively remains constant over the nine year period.

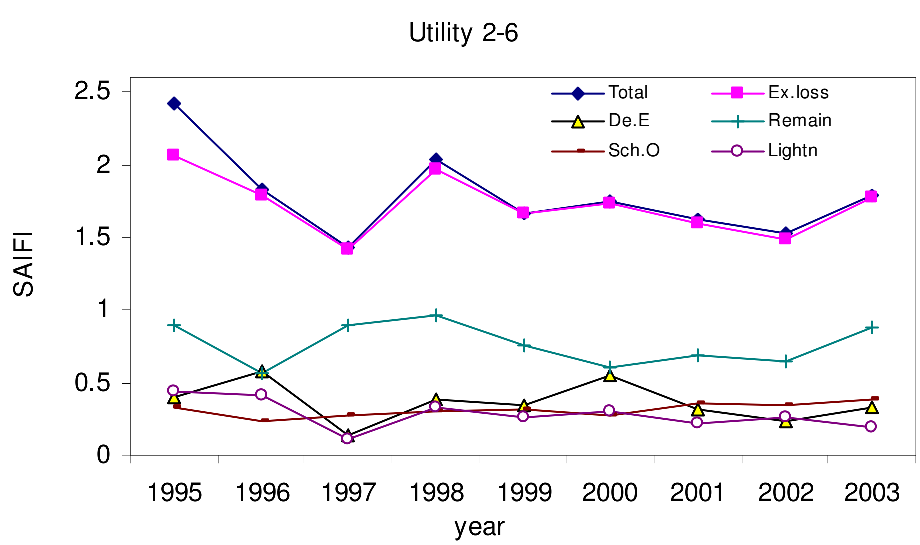


Figure 3.25 Major cause contributions to the SAIFI for Utility 2-6

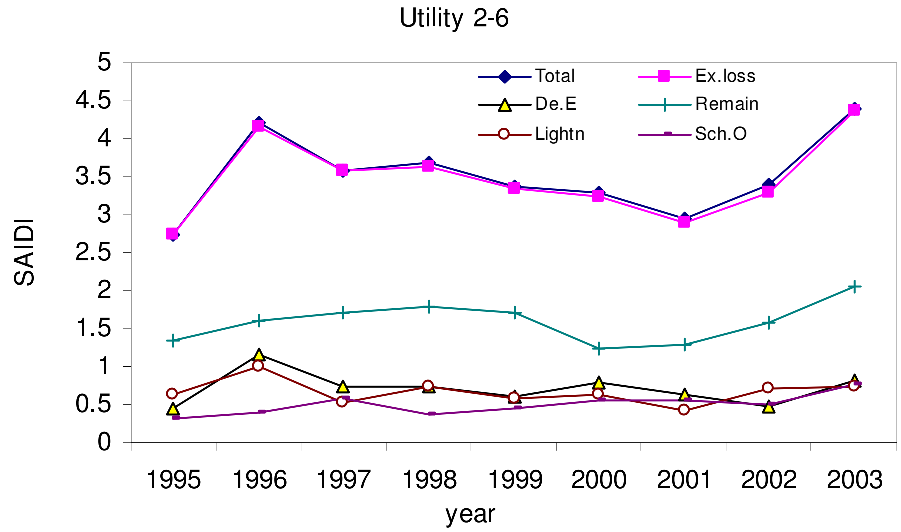


Figure 3.26 Major cause contributions to the SAIDI for Utility 2-6

3.3.3 Region systems

Region 1 is an aggregated utility created by pooling the data for the seven urban utilities (1-1 to 1-7). It has a relatively small service area and a very high load density. The number of underground and overhead circuits in Region 1 is very similar.

It can be seen from Figure 3.27 that the four largest contributors to SAIFI are Loss of Supply, Defective Equipment, Foreign Interference and Adverse Weather. The average Loss of Supply is 28% of the Total index and its variability is also the largest. Defective Equipment and Foreign Interference are two important contributors to SAIFI, but are generally constant. Adverse Weather contributes to the fluctuations in the Total index profile. The SAIDI profile in Figure 3.28 shows that Loss of Supply has a generally smaller effect (about 20%) on the Total index except for 2003 when some utilities experienced the “August 14 blackout” and the resulting long restoration times. Adverse Weather has more influence on SAIDI (15%) than it does on SAIFI (12%).

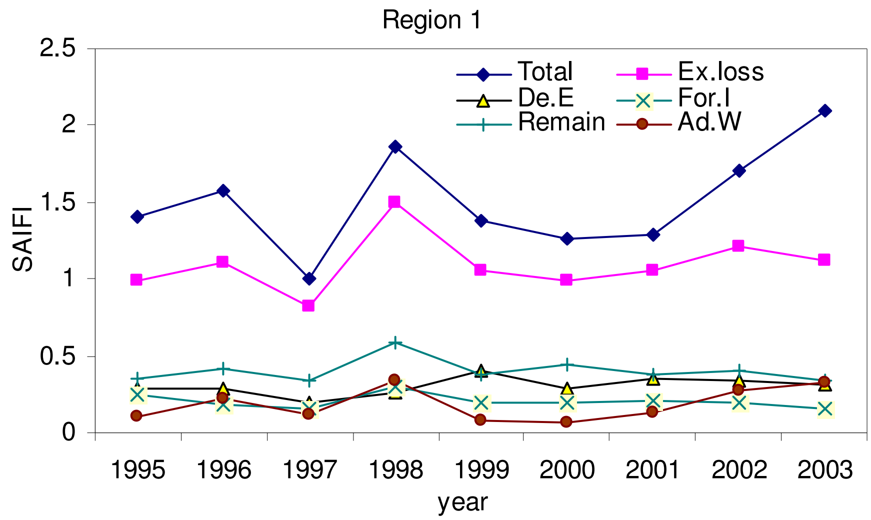


Figure 3.27 Major cause contributions to the SAIFI for System Region 1

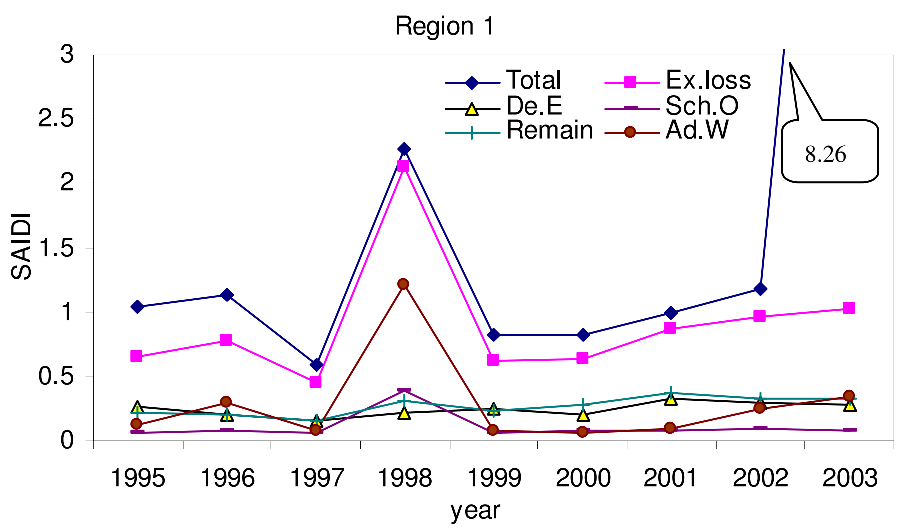


Figure 3.28 Major cause contributions to the SAIDI for System Region 1

Region 2 is the aggregated system created by pooling the data from the six integrated utilities (2-1 to 2-6). The total area served by Region 2 is about 400 times that of Region 1 and the load density is very low. It has also a relatively high circuit ratio. The Total indices of Region 2 are generally higher than those of Region 1, which indicates that the reliability of urban systems is usually better than that of integrated/rural systems.

Figures 3.29 and 3.30 show the major cause codes for Region 2. It can be seen from Figure 3.29 that Loss of Supply makes a significant contribution to the total SAIFI for Region 2. The average Loss of Supply contribution is approximately 35% of the total SAIFI. The others factor are relatively constant. The effect of Loss of Supply on SAIDI is smaller than on SAIFI, and provides 18% of the total SAIDI. Scheduled Outages and Defective Equipment provide slightly higher contributions to SAIDI than to SAIFI. Adverse Weather has almost twice the percentage influence on SAIDI than it has on SAIFI and also has larger variability.

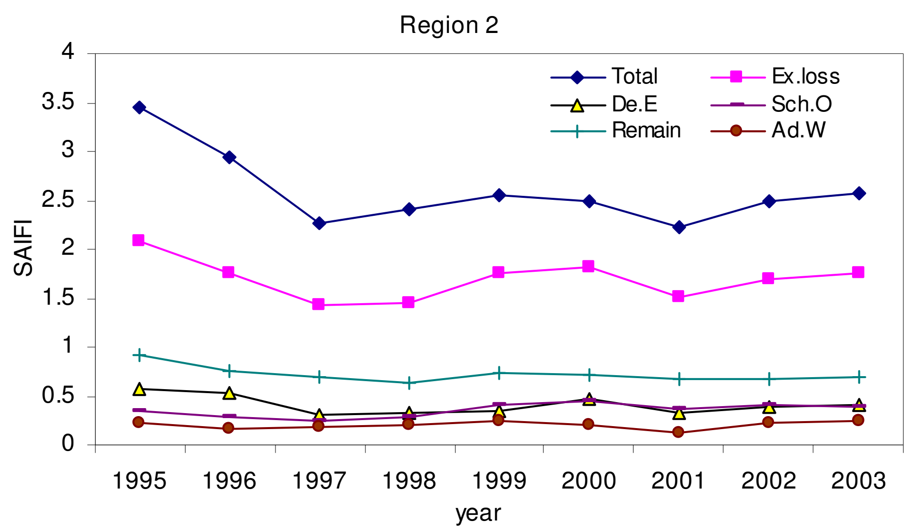


Figure 3.29 Major cause contributions to the SAIFI for System Region 2

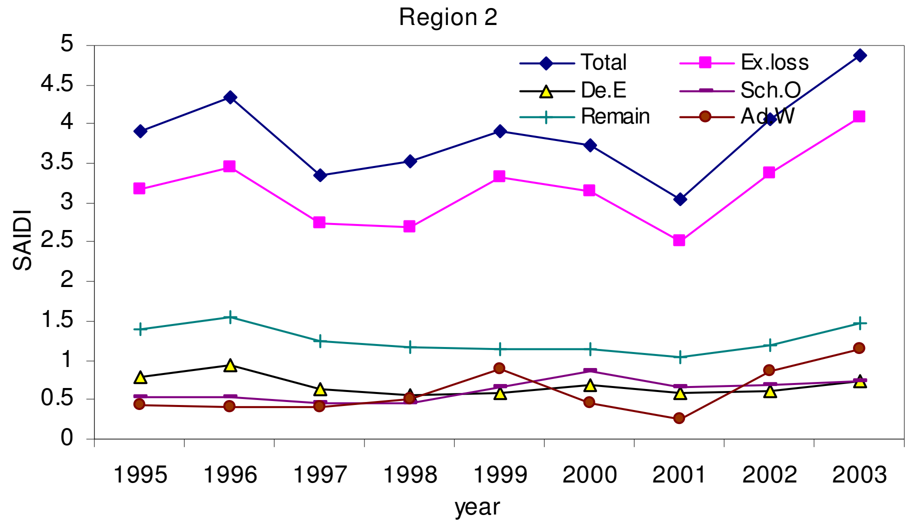


Figure 3.30 Major cause contributions to the SAIDI for System Region 2

Region T is the aggregation of the thirteen individual utilities. It can be seen from Figure 3.31 and 3.32 that Loss of Supply, Scheduled Outages, Defective Equipment and Adverse Weather are the four major contributors to both indices. Loss of Supply has more influence on SAIFI than on SAIDI except for the year 2003. Adverse Weather creates more variability in SAIDI than in SAIFI. The other two contributors are relatively constant.

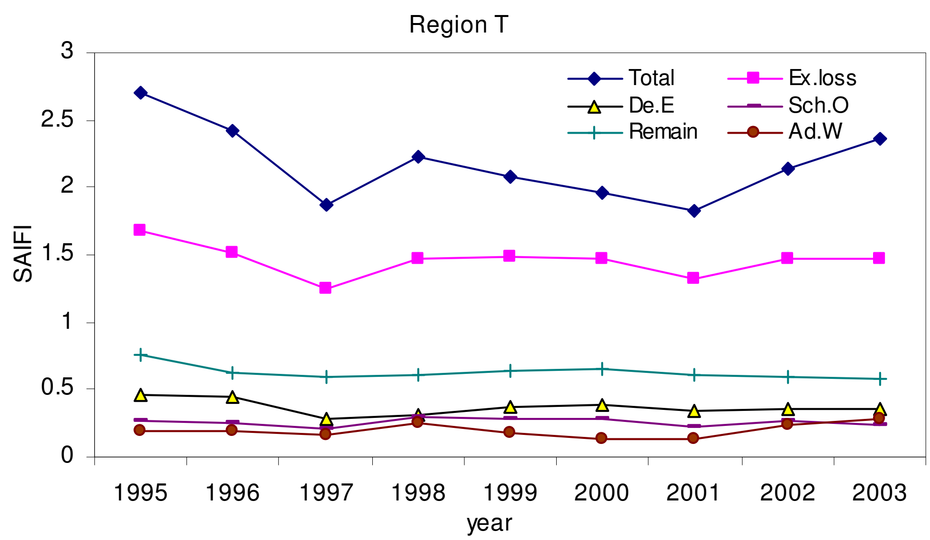


Figure 3.31 Major cause contributions to the SAIFI for System Region T

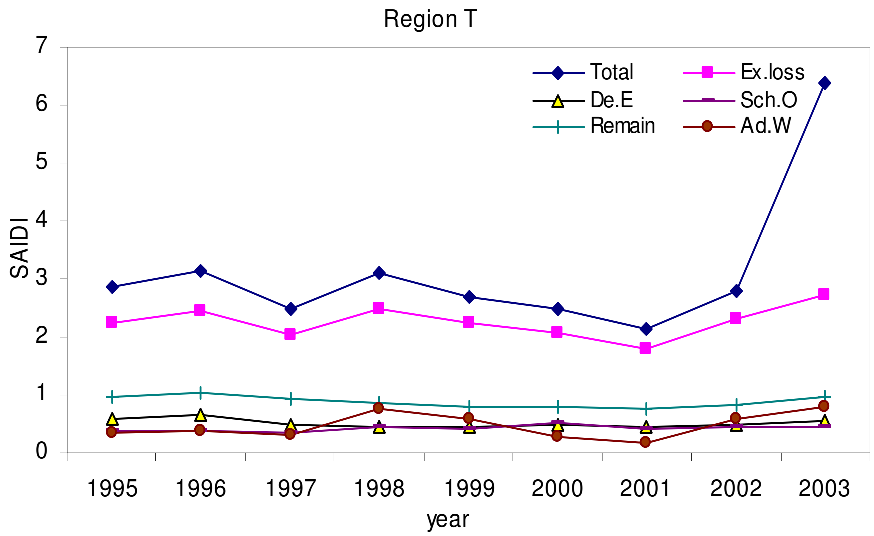


Figure 3.32 Major cause contributions to the SAIDI for System Region T

3.3.4 Canada System

Including IceStorm 98 and the 2003 significant events

The Canada aggregation represents a huge integrated system as described in Chapter 2. The number of customers represented in the Canada system in 2003 is approximately 11.58 million. The service area is approximately 2.83 million km^2, and the peak load is approximately 79,178 MW. The underground and overhead circuit lengths are 112,643 km and 680,275 km respectively. The circuit ratio of overhead to underground is approximately 6.04, and the load density is approximately 28 kW/ km^2. The major cause contributions of system Canada are shown in Figures 3.33 and 3.34. The significant influence on the SAIFI and SAIDI indices of Ice Storm 98 are clearly seen in these figures. Loss of Supply and Adverse Weather are the major contributors to SAIDI in the year 2003. The other cause code contributors are relatively small and constant.

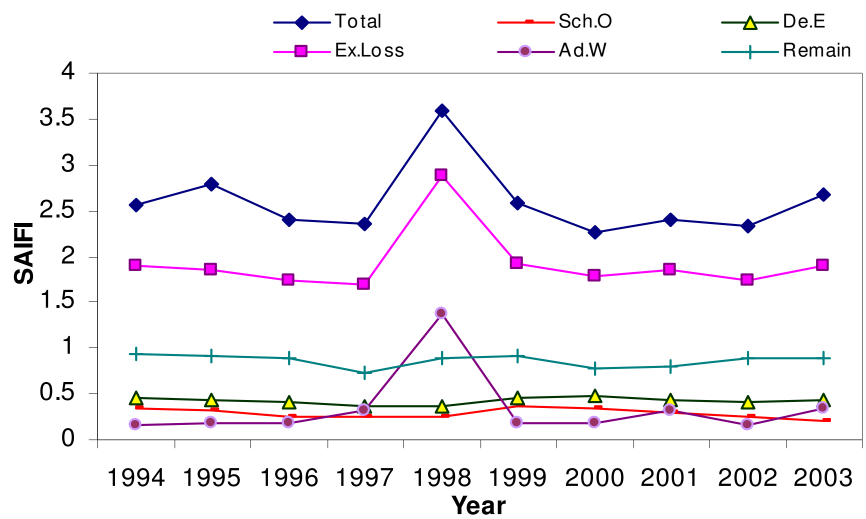


Figure 3.33 Major cause contributions to the SAIFI for the Canada system

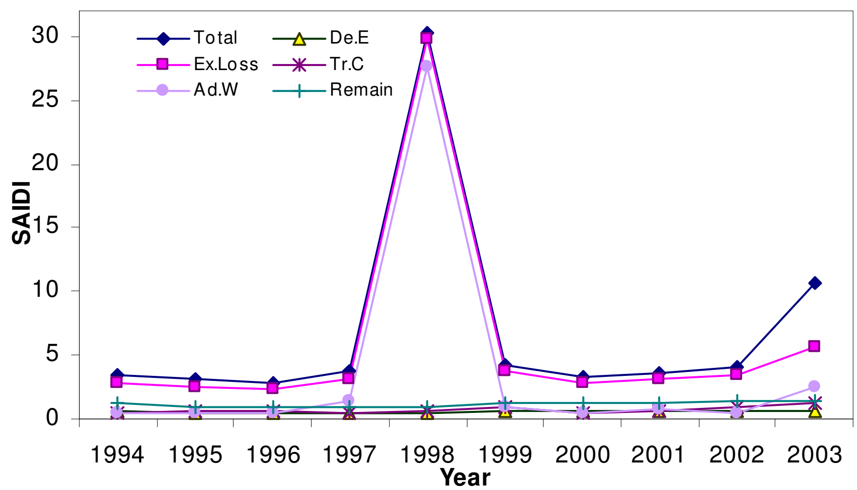


Figure 3.34 Major cause contributions to the SAIDI for the Canada system

Excluding IceStorm 98 and the 2003 significant events

Figures 3.35 and 3.36 show the major cause code contribution for the Canada system excluding the *IceStorm 98* and the *2003 significant events.* It can be seen from Figure 3.35 that Loss of Supply makes a significant contribution to the overall SAIFI and accounts for approximately 30% of the Total index. It also exhibits considerable variability and therefore makes a significant contribution to the annual index variability. Defective

Equipment and Tree Contact provide significant contributions to the annual index but are relatively constant contributors over the ten-year period.

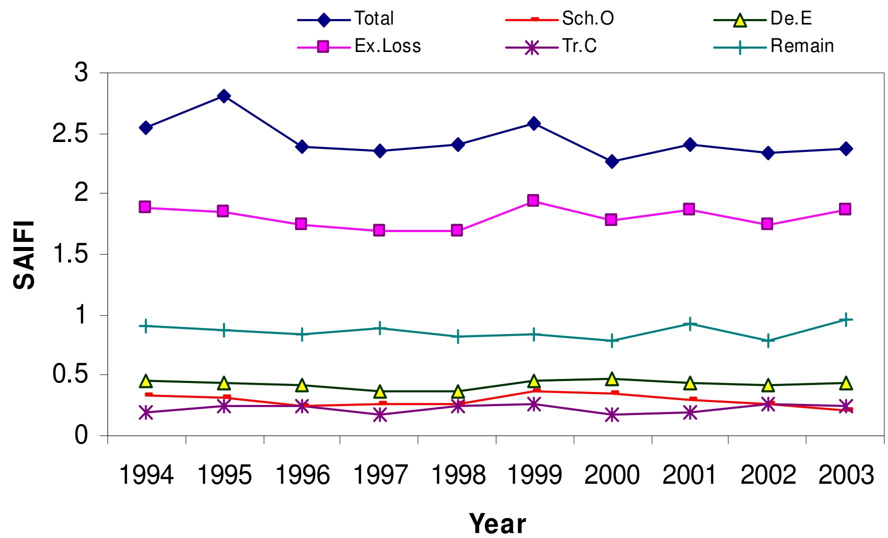


Figure 3.35 Major cause contributions to the SAIFI for the Canada system

Figure 3.36 shows the major cause contributions to the SAIDI index for the Canada system. Loss of Supply makes a relatively smaller contribution to SAIDI compared to its contribution to SAIFI. Adverse Weather is a major contributor to both the annual SAIDI and the variability of the index.

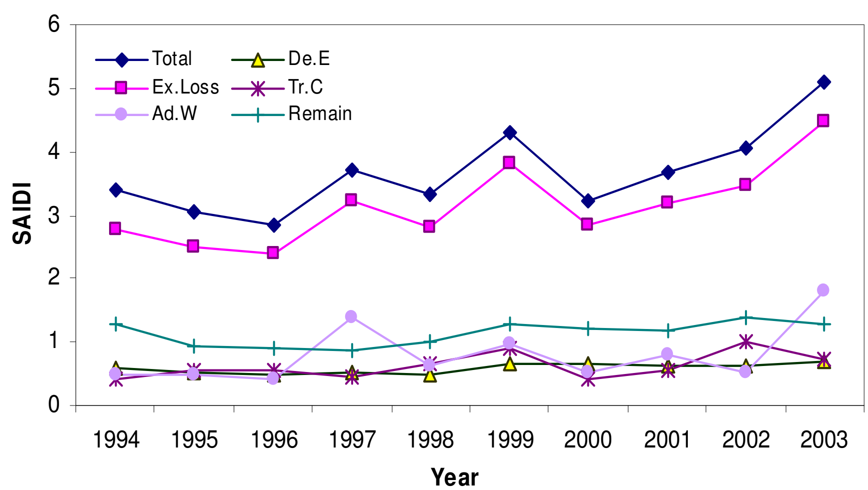


Figure 3.36 Major cause contributions to the SAIDI for the Canada system

3.4 Summary

The CEA Service Continuity Reports indicate the historical performance of the participating Canadian utilities. These data not only include the total indices but the interruption cause contributions, which are very valuable for analyzing utility past performance. The contributions to the service continuity indices can come from quite different causes in urban and rural systems. This chapter presents the interruption contributions for the thirteen utility systems over the last nine years. In general, Foreign Interference, and Lightning have a relatively large effect on the SAIFI of urban utilities. Adverse Weather and Scheduled Outages have a relatively high influence on the SAIDI of integrated utilities. Defective Equipment creates a large contribution to the performance indices in virtually all systems. The system reliability would be improved dramatically if this effect could be reduced. Loss of Supply is the biggest contributor to SAIFI for many utilities and has a significant influence on the 2003 SAIDI of some utilities due to the blackout in eastern Canada.

It is noted earlier in this chapter that the system reliability characteristics of individual utilities differ due to a wide range of factors. The SAIFI and the SAIDI graphs presented in the chapter indicate the performance of thirteen utilities over a nine year period. The difference between the utilities in term of "geography, climate, customer mix, growth rate, system age, resource mix, degree of interconnection, impact of significant events" [28] etc make it very difficult if not impossible to directly compare individual utility performance.

The CEA Policy Paper on Benchmarking Data in Regulatory Settings (BD/RS) notes that there are inherent challenges in attempting to benchmark the performance of a utility with that of other utilities and that "CEA members do not support a peer-to-peer approach when accessing a company's performance" [28]. The analysis and figures presented in this chapter clearly indicate the different cause code contributions to the individual utility service continuity performance. The BD/RS Paper suggests that "trending the performance of an individual utility over time should be used as opposed to peer-to-peer benchmarking."   The data presented in this chapter supports this position.

No attempt has been made in this research to create a suggested index value that all the utilities should attempt to achieve or to compare the performance of one utility with that of another. The SAIFI and SAIDI annual profiles provide valuable information for utilities to compare their current performance with their past performance and to improve their system reliability. Analyses of interruption causes and their contributions are very valuable in system risk assessment and remedial action. The data on the performance of an individual utility over time is expressed in the form of probability distributions in the next chapter and used to create possible reward/penalty structures in a PBR framework and to analyze the potential financial risk faced by a utility.

CHAPTER 4

RELIABILITY INDEX PROBABILITY DISTRIBUTIONS AND RISK ANALYSIS USING R/PS

4.1 Introduction

Regulatory authorities are increasingly considering adopting performance-based regulation (PBR) to provide incentives for distribution utilities to gain economic efficiency. In this approach, a specified service standard is established in order to discourage utilities from sacrificing service reliability while pursuing economic incentives. Performance standards are tied to a reward/penalty structure (R/PS), which can be effectively based on historic reliability records. Risk assessments and remedial work can be performed by integrating the historic data into the PBR plan [27].

The Canadian Electricity Association (CEA) has a long history of recording and disseminating information on the levels of service continuity provided by its member utilities. This chapter utilizes the CEA historic reliability data presented in Chapter 3. Probability distributions are developed to illustrate the potential financial risks associated with assigned reward/penalty structures.

The Ontario Energy Board in Canada has stated that it will use utility historic performance to establish specified service reliability standards, and requires that utilities have at least three years of reliability data. It is worth noting that the Board only requires the utility's current performance to be not worse than its past performance. Utilities therefore, only need to compare themselves with their own past performance rather than with that of other utilities. As noted in Chapter 3, each utility has different geography, configuration, climate, system age, growth rate, customer mix and other factors [28]. It is therefore not reasonable to attempt to create a single uniform fixed framework to assess all utilities. This principle is followed in this research and the reward/ penalty structures introduced in Section 4.3 are based on individual utility past performance.

The Ontario Energy Board did not state in the first generation PBR plan what would happen if utility reliability indices are out of the expected range. After sufficient data are collected, a RPS could be introduced into a second generation PBR plan to encourage electric distribution utilities to maintain appropriate reliability levels. In this case, PBR provides the electricity distribution utilities with incentives to operate efficiently and to innovate. It could also introduce potential financial risks due to the uncertainty associated with future system performance.

4.2 Reliability Index Distributions

Reliability index distributions based on ten year of historical data (from 1994 to 2003) were created for all the thirteen individual utilities. The distributions for two selected utilities are shown in this section and used in a PBR analysis in Section 4.4. Utility 1-3, designated as U1-3, is a small urban utility with high load density and Utility 2-3 designated as U2-3 is an integrated utility with relatively low load density.

The annual performances of these two utilities are represented by the histograms shown in Figures 4.1-4.2. The index distributions are developed using Sturges' Rule [29]. The number of class intervals K and the class interval width W in the histograms shown in Figures 4.1-4.2 are determined using Equation 4.1 and 4.2.

$$K = 1 + 3.3 \times \log_{10} N \qquad \text{N is the total number of samples} \qquad (4.1)$$

$$W = \frac{\max sample\ value - \min sample\ value}{K} \tag{4.2}$$

Table 4.1 Average SAIFI and SAIDI and their standard deviations

System	SAIFI		SAIDI	
	Ave.	S.D	Ave.	S.D
U1-3	1.446	0.880	1.036	0.479
U2-3	1.807	0.175	3.347	0.486

There are only ten observations of each index in this analysis. It was assumed that each system remains relatively constant over the period in regard to design and operational changes. This is a relatively broad assumption. These histograms therefore provide approximate probability distributions of the indices. The histograms contain influences from topological changes, maintenance practices and operational policies. The historical data however, contain valuable information on the variation in the annual SAIFI and SAIDI service continuity indices, and provide an appreciation of the variation that can be expected in the future.

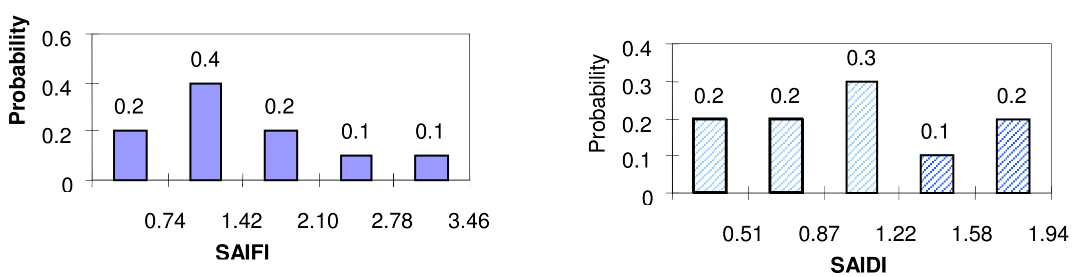


Figure 4.1 Index distributions for Utility 1-3

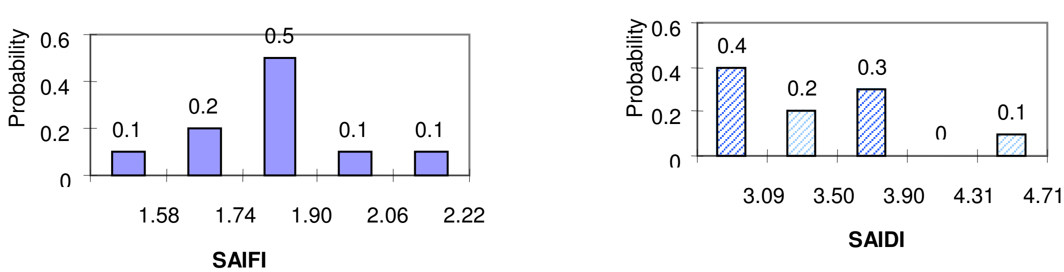


Figure 4.2 Index distributions for Utility 2-3

4.3 Reward/Penalty Structure

A reward/penalty structure (R/PS) integrated in a PBR plan works like a contract between a utility and its regulatory agency. The PBR protocol rewards the utility for providing good reliability and penalizes it for providing poor reliability. A common method of implementing a R/PS is shown in Figure 4.3. This structure has a "dead zone" where neither a penalty nor a reward is assessed. If the reliability is lower than the dead zone boundary, a penalty is assessed. The penalty increases as the performance degrades and is frozen at a maximum penalty value. If the reliability is better than the dead zone boundary, a reward is given. The rewards increase as the performance improves and is frozen when the maximum reward value is reached [27].

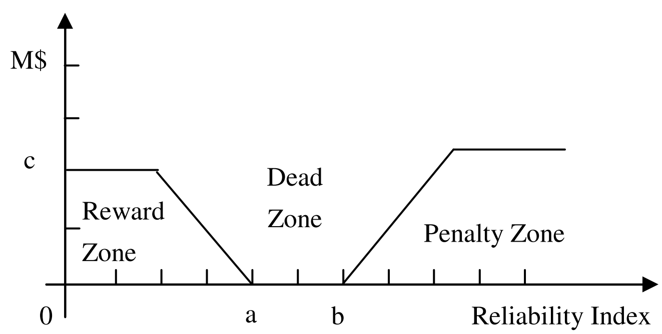


Figure 4.3 A general reward/penalty structure

The structure described in Figure 4.3 can be expressed by a mathematical function, as shown in Equation 4.3. The financial risk associated with an imposed reward/penalty structure (R/PS) can be estimated by combining this structure with a related service reliability index expressed in the form of a probability distribution. The expected system reward/ penalty payment (ERP) is given by Equation 4.4 and could include both SAIFI and SAIDI contributions.

$$R/PS = f(\text{Re}liability \quad Index) \tag{4.3}$$

$$ERP = \sum RPi * Pi \tag{4.4}$$

where *RPi* is the reward/penalty payment for $SAIFI_i$ or $SAIDI_i$;

Pi is the probability of $SAIFI_i$ or $SAIDI_i$.

It can be seen from Equations (4.3) and (4.4) that the imposed reward/penalty structures dictate the system expected reward/penalty payments. Imposed reward/penalty policies should be carefully designed in order to encourage distribution utilities to maintain appropriate reliability levels.

In order to initiate a PBR protocol, the historical average reliability index should reside in the dead zone of the proposed reward/penalty structure, and preferably at the dead zone center. The dead zone width should be related to the standard deviation of the historic data, and was set for illustrative purposes at twice the standard deviation in the studies described in this paper. The remaining parameters in the reward/penalty structure should be related to the incentive philosophy established by the regulatory authority.

4.4 Risk Analysis Using a R/PS

The Ontario first generation PBR plan requires that those utilities that have at least 3 years of reliability data should at minimum remain within the range of their historic performance. Some utilities have collected data for many years while others have virtually no data. Those with long periods of record will undoubtedly have some bad performance years in their records, which will significantly increase the index ranges. These performance levels may not be acceptable in the new regime.

Performance measures in the first generation PBR plan are intended to minimize bad outcomes in the future. After enough reliability data are collected and experience is accumulated, a new scheme involving reward/penalty policies may be introduced in the second generation PBR plan.

As noted earlier, the average historic values of the reliability indices are preferably located at the dead zone centre. The dead zone width was taken to be twice the index distribution standard deviation in the following studies. This process was used to create the dead zones shown in Table 4.2, using the ten years of historical data for the two representative utility systems.

Table 4.2 The dead zones for the representative utilities

System	Dead Zones			
	SAIFI (f/yr)		SAIDI (hr/yr)	
U 1-3	0.566	2.326	0.557	1.515
U 2-3	1.632	1.982	2.861	3.833

The methodology used to establish the dead zone values shown in Table 4.2 provides a consistent approach to create the maximum and minimum bounds based on the utility past performance. The decision to use ± 1 standard deviations is arbitrary and should be studied by the regulator. This approach was used to examine the effect of dead zone location on the two utility systems.

Figure 4.4 shows the SAIFI and SAIDI distributions and the hypothetical R/PS for System U1-3. The figure shows that there is a slightly less than 20% probability of SAIFI being in the penalty zone. There is also a slightly less than 20% probability that the SAIFI will be in the reward zone and a 40% probability that it will be close to the reward boundary. There are little more than 20% probabilities associated with both the reward and the penalty zones for the SAIDI distribution. The distribution of this system's performance is relatively dispersed which increases its financial risk. Figure 4.4 suggests that this utility could decrease its risk and obtain increased benefits by consciously making reliability improvements.

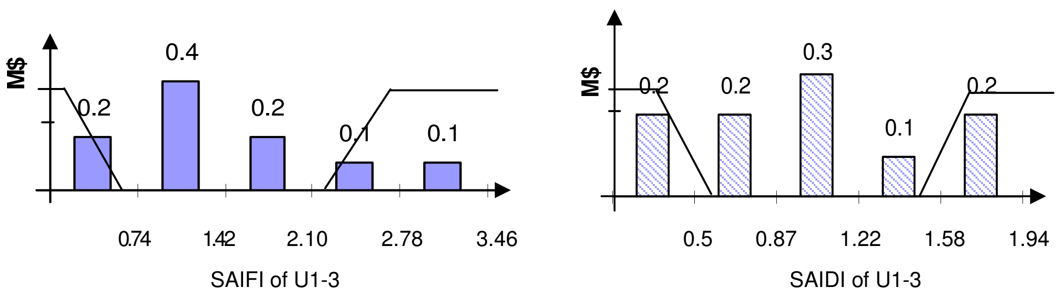


Figure 4.4 Combined SAIFI and SAIDI histograms and hypothetical reward/ penalty structures (U1-3)

Figure 4.5 shows the SAIFI and SAIDI distributions and the hypothetical R/PS for System I. There is a slightly higher than 10% probability of SAIFI being in the reward zone. There is also a slightly higher than 10% probability of SAIFI being in the penalty zone and a slightly lower than 10% probability of SAIFI being close to the penalty zone. There is a slightly lower than 40% probability of SAIDI residing in the reward zone and a 10% probability in the penalty zone. This system could expect to earn rewards in the future, and could earn more through system reliability improvements. Similar analyses were conducted for the remaining systems but are not shown in this thesis.

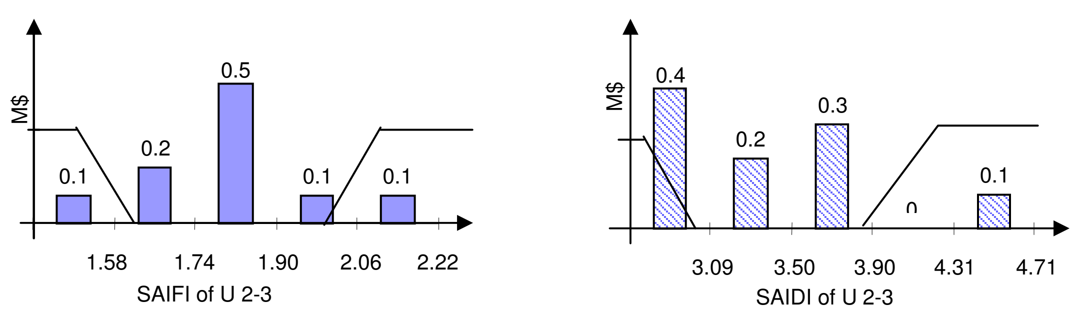


Figure 4.5 Combination of the SAIFI and SAIDI histograms and hypothetical reward/penalty structures (U2-3)

It is difficult to contemplate the application of a RPS for those utilities who have not compiled a history of their reliability performance. The statistics for the first year of record provide a starting point but provide no indication of a reasonable dead zone. A single point dead zone is shown in Figure 4.6 [21].

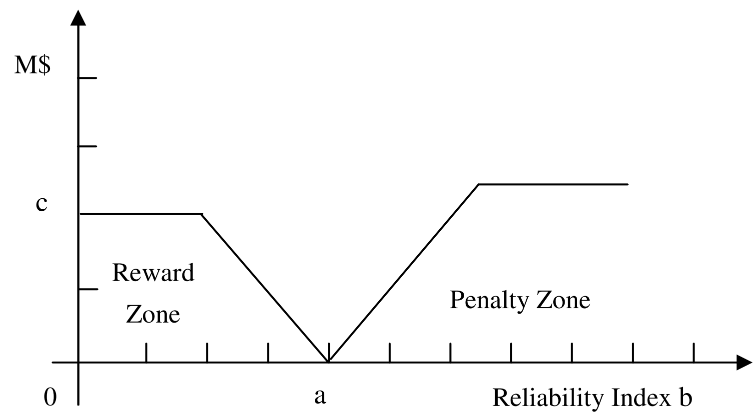


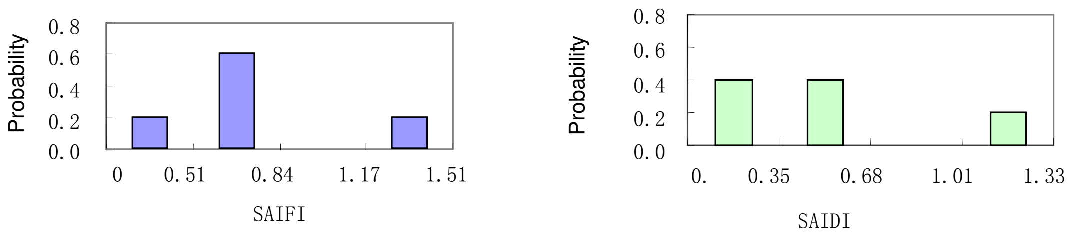
Figure 4.6 The reward/penalty structure without a dead zone

Under the scheme shown in Figure 4.6, a system with a short operating history would face relatively high financial risks due to the fact that there is no prescribed dead zone. It is obvious that in these cases, additional data are required to create a reasonable dead zone.

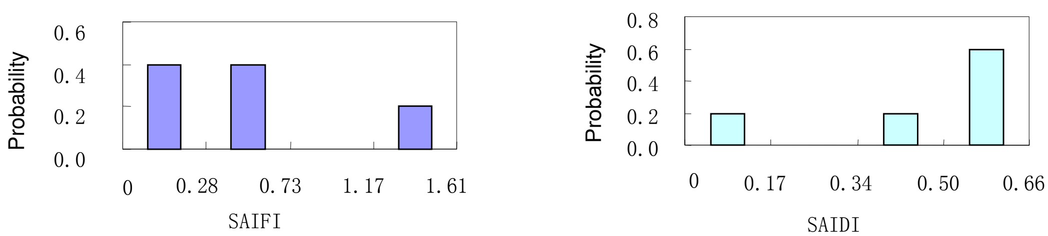
It can be seen from the above discussion that considerable care is required to establish appropriate dead zone boundaries for both SAIFI and SAIDI. These boundaries should not unduly penalize a utility and should provide appropriate incentives for a utility to improve its reliability performance. A reward/penalty structure based on the distributions associated with historical utility performance could permit the examination of the potential financial risk to a utility and provide a consistent and progressive approach to performance based regulation.

4.5 SAIFI and SAIDI distributions based on five year performances

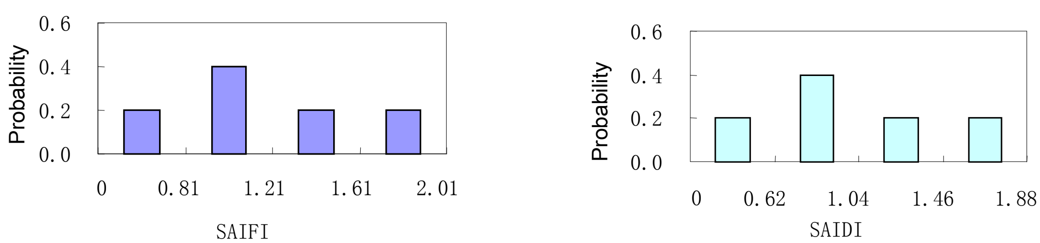
The analysis described in the previous section is based on utility performance over the past ten years. More data is generally better from the statistical point of view as it provides a comprehensive reflection of the system performance. The configuration, topology or the management philosophy of a system, however, could change considerably over a long period and therefore make the analysis invalid. In was therefore decided to use a five year period of record. Similar periods have been used in utility analysis and by the CEA. Five year reliability index distributions are used to illustrate utility past performance in this section. The performance index distributions using the data from 1999-2003 for the thirteen utilities are shown in Figure 4.7.



Index distributions for utility 1-1

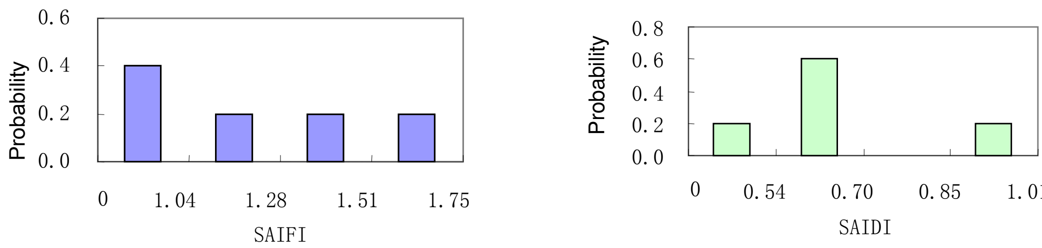


Index distributions for utility 1-2

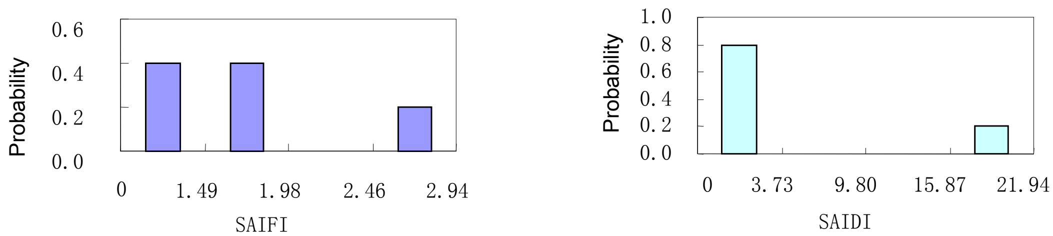


Index distributions for utility 1-3

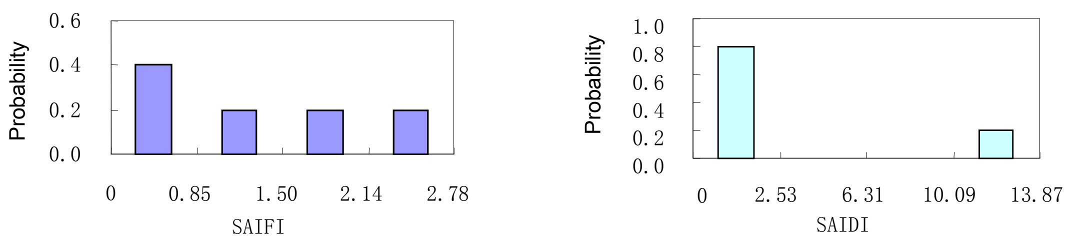
Figure 4.7 SAIFI and SAIDI distributions for the thirteen utilities



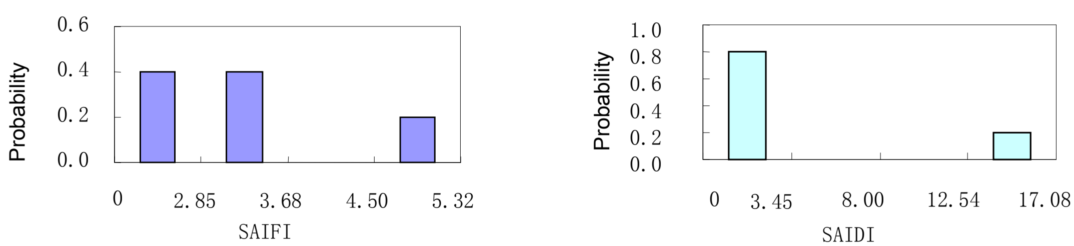
Index distributions for utility 1-4



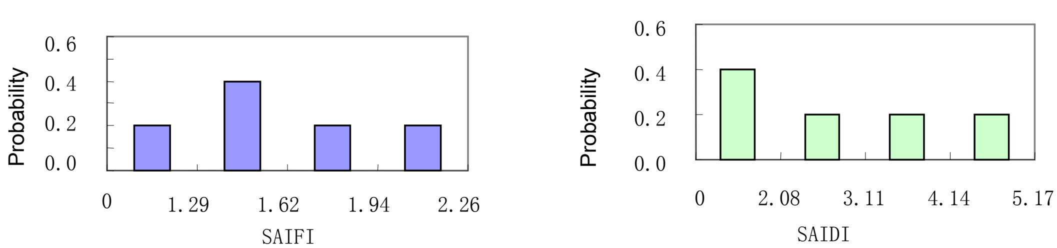
Index distributions for utility 1-5



Index distributions for utility 1-6

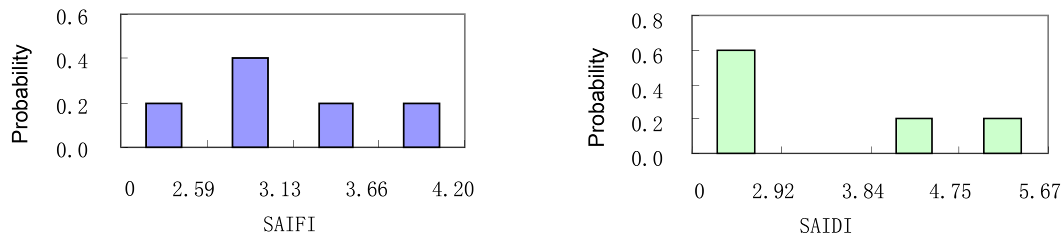


Index distributions for utility 1-7

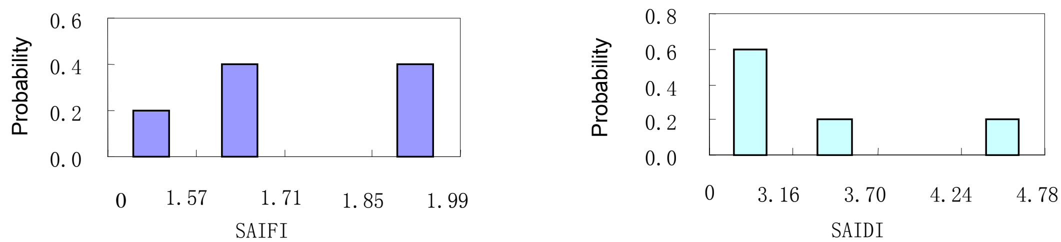


Index distributions for utility 2-1

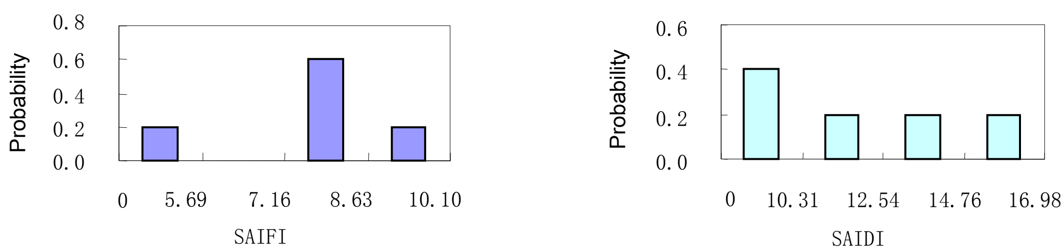
Figure 4.7 SAIFI and SAIDI distributions for the thirteen utilities (Continued)



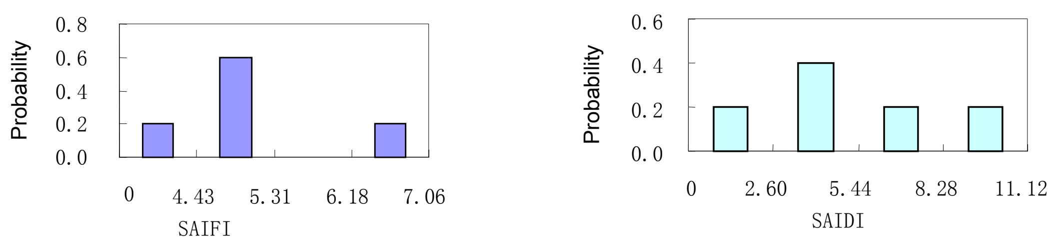
Index distributions for utility 2-2



Index distributions for utility 2-3



Index distributions for utility 2-4



Index distributions for utility 2-5

Index distributions for utility 2-6

Figure 4.7 SAIFI and SAIDI distributions for the thirteen utilities (Continued)

Using the SAIFI profile for Utility 1-1 as an example, the value "0.51" on the SAIFI axis represents the SAIFI values between 0 and 0.51, not including 0.51. The value "0.84" represents the SAIFI value between 0.51 and 0.84, not including 0.84 and so on. The other graphs follow the same rule. The distributions shown in Figure 4.7 provide a pictorial view of the performance of each utility. The system risk analysis in the next section is conducted using the actual data values rather than the distributions.

The histograms in Figure 4.7 show the index distributions of the thirteen utilities over the five year period and provide valuable information. The performances of the individual utilities vary considerably due to the different system characteristics. Some utilities have wide performance ranges while others have narrower ranges. The distributions also have quite different variant axis scales. It is therefore not possible to directly compare these distributions for the purpose of comparing utility reliability performance.

4.6 Utility Risk Assessment

4.6.1 Introduction to risk assessment

As noted earlier, CEA members do not support a peer-to-peer approach when assessing company performance and particularly to establish pass/fail criteria for breach and consequence, due to the complexity associated with identifying true "peers". As a result of the complexity of "peer" benchmarking, it has been proposed that trending the performance of an individual utility over time should be used as opposed to peer-to-peer benchmarking [28]. In this research, the establishment of utility reward/penalty structures are based on the individual utility performances itself rather than the performances of other utilities.

There are many ways to establish a reward/penalty structure. The performance index mean values and the standard deviations are valuable indicators of the magnitude and dispersion of the indices. They are also easily calculated and understand. Ideally, the data should cover a number of years. As noted earlier, this is not always possible. The Ontario Energy Board noted that a utility should collect at least three years of data in order to provide a good reference.

The following section presents an analysis of the financial risk for the two sample utilities in 2004. These utilities have five year of data (1999-2003) and the systems are assumed to have remained relatively constant during this period. In this analysis, the Average minus the Standard Deviation (Ave.-S.D) and the Average plus the Standard Deviation (Ave.+ S.D) are utilized as the reward and penalty threshold values.

It is assumed in this analysis that if the reliability index in the next year is lower than the Ave.-S.D, the utility will receive a 10 M$ reward. If the utility's reliability index in the next year is higher than the Ave.+ S.D, the utility will face a 10 M$ penalty (Figure 4.8). This is a simple hypothetical R/PS.

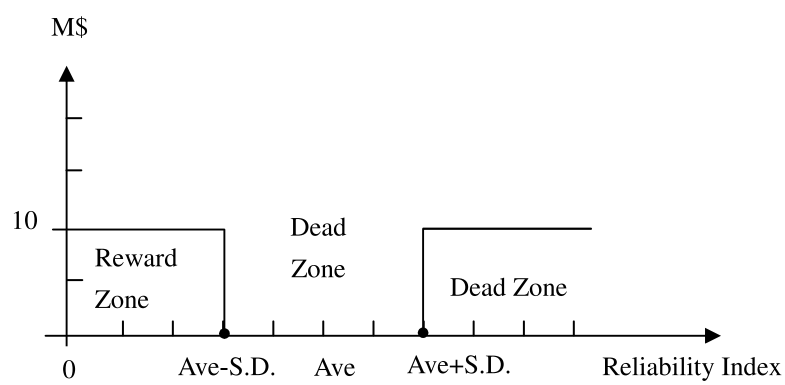


Figure 4.8 The hypothetical Reward /Penalty Structure

The focus in this study is on the dead zone boundaries of the reward/penalty structure. The threshold slopes of the R/PS are assumed to be vertical as shown in Figure 4.8. This makes the financial impact very intense. It could be gentler and more gradual by giving each boundary a slope factor.

The analysis assumes that the utility regulator will use different past year data sets to establish the R/PS. The following presents a comparison of the Expected Payment to/from the utility assuming that 5 year, 4year, 3year, 2year, and 1 year data sets are used to create the R/PS.

In reality, a regulator would not assess a utility based only on its performance of the last year. The mean values created from 3 to 5 year data sets provide a reasonable indication of the utility's past performance and is used as the midpoints of the R/PS dead zone. The width of the dead zone is an important parameter in an R/PS and should be carefully considered by the regulator. The dead zone width of two S.D. used in this study is quite arbitrary and the impact of changing the dead zone width is considered later in this thesis. It is important to note that the 1 year – 5 year data sets are used to create the R/PS used in this analysis. The probability of a utility achieving a certain SAIFI or SAIDI value are determined by the performance of that utility over the past five years. This performance is shown pictorially by the index probability distributions in Figure 4.7. The SAIDI distribution of Utility 1-3 is used in the next section to illustrate the procedure.

4.6.2 Case study of R/PS using different year data bases

The SAIDI distribution of Utility 1-3 is selected as an example to illustrate the R/PS. Figure 4.9 shows the five R/PS obtained using the different year data sets imposed on the SAIDI distribution (1999-2003) of Utility 1-3. In this figure, "2 yrs" means the R/PS is created using the average value and standard deviation for the past 2 years (2002-2003), "3 yrs" indicates Ave. and S.D. for the past 3 years (2001, 2002, 2003) and so on.

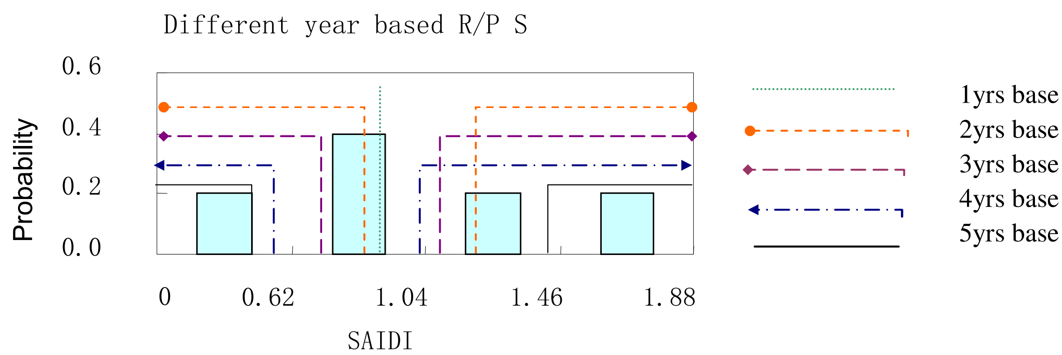


Figure 4.9 Different R/PS with the SAIDI distribution for Utility 1-3.

The graph shows a pictorial view of the impact of different R/PS on the system index distribution. It can be seen that in the 1 year based R/PS, there is only one boundary that splits the distribution into two parts. The probability of getting a reward or penalty for this utility is large and therefore so is the risk. In this particular case, it can be seen that moving from a 2 year to 5 year based R/PS creates a shift in the dead zone of R/PS from the right to the left, which makes the probability of receiving a reward decrease. The width of the dead zone increases, which makes the probability of zero payment (no reward/penalty) larger and at the same time, reduces the probability of a penalty.

The financial risks to the utility using the five data sets are shown in Table 4.4 for Utility 1-3. The expected reward penalty payment (ERP) is calculated using Equation 4.4 and is shown simply as the "Expected Payment" in subsequent tables. A positive Expected Payment means the utility receives money and a negative value indicates it should pay money to the regulator. It can be seen from Table 4.4 that the S.D. of the annual SAIDI increases with the move from 1yr to 5yr data. The boundaries of the dead zone depend on the average value and standard deviation of the data sets. As the Ave. increases, the R/PS moves to the right and as the S.D. increases the dead zone widens.

The largest probability of a reward due to SAIDI is using the 1yr and 2yr based R/PS. In this case, the probability of a reward is 60% and 40% respectively. The probability of a reward is 20% in the 3yr, 4yr and 5yr based R/PS. The range of the dead zone is similar for the 2yr, 3yr and 4yr data sets. The probability of the SAIDI being in the 5yr dead zone is 60%. This reduces to 40% for the 2, 3, 4yr dead zones and 0% in the 1yr dead zone.

Table 4.4 System financial risks using different year based R/PS, Utility 1-3

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Probability Penalty	Probability D.Z.	Expected Payment
SAIFI						
5-year data	1.142	0.456	20%	20%	60%	0.00 M$
4-year data	0.975	0.303	20%	40%	40%	-2.00 M$
3-year data	1.097	0.221	20%	40%	40%	-2.00 M$
2-year data	1.175	0.247	20%	20%	60%	0.00 M$
1-year data	1.000	0.000	60%	40%	-0%	2.00 M$
SAIDI						
5-year data	0.942	0.469	20%	20%	60%	0.00 M$
4-year data	0.760	0.270	20%	40%	40%	-2.00 M$
3-year data	0.877	0.166	20%	40%	40%	-2.00 M$
2-year data	0.955	0.134	40%	20%	40%	2.00 M$
1-year data	0.860	0.000	60%	40%	-0%	2.00 M$

D.Z: Dead Zone

Although the expected payment is positive using 2yrs as the R/PS reference, it is based on only two observations. The actual payment could be quite volatile and the R/PS may not provide a valid measure of the performance of the system. There is only one data point in a 1yr based R/PS and the distribution is divided into only two sections, the reward and penalty zones. There is no dead zone in this condition and as noted at the beginning of this chapter, a utility could face a large financial risk if there is no dead zone. It also can be seen from the Table 4.4 that the expected financial payments based on 1 and 2yr data are rewards. The expected financial payments based on 3 and 4 yr periods are all penalties. As noted above, there is considerable variability associated with a 1 to 2 yr structure. Using 3 to 5yr data sets to create an R/PS provides a more stable framework.

Based on the above analysis, this utility could be facing a penalty based on its historical performance. This is a warning to this utility and if it can make some improvements to its system, it is quite possible that it will escape the penalty. Table 4.5 shows the financial risks and the expected payments for Utility 2-3. Similar results for the remaining eleven utilities are shown in Appendix 1.

Table 4.5 System financial risks using different year based R/PS, Utility 2-3

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Probability Penalty	Probability D.Z.	Expected Payment
SAIFI						
5-year data	1.728	0.172	20%	20%	60%	0.00 M$
4-year data	1.745	0.194	20%	0%	80%	2.00 M$
3-year data	1.767	0.232	20%	0%	80%	2.00 M$
2-year data	1.690	0.269	0%	0%	100%	0.00 M$
1-year data	1.880	0.000	80%	20%	0%	6.00 M$
SAIDI						
5-year data	3.366	0.686	0%	20%	80%	-2.00 M$
4-year data	3.482	0.733	0%	20%	80%	-2.00 M$
3-year data	3.633	0.818	0%	20%	80%	-2.00 M$
2-year data	3.700	1.146	0%	0%	100%	0.00 M$
1-year data	4.510	0.000	100%	0%	0%	10.00 M$

In Table 4.4, the expected payments based on SAIFI and SAIDI are very similar. This is not the case for Utility 2-3 as shown in Table 4.5. In this case, the utility receives a reward based on the 3 and 4yr SAIFI data set and a penalty based on the 3-5yr SAIDI data sets. This could indicate to the utility that attention should be paid to the service restoration practices and policies employed by the utility and improvements made in this regard.

The results shown in Table 4.4, 4.5 and Appendix 1, indicate that if the regulator sets the reward/penalty structure based on the 1yr data, most of the thirteen utilities have extremely high reward probabilities compared to those of other year based R/PS. All the expected payments are positive except for Utility 1-4 and the SAIFI of Utility 2-2. This also implies that the last year (2003) was a generally bad performance year for most of the utilities. This therefore has a big influence on the R/PS. If a single high value is utilized to set the

R/PS, most of the probability will fall on the left side, which is the reward zone. The calculated expected payment in the next year looks quite positive but may not reflect the actual situation and characteristics of the utility.

4.7 Analysis of the R/PS for Three Hypothetical Dead Zone Widths

In the previous section, the dead zone width is determined using Ave.±1 S.D. The financial risk and expected payment could change if the dead zone width is changed. The analysis in this section is focused on the influence of different dead zone widths on the system financial risk. This study uses the 5yr data sets to establish the R/PS dead zone center and 0.5 standard deviations (0.5 S.D.), 1standard deviation (1.0 S.D.) and 1.5 standard deviations (1.5 S.D.) are used to determine the dead zone widths.

4.7.1 Analysis of Utility 1-3

SAIFI of Utility 1-3

Figure 4.10 shows the 5 year data distribution for SAIFI and the three R/PS for Utility 1-3.

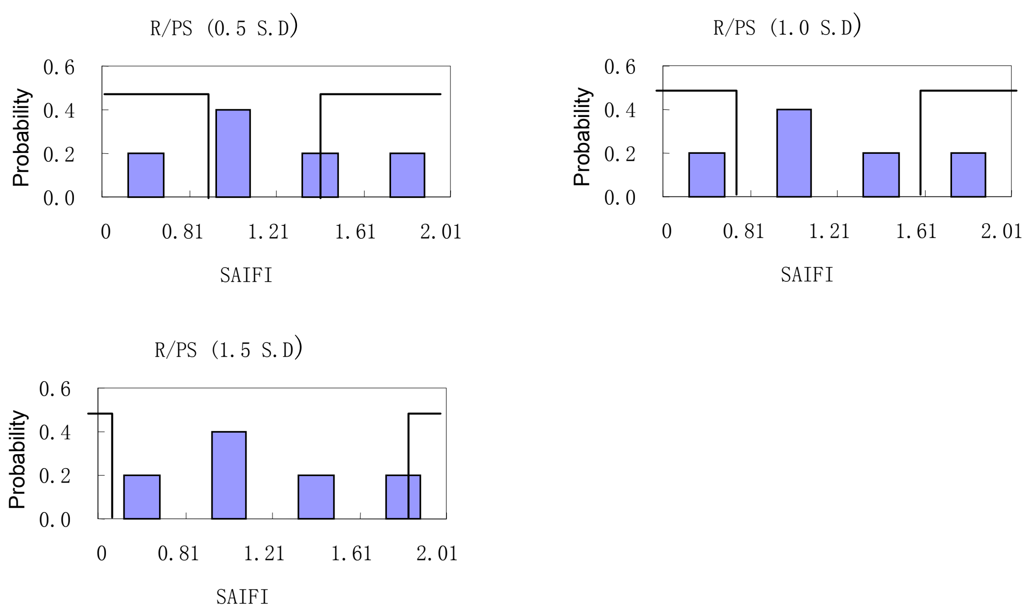


Figure 4.10 Three hypothetical dead zone widths on the SAIFI distribution for U1-3

The three diagrams in Figure 4.10 illustrated pictorially how the dead zone probabilities increase as the dead zone width increase. If the band is large, there will be very little reward or penalty and therefore no incentive for improvement

Table 4.6 shows a quantitative comparison of the three R/PS using the different dead zone widths and the SAIFI data. It can be seen from this table that when the dead zone is based on 0.5 S.D, which is the smallest range, the probability of reward and penalty are both 20%. When the dead zone is based on 1.0 S.D., the probabilities remain the same. They are both 0% for the 1.5 S.D case. Case 3 has the largest dead zone and this system has the lowest risk for the three cases and a zero probability of obtaining a reward.

Table 4.6 Comparison of the R/PS for the three dead zones on the SAIFI distribution for U1-3

Case	1	2	3
R/P S	0.5 S.D	1.0 S.D	1.5 S.D
Ave.	1.142	1.142	1.142
S.D.	0.456	0.456	0.456
D.Z. boundary	0.914~1.370	0.686~1.598	0.457~1.827
Risk	Probability		
Reward	20%	20%	0%
Penalty	20%	20%	0%
Zero	60%	60%	100%
Exp. Payment (M$)	**0.00**	**0.00**	**0.00**

D.Z.: Dead Zone

SAIDI of Utility 1-3

Figure 4.11 shows the 5 year data distribution for SAIDI and the three R/PS for Utility1-3. The effect of increasing the dead zone width is similar to that shown for SAIFI in this case.

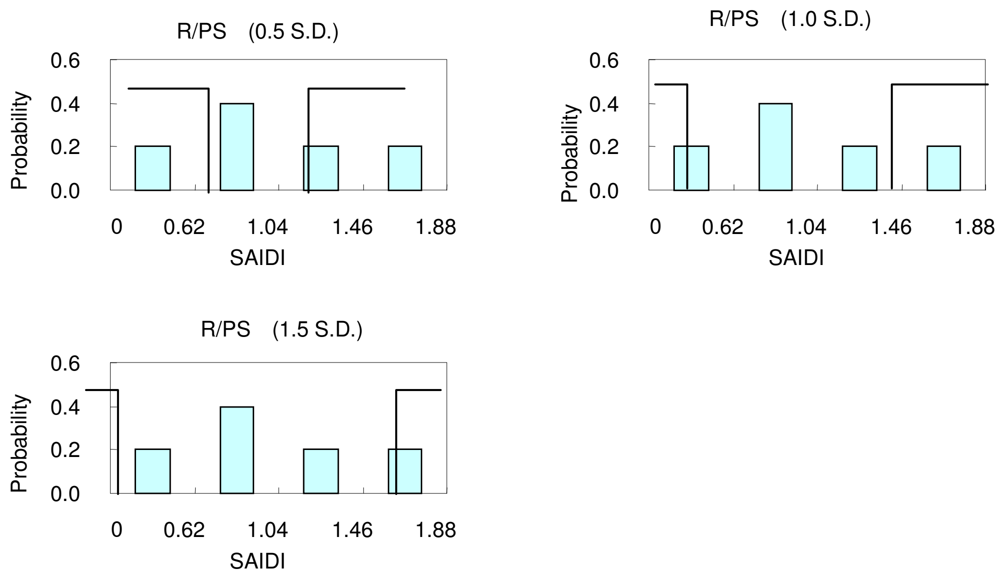


Figure 4.11 Three hypothetical dead zone widths on the SAIDI distribution for U1-3

Table 4.7 shows the quantitative effects when the three dead zones are applied to the SAIDI distribution. The results are similar to those for SAIFI. The probabilities of both reward and penalty for Case 1 and 2 are 20% and are 0% and 20% respectively in Case 3.

Table 4.7 Comparison of the R/PS for the three dead zones on the SAIDI distribution for U1-3

Case	1	2	3
R/P S	0.5 S.D	1.0 S.D	1.5 S.D
Ave.	0.942	0.942	0.942
S.D.	0.469	0.469	0.469
D.Z. boundary	0.707~1.177	0.473~1.411	0.238~1.646
Risk	Probability		
Reward	20%	20%	0%
Penalty	20%	20%	20%
Zero	60%	60%	80%
Exp. Payment (M$)	**0.00**	**0.00**	**-2.00**

D.Z.: Dead Zone

The peak value in the SAIDI distribution is skewed to the left and the tail to the right is longer than the tail to the left. A distribution with such a shape is said to be positively skewed. In this case, when the dead zone is narrow, the probability of SAIDI falling in the reward zone is large. As the dead zone widens, the probability of a reward is reduced. The probability of a penalty also reduces but some remains due the long tail of the SAIDI distribution. The expected payment is 0M$ for the 0.5 S.D and 1.0 S.D R/PS. A financial penalty of 2.0M$ will be charged to Utility1-3 if the 1.5 S.D R/PS is applied.

4.7.2 Analysis of Utility 2-3

SAIFI of Utility 2-3

Figure 4.12 and Table 4.8 show a similar analysis of the R/PS dead zone width for Utility2-3.

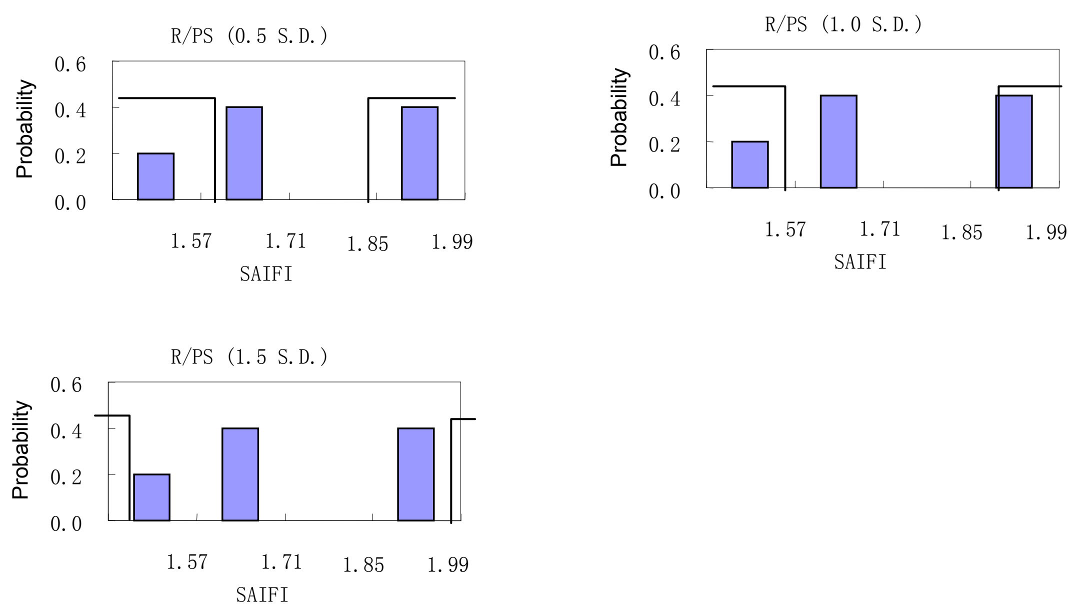


Figure 4.12 Three hypothetical dead zone widths on the SAIFI distribution for U2-3

It can be seen from Table 4.8 that the probability of a penalty due to SAIFI for this utility is 40% in Case 1. The system reliability financial risk is reduced to 20% by applying the 1.0 S.D structure. The dead zone is too wide in Case 3 as the entire probability resides within the dead zone and the R/PS has no influence on the utility.

Table 4.8 Comparison of the R/PS for the three dead zones on the SAIFI distribution for U2-3

Case	1	2	3
R/P S	0.5 S.D	1.0 S.D	1.5 S.D
Ave.	1.728	1.728	1.728
S.D.	0.172	0.172	0.172
D.Z. boundary	1.642~1.814	1.556~1.900	1.469~1.987
Risk	Probability		
Reward	20%	20%	0%
Penalty	40%	20%	0%
Zero	40%	60%	100%
Exp. Payment (M$)	**-2.00**	**0.00**	**0.00**

D.Z.: Dead Zone

SAIDI of Utility 2-3

It can be seen from Figure 4.13 that the distribution of SAIDI for Utility 2-3 is positively skewed (peak value skewed to the left) and has a relatively long tail. This indicates that a smaller dead zone should result in a higher probability of reward.

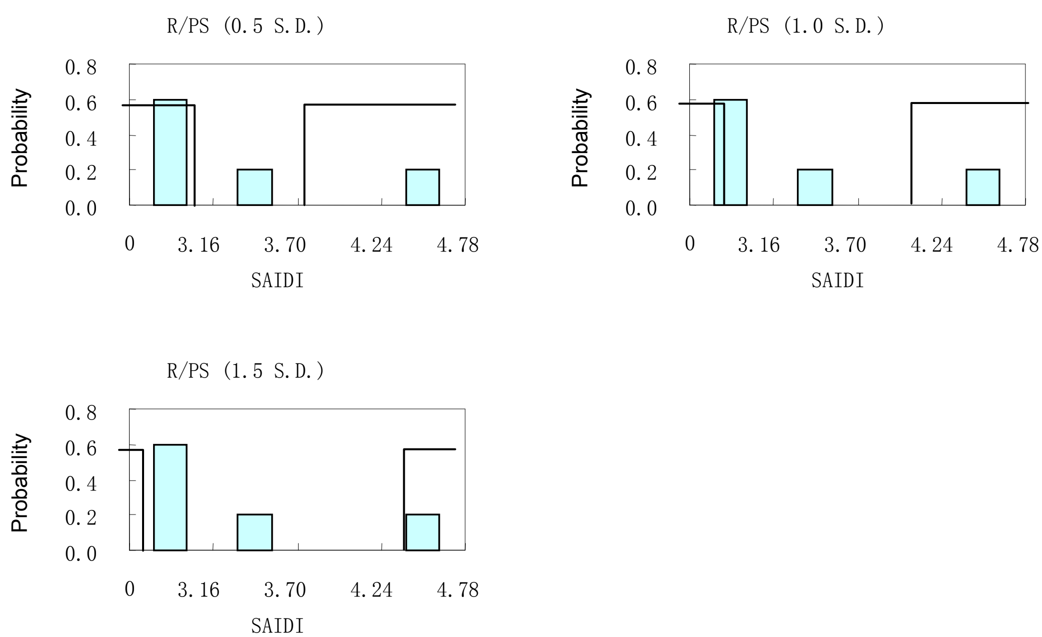


Figure 4.13 Three hypothetical dead zone widths on the SAIDI distribution for U2-3

Table 4.9 shows that in this case, the expected payment for the smallest band (0.5 S.D.) R/PS is a 2M$ reward. This utility faces an expected penalty when larger bands are applied.

Table 4.9 Comparison of the R/PS for the three dead zones on the SAIDI distribution for U2-3

Case	1	2	3
R/P S	0.5 S.D	1.0 S.D	1.5 S.D
Ave.	3.366	3.366	3.366
S.D.	0.686	0.686	0.686
D.Z. boundary	3.023~3.709	2.680~4.052	2.337~4.395
Risk	Probability		
Reward	40%	0%	0%
Penalty	20%	20%	20%
Zero	40%	80%	80%
Exp. Payment (M$)	**2.00**	**-2.00**	**-2.00**

4.8 Analysis of Different R/PS Slopes

Section 4.7 discusses the influence of the R/PS dead zone on the utility financial risk and the expected payment. The boundary slopes of the R/PS in the previous sections are assumed to be vertical. This makes the financial impact very abrupt as can be seen in the last section. The financial impact could be gentler and more gradual by giving each boundary a slope. Different slopes are applied to the R/PS boundary in this section to examine this impact.

Figure 4.14 shows three possible R/PS boundaries. The 5yr based data set is used to establish the R/PS and the dead zone width is 1.0 S.D in this study. This section is focused on the influence that the three slopes have on the system financial charges. Utility 1-3 is selected as an example for illustration purposes and SAIFI probability distribution is shown in Figure 4.15.

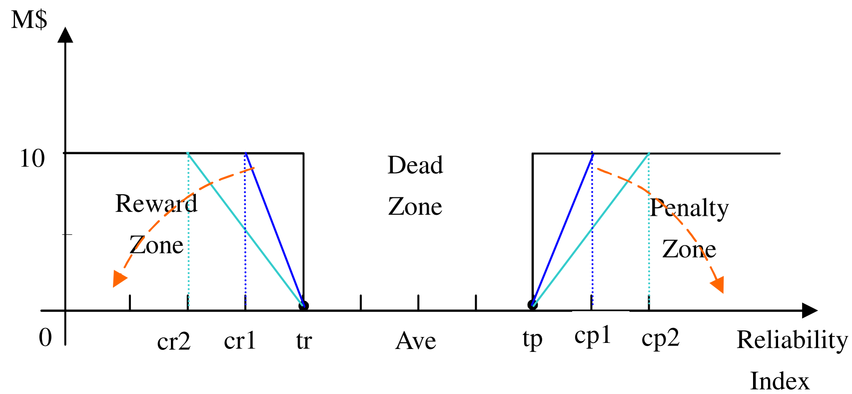


Figure 4.14 Three possible boundary slopes in an R/PS

In Figure 4.14, tr is the reward start point, tr to cr is the increasing reward zone and cr to 0 is the fixed reward zone. Similarly, tp is the penalty start point, tp to cp is the increasing penalty zone and cp and up is the fixed penalty zone. In this study, the maximum reward and penalty payments are assumed to be 10 M$. The three studies are designated as R/PS A, B and C.

In R/PS A: tr = Ave-1.0S.D; tp =Ave+1.0S.D; the boundaries are vertical.

In R/PS B: tr = Ave-1.0S.D; tp =Ave+1.0S.D; cr1 =Ave -1.5S.D; cp1= Ave +1.5S.D.

In R/PS C: tr = Ave-1.0S.D; tp =Ave+1.0S.D; cr2 =Ave -2.0S.D; cp2= Ave +2.0S.D.

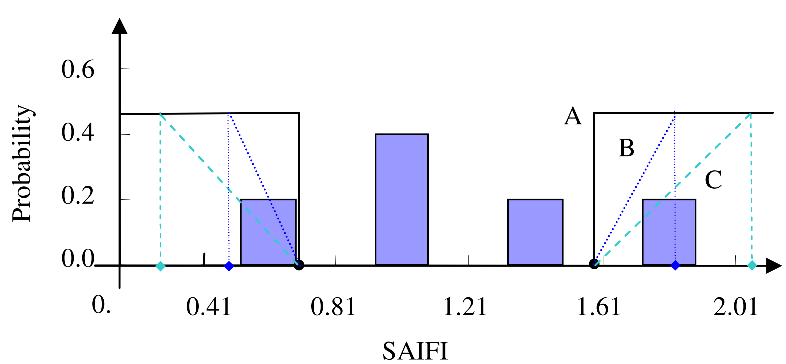


Figure 4.15 Three boundary slopes in a SAIFI R/PS

Tables 4.10 and 4.11 show a comparison of the expected financial charges for Utility 1-3 when the three different boundary slopes are applied to the R/PS. It can be seen from Table 4.10 that the reward and penalty probabilities are as shown in Table 4.6, the dead zone is the same. The expected payments however are quite different. The boundary slope in Case A is vertical and there are 20% probabilities located in both the reward and penalty zones. The reward and penalty counteract each other and 0M$ is charged to this utility. Although the probabilities residing in each zone are the same in Case B, the location of the index with respect to the boundaries is different. The slope softens the expected payment but the contributions are different and depend on the index locations. It can be seen from Figure 4.15 that the probability of a penalty is located further from the boundary than that of a reward. The expected penalty therefore, is higher than the expected reward and the utility will be charged 1.194M$ as a penalty in this case. Case C shows the gentlest R/PS slope in the three cases. The utility still expects to receive a penalty but the value reduces to 0.596M$. The SAIDI distribution has similar characteristics to those for SAIFI and the expected payments for the three R/PS are shown in Table 4.11.

Table 4.10 Financial risk for different R/PS slopes using the SAIFI distribution for Utility 1-3

R/P S	A	B	C
Ave.	1.142	1.142	1.142
S.D.	0.456	0.456	0.456
D.Z. boundary	0.686~1.598	0.686~1.598	0.686~1.598
Risk	Probability		
Reward	20%	20%	20%
Penalty	20%	20%	20%
Zero	60%	60%	60%
Exp. Payment (M$)	**0.00**	**-1.194**	**-0.596**

D.Z.: Dead Zone

Table 4.11 Financial risk for different R/PS slopes using the SAIDI distribution for Utility 1-3

R/PS	A	B	C
Ave.	0.942	0.942	0.942
S.D.	0.469	0.469	0.469
D.Z. boundary	0.473~1.411	0.473~1.411	0.473~1.411
Risk	Probability		
Reward	20%	20%	20%
Penalty	20%	20%	20%
Zero	60%	60%	60%
Exp. Payment (M$)	**0.00**	**-1.463**	**-0.836**

D.Z.: Dead Zone

4.9 Analysis of Different R/PS Slopes on the Actual Payment

The previous sections in this chapter introduce the concepts of predicted risk and expected payments. The expected payment based on utility past performance can serve as a quantitative indicator of the financial risk faced by a utility in a R/PS regime. The calculated payment is an expected value and may be quite different from the actual payment in a future year. This section calculates the actual financial payment for year 2004, assuming that 2004 is the current year to be assessed based on information from previous years. The study shows what the actual utility payment will be if this framework is applied. Previous studies show that 3yr to 5yr data sets can be used to establish reasonable reward/penalty structures. The Ontario Energy Board indicated that a utility should have at least three years of data. The study in this section uses the past 3yr data set to create the R/PS applied to compute the actual payment for 2004. The dead zone of the R/PS is the Ave. ± 1.0 S.D.

This study also examines the sensitivity of the financial charges due to the different slopes used in the reward/penalty structure. Tables 4.11 and 4.12 show the influence of these slopes on the system financial charges. The maximum reward/penalty is designated as 1.0

per unit and can be multiplied by the appropriate base value designated by the regulator to give actual dollars.

Tables 4.12 and 4.13 show the actual financial payments for 2004 with the three slope frameworks for Utilities 1-3 and 2-3. Similar information for the other eleven utilities is shown in Appendix 2.

Table 4.12 The 2004 actual financial payments for the three R/PS with different slopes for Utility 1-3

U 1-3	Ave.	S.D.	2004data	Financial	Payment	(Per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.097	0.221	1.330	-1	-0.107	-0.054
SAIDI	0.877	0.166	1.040	0	0	0
Total				**-1**	**-0.107**	**-0.054**

Table 4.13 The 2004 actual financial payments for the three R/PS with different slopes for Utility 2-3

U 2-3	Ave.	S.D.	2004data	Financial	Payment	(Per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.767	0.232	2.290	-1	-1	-1
SAIDI	3.633	0.818	4.770	-1	-0.778	-0.389
Total				**-2**	**-1.778**	**-1.389**

It can be seen from Table 4.12 and 4.13 that with R/PS A, the payments for the two utilities are severe due to the abrupt vertical boundary. In R/PS B, the slope in both reward and penalty boundaries decrease the financial charges if the utilities indices are relatively close to the boundary point. In R/PS C, the slope is gentler and the financial charges are further decreased. In the case of the SAIFI for Utility 1-3, the financial payment is -1 per unit$ for structure A. This is greatly reduced in structures B and C. The financial penalty for R/PS C decreases to 5% of that for R/PS A. In the case of SAIFI for Utility 2-3, however, the payment is -1 per unit$ for all three structures and is not affected by the slope factor. The

SAIDI penalty payment decreases with decreasing slope. The results show that Utility 1-3 had relatively better performance in year 2004 compared to its past performance than did Utility 2-3..

4.10 Summary

The basic concept of reward/penalty structures (R/PS) is introduced in this chapter. In a performance based regulation regime, distribution utilities are provided with economic incentives to operate efficiently and economically. The R/PS as part of a PBR plan has a critical influence on the utility financial payments. The determination of an appropriate R/PS therefore should be objective and fair to each utility. Some utilities have a long history of data collection while others have only a few years of data. The studies in this chapter show that is very difficult to create an appropriate R/PS based on a relatively small amount of data.

The performance data from two utilities are used in this chapter to initiate the concept of imposing R/PS on the reliability index distributions. These studies were based on data for a 10 year period. Utilities can have large changes in configuration, topology or management philosophy over a 10 year period and therefore it has been suggested that shorter periods should be used. The remaining analyses in this chapter are based on 5 year performance periods.

There are many ways to create a R/PS. In this chapter, several methods are utilized to develop R/PS frameworks. Different year data sets are utilized to determine R/PS for the two study utilities and the implications of using 3-5 yr data sets are illustrated.

An analysis of R/PS for three different dead zone widths is presented in this chapter using the two test utilities. The results show that the impact of the structure is large if a small dead zone is applied. Utilities with negatively skewed distributions will face more financial risk than those with positively skewed distributions under this condition. The R/PS in Case 3 has the largest dead zone and minimal influence as most of the index probabilities reside within the dead zone. This structure therefore provides the least incentive for utility improvements.

An analysis of different boundary slopes in the R/PS is illustrated in this chapter to examine the corresponding financial impacts. The R/PS boundaries in the earlier sections are vertical which create abrupt financial charges. The studies show that the expected payments are reduced considerably as the boundary slopes are reduced.

The analysis conducted to determine the effect of boundary slope changes was extended to consider the practical situation in which a utility has a R/PS framework provided by the regulator and applies the performance indices for the year in question to this R/PS. The R/PS was structured using 2001-2003 data and 2004 is the year in question. This chapter illustrates the actual payments that could be required by the two test utilities using the three boundary slopes. Similar results are provided in Appendix 2 for the remaining utilities.

The concept of Major Outage Years (MOY) is introduced in the next chapter, and relevant analyses are conducted.

CHAPTER 5

MAJOR OUTAGE YEAR ANALYSIS

5.1 Introduction

The utility performance data used in the research described in this thesis is presented in graphical form in Chapter 3. The data presented include the total indices and the contribution of each cause code. It can clearly be seen from the figures that the performance indices of some utilities are extremely high in certain years. These years are defined in this thesis as major outage years (MOY) and should receive special utility attention. Identifying a major outage year is an important task for a utility and provides an opportunity and incentive to analyze the weak points of the system and to improve the system performance accordingly.

Chapter 4 illustrates the use of previous year performance indices to create R/PS. The occurrence of MOY in the data used to establish an R/PS can create inconsistencies in the evaluation of financial payments for future utility performance. The MOY can be considered to reflect unusual utility performance and therefore not used in setting R/PS standards. This is illustrated by application to the test utilities in next chapter.

The definition of a MOY is obviously a very important factor. As noted earlier, the CEA Benchmarking Data in Regulatory Settings (BD/RS) Report indicates that due to the wide difference in Canadian utilities, utility benchmarking should be done using a utilities' own data and not on utility to utility performance. This approach has been applied in this research to determine individual utility MOY.

It is essential to define a major outage year in a clear and easily understandable manner. As noted earlier, applying a fixed threshold value to every utility is not fair due to the different utility characteristics. It is also important to determine how high the utility reliability index should be before the year is deemed a major outage year. In this research, the average values and standard deviations of the past years indices are used to define a major outage year. The overall indices are composed of the ten cause code contributions, each of which is an integral part of the total indices. In a major outage year, some cause codes make significantly higher contributions to the total index than in other years. These cause codes should be given increased attention and thoroughly investigated by the utility concerned.

5.2 Major Event Day (MED)

The IEEE Standard 1366TM -2003 presents a method to define a major event day (MED). The approach used to set the threshold of a major event day is known as the "Two Point Five Beta" method. This approach used 2.5 standard deviations to establish the identification threshold. This procedure is based on the assumption that the daily SAIDI follows a lognormal distribution which can be transformed into a normal distribution. The multiplier of 2.5 was considered to provide a reasonable evaluation. The expected number of MED is 2.3 days per year using 2.5 standard deviations [30].

A rolling period of five years daily of SAIDI values is recommended in this method. The natural logarithm of each value is obtained and the average and standard deviation of the natural logarithms are calculated. The MED threshold is computed as $T_{MED} = \exp(\alpha + 2.5\beta)$ where α is the average and β is the standard deviation. Those days in the following year with the daily SAIDI > T_{MED} are classified as major event days and excluded from the calculation of the annual SAIDI. The procedure is described in detail in IEEE Standard 1366TM-2003 [30].

In order to apply the MED approach, the system SAIDI for each day in the study period must be known. These data reside in the individual utility databases.

The research described in this thesis utilizes the annual SAIFI and SAIDI values provided to CEA by Canadian utilities, rather than the daily SAIDI. The sample size used in the MOY approach is very small and therefore it is not reasonable to conclude that the annual reliability indices have specific distributions such as normal, lognormal or Poisson distributions. The following sections present the method used in this thesis to determine the MOY and the cause contributions to these MOY.

5.3 Classification of Major Outage Years (MOY)

The results in the following tables are generally based on the nine years of utility system performance data from 1995-2003. The exceptions are: Utility 1-2 has 8 years of data (1996-2003), Utility 1-5 has 5 years of data (1999-2003), Utility 1-7 has 6 years of data (1998-2003), Utility 2-1 has 7 years of data (1997-2003), and System Canada has 10 years of data (1994-2003).

In this analysis, the average value and standard deviation of each cause code is calculated and used to set the MOY threshold. The four MOY test thresholds, Ave+1S.D, Ave+2S.D, Ave+2.5S.D and Ave+3 S.D are used. Any year in the study period that has a higher value than the assigned thresholds is defined as a MOY. Each MOY should be analyzed and investigated in depth to ascertain why this occurred. It is worth noting that the effect of MOY can be seen in the interruption cause code graphs in Chapter 3. The following numerical analysis however, contains more specific information than can be obtained by simply looking at the graphs. There are many possible thresholds for MOY identification. This is a matter of judgment and obviously if a year is to be classified as a MOY, years with this level of utility performance should not occur too often.

The following tables for Utility 1-3 and 2-3 display the MOY using the four test thresholds. The results for the other utilities are given in Appendix 3. This procedure is applied to both the SAIFI and SAIDI data. It should be noted that the MED approach described in [30] is directly applied only to SAIDI.

5.3.1 Analysis of Utility 1-3

The following MOY analysis indicates the years that the designated index exceeded the specified threshold and the relative frequency, expressed as a percentage, of MOY in the period.

Tables 5.1 to 5.4 show that for Utility 1-3, when the threshold is the Ave+1.0 S.D, for both SAIFI and SAIDI, the probability of MOY for each cause code is 11% or more. This indicates that at least one year in this period is a major outage year for all the cause codes. The specific MOY for SAIFI and SAIDI at the Ave+1.0S.D threshold are generally similar but are not identical. The MOY for Loss of Supply occurred in 1995 and 1999 for SAIFI but only occurred in 1999 for SAIDI. The MOY for Adverse Environment occurred in 2001 for SAIFI and in 1996, 1997, 2001 for SAIDI. The SAIDI value is largely influenced by the repair or restoration procedures used by the utility in response to the actual outage events. This is one of the factors that should be investigated more deeply by the utility in question.

The years identified as MOY decrease as the threshold increases. As an example, using SAIFI and the Ave+2.5S.D as the threshold results in only a few identified MOY. The year 1996 is a MOY due to Scheduled Outages and Adverse Weather and the 2001 is a MOY for Adverse Environment. In the case of SAIDI for Utility 1-3, when the MOY threshold is set at the Ave+2.0 S.D, the three years of MOY due to Adverse Environment noted above are filtered out and all the years are designated as being normal. When the threshold is set at the Ave+2.5 S.D, only two years are identified. They are 2001 for Unknown and 1996 for Adverse Weather. As in the SAIFI analysis, no years are classified as Major outage years using the Ave +3.0S.D level. Setting the threshold at this level removes all the years in the MOY category.

Table 5.1 SAIFI MOY Analysis, Utility 1-3 (Ave.+ 1&2 S.D)

Cause code	Ave.	S.D	**Threshold= Ave+ 1.0 S.D**			**Threshold= Ave+ 2.0 S.D**		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.031	0.047	1	2001	11%	1	2001	11%
Sch.O	0.056	0.061	1	1996	11%	1	1996	11%
Los.S	0.418	0.513	2	1995, 1999	22%	0	0	0%
Tr.C	0.081	0.055	1	1999	11%	0	0	0%
Lightn	0.132	0.128	2	1998, 2003	22%	0	0	0%
De.E	0.287	0.224	1	1995	11%	1	1995	11%
Ad.W	0.034	0.070	1	1996	11%	1	1996	11%
Ad.En	0.014	0.033	1	2001	11%	1	2001	11%
Hu.E	0.094	0.075	2	1995, 2000	22%	1	1995	11%
For.I	0.108	0.074	2	1998, 2001	22%	0	0	0%
Total	1.260	0.695	1	1995	11%	0	0	0%

Note: m is the number of major outage year

Table 5.2 SAIFI MOY Analysis, Utility 1-3 (Ave.+ 2.5&3 S.D)

Cause code	Ave.	S.D	**Threshold= Ave+2.5 S.D**			**Threshold= Ave+ 3.0 S.D**		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.031	0.047	0	0	0%	0	0	0%
Sch.O	0.056	0.061	1	1996	11%	0	0	0%
Los.S	0.418	0.513	0	0	0%	0	0	0%
Tr.C	0.081	0.055	0	0	0%	0	0	0%
Lightn	0.132	0.128	0	0	0%	0	0	0%
De.E	0.287	0.224	0	0	0%	0	0	0%
Ad.W	0.034	0.070	1	1996	11%	0	0	0%
Ad.En	0.014	0.033	1	2001	11%	0	0	0%
Hu.E	0.094	0.075	0	0	0%	0	0	0%
For.I	0.108	0.074	0	0	0%	0	0	0%
Total	1.260	0.695	0	0	0%	0	0	0%

Table 5.3 SAIDI MOY Analysis, Utility 1-3 (Ave.+ 1&2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+ 2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.019	0.036	1	2001	11%	1	2001	11%
Sch.O	0.050	0.019	2	1996, 1998	22%	1	1996	11%
Los.S	0.178	0.285	1	1999	11%	1	1999	11%
Tr.C	0.090	0.067	1	1999	11%	1	1999	11%
Lightn	0.101	0.097	1	2003	11%	1	2003	11%
De.E	0.312	0.165	1	1995	11%	0	0	0%
Ad.W	0.088	0.222	1	1996	11%	1	1996	11%
Ad.En	0.008	0.012	3	1996,1997, 2001	33%	0	0	0%
Hu.E	0.026	0.022	2	1995, 1997	22%	0	0	0%
For.I	0.091	0.090	1	1998	11%	1	1998	11%
Total	0.956	0.430	1	1999	11%	0	0	0%

Table 5.4 SAIDI MOY Analysis Utility 1-3 (Ave.+ 2.5&3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+ 3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.019	0.036	1	2001	11%	0	0	0%
Sch.O	0.050	0.019	0	0	0%	0	0	0%
Los.S	0.178	0.285	0	0	0%	0	0	0%
Tr.C	0.090	0.067	0	0	0%	0	0	0%
Lightn	0.101	0.097	0	0	0%	0	0	0%
De.E	0.312	0.165	0	0	0%	0	0	0%
Ad.W	0.088	0.222	1	1996	11%	0	0	0%
Ad.En	0.008	0.012	0	0	0%	0	0	0%
Hu.E	0.026	0.022	0	0	0%	0	0	0%
For.I	0.091	0.090	0	0	0%	0	0	0%
Total	0.956	0.430	0	0	0%	0	0	0%

Tables 5.1 to 5.4 illustrate that the contributions to the overall SAIFI and SAIDI indices from the different cause codes over the period in question are highly variable, and can be considered to be major in certain years. It is important to identify these years, but it is perhaps more important to use this knowledge to investigate the reason why they occurred.

5.3.2 Analysis of Utility 2-3

Tales 5.5 to 5.8 show a similar analysis of MOY for the integrated Utility 2-3. It can be seen from the SAIFI MOY analysis in Table 5.5 that for the Ave+1.0S.D threshold, there are more than one MOY in each cause code. Three years are identified as MOY for Human Element. There are two MOY for the cause codes of Unknown, Scheduled Outages and Lighting. The MOY for these cause codes are all filtered out when the threshold is the Ave+2.0S.D. Only one year is classified to be a MOY at this level. This is 2001 due to Loss of Supply. No years are identified as MOY for any cause code when the threshold moves to the Ave+2.5S.D, as compared to the Ave+3.0S.D for Utility 1-3.

In the SAIDI analysis shown in Table 5.7, there is one or more years identified as a MOY in each cause code in the first category. These MOY, however, are different from those for SAIFI. Three years are classified as MOY for Scheduled Outages in SAIDI while only two of them are in SAIFI. Years 2001 and 2003 are MOY due to Loss of Supply compared to only 2001 in SAIFI. The MOY reduces to only two years when the threshold is Ave+2.0S.D. They are 2001 for Loss of Supply and Human Element and 2003 for Adverse Weather and Total SAIDI. It is important to note that the occurrence of MOY for certain cause codes does not mean that these cause codes make higher contributions to the magnitude of the total index than other cause codes. The occurrence of MOY indicates unusual performance in this cause code in this year compared to that in other years in the study period.

Table 5.5 SAIFI MOY Analysis, Utility 2-3 (Ave.+ 1&2 S.D)

Cause code	Ave.	S.D	**Threshold= Ave+1.0 S.D**			**Threshold= Ave+ 2.0 S.D**		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.180	0.051	2	1998 , 1999	22%	0	0	0%
Sch.O	0.416	0.070	2	1995 , 2003	22%	0	0	0%
Los.S	0.168	0.224	1	2001	11%	1	2001	11%
Tr.C	0.102	0.029	1	1997	11%	0	0	0%
Lightn	0.181	0.093	2	1997 , 2000	22%	0	0	0%
De.E	0.371	0.082	1	1997	11%	0	0	0%
Ad.W	0.132	0.058	1	1998	11%	0	0	0%
Ad.En	0.028	0.014	1	1999	11%	0	0	0%
Hu.E	0.020	0.017	3	1995,1997 ,2001	33%	0	0	0%
For.I	0.202	0.032	1	1997	11%	0	0	0%
Total	1.797	0.182	1	1997	11%	0	0	0%

Table 5.6 SAIFI MOY Analysis, Utility 2-3 (Ave.+ 2.5&3 S.D)

Cause code	Ave.	S.D	**Threshold= Ave+2.5 S.D**			**Threshold= Ave+ 3.0 S.D**		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.180	0.051	0	0	0%	0	0	0%
Sch.O	0.416	0.070	0	0	0%	0	0	0%
Los.S	0.168	0.224	0	0	0%	0	0	0%
Tr.C	0.102	0.029	0	0	0%	0	0	0%
Lightn	0.181	0.093	0	0	0%	0	0	0%
De.E	0.371	0.082	0	0	0%	0	0	0%
Ad.W	0.132	0.058	0	0	0%	0	0	0%
Ad.En	0.028	0.014	0	0	0%	0	0	0%
Hu.E	0.020	0.017	0	0	0%	0	0	0%
For.I	0.202	0.032	0	0	0%	0	0	0%
Total	1.797	0.182	0	0	0%	0	0	0%

Table 5.7 SAIDI MOY Analysis, Utility 2-3 (Ave.+ 1&2 S.D)

Cause code	Ave.	S.D	**Threshold= Ave+1.0 S.D**			**Threshold= Ave+ 2.0 S.D**		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.266	0.067	1	1998	11%	0	0	0%
Sch.O	0.849	0.179	3	1995, 2000, 2003	33%	0	0	0%
Los.S	0.288	0.426	2	2001, 2003	22%	1	2001	11%
Tr.C	0.236	0.087	1	2003	11%	0	0	0%
Lightn	0.333	0.144	1	1997	11%	0	0	0%
De.E	0.661	0.139	1	1997	11%	0	0	0%
Ad.W	0.342	0.206	1	2003	11%	1	2003	11%
Ad.En	0.102	0.076	2	1998, 1999	22%	0	0	0%
Hu.E	0.011	0.009	1	2001	11%	1	2001	11%
For.I	0.287	0.059	1	2003	11%	0	0	0%
Total	3.376	0.507	1	2003	11%	1	2003	11%

Table 5.8 SAIDI MOY Analysis, Utility 2-3 (Ave.+ 2.5&3 S.D)

Cause code	Ave.	S.D	**Threshold= Ave+ 2.5 S.D**			**Threshold= Ave+ 3.0 S.D**		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.266	0.067	0	0	0%	0	0	0%
Sch.O	0.849	0.179	0	0	0%	0	0	0%
Los.S	0.288	0.426	0	0	0%	0	0	0%
Tr.C	0.236	0.087	0	0	0%	0	0	0%
Lightn	0.333	0.144	0	0	0%	0	0	0%
De.E	0.661	0.139	0	0	0%	0	0	0%
Ad.W	0.342	0.206	0	0	0%	0	0	0%
Ad.En	0.102	0.076	0	0	0%	0	0	0%
Hu.E	0.011	0.009	0	0	0%	0	0	0%
For.I	0.287	0.059	0	0	0%	0	0	0%
Total	3.376	0.507	0	0	0%	0	0	0%

A high number of MOY are identified when the applied threshold is low. When the threshold is increased, the boundary shifts to the right and the number of MOY is reduced. When the threshold moves to a relatively high level, e.g. Ave+3.0S.D (Ave+2.5S.D for some utilities), no years are identified as MOY and every year is considered to be normal. This analysis was conducted using data for the 1995-2003 period. During this period there were no MOY determined using the Ave+3.0S.D threshold for any cause code or for the Total index for the thirteen utilities.

A major event is usually assigned to one or more cause codes. It could be assigned with another cause code due to coincidence or because that cause is affected by other causes. e.g. Adverse Weather that is severe in one year could results in a high Tree Contact value. The MOY threshold should not be set at too low a level. As shown in Table 5.1-5.8, a large number of years are designated as MOY when the threshold is set at the Ave+1.0S.D. The threshold should be at least 2.0S.D from the mean in order to provide some reasonable discrimination.

5.4 Major Outage Year Analysis for 2004

The previous studies present a MOY analysis for the thirteen utilities over a designated period. This section uses the same methodology to assess the year 2004. The objective is to determine whether or not 2004 is a MOY for each individual cause code and the Total index based on the average value and the standard deviation of previous year indices (not including 2004).

In this section, four test thresholds are utilized to identify the MOY. These are Ave+1.0 S.D, Ave+2.0 S.D, Ave+2.5S.D and Ave+3.0 S.D, as in Section 5.3. If the indices of 2004 are higher than the threshold, then 2004 is classified as a MOY for that cause code. It is also important to examine the total system indices.

As noted earlier, there is a wide range of possible thresholds. The higher the threshold, the stricter is the MOY classification. If the threshold is set too low, the years with slightly higher indices will be classified as MOY and will not provide sufficient information to permit the utility to focus on improving its system reliability. On the other hand, if the MOY threshold is set too high, significant events will not be recognized and will be considered as normal system behavior. This again may lead to a lack of action in the particular cause category. The following tables illustrate the sensitivity of setting different thresholds.

An important point to consider is should a MOY in the past reference period be removed and not utilized to analyze year 2004? If the MOY in previous years is included, it will affect the threshold. A MOY will drive up both the average value and standard deviation. If the MOY is due to a tremendous event, the Ave. and S.D of the reference period indices are both high and therefore so is the threshold. This will make the analyzed year look more normal despite the fact that this year may also have very high indices. If all MOY are removed from the utility performance history, the data will be damped down which makes the target year much easier to be classified as a MOY. In this chapter, the MOY data of past years are included to classify 2004. Utility 1-3 and 2-3 are selected as examples. The relevant material for the other eleven utilities and four systems are shown in Appendix 4.

Tables 5.9-5.10 show the MOY analysis for Utility 1-3. The year 2004 is identified as a MOY for four cause codes using SAIFI when the Ave+1.0S.D threshold is applied. When the threshold is the Ave+2.0S.D, only Human Element is determined to have a MOY in this year. Using SAIDI, a MOY in 2004 is identified for the three cause codes of Scheduled Outages, Tree Contact, and Human Element. The Scheduled Outages and Human Element cause code are identified for all four thresholds. This shows that the performance in 2004 due to these two contributors is unusual. The Total indices, however, seem relatively normal for this year.

Tables 5.11 and 5.12 show the results for Utility 2-3. It can be seen that when using SAIFI, the Loss of Supply is identified to be a MOY in 2004 for the first two thresholds. The Total SAIFI is identified as a MOY in 2004 for the first three thresholds. Using SAIDI, four cause codes and the Total index indicate a MOY for the Ave+1.0S.D threshold. Two cause codes and the Total index are identified using the Ave+2.0S.D threshold. The year 2004 is considered to be normal for all the ten cause codes and the Total index when the threshold is the Ave+3.0S.D.

Table 5.9 SAIFI MOY 2004 Analysis, Utility 1-3

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.01	0.031	0.047	0	0	0	0
Sch.O	0.11	0.056	0.061	0	0	0	0
Los.S	0.00	0.418	0.513	0	0	0	0
Tr.C	0.17	0.081	0.055	2004	0	0	0
Lightn	0.00	0.132	0.128	0	0	0	0
De.E	0.54	0.287	0.224	2004	0	0	0
Ad.W	0.00	0.034	0.070	0	0	0	0
Ad.En	0.00	0.014	0.033	0	0	0	0
Hu.E	0.28	0.094	0.075	2004	2004	0	0
For.I	0.22	0.108	0.074	2004	0	0	0
Total	1.33	1.260	0.695	0	0	0	0

Note: in the fourth column, ‘0’ indicates 2004 is not a MOY for that cause code

Table 5.10 SAIDI MOY 2004 Analysis, Utility 1-3

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.01	0.019	0.036	0	0	0	0
Sch.O	0.15	0.050	0.019	2004	2004	2004	2004
Los.S	0.00	0.178	0.285	0	0	0	0
Tr.C	0.25	0.090	0.067	2004	2004	0	0
Lightn	0.00	0.101	0.097	0	0	0	0
De.E	0.38	0.312	0.165	0	0	0	0
Ad.W	0.00	0.088	0.222	0	0	0	0
Ad.En	0.00	0.008	0.012	0	0	0	0
Hu.E	0.10	0.026	0.022	2004	2004	2004	2004
For.I	0.17	0.091	0.090	0	0	0	0
Total	1.04	0.956	0.430	0	0	0	0

Table 5.11 SAIFI MOY 2004 Analysis, Utility 2-3

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.14	0.180	0.051	0	0	0	0
Sch.O	0.46	0.416	0.070	0	0	0	0
Los.S	0.72	0.168	0.224	2004	2004	0	0
Tr.C	0.09	0.102	0.029	0	0	0	0
Lightn	0.14	0.181	0.093	0	0	0	0
De.E	0.39	0.371	0.082	0	0	0	0
Ad.W	0.14	0.132	0.058	0	0	0	0
Ad.En	0.03	0.028	0.014	0	0	0	0
Hu.E	0.02	0.020	0.017	0	0	0	0
For.I	0.15	0.202	0.032	0	0	0	0
Total	2.29	1.797	0.182	2004	2004	2004	0

Table 5.12 SAIDI MOY 2004 Analysis, Utility 2-3

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.17	0.266	0.067	0	0	0	0
Sch.O	1.09	0.849	0.179	2004	0	0	0
Los.S	1.23	0.288	0.426	2004	2004	0	0
Tr.C	0.30	0.236	0.087	0	0	0	0
Lightn	0.37	0.333	0.144	0	0	0	0
De.E	0.86	0.661	0.139	2004	0	0	0
Ad.W	0.34	0.342	0.206	0	0	0	0
Ad.En	0.10	0.102	0.076	0	0	0	0
Hu.E	0.03	0.011	0.009	2004	2004	0	0
For.I	0.28	0.287	0.059	0	0	0	0
Total	4.77	3.376	0.507	2004	2004	2004	0

Summary of the MOY 2004 analysis for all the study systems:

It can be seen from the results shown in Tables 5.9-5.12 and Appendix 4 that most of the utilities have relatively normal performance in 2004. In order to help determine if 2004 is a

MOY, the cause codes designated by the four thresholds are shown in Tables 5.13-5.16, for each utility.

Table 5.13 shows that at the lowest threshold of the Ave+1.0S.D, there are twelve systems that identify 2004 as a MOY out of the sixteen systems for one or more cause codes. Four systems Utility 1-1, 1-6, 2-5 and Region 1 identify 2004 as a normal year. Utility 2-1 and 2-3 identify 2004 as a MOY using the Total indices. Utility 2-3 has 2004 identified as a MOY for both the Total SAIFI and SAIDI indices. Some utilities, such as Utility1-2, 1-5 and 2-2 only have MOY for 2004 in one or two cause codes.

Table 5.13 MOY 2004 Analysis using a Threshold = Ave+ 1.0 S.D

System	SAIFI	SAIDI
Utility 1-2	Los.S	Los.S, De.E
Utility 1-3	Tr.C, De.E, Hu.E, For.I	Sch.O, Tr.C, Hu.E
Utility 1-4	Los.S, Hu.E	Hu.E
Utility 1-5	Unkn	Ad.En
Utility 1-7	Los.S, For.I	
Utility 2-1	Los.S, Lightn, De.E, **Total**	Los.S, Tr.C, Lightn
Utility 2-2	Tr.C, Hu.E	Sch.O
Utility 2-3	Los.S, **Total**	Sch.O, Los.S, De.E, Hu.E, **Total**
Utility 2-4	Tr.C, Ad.En, Hu.E, For.I	Sch.O, Ad.En
Utility 2-6	Sch.O	Hu.E, For.I
Region 2	Tr.C	Ad.En
Canada	Unkn	Unkn, De.E, For.I

Table 5.14 MOY 2004 Analysis using a Threshold = Ave+ 2.0 S.D

System	SAIFI	SAIDI
Utility 1-2	Los.S	Los.S
Utility 1-3	Hu.E	Sch.O, Hu.E， Tr.C
Utility 1-4		Hu.E
Utility 1-5		Ad.En
Utility 2-1	Los.S	Los.S, Lightn
Utility 2-2	Hu.E	
Utility 2-3	Los.S, **Total**	Los.S, Hu.E, **Total**
Utility 2-4	Ad.En, Hu.E	Ad.En
Canada		De.E

Table 5.14 shows the situation when the threshold is the Ave+2.0S.D. The number of utilities identified as having a MOY shrinks from twelve to eight utilities. The number of cause codes for Utility 2-1 reduces from three to one (Loss of Supply) using SAIFI. The Total SAIFI is also filtered out.

Table 5.15 shows that when the threshold is based on Ave+2.5S.D, there are seven utilities remaining, five of which have no MOY identified for any cause code using SAIFI. Utility 2-3 is the only utility to have a MOY identified based on the Total index.

Table 5.15 MOY 2004 Analysis using a Threshold = Ave+ 2.5 S.D

System	SAIFI	SAIDI
Utility 1-2	Los.S	Los.S
Utility 1-3		Sch.O, Hu.E
Utility 1-4		Hu.E
Utility 1-5		Ad.En
Utility 2-1		Los.S, Lightn
Utility 2-3	**Total**	**Total**
Utility 2-4	Ad.En, Hu.E	Ad.En
Canada		De.E

There are only six utilities remaining in Table 5.16 where the threshold is the Ave+3S.D. There is relatively little change for the last two thresholds.

Table 5.16 MOY 2004 Analysis using a Threshold = Ave+ 3.0 S.D

System	SAIFI	SAIDI
Utility 1-2	Los.S	Los.S
Utility 1-3		Sch.O, Hu.E
Utility 1-4		Hu.E
Utility 1-5		Ad.En
Utility 2-1		Los.S
Utility 2-3		**Total**
Utility 2-4	Ad.En, Hu.E	Ad.En
Canada		De.E

In the last case, where the threshold is the Ave+ 3.0 S.D, the year 2004 is identified as a

MOY for certain cause codes for six utilities. These are Utilities 1-2, 1-3, 1-4, 1-5, 2-3 and 2-4. Although most of these utilities do not designate this year as a MOY based on the Total index, they should pay extra attention to the identified cause codes. These cause codes show much higher values in 2004 than in the review period and contribute variability and uncertainty to the system performance. The Total index is the most important parameter from a customer viewpoint. Tables 5.14-5.16 show that only Utility 2-3 has a MOY designation for 2004 using the Total index. This indicates that all the utilities except Utility 2-3 had a relatively normal year in 2004.

5.5 Major Outage Year Analysis for 2003

The previous section presents an assessment of the year 2004 as a major outage year. The results show that 2004 is quite a normal year and is even a good performance year for some utilities. In this section, the same methodology is applied to assess the year 2003. The thirteen utilities and the four pooled systems are assessed using their historical data from 1995 -2002.

Tables 5.17-5.20 show the analysis for the two test utilities 1-3 and 2-3. The results for the remaining systems are shown in Appendix 5. It can be seen from Table 5.17, that 2003 is identified as a MOY for Utility 1-3 in only the Lightning cause code at the first three thresholds using SAIFI. The other cause codes and the Total SAIFI are quite normal for this year. The year 2003 also had bad Lightning performance using SAIDI and is identified as a MOY at all the thresholds, as shown in Table 5.18. The remaining cause codes can be considered to be quite normal at the four thresholds.

Tables 5.19-5.20 show the analysis for Utility 2-3. Year 2003 is classified as a MOY for three cause codes using SAIFI when the threshold is the Ave+1.0S.D. This year is not considered to be severe for these cause codes as they are not designated when the threshold is set higher. In the case of SAIDI, five cause codes and the Total index are designated as

MOY for this year using the first threshold. Utility 2-3 experienced poor performance due to Tree Contact and Adverse Weather and this affected the Total SAIDI.

Table 5.17 SAIFI MOY 2003 Analysis, Utility 1-3

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5S.D	Ave+3 S.D
Unkn	0.03	0.031	0.050	0	0	0	0
Sch.O	0.05	0.056	0.065	0	0	0	0
Los.S	0.07	0.461	0.530	0	0	0	0
Tr.C	0.13	0.075	0.056	0	0	0	0
Lightn	0.37	0.103	0.099	2003	2003	2003	0
De.E	0.23	0.294	0.238	0	0	0	0
Ad.W	0.02	0.036	0.075	0	0	0	0
Ad.En	0.00	0.016	0.035	0	0	0	0
Hu.E	0.08	0.096	0.080	0	0	0	0
For.I	0.02	0.119	0.071	0	0	0	0
Total	1.00	1.292	0.735	0	0	0	0

Table 5.18 SAIDI MOY 2003 Analysis, Utility 1-3

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5S.D	Ave+3 S.D
Unkn	0.02	0.019	0.038	0	0	0	0
Sch.O	0.05	0.050	0.021	0	0	0	0
Los.S	0.01	0.199	0.297	0	0	0	0
Tr.C	0.13	0.085	0.069	0	0	0	0
Lightn	0.30	0.076	0.066	2003	2003	2003	2003
Def. E	0.32	0.311	0.177	0	0	0	0
Ad.W	0.03	0.095	0.237	0	0	0	0
Ad.En	0.00	0.009	0.012	0	0	0	0
Hu.E	0.01	0.028	0.023	0	0	0	0
FOR.I	0.00	0.102	0.088	0	0	0	0
Total	0.86	0.968	0.458	0	0	0	0

Table 5.19 SAIFI MOY 2003 Analysis, Utility 2-3

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5S.D	Ave+3 S.D
Unkn	0.11	0.189	0.046	0	0	0	0
Sch.O	0.50	0.405	0.067	2003	0	0	0
Los.S	0.37	0.143	0.226	2003	0	0	0
Tr.C	0.13	0.099	0.029	2003	0	0	0
Lightn	0.09	0.193	0.093	0	0	0	0
De.E	0.31	0.379	0.084	0	0	0	0
Ad.W	0.15	0.130	0.062	0	0	0	0
Ad.En	0.01	0.030	0.013	0	0	0	0
Hu.E	0.00	0.022	0.017	0	0	0	0
For.I	0.21	0.201	0.034	0	0	0	0
Total	1.88	1.786	0.192	0	0	0	0

Table 5.20 SAIDI MOY 2003 Analysis, Utility 2-3

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5S.D	Ave+3 S.D
Unkn	0.25	0.268	0.071	0	0	0	0
Sch.O	1.04	0.825	0.175	2003	0	0	0
Los.S	0.78	0.226	0.411	2003	0	0	0
Tr.C	0.40	0.215	0.065	2003	2003	2003	0
Lightn	0.20	0.350	0.145	0	0	0	0
De.E	0.68	0.659	0.149	0	0	0	0
Ad.W	0.76	0.290	0.143	2003	2003	2003	2003
Ad.En	0.02	0.113	0.075	0	0	0	0
Hu.E	0.00	0.013	0.009	0	0	0	0
For.I	0.38	0.275	0.051	2003	2003	0	0
Total	4.51	3.234	0.294	2003	2003	2003	2003

Summary of the **MOY 2003 analysis for all the study systems:**

It can be seen from the results in Table 5.17-5.20 and Appendix 5 that the 2003 indices for most of the study utilities are higher than their average historical performance. Table 5.21

shows that at the lowest level, where the threshold is Ave+1.0S.D, all the sixteen systems have 2003 as a MOY for various cause codes. Ten systems have a MOY for 2003 for the Total index, which should be a cause for concern to customers. Utilities 1-1, 1-2, 1-3, 1-4 and utility 2-5 have relatively better performance in 2003 and exceed the threshold only in one or two cause codes and do not experience a MOY in their Total index.

Table 5.21 MOY 2003 Analysis using the Threshold = Ave+ 1.0 S.D

System	SAIFI	SAIDI
Utility 1-1	Unkn, Ad.W	Unkn, Ad.W
Utility 1-2		Unkn
Utility 1-3	Lightn	Lightn
Utility 1-4	Unkn	De.E
Utility 1-5	Sch.O, Los.S, De.E, Ad.W, Ad.En, **Total**	Unkn, Los.S, Ad.W, For.I, **Total**
Utility 1-6	Unkn, Los.S, De.E, Hu.E, For.I, **Total**	Los.S, Ad.En, **Total**
Utility 1-7	Los.S, Tr.C, Ad.W, Ad.En, **Total**	Los.S, Tr.C, Ad.W, **Total**
Utility 2-1	Ad.W, For.I, **Total**	Los.S, Ad.W, For.I, **Total**
Utility 2-2	Ad.En, For.I	Ad.W, Ad.En, For.I, **Total**
Utility 2-3	Sch.O, Los.S, Tr.C	Sch.O, Los.S, Tr.C, Ad.W, For.I, **Total**
Utility 2-4	Lightn., De.E, Ad.En	De.E
Utility 2-5	For.I	For.I
Utility 2-6	Sch.O, For.I	Sch.O, Tr.C, **Total**
Region 1	Unkn, Los.S, Ad.W, **Total**	Unkn, Los.S, Tr.C, **Total**
Region 2	Ad.W, For.I	Tr.C, Ad.W, Ad.En, For.I, **Total**
Region T	Los.S, Ad.W, For.I	Los.S, Tr.C, Ad.W, Ad.En, For.I, **Total**
Canada	Tr.C, Ad.En, For.I	Unkn, Sch.O, Los.S, Tr.C, De.E, Ad.En, Hu.E, For.I

Table 5.22 shows that when the MOY threshold is the Ave+2.0 S.D, the number of cause codes identified as having a MOY is reduced considerably for some utilities. The assigned MOY due to SAIDI only decreases by one utility from the Total index perspective, even though the threshold is increased significantly.

Table 5.22 MOY 2003 Analysis using the Threshold = Ave+ 2.0 S.D

System	SAIFI	SAIDI
Utility 1-1	Unkn, Ad.W	Unkn, Ad.W
Utility 1-2		Unkn
Utility 1-3	Lightn	Lightn
Utility 1-4		
Utility 1-5	Sch.O, Los.S, **Total**	Unkn, Los.S, Ad.W, **Total**
Utility 1-6	Los.S, Hu.E	Los.S, Ad.En, **Total**
Utility 1-7	Los.S, Tr.C, Ad.W, **Total**	Los.S, Tr.C, Ad.W, **Total**
Utility 2-1		Ad.W, **Total**
Utility 2-2	Ad.En, For.I	Ad.En, For.I
Utility 2-3		Tr.C, Ad.W, For.I, **Total**
Utility 2-4	Ad.En	De.E
Utility 2-5		
Utility 2-6		Sch.O, Tr.C, **Total**
Region 1	Los.S, **Total**	Los.S, Tr.C, **Total**
Region 2	For.I	Tr.C, Ad.W, **Total**
Region T	Ad.W	Los.S, Tr.C, **Total**
Canada	Ad.En, For.I	Unkn, Los.S, Tr.C, Ad.En, For.I

Table 5.23 shows the results when the threshold is the Ave+2.5S.D, Utility 1-4 and Utility 2-5 have no designated MOY in 2003 for any cause code using both SAIFI and SAIDI. This indicates that these utilities had relatively good performance in this year.

Table 5.24 shows that when the threshold is the Ave+3.0S.D, Utility 1-5, 1-6, 1-7 exhibit the same performance as in Table 5.23. Only Utility 2-3 has a MOY for its Total index in the integrated utility group. Region 1 is an aggregate of the seven urban utilities. Its performance is influenced by that of Utility 1-5, 1-6 and 1-7 which have relatively poor performance in 2003, especially for the Loss of Supply cause code. Region 1 thus has a MOY for 2003 in the Loss of Supply and the Total index categories.

Table 5.23 MOY 2003 Analysis using the Threshold = Ave.+ 2.5 S.D

System	SAIFI	SAIDI
Utility 1-1	Unkn, Ad.W	Unkn, Ad.W
Utility 1-2		Unkn
Utility 1-3	Lightn	Lightn
Utility 1-4		
Utility 1-5	Sch.O, Los.S, **Total**	Unkn, Los.S, Ad.W, **Total**
Utility 1-6	Los.S, Hu.E	Los.S, **Total**
Utility 1-7	Los.S, Tr.C, Ad.W, **Total**	Los.S, Tr.C, Ad.W, **Total**
Utility 2-1		Ad.W
Utility 2-2	Ad.En	Ad.En
Utility 2-3		Tr.C, Ad.W, **Total**
Utility 2-4	Ad.En	
Utility 2-5		
Utility 2-6		Sch.O, Tr.C
Region 1	Los.S	Los.S, **Total**
Region 2		Tr.C, Ad.W, **Total**
Region T		Los.S, Tr.C, **Total**
Canada		Unkn, Los.S, Tr.C, For.I

Table 5.24 MOY 2003 Analysis using the Threshold = Ave+ 3.0 S.D

System	SAIFI	SAIDI
Utility 1-1	Unkn, Ad.W	Unkn, Ad.W
Utility 1-2		Unkn
Utility 1-3		Lightn
Utility 1-4		
Utility 1-5	Sch.O, Los.S, **Total**	Unkn, Los.S, Ad.W, **Total**
Utility 1-6	Los.S, Hu.E	Los.S, **Total**
Utility 1-7	Los.S, Tr.C, Ad.W, **Total**	Los.S, Tr.C, Ad.W, **Total**
Utility 2-1		Ad.W
Utility 2-2	Ad.En	Ad.En
Utility 2-3		Ad.W, **Total**
Utility 2-4	Ad.En	
Utility 2-5		
Utility 2-6		Tr.C
Region 1	Los.S	Los.S, **Total**
Region 2		Tr.C
Region T		Los.S, Tr.C, **Total**
Canada		Unkn, Los.S

Region 2 experienced a much better year in 2003 than Region 1 as Tree Contact is the only cause code that is identified to have a MOY in 2003 and can be attributed to Utility 2-6.

Tables 5.21-5.24 show the impact of the four thresholds on the classification of MOY. In regard to the Total index, 2003 is a MOY for Utilities 1-5, 1-6, 1-7, 2-3, Region 1 and Region T. As noted at the beginning of this chapter, these utilities should pay particular attention to the cause codes which make high performance contributions in this year. Other utilities such as Utilities 1-1 to 1-4, 2-1 and 2-2 do not identify a MOY for 2003 based on the Total index. They should, however, recognize and consider investigating the specific cause codes identified in Table 5.24.

5.6 Summary

The main focus in this chapter is the development of a method to identify a major outage year (MOY). An analysis of the MOY for over a nine year study period has been conducted for each utility. The MOY threshold is not a specific value applied to every utility. The MOY classification follows the basic principle that the threshold for a utility is based on the average and standard deviation of the annual performance indices of that utility over the review period. The results for four hypothetical MOY thresholds are illustrated and compared. As noted earlier, the identification of a MOY becomes more strict as the threshold is increased. The results provide utilities with valuable information on which years during the review period exhibit abnormal performance and what cause codes make the biggest contribution to this performance. These studies provide information on which cause codes to investigate in more depth and make the necessary improvements.

The same basic methodology is applied to assess the system performance in a specific year. The four thresholds used to identify the MOY in 2004 are those used in the previous analysis. The results show that 2004 was a relatively normal year for most of the study utilities. The MOY thresholds for 2004 include data for 2003, which is shown earlier as a bad year for some utilities. A similar analysis for 2003 is also conducted. The results show that 2003 is a bad performance year for some utilities and is identified as a MOY based not only on the Total index but also on many of the cause codes.

Years identified as MOY should be given extra utility and regulator attention. Those years identified as MOY indicate abnormal utility performance and could possible be excluded in the establishment of a financial payment framework. This is considered in the next chapter by conducting financial risk assessments excluding the MOY based on the Total index and the Ave+2.0S.D threshold.

CHAPTER 6

FINANCIAL RISK ASSESSMENT EXCLUDING MAJOR OUTAGE YEAR AND LOSS OF SUPPLY

6.1 Introduction

The determination of major outage years (MOY) is examined in Chapter 5. The first objective of this study was to develop a procedure that could be used to classify MOY in terms of the impact of MOY on overall system performance and the contribution of the individual cause codes to this performance.

The second objective in identifying MOY is in regard to the creation of possible performance based regulation frameworks. Past performance data will be utilized by regulators to establish reward/penalty structures (R/PS). One task faced by the regulator is to decide whether or not to include MOY in R/PS determination. The results presented in Chapter 5 indicate that 2003 was a MOY for many utilities. The analysis in this chapter extends the work in Chapter 4 by examining the effect of excluding MOY from R/PS analysis. The MOY is determined in this study using the Ave+2.0S.D threshold. Three years of data are used to set the R/PS in this chapter. The distributions of the performance indices are based on five years of data.

This chapter presents the financial risk assessments for 2004, including and excluding major outage years for the two test utilities. Additional utility studies are presented in Appendix 6. The R/PS threshold changes after removing a MOY. The removal of a MOY causes the dead zone to move to the left and the width is decreased. The financial risk can be very different from that determined without excluding MOY. This is an important consideration for the regulator.

6.2 Financial Risk Assessment Including and Excluding Major Outage Years

This section presents a comparison of the financial risks including and excluding MOY. Chapter 5 shows that six utilities and three Region systems had a MOY in 2003 when the MOY threshold is the Ave+2.0S.D. The results of an analysis on Utility 1-5 and Utility 2-3 are presented in Table 6.1 and 6.2. The relevant information for other utilities is shown in Appendix 6. Five years of performance data is used in this analysis. The R/PS is determined using a three year data set, as in Chapter 4. The designation 'Normal' indicates that no data (MOY) are excluded. The term Exc.MOY indicates that if a year in the 3yr data set is a MOY, it is removed and replaced by the data for a previous year to set the R/PS. The three year data set is 2001-2003 including the MOY and 2000-2002 excluding the MOY.

Tables 6.1 and 6.2 show the reward and penalty probabilities and the expected payments for the two test utilities under a normal R/PS, and the R/PS excluding the MOY.

Table 6.1 Comparison of the financial risks including and excluding MOY, U1-5

		Ave.	S.D.	Probabilities			Expected	Change
				Reward	Penalty	D.Z.	Payment	
SAIFI	Normal	1.920	0.731	0%	20%	80%	-2.00 M$	
	Exc.MOY	1.653	0.352	20%	20%	60%	0.00 M$	2.00 M$
SAIDI	Normal	6.923	10.375	0%	20%	80%	-2.00 M$	
	Exc.MOY	0.870	0.270	0%	40%	60%	-4.00 M$	-2.00 M$

Exc.MOY: Excluding major outage year

D.Z: Dead Zone

In Expected Payment, '-' indicates penalty payment to the regulator.

Table 6.2 Comparison of the financial risks including and excluding MOY, U2-3

		Ave.	S.D.	Probabilities Reward	Penalty	D.Z.	Expected Payment	Change
SAIFI	Normal	1.767	0.232	20%	0%	80%	2.00 M$	
	Exc.MOY	1.700	0.211	0%	20%	80%	-2.00 M$	-4.00 M$
SAIDI	Normal	3.633	0.818	0%	20%	80%	-2.00 M$	
	Exc.MOY	3.140	0.320	0%	40%	60%	-4.00 M$	-2.00 M$

It can be seen from Table 6.1 that after excluding the MOY in 2003, both the Ave. and S.D for the R/PS decrease. The dead zone shifts to the left and the width is decreased. The probability of both SAIFI and SAIDI residing in the dead zone is reduced from 80% to 60%. The penalty for this utility increases from 20% to 40% for SAIDI. The expected payment is increased for SAIFI but decreased for SAIDI.

The reward probability due to SAIFI is reduced by 20% and the penalty probability is increased by 20% for Utility 2-3, as shown in Table 6.2. This is due to the modified dead zone and results in a 4M$ expected penalty payment. The penalty probability also increases by 20% due to SAIDI and the expected penalty increases from 2M$ to 4M$.

Overall, the expected payments in 2004 for Utility 1-5 improve for SAIFI and get worse for SAIDI. In the case of Utility 2-3, the expected payment situation deteriorates for both SAIFI and SAIDI. This is because including of the MOY places the R/PS further to the right in the performance distribution which tends to make the distribution looks better in the R/PS. After the MOY is removed, the R/P S shifts to the left and the probability of being in the reward zone decreases and that in the penalty zone increases. The magnitude of the changes are different for every utility, as the standard deviation affecting the dead zone width also changes after removing the MOY, which influences the performance probabilities located in each zone. As shown in Tables 6.1 and 6.2 and Appendix 6, six utilities have increased expected penalty payments after excluding the 2003 MOY, two remain the same and only one utility potentially benefits from removing the MOY. The actual rewards or penalty will depend on the actual performance in 2004.

6.3 2004 Actual Payment Including and Excluding Major Outage Year

Table 6.3 and 6.4 show an actual payment comparison based on the 2004 performance for the two test utilities including and excluding MOY. The three R/PS slope structures used in Section 4.8 were applied to determine the annual 2004 payments. This R/PS A structure is used in the analysis shown in Tables 6.1 and 6.2.

It can be seen from Tables 6.3 and 6.4 that Utility 1-5 is rewarded in 2004. The reward payment does not change by excluding MOY 2003 in R/PS A. The financial payments for this utility are generally better after excluding the MOY.

Table 6.3 2004 Actual payment including MOY, U1-5

U 1-5	Ave.	S.D	2004data	Financial	Payment	(per unit)
				R/PS A	R/PS B	R/PS C
SAIFI	1.920	0.731	1.030	1	0.434	0.217
SAIDI	6.923	10.375	0.770	0	0	0
Total				**1**	**0.434**	**0.217**

Table 6.4 2004 Actual payment excluding MOY, U1-5

U 1-5	Ave.	S.D	2004data	Financial	Payment	(per unit)
				R/PS A	R/PS B	R/PS C
SAIFI	1.653	0.352	1.030	1	1	0.77
SAIDI	0.870	0.270	0.770	0	0	0
Total				**1**	**1**	**0.77**

Tables 6.5 and 6.6 show that Utility 2-3 receives a penalty. This penalty does not change by excluding the MOY in R/PS A. The penalty remains the same when the MOY is excluded regardless of the slope. The payments usually decrease as the R/PS slopes decrease and therefore excluding the MOY in this case works against the utility.

Similar analyses were conducted for the remaining utilities and are shown in Appendix 7. The results show that for the nine systems with a MOY in the study period, three benefited financially from excluding the MOY, four received an increased penalty and two remain the same.

Table 6.5 2004 Actual payment including MOY, U2-3

U2-3	Ave.	S.D	2004data	Financial	Payment	(per unit)
				R/PS A	R/PS B	R/PS C
SAIFI	1.767	0.232	2.290	-1	-1	-1
SAIDI	3.633	0.818	4.770	-1	-0.778	-0.389
Total				**-2**	**-1.778**	**-1.389**

Table 6.6 2004 Actual payment excluding MOY, U2-3

U2-3	Ave.	S.D	2004data	Financial	Payment	(per unit)
				R/PS A	R/PS B	R/PS C
SAIFI	1.700	0.211	2.290	-1	-1	-1
SAIDI	3.140	0.320	4.770	-1	-1	-1
Total				**-2**	**-2**	**-2**

6.4 Financial Risk Assessment Including and Excluding Loss of Supply

Loss of Supply can be considered as a special cause code. As noted in Chapter 3, Loss of Supply is due to problems outside the distribution system which are not under the control of the distribution utility. The performance contribution due to Loss of Supply is therefore removed from the total performance index in some jurisdictions.

This section illustrates the impact on the expected financial risk in the study cases (13 utilities, 4 systems) of including and excluding the Loss of Supply contribution. Five year data sets are used in this analysis. The reward/penalty structures are determined using three year data sets and the dead zone width is two standard deviations. The results of this study for Utility 1-3 and 2-3 are shown in Table 6.3 and 6.4 and similar information for the other study cases is given in Appendix 8.

It can be seen in Table 6.7 for the SAIFI case, that the probability of reward for Utility 1-3 increases by 20% and the penalty probability decreases by 40%. The expected payment due to SAIFI changes from a 2M$ penalty to a 4M$ reward, which is a big potential improvement. The SAIDI financial payment responds in the same manner.

Table 6.7 Comparison of the financial risks including and excluding Loss of Supply, U1-3

		Ave.	S.D.	Probabilities			Expected	Change
				Reward	Penalty	D.Z.	Payment	
SAIFI	Normal	1.097	0.221	20%	40%	40%	-2.00 M$	
	Exc.Loss	0.860	0.130	40%	0%	60%	4.00 M$	6.00 M$
SAIDI	Normal	0.877	0.166	20%	40%	40%	-2.00 M$	
	Exc.Loss	0.800	0.070	40%	0%	60%	4.00 M$	6.00 M$

Exc.Loss: Excluding the cause code of Loss of Supply
D.Z.: Dead Zone
In Expected Payment, '-' indicates penalty payment to the regulator.

Table 6.8 shows a quite different result for Utility 2-3. In this case, the SAIFI reward decreases by 20% and the penalty increases by 60% after excluding the Loss of Supply. The expected utility reward of 2M$ becomes a 6M$ payment. Excluding the Loss of Supply has no influence on the SAIDI financial risk in this case. The overall financial risk for this utility becomes worse after excluding Loss of Supply.

Table 6.8 Comparison of the financial risks including and excluding Loss of Supply, U2-3

		Ave.	S.D.	Probabilities			Expected	Change
				Reward	Penalty	D.Z.	Payment	
SAIFI	Normal	1.767	0.232	20%	0%	80%	2.00 M$	
	Exc.Loss	1.327	0.163	0%	60%	40%	-6.00 M$	-8.00.M$
SAIDI	Normal	3.633	0.818	0%	20%	80%	-2.00 M$	
	Exc.Loss	2.823	0.786	0%	20%	80%	-2.00 M$	0.00M$

Combining the expected payments from SAIFI and SAIDI, the results in Table 6.7-6.8 and Appendix 8 show that Utilities 1-1, 1-2, 2-6 have no difference in their expected financial payments due to excluding Loss of Supply. Nine systems have improvements in their expected payment. They are U1-3, U1-4, U1-5, U1-6, U1-7, U2-1, U2-2, Region 1, and Region T. Five systems U2-3, U2-4, U2-5, Region 2, and Canada pay more when Loss of

Supply is removed.

It can be seen that most of the systems that receive increased benefit by excluding Loss of Supply are urban systems. This is particularly true for U1-5, U1-6, 1-7, which have large Loss of Supply values in 2003. This cause code also creates a relatively large performance variability for these utilities. Chapter 3 shows that Loss of Supply in integrated utilities has generally less performance variability than in urban systems. Two integrated systems show better rewards after removing the Loss of Supply contribution, but the increase is generally less than that for the urban utilities. Four of the six urban utilities show increase in the expected rewards and two show no change due to the exclusion of Loss of Supply. The Loss of Supply analysis is focused on the expected reward/penalty payment including and excluding this contribution. The following is an analysis of the payments that result due to the actual performance in the year 2004 under these conditions.

6.5 2004 Actual Payment Including and Excluding Loss of Supply

What is obviously important to a utility is what reward or penalty they would receive based on their actual reliability indices, if a R/PS is applied. This may be different from the expected payment discussed in the last section. Tables 6.9-6.12 show the actual utility payments for the 2004 performance based on the three R/PS. The differences between including and excluding the Loss of Supply contribution are shown in these tables. Similar information for the other utilities is shown in Appendix 2 and Appendix 9.

It can be seen from Tables 6.9-6.10 that Utility 1-3 will receive penalty payments both including and excluding Loss of Supply. The penalty payment increases in the exclusion case. It is important to note that the Loss of Supply contribution is zero in 2004 and is not zero in previous years. The exclusion of Loss of Supply increases the financial loss to this utility in 2004.

Tables 6.11-612 show the result for Utility 2-3. It can be seen that this utility receives a penalty when Loss of Supply is included in the R/PS assessment, but this penalty will be reduced considerably by not including the Loss of Supply contribution.

Table 6.9 2004 Actual payment including Loss of Supply, U1-3

U1-3	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.097	0.221	1.330	-1	-0.107	-0.054
SAIDI	0.877	0.166	1.040	0	0	0
Total				**-1**	**-0.107**	**-0.054**

Table 6.10 2004 Actual payment excluding Loss of Supply, U1-3

U1-3	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	0.860	0.130	1.330	-1	-1	-1
SAIDI	0.800	0.070	1.040	-1	-1	-1
Total				**-2**	**-2**	**-2**

Table 6.11 2004 Actual payment including Loss of Supply, U2-3

U2-3	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.767	0.232	2.290	-1	-1	-1
SAIDI	3.633	0.818	4.770	-1	-0.778	-0.389
Total				**-2**	**-1.778**	**-1.389**

Table 6.12 2004 Actual payment excluding Loss of Supply, U2-3

U2-3	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.327	0.163	1.570	-1	-0.993	-0.497
SAIDI	2.823	0.786	3.540	0	0	0
Total				**-1**	**-0.993**	**-0.497**

Tables 6.9-6.12 and Appendix 2 and 9 show in general that for the seventeen systems, five utilities benefit by excluding the Loss of Supply contribution. They are U1-4, U1-6, U1-7, U2-3 and Region 1. Eight utilities show worse results. They are U1-1, U1-3, U1-5, U2-2, U2-4, U2-5, U2-6 and Region T. The four remaining systems are unaffected by exclusion.

The utilities benefiting by exclusion usually have a big Loss of Supply contribution in 2004 or have a larger difference in 2004 than the difference in the average of the previous years. Utilities showing worse results usually have a small Loss of Supply contribution in 2004. The utilities U1-1, U1-3 and U2-6 show zero in this cause code for 2004.

6.6 Summary

This chapter combines the concept of creating reward/penalty structures using the historical performance data with the MOY identification analysis presented in Chapter 5. The results presented in this chapter provide a comparison of the financial risks in the study utilities of including and excluding MOY in the analysis. Major outage years are generally rare and therefore could possibly be excluded when setting R/PS in performance based regulation (PBR).

A different situation exists in regard to the Loss of Supply contribution. In a non-vertically integrated utility environment, the Loss of Supply contribution to the performance indices is not under the control of the distribution utilities. The data in Chapter 3 show that in many cases， Loss of Supply is a major contributor to the performance indices. This is particularly the case for urban utilities. The Loss of Supply component is removed from the distribution system performance indices in some jurisdictions. The effects of including and excluding the Loss of Supply contribution on the financial risk and possible payments due to actual performance are illustrated in this chapter.

The basic objective in doing the studies described in this chapter is to provide regulators and utilities with valuable information on the characteristics and responses of possible R/PS and to help in the development of fair and feasible reward and penalty structures for individual utilities based on their different characteristics. An overall summary of the research work described in this thesis is presented in the next and final chapter.

CHAPTER 7

SUMMARY AND CONCLUSIONS

This thesis describes the research conducted on the use of historical performance data in assessing the financial risk for a power distribution utility in a performance based regulation regime. Research is also conducted on interruption cause contribution analysis. The uncertainty associated with future performance can introduce considerable financial risk to a utility in such a regime. It is important for a utility to identify the major interruption cause contributions and to utilize this information to improve its system reliability in order to reduce the risk in the future.

The historical utility data used in this research are taken from the Canadian Electrical Association (CEA) annual reports. The CEA has a long history of assessing customer service reliability levels through the production of its annual Service Continuity Report. The individual utility data in these reports are confidential and only provided to the participating utilities. Thirteen utilities that participate in the CEA data reporting activity agreed to provide their individual utility data for the research described in this thesis. These utilities are anonymous and are referred to by numerical designations in accordance with the CEA protocol. This research could not have been conducted without the support of these utilities.

The objectives of the research described in this thesis are to examine and analyze the variations in the annual performance indices of the thirteen participating utilities and the aggregated systems using the overall indices and the cause codes contributing to the overall values, to examine the possible utilization of historic utility reliability indices to create suitable reward/penalty structures in a PBR protocol, to develop an approach to recognize adverse utility performance in the form of Major Outage Years (MOY) and to examine the influence of the MOY performance in PBR decision making.

General concepts of electric power systems and distribution systems are briefly reviewed in Chapter 1. Power system reliability evaluation and the three functional zones and hierarchical levels associated with generation, transmission and distribution facilities are introduced. This chapter also provides a brief introduction to power system deregulation, performance based regulation and the Canadian Electrical Association.

Chapter 2 describes the power distribution system and the basic distribution system reliability indices. The distribution system reliability indices used in practice are also illustrated. This chapter illustrates the difference between future predictive assessment and past performance based assessment. The former includes both analytical techniques and simulation methods and has been the focus of a number of graduate student research projects in the Power System Research Group at the University at the Saskatchewan. The focus in this thesis is on the assessment of past performance and therefore the analytical and simulation predictive techniques are only illustrated by relatively simple examples. The annual variability of the predicted indices can be obtained using a sequential simulation approach. In past performance based assessment, similar information is obtained by recording the frequencies and durations of actual system interruptions. Those data show the actual system performance due to a wide range of internal and external factors and provide valuable information on predicting future system performance.

The CEA maintains a comprehensive database of component and system outage data on behalf of it member utilities [19]. The CEA Service Continuity Reports are compiled on behalf of the participating Canadian utilities and provide a valuable reference on the historical performance of these utilities. As noted earlier, the individual utility performance data in these reports are confidential. The data provided by the thirteen utilities are real life data and are not easily accessible by a third party. The research work described in this thesis is a unique opportunity to examine the historic variability of utility reliability performance of a wide range of actual utility systems.

Chapter 3 presents the SAIFI and SAIDI profiles which indicate the performance of the thirteen utility systems and the Canada integrated system over the last nine years. These data include the total indices and the interruption cause contributions. The contributions to the service continuity indices can come from quite different causes in urban and rural systems. The figures in this chapter show the four major interruption contributions and the total indices for the thirteen utility systems over the study period. The system reliability characteristics of the individual utilities differ due to a wide range of factors. Factors such as "geography, climate, customer mix, growth rate, system age, resource mix, degree of interconnection, impact of significant events" [28] etc make it very difficult to directly compare individual utility performance. The CEA Policy Paper on Benchmarking Data in Regulatory Settings (BD/RS) notes that there are inherent challenges in attempting to benchmark the performance of a utility with that of other utilities and that "CEA members do not support a peer-to-peer approach when accessing a company's performance" [28]. The analysis and figures presented in this chapter clearly indicate the different cause code contributions to the individual utility service continuity performance. The BD/RS Paper suggests that "trending the performance of an individual utility over time should be used as opposed to peer-to-peer benchmarking." The data presented in this chapter supports this position. The SAIFI and SAIDI annual profiles provide valuable information for utilities to compare their current performance with their past performance and to improve their system reliability.

Chapter 4 introduces the basic concept of reliability based reward/penalty structures (R/PS). The data on the performance of an individual utility over time is expressed in the form of probability distributions in this chapter. The data is also used to create possible reward/penalty structures in a PBR framework and to analyze the potential financial risk faced by a utility. Distribution utilities in a performance based regulation (PBR) regime are provided with economic incentives to operate efficiently and economically. A R/PS is an integral part of a PBR plan and has a critical influence on the financial payments to a utility. The determination of the various R/PS therefore should be fair and objective to each utility.

The analyses conducted on one urban utility and one integrated utility are displayed in the main body of this thesis. Similar analyses on the remaining utilities and aggregated systems are given in the appendices. This chapter presents the performance index distributions for the two utilities imposed on R/PS based on ten years of data. Further analyses are generally based on five year performance data sets as a utility could have a large change in its configuration, topology or management philosophy over a longer period. Several methods are utilized to develop R/PS frameworks in Chapter 4. Different year data sets are utilized to determine R/PS for the two study utilities and the implications of using the three to five year data sets are illustrated. The effect on the payment probabilities associated with the reward/penalty boundaries is examined by varying the dead zone width using vertical dead zone boundaries. A sensitivity analysis of different boundary slopes in the R/PS is used to examine the corresponding financial impacts. Vertical R/PS boundaries create abrupt financial charges. The studies show that reducing the boundary slopes will considerably reduce the expected payments.

The analyses on the effect of boundary slope changes was extended to consider the practical situation in which a utility has a R/PS framework provided by the regulator and applies the performance indices for the year 2004 to this R/PS. This chapter illustrates the actual payments for 2004 that would apply to the two test utilities using the three boundary slopes. Similar results for all the utilities and systems are shown in Appendix 2.

Determination of an expected reward or penalty provides an indication of the financial risk faced by the utility. This indication is determined using an appreciation of the performance index magnitudes and variabilities based on past performance. A utility could attempt to take some remedial action in the following year based on the perceived financial risk. This is a relatively short time to actually place in operation significant remedial action but could possibly prove effective in regard to increased activities such as tree trimming and operating practices. The actual reward or penalty levied by the regulator will depend on the actual performance in the specific year under consideration. The performance indices are random variables and therefore can vary considerably from year to year. It is important to appreciate that the financial risk analysis could indicate an expected reward. This does not imply that the actual outcome will automatically be a reward in the following year. This outcome depends on the unique performance in that year.

The concept of a major outage year (MOY) is introduced in Chapter 5. This chapter is focused on developing a method to classify major outage years. The threshold of a MOY is not a specific value but its calculation follows the same basic principle for each utility. The results for four hypothetical MOY thresholds are illustrated and compared. The identification of a MOY becomes more strict as the threshold is increased. The results provide utilities with valuable information on which years during the review period exhibit abnormal performance and what cause codes make the biggest contribution to this performance. These studies provide information on which cause codes should be investigated in more depth and where to make necessary improvements. The basic MOY methodology is applied to assess the system performance in the year 2004 using the same four thresholds. A similar analysis is also conducted for the year 2003. The results show that 2004 was a relatively normal year for most of the study utilities and 2003 is a bad performance year for some utilities, and is identified as a MOY based on the Total index and a number of cause codes. Years identified as MOY should be given extra utility and regulator attention. Years identified as MOY indicate abnormal utility performance and could possibly be excluded in the establishment of a financial payment framework. It is important to note that the objective is to develop a fair and transparent procedure to establish a R/PS. The actual performance indices in particular year are not modified to recognize major outage events that occurred in that year.

A comparison of the financial risks in the study utilities due to including and excluding MOY in the analysis is presented in Chapter 6 by combining the R/PS in Chapter 4 with the MOY identification analysis presented in Chapter 5. The analysis described in this thesis show that MOY are generally rare and therefore could possibly be excluded when setting R/PS in performance based regulation (PBR). This was examined by application to the year 2004 for two test utilities. Similar analyses for the remaining utilities are shown in Appendix 7.

In a non-vertically integrated utility environment, Loss of Supply contributions are not under the control of the distribution utilities and can be a big factor in the utility performance for a particular year. The associated uncertainty will result in increased potential risk for distribution utilities. The effects of including and excluding the Loss of Supply contribution on the financial risk and possible payments due to actual performance are illustrated in Chapter 4. Similar analyses including and excluding the Loss of Supply contribution using the 2004 data are illustrated in Chapter 6. These studies are intended to provide regulators and utilities with valuable information on the characteristics and responses of possible R/PS and to help in the development of fair and feasible reward and penalty structures for individual utilities based on their different characteristics.

The future reliability performance of a utility is uncertain and therefore decisions made on the design of an appropriate R/PS should recognize this uncertainty and attempt to create a structure that is fair to both the regulator and the utility. There is a wide range of possible R/PS. The data presented in this thesis illustrates that a single framework with fixed numerical parameters cannot be fairly applied to all utilities. This research investigates the concept of designing an appropriate R/PS framework for a specific utility based on its own past performance. The R/PS framework should change as the system changes and provide incentives for utilities to improve their service performance. It may be necessary to apply a developed framework for more than one year in order to provide stability and utility response. These issues should be studied by both the regulator and the utility in question.

The research described in this thesis is based on actual utility data and provides insight on the financial response of possible R/PS frameworks when applied to a wide range of utilities. It is expected that this research will prove valuable to both utilities and regulators engaged in the development and application of R/PS in performance based regulation.

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Appendix 1

System Financial Risks Using Different Year Based R/PS

The following tables show the system financial risks using the 1 year-5 year data sets based R/PS presented in Chapter 4 for the thirteen utilities and four systems. All system performances are based on five years.

Table A1.1 System financial risks using different year based R/PS, Utility 1-1

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Probability Penalty	Probability D.Z.	Expected Payment
SAIFI						
5-year data	0.698	0.381	0%	20%	80%	-2.00 M$
4-year data	0.700	0.440	0%	20%	80%	-2.00 M$
3-year data	0.757	0.520	0%	20%	80%	-2.00 M$
2-year data	0.965	0.530	20%	0%	80%	2.00 M$
1-year data	1.340	0.000	100%	0%	0%	10.00 M$
SAIDI						
5-year data	0.512	0.385	0%	20%	80%	-2.00 M$
4-year data	0.550	0.434	0%	20%	80%	-2.00 M$
3-year data	0.670	0.442	20%	20%	60%	0.00 M$
2-year data	0.840	0.467	60%	0%	40%	6.00 M$
1-year data	1.170	0.000	100%	0%	0%	10.00 M$

D.Z: Dead Zone

Table A1.2 System financial risks using different year based R/PS, Utility 1-2

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Probability Penalty	Probability D.Z.	Expected Payment
SAIFI						
5-year data	0.470	0.532	0%	20%	80%	-2.00 M$
4-year data	0.573	0.554	0%	20%	80%	-2.00 M$
3-year data	0.643	0.656	0%	20%	80%	-2.00 M$
2-year data	0.845	0.785	20%	0%	80%	2.00 M$
1-year data	0.290	0.000	60%	40%	-0%	2.00 M$
R/PS based on N-yr data	Ave.	S.D	Probability Reward	Probability Penalty	Probability D.Z.	Expected Payment
5-year data	0.434	0.198	20%	0%	80%	2.00 M$
4-year data	0.520	0.055	40%	20%	40%	2.00 M$
3-year data	0.543	0.035	40%	20%	40%	2.00 M$
2-year data	0.560	0.028	60%	0%	40%	6.00 M$
1-year data	0.540	0.000	80%	20%	-0%	6.00 M$

Table A1.3 System financial risks using different year based R/PS, Utility 1-3

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Probability Penalty	Probability D.Z.	Expected Payment
SAIFI						
5-year data	1.142	0.456	20%	20%	60%	0.00 M$
4-year data	0.975	0.303	20%	40%	40%	-2.00 M$
3-year data	1.097	0.221	20%	40%	40%	-2.00 M$
2-year data	1.175	0.247	20%	20%	60%	0.00 M$
1-year data	1.000	0.000	60%	40%	-0%	2.00 M$
SAIDI						
5-year data	0.942	0.469	20%	20%	60%	0.00 M$
4-year data	0.760	0.270	20%	40%	40%	-2.00 M$
3-year data	0.877	0.166	20%	40%	40%	-2.00 M$
2-year data	0.955	0.134	40%	20%	40%	2.00 M$
1-year data	0.860	0.000	60%	40%	-0%	2.00 M$

D.Z: Dead Zone

Table A1.4 System financial risks using different year based R/PS, Utility 1-4

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Probability Penalty	Probability D.Z.	Expected Payment
SAIFI						
5-year data	1.168	0.300	0%	20%	80%	-2.00 M$
4-year data	1.135	0.336	0%	20%	80%	-2.00 M$
3-year data	1.160	0.407	0%	20%	80%	-2.00 M$
2-year data	1.275	0.502	0%	0%	100%	0.00 M$
1-year data	0.920	0.000	20%	80%	0%	-6.00 M$
SAIDI						
5-year data	0.652	0.171	20%	20%	60%	0.00 M$
4-year data	0.657	0.197	20%	20%	60%	0.00 M$
3-year data	0.673	0.238	0%	20%	80%	-2.00 M$
2-year data	0.695	0.332	0%	0%	100%	0.00 M$
1-year data	0.460	0.000	20%	80%	0%	-6.00 M$

Table A1.5 System financial risks using different year based R/PS, Utility 1-5

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Probability Penalty	Probability D.Z.	Expected Payment
SAIFI						
5-year data	1.816	0.563	20%	20%	60%	0.00 M$
4-year data	1.915	0.597	20%	20%	60%	0.00 M$
3-year data	1.920	0.731	0%	20%	80%	-2.00 M$
2-year data	1.975	1.025	0%	0%	100%	0.00 M$
1-year data	2.700	0.000	100%	0%	0%	10.00 M$
SAIDI						
5-year data	4.442	8.085	0%	20%	80%	-2.00 M$
4-year data	5.377	9.018	0%	20%	80%	-2.00 M$
3-year data	6.923	10.375	0%	20%	80%	-2.00 M$
2-year data	9.795	12.876	0%	0%	100%	0.00 M$
1-year data	18.900	0.000	100%	0%	0%	10.00 M$

Table A1.6 System financial risks using different year based R/PS, Utility 1-6

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	1.300	0.789	0%	20%	80%	-2.00 M$
4-year data	1.425	0.852	20%	20%	60%	0.00 M$
3-year data	1.723	0.745	60%	0%	40%	6.00 M$
2-year data	2.100	0.509	60%	0%	40%	6.00 M$
1-year data	2.460	0.000	100%	0%	0%	10.00 M$
SAIDI						
5-year data	3.196	4.918	0%	20%	80%	-2.00 M$
4-year data	3.785	5.471	0%	20%	80%	-2.00 M$
3-year data	4.833	6.189	0%	20%	80%	-2.00 M$
2-year data	6.645	7.545	0%	0%	100%	0.00 M$
1-year data	11.980	0.000	100%	0%	0%	10.00 M$

Table A1.7 System financial risks using different year based R/PS, Utility 1-7

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	3.236	0.973	0%	20%	80%	-2.00 M$
4-year data	3.435	0.999	0%	20%	80%	-2.00 M$
3-year data	3.523	1.204	0%	20%	80%	-2.00 M$
2-year data	3.915	1.407	20%	0%	80%	2.00 M$
1-year data	4.910	0.000	100%	0%	0%	10.00 M$
SAIDI						
5-year data	3.236	0.973	0%	20%	80%	-2.00 M$
4-year data	3.435	0.999	0%	20%	80%	-2.00 M$
3-year data	3.523	1.204	0%	20%	80%	-2.00 M$
2-year data	3.915	1.407	20%	0%	80%	2.00 M$
1-year data	4.910	0.000	100%	0%	0%	10.00 M$

Table A1.8 System financial risks using different year based R/PS, Utility 2-1

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	1.630	0.374	20%	20%	60%	0.00 M$
4-year data	1.755	0.287	40%	20%	40%	2.00 M$
3-year data	1.810	0.324	40%	0%	60%	4.00 M$
2-year data	1.985	0.163	60%	0%	40%	6.00 M$
1-year data	1.870	0.000	80%	20%	-0%	6.00 M$
SAIDI						
5-year data	2.942	1.324	20%	20%	60%	0.00 M$
4-year data	3.288	1.241	20%	20%	60%	0.00 M$
3-year data	3.573	1.349	40%	0%	60%	4.00 M$
2-year data	4.330	0.453	60%	0%	40%	6.00 M$
1-year data	4.650	0.000	100%	0%	0%	10.00 M$

Table A1.9 System financial risks using different year based R/PS, Utility 2-2

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	2.990	0.619	20%	20%	60%	0.00 M$
4-year data	2.755	0.377	20%	40%	40%	-2.00 M$
3-year data	2.597	0.251	20%	40%	40%	-2.00 M$
2-year data	2.490	0.240	0%	60%	40%	-6.00 M$
1-year data	2.320	0.000	20%	80%	0%	-6.00 M$
SAIDI						
5-year data	3.516	1.348	0%	20%	80%	-2.00 M$
4-year data	3.770	1.412	0%	20%	80%	-2.00 M$
3-year data	4.140	1.473	60%	0%	40%	6.00 M$
2-year data	4.980	0.325	60%	0%	40%	6.00 M$
1-year data	5.210	0.000	100%	0%	0%	10.00 M$

Table A1.10 System financial risks using different year based R/PS, Utility 2-3

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	1.728	0.172	20%	20%	60%	0.00 M$
4-year data	1.745	0.194	20%	0%	80%	2.00 M$
3-year data	1.767	0.232	20%	0%	80%	2.00 M$
2-year data	1.690	0.269	0%	0%	100%	0.00 M$
1-year data	1.880	0.000	80%	20%	0%	6.00 M$
SAIDI						
5-year data	3.366	0.686	0%	20%	80%	-2.00 M$
4-year data	3.482	0.733	0%	20%	80%	-2.00 M$
3-year data	3.633	0.818	0%	20%	80%	-2.00 M$
2-year data	3.700	1.146	0%	0%	100%	0.00 M$
1-year data	4.510	0.000	100%	0%	0%	10.00 M$

Table A1.11 System financial risks using different year based R/PS, Utility 2-4

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	7.592	1.647	20%	20%	60%	0.00 M$
4-year data	8.252	0.842	40%	20%	40%	2.00 M$
3-year data	8.210	1.026	20%	20%	60%	0.00 M$
2-year data	8.620	1.047	40%	0%	60%	4.00 M$
1-year data	7.880	0.000	60%	40%	-0%	2.00 M$
SAIDI						
5-year data	12.090	2.671	20%	20%	60%	0.00 M$
4-year data	12.813	2.456	40%	20%	40%	2.00 M$
3-year data	11.793	1.678	40%	20%	40%	2.00 M$
2-year data	12.660	1.061	40%	20%	40%	2.00 M$
1-year data	11.910	0.000	60%	40%	-0%	2.00 M$

Table A1.12 System financial risks using different year based R/PS, Utility 2-5

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	5.102	0.962	20%	20%	60%	0.00 M$
4-year data	4.723	0.522	20%	20%	60%	0.00 M$
3-year data	4.653	0.617	20%	20%	60%	0.00 M$
2-year data	4.985	0.318	20%	20%	60%	0.00 M$
1-year data	5.210	0.000	80%	20%	-0%	6.00 M$
SAIDI						
5-year data	5.838	2.310	0%	20%	80%	-2.00 M$
4-year data	4.873	0.948	20%	40%	40%	-2.00 M$
3-year data	4.520	0.775	20%	40%	40%	-2.00 M$
2-year data	4.915	0.516	20%	40%	40%	-2.00 M$
1-year data	5.280	0.000	60%	40%	-0%	2.00 M$

Table A1.13 System financial risks using different year based R/PS, Utility 2-6

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	1.672	0.104	20%	20%	60%	0.00 M$
4-year data	1.673	0.120	20%	0%	80%	2.00 M$
3-year data	1.647	0.132	0%	20%	80%	-2.00 M$
2-year data	1.660	0.184	0%	0%	100%	0.00 M$
1-year data	1.790	0.000	100%	0%	0%	10.00 M$
SAIDI						
5-year data	3.484	0.536	0%	20%	80%	-2.00 M$
4-year data	3.510	0.615	0%	20%	80%	-2.00 M$
3-year data	3.580	0.734	0%	20%	80%	-2.00 M$
2-year data	3.890	0.707	20%	0%	80%	2.00 M$
1-year data	4.390	0.000	100%	0%	0%	10.00 M$

Table A1.14 System financial risks using different year based R/PS, Region 1

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	1.548	0.357	0%	20%	80%	-2.00 M$
4-year data	1.590	0.397	0%	20%	80%	-2.00 M$
3-year data	1.700	0.405	40%	0%	60%	4.00 M$
2-year data	1.905	0.276	60%	0%	40%	6.00 M$
1-year data	2.100	0.000	100%	0%	0%	10.00 M$
SAIDI						
5-year data	2.418	3.269	0%	20%	80%	-2.00 M$
4-year data	2.815	3.633	0%	20%	80%	-2.00 M$
3-year data	3.480	4.141	0%	20%	80%	-2.00 M$
2-year data	4.720	5.006	0%	0%	100%	0.00 M$
1-year data	8.260	0.000	100%	0%	0%	10.00 M$

Table A1.15 System financial risks using different year based R/PS, Region 2

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	2.462	0.134	20%	0%	80%	2.00 M$
4-year data	2.440	0.144	20%	0%	80%	2.00 M$
3-year data	2.427	0.174	20%	0%	80%	2.00 M$
2-year data	2.525	0.049	20%	0%	80%	2.00 M$
1-year data	2.560	0.000	100%	0%	0%	10.00 M$
SAIDI						
5-year data	3.922	0.658	20%	20%	60%	0.00 M$
4-year data	3.927	0.760	20%	20%	60%	0.00 M$
3-year data	3.993	0.916	20%	0%	80%	2.00 M$
2-year data	4.465	0.587	40%	0%	60%	4.00 M$
1-year data	4.880	0.000	100%	0%	0%	10.00 M$

Table A1.16 System financial risks using different year based R/PS, Region T

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	2.074	0.203	20%	20%	60%	0.00 M$
4-year data	2.072	0.235	20%	20%	60%	0.00 M$
3-year data	2.110	0.272	20%	0%	80%	2.00 M$
2-year data	2.255	0.148	60%	0%	40%	6.00 M$
1-year data	2.360	0.000	100%	0%	0%	10.00 M$
SAIDI						
5-year data	3.298	1.734	0%	20%	80%	-2.00 M$
4-year data	3.453	1.962	0%	20%	80%	-2.00 M$
3-year data	3.773	2.271	0%	20%	80%	-2.00 M$
2-year data	4.580	2.531	0%	0%	100%	0.00 M$
1-year data	6.370	0.000	100%	0%	0%	10.00 M$

Table A1.17 System financial risks using different year based R/PS, Canada

R/PS based on N-yr data	Ave.	S.D	Probability Reward	Penalty	D.Z.	Expected Payment
SAIFI						
5-year data	2.392	0.124	20%	20%	60%	0.00 M$
4-year data	2.343	0.064	20%	40%	40%	-2.00 M$
3-year data	2.370	0.040	40%	20%	40%	2.00 M$
2-year data	2.350	0.028	20%	40%	40%	-2.00 M$
1-year data	2.370	0.000	60%	40%	-0%	2.00 M$
SAIDI						
5-year data	4.076	0.708	20%	20%	60%	0.00 M$
4-year data	4.018	0.803	0%	20%	80%	-2.00 M$
3-year data	4.280	0.745	20%	20%	60%	0.00 M$
2-year data	4.585	0.742	40%	0%	60%	4.00 M$
1-year data	5.110	0.000	100%	0%	0%	10.00 M$

Appendix 2

The Actual Financial Payments for 2004 Using the Three R/PS Slopes

The following tables show the actual financial payments for all the study utilities and systems for the year 2004 using the three slope frameworks presented in Chapter 4.

Table A2.1 The 2004 actual financial payments for the three R/PS slopes, U1-1

U1-1	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	0.757	0.520	0.150	1	0.331	0.166
SAIDI	0.670	0.442	0.180	1	0.216	0.108
Total				**2**	**0.547**	**0.274**

Note: In financial payment volume, '-' means penalty payment

Table A2.2 The 2004 actual financial payments for the three R/PS slopes, U1-2

U1-2	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	0.643	0.656	0.590	0	0	0
SAIDI	0.543	0.035	0.990	-1	-1	-1
Total				**-1**	**-1**	**-1**

Table A2.3 The 2004 actual financial payments for the three R/PS slopes, U1-3

U1-3	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.097	0.221	1.330	-1	-0.107	-0.054
SAIDI	0.877	0.166	1.040	0	0	0
Total				**-1**	**-0.107**	**-0.054**

Table A2.4 The 2004 actual financial payments for the three R/PS slopes, U1-4

U1-4	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.160	0.407	1.070	0	0	0
SAIDI	0.673	0.238	0.450	0	0	0
Total				0	0	0

Table A2.5 The 2004 actual financial payments for the three R/PS slopes, U1-5

U1-5	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.920	0.731	1.030	1	0.434	0.217
SAIDI	6.923	10.375	0.770	0	0	0
Total				**1**	**0.434**	**0.217**

Table A2.6 The 2004 actual financial payments for the three R/PS slopes, U1-6

U1-6	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.723	0.745	0.660	1	0.854	0.427
SAIDI	4.833	6.189	0.760	0	0	0
Total				**1**	**0.854**	**0.427**

Table A2.7 The 2004 actual financial payments for the three R/PS slopes, U1-7

U1-7	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	3.523	1.204	2.190	1	0.214	0.107
SAIDI	6.357	7.336	1.520	0	0	0
Total				**1**	**0.214**	**0.107**

Table A2.8 The 2004 actual financial payments for the three R/PS slopes, U2-1

U2-1	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.810	0.324	2.040	0	0	0
SAIDI	3.573	1.349	3.350	0	0	0
Total				0	0	0

Table A2.9 The 2004 actual financial payments for the three R/PS slopes, U2-2

U2-2	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	2.597	0.251	2.390	0	0	0
SAIDI	4.140	1.473	2.440	1	0.308	0.154
Total				1	0.308	0.154

Table A2.10 The 2004 actual financial payments for the three R/PS slopes, U2-3

U2-3	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.767	0.232	2.290	-1	-1	-1
SAIDI	3.633	0.818	4.770	-1	-0.778	-0.389
Total				**-2**	**-1.778**	**-1.389**

Table A2.11 The 2004 actual financial payments for the three R/PS slopes, U2-4

U2-4	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	8.210	1.026	5.800	1	1	1
SAIDI	11.793	1.678	11.150	0	0	0
Total				**1**	**1**	**1**

Table A2.12 The 2004 actual financial payments for the three R/PS slopes, U2-5

U2-5	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	4.653	0.617	3.580	1	1	0.74
SAIDI	4.520	0.775	4.860	0	0	0
Total				**1**	**1**	**0.74**

Table A2.13 The 2004 actual financial payments for the three R/PS slopes, U2-6

U2-6	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.647	0.132	1.820	-1	-0.626	-0.313
SAIDI	3.580	0.734	3.220	0	0	0
Total				**-1**	**-0.626**	**-0.313**

Table A2.14 The 2004 actual financial payments for the three R/PS slopes, Region 1

Region1	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.700	0.405	1.080	1	1	0.531
SAIDI	3.480	4.141	0.760	0	0	0
Total				**1**	**1**	**0.531**

Table A2.15 The 2004 actual financial payments for the three R/PS slopes, Region 2

Region2	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	2.427	0.174	2.370	0	0	0
SAIDI	3.993	0.916	3.880	0	0	0
Total				**0**	**0**	**0**

Table A2.16 The 2004 actual financial payments for the three R/PS slopes, Region T

RegionT	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	2.110	0.272	1.800	1	0.278	0.139
SAIDI	3.773	2.271	2.500	0	0	0
Total				**1**	**0.278**	**0.139**

Table A2.17 The 2004 actual financial payments for the three R/PS slopes, Canada

Canada	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	2.470	0.178	1.980	1	1	1
SAIDI	6.127	3.922	3.950	0	0	0
Total				**1**	**1**	**1**

Appendix 3

Major Outage Year Analysis

The following tables show the major outage years (MOY) for the thirteen utilities and the integrated systems over the study period (1995-2003) using the four test thresholds. The MOY analyses are presented in Chapter 5.

Table A3.1 SAIFI MOY Analysis, Utility 1-1 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+ 1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.010	0.026	1	2003	11%	1	2003	11%
Sch.O	0.020	0.000	0	0	0%	0	0	0%
Los.S	0.813	1.211	1	1996	11%	1	1996	11%
Tr.C	0.030	0.047	2	1996, 1997	22%	0	0	0%
Lightn	0.019	0.033	2	1996, 1997	22%	0	0	0%
De.E	0.348	0.300	2	1996, 1998	22%	0	0	0%
Ad.W	0.167	0.259	1	2003	11%	1	2003	11%
Ad.En	0.000	0.000	0	0	0%	0	0	0%
Hu.E	0.108	0.227	1	1996	11%	1	1996	11%
For.I	0.162	0.113	2	1997, 2000	22%	0	0	0%
Total	1.677	1.732	1	1996	11%	1	1996	11%

Note: m is the number of major outage year

Table A3.2 SAIFI MOY Analysis, Utility 1-1 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.010	0.047	1	2003	11%	0	0	0%
Sch.O	0.020	0.061	0	0	0%	0	0	0%
Los.S	0.813	0.513	0	0	0%	0	0	0%
Tr.C	0.030	0.055	0	0	0%	0	0	0%
Lightn	0.019	0.128	0	0	0%	0	0	0%
De.E	0.348	0.224	0	0	0%	0	0	0%
Ad.W	0.167	0.070	0	0	0%	0	0	0%
Ad.En	0.000	0.033	0	0	0%	0	0	0%
Hu.E	0.108	0.075	1	1996	11%	0	0	0%
For.I	0.162	0.074	0	0	0%	0	0	0%
Total	1.677	0.695	0	0	0%	0	0	0%

Table A3.3 SAIDI MOY Analysis, Utility 1-1 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.011	0.027	1	2003	11%	1	2003	11%
Sch.O	0.020	0.000	0	0	0%	0	0	0%
Los.S	0.432	0.602	2	1997, 1998	22%	0	0	0%
Tr.C	0.027	0.045	2	1996, 2002	22%	1	1996	11%
Lightn	0.031	0.050	1	1995	11%	1	1995	11%
De.E	0.260	0.197	1	1996	11%	1	1996	11%
Ad.W	0.162	0.248	1	2003	11%	1	2003	11%
Ad.En	0.000	0.000	0	0	0%	0	0	0%
Hu.E	0.039	0.091	1	1998	11%	1	1998	11%
For.I	0.079	0.059	1	1998	11%	1	1998	11%
Total	1.061	0.828	3	1996,1997,1998	33%	0	0	0%

Table A3.4 SAIDI MOY Analysis, Utility 1-1 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.011	0.027	1	2003	11%	0	0	0%
Sch.O	0.020	0.000	0	0	0%	0	0	0%
Los.S	0.432	0.602	0	0	0%	0	0	0%
Tr.C	0.027	0.045	0	0	0%	0	0	0%
Lightn	0.031	0.050	0	0	0%	0	0	0%
De.E	0.260	0.197	0	0	0%	0	0	0%
Ad.W	0.162	0.248	1	2003	11%	0	0	0%
Ad.En	0.000	0.000	0	0	0%	0	0	0%
Hu.E	0.039	0.091	1	1998	11%	0	0	0%
For.I	0.079	0.059	0	0	0%	0	0	0%
Total	1.061	0.828	0	0	0%	0	0	0%

Table A3.5 SAIFI MOY Analysis, Utility 1-2 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.067	0.108	1	1998	13%	1	1998	13%
Sch.O	0.000	0.000	0	0	0%	0	0	0%
Los.S	0.000	0.000	0	0	0%	0	0	0%
Tr.C	0.001	0.004	1	1997	13%	1	1997	13%
Lightn	0.044	0.072	1	2000	13%	1	2000	13%
De.E	0.191	0.151	2	1996, 2002	25%	0	0	0%
Ad.W	0.061	0.121	1	1997	13%	1	1997	13%
Ad.En	0.016	0.046	1	1998	13%	1	1998	13%
Hu.E	0.020	0.037	2	1996, 2002	25%	0	0	0%
For.I	0.181	0.316	1	2002	13%	1	2002	13%
Total	0.584	0.449	2	1998, 2002	25%	0	0	0%

Table A3.6 SAIFI MOY Analysis, Utility 1-2 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.067	0.108	0	0	0%	0	0	0%
Sch.O	0.000	0.000	0	0	0%	0	0	0%
Los.S	0.000	0.000	0	0	0%	0	0	0%
Tr.C	0.001	0.004	0	0	0%	0	0	0%
Lightn	0.044	0.072	0	0	0%	0	0	0%
De.E	0.191	0.151	0	0	0%	0	0	0%
Ad.W	0.061	0.121	0	0	0%	0	0	0%
Ad.En	0.016	0.046	0	0	0%	0	0	0%
Hu.E	0.020	0.037	0	0	0%	0	0	0%
For.I	0.181	0.316	0	0	0%	0	0	0%
Total	0.584	0.449	0	0	0%	0	0	0%

Table A3.7 SAIDI MOY Analysis, Utility 1-2 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.069	0.096	2	1998, 2003	25%	0	0	0%
Sch.O	0.000	0.000	0	0	0%	0	0	0%
Los.S	0.000	0.000	0	0	0%	0	0	0%
Tr.C	0.001	0.004	1	1997	13%	1	1997	13%
Lightn	0.049	0.079	1	2000	13%	1	2000	13%
De.E	0.266	0.187	1	1997	13%	0	0	0%
Ad.W	0.133	0.226	1	1997	13%	1	1997	13%
Ad.En	0.023	0.060	1	1998	13%	1	1998	13%
Hu.E	0.063	0.173	1	1996	13%	1	1996	13%
For.I	0.113	0.145	1	1998	13%	1	1998	13%
Total	0.715	0.421	2	1996, 1997	25%	0	0	0%

Table A3.8 SAIDI MOY Analysis, Utility 1-2 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.069	0.096	0	0	0%	0	0	0%
Sch.O	0.000	0.000	0	0	0%	0	0	0%
Los.S	0.000	0.000	0	0	0%	0	0	0%
Tr.C	0.001	0.004	0	0	0%	0	0	0%
Lightn	0.049	0.079	0	0	0%	0	0	0%
De.E	0.266	0.187	0	0	0%	0	0	0%
Ad.W	0.133	0.226	0	0	0%	0	0	0%
Ad.En	0.023	0.060	0	0	0%	0	0	0%
Hu.E	0.063	0.173	0	0	0%	0	0	0%
For.I	0.113	0.145	0	0	0%	0	0	0%
Total	0.715	0.421	0	0	0%	0	0	0%

Table A3.9 SAIFI MOY Analysis, Utility 1-3 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.031	0.047	1	2001	11%	1	2001	11%
Sch.O	0.056	0.061	1	1996	11%	1	1996	11%
Los.S	0.418	0.513	2	1995, 1999	22%	0	0	0%
Tr.C	0.081	0.055	1	1999	11%	0	0	0%
Lightn	0.132	0.128	2	1998, 2003	22%	0	0	0%
De.E	0.287	0.224	1	1995	11%	1	1995	11%
Ad.W	0.034	0.070	1	1996	11%	1	1996	11%
Ad.En	0.014	0.033	1	2001	11%	1	2001	11%
Hu.E	0.094	0.075	2	1995, 2000	22%	1	1995	11%
For.I	0.108	0.074	2	1998, 2001	22%	0	0	0%
Total	1.260	0.695	1	1995	11%	0	0	0%

Table A3.10 SAIFI MOY Analysis, Utility 1-3 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.031	0.047	0	0	0%	0	0	0%
Sch.O	0.056	0.061	1	1996	11%	0	0	0%
Los.S	0.418	0.513	0	0	0%	0	0	0%
Tr.C	0.081	0.055	0	0	0%	0	0	0%
Lightn	0.132	0.128	0	0	0%	0	0	0%
De.E	0.287	0.224	0	0	0%	0	0	0%
Ad.W	0.034	0.070	1	1996	11%	0	0	0%
Ad.En	0.014	0.033	1	2001	11%	0	0	0%
Hu.E	0.094	0.075	0	0	0%	0	0	0%
For.I	0.108	0.074	0	0	0%	0	0	0%
Total	1.260	0.695	0	0	0%	0	0	0%

Table A3.11 SAIDI MOY Analysis, Utility 1-3 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.019	0.036	1	2001	11%	1	2001	11%
Sch.O	0.050	0.019	2	1996, 1998	22%	1	1996	11%
Los.S	0.178	0.285	1	1999	11%	1	1999	11%
Tr.C	0.090	0.067	1	1999	11%	1	1999	11%
Lightn	0.101	0.097	1	2003	11%	1	2003	11%
De.E	0.312	0.165	1	1995	11%	0	0	0%
Ad.W	0.088	0.222	1	1996	11%	1	1996	11%
Ad.En	0.008	0.012	3	1996,1997, 2001	33%	0	0	0%
Hu.E	0.026	0.022	2	1995, 1997	22%	0	0	0%
For.I	0.091	0.090	1	1998	11%	1	1998	11%
Total	0.956	0.430	1	1999	11%	0	0	0%

Table A3.12 SAIDI MOY Analysis, Utility 1-3 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.019	0.036	1	2001	11%	0	0	0%
Sch.O	0.050	0.019	0	0	0%	0	0	0%
Los.S	0.178	0.285	0	0	0%	0	0	0%
Tr.C	0.090	0.067	0	0	0%	0	0	0%
Lightn	0.101	0.097	0	0	0%	0	0	0%
De.E	0.312	0.165	0	0	0%	0	0	0%
Ad.W	0.088	0.222	1	1996	11%	0	0	0%
Ad.En	0.008	0.012	0	0	0%	0	0	0%
Hu.E	0.026	0.022	0	0	0%	0	0	0%
For.I	0.091	0.090	0	0	0%	0	0	0%
Total	0.956	0.430	0	0	0%	0	0	0%

Table A3.13 SAIFI MOY Analysis, Utility 1-4 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.048	0.030	2	1999, 2003	22%	1	1999	11%
Sch.O	0.104	0.091	3	1995 1996 1997	33%	0	0	0%
Los.S	0.314	0.126	1	2002	11%	0	0	0%
Tr.C	0.038	0.019	3	1995 1996 1997	33%	0	0	0%
Lightn	0.067	0.025	1	1998	11%	0	0	0%
De.E	0.191	0.046	1	1996	11%	1	1996	11%
Ad.W	0.149	0.141	2	1996, 2002	22%	0	0	0%
Ad.En	0.067	0.071	1	2002	11%	1	2002	11%
Hu.E	0.029	0.013	2	1999 , 2002	22%	0	0	0%
For.I	0.278	0.088	2	1995, 1998	22%	1	1998	11%
Total	1.284	0.278	2	1996, 2002	22%	0	0	0%

Table A3.14 SAIFI MOY Analysis, Utility 1-4 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.048	0.030	0	0	0%	0	0	0%
Sch.O	0.104	0.091	0	0	0%	0	0	0%
Los.S	0.314	0.126	0	0	0%	0	0	0%
Tr.C	0.038	0.019	0	0	0%	0	0	0%
Lightn	0.067	0.025	0	0	0%	0	0	0%
De.E	0.191	0.046	0	0	0%	0	0	0%
Ad.W	0.149	0.141	0	0	0%	0	0	0%
Ad.En	0.067	0.071	0	0	0%	0	0	0%
Hu.E	0.029	0.013	0	0	0%	0	0	0%
For.I	0.278	0.088	0	0	0%	0	0	0%
Total	1.284	0.278	0	0	0%	0	0	0%

Table A3.15 SAIDI MOY Analysis, Utility 1-4 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.008	0.010	1	1999	11%	1	1999	11%
Sch.O	0.056	0.028	1	1998	11%	0	0	0%
Los.S	0.124	0.084	2	1999, 2000	22%	0	0	0%
Tr.C	0.018	0.011	2	1995, 1997	22%	1	1997	11%
Lightn	0.012	0.010	1	1997	11%	0	0	0%
De.E	0.113	0.037	1	2003	11%	0	0	0%
Ad.W	0.120	0.141	2	1996, 2002	22%	0	0	0%
Ad.En	0.063	0.086	2	2001, 2002	22%	0	0	0%
Hu.E	0.003	0.005	3	1999, 2000, 2001	33%	0	0	0%
For.I	0.088	0.040	2	1998, 1999	22%	0	0	0%
Total	0.606	0.165	1	2002	11%	0	0	0%

Table A3.16 SAIDI MOY Analysis, Utility 1-4 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.008	0.010	0	0	0%	0	0	0%
Sch.O	0.056	0.028	0	0	0%	0	0	0%
Los.S	0.124	0.084	0	0	0%	0	0	0%
Tr.C	0.018	0.011	0	0	0%	0	0	0%
Lightn	0.012	0.010	0	0	0%	0	0	0%
De.E	0.113	0.037	0	0	0%	0	0	0%
Ad.W	0.120	0.141	0	0	0%	0	0	0%
Ad.En	0.063	0.086	0	0	0%	0	0	0%
Hu.E	0.003	0.005	0	0	0%	0	0	0%
For.I	0.088	0.040	0	0	0%	0	0	0%
Total	0.606	0.165	0	0	0%	0	0	0%

Table A3.17 SAIFI MOY Analysis, Utility 1-5 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.060	0.025	0	0	0%	0	0	0%
Sch.O	0.092	0.028	1	2003	20%	0	0	0%
Los.S	0.590	0.727	1	2003	20%	0	0	0%
Tr.C	0.050	0.010	0	0	0%	0	0	0%
Lightn	0.246	0.270	1	2000	20%	0	0	0%
De.E	0.400	0.138	1	2001	20%	0	0	0%
Ad.W	0.196	0.123	1	2003	20%	0	0	0%
Ad.En	0.010	0.010	0	0	0%	0	0	0%
Hu.E	0.022	0.013	1	2000	20%	0	0	0%
For.I	0.150	0.069	1	2002	20%	0	0	0%
Total	1.816	0.563	1	2003	20%	0	0	0%

Table A3.18 SAIFI MOY Analysis, Utility 1-5 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.060	0.025	0	0	0%	0	0	0%
Sch.O	0.092	0.028	0	0	0%	0	0	0%
Los.S	0.590	0.727	0	0	0%	0	0	0%
Tr.C	0.050	0.010	0	0	0%	0	0	0%
Lightn	0.246	0.270	0	0	0%	0	0	0%
De.E	0.400	0.138	0	0	0%	0	0	0%
Ad.W	0.196	0.123	0	0	0%	0	0	0%
Ad.En	0.010	0.010	0	0	0%	0	0	0%
Hu.E	0.022	0.013	0	0	0%	0	0	0%
For.I	0.150	0.069	0	0	0%	0	0	0%
Total	1.816	0.563	0	0	0%	0	0	0%

Table A3.19 SAIDI MOY Analysis, Utility 1-5 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.028	0.036	1	2003	20%	0	0	0%
Sch.O	0.144	0.046	0	0	0%	0	0	0%
Los.S	3.670	7.917	1	2003	20%	0	0	0%
Tr.C	0.028	0.008	1	2001	20%	0	0	0%
Lightn	0.080	0.053	1	1999	20%	0	0	0%
De.E	0.256	0.105	1	2001	20%	0	0	0%
Ad.W	0.132	0.152	1	2003	20%	0	0	0%
Ad.En	0.014	0.011	1	2000	20%	0	0	0%
Hu.E	0.006	0.005	0	0	0%	0	0	0%
For.I	0.090	0.032	1	2003	20%	0	0	0%
Total	4.442	8.085	1	2003	20%	0	0	0%

Table A3.20 SAIDI MOY Analysis, Utility 1-5 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.028	0.036	0	0	0%	0	0	0%
Sch.O	0.144	0.046	0	0	0%	0	0	0%
Los.S	3.670	7.917	0	0	0%	0	0	0%
Tr.C	0.028	0.008	0	0	0%	0	0	0%
Lightn	0.080	0.053	0	0	0%	0	0	0%
De.E	0.256	0.105	0	0	0%	0	0	0%
Ad.W	0.132	0.152	0	0	0%	0	0	0%
Ad.En	0.014	0.011	0	0	0%	0	0	0%
Hu.E	0.006	0.005	0	0	0%	0	0	0%
For.I	0.090	0.032	0	0	0%	0	0	0%
Total	4.442	8.085	0	0	0%	0	0	0%

Table A3.21 SAIFI MOY Analysis, Utility 1-6 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.057	0.038	2	2002, 2003	22%	0	0	0%
Sch.O	0.193	0.275	1	1998	11%	1	1998	11%
Los.S	0.426	0.493	1	2003	11%	1	2003	11%
Tr.C	0.031	0.021	2	1998, 2001	22%	0	0	0%
Lightn	0.041	0.038	2	1996, 1998	22%	0	0	0%
De.E	0.258	0.098	1	2002	11%	0	0	0%
Ad.W	0.214	0.451	1	1998	11%	1	1998	11%
Ad.En	0.012	0.019	1	2001	11%	1	2001	11%
Hu.E	0.038	0.023	1	2003	11%	1	2003	11%
For.I	0.078	0.031	3	1999, 2001, 2003	33%	0	0	0%
Total	1.348	0.831	2	1998, 2003	22%	0	0	0%

Table A3.22 SAIFI MOY Analysis, Utility 1-6 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.057	0.038	0	0	0%	0	0	0%
Sch.O	0.193	0.275	1	1998	11%	0	0	0%
Los.S	0.426	0.493	0	0	0%	0	0	0%
Tr.C	0.031	0.021	0	0	0%	0	0	0%
Lightn	0.041	0.038	0	0	0%	0	0	0%
De.E	0.258	0.098	0	0	0%	0	0	0%
Ad.W	0.214	0.451	1	1998	11%	0	0	0%
Ad.En	0.012	0.019	1	2001	11%	0	0	0%
Hu.E	0.038	0.023	0	0	0%	0	0	0%
For.I	0.078	0.031	0	0	0%	0	0	0%
Total	1.348	0.831	0	0	0%	0	0	0%

Table A3.23 SAIDI MOY Analysis, Utility 1-6 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.046	0.033	1	2002	11%	1	2002	11%
Sch.O	0.236	0.447	1	1998	11%	1	1998	11%
Los.S	1.521	3.516	1	2003	11%	1	2003	11%
Tr.C	0.048	0.030	2	1996, 2001	22%	0	0	0%
Lightn	0.056	0.053	2	1996, 1998	22%	0	0	0%
De.E	0.333	0.158	1	1995	11%	0	0	0%
Ad.W	0.759	1.904	1	1998	11%	1	1998	11%
Ad.En	0.012	0.016	2	2001, 2003	22%	0	0	0%
Hu.E	0.031	0.026	1	1997	11%	1	1997	11%
For.I	0.104	0.054	2	1995, 2001	22%	0	0	0%
Total	3.146	3.972	2	1998, 2003	22%	1	2003	11%

Table A3.24 SAIDI MOY Analysis, Utility 1-6 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.046	0.033	0	0	0%	0	0	0%
Sch.O	0.236	0.447	1	1998	11%	0	0	0%
Los.S	1.521	3.516	1	2003	11%	0	0	0%
Tr.C	0.048	0.030	0	0	0%	0	0	0%
Lightn	0.056	0.053	0	0	0%	0	0	0%
De.E	0.333	0.158	0	0	0%	0	0	0%
Ad.W	0.759	1.904	1	1998	11%	0	0	0%
Ad.En	0.012	0.016	0	0	0%	0	0	0%
Hu.E	0.031	0.026	0	0	0%	0	0	0%
For.I	0.104	0.054	0	0	0%	0	0	0%
Total	3.146	3.972	0	0	0%	0	0	0%

Table A3.25 SAIFI MOY Analysis, Utility 1-7 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.097	0.053	1	2002	17%	0	0	0%
Sch.O	0.157	0.066	1	1998	17%	0	0	0%
Los.S	0.608	0.587	1	2003	17%	0	0	0%
Tr.C	0.090	0.052	1	2003	17%	0	0	0%
Lightn	0.278	0.144	1	2000	17%	1	2000	17%
De.E	0.783	0.187	1	1999	17%	0	0	0%
Ad.W	0.500	0.420	1	2003	17%	0	0	0%
Ad.En	0.117	0.105	1	2001	17%	0	0	0%
Hu.E	0.085	0.055	2	2001, 2002	33%	0	0	0%
For.I	0.313	0.124	1	2000	17%	0	0	0%
Total	3.028	1.008	1	2003	17%	0	0	0%

Table A3.26 SAIFI MOY Analysis, Utility 1-7 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.097	0.053	0	0	0%	0	0	0%
Sch.O	0.157	0.066	0	0	0%	0	0	0%
Los.S	0.608	0.587	0	0	0%	0	0	0%
Tr.C	0.090	0.052	0	0	0%	0	0	0%
Lightn	0.278	0.144	0	0	0%	0	0	0%
De.E	0.783	0.187	0	0	0%	0	0	0%
Ad.W	0.500	0.420	0	0	0%	0	0	0%
Ad.En	0.117	0.105	0	0	0%	0	0	0%
Hu.E	0.085	0.055	0	0	0%	0	0	0%
For.I	0.313	0.124	0	0	0%	0	0	0%
Total	3.028	1.008	0	0	0%	0	0	0%

Table A3.27 SAIDI MOY Analysis, Utility 1-7 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.025	0.016	1	2002	17%	0	0	0%
Sch.O	0.170	0.056	0	0	0%	0	0	0%
Los.S	2.292	4.862	1	2003	17%	1	2003	17%
Tr.C	0.095	0.110	1	2003	17%	0	0	0%
Lightn	0.150	0.098	1	2000	17%	0	0	0%
De.E	0.478	0.140	1	1999	17%	0	0	0%
Ad.W	0.445	0.486	1	2003	17%	0	0	0%
Ad.En	0.100	0.088	1	2001	17%	0	0	0%
Hu.E	0.033	0.024	1	2002	17%	0	0	0%
For.I	0.213	0.107	1	2002	17%	0	0	0%
Total	4.002	5.317	1	2003	17%	1	2003	17%

Table A3.28 SAIDI MOY Analysis, Utility 1-7 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.025	0.016	0	0	0%	0	0	0%
Sch.O	0.170	0.056	0	0	0%	0	0	0%
Los.S	2.292	4.862	0	0	0%	0	0	0%
Tr.C	0.095	0.110	0	0	0%	0	0	0%
Lightn	0.150	0.098	0	0	0%	0	0	0%
De.E	0.478	0.140	0	0	0%	0	0	0%
Ad.W	0.445	0.486	0	0	0%	0	0	0%
Ad.En	0.100	0.088	0	0	0%	0	0	0%
Hu.E	0.033	0.024	0	0	0%	0	0	0%
For.I	0.213	0.107	0	0	0%	0	0	0%
Total	4.002	5.317	0	0	0%	0	0	0%

Table A3.29 SAIFI MOY Analysis, Utility 2-1 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.109	0.024	1	1997	14%	0	0	0%
Sch.O	0.179	0.058	2	2000 , 2002	29%	0	0	0%
Los.S	0.321	0.116	1	2002	14%	0	0	0%
Tr.C	0.061	0.027	1	2001	14%	0	0	0%
Lightn	0.156	0.039	1	2000	14%	0	0	0%
De.E	0.203	0.076	1	2002	14%	0	0	0%
Ad.W	0.144	0.116	2	2002 , 2003	29%	0	0	0%
Ad.En	0.011	0.011	1	2002	14%	0	0	0%
Hu.E	0.040	0.027	1	2001	14%	0	0	0%
For.I	0.194	0.129	2	2002 , 2003	29%	0	0	0%
Total	1.414	0.479	1	2002	14%	0	0	0%

Table A3.30 SAIFI MOY Analysis, Utility 2-1 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.109	0.024	0	0	0%	0	0	0%
Sch.O	0.179	0.058	0	0	0%	0	0	0%
Los.S	0.321	0.116	0	0	0%	0	0	0%
Tr.C	0.061	0.027	0	0	0%	0	0	0%
Lightn	0.156	0.039	0	0	0%	0	0	0%
De.E	0.203	0.076	0	0	0%	0	0	0%
Ad.W	0.144	0.116	0	0	0%	0	0	0%
Ad.En	0.011	0.011	0	0	0%	0	0	0%
Hu.E	0.040	0.027	0	0	0%	0	0	0%
For.I	0.194	0.129	0	0	0%	0	0	0%
Total	1.414	0.479	0	0	0%	0	0	0%

Table A3.31 SAIDI MOY Analysis, Utility 2-1 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.116	0.033	2	1997 , 2000	29%	0	0	0%
Sch.O	0.323	0.114	1	2002	14%	0	0	0%
Los.S	0.340	0.214	2	2002 , 2003	29%	0	0	0%
Tr.C	0.116	0.054	1	2001	14%	0	0	0%
Lightn	0.294	0.061	1	2000	14%	0	0	0%
De.E	0.321	0.117	1	2002	14%	0	0	0%
Ad.W	0.640	0.831	1	2003	14%	0	0	0%
Ad.En	0.020	0.020	1	2000	14%	0	0	0%
Hu.E	0.051	0.029	1	2001	14%	0	0	0%
For.I	0.239	0.163	2	2002 , 2003	29%	0	0	0%
Total	2.460	1.360	2	2002 , 2003	29%	0	0	0%

Table A3.32 SAIDI MOY Analysis, Utility 2-1 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.116	0.033	0	0	0%	0	0	0%
Sch.O	0.323	0.114	0	0	0%	0	0	0%
Los.S	0.340	0.214	0	0	0%	0	0	0%
Tr.C	0.116	0.054	0	0	0%	0	0	0%
Lightn	0.294	0.061	0	0	0%	0	0	0%
De.E	0.321	0.117	0	0	0%	0	0	0%
Ad.W	0.640	0.831	0	0	0%	0	0	0%
Ad.En	0.020	0.020	0	0	0%	0	0	0%
Hu.E	0.051	0.029	0	0	0%	0	0	0%
For.I	0.239	0.163	0	0	0%	0	0	0%
Total	2.460	1.360	0	0	0%	0	0	0%

Table A3.33 SAIFI MOY Analysis, Utility 2-2 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.099	0.062	1	1997	11%	1	1997	11%
Sch.O	0.138	0.060	1	1996	11%	1	1996	11%
Los.S	3.106	1.618	2	1996, 1997	22%	0	0	0%
Tr.C	0.108	0.025	1	1996	11%	0	0	0%
Lightn	0.040	0.029	2	2000, 2002	22%	1	2000	11%
De.E	0.194	0.097	2	1996, 1997	22%	0	0	0%
Ad.W	0.184	0.069	1	2002	11%	0	0	0%
Ad.En	0.021	0.020	1	2003	11%	0	0	0%
Hu.E	0.031	0.033	2	1995, 1996	22%	0	0	0%
For.I	0.179	0.063	2	1997, 2003	22%	0	0	0%
Total	4.101	1.810	2	1996, 1997	22%	0	0	0%

Table A3.34 SAIFI MOY Analysis, Utility 2-2 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.099	0.062	0	0	0%	0	0	0%
Sch.O	0.138	0.060	1	1996	11%	0	0	0%
Los.S	3.106	1.618	0	0	0%	0	0	0%
Tr.C	0.108	0.025	0	0	0%	0	0	0%
Lightn	0.040	0.029	0	0	0%	0	0	0%
De.E	0.194	0.097	0	0	0%	0	0	0%
Ad.W	0.184	0.069	0	0	0%	0	0	0%
Ad.En	0.021	0.020	0	0	0%	0	0	0%
Hu.E	0.031	0.033	0	0	0%	0	0	0%
For.I	0.179	0.063	0	0	0%	0	0	0%
Total	4.101	1.810	0	0	0%	0	0	0%

Table A3.35 SAIDI MOY Analysis, Utility 2-2 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.116	0.069	1	1997	11%	1	1997	11%
Sch.O	0.261	0.219	1	1996	11%	1	1996	11%
Los.S	1.479	0.730	1	1996	11%	1	1996	11%
Tr.C	0.279	0.128	1	2002	11%	1	2002	11%
Lightn	0.069	0.043	3	1995, 2000, 2002	33%	0	0	0%
De.E	0.333	0.149	1	1996	11%	0	0	0%
Ad.W	0.691	0.569	2	2002, 2003	22%	0	0	0%
Ad.En	0.132	0.264	1	2003	11%	1	2003	11%
Hu.E	0.014	0.028	1	1996	11%	1	1996	11%
For.I	0.250	0.086	1	2003	11%	0	0	0%
Total	3.626	1.412	2	1996, 2003	22%	0	0	0%

Table A3.36 SAIDI MOY Analysis, Utility 2-2 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.099	0.062	0	0	0%	0	0	0%
Sch.O	0.138	0.060	1	1996	11%	0	0	0%
Los.S	3.106	1.618	0	0	0%	0	0	0%
Tr.C	0.108	0.025	0	0	0%	0	0	0%
Lightn	0.040	0.029	0	0	0%	0	0	0%
De.E	0.194	0.097	0	0	0%	0	0	0%
Ad.W	0.184	0.069	0	0	0%	0	0	0%
Ad.En	0.021	0.020	1	2003	11%	0	0	0%
Hu.E	0.031	0.033	0	0	0%	0	0	0%
For.I	0.179	0.063	0	0	0%	0	0	0%
Total	4.101	1.810	0	0	0%	0	0	0%

Table A3.37 SAIFI MOY Analysis, Utility 2-3 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.180	0.051	2	1998 , 1999	22%	0	0	0%
Sch.O	0.416	0.070	2	1995 , 2003	22%	0	0	0%
Los.S	0.168	0.224	1	2001	11%	1	2001	11%
Tr.C	0.102	0.029	1	1997	11%	0	0	0%
Lightn	0.181	0.093	2	1997, 2000	22%	0	0	0%
De.E	0.371	0.082	1	1997	11%	0	0	0%
Ad.W	0.132	0.058	1	1998	11%	0	0	0%
Ad.En	0.028	0.014	1	1999	11%	0	0	0%
Hu.E	0.020	0.017	3	1995, 1997, 2001	33%	0	0	0%
For.I	0.202	0.032	1	1997	11%	0	0	0%
Total	1.797	0.182	1	1997	11%	0	0	0%

Table A3.38 SAIFI MOY Analysis, Utility 2-3 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.180	0.051	0	0	0%	0	0	0%
Sch.O	0.416	0.070	0	0	0%	0	0	0%
Los.S	0.168	0.224	0	0	0%	0	0	0%
Tr.C	0.102	0.029	0	0	0%	0	0	0%
Lightn	0.181	0.093	0	0	0%	0	0	0%
De.E	0.371	0.082	0	0	0%	0	0	0%
Ad.W	0.132	0.058	0	0	0%	0	0	0%
Ad.En	0.028	0.014	0	0	0%	0	0	0%
Hu.E	0.020	0.017	0	0	0%	0	0	0%
For.I	0.202	0.032	0	0	0%	0	0	0%
Total	1.797	0.182	0	0	0%	0	0	0%

Table A3.39 SAIDI MOY Analysis, Utility 2-3 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.266	0.067	1	1998	11%	0	0	0%
Sch.O	0.849	0.179	3	1995, 2000, 2003	33%	0	0	0%
Los.S	0.288	0.426	2	2001, 2003	22%	1	2001	11%
Tr.C	0.236	0.087	1	2003	11%	0	0	0%
Lightn	0.333	0.144	1	1997	11%	0	0	0%
De.E	0.661	0.139	1	1997	11%	0	0	0%
Ad.W	0.342	0.206	1	2003	11%	1	2003	11%
Ad.En	0.102	0.076	2	1998, 1999	22%	0	0	0%
Hu.E	0.011	0.009	1	2001	11%	1	2001	11%
For.I	0.287	0.059	1	2003	11%	0	0	0%
Total	3.376	0.507	1	2003	11%	1	2003	11%

Table A3.40 SAIDI MOY Analysis, Utility 2-3 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.266	0.067	0	0	0%	0	0	0%
Sch.O	0.849	0.179	0	0	0%	0	0	0%
Los.S	0.288	0.426	0	0	0%	0	0	0%
Tr.C	0.236	0.087	0	0	0%	0	0	0%
Lightn	0.333	0.144	0	0	0%	0	0	0%
De.E	0.661	0.139	0	0	0%	0	0	0%
Ad.W	0.342	0.206	0	0	0%	0	0	0%
Ad.En	0.102	0.076	0	0	0%	0	0	0%
Hu.E	0.011	0.009	0	0	0%	0	0	0%
For.I	0.287	0.059	0	0	0%	0	0	0%
Total	3.376	0.507	0	0	0%	0	0	0%

Table A3.41 SAIFI MOY Analysis, Utility 2-4 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.620	0.255	3	1997, 1998, 1999	33%	0	0	0%
Sch.O	1.329	0.426	1	2002	11%	0	0	0%
Los.S	2.241	1.082	1	2001	11%	0	0	0%
Tr.C	0.033	0.038	1	2000	11%	1	2000	11%
Lightn	0.396	0.314	2	2002, 2003	22%	0	0	0%
De.E	0.784	0.459	3	2000, 2002, 2003	33%	0	0	0%
Ad.W	0.622	0.258	1	2002	11%	1	2002	11%
Ad.En	0.111	0.038	1	2003	11%	0	0	0%
Hu.E	0.082	0.054	2	2000, 2001	22%	0	0	0%
For.I	0.111	0.044	1	1996	11%	0	0	0%
Total	6.330	1.970	2	2000, 2002	22%	0	0	0%

Table A3.42 SAIFI MOY Analysis, Utility 2-4 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.620	0.255	0	0	0%	0	0	0%
Sch.O	1.329	0.426	0	0	0%	0	0	0%
Los.S	2.241	1.082	0	0	0%	0	0	0%
Tr.C	0.033	0.038	1	2000	11%	0	0	0%
Lightn	0.396	0.314	0	0	0%	0	0	0%
De.E	0.784	0.459	0	0	0%	0	0	0%
Ad.W	0.622	0.258	0	0	0%	0	0	0%
Ad.En	0.111	0.038	0	0	0%	0	0	0%
Hu.E	0.082	0.054	0	0	0%	0	0	0%
For.I	0.111	0.044	0	0	0%	0	0	0%
Total	6.330	1.970	0	0	0%	0	0	0%

Table A3.43 SAIDI MOY Analysis, Utility 2-4 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	1.106	0.666	1	1995	11%	0	0	0%
Sch.O	2.674	0.975	2	2000, 2002	22%	0	0	0%
Los.S	2.140	1.381	2	2000, 2001	22%	0	0	0%
Tr.C	0.079	0.104	1	2000	11%	1	2000	11%
Lightn	0.371	0.253	1	1996	11%	0	0	0%
De.E	1.502	0.798	2	2002, 2003	22%	0	0	0%
Ad.W	1.818	0.893	2	2000, 2002	22%	0	0	0%
Ad.En	0.329	0.295	1	1999	11%	1	1999	11%
Hu.E	0.054	0.044	1	2001	11%	1	2001	11%
For.I	0.198	0.116	1	1999	11%	1	1999	11%
Total	10.271	3.006	2	2000, 2002	22%	0	0	0%

Table A3.44 SAIDI MOY Analysis, Utility 2-4 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	1.106	0.666	0	0	0%	0	0	0%
Sch.O	2.674	0.975	0	0	0%	0	0	0%
Los.S	2.140	1.381	0	0	0%	0	0	0%
Tr.C	0.079	0.104	1	2000	11%	1	0	0%
Lightn	0.371	0.253	0	0	0%	0	0	0%
De.E	1.502	0.798	0	0	0%	0	0	0%
Ad.W	1.818	0.893	0	0	0%	0	0	0%
Ad.En	0.329	0.295	0	0	0%	0	0	0%
Hu.E	0.054	0.044	0	0	0%	0	0	0%
For.I	0.198	0.116	0	0	0%	0	0	0%
Total	10.271	3.006	0	0	0%	0	0	0%

Table A3.45 SAIFI MOY Analysis, Utility 2-5 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.228	0.196	1	1995	11%	1	1995	11%
Sch.O	0.594	0.364	2	1999, 2000	22%	0	0	0%
Los.S	2.749	0.770	2	1995, 1998	22%	0	0	0%
Tr.C	0.064	0.055	1	1999	11%	1	1999	11%
Lightn	0.064	0.029	2	1998, 2002	22%	0	0	0%
De.E	0.793	0.193	1	1995	11%	1	1995	11%
Ad.W	0.319	0.206	2	1999, 2000	22%	1	1999	11%
Ad.En	0.077	0.170	1	1999	11%	1	1999	11%
Hu.E	0.092	0.038	2	1997, 2000	22%	0	0	0%
For.I	0.073	0.028	0	0	0%	0	0	0%
Total	5.056	1.057	2	1995, 1999	22%	0	0	0%

Table A3.46 SAIFI MOY Analysis, Utility 2-5 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.228	0.196	0	0	0%	0	0	0%
Sch.O	0.594	0.364	0	0	0%	0	0	0%
Los.S	2.749	0.770	0	0	0%	0	0	0%
Tr.C	0.064	0.055	0	0	0%	0	0	0%
Lightn	0.064	0.029	0	0	0%	0	0	0%
De.E	0.793	0.193	0	0	0%	0	0	0%
Ad.W	0.319	0.206	0	0	0%	0	0	0%
Ad.En	0.077	0.170	1	1999	11%	0	0	0%
Hu.E	0.092	0.038	0	0	0%	0	0	0%
For.I	0.073	0.028	0	0	0%	0	0	0%
Total	5.056	1.057	0	0	0%	0	0	0%

Table A3.47 SAIDI MOY Analysis, Utility 2-5 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.249	0.299	1	1995	11%	1	1995	11%
Sch.O	0.960	0.536	2	1999, 2000	22%	0	0	0%
Los.S	2.231	1.020	1	1998	11%	1	1998	11%
Tr.C	0.086	0.075	1	1999	11%	1	1999	11%
Lightn	0.132	0.068	1	2002	11%	1	2002	11%
De.E	1.051	0.281	1	1995	11%	0	0	0%
Ad.W	0.888	0.983	1	1999	11%	1	1999	11%
Ad.En	0.054	0.072	1	1999	11%	1	1999	11%
Hu.E	0.046	0.021	2	2000, 2001	22%	0	0	0%
For.I	0.094	0.032	2	2002, 2003	22%	0	0	0%
Total	5.791	1.889	1	1999	11%	1	1999	11%

Table A3.48 SAIDI MOY Analysis, Utility 2-5 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.249	0.299	0	0	0%	0	0	0%
Sch.O	0.960	0.536	0	0	0%	0	0	0%
Los.S	2.231	1.020	0	0	0%	0	0	0%
Tr.C	0.086	0.075	0	0	0%	0	0	0%
Lightn	0.132	0.068	0	0	0%	0	0	0%
De.E	1.051	0.281	0	0	0%	0	0	0%
Ad.W	0.888	0.983	1	1999	11%	0	0	0%
Ad.En	0.054	0.072	0	0	0%	0	0	0%
Hu.E	0.046	0.021	0	0	0%	0	0	0%
For.I	0.094	0.032	0	0	0%	0	0	0%
Total	5.791	1.889	0	0	0%	0	0	0%

Table A3.49 SAIFI MOY Analysis, Utility 2-6 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.130	0.037	1	1995	11%	0	0	0%
Sch.O	0.312	0.048	1	2003	11%	0	0	0%
Los.S	0.064	0.112	1	1995	11%	1	1995	11%
Tr.C	0.156	0.046	1	1997	11%	0	0	0%
Lightn	0.280	0.104	2	1995, 1996	22%	0	0	0%
De.E	0.364	0.138	2	1996, 2000	22%	0	0	0%
Ad.W	0.179	0.076	1	1998	11%	0	0	0%
Ad.En	0.033	0.029	2	1995, 1998	22%	0	0	0%
Hu.E	0.053	0.086	1	1997	11%	1	1997	11%
For.I	0.213	0.084	1	2003	11%	0	0	0%
Total	1.786	0.295	1	1995	11%	1	1995	11%

Table A3.50 SAIFI MOY Analysis, Utility 2-6 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.130	0.037	0	0	0%	0	0	0%
Sch.O	0.312	0.048	0	0	0%	0	0	0%
Los.S	0.064	0.112	1	1995	11%	0	0	0%
Tr.C	0.156	0.046	0	0	0%	0	0	0%
Lightn	0.280	0.104	0	0	0%	0	0	0%
De.E	0.364	0.138	0	0	0%	0	0	0%
Ad.W	0.179	0.076	0	0	0%	0	0	0%
Ad.En	0.033	0.029	0	0	0%	0	0	0%
Hu.E	0.053	0.086	1	1997	11%	0	0	0%
For.I	0.213	0.084	0	0	0%	0	0	0%
Total	1.786	0.295	0	0	0%	0	0	0%

Table A3.51 SAIDI MOY Analysis, Utility 2-6 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.222	0.060	1	2001	11%	0	0	0%
Sch.O	0.498	0.137	1	2003	11%	0	0	0%
Los.S	0.046	0.028	1	2002	11%	0	0	0%
Tr.C	0.451	0.223	1	2003	11%	1	2003	11%
Lightn	0.667	0.166	1	1996	11%	1	1996	11%
De.E	0.713	0.210	1	1996	11%	1	1996	11%
Ad.W	0.428	0.146	2	1998, 1999	22%	0	0	0%
Ad.En	0.038	0.019	3	1995, 1998, 2002	33%	0	0	0%
Hu.E	0.038	0.023	2	1998, 2002	22%	0	0	0%
For.I	0.418	0.120	1	1996	11%	1	1996	11%
Total	3.518	0.533	2	1996, 2003	22%	0	0	0%

Table A3.52 SAIDI MOY Analysis, Utility 2-6 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.222	0.060	0	0	0%	0	0	0%
Sch.O	0.498	0.137	0	0	0%	0	0	0%
Los.S	0.046	0.028	0	0	0%	0	0	0%
Tr.C	0.451	0.223	0	0	0%	0	0	0%
Lightn	0.667	0.166	0	0	0%	0	0	0%
De.E	0.713	0.210	0	0	0%	0	0	0%
Ad.W	0.428	0.146	0	0	0%	0	0	0%
Ad.En	0.038	0.019	0	0	0%	0	0	0%
Hu.E	0.038	0.023	0	0	0%	0	0	0%
For.I	0.418	0.120	0	0	0%	0	0	0%
Total	3.518	0.533	0	0	0%	0	0	0%

Table A3.53 SAIFI MOY Analysis, Region 1 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.051	0.018	3	1999, 2002, 2003	33%	0	0	0%
Sch.O	0.124	0.087	1	1998	11%	1	1998	11%
Los.S	0.417	0.236	1	2003	11%	1	2003	11%
Tr.C	0.046	0.007	0	0	0%	0	0	0%
Lightn	0.098	0.051	1	2000	11%	1	2000	11%
De.E	0.301	0.057	1	1999	11%	0	0	0%
Ad.W	0.188	0.108	2	1998, 2003	22%	0	0	0%
Ad.En	0.041	0.035	2	2001, 2002	22%	0	0	0%
Hu.E	0.042	0.008	1	1996	11%	1	1996	11%
For.I	0.202	0.045	1	1998	11%	1	1998	11%
Total	1.511	0.339	2	1998, 2003	22%	0	0	0%

Table A3.54 SAIFI MOY Analysis, Region 1 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.051	0.018	0	0	0%	0	0	0%
Sch.O	0.124	0.087	0	0	0%	0	0	0%
Los.S	0.417	0.236	0	0	0%	0	0	0%
Tr.C	0.046	0.007	0	0	0%	0	0	0%
Lightn	0.098	0.051	0	0	0%	0	0	0%
De.E	0.301	0.057	0	0	0%	0	0	0%
Ad.W	0.188	0.108	0	0	0%	0	0	0%
Ad.En	0.041	0.035	0	0	0%	0	0	0%
Hu.E	0.042	0.008	0	0	0%	0	0	0%
For.I	0.202	0.045	0	0	0%	0	0	0%
Total	1.511	0.339	0	0	0%	0	0	0%

Table A3.55 SAIDI MOY Analysis, Region 1 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.023	0.012	2	2002, 2003	22%	0	0	0%
Sch.O	0.109	0.102	1	1998	11%	1	1998	11%
Los.S	0.999	2.338	1	2003	11%	1	2003	11%
Tr.C	0.037	0.013	2	1998, 2003	22%	0	0	0%
Lightn	0.047	0.015	1	2000	11%	0	0	0%
De.E	0.242	0.058	1	2001	11%	0	0	0%
Ad.W	0.284	0.365	1	1998	11%	1	1998	11%
Ad.En	0.037	0.041	1	2001	11%	1	2001	11%
Hu.E	0.018	0.008	2	1996, 1997	22%	0	0	0%
For.I	0.103	0.033	1	1998	11%	0	0	0%
Total	1.904	2.430	1	2003	11%	1	2003	11%

Table A3.56 SAIDI MOY Analysis, Region 1 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.023	0.012	0	0	0%	0	0	0%
Sch.O	0.109	0.102	1	1998	11%	0	0	0%
Los.S	0.999	2.338	1	2003	11%	0	0	0%
Tr.C	0.037	0.013	0	0	0%	0	0	0%
Lightn	0.047	0.015	0	0	0%	0	0	0%
De.E	0.242	0.058	0	0	0%	0	0	0%
Ad.W	0.284	0.365	1	1998	11%	0	0	0%
Ad.En	0.037	0.041	0	0	0%	0	0	0%
Hu.E	0.018	0.008	0	0	0%	0	0	0%
For.I	0.103	0.033	0	0	0%	0	0	0%
Total	1.904	2.430	1	2003	11%	0	0	0%

Table A3.57 SAIFI MOY Analysis, Region 2 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.167	0.066	1	1995	11%	1	1995	11%
Sch.O	0.358	0.070	1	2000	11%	0	0	0%
Los.S	0.907	0.232	2	1995, 1996	22%	1	1995	11%
Tr.C	0.101	0.016	2	1997, 2001	22%	0	0	0%
Lightn	0.191	0.042	2	1995, 1996	22%	0	0	0%
De.E	0.411	0.092	2	1995, 1996	22%	0	0	0%
Ad.W	0.202	0.039	1	2003	11%	0	0	0%
Ad.En	0.036	0.027	1	1999	11%	1	1999	11%
Hu.E	0.051	0.033	1	1997	11%	1	1997	11%
For.I	0.177	0.054	1	2003	11%	0	0	0%
Total	2.598	0.381	1	1995	11%	1	1995	11%

Table A3.58 SAIFI MOY Analysis, Region 2 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.167	0.066	0	0	0%	0	0	0%
Sch.O	0.358	0.070	0	0	0%	0	0	0%
Los.S	0.907	0.232	0	0	0%	0	0	0%
Tr.C	0.101	0.016	0	0	0%	0	0	0%
Lightn	0.191	0.042	0	0	0%	0	0	0%
De.E	0.411	0.092	0	0	0%	0	0	0%
Ad.W	0.202	0.039	0	0	0%	0	0	0%
Ad.En	0.036	0.027	0	0	0%	0	0	0%
Hu.E	0.051	0.033	0	0	0%	0	0	0%
For.I	0.177	0.054	0	0	0%	0	0	0%
Total	2.598	0.381	0	0	0%	0	0	0%

Table A3.59 SAIDI MOY Analysis, Region 2 (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.236	0.114	1	1995	11%	1	1995	11%
Sch.O	0.623	0.138	1	2000	11%	0	0	0%
Los.S	0.697	0.130	2	1996, 1998	22%	0	0	0%
Tr.C	0.253	0.076	1	2003	11%	1	2003	11%
Lightn	0.397	0.087	1	1996	11%	1	1996	11%
De.E	0.679	0.125	1	1996	11%	1	1996	11%
Ad.W	0.596	0.297	2	1999, 2003	22%	0	0	0%
Ad.En	0.060	0.024	2	1999, 2003	22%	0	0	0%
Hu.E	0.037	0.013	2	2001, 2002	22%	0	0	0%
For.I	0.286	0.067	2	1996, 2003	22%	0	0	0%
Total	3.860	0.544	1	2003	11%	0	0	0%

Table A3.60 SAIDI MOY Analysis, Region 2 (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.236	0.114	0	0	0%	0	0	0%
Sch.O	0.623	0.138	0	0	0%	0	0	0%
Los.S	0.697	0.130	0	0	0%	0	0	0%
Tr.C	0.253	0.076	0	0	0%	0	0	0%
Lightn	0.397	0.087	0	0	0%	0	0	0%
De.E	0.679	0.125	0	0	0%	0	0	0%
Ad.W	0.596	0.297	0	0	0%	0	0	0%
Ad.En	0.060	0.024	0	0	0%	0	0	0%
Hu.E	0.037	0.013	0	0	0%	0	0	0%
For.I	0.286	0.067	0	0	0%	0	0	0%
Total	3.860	0.544	0	0	0%	0	0	0%

Table A3.61 SAIFI MOY Analysis, Region T (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.124	0.039	1	1995	11%	1	1995	11%
Sch.O	0.260	0.030	2	1998, 1999	22%	0	0	0%
Los.S	0.721	0.188	2	1995, 1996	22%	0	0	0%
Tr.C	0.080	0.011	1	1997	11%	0	0	0%
Lightn	0.154	0.035	1	2000	11%	0	0	0%
De.E	0.369	0.059	2	1995, 1996	22%	0	0	0%
Ad.W	0.197	0.053	2	1998, 2003	22%	0	0	0%
Ad.En	0.038	0.016	1	1999	11%	0	0	0%
Hu.E	0.048	0.022	1	1997	11%	1	1997	11%
For.I	0.184	0.035	1	2003	11%	0	0	0%
Total	2.178	0.285	1	1995	11%	0	0	0%

Table A3.62 SAIFI MOY Analysis, Region T (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.124	0.039	0	0	0%	0	0	0%
Sch.O	0.260	0.030	0	0	0%	0	0	0%
Los.S	0.721	0.188	0	0	0%	0	0	0%
Tr.C	0.080	0.011	0	0	0%	0	0	0%
Lightn	0.154	0.035	0	0	0%	0	0	0%
De.E	0.369	0.059	0	0	0%	0	0	0%
Ad.W	0.197	0.053	0	0	0%	0	0	0%
Ad.En	0.038	0.016	0	0	0%	0	0	0%
Hu.E	0.048	0.022	0	0	0%	0	0	0%
For.I	0.184	0.035	0	0	0%	0	0	0%
Total	2.178	0.285	0	0	0%	0	0	0%

Table A3.63 SAIDI MOY Analysis, Region T (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.154	0.074	1	1995	11%	1	1995	11%
Sch.O	0.416	0.057	1	2000	11%	0	0	22%
Los.S	0.854	1.050	1	2003	11%	1	2003	22%
Tr.C	0.167	0.047	1	2003	11%	1	2003	11%
Lightn	0.261	0.058	1	1996	11%	1	1996	11%
De.E	0.508	0.075	2	1995, 1996	22%	1	1996	22%
Ad.W	0.464	0.219	2	1998, 2003	22%	0	0	22%
Ad.En	0.051	0.020	1	2001	11%	0	0	11%
Hu.E	0.030	0.007	2	2001, 2002	22%	0	0	11%
For.I	0.212	0.032	2	1996, 2003	22%	0	0	11%
Total	3.119	1.257	1	2003	11%	1	2003	11%

Table A3.64 SAIDI MOY Analysis, Region T (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.154	0.074	0	0	0%	0	0	0%
Sch.O	0.416	0.057	0	0	0%	0	0	0%
Los.S	0.854	1.050	1	2003	11%	0	0	0%
Tr.C	0.167	0.047	0	0	0%	0	0	0%
Lightn	0.261	0.058	0	0	0%	0	0	0%
De.E	0.508	0.075	0	0	0%	0	0	0%
Ad.W	0.464	0.219	0	0	0%	0	0	0%
Ad.En	0.051	0.020	0	0	0%	0	0	0%
Hu.E	0.030	0.007	0	0	0%	0	0	0%
For.I	0.212	0.032	0	0	0%	0	0	0%
Total	3.119	1.257	1	2003	11%	0	0	0%

Table A3.65 SAIFI MOY Analysis, Canada (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.215	0.024	2	1995, 1999	20%	0	0	0%
Sch.O	0.291	0.051	2	1999, 2000	20%	0	0	0%
Los.S	0.668	0.129	1	1995	10%	1	1995	10%
Tr.C	0.229	0.036	3	1999, 2002, 2003	30%	0	0	0%
Lightn	0.160	0.046	1	1994	10%	0	0	0%
De.E	0.425	0.033	1	2000	10%	0	0	0%
Ad.W	0.344	0.364	1	1998	10%	1	1998	10%
Ad.En	0.046	0.014	1	2003	10%	0	0	0%
Hu.E	0.051	0.013	2	1994, 1995	20%	0	0	0%
For.I	0.169	0.019	2	2000, 2003	20%	0	0	0%
Total	2.593	0.386	1	1998	10%	1	1998	10%

Table A3.66 SAIFI MOY Analysis, Canada (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.215	0.024	0	0	0%	0	0	0%
Sch.O	0.291	0.051	0	0	0%	0	0	0%
Los.S	0.668	0.129	0	0	10%	0	0	10%
Tr.C	0.229	0.036	0	0	0%	0	0	0%
Lightn	0.160	0.046	0	0	0%	0	0	0%
De.E	0.425	0.033	0	0	0%	0	0	0%
Ad.W	0.344	0.364	1	1998	10%	0	0	10%
Ad.En	0.046	0.014	0	0	0%	0	0	0%
Hu.E	0.051	0.013	0	0	0%	0	0	0%
For.I	0.169	0.019	0	0	0%	0	0	0%
Total	2.593	0.386	1	1998	10%	0	0	10%

Table A3.67 SAIDI MOY Analysis, Canada (Ave. + 1 & 2 S.D)

Cause code	Ave.	S.D	Threshold= Ave+1.0 S.D			Threshold= Ave+2.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.198	0.049	1	2003	20%	1	2003	10%
Sch.O	0.361	0.075	3	2000, 2002, 2003	20%	0	0	0%
Los.S	0.950	1.410	1	2003	20%	1	2003	10%
Tr.C	0.672	0.268	2	2002, 2003	20%	0	0	0%
Lightn	0.261	0.109	3	1994, 1999, 2002	30%	0	0	0%
De.E	0.590	0.074	2	2000, 2003	20%	0	0	0%
Ad.W	3.563	8.479	1	1998	20%	1	1998	10%
Ad.En	0.066	0.021	2	2002, 2003	20%	0	0	0%
Hu.E	0.037	0.012	3	1994, 1995, 2003	30%	0	0	0%
For.I	0.221	0.041	1	2003	10%	0	0	0%
Total	6.924	8.527	1	1998	10%	1	1998	10%

Table A3.68 SAIDI MOY Analysis, Canada (Ave. + 2.5 & 3 S.D)

Cause code	Ave.	S.D	Threshold= Ave+2.5 S.D			Threshold= Ave+3.0 S.D		
			m	MOY	Percent	m	MOY	Percent
Unkn	0.198	0.049	0	0	0%	0	0	0%
Sch.O	0.361	0.075	0	0	0%	0	0	0%
Los.S	0.950	1.410	1	2003	10%	0	0	0%
Tr.C	0.672	0.268	0	0	0%	0	0	0%
Lightn	0.261	0.109	0	0	0%	0	0	0%
De.E	0.590	0.074	0	0	0%	0	0	0%
Ad.W	3.563	8.479	1	1998	10%	0	0	0%
Ad.En	0.066	0.021	0	0	0%	0	0	0%
Hu.E	0.037	0.012	0	0	0%	0	0	0%
For.I	0.221	0.041	0	0	0%	0	0	0%
Total	6.924	8.527	1	1998	10%	0	0	0%

Appendix 4

Major Outage Year Analysis for 2004

The following tables show the MOY identification for 2004 for the thirteen utilities and the integrated systems using the four test thresholds presented in Chapter 5.

Table A4.1 SAIFI MOY 2004 Analysis, Utility 1-1

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.00	0.010	0.026	0	0	0	0
Sch.O	0.02	0.020	0.000	0	0	0	0
Los.S	0.00	0.813	1.211	0	0	0	0
Tr.C	0.00	0.030	0.047	0	0	0	0
Lightn	0.00	0.019	0.033	0	0	0	0
De.E	0.07	0.348	0.300	0	0	0	0
Ad.W	0.03	0.167	0.259	0	0	0	0
Ad.En	0.00	0.000	0.000	0	0	0	0
Hu.E	0.02	0.108	0.227	0	0	0	0
For.I	0.01	0.162	0.113	0	0	0	0
Total	0.15	1.677	1.732	0	0	0	0

Note: in the fourth column, '0' indicates 2004 is not a MOY for that cause code

Table A4.2 SAIDI MOY 2004 Analysis, Utility 1-1

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.00	0.011	0.027	0	0	0	0
Sch.O	0.02	0.020	0.000	0	0	0	0
Los.S	0.00	0.432	0.602	0	0	0	0
Tr.C	0.00	0.027	0.045	0	0	0	0
Lightn	0.00	0.031	0.050	0	0	0	0
De.E	0.07	0.260	0.197	0	0	0	0
Ad.W	0.06	0.162	0.248	0	0	0	0
Ad.En	0.00	0.000	0.000	0	0	0	0
Hu.E	0.02	0.039	0.091	0	0	0	0
For.I	0.01	0.079	0.059	0	0	0	0
Total	0.18	1.061	0.828	0	0	0	0

Table A4.3 SAIFI MOY 2004 Analysis, Utility 1-2

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.06	0.067	0.108	0	0	0	0
Sch.O	0.00	0.000	0.000	0	0	0	0
Los.S	0.26	0.000	0.000	2004	2004	2004	2004
Tr.C	0.00	0.001	0.004	0	0	0	0
Lightn	0.00	0.044	0.072	0	0	0	0
De.E	0.27	0.191	0.151	0	0	0	0
Ad.W	0.00	0.061	0.121	0	0	0	0
Ad.En	0.00	0.016	0.046	0	0	0	0
Hu.E	0.00	0.020	0.037	0	0	0	0
For.I	0.01	0.181	0.316	0	0	0	0
Total	0.59	0.584	0.449	0	0	0	0

Table A4.4 SAIDI MOY 2004 Analysis, Utility 1-2

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.07	0.069	0.096	0	0	0	0
Sch.O	0.00	0.000	0.000	0	0	0	0
Los.S	0.32	0.000	0.000	2004	2004	2004	2004
Tr.C	0.00	0.001	0.004	0	0	0	0
Lightn	0.00	0.049	0.079	0	0	0	0
De.E	0.58	0.266	0.187	2004	0	0	0
Ad.W	0.00	0.133	0.226	0	0	0	0
Ad.En	0.00	0.023	0.060	0	0	0	0
Hu.E	0.00	0.063	0.173	0	0	0	0
For.I	0.02	0.113	0.145	0	0	0	0
Total	0.99	0.715	0.421	0	0	0	0

Table A4.5 SAIFI MOY 2004 Analysis, Utility 1-3

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.01	0.031	0.047	0	0	0	0
Sch.O	0.11	0.056	0.061	0	0	0	0
Los.S	0.00	0.418	0.513	0	0	0	0
Tr.C	0.17	0.081	0.055	2004	0	0	0
Lightn	0.00	0.132	0.128	0	0	0	0
De.E	0.54	0.287	0.224	2004	0	0	0
Ad.W	0.00	0.034	0.070	0	0	0	0
Ad.En	0.00	0.014	0.033	0	0	0	0
Hu.E	0.28	0.094	0.075	2004	2004	0	0
For.I	0.22	0.108	0.074	2004	0	0	0
Total	1.33	1.260	0.695	0	0	0	0

Table A4.6 SAIDI MOY 2004 Analysis, Utility 1-3

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.01	0.019	0.036	0	0	0	0
Sch.O	0.15	0.050	0.019	2004	2004	2004	2004
Los.S	0.00	0.178	0.285	0	0	0	0
Tr.C	0.25	0.090	0.067	2004	2004	0	0
Lightn	0.00	0.101	0.097	0	0	0	0
De.E	0.38	0.312	0.165	0	0	0	0
Ad.W	0.00	0.088	0.222	0	0	0	0
Ad.En	0.00	0.008	0.012	0	0	0	0
Hu.E	0.10	0.026	0.022	2004	2004	2004	2004
For.I	0.17	0.091	0.090	0	0	0	0
Total	1.04	0.956	0.430	0	0	0	0

Table A4.7 SAIFI MOY 2004 Analysis, Utility 1-4

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.04	0.048	0.030	0	0	0	0
Sch.O	0.01	0.104	0.091	0	0	0	0
Los.S	0.47	0.314	0.126	2004	0	0	0
Tr.C	0.00	0.038	0.019	0	0	0	0
Lightn	0.06	0.067	0.025	0	0	0	0
De.E	0.19	0.191	0.046	0	0	0	0
Ad.W	0.03	0.149	0.141	0	0	0	0
Ad.En	0.04	0.067	0.071	0	0	0	0
Hu.E	0.05	0.029	0.013	2004	0	0	0
For.I	0.18	0.278	0.088	0	0	0	0
Total	1.07	1.284	0.278	0	0	0	0

Table A4.8 SAIDI MOY 2004 Analysis, Utility 1-4

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.00	0.008	0.010	0	0	0	0
Sch.O	0.02	0.056	0.028	0	0	0	0
Los.S	0.18	0.124	0.084	0	0	0	0
Tr.C	0.00	0.018	0.011	0	0	0	0
Lightn	0.02	0.012	0.010	0	0	0	0
De.E	0.09	0.113	0.037	0	0	0	0
Ad.W	0.04	0.120	0.141	0	0	0	0
Ad.En	0.03	0.063	0.086	0	0	0	0
Hu.E	0.02	0.003	0.005	2004	2004	2004	2004
For.I	0.06	0.088	0.040	0	0	0	0
Total	0.45	0.606	0.165	0	0	0	0

Table A4.9 SAIFI MOY 2004 Analysis, Utility 1-5

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.09	0.060	0.025	2004	0	0	0
Sch.O	0.07	0.092	0.028	0	0	0	0
Los.S	0.05	0.590	0.727	0	0	0	0
Tr.C	0.05	0.050	0.010	0	0	0	0
Lightn	0.11	0.246	0.270	0	0	0	0
De.E	0.39	0.400	0.138	0	0	0	0
Ad.W	0.13	0.196	0.123	0	0	0	0
Ad.En	0.01	0.010	0.010	0	0	0	0
Hu.E	0.02	0.022	0.013	0	0	0	0
For.I	0.11	0.150	0.069	0	0	0	0
Total	1.03	1.816	0.563	0	0	0	0

Table A4.10 SAIDI MOY 2004 Analysis, Utility 1-5

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.02	0.028	0.036	0	0	0	0
Sch.O	0.13	0.144	0.046	0	0	0	0
Los.S	0.07	3.670	7.917	0	0	0	0
Tr.C	0.03	0.028	0.008	0	0	0	0
Lightn	0.08	0.080	0.053	0	0	0	0
De.E	0.25	0.256	0.105	0	0	0	0
Ad.W	0.06	0.132	0.152	0	0	0	0
Ad.En	0.06	0.014	0.011	2004	2004	2004	2004
Hu.E	0.00	0.006	0.005	0	0	0	0
For.I	0.06	0.090	0.032	0	0	0	0
Total	0.77	4.442	8.085	0	0	0	0

Table A4.11 SAIFI MOY 2004 Analysis, Utility 1-6

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.02	0.057	0.038	0	0	0	0
Sch.O	0.02	0.193	0.275	0	0	0	0
Los.S	0.14	0.426	0.493	0	0	0	0
Tr.C	0.01	0.031	0.021	0	0	0	0
Lightn	0.01	0.041	0.038	0	0	0	0
De.E	0.29	0.258	0.098	0	0	0	0
Ad.W	0.10	0.214	0.451	0	0	0	0
Ad.En	0.00	0.012	0.019	0	0	0	0
Hu.E	0.01	0.038	0.023	0	0	0	0
For.I	0.06	0.078	0.031	0	0	0	0
Total	0.66	1.348	0.831	0	0	0	0

Table A4.12 SAIDI MOY 2004 Analysis, Utility 1-6

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.02	0.046	0.033	0	0	0	0
Sch.O	0.08	0.236	0.447	0	0	0	0
Los.S	0.03	1.521	3.516	0	0	0	0
Tr.C	0.01	0.048	0.030	0	0	0	0
Lightn	0.01	0.056	0.053	0	0	0	0
De.E	0.35	0.333	0.158	0	0	0	0
Ad.W	0.17	0.759	1.904	0	0	0	0
Ad.En	0.01	0.012	0.016	0	0	0	0
Hu.E	0.01	0.031	0.026	0	0	0	0
For.I	0.07	0.104	0.054	0	0	0	0
Total	0.76	3.146	3.972	0	0	0	0

Table A4.13 SAIFI MOY 2004 Analysis, Utility 1-7

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.19	0.097	0.053	2004	0	0	0
Sch.O	0.14	0.157	0.066	0	0	0	0
Los.S	0.17	0.608	0.587	0	0	0	0
Tr.C	0.05	0.090	0.052	0	0	0	0
Lightn	0.35	0.278	0.144	0	0	0	0
De.E	0.62	0.783	0.187	0	0	0	0
Ad.W	0.05	0.500	0.420	0	0	0	0
Ad.En	0.06	0.117	0.105	0	0	0	0
Hu.E	0.12	0.085	0.055	0	0	0	0
For.I	0.46	0.313	0.124	2004	0	0	0
Total	2.19	3.028	1.008	0	0	0	0

Table A4.14 SAIDI MOY 2004 Analysis, Utility 1-7

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.02	0.025	0.016	0	0	0	0
Sch.O	0.19	0.170	0.056	0	0	0	0
Los.S	0.26	2.292	4.862	0	0	0	0
Tr.C	0.06	0.095	0.110	0	0	0	0
Lightn	0.20	0.150	0.098	0	0	0	0
De.E	0.42	0.478	0.140	0	0	0	0
Ad.W	0.01	0.445	0.486	0	0	0	0
Ad.En	0.05	0.100	0.088	0	0	0	0
Hu.E	0.03	0.033	0.024	0	0	0	0
For.I	0.28	0.213	0.107	0	0	0	0
Total	1.52	4.002	5.317	0	0	0	0

Table A4.15 SAIFI MOY 2004 Analysis, Utility 2-1

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.12	0.109	0.024	0	0	0	0
Sch.O	0.19	0.179	0.058	0	0	0	0
Los.S	0.60	0.321	0.116	2004	2004	0	0
Tr.C	0.06	0.061	0.027	0	0	0	0
Lightn	0.23	0.156	0.039	2004	0	0	0
De.E	0.33	0.203	0.076	2004	0	0	0
Ad.W	0.21	0.144	0.116	0	0	0	0
Ad.En	0.02	0.011	0.011	0	0	0	0
Hu.E	0.01	0.040	0.027	0	0	0	0
For.I	0.28	0.194	0.129	0	0	0	0
Total	2.04	1.414	0.479	2004	0	0	0

Table A4.16 SAIDI MOY 2004 Analysis, Utility 2-1

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.11	0.116	0.033	0	0	0	0
Sch.O	0.35	0.323	0.114	0	0	0	0
Los.S	0.89	0.340	0.214	2004	2004	2004	0
Tr.C	0.17	0.116	0.054	2004	0	0	0
Lightn	0.45	0.294	0.061	2004	2004	2004	0
De.E	0.43	0.321	0.117	0	0	0	0
Ad.W	0.61	0.640	0.831	0	0	0	0
Ad.En	0.03	0.020	0.020	0	0	0	0
Hu.E	0.00	0.051	0.029	0	0	0	0
For.I	0.32	0.239	0.163	0	0	0	0
Total	3.35	2.460	1.360	0	0	0	0

Table A4.17 SAIFI MOY 2004 Analysis, Utility 2-2

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.06	0.099	0.062	0	0	0	0
Sch.O	0.19	0.138	0.060	0	0	0	0
Los.S	1.33	3.106	1.618	0	0	0	0
Tr.C	0.14	0.108	0.025	2004	0	0	0
Lightn	0.04	0.040	0.029	0	0	0	0
De.E	0.16	0.194	0.097	0	0	0	0
Ad.W	0.20	0.184	0.069	0	0	0	0
Ad.En	0.00	0.021	0.020	0	0	0	0
Hu.E	0.10	0.031	0.033	2004	2004	0	0
For.I	0.16	0.179	0.063	0	0	0	0
Total	2.39	4.101	1.810	0	0	0	0

Table A4.18 SAIDI MOY 2004 Analysis, Utility 2-2

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.06	0.116	0.069	0	0	0	0
Sch.O	0.55	0.261	0.219	2004	0	0	0
Los.S	0.58	1.479	0.730	0	0	0	0
Tr.C	0.21	0.279	0.128	0	0	0	0
Lightn	0.06	0.069	0.043	0	0	0	0
De.E	0.27	0.333	0.149	0	0	0	0
Ad.W	0.45	0.691	0.569	0	0	0	0
Ad.En	0.01	0.132	0.264	0	0	0	0
Hu.E	0.03	0.014	0.028	0	0	0	0
For.I	0.22	0.250	0.086	0	0	0	0
Total	2.44	3.626	1.412	0	0	0	0

Table A4.19 SAIFI MOY 2004 Analysis, Utility 2-3

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.14	0.180	0.051	0	0	0	0
Sch.O	0.46	0.416	0.070	0	0	0	0
Los.S	0.72	0.168	0.224	2004	2004	0	0
Tr.C	0.09	0.102	0.029	0	0	0	0
Lightn	0.14	0.181	0.093	0	0	0	0
De.E	0.39	0.371	0.082	0	0	0	0
Ad.W	0.14	0.132	0.058	0	0	0	0
Ad.En	0.03	0.028	0.014	0	0	0	0
Hu.E	0.02	0.020	0.017	0	0	0	0
For.I	0.15	0.202	0.032	0	0	0	0
Total	2.29	1.797	0.182	2004	2004	2004	0

Table A4.20 SAIDI MOY 2004 Analysis, Utility 2-3

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.17	0.266	0.067	0	0	0	0
Sch.O	1.09	0.849	0.179	2004	0	0	0
Los.S	1.23	0.288	0.426	2004	2004	0	0
Tr.C	0.30	0.236	0.087	0	0	0	0
Lightn	0.37	0.333	0.144	0	0	0	0
De.E	0.86	0.661	0.139	2004	0	0	0
Ad.W	0.34	0.342	0.206	0	0	0	0
Ad.En	0.10	0.102	0.076	0	0	0	0
Hu.E	0.03	0.011	0.009	2004	2004	0	0
For.I	0.28	0.287	0.059	0	0	0	0
Total	4.77	3.376	0.507	2004	2004	2004	0

Table A4.21 SAIFI MOY 2004 Analysis, Utility 2-4

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.23	0.620	0.255	0	0	0	0
Sch.O	1.73	1.329	0.426	0	0	0	0
Los.S	1.82	2.241	1.082	0	0	0	0
Tr.C	0.09	0.033	0.038	2004	0	0	0
Lightn	0.03	0.396	0.314	0	0	0	0
De.E	0.80	0.784	0.459	0	0	0	0
Ad.W	0.49	0.622	0.258	0	0	0	0
Ad.En	0.29	0.111	0.038	2004	2004	2004	2004
Hu.E	0.26	0.082	0.054	2004	2004	2004	2004
For.I	0.16	0.111	0.044	2004	0	0	0
Total	5.80	6.330	1.970	0	0	0	0

Table A4.22 SAIDI MOY 2004 Analysis, Utility 2-4

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.38	1.106	0.666	0	0	0	0
Sch.O	3.90	2.674	0.975	2004	0	0	0
Los.S	1.09	2.140	1.381	0	0	0	0
Tr.C	0.08	0.079	0.104	0	0	0	0
Lightn	0.04	0.371	0.253	0	0	0	0
De.E	1.41	1.502	0.798	0	0	0	0
Ad.W	2.01	1.818	0.893	0	0	0	0
Ad.En	1.85	0.329	0.295	2004	2004	2004	2004
Hu.E	0.08	0.054	0.044	0	0	0	0
For.I	0.31	0.198	0.116	0	0	0	0
Total	11.15	10.271	3.006	0	0	0	0

Table A4.23 SAIFI MOY 2004 Analysis, Utility 2-5

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.09	0.228	0.196	0	0	0	0
Sch.O	0.48	0.594	0.364	0	0	0	0
Los.S	1.51	2.749	0.770	0	0	0	0
Tr.C	0.07	0.064	0.055	0	0	0	0
Lightn	0.01	0.064	0.029	0	0	0	0
De.E	0.87	0.793	0.193	0	0	0	0
Ad.W	0.35	0.319	0.206	0	0	0	0
Ad.En	0.03	0.077	0.170	0	0	0	0
Hu.E	0.08	0.092	0.038	0	0	0	0
For.I	0.08	0.073	0.028	0	0	0	0
Total	3.58	5.056	1.057	0	0	0	0

Table A4.24 SAIDI MOY 2004 Analysis, Utility 2-5

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.09	0.249	0.299	0	0	0	0
Sch.O	0.77	0.960	0.536	0	0	0	0
Los.S	1.70	2.231	1.020	0	0	0	0
Tr.C	0.16	0.086	0.075	0	0	0	0
Lightn	0.04	0.132	0.068	0	0	0	0
De.E	1.20	1.051	0.281	0	0	0	0
Ad.W	0.72	0.888	0.983	0	0	0	0
Ad.En	0.06	0.054	0.072	0	0	0	0
Hu.E	0.03	0.046	0.021	0	0	0	0
For.I	0.10	0.094	0.032	0	0	0	0
Total	4.86	5.791	1.889	0	0	0	0

Table A4.25 SAIFI MOY 2004 Analysis, Utility 2-6

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.13	0.130	0.037	0	0	0	0
Sch.O	0.40	0.312	0.048	2004	0	0	0
Los.S	0.00	0.064	0.112	0	0	0	0
Tr.C	0.20	0.156	0.046	0	0	0	0
Lightn	0.17	0.280	0.104	0	0	0	0
De.E	0.37	0.364	0.138	0	0	0	0
Ad.W	0.24	0.179	0.076	0	0	0	0
Ad.En	0.02	0.033	0.029	0	0	0	0
Hu.E	0.03	0.053	0.086	0	0	0	0
For.I	0.27	0.213	0.084	0	0	0	0
Total	1.82	1.786	0.295	0	0	0	0

Table A4.26 SAIDI MOY 2004 Analysis, Utility 2-6

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.17	0.222	0.060	0	0	0	0
Sch.O	0.59	0.498	0.137	0	0	0	0
Los.S	0.00	0.046	0.028	0	0	0	0
Tr.C	0.09	0.451	0.223	0	0	0	0
Lightn	0.43	0.667	0.166	0	0	0	0
De.E	0.73	0.713	0.210	0	0	0	0
Ad.W	0.57	0.428	0.146	0	0	0	0
Ad.En	0.02	0.038	0.019	0	0	0	0
Hu.E	0.07	0.038	0.023	2004	0	0	0
For.I	0.55	0.418	0.120	2004	0	0	0
Total	3.22	3.518	0.533	0	0	0	0

Table A4.27 SAIFI MOY 2004 Analysis, Region 1

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.06	0.051	0.018	0	0	0	0
Sch.O	0.04	0.124	0.087	0	0	0	0
Los.S	0.24	0.417	0.236	0	0	0	0
Tr.C	0.03	0.046	0.007	0	0	0	0
Lightn	0.09	0.098	0.051	0	0	0	0
De.E	0.32	0.301	0.057	0	0	0	0
Ad.W	0.06	0.188	0.108	0	0	0	0
Ad.En	0.02	0.041	0.035	0	0	0	0
Hu.E	0.05	0.042	0.008	0	0	0	0
For.I	0.17	0.202	0.045	0	0	0	0
Total	1.08	1.511	0.339	0	0	0	0

Table A4.28 SAIDI MOY 2004 Analysis, Region 1

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.01	0.023	0.012	0	0	0	0
Sch.O	0.08	0.109	0.102	0	0	0	0
Los.S	0.12	0.999	2.338	0	0	0	0
Tr.C	0.03	0.037	0.013	0	0	0	0
Lightn	0.05	0.047	0.015	0	0	0	0
De.E	0.25	0.242	0.058	0	0	0	0
Ad.W	0.07	0.284	0.365	0	0	0	0
Ad.En	0.03	0.037	0.041	0	0	0	0
Hu.E	0.02	0.018	0.008	0	0	0	0
For.I	0.09	0.103	0.033	0	0	0	0
Total	0.76	1.904	2.430	0	0	0	0

Table A4.29 SAIFI MOY 2004 Analysis, Region 2

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.12	0.167	0.066	0	0	0	0
Sch.O	0.38	0.358	0.070	0	0	0	0
Los.S	0.65	0.907	0.232	0	0	0	0
Tr.C	0.12	0.101	0.016	2004	0	0	0
Lightn	0.15	0.191	0.042	0	0	0	0
De.E	0.44	0.411	0.092	0	0	0	0
Ad.W	0.24	0.202	0.039	0	0	0	0
Ad.En	0.03	0.036	0.027	0	0	0	0
Hu.E	0.04	0.051	0.033	0	0	0	0
For.I	0.22	0.177	0.054	0	0	0	0
Total	2.37	2.598	0.381	0	0	0	0

Table A4.30 SAIDI MOY 2004 Analysis, Region 2

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.14	0.236	0.114	0	0	0	0
Sch.O	0.70	0.623	0.138	0	0	0	0
Los.S	0.76	0.697	0.130	0	0	0	0
Tr.C	0.16	0.253	0.076	0	0	0	0
Lightn	0.33	0.397	0.087	0	0	0	0
De.E	0.72	0.679	0.125	0	0	0	0
Ad.W	0.61	0.596	0.297	0	0	0	0
Ad.En	0.09	0.060	0.024	2004	0	0	0
Hu.E	0.04	0.037	0.013	0	0	0	0
For.I	0.35	0.286	0.067	0	0	0	0
Total	3.88	3.860	0.544	0	0	0	0

Table A4.31 SAIFI MOY 2004 Analysis, Canada

SAIFI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.24	0.215	0.024	2004	0	0	0
Sch.O	0.19	0.291	0.051	0	0	0	0
Los.S	0.42	0.668	0.129	0	0	0	0
Tr.C	0.24	0.229	0.036	0	0	0	0
Lightn	0.06	0.160	0.046	0	0	0	0
De.E	0.45	0.425	0.033	0	0	0	0
Ad.W	0.14	0.344	0.364	0	0	0	0
Ad.En	0.02	0.046	0.014	0	0	0	0
Hu.E	0.05	0.051	0.013	0	0	0	0
For.I	0.18	0.169	0.019	0	0	0	0
Total	1.98	2.593	0.386	0	0	0	0

Table A4.32 SAIDI MOY 2004 Analysis, Canada

SAIDI	Year 2004	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.26	0.198	0.049	2004	0	0	0
Sch.O	0.34	0.361	0.075	0	0	0	0
Los.S	0.46	0.950	1.410	0	0	0	0
Tr.C	0.91	0.672	0.268	0	0	0	0
Lightn	0.10	0.261	0.109	0	0	0	0
De.E	0.83	0.590	0.074	2004	2004	2004	2004
Ad.W	0.66	3.563	8.479	0	0	0	0
Ad.En	0.05	0.066	0.021	0	0	0	0
Hu.E	0.04	0.037	0.012	0	0	0	0
For.I	0.29	0.221	0.041	2004	0	0	0
Total	3.95	6.924	8.527	0	0	0	0

Appendix 5

Major Outage Year Analysis for 2003

The following tables show the MOY identification for 2003 for the thirteen utilities and the integrated systems using the four test thresholds presented in Chapter 5.

Table A5.1 SAIFI MOY 2003 Analysis, Utility 1-1

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.08	0.001	0.004	2003	2003	2003	2003
Sch.O	0.02	0.020	0.000	0	0	0	0
Los.S	0.11	0.901	1.263	0	0	0	0
Tr.C	0.00	0.034	0.049	0	0	0	0
Lightn	0.00	0.021	0.034	0	0	0	0
De.E	0.23	0.362	0.317	0	0	0	0
Ad.W	0.78	0.090	0.128	2003	2003	2003	2003
Ad.En	0.00	0.000	0.000	0	0	0	0
Hu.E	0.00	0.121	0.239	0	0	0	0
For.I	0.12	0.168	0.119	0	0	0	0
Total	1.34	1.719	1.846	0	0	0	0

Note: in the fourth column, '0' indicates 2003 is not a MOY for that cause code

Table A5.2 SAIDI MOY 2003 Analysis, Utility 1-1

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.08	0.003	0.007	2003	2003	2003	2003
Sch.O	0.02	0.020	0.000	0	0	0	0
Los.S	0.02	0.484	0.622	0	0	0	0
Tr.C	0.00	0.030	0.047	0	0	0	0
Lightn	0.00	0.035	0.052	0	0	0	0
De.E	0.15	0.274	0.206	0	0	0	0
Ad.W	0.79	0.084	0.084	2003	2003	2003	2003
Ad.En	0.00	0.000	0.000	0	0	0	0
Hu.E	0.00	0.044	0.096	0	0	0	0
For.I	0.11	0.075	0.062	0	0	0	0
Total	1.17	1.048	0.884	0	0	0	0

Table A5.3 SAIFI MOY 2003 Analysis, Utility 1-2

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.16	0.054	0.110	0	0	0	0
Sch.O	0.00	0.000	0.000	0	0	0	0
Los.S	0.00	0.000	0.000	0	0	0	0
Tr.C	0.00	0.001	0.004	0	0	0	0
Lightn	0.00	0.050	0.075	0	0	0	0
De.E	0.09	0.206	0.157	0	0	0	0
Ad.W	0.03	0.066	0.130	0	0	0	0
Ad.En	0.00	0.019	0.049	0	0	0	0
Hu.E	0.00	0.023	0.039	0	0	0	0
For.I	0.01	0.206	0.333	0	0	0	0
Total	0.29	0.626	0.468	0	0	0	0

Table A5.4 SAIDI MOY 2003 Analysis, Utility 1-2

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.25	0.043	0.067	2003	2003	2003	2003
Sch.O	0.00	0.000	0.000	0	0	0	0
Los.S	0.00	0.000	0.000	0	0	0	0
Tr.C	0.00	0.001	0.004	0	0	0	0
Lightn	0.00	0.056	0.083	0	0	0	0
De.E	0.18	0.279	0.198	0	0	0	0
Ad.W	0.10	0.137	0.243	0	0	0	0
Ad.En	0.00	0.026	0.064	0	0	0	0
Hu.E	0.00	0.071	0.185	0	0	0	0
For.I	0.01	0.127	0.150	0	0	0	0
Total	0.54	0.740	0.448	0	0	0	0

Table A5.5 SAIFI MOY 2003 Analysis, Utility 1-3

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.03	0.031	0.050	0	0	0	0
Sch.O	0.05	0.056	0.065	0	0	0	0
Los.S	0.07	0.461	0.530	0	0	0	0
Tr.C	0.13	0.075	0.056	0	0	0	0
Lightn	0.37	0.103	0.099	2003	2003	2003	0
De.E	0.23	0.294	0.238	0	0	0	0
Ad.W	0.02	0.036	0.075	0	0	0	0
Ad.En	0.00	0.016	0.035	0	0	0	0
Hu.E	0.08	0.096	0.080	0	0	0	0
For.I	0.02	0.119	0.071	0	0	0	0
Total	1.00	1.292	0.735	0	0	0	0

Table A5.6 SAIDI MOY 2003 Analysis, Utility 1-3

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.02	0.019	0.038	0	0	0	0
Sch.O	0.05	0.050	0.021	0	0	0	0
Los.S	0.01	0.199	0.297	0	0	0	0
Tr.C	0.13	0.085	0.069	0	0	0	0
Lightn	0.30	0.076	0.066	2003	2003	2003	2003
De.E	0.32	0.311	0.177	0	0	0	0
Ad.W	0.03	0.095	0.237	0	0	0	0
Ad.En	0.00	0.009	0.012	0	0	0	0
Hu.E	0.01	0.028	0.023	0	0	0	0
For.I	0.00	0.102	0.088	0	0	0	0
Total	0.86	0.968	0.458	0	0	0	0

Table A5.7 SAIFI MOY 2003 Analysis, Utility 1-4

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.08	0.044	0.030	2003	0	0	0
Sch.O	0.02	0.115	0.091	0	0	0	0
Los.S	0.14	0.336	0.115	0	0	0	0
Tr.C	0.02	0.040	0.019	0	0	0	0
Lightn	0.08	0.065	0.027	0	0	0	0
De.E	0.18	0.192	0.049	0	0	0	0
Ad.W	0.11	0.154	0.150	0	0	0	0
Ad.En	0.03	0.071	0.075	0	0	0	0
Hu.E	0.02	0.030	0.013	0	0	0	0
For.I	0.24	0.283	0.093	0	0	0	0
Total	0.92	1.330	0.258	0	0	0	0

Table A5.8 SAIDI MOY 2003 Analysis, Utility 1-4

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.00	0.009	0.010	0	0	0	0
Sch.O	0.06	0.055	0.030	0	0	0	0
Los.S	0.04	0.135	0.083	0	0	0	0
Tr.C	0.01	0.019	0.011	0	0	0	0
Lightn	0.01	0.013	0.010	0	0	0	0
De.E	0.17	0.106	0.032	2003	0	0	0
Ad.W	0.05	0.129	0.148	0	0	0	0
Ad.En	0.00	0.071	0.089	0	0	0	0
Hu.E	0.00	0.004	0.005	0	0	0	0
For.I	0.12	0.084	0.040	0	0	0	0
Total	0.46	0.624	0.166	0	0	0	0

Table A5.9 SAIFI MOY 2003 Analysis, Utility 1-5

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.02	0.070	0.014	0	0	0	0
Sch.O	0.14	0.080	0.008	2003	2003	2003	2003
Los.S	1.85	0.275	0.206	2003	2003	2003	2003
Tr.C	0.04	0.052	0.010	0	0	0	0
Lightn	0.02	0.302	0.276	0	0	0	0
De.E	0.22	0.445	0.110	0	0	0	0
Ad.W	0.33	0.163	0.112	2003	0	0	0
Ad.En	0.02	0.007	0.010	2003	0	0	0
Hu.E	0.01	0.025	0.013	0	0	0	0
For.I	0.05	0.175	0.047	0	0	0	0
Total	2.70	1.595	0.310	2003	2003	2003	2003

Table A5.10 SAIDI MOY 2003 Analysis, Utility 1-5

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.09	0.013	0.013	2003	2003	2003	2003
Sch.O	0.07	0.163	0.024	0	0	0	0
Los.S	17.83	0.130	0.149	2003	2003	2003	2003
Tr.C	0.03	0.028	0.010	0	0	0	0
Lightn	0.05	0.088	0.059	0	0	0	0
De.E	0.28	0.250	0.121	0	0	0	0
Ad.W	0.39	0.068	0.057	2003	2003	2003	2003
Ad.En	0.02	0.013	0.013	0	0	0	0
Hu.E	0.01	0.005	0.006	0	0	0	0
For.I	0.13	0.080	0.027	2003	0	0	0
Total	18.90	0.828	0.236	2003	2003	2003	2003

Table A5.11 SAIFI MOY 2003 Analysis, Utility 1-6

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.10	0.051	0.036	2003	0	0	0
Sch.O	0.03	0.214	0.286	0	0	0	0
Los.S	1.56	0.284	0.267	2003	2003	2003	2003
Tr.C	0.02	0.033	0.022	0	0	0	0
Lightn	0.01	0.045	0.039	0	0	0	0
De.E	0.35	0.246	0.098	2003	0	0	0
Ad.W	0.18	0.219	0.482	0	0	0	0
Ad.En	0.01	0.013	0.020	0	0	0	0
Hu.E	0.09	0.031	0.012	2003	2003	2003	2003
For.I	0.11	0.074	0.030	2003	0	0	0
Total	2.46	1.209	0.768	2003	0	0	0

Table A5.12 SAIDI MOY 2003 Analysis, Utility 1-6

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.06	0.044	0.035	0	0	0	0
Sch.O	0.09	0.254	0.474	0	0	0	0
Los.S	10.83	0.357	0.445	2003	2003	2003	2003
Tr.C	0.04	0.049	0.032	0	0	0	0
Lightn	0.01	0.061	0.053	0	0	0	0
De.E	0.45	0.319	0.162	0	0	0	0
Ad.W	0.27	0.820	2.026	0	0	0	0
Ad.En	0.04	0.009	0.014	2003	2003	0	0
Hu.E	0.05	0.029	0.027	0	0	0	0
For.I	0.14	0.100	0.056	0	0	0	0
Total	11.98	2.041	2.343	2003	2003	2003	2003

Table A5.13 SAIFI MOY 2003 Analysis, Utility 1-7

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.06	0.104	0.056	0	0	0	0
Sch.O	0.12	0.164	0.071	0	0	0	0
Los.S	1.76	0.378	0.181	2003	2003	2003	2003
Tr.C	0.18	0.072	0.031	2003	2003	2003	2003
Lightn	0.21	0.292	0.157	0	0	0	0
De.E	0.79	0.782	0.209	0	0	0	0
Ad.W	1.33	0.334	0.117	2003	2003	2003	2003
Ad.En	0.21	0.098	0.106	2003	0	0	0
Hu.E	0.03	0.096	0.053	0	0	0	0
For.I	0.22	0.332	0.129	0	0	0	0
Total	4.91	2.652	0.456	2003	2003	2003	2003

Table A5.14 SAIDI MOY 2003 Analysis, Utility 1-7

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.01	0.028	0.016	0	0	0	0
Sch.O	0.14	0.176	0.061	0	0	0	0
Los.S	12.21	0.308	0.181	2003	2003	2003	2003
Tr.C	0.30	0.054	0.050	2003	2003	2003	2003
Lightn	0.17	0.146	0.109	0	0	0	0
De.E	0.33	0.508	0.134	0	0	0	0
Ad.W	1.33	0.268	0.245	2003	2003	2003	2003
Ad.En	0.14	0.092	0.096	0	0	0	0
Hu.E	0.05	0.030	0.025	0	0	0	0
For.I	0.13	0.230	0.111	0	0	0	0
Total	14.81	1.840	0.540	2003	2003	2003	2003

Table A5.15 SAIFI MOY 2003 Analysis, Utility 2-1

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.09	0.112	0.025	0	0	0	0
Sch.O	0.20	0.175	0.062	0	0	0	0
Los.S	0.40	0.308	0.121	0	0	0	0
Tr.C	0.08	0.058	0.028	0	0	0	0
Lightn	0.18	0.152	0.041	0	0	0	0
De.E	0.24	0.197	0.081	0	0	0	0
Ad.W	0.31	0.117	0.098	2003	0	0	0
Ad.En	0.01	0.012	0.012	0	0	0	0
Hu.E	0.01	0.045	0.026	0	0	0	0
For.I	0.35	0.168	0.120	2003	0	0	0
Total	1.87	1.338	0.477	2003	0	0	0

Table A5.16 SAIDI MOY 2003 Analysis, Utility 2-1

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.09	0.120	0.034	0	0	0	0
Sch.O	0.37	0.315	0.123	0	0	0	0
Los.S	0.62	0.293	0.192	2003	0	0	0
Tr.C	0.16	0.108	0.055	0	0	0	0
Lightn	0.33	0.288	0.064	0	0	0	0
De.E	0.37	0.313	0.126	0	0	0	0
Ad.W	2.21	0.378	0.504	2003	2003	2003	2003
Ad.En	0.03	0.018	0.021	0	0	0	0
Hu.E	0.01	0.058	0.025	0	0	0	0
For.I	0.46	0.202	0.142	2003	0	0	0
Total	4.65	2.095	1.049	2003	2003	0	0

Table A5.17 SAIFI MOY 2003 Analysis, Utility 2-2

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.07	0.103	0.066	0	0	0	0
Sch.O	0.14	0.138	0.064	0	0	0	0
Los.S	1.40	3.319	1.589	0	0	0	0
Tr.C	0.08	0.111	0.024	0	0	0	0
Lightn	0.02	0.043	0.030	0	0	0	0
De.E	0.05	0.213	0.086	0	0	0	0
Ad.W	0.21	0.181	0.073	0	0	0	0
Ad.En	0.06	0.016	0.014	2003	2003	2003	2003
Hu.E	0.00	0.035	0.033	0	0	0	0
For.I	0.28	0.166	0.054	2003	2003	0	0
Total	2.32	4.324	1.798	0	0	0	0

Table A5.18 SAIDI MOY 2003 Analysis, Utility 2-2

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.17	0.109	0.071	0	0	0	0
Sch.O	0.37	0.248	0.230	0	0	0	0
Los.S	1.50	1.476	0.780	0	0	0	0
Tr.C	0.32	0.274	0.136	0	0	0	0
Lightn	0.04	0.072	0.044	0	0	0	0
De.E	0.12	0.360	0.135	0	0	0	0
Ad.W	1.47	0.594	0.522	2003	0	0	0
Ad.En	0.82	0.046	0.059	2003	2003	2003	2003
Hu.E	0.00	0.016	0.029	0	0	0	0
For.I	0.40	0.231	0.070	2003	2003	0	0
Total	5.21	3.427	1.369	2003	0	0	0

Table A5.19 SAIFI MOY 2003 Analysis, Utility 2-3

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.11	0.189	0.046	0	0	0	0
Sch.O	0.50	0.405	0.067	2003	0	0	0
Los.S	0.37	0.143	0.226	2003	0	0	0
Tr.C	0.13	0.099	0.029	2003	0	0	0
Lightn	0.09	0.193	0.093	0	0	0	0
De.E	0.31	0.379	0.084	0	0	0	0
Ad.W	0.15	0.130	0.062	0	0	0	0
Ad.En	0.01	0.030	0.013	0	0	0	0
Hu.E	0.00	0.022	0.017	0	0	0	0
For.I	0.21	0.201	0.034	0	0	0	0
Total	1.88	1.786	0.192	0	0	0	0

Table A5.20 SAIDI MOY 2003 Analysis, Utility 2-3

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.25	0.268	0.071	0	0	0	0
Sch.O	1.04	0.825	0.175	2003	0	0	0
Los.S	0.78	0.226	0.411	2003	0	0	0
Tr.C	0.40	0.215	0.065	2003	2003	2003	0
Lightn	0.20	0.350	0.145	0	0	0	0
De.E	0.68	0.659	0.149	0	0	0	0
Ad.W	0.76	0.290	0.143	2003	2003	2003	2003
Ad.En	0.02	0.113	0.075	0	0	0	0
Hu.E	0.00	0.013	0.009	0	0	0	0
For.I	0.38	0.275	0.051	2003	2003	0	0
Total	4.51	3.234	0.294	2003	2003	2003	2003

Table A5.21 SAIFI MOY 2003 Analysis, Utility 2-4

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.33	0.656	0.247	0	0	0	0
Sch.O	1.49	1.309	0.451	0	0	0	0
Los.S	2.61	2.195	1.147	0	0	0	0
Tr.C	0.03	0.034	0.041	0	0	0	0
Lightn	0.82	0.343	0.290	2003	0	0	0
De.E	1.49	0.696	0.401	2003	0	0	0
Ad.W	0.75	0.606	0.271	0	0	0	0
Ad.En	0.18	0.103	0.029	2003	2003	2003	0
Hu.E	0.10	0.080	0.057	0	0	0	0
For.I	0.08	0.115	0.045	0	0	0	0
Total	7.88	6.136	2.013	0	0	0	0

Table A5.22 SAIDI MOY 2003 Analysis, Utility 2-4

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.68	1.159	0.691	0	0	0	0
Sch.O	2.60	2.684	1.041	0	0	0	0
Los.S	2.87	2.049	1.447	0	0	0	0
Tr.C	0.05	0.083	0.111	0	0	0	0
Lightn	0.25	0.386	0.266	0	0	0	0
De.E	2.85	1.334	0.660	2003	2003	0	0
Ad.W	1.97	1.799	0.953	0	0	0	0
Ad.En	0.47	0.311	0.311	0	0	0	0
Hu.E	0.03	0.058	0.047	0	0	0	0
For.I	0.14	0.205	0.122	0	0	0	0
Total	11.91	10.066	3.145	0	0	0	0

Table A5.23 SAIFI MOY 2003 Analysis, Utility 2-5

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.07	0.248	0.200	0	0	0	0
Sch.O	0.62	0.591	0.389	0	0	0	0
Los.S	3.05	2.711	0.814	0	0	0	0
Tr.C	0.04	0.068	0.058	0	0	0	0
Lightn	0.06	0.065	0.031	0	0	0	0
De.E	0.88	0.782	0.203	0	0	0	0
Ad.W	0.28	0.324	0.220	0	0	0	0
Ad.En	0.04	0.081	0.182	0	0	0	0
Hu.E	0.07	0.095	0.039	0	0	0	0
For.I	0.10	0.070	0.028	2003	0	0	0
Total	5.21	5.036	1.128	0	0	0	0

Table A5.24 SAIDI MOY 2003 Analysis, Utility 2-5

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.07	0.271	0.312	0	0	0	0
Sch.O	0.94	0.963	0.573	0	0	0	0
Los.S	2.05	2.254	1.088	0	0	0	0
Tr.C	0.04	0.091	0.078	0	0	0	0
Lightn	0.14	0.131	0.072	0	0	0	0
De.E	1.20	1.033	0.294	0	0	0	0
Ad.W	0.58	0.926	1.044	0	0	0	0
Ad.En	0.06	0.054	0.077	0	0	0	0
Hu.E	0.06	0.044	0.021	0	0	0	0
For.I	0.14	0.089	0.029	2003	0	0	0
Total	5.28	5.855	2.009	0	0	0	0

Table A5.25 SAIFI MOY 2003 Analysis, Utility 2-6

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.15	0.128	0.038	0	0	0	0
Sch.O	0.38	0.304	0.043	2003	0	0	0
Los.S	0.01	0.071	0.118	0	0	0	0
Tr.C	0.19	0.151	0.047	0	0	0	0
Lightn	0.19	0.291	0.105	0	0	0	0
De.E	0.33	0.369	0.147	0	0	0	0
Ad.W	0.19	0.177	0.081	0	0	0	0
Ad.En	0.01	0.036	0.029	0	0	0	0
Hu.E	0.02	0.058	0.091	0	0	0	0
For.I	0.32	0.200	0.079	2003	0	0	0
Total	1.79	1.785	0.316	0	0	0	0

Table A5.26 SAIDI MOY 2003 Analysis, Utility 2-6

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.22	0.222	0.064	0	0	0	0
Sch.O	0.76	0.465	0.102	2003	2003	2003	0
Los.S	0.03	0.048	0.030	0	0	0	0
Tr.C	0.96	0.387	0.123	2003	2003	2003	2003
Lightn	0.73	0.659	0.175	0	0	0	0
De.E	0.82	0.700	0.220	0	0	0	0
Ad.W	0.45	0.425	0.156	0	0	0	0
Ad.En	0.02	0.040	0.019	0	0	0	0
Hu.E	0.03	0.039	0.024	0	0	0	0
For.I	0.37	0.424	0.127	0	0	0	0
Total	4.39	3.409	0.449	2003	2003	0	0

Table A5.27 SAIFI MOY 2003 Analysis, Region 1

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.07	0.049	0.017	2003	0	0	0
Sch.O	0.06	0.133	0.089	0	0	0	0
Los.S	0.98	0.346	0.113	2003	2003	2003	2003
Tr.C	0.05	0.045	0.008	0	0	0	0
Lightn	0.08	0.100	0.055	0	0	0	0
De.E	0.31	0.300	0.060	0	0	0	0
Ad.W	0.33	0.170	0.100	2003	0	0	0
Ad.En	0.04	0.041	0.038	0	0	0	0
Hu.E	0.04	0.042	0.009	0	0	0	0
For.I	0.15	0.209	0.043	0	0	0	0
Total	2.10	1.438	0.275	2003	2003	0	0

Table A5.28 SAIDI MOY 2003 Analysis, Region 1

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.04	0.021	0.011	2003	0	0	0
Sch.O	0.08	0.113	0.109	0	0	0	0
Los.S	7.23	0.220	0.098	2003	2003	2003	2003
Tr.C	0.06	0.034	0.011	2003	2003	0	0
Lightn	0.05	0.046	0.016	0	0	0	0
De.E	0.29	0.236	0.059	0	0	0	0
Ad.W	0.34	0.278	0.390	0	0	0	0
Ad.En	0.03	0.038	0.044	0	0	0	0
Hu.E	0.02	0.018	0.009	0	0	0	0
For.I	0.12	0.101	0.034	0	0	0	0
Total	8.26	1.110	0.506	2003	2003	2003	2003

Table A5.29 SAIFI MOY 2003 Analysis, Region 2

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.11	0.174	0.067	0	0	0	0
Sch.O	0.39	0.354	0.074	0	0	0	0
Los.S	0.82	0.917	0.245	0	0	0	0
Tr.C	0.11	0.100	0.017	0	0	0	0
Lightn	0.16	0.195	0.043	0	0	0	0
De.E	0.40	0.413	0.098	0	0	0	0
Ad.W	0.25	0.196	0.037	2003	0	0	0
Ad.En	0.02	0.038	0.028	0	0	0	0
Hu.E	0.02	0.055	0.033	0	0	0	0
For.I	0.27	0.165	0.044	2003	2003	0	0
Total	2.56	2.603	0.407	0	0	0	0

Table A5.30 SAIDI MOY 2003 Analysis, Region 2

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.17	0.244	0.119	0	0	0	0
Sch.O	0.73	0.610	0.141	0	0	0	0
Los.S	0.80	0.684	0.133	0	0	0	0
Tr.C	0.44	0.230	0.032	2003	2003	2003	2003
Lightn	0.39	0.398	0.093	0	0	0	0
De.E	0.74	0.671	0.131	0	0	0	0
Ad.W	1.14	0.528	0.230	2003	2003	2003	0
Ad.En	0.09	0.056	0.023	2003	0	0	0
Hu.E	0.02	0.039	0.012	0	0	0	0
For.I	0.36	0.276	0.065	2003	0	0	0
Total	4.88	3.732	0.413	2003	2003	2003	0

Table A5.31 SAIFI MOY 2003 Analysis, Region T

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.10	0.128	0.041	0	0	0	0
Sch.O	0.24	0.263	0.031	0	0	0	0
Los.S	0.89	0.700	0.189	2003	0	0	0
Tr.C	0.09	0.079	0.011	0	0	0	0
Lightn	0.12	0.159	0.034	0	0	0	0
De.E	0.36	0.370	0.063	0	0	0	0
Ad.W	0.28	0.186	0.045	2003	2003	0	0
Ad.En	0.03	0.039	0.017	0	0	0	0
Hu.E	0.03	0.050	0.022	0	0	0	0
For.I	0.22	0.180	0.035	2003	0	0	0
Total	2.36	2.155	0.296	0	0	0	0

Table A5.32 SAIDI MOY 2003 Analysis, Region T

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.11	0.160	0.077	0	0	0	0
Sch.O	0.44	0.412	0.061	0	0	0	0
Los.S	3.64	0.506	0.116	2003	2003	2003	2003
Tr.C	0.27	0.154	0.028	2003	2003	2003	2003
Lightn	0.24	0.264	0.061	0	0	0	0
De.E	0.54	0.504	0.079	0	0	0	0
Ad.W	0.79	0.424	0.195	2003	0	0	0
Ad.En	0.07	0.049	0.020	2003	0	0	0
Hu.E	0.02	0.031	0.006	0	0	0	0
For.I	0.25	0.207	0.031	2003	0	0	0
Total	6.37	2.712	0.325	2003	2003	2003	2003

Table A5.33 SAIFI MOY 2003 Analysis, Canada

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.23	0.213	0.025	0	0	0	0
Sch.O	0.21	0.300	0.045	0	0	0	0
Los.S	0.78	0.656	0.130	0	0	0	0
Tr.C	0.27	0.224	0.035	2003	0	0	0
Lightn	0.08	0.169	0.039	0	0	0	0
De.E	0.44	0.423	0.035	0	0	0	0
Ad.W	0.35	0.343	0.386	0	0	0	0
Ad.En	0.07	0.043	0.012	2003	2003	0	0
Hu.E	0.06	0.050	0.013	0	0	0	0
For.I	0.20	0.166	0.016	2003	2003	0	0
Total	2.67	2.584	0.408	0	0	0	0

Table A5.34 SAIDI MOY 2003 Analysis, Canada

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.32	0.184	0.026	2003	2003	2003	2003
Sch.O	0.44	0.352	0.074	2003	0	0	0
Los.S	4.96	0.504	0.062	2003	2003	2003	2003
Tr.C	1.20	0.613	0.205	2003	2003	2003	0
Lightn	0.15	0.273	0.107	0	0	0	0
De.E	0.69	0.579	0.069	2003	0	0	0
Ad.W	2.44	3.688	8.984	0	0	0	0
Ad.En	0.10	0.062	0.019	2003	2003	0	0
Hu.E	0.05	0.036	0.011	2003	0	0	0
For.I	0.30	0.212	0.033	2003	2003	2003	0
Total	10.65	6.510	8.937	0	0	0	0

Table A5.35 SAIFI MOY 2003 Analysis, Canada (Excluding 1998 Ice Storm)

SAIFI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.23	0.213	0.025	0	0	0	0
Sch.O	0.21	0.300	0.045	0	0	0	0
Los.S	0.78	0.656	0.130	0	0	0	0
Tr.C	0.27	0.224	0.035	2003	0	0	0
Lightn	0.08	0.169	0.039	0	0	0	0
De.E	0.44	0.423	0.035	0	0	0	0
Ad.W	0.35	0.213	0.062	2003	2003	0	0
Ad.En	0.07	0.043	0.012	2003	2003	0	0
Hu.E	0.06	0.050	0.013	0	0	0	0
For.I	0.20	0.166	0.016	2003	2003	0	0
Total	2.67	2.453	0.166	2003	0	0	0

Table A5.36 SAIDI MOY 2003 Analysis, Canada (Excluding 1998 Ice Storm)

SAIDI	Year 2003	Ave & S.D for the review period		MOY designation at the assigned threshold			
Cause code		Ave.	S.D	Ave+1 S.D	Ave+2 S.D	Ave+2.5 S.D	Ave+3 S.D
Unkn	0.32	0.184	0.026	2003	2003	2003	2003
Sch.O	0.44	0.352	0.074	2003	0	0	0
Los.S	4.96	0.504	0.062	2003	2003	2003	2003
Tr.C	1.20	0.613	0.205	2003	2003	2003	0
Lightn	0.15	0.273	0.107	0	0	0	0
De.E	0.69	0.579	0.069	2003	0	0	0
Ad.W	2.44	0.689	0.310	2003	2003	2003	2003
Ad.En	0.10	0.062	0.019	2003	2003	0	0
Hu.E	0.05	0.036	0.011	2003	0	0	0
For.I	0.30	0.212	0.033	2003	2003	2003	0
Total	10.65	3.511	0.469	2003	2003	2003	2003

Appendix 6

Comparison of the Financial Risks Including and Excluding MOY

The following tables show the system financial risks and expected payments for six utilities and three region systems under a normal R/PS, and R/PS excluding the MOY. The analysis is presented in Chapter 6.

Table A6.1 Comparison of the financial risks including and excluding MOY, U1-5

		Ave.	S.D.	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Change
SAIFI	Normal	1.920	0.731	0%	20%	80%	-2.00 M$	
	Exc.MOY	1.653	0.352	20%	20%	60%	0.00 M$	2.00 M$
SAIDI	Normal	6.923	10.375	0%	20%	80%	-2.00 M$	
	Exc.MOY	0.870	0.270	0%	40%	60%	-4.00 M$	-2 .00M$

Exc.MOY: Excluding major outage year: D.Z: Dead Zone
Exp.Pay: Expected Payment, '-' indicates penalty payment to the regulator.

Table A6.2 Comparison of the financial risks including and excluding MOY, U1-6

		Ave.	S.D.	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Change
SAIFI	Normal	1.723	0.745	60%	0%	40%	6.00 M$	
	Exc.MOY	1.080	0.612	0%	40%	60%	-4.00 M$	-10.00 M$
SAIDI	Normal	4.833	6.189	0%	20%	80%	-2.00 M$	
	Exc.MOY	1.053	0.361	20%	20%	60%	0.00 M$	2.00 M$

Table A6.3 Comparison of the financial risks including and excluding MOY, U1-7

		Ave.	S.D.	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Change
SAIFI	Normal	3.523	1.204	0 %	2 0 %	8 0 %	-2.00 M$	
	Exc.MOY	2.943	0.216	2 0 %	4 0 %	4 0 %	-2.00 M$	0 M$
SAIDI	Normal	6.357	7.336	0 %	2 0 %	8 0 %	-2.00 M$	
	Exc.MOY	2.150	0.471	4 0 %	2 0 %	4 0 %	2.00 M$	4.00 M$

Table A6.4 Comparison of the financial risks including and excluding MOY, U2-1

		Ave.	S.D.	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Change
SAIFI	Normal	1.810	0.324	40%	0%	60%	4.00 M$	
	Exc.MOY	1.717	0.338	20%	20%	60%	0.00 M$	-4.00M$
SAIDI	Normal	3.573	1.349	40%	0%	60%	4.00 M$	
	Exc.MOY	2.833	1.036	20%	40%	40%	-2.00 M$	-6.00M$

Table A6.5 Comparison of the financial risks including and excluding MOY, U2-3

		Ave.	S.D.	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Change
SAIFI	Normal	1.767	0.232	20%	0%	80%	2.00 M$	
	Exc.MOY	1.700	0.211	0%	20%	80%	-2.00 M$	-4.00 M$
SAIDI	Normal	3.633	0.818	0%	20%	80%	-2.00 M$	
	Exc.MOY	3.140	0.320	0%	40%	60%	-4.00 M$	-2.00 M$

Table A6.6 Comparison of the financial risks including and excluding MOY, U2-6

		Ave.	S.D.	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Change
SAIFI	Normal	1.647	0.132	0%	20%	80%	-2.00 M$	
	Exc.MOY	1.633	0.111	0%	40%	60%	-4.00 M$	-2.00M$
SAIDI	Normal	3.580	0.734	0%	20%	80%	-2.00 M$	
	Exc.MOY	3.217	0.227	20%	20%	60%	0.00 M$	2.00M$

Table A6.7 Comparison of the financial risks including and excluding MOY, Region 1

		Ave.	S.D.	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Change
SAIFI	Normal	1.700	0.405	40%	0%	60%	4.00 M$	
	Exc.MOY	1.420	0.252	0%	40%	60%	-4.00 M$	-8.00 M$
SAIDI	Normal	3.480	4.141	0%	20%	80%	-2.00 M$	
	Exc.MOY	1.000	0.180	20%	20%	60%	0.00 M$	2.00 M$

Table A6.8 Comparison of the financial risks including and excluding MOY, Region 2

		Ave.	S.D.	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Change
SAIFI	Normal	2.427	0.174	20%	0%	80%	2.00 M$	
	Exc.MOY	2.400	0.147	20%	40%	40%	-2.00 M$	-4.00M$
SAIDI	Normal	3.993	0.916	20%	0%	80%	2.00 M$	
	Exc.MOY	3.610	0.511	20%	20%	60%	0.00 M$	-2.00M$

Table A6.9 Comparison of the financial risks including and excluding MOY, Region T

		Ave.	S.D.	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Change
SAIFI	Normal	2.110	0.272	20%	0%	80%	2.00 M$	
	Exc.MOY	1.977	0.166	0%	40%	60%	-4.00 M$	-6.00 M$
SAIDI	Normal	3.773	2.271	0%	20%	80%	-2.00 M$	
	Exc.MOY	2.480	0.315	20%	20%	60%	0.00 M$	2.00 M$

Appendix 7

The Actual Payments for 2004 Excluding MOY

The following tables show the actual payments based on 2004 performance for six utilities and three region systems using three R/PS slopes excluding the MOY. The analysis is presented in Chapter 6. The actual payments for 2004 including MOY are shown in Appendix 2.

Table A7.1 2004 Actual Payments excluding MOY, U1-5

U1-5	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.653	0.352	1.030	1	1	0.77
SAIDI	0.870	0.270	0.770	0	0	0
Total				1	1	0.77

Excluding MOY 2003

Table A7.2 2004 Actual Payments excluding MOY, U1-6

U1-6	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.080	0.612	0.660	0	0	0
SAIDI	1.053	0.361	0.760	0	0	0
Total				0	0	0

Excluding MOY 2003

Table A7.3 2004 Actual Payments excluding MOY, U1-7

U1-7	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	2.943	0.216	2.190	1	1	1
SAIDI	2.150	0.471	1.520	1	0.674	0.337
Total				2	1.674	1.337

Excluding MOY 2003

Table A7.4 2004 Actual Payments excluding MOY, U2-1

U2-1	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.810	0.324	2.040	0	0	0
SAIDI	3.573	1.349	3.350	0	0	0
Total				0	0	0

Excluding MOY 2003

Table A7.5 2004 Actual Payments excluding MOY, U2-3

U2-3	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.700	0.211	2.290	-1	-1	-1
SAIDI	3.140	0.320	4.770	-1	-1	-1
Total				−2	−2	−2

Excluding MOY 2003

Table A7.6 2004 Actual Payments excluding MOY, U2-6

U2-6	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.633	0.111	1.820	-1	-1	-0.688
SAIDI	3.217	0.227	3.220	0	0	0
Total				−1	−1	−0. 688

Excluding MOY 2003

Table A7.7 2004 Actual Payments excluding MOY, Region 1

Region 1	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.420	0.252	1.080	1	0.703	0.351
SAIDI	1.000	0.180	0.760	1	0.667	0.333
Total				2	1. 37	0. 684

Excluding MOY 2003

Table A7.8 2004 Actual Payments excluding MOY, Region 2

Region 2	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	2.400	0.147	2.370	0	0	0
SAIDI	3.610	0.511	3.880	0	0	0
Total				0	0	0

Excluding MOY 2003

Table A7.9 2004 Actual Payments excluding MOY, Region T

Region T	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.977	0.166	1.800	1	0.133	0.067
SAIDI	2.480	0.315	2.500	0	0	0
Total				1	0. 133	0. 067

Excluding MOY 2003

Appendix 8

Comparison of Financial Risks Including and Excluding Loss of Supply

The following tables show the impact on the expected financial risks for the thirteen utilities and four systems including and excluding Loss of Supply contribution. The analysis is presented in Chapter 6.

Table A8.1 Comparison of financial risks including and excluding Loss of Supply, U1-1

U1-1		Ave.	S.D	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Increase
SAIFI	Normal	0.757	0.520	0%	20%	80%	-2.00 M$	
	Exc.Loss	0.697	0.489	0%	20%	80%	-2.00 M$	0.00 M$
SAIDI	Normal	0.670	0.442	20%	20%	60%	0.00 M$	
	Exc.Loss	0.660	0.435	20%	20%	60%	0.00 M$	0.00 M$

Exc.Loss: Excluding Loss of Supply
Dead: Dead Zone
Exp.Pay: Expected Payment, '-' means penalty payment to the regulator.

Table A8.2 Comparison of financial risks including and excluding Loss of Supply, U1-2

U1-2		Ave.	S.D	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Increase
SAIFI	Normal	0.643	0.656	0%	20%	80%	-2.00 M$	
	Exc.Loss	0.643	0.656	0%	20%	80%	-2.00 M$	0.00 M$
SAIDI	Normal	0.543	0.035	40%	20%	40%	-2.00 M$	
	Exc.Loss	0.543	0.035	40%	20%	40%	-2.00 M$	0.00 M$

Table A8.3 Comparison of financial risks including and excluding Loss of Supply, U1-3

U1-3		Ave.	S.D	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Increase
SAIFI	Normal	1.097	0.221	20%	40%	40%	-2.00 M$	
	Exc.Loss	0.860	0.130	40%	0%	60%	4.00 M$	6.00 M$
SAIDI	Normal	0.877	0.166	20%	40%	40%	-2.00 M$	
	Exc.Loss	0.800	0.070	40%	0%	60%	4.00 M$	6.00 M$

Table A8.4 Comparison of financial risks including and excluding Loss of Supply, U1-4

U1-4		Ave. S.D	Probabilities Reward Penalty D.Z.	Exp.Pay	Increase
SAIFI	Normal	1.160 0.407	0% 20% 80%	-2.00 M$	
	Exc.Loss	0.893 0.241	0% 20% 80%	-2.00 M$	0.00 M$
SAIDI	Normal	0.673 0.238	0% 20% 80%	-2.00 M$	
	Exc.Loss	0.587 0.165	60% 0% 40%	6.00 M$	8.00 M$

Table A8.5 Comparison of financial risks including and excluding Loss of Supply, U1-5

U1-5		Ave. S.D	Probabilities Reward Penalty D.Z.	Exp.Pay	Increase
SAIFI	Normal	1.920 0.731	0% 20% 80%	-2.00 M$	
	Exc.Loss	1.107 0.235	20% 20% 60%	0.00 M$	2.00 M$
SAIDI	Normal	6.923 10.375	0% 20% 80%	-2.00 M$	
	Exc.Loss	0.863 0.196	40% 20% 40%	2.00 M$	4.00M$

Table A8.6 Comparison of financial risks including and excluding Loss of Supply, U1-6

U1-6		Ave. S.D	Probabilities Reward Penalty D.Z.	Exp.Pay	Increase
SAIFI	Normal	1.723 0.745	60% 0% 40%	6.00 M$	
	Exc.Loss	0.857 0.051	60% 0% 40%	6.00 M$	0.00M$
SAIDI	Normal	4.833 6.189	0% 20% 80%	-2.00 M$	
	Exc.Loss	1.063 0.090	60% 0% 40%	6.00 M$	8.00M$

Table A8.7 Comparison of financial risks including and excluding Loss of Supply, U1-7

U1-7		Ave. S.D	Probabilities Reward Penalty D.Z.	Exp.Pay	Increase
SAIFI	Normal	3.523 1.204	0% 20% 80%	-2.00 M$	
	Exc.Loss	2.677 0.418	20% 20% 60%	0.00 M$	2.00M$
SAIDI	Normal	6.357 7.336	0% 20% 80%	-2.00 M$	
	Exc.Loss	2.067 0.556	40% 0% 60%	4.00 M$	6.00M$

Table A8.8 Comparison of financial risks including and excluding Loss of Supply, U2-1

U2-1		Ave. S.D	Probabilities Reward Penalty D.Z.	Exp.Pay	Increase
SAIFI	Normal	1.810 0.324	40% 0% 60%	4.00 M$	
	Exc.Loss	1.423 0.194	60% 0% 40%	6.00 M$	2.00.M$
SAIDI	Normal	3.573 1.349	40% 0% 60%	4.00 M$	
	Exc.Loss	3.080 1.123	40% 0% 60%	4.00 M$	0.00M$

Table A8.9 Comparison of financial risks including and excluding Loss of Supply, U2-2

U2-2		Ave. S.D	Probabilities Reward Penalty D.Z.	Exp.Pay	Increase
SAIFI	Normal	2.597 0.251	20% 40% 40%	-2.00 M$	
	Exc.Loss	0.910 0.066	60% 0% 40%	6.00 M$	8.00.M$
SAIDI	Normal	4.140 1.473	60% 0% 40%	6.00 M$	
	Exc.Loss	2.813 1.111	60% 0% 40%	6.00 M$	0.00M$

Table A8.10 Comparison of financial risks including and excluding Loss of Supply, U2-3

U2-3		Ave. S.D	Probabilities Reward Penalty D.Z.	Exp.Pay	Increase
SAIFI	Normal	1.767 0.232	20% 0% 80%	2.00 M$	
	Exc.Loss	1.327 0.163	0% 60% 40%	-6.00 M$	-8.00.M$
SAIDI	Normal	3.633 0.818	0% 20% 80%	-2.00 M$	
	Exc.Loss	2.823 0.786	0% 20% 80%	-2.00 M$	0.00M$

Table A8.11 Comparison of financial risks including and excluding Loss of Supply, U2-4

U2-4		Ave. S.D	Probabilities Reward Penalty D.Z.	Exp.Pay	Increase
SAIFI	Normal	8.210 1.026	20% 20% 60%	0.00 M$	
	Exc.Loss	5.087 1.235	20% 0% 80%	2.00 M$	-2.00.M$
SAIDI	Normal	11.793 1.678	40% 20% 40%	2.00 M$	
	Exc.Loss	8.920 2.462	20% 20% 60%	0.00 M$	-2.00M$

Table A8.12 Comparison of financial risks including and excluding Loss of Supply, U2-5

U2-5		Ave. S.D	Probabilities Reward Penalty D.Z.	Exp.Pay	Increase
SAIFI	Normal	4.653 0.617	20% 20% 60%	0.00 M$	
	Exc.Loss	2.113 0.136	20% 40% 40%	-2.00 M$	-2.00.M$
SAIDI	Normal	4.520 0.775	20% 40% 40%	-2.00 M$	
	Exc.Loss	3.043 0.196	20% 40% 40%	-2.00 M$	0.00M$

Table A8.13 Comparison of financial risks including and excluding Loss of Supply, U2-6

U2-6		Ave. S.D	Probabilities Reward Penalty D.Z.	Exp.Pay	Increase
SAIFI	Normal	1.647 0.132	0% 20% 80%	-2.00 M$	
	Exc.Loss	1.620 0.147	0% 20% 80%	-2.00 M$	0.00.M$
SAIDI	Normal	3.580 0.734	0% 20% 80%	-2.00 M$	
	Exc.Loss	3.517 0.759	0% 20% 80%	-2.00 M$	0.00M$

Table A8.14 Comparison of financial risks including and excluding Loss of Supply, Region1

Region 1		Ave.	S.D	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Increase
SAIFI	Normal	1.700	0.405	40%	0%	60%	4.00 M$	
	Exc.Loss	1.130	0.075	20%	20%	60%	0.00 M$	-4.00.M$
SAIDI	Normal	3.480	4.141	0%	20%	80%	-2.00 M$	
	Exc.Loss	0.953	0.080	60%	0%	40%	6.00 M$	8.00M$

Table A8.15 Comparison of financial risks including and excluding Loss of Supply, Region2

Region 2		Ave.	S.D	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Increase
SAIFI	Normal	2.427	0.174	20%	0%	80%	2.00 M$	
	Exc.Loss	1.647	0.121	20%	20%	60%	0.00 M$	-2.00.M$
SAIDI	Normal	3.993	0.916	20%	0%	80%	2.00 M$	
	Exc.Loss	3.320	0.786	20%	0%	80%	2.00 M$	0.00M$

Table A8.16 Comparison of financial risks including and excluding Loss of Supply, RegionT

Region T		Ave.	S.D	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Increase
SAIFI	Normal	2.110	0.272	20%	0%	80%	2.00 M$	
	Exc.Loss	1.423	0.090	20%	0%	80%	2.00 M$	0.00.M$
SAIDI	Normal	3.773	2.271	0%	20%	80%	-2.00 M$	
	Exc.Loss	2.280	0.466	20%	0%	80%	2.00 M$	4.00M$

Table A8.17 Comparison of financial risks including and excluding Loss of Supply, Canada

Canada		Ave.	S.D	Probabilities Reward	Penalty	D.Z.	Exp.Pay	Increase
SAIFI	Normal	2.370	0.040	40%	20%	40%	2.00 M$	
	Exc.Loss	1.830	0.079	20%	20%	60%	0.00 M$	-2.00.M$
SAIDI	Normal	4.280	0.745	20%	20%	60%	0.00 M$	
	Exc.Loss	4.143	1.351	0%	20%	80%	-2.00 M$	-2.00M$

Appendix 9

2004 Actual Financial Payments Excluding Loss of Supply

The following tables show the actual payments for 2004 performance excluding the Loss of Supply contribution using the three R/PS slopes. The results are for the thirteen utilities and four systems. The actual payments for 2004 including Loss of Supply are shown in Appendix 2 for comparison purposes.

Table A9.1 2004 actual payments excluding Loss of Supply, U1-1

U 1-1	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	0.697	0.489	0.150	1	0.237	0.118
SAIDI	0.660	0.435	0.180	1	0.208	0.104
Total				**2**	**0.445**	**0.222**

Table A9.2 2004 actual payments excluding Loss of Supply, U1-2

U 1-2	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	0.643	0.656	0.330	0	0	0
SAIDI	0.543	0.035	0.670	-1	-1	-1
Total				**-1**	**-1**	**-1**

Table A9.3 2004 actual payments excluding Loss of Supply, U1-3

U1-3	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	0.860	0.130	1.330	-1	-1	-1
SAIDI	0.800	0.070	1.040	-1	-1	-1
Total				**-2**	**-2**	**-2**

Table A9.4 2004 actual payments excluding Loss of Supply, U1-4

U 1-4	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	0.893	0.241	0.600	1	0.435	0.218
SAIDI	0.587	0.165	0.270	1	1	0.919
Total				**2**	**1.435**	**1.137**

Table A9.5 2004 actual payments excluding Loss of Supply, U1-5

U 1-5	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.107	0.235	0.980	0	0	0
SAIDI	0.863	0.196	0.700	0	0	0
Total				**0**	**0**	**0**

Table A9.6 2004 actual payments excluding Loss of Supply, U1-6

U 1-6	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	0.857	0.051	0.520	1	1	1
SAIDI	1.063	0.090	0.730	1	1	1
Total				**2**	**2**	**2**

Table A9.7 2004 actual payments excluding Loss of Supply, U1-7

U 1-7	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	2.677	0.418	2.020	1	1	0.572
SAIDI	2.067	0.556	1.260	1	0.9	0.45
Total				**2**	**1.9**	**1.022**

Table A9.8 2004 actual payments excluding Loss of Supply, U2-1

U 2-1	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.423	0.194	1.440	0	0	0
SAIDI	3.080	1.123	2.460	0	0	0
Total				**0**	**0**	**0**

Table A9.9 2004 actual payments excluding Loss of Supply, U2-2

U 2-2	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	0.910	0.066	1.060	-1	-1	-1
SAIDI	2.813	1.111	1.860	0	0	0
Total				**-1**	**-1**	**-1**

Table A9.10 2004 actual payments excluding Loss of Supply, U2-3

U2-3	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.327	0.163	1.570	-1	-0.993	-0.497
SAIDI	2.823	0.786	3.540	0	0	0
Total				**-1**	**-0.993**	**-0.497**

Table A9.11 2004 actual payments excluding Loss of Supply, U2-4

U2-4	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	5.087	1.235	3.980	0	0	0
SAIDI	8.920	2.462	10.060	0	0	0
Total				**0**	**0**	**0**

Table A9.12 2004 actual payments excluding Loss of Supply, U2-5

U 2-5	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	2.113	0.136	2.070	0	0	0
SAIDI	3.043	0.196	3.160	0	0	0
Total				**0**	**0**	**0**

Table A9.13 2004 actual payments excluding Loss of Supply, U2-6

U 2-6	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.620	0.147	1.820	-1	-0.715	-0.358
SAIDI	3.517	0.759	3.220	0	0	0
Total				**-1**	**-0.715**	**-0.358**

Table A9.14 2004 actual payments excluding Loss of Supply, Region 1

Region 1	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.130	0.075	0.840	1	1	1
SAIDI	0.953	0.080	0.640	1	1	1
Total				**2**	**2**	**2**

Table A9.15 2004 actual payments excluding Loss of Supply, Region 2

Region 2	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.647	0.121	1.720	0	0	0
SAIDI	3.320	0.786	3.120	0	0	0
Total				**0**	**0**	**0**

Table A9.16 2004 actual payments excluding Loss of Supply, Region T

Region T	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.423	0.090	1.330	1	0.083	0.041
SAIDI	2.280	0.466	2.020	0	0	0
Total				**1**	**0.083**	**0.041**

Table A9.17 2004 actual payments excluding Loss of Supply, Canada

Canada	Ave.	S.D	2004data	Financial	Payment	(per unit$)
				R/PS A	R/PS B	R/PS C
SAIFI	1.830	0.079	1.560	1	1	1
SAIDI	4.143	1.351	3.490	0	0	0
Total				**1**	**1**	**1**