

COMMONWEALTH OF VIRGINIA
STATE CORPORATION COMMISSION



**Investigation Of Dominion Virginia Power's
Performance Relative To
The January 30, 2000, Freezing Rain Storm
And System Reliability**

Staff Report

December 2000

TABLE OF CONTENTS

EXECUTIVE SUMMARY	ii
I. INTRODUCTION	1
II. THE SUPER BOWL SUNDAY FREEZING RAIN STORM	
Introduction	2
Background	2
The Storm in Perspective	3
Preparation Prior to the Storm	9
Restoration Following the Storm	10
Customer Service	20
Customer Callbacks	24
Communications Via Media	26
Clean-up and Right-of-Way Enhancements	27
Lessons Learned	29
A Case Study of Restoration and Reliability Improvements	31
Summary and Conclusions	34
III. AN OVERVIEW OF SYSTEM RELIABILITY	
Introduction	37
SCC Monitoring of Reliability	37
Dominion Virginia Power's Reliability Monitoring Program	38
System Performance Objectives	40
System Performance	40
Comparison with Other Utilities	46
Customer Perceptions of Performance	48
Worst Circuit Analysis	50
Improvement Projects	52
Maintenance Programs	53
Expenditures and Resources Dedicated to Reliable Service	54
Tree Trimming Programs for Maintaining Reliable service	57
Summary and Conclusions	63
IV. DISCUSSION AND ASSESSMENT OF RELATED ISSUES	
Introduction	68
General Perspectives on Reliability	68
Feasibility of Relocating Overhead Facilities to Underground	70
Assessment of Vulnerability and Response to Major Storms	74
Summary and Conclusions	78
V. KEY FINDINGS AND ACTION ITEMS	80
APPENDIX A: 1999 MAJOR STORMS	A-1

EXECUTIVE SUMMARY

The primary purpose of this report is to present the results of an analysis by the State Corporation Commission Staff ("Staff") of Dominion Virginia Power's ("the Company's") performance relative to power outages and service restoration following the January 30, 2000, Super Bowl Sunday freezing rain storm. The report addresses the severity of the storm's impact relative to previous storms, analyzes Dominion Virginia Power's response to the storm, identifies the Company's plans for improved response to future storms, and presents the Company's corrective actions to make the system less vulnerable to storms. The report also addresses the adequacy of Dominion Virginia Power's overall system reliability. The report concludes with a discussion of general issues related to electric distribution system reliability, a summary of the Staff's conclusions, and actions to be completed.

As a result of its investigation, the Staff has concluded that Dominion Virginia Power's restoration efforts after the Super Bowl Sunday freezing rain storm were not substandard by any suitable measure of performance. The Staff found no evidence that restoration following recent storms has been delayed because of inadequate personnel resources, equipment availability, or inventory levels. In addition, the Staff is not aware of any deficiencies in the design of Dominion Virginia Power's distribution system infrastructure to withstand storms. Dominion Virginia Power has committed to implement enhancements to the

Company's storm management operation to improve the accuracy of customer outage information and estimated restoration times.

With respect to system reliability, the Staff finds that Dominion Virginia Power's administrative program to monitor and improve distribution reliability failed to identify and implement, in a timely manner, corrective actions for pockets of customers who have experienced poor reliability on a sustained basis. Since 1997, after restructuring its distribution operations service performance department, Dominion Virginia Power has achieved annual improvements in average system reliability following several years of declining average system reliability in the early to mid-1990s. However, there are pockets of customers whose reliability has not benefited from the recent improvements in the overall system average reliability. The Staff believes that Dominion Virginia Power must implement actions and dedicate resources that will enable the Company to improve distribution reliability, not only on a system average basis but also for pockets of customers who continue to experience poor reliability. Dominion Virginia Power has committed to improve reliability in the future.

The Staff is convinced that failure of the Company's tree-trimming programs to keep pace with tree growth into distribution system rights-of-way is primarily responsible for not only the problems encountered during recent major storms, but also the poor reliability experienced by small pockets of customers on a sustained basis. The Staff believes that the Company has undertaken activities that will reduce system vulnerability to storms as well as improve overall

reliability in the future. Of particular importance are (1) the Company's \$2.4 million average annual increase in routine tree trimming expenditures (from \$14.1 million per year on average for the seven year period 1990-1996) to \$16.5 million per year on average for the four year period 1997-2000 and (2) the Company's plan to spend an additional \$2.5 million annually on its newly implemented tree-removal program for at least the next three years. Time will demonstrate whether or not these are sufficient levels of investment to enable a timely response to customers currently experiencing less than adequate levels of reliability.

As a result of its analysis, the Staff recommends that Dominion Virginia Power review its process for identifying and addressing needed reliability improvements to ensure the timely resolution of concerns relative to all customers. This should include an evaluation, in cooperation with Commission Staff, of the need to expand the Company's annual review of worst circuits and devices on the system. In addition, the Staff recommends that Dominion Virginia Power intensify its tree trimming operations in order to meet its requirement to provide reliable service to all customers. Where additional tree trimming is not effective in achieving an adequate level of reliability, the Company should evaluate alternative measures, including consideration of relocating overhead facilities to underground.

Finally, the Staff is in the process of developing a more formal system to monitor electric distribution system reliability, which will include auditing industry-accepted measures of system reliability. Long term monitoring of

reliability will be necessary to determine whether the Company's management of resources and expenditures on maintaining and improving reliability are sufficient. In the meantime, the Staff will intensify its efforts to ensure all electric customers are provided an adequate level of reliability. As part of its efforts, the Staff will obtain and review an updated outage history one year after initial resolution of every consumer reliability complaint.

I. INTRODUCTION

On Super Bowl Sunday, January 30, 2000, a freezing rain storm swept through Virginia, interrupting power to 285,000 Dominion Virginia Power customers in central Virginia and leaving some customers without power for over three days. The purpose of this report is to provide the results of an investigation by the Staff of the Virginia State Corporation Commission ("Commission") that analyzed Dominion Virginia Power's preparation for and response to the Super Bowl Sunday freezing rain storm and assessed the Company's overall system reliability. The scope of the report is provided in this introduction and summary.

The report addresses the severity of the storm's impact, preparations made in anticipation of the storm, restoration performance, customer service preparations, customer callbacks, communications with the media, clean-up and right-of-way enhancement, lessons learned, and specific restoration and reliability improvements. The report also addresses the adequacy of Dominion Virginia Power's overall system reliability. The report concludes with a general discussion of issues related to electric distribution system reliability, a summary of the Staff's conclusions, and actions to be completed.

II. THE SUPER BOWL SUNDAY FREEZING RAIN STORM

Introduction

This chapter presents the results of the Staff's investigation of Dominion Virginia Power's performance relative to the Super Bowl Sunday, January 30, 2000, freezing rain storm. The chapter includes background information about the storm's impacts and attempts to provide a historical analysis of the magnitude and frequency of storms on Dominion Virginia Power's system. The chapter also presents the Staff's analysis and evaluation of Dominion Virginia Power's preparation prior to the storm and restoration performance following the storm. Discussions relative to customer service, communications via the media, post storm clean up, and lessons learned are provided as well. The chapter concludes with a case study of the restoration effort following the storm and reliability improvements planned in an area of the Company's territory in western Henrico County.

Background

The mixture of snow, sleet, and primarily freezing rain that swept through Virginia on Super Bowl Sunday, January 30, 2000, interrupted power to 285,000 Dominion Virginia Power customers in central Virginia; total restoration required just over three days. The hardest hit areas in terms of outages were the Richmond and Midlothian areas. The storm resulted in approximately 5,000 damage locations on Dominion Virginia Power's system as a result of ice, fallen trees and limbs, equipment failures, and an assortment of other causes. The areas that

incurred the most severe physical damage to the Company's distribution facilities were Powhatan County, Goochland County, and Henrico County.

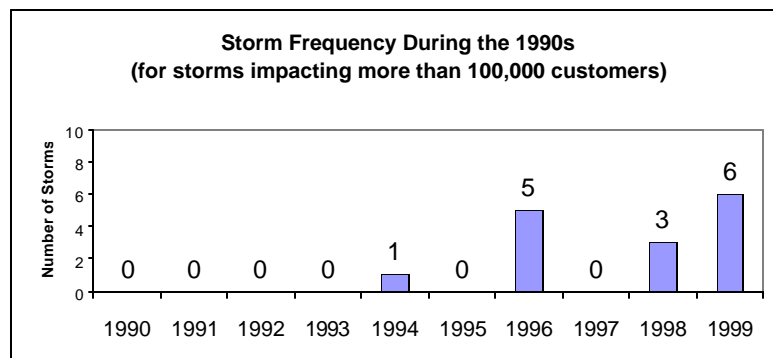
Of the total outage events, approximately 35 percent were attributed to the accumulation of ice; however, the Staff believes that unidentified tree limbs contributed significantly to this number. In addition, 31 percent were the result of fallen trees; 18 percent were the result of identified tree limbs on lines, 4 percent were the result of Company-owned equipment failures, and over 10 percent were the result of assorted other causes. The proportion of outages caused by Company-owned equipment was not excessive, and therefore it is the Staff's conclusion that the preponderance of outages caused by the Super Bowl Sunday freezing rain storm were tree-related events.

The Storm in Perspective

In an attempt to place the Super Bowl storm in perspective, the Staff reviewed the available storm data from Dominion Virginia Power's historical records and internal media documents. Any conclusions reached as a result of the Staff's analysis of these records may overstate the quality of the information. The collection of storms analyzed is not exhaustive and the attributes used to quantify storm impact – such as the number of customers affected and duration of the outages – may not have been consistent over the period of time studied.¹

¹ Dominion Virginia Power believes its storm records are fairly accurate since 1992, and an additional improvement in accuracy was made in 1997. The Company reports that its records prior to 1992 are less accurate but consistent with industry reporting standards of that time. In addition, the Company only recently began reporting *total customers affected* in addition to *peak customers affected*.

During the 1990s, Dominion Virginia Power's system experienced approximately 15 major storms² of the type that impacted more than 100,000 customers. Although the average is only 1.5 major storms per year impacting in excess of 100,000 customers, in some years there were no such storms, while in other years there were multiple major storms impacting in excess of 100,000 customers. For example, Dominion Virginia Power reported that no major storm impacted more than 100,000 customers in Virginia in 1990-1993, 1995, and 1997 and only one such storm impacted Virginia in 1994. However, during a 9-month period in 1996, there were 5 major storms that impacted more than 100,000 customers; and since the summer of 1998 there have been 11 major storms (through June of 2000) that impacted more than 100,000 customers. A graph of storm frequency during the 1990s is provided in the following figure.



² Dominion Virginia Power classifies an event as a major storm when all of the following conditions occur: (1) The National Weather Service declares a severe weather warning or severe weather watch for the area. (2) Significant physical damage has been sustained. (3) More than 10,000 customers in the storm area or 10% of the customers in a local office area are without service sometime during or immediately after the event's effects. In certain sections of this report, the Staff analyzes major storms impacting in excess of 100,000 customers in order to focus on events that are more likely to cause extended outages.

A review of past major storms on Dominion Virginia Power's territory may provide some insight into whether or not the occurrence of long-duration outages experienced from major storms since 1998, including the three-day restoration associated with the Super Bowl freezing rain storm, is a relatively new phenomenon. In a sampling of approximately 40 major storms that impacted at least 10,000 customers on Dominion Virginia Power's territory from 1969 to 2000, the number of days to fully restore service averaged 2.3 days per storm, ranging from a low of less than one day to a high of ten days after the 1998 Christmas Eve ice storm. In 1969 and 1972 ice storms left customers without power for up to four days. In 1978 as a result of two separate freezing rain/ice storms, full restoration required up to five days in each case. The Company required seven days to complete full restoration after an ice storm in 1994 and six days after Hurricane Fran in 1996. It is apparent that long-duration outages are not a new phenomenon, and the three-day restoration associated with the Super Bowl freezing rain storm does not appear extreme in this context. Storms should impact different regions more or less randomly, except hurricanes typically impact the eastern region while winter storms normally impact the central and northwest regions. However, clusters of storms impacting a local area over a relatively short period of time are possible and could lead to customer hypersensitivity, as well as point to potential weaknesses in the distribution system.

Dominion Virginia Power is not the only utility in recent years to experience record outages. Although Dominion Virginia Power fared worse than

surrounding utilities during the Super Bowl ice storm because the freezing rain was most significant in central Virginia, surrounding utilities have not fared so well in other recent storms. For example, while Dominion Virginia Power lost 540,000 customers for up to six days from Hurricane Fran in 1996, Duke Power and CP&L fared even worse: Duke lost 500,000 customers for up to eight days and CP&L lost 780,000 customers for up to fourteen days. The New York ice storm of 1998 impacted only 120,000 of Niagara Mohawk's customers, but full restoration of service required 23 days, even with help from foreign utilities including crews from Dominion Virginia Power. In the Northern Virginia ice storm of 1999, Dominion Virginia Power restored service in only two days, but Baltimore Gas & Electric and Pepco required 5 and 6 days, respectively, to restore service. Finally, in the two southeastern winter storms one week prior to the Super Bowl ice storm, Dominion Virginia Power lost only 60,000 customers for a period of one day; Georgia Power, Duke, and CP&L lost well over 100,000 customers for 4 or 5 days.

Although it's clear that the occurrence of infrequent long-duration outages is not a new phenomenon, critics have expressed concern that average outage duration has increased with time, in spite of significant increases by the Company in the average customers restored per day after an outage from a major storm. Past data do not support this hypothesis. During the 1970s, 1980s, and 1990s, restoration times averaged approximately two days per storm over 114 major storms for which data were available. From the beginning of 1997 through the

first six months of 2000, the average restoration time for 49 major storms was approximately 1.7 days. During this same period of time, the average number of customers restored has increased from 20,000³ customers restored per day in the 1970s to 77,000 customers restored per day since 1997. The Company restored an average of 95,000 per day after the Super Bowl ice storm. It should be noted however that the number of customers also has increased significantly and that most new customer connects receive underground service. Increased customer density on the Company's circuits would tend to increase both the number of customers impacted by a storm and the number of customers restored per day during the restoration. It is also important to note that the number of storms analyzed may not represent all of the major storms that have impacted Dominion Virginia Power's system, given the potential deficiencies in historical records. Again, as mentioned previously, the use of peak instead of total customers impacted by storms skews the calculations of restoration rates.

The variations in the number of customers interrupted and the restoration times associated with different storms suggest that the impacts caused by major storms may be a function of several factors. For example, the storm impact may be more a function of the type and severity of the storm, as well as the location of the storm relative to customer density and system infrastructure, than it is a

³ The 20,000 customers restored per day in the 1970s is probably understated since the numbers most likely are derived from the peak number of customers out at any one time following a storm as opposed to the total number of customers affected. However, even if the total number of customers were as much as double the peak number of customers, the average restoration rate calculated since 1997 would still demonstrate a substantial increase over the average restoration rate of the 1970s.

function of decreasing system integrity. In 1978 a system-wide windstorm affected 136,600 customers but only required two days to restore service, an average of 68,300 customers restored per day. Two months later a western Virginia ice storm impacted only 33,000 customers but required five days to restore service, an average restoration rate of only 6600 customers per day. In 1998, the Christmas Eve ice storm impacted 401,000 customers and required ten days to restore service, an average of only 40,100 customers per day.⁴ Three weeks later the Northwest ice storm impacted 214,000 customers but only required two days for restoration, an average of 107,000 customers restored per day.

Based on the previous data, the Staff concludes that there is no apparent long-term increasing trend for the restoration of service following major storms over the past 30 years. However, the Company's records do seem to indicate that the number of customers impacted by major storms increased gradually from 1970 through the early 1990s, and then increased significantly during the mid to late 1990s. The increase observed in the mid to late 1990s could be a function of several factors: increased customer density, a transition from reporting peak customer outages to total customer outages, lack of sufficient increases in right-of-way maintenance and tree trimming to match increasing tree density, or a random increase in the frequency, intensity, and geographic scale of hurricanes and

⁴ It should be noted, however, that the 1998 Christmas Eve ice storm was much more destructive to Dominion Virginia Power's system than the 2000 Super Bowl freezing rain storm. The Christmas Eve ice storm resulted in 12,300 damage locations and the Company replaced 815 poles, 3,144 cross arms, and 94 transformers. By comparison, the Super Bowl freezing rain storm resulted in 5,000 damage locations and the Company replaced only 22 poles, 190 cross arms, and 17 transformers.

freezing rain storms – the type of winter storm most destructive to utility infrastructure.

Preparation Prior to the Storm

Dominion Virginia Power's meteorologists track developing weather systems that have the potential to impact the Company's distribution system. The meteorologists alerted the Company to a possible weather threat days before the Super Bowl freezing rain storm. Weather updates were provided to critical Company personnel starting Friday, January 28, 2000. At that time, major outages were forecasted as unlikely, but possible; widespread minor outages were predicted as likely. Dominion Virginia Power began issuing press releases on January 28, 2000, warning of potential outages due to approaching weather.

In preparation for the possibility of major outages, the Company added 58 additional craft personnel to the normal Sunday complement in Richmond and surrounding area offices. In addition, the Company had 442 craft personnel on standby for the entire week and another 507 craft personnel available for callout. Dominion Virginia Power arranged for 200 line contractors and 600 tree contractors to be available if necessary. The Company also contacted Allegheny Power, Baltimore Gas & Electric, Pennsylvania Power & Light, and American Electric Power to request first right of refusal for their services, if needed.

The Company reports that material availability was checked at the central warehouse and local offices, and was increased to levels needed to respond to a

major storm. In addition, material vendors were notified to be prepared in the event Dominion Virginia Power should need additional material.

Dominion Virginia Power's system storm center has a duty person on call 24 hours a day, 7 days a week to open the center as conditions dictate. The system storm center opened early Sunday morning, January 30, 2000, in advance of the storm hitting Dominion Virginia Power's service territory.

Normally, when Dominion Virginia Power has advance warning of an impending major weather event and is relatively sure which geographic areas will be impacted, the Company calls registered medical customers, as a courtesy, to inform them of the potential for outages. The Company recommends such customers take the actions they feel are necessary to meet their individual needs. Dominion Virginia Power tries to avoid alarming registered medical customers unnecessarily, because the individual precautions they take could create a hardship, financial or otherwise. While impending hurricanes are typically easier to predict, the amount of ice accumulation and the resulting outages in specific geographic areas from potential ice storms are more difficult to forecast. Registered medical customers were not called prior to the Super Bowl freezing rain storm, but according to Dominion Virginia Power most were subsequently called during the later days of restoration.

Restoration Following the Storm

In order to evaluate Dominion Virginia Power's restoration efforts following the Super Bowl freezing rain storm, it is important to understand the

Company's general restoration policy relative to any major storm. Therefore, this section begins with a review of the relationship between the basic characteristics of a typical distribution circuit design and restoration of service, addresses restoration priorities, and explains the Company's restoration management. This section concludes with the Staff's analysis of the Company's restoration following the Super Bowl storm.

Service-Restoration/Circuit-Design Relationship. A description of a typical distribution circuit design may assist in understanding the Company's typical restoration effort following a major storm. High-voltage transmission lines deliver power from electrical generating stations to substations located throughout the Company's service area. At the substation, transformers reduce this power to lower voltages for delivery to customers over distribution lines or circuits. Various protective devices are located along a distribution line. These devices operate automatically and isolate downline sections of the circuit when a fault is experienced on the line, thereby protecting facilities from damaging, sustained fault currents and limiting outages to the immediate and sequential downline sections of the circuit where the fault has occurred.

Each distribution line is protected by a circuit breaker at the substation. Typically, one or more sectionalizers and/or reclosers will be installed downline from the substation along the main-line circuit or branches of the circuit. Secondary lines, usually protected by line fuses, tap into the main-line sections of the circuit. Customers are served directly from fuse-protected transformers, which

further reduce the voltage of power fed by either main-line or secondary sections of the circuit. The important point to note is that there may be several sequential protective devices between the substation and a customer.

The operation of any of these protective devices resulting from line faults will interrupt service to the customer. Consequently, all of the faults downline from each of these sequential devices must be cleared and facilities repaired before service can be restored to the customer. During restoration efforts, each repair location or project corresponds to a protective device on the Company's distribution lines. Therefore, restoring service to any individual customer may require several sequential repair projects between the substation where the distribution line originates and the customer's meter.

Restoration Priorities. As weather conditions permit following a storm, Dominion Virginia Power affords the highest restoration priority to essential public health and safety facilities such as hospitals, fire stations, 911 emergency call centers, and major water pumping facilities. The Company also responds with the highest priority to remedy situations where damaged equipment poses a significant threat to public safety, such as a live high voltage wire down on a road. The prioritization of other restoration projects is driven by an attempt to restore service to the most number of customers in the shortest period of time. The Company has both economic and public service incentives to execute its publicized restoration schedule.

Since it takes a few days to patrol and reasonably assess thousands of miles of damaged circuits following a major storm event, utility management must initially make decisions regarding the marshalling and deployment of resources without the benefit of full information. The difficulty of this task is compounded by the demands of managing and coordinating the logistics of an unusually large workforce, including many non-Company workers, who must perform dangerous work, frequently under inclement weather conditions.

As previously indicated, it is electrically necessary to begin restoration work on each circuit at its source substation and proceed sequentially to the end of the circuit. Therefore, in general, main-line circuits are repaired first, as all secondary circuits feed from these lines. Next, repair sites on the secondary circuits are prioritized in a declining order, beginning with the ones that will restore service to the most customers with each repair; however, there are several complicating factors that determine when any individual service is restored.

Immediately following a major storm, Dominion Virginia Power has a reasonable idea of the number of customers who have lost power, their location, and the protective devices furthest upstream from those customers that have operated and locked-out. However, the Company initially has incomplete and limited information about the status of other devices downline from these locked-out devices. Additionally, the Company does not know the specific cause or severity of damage to facilities downline of the locked-out devices. The work required for each repair project may vary substantially, ranging from a relatively

simple replacement of a fuse (perhaps a five minute job) to a virtual rebuild of sections of the circuit (sometimes requiring days).

Obviously, these two contrasting scenarios require vastly different repair resources in terms of manpower, materials, and restoration equipment. Since the objective is to restore service to the maximum number of customers in the shortest period of time, several factors in addition to the number of outages downline from each device must be considered in establishing restoration priority. Area field personnel have the most detailed information regarding damaged facilities and required restoration resources within a certain area and are in the best position to evaluate such considerations and deploy available resources accordingly within that specific area.

Restoration Management. As major storm conditions subside, Dominion Virginia Power, in addition to dispatching crews to high priority repair locations, dispatches any remaining available repair crews to the largest and most readily accessible main-line circuits. Each local office assigns responsibility to "point men" (second level supervisory personnel) for restoration repairs in specific geographical areas. A point man may supervise four to five foremen. In turn, a foreman may have six to twelve linemen under his direct control.

Each morning of the restoration process, the point man is assigned a daily package of repair jobs within his geographic area that reflect those devices with the highest number of associated customer outages. However, it is the point man's responsibility, along with his foremen, to make actual in-field evaluations of the

most productive deployment of resources in working the assigned jobs in the package, as well as maximizing overall restoration efficiency for his area.

For example, a point man may be able to determine that two jobs restoring 50 people each would require one hour of work with available resources and should therefore precede the priority of one repair job restoring 75 people that requires eight hours. As another example of the necessity of this flexibility, a larger job may require a varying number of linemen during different parts of the repair job. Between periods when the full complement of assigned linemen are needed, rather than having those linemen idly wait, the foreman may assign them to patrol area facilities and replace blown fuses or to other smaller repair jobs in the area. Given logistical and time considerations of travel, set-up, clean-up and return, it may be largely inefficient to re-deploy these linemen for a short period to another larger job at some distance. Additionally, restoration vehicles and equipment needed for a larger job may also be occupied at the current job site. In fact, consistent with this approach, at the point when most main-line and larger secondary sections of circuits in an area have been restored, it becomes more productive to complete repairs of all remaining outages in a neighborhood before moving on to the next neighborhood to reduce non-productive travel time. This usually occurs toward the end of the restoration process, but would vary by area.

The restoration work that results from widespread, devastating weather events will always exceed the immediate resources of the local utility. It is traditional in such situations to call upon neighboring utilities and contractors to

accelerate the restoration work. Guides are assigned to each Dominion Virginia Power supervisor (foreman) that is unfamiliar with the work area. Contractor crews, except some that are familiar with the work area, are assigned a Dominion Virginia Power supervisor. If the supervisor is not familiar with the assigned work area, he is given a guide. Contractor crews that work a large job at one location each day are not typically assigned a guide or a Dominion Virginia Power supervisor. Guides sometimes provide maps and directions; they also lead crews to outage locations. Depending on the situation, they may lead the crews to the first job site and then patrol ahead to the next work locations, checking back periodically, or they may stay with the crews until they are ready to go to the next location. Guides also serve as a resource to handle field support activities, such as obtaining materials or meals, that enable the crews to focus their efforts on restoration work.

Contract tree crews are also necessary for restoration after a major storm. Some tree crews are teamed with line crews and accompany them to each job site, thus following the priorities of the line crew. Other tree crews work independently with a Dominion Virginia Power guide and clear trees ahead of line crews where energized conductors or other safety issues are not a concern. The number of customers affected and extent of damage are used to prioritize work for these crews.

In any restoration effort, safety is the ultimate limiting factor as to how many field personnel can work at one time. Adding more line crews increases the

risk to safety and can lead to a potentially hazardous situation as circuits become overpopulated with workers. Safe operating practices demand knowledge of the status of all line personnel possibly impacted by a re-energized line during service restoration. Having different types of workers, from line crews to tree crews to patrollers, simultaneously working in the same area can complicate this endeavor. As more crews are added in the field, more time must be spent verifying their status. This can actually lengthen the restoration effort.

Technological advances will allow crews to work more efficiently in the field during major service restoration activities. Mobile data dispatch ("MDD"), implemented in 1999, equipped many line trucks with computers. The computers enable line crews, in a more timely manner, to update work location and progress, provide estimated restoration times and prioritize projects based on number of customers affected, geographic location or other criteria. Two additional systems being implemented in the near future – automated mapping and geographic information systems – will provide field personnel with more accurate and timely information through the same computers. These new systems will also assist local offices in better tracking work progress and crew location. Technology will improve the efficiency of crews restoring service and allow local offices to manage field activities more efficiently.

The Super Bowl Storm. Dominion Virginia Power's total labor resources for the Super Bowl freezing rain storm restoration consisted of 2,700 personnel, including 1,200 Dominion Virginia Power craft workers, 900 Dominion Virginia

Power support personnel, and 600 tree and line contractors. Included among the aforementioned labor force were 500 Dominion Virginia Power employees (craft and support personnel) and 450 contractors that had been called in from the Northwest and Eastern Regions. The estimated total cost of restoration for the Super Bowl storm amounted to approximately \$8,038,000. Dominion Virginia Power labor cost \$2,563,000 and contractor services cost \$4,073,000. Materials and supplies cost \$47,000, and vehicles and miscellaneous items cost \$1,355,000. The Company repaired 5,000 damage locations and replaced 22 poles, 190 crossarms, and 17 transformers. The Staff found no evidence of material shortages that might have delayed restoration.

Customers within eleven of Dominion Virginia Power's local offices experienced outages from the freezing rain storm: customers served by the Company's local offices in Gloucester, South Hill, Farmville, South Boston, Springfield, Petersburg, Northern Neck, and Fredericksburg were returned to service within one day; full restoration in the Richmond, Midlothian, and East Richmond local offices required slightly more than three days. The Company restored service to all 285,000 affected customers in just over three days, including 150,000 customers in the first day following the storm, 89,000 customers in the second day, and 46,000 in the final day.

As indicated previously, the Company's general policy with respect to restoration priority is to complete the jobs that will restore the greatest number of customers first. The following chart, which shows the number of jobs completed

on each day and the number of customers restored per job completed, is an indication that the Company's performance was consistent with this policy. The chart shows that the average number of customers restored with each outage-related job completed was 770 on January 30th, 327 on January 31st, 54 on February 1st, and 21 on February 2nd. So, by completing only 132 outage-related jobs on January 30th, the Company was able to restore service to over 100,000 customers. On February 2nd, the Company had to complete 708 outage-related jobs in order to restore service to the final 15,000 customers.



Generally, Dominion Virginia Power's performance relative to the restoration of power after the Super Bowl freezing rain storm – measured against both the Company's and other utilities' historical efforts in similar storms – appears to have been satisfactory. This conclusion is based on the extent of damage to the Company's infrastructure, the restoration rate or time to complete restoration, and the foregoing data that are consistent with the Company's restoration policy. Admittedly, post-storm restoration efforts are conducted in an

environment that is inherently chaotic and dynamic, and decisions must be made with incomplete information. Realistically, a totally perfect assemblage and deployment of restoration resources can never be achieved. Nevertheless, the restoration process can always be improved, and the Staff is anxious to see prudent systemic enhancements identified and implemented.

Customer Service

Pre-storm preparation provided 75 agents prescheduled to augment the normal weekend staff at 2 p.m. on Sunday, January 30th. Effective Monday, January 31st the 250 employees that normally staff the customer service centers provided continued coverage 24 hours a day through the duration of service restoration. During peak hours 180 employees were available to answer customer calls. The decision to call in additional staffing from other departments is determined by considering several criteria, including the number of customers impacted, the anticipated duration of the restoration, and whether or not the storm occurred during a holiday when employee staffing may be lower than normal. Dominion Virginia Power did not perceive a need to call in employees from other departments during the Super Bowl freezing rain storm in order to adequately staff the customer service centers.

Responding to lights out calls, including major events, is a part of all new-hire training. The types of outages that can occur, how outages are categorized for restoration, and how to interpret trouble description codes are examples of what agents learn during training. In the past year the customer service centers have

partnered with the regional operating centers to assist with new-hire training and to re-train employees on the trouble reporting process. In the event that supplemental employees are used to respond to customer inquiries, they receive refresher training before they are added to the staffing. All employees are able to access and interpret the computer screens providing restoration information.

The customer service center agents use restoration information entered on individual project information computer screens, as well as general area announcements from the regional operations centers, to update customers on the estimated repair times of their electric service. Dominion Virginia Power has reported that approximately 76 percent of the restoration projects were assigned repair time estimates after the Super Bowl freezing rain storm. However, given that 24 percent of the projects did not receive an estimated repair time and that many projects were completed well ahead of the estimated repair time, the Company believes there is room for improvement and the Staff agrees. According to Dominion Virginia Power, the policy to proactively call in pre-repair data was not considered by all linemen to be a priority, but implementation of new mobile data dispatch technology should result in improved use of estimated repair times.

The Company noted also that many customers affected by local "downline" equipment problems unknown to the Company early in the outage may have been given assurances from the customer service center representatives that their service might be restored when larger "upline" projects were completed. The customer service representatives have been trained to tell customers that service

will be restored to most customers attached to a large upline device when that device project is completed, but that further "downline" damage can in some cases prevent the restoration of their particular service. Dominion Virginia Power believes a considerable amount of misunderstanding and confusion can occur even though its customer service representatives are trained to alert customers to this condition. A Dominion Virginia Power task team reportedly has recommended computer system enhancements that should provide some improvement in the accuracy of estimated restoration times given to customers and improve the way customer outage information is shared between the regional operations centers and the customer service center. The Staff will continue to monitor the accuracy of restoration estimates provided during future severe storms to determine whether these improvements have been effective.

In spite of any potential improvements in the accuracy of restoration estimates, the Staff believes it is important for the public to realize that estimation of repair times for individual customers is not precise. In addition, the collection of data to establish accurate estimated repair times for each project is more difficult in a massive storm event such as the Super Bowl storm where over 4000 restoration work requests were initiated. In some cases, estimates might vary substantially due to related but unknown equipment problems or other circumstances beyond the Company's control. In addition, linemen should not be expected to overly refine restoration estimates at the expense of making timely repairs. Most important is clear communication of what is and isn't known.

Customers who call the Company during normal operations usually have an opportunity to report outages either by means of an automated voice response unit ("VRU") or by holding to speak to a customer service agent. However, during a major outage, when the number of calls to the Company saturates the capability of the Company's system, overflow calls are automatically transferred to a contractor's VRU. For example, of the 71,645 calls made to the customer service center on Sunday, January 30th, the first day of the Super Bowl freezing rain storm, 63 percent of the calls were automatically forwarded to the contractor's VRU; 37 percent were given the choice of using Dominion Virginia Power's VRU or speaking to a customer service agent. The percentage of calls given the option to speak to a customer service agent increased to 43 percent on Monday, 96 percent on Tuesday, and 89 percent on Wednesday. For those customers who were given the option to speak to an agent and decided to hold, the average wait was 114 seconds on Sunday, January 30th; 117 seconds on Monday, January 31st; 104 seconds on Tuesday, February 1st. Of course, actual wait times for most of those customers would have been higher or lower than the average, and could have exceeded 5 minutes. No doubt, some customers, frustrated by the wait, might hang up prior to being connected with a customer service agent, or make multiple calls attempting to reach an agent. Nevertheless, either by talking to Dominion Virginia Power agents or by using the Company's or contractor's VRUs, all customers who called were able to report their outages if they chose to do so, unless the telephone company's phone lines were out of service. On the final day

of restoration, understanding the needs of customers still without power, Dominion Virginia Power designated 20 of the most seasoned agents to answer all calls related to outages.

Customer Callbacks

As outage work orders are completed, field crews contact operating centers to close the work orders. Once work orders are closed, phone calls can be made to each customer that called to report an outage. These callbacks are used to verify that each customer's power has been restored. If some customers are still without power, a new outage call is logged into the trouble reporting system ("TRS"); this automated analysis system determines what transformers or devices are still out of service, and a new work order is created. This callback process is normally handled by customer service center representatives, a callback vendor, or an automated callback system that allows customers to use their touch tone phone to verify whether power has been restored. While Dominion Virginia Power normally stops using this callback process after 11:00 p.m. to avoid disturbing customers during nighttime hours, there were instances where late night callbacks were made during the Super Bowl freezing rain storm. Also, some customers may have received more than one callback due to the fact that the computer system allows customers to be affected by multiple work orders at the same time (such as a main line work order and a transformer level work order).

During this event, callbacks were made after 11:00 p.m. in an attempt to improve crew productivity the following day. The decision to not call customers

after 11:00 p.m. relieves customer inconvenience at the expense of some loss of productivity as crews the next day may respond to locations where power has already been restored. In the future, efforts will be focused on performing callbacks before 11:00 p.m., according to normal company practice during major storms. Some outages occurring after hours or on weekends during non-major storm periods require crews to be called in to work from home. In these situations, Dominion Virginia Power considers late night callbacks necessary to ensure that all customers have been restored before sending crews home.

Regarding multiple callbacks, Dominion Virginia Power plans to focus callbacks only on customers where there is a relatively high degree of certainty that service has been restored. For customers still without power, the TRS will be updated with the date and time of the callback and noted "Customer Still Without Power" to reduce the likelihood of a repeat callback for the same purpose. This new procedure will reduce the overall call volume, focus the calls to a group with a high probability that service has been restored, and reduce the overall potential to call customers multiple times.

In some cases, multiple callbacks are necessary and should be considered acceptable, especially during major storm events. The opportunity for line damage in multiple locations following a major storm event creates a scenario where customers at the end of the line may receive calls when different upline devices are restored. The alternative of performing extensive line patrols after energizing each main line device is not practical during a major restoration effort.

Likewise, expecting customers to call if their service has not been restored is not considered a practical alternative to multiple callbacks either. Both alternatives would result in longer outages for customers.

Communications Via Media

Communication through television, radio, newspaper, and press releases allows Dominion Virginia Power to provide general updates to a larger audience. Distributing information using the media also ensures a consistent message.

Dominion Virginia Power visited local television stations six times to provide updates with regards to storm restoration during the Super Bowl freezing rain storm. A senior vice-president visited network affiliates WWBT NBC12, WRIC TV8, and WTVR News6 on the mornings of January 31st and February 1st to do interviews regarding restoration activities. These interviews focused on Dominion Virginia Power's restoration methodology of handling emergency and public service outages first, then doing work to restore main feeders serving large numbers of customers, and then restoring individual customers. There was also considerable discussion regarding the estimated restoration date for most customers. In addition to these in-studio interviews, Dominion Virginia Power representatives also conducted on-site interviews on approximately five different occasions at the system storm center at One James River Plaza. Television crews also interviewed field crews on many occasions during restoration activities.

Local radio stations, including WRVA and WLXO, covered Dominion Virginia Power's restoration activities during the Super Bowl freezing rain storm

by broadcasting interviews with corporate communications personnel. These interviews were used as opportunities to update customers on the extent of damage, number of customers without power, number of crews working, general restoration times, and procedures for reporting power outages of hazardous situations. In addition to television and radio coverage, Dominion Virginia Power also provided information and interviews that contributed to several articles in local newspapers, including the Richmond Times-Dispatch, The Washington Times, and The Washington Post.

Along with television, radio, and newspaper communications, Dominion Virginia Power also issued press releases during this event. From January 28th to February 2nd Dominion Virginia Power issued 11 press releases regarding the Super Bowl freezing rain storm. These press releases were updated every 8-12 hours and provided information on restoration status, work force size, extent of damage, phone numbers to report power outages or downed power lines, and precautions during power outages. These press releases were distributed to the media and were also available on Dominion Virginia Power's web site.

Clean-up and Right-of-Way Enhancement

The scope of Dominion Virginia Power's planned storm clean-up efforts and right-of-way enhancement following the Super Bowl freezing rain storm incorporated several components. In addition to newly identified clean-up work and follow-up to customer calls resulting from the ice storm, the Company had scheduled tree related follow-up work resulting from Hurricane Floyd, as well as

pre-planned tree removal program work that had been identified in the fourth quarter of 1999 for the year 2000. Clean-up efforts focused on removing broken limbs, hangers, and trees leaning toward the Company's facilities as identified during circuit patrols. Knowing that many of the areas identified in 1999 for the year 2000 tree removal program were impacted by both Hurricane Floyd and the freezing rain storm, the Company focused tree improvement efforts on portions of approximately fifty circuits. Nearly half of the fifty circuits were located in the Richmond, East Richmond, and Midlothian service areas. This plan was based on the reliability groups' root-cause analyses of "worst circuits" and "worst devices", as well as storm ravaged areas noted during restoration work.

The corporate-wide, planned tree removal program plan for 2000 addressed over 90 circuits in total with an estimated increase in spending of \$2.5 million, which increase will continue through 2003 at a minimum. The geographic area of this corporate-wide program included the following locations:

- Eleven local offices in the Central Operating Region – Richmond, East Richmond, Midlothian, Petersburg, Southside, South Boston, Farmville, Altavista, Gloucester, Northern Neck, and Fredericksburg.
- Five local offices in the Eastern Operating Region – Williamsburg, Hampton, Virginia Beach, Chesapeake and Chuckatuck.
- Five local offices in the Northwest Operating Region – Alexandria/Arlington, Fairfax, Herndon, Leesburg, and Charlottesville.

Dominion Virginia Power plans to continue its increased spending on either the tree removal program or other tree trimming programs, as appropriate, in

future years. According to Dominion Virginia Power, mileage information for the tree removal program is not available due to the widespread nature of the work. In some instances, the work may cover removing only a few trees over a mile of line, while in other areas, hundreds of trees are removed over a mile of line. The geographic area for future tree removal work will be determined annually by the reliability groups. Therefore, it is difficult to accurately quantify.

Lessons Learned

As a matter of Company policy, Dominion Virginia Power performs system storm critiques following each major storm. Critiques following several recent storms, including the 1998 Christmas Eve ice storm and Hurricane Floyd in 1999, identified several opportunities for improvements. As a result of these critiques, Dominion Virginia Power has modified its storm management plan to improve the effectiveness of restoration efforts. This plan provides a structure for assigning employee duties during major storm restoration, as well as guidelines to improve the efficiency of field crews, but does not involve an increase in the number of linemen in the field. Included in the plan are staffing models for the local office level, the regional storm center, and the system storm center. Also included are guidelines for creating response teams to accompany line crews during major restoration efforts. These teams include support personnel such as a point person, team leaders, logistics coordinators, guides, patrollers, and mechanics. Employees are assigned specific storm duties based on the knowledge and skills gained through their normal job duties. Employees from areas and business units not

affected by the storm are used in an effort to maximize resources during the restoration effort.

Other improvements include the use of additional cell phones for faster communications between field crews and operating centers, information technology support personnel to ensure all systems are functioning properly, and regular communications between the storm centers and the customer service centers to provide customers with the most up-to-date information. As reported previously, a Company task team has recommended computer system enhancements designed to improve estimated restoration times given to customers during major storm events.

As a result of this action plan, Dominion Virginia Power believes storm restoration efforts have been better coordinated and more effective. Evidence of this, according to the Company, is provided by the continuing improvements in the average number of customers restored per day during major storm events (adjusted for amount of physical damage to facilities).

Dominion Virginia Power conducted a system storm critique of the Super Bowl freezing rain storm on February 16, 2000. The Company concluded, and the Staff agrees, that it performed satisfactorily relative to the restoration effort, execution of its major storm plan, television and radio coverage, and material availability. The Company identified concerns with respect to the contractor fatality, customer communications, newspaper coverage, and tree trimming. As a result of the identification of these concerns, the Company has taken actions

designed to increase the safety focus on contractors during major storm restoration, improve the accuracy of customer outage information, and complete previously unscheduled tree removal work in storm ravaged areas.

A Case Study of Restoration and Reliability Improvements in Henrico County

While a number of areas on Dominion Virginia Power's territory were severely impacted by the Super Bowl freezing rain storm, this section will focus on the Tuckahoe District in Western Henrico County. The Tuckahoe District, like a number of areas in Western Henrico County, has suffered through numerous major storms in recent history – not only the Super Bowl freezing rain storm, but also the June 1998 three-wave thunderstorms, the 1998 Christmas Eve ice storm, and Hurricanes Dennis and Floyd in 1999. Dominion Virginia Power's infrastructure has sustained substantial damage in that area as well and Dominion Virginia Power has expended millions of dollars in restoration efforts. In addition, the SCC received numerous complaints from customers in the Tuckahoe District after the Super Bowl storm. Customers have been dissatisfied with the frequency of outages, the duration of outages, and the accuracy of restoration information provided by the Company's customer service representatives. While Dominion Virginia Power has an overall record of providing reasonably reliable service on a system average basis, in general, and the Richmond area,⁵ in particular, the

⁵ In recent years, Dominion Virginia Power's local Richmond office area region, which includes the Tuckahoe district, has experienced a level of reliability that has been either average or better than the system average. In the 1998 and 1999 "service performance rankings" (excluding major storms) the

Company has acknowledged a problem with the reliability of service in certain pockets of its distribution system, including areas in the Tuckahoe District.

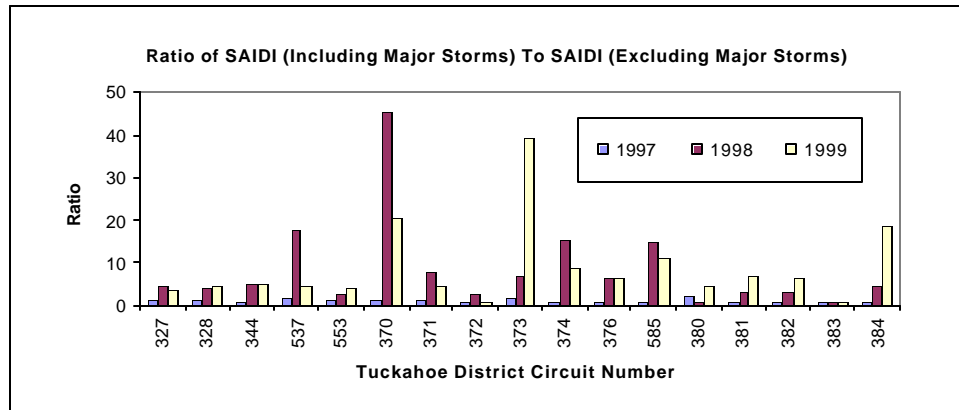
The Tuckahoe District is served by 3 substations – River Road, Northwest, and Short Pump – and 17 circuits. Only one of these circuits appeared on the Company's "worst 10 circuits" in the Central Region, while five others were among the Central Region's 50 worst circuits (excluding major storms) for at least one year during the period 1997-1999. Obviously, excluding major storms from outage data artificially enhances the numerical value of any particular reliability index, such as SAIDI,⁶ that may be used to measure reliability performance. Conversely for example, if major storms were to be included in outage duration data, a customer's outage duration over the period of a year would be longer than the duration of outages calculated for "bluebird" days only. Utilities often exclude major storm data from the calculation of reliability indices in order to eliminate the random effects of events beyond their control. On the other hand, evaluation of reliability data including major storm data can be important in determining the vulnerability of the system to major storms.

The bar graph below provides one possible measure of identifying the extent to which individual circuits in the Tuckahoe District were impacted by major storms during the period 1997-1999. For example, consider the "1998 bar"

Richmond office area ranked 17th and fifth best, respectively, among 35 local office areas. In the 1998 and 1999 service performance rankings including all major storms, the Richmond office area ranked 18th and 16th, respectively.

⁶ SAIDI – System Average Interruption Duration Index, the average number of minutes in a year that the typical customer is interrupted.

for circuit 370: the value of SAIDI (including major storms) is 45 times greater than the value of SAIDI when only "bluebird" days are considered.



Dominion Virginia Power has undertaken work on the circuits feeding the Tuckahoe District in order to improve the reliability of service to the customers in that area. Reliability improvement work on the circuits serving the Tuckahoe District of Henrico County can be divided into five different categories:

- New device installation (including loop scheme reclosers)
- Underground cable correction (replacing vintage underground cable or installing step-down transformers to reduce voltage)
- Tree trimming
- Routine patrols and inspections
- Preventative maintenance and replacement of distribution equipment

Projects involving new device installations on five circuits (including loop scheme reclosers) that should improve service reliability to the Tuckahoe District are expected to be completed by December 31, 2000, at a cost of \$160,000. Underground cable correction projects that should improve service reliability to

the Tuckahoe District were completed on five circuits as of October 1, 2000, at a cost of \$69,000; one other underground cable correction project was scheduled to be completed by November 30, 2000, at a cost of \$31,000. Tree removal projects that will improve service reliability to the Tuckahoe District were completed on 11 circuits as of August 1, 2000, at a cost of \$423,000; these projects are in addition to routine tree trimming. Routine patrols and inspections of the circuits located in the Tuckahoe District are expected to be completed by December 31, 2000, with a cost of \$15,450. Finally, preventative maintenance and replacement of distribution equipment that will affect circuits in the Tuckahoe District are to be completed by December 31, 2000, at a cost of \$17,280.

The total of all the aforementioned reliability improvement projects for the Tuckahoe District that either have been or are scheduled to be completed in 2000 is \$715,840. The Commission Staff will follow up on these projects and will continue to monitor the circuits in the Tuckahoe District and other areas of Dominion Virginia Power's territory to determine the impact of these and other projects on system reliability.

Summary and Conclusions

This chapter presented the results of the Staff's investigation of Dominion Virginia Power's performance relative to the Super Bowl Sunday, January 30, 2000, freezing rain storm. The chapter summarized the magnitude of the storm impacts and attempted to place the storm in historical perspective. The chapter also presented the Staff's analysis and evaluation of Dominion Virginia Power's

preparation prior to the storm and restoration performance following the storm. Discussions relative to customer service, communications via the media, post storm clean up, and lessons learned were provided as well. The chapter concluded with a case study relative to storm restoration and reliability improvements in the Tuckahoe District of Henrico County.

The Staff believes that Dominion Virginia Power's preparation and actions taken prior to the storm were reasonable and that the Company adequately implemented its prioritization plan during the Storm. Compared to previous storms, the time required for full restoration of service was reasonable given the number of customers impacted and the extent of damage to the distribution system. Dominion Virginia Power's communications with the media and the public following the storm were satisfactory with the exception of some apparent cases of miscommunication or misunderstanding of estimates of restoration times. The Company is implementing computer enhancements designed to improve the accuracy of customer outage information and restoration times. However, given the uncertainties surrounding restoration work following a major storm and the heightened sensitivity of customers frustrated by lengthy and disruptive power outages, it is unlikely that there will ever be full consumer satisfaction regarding estimates of restoration times.

A review of the outage causes associated with the storm leads to the conclusion that trees were the major contributor. This raises issues related to trimming of trees for adequate right-of-way clearance. Tree trimming and other

issues relevant to overall system reliability, as well as system vulnerability to major storms are discussed in the remaining chapters of this report.

III. AN OVERVIEW OF DOMINION VIRGINIA POWER'S SYSTEM RELIABILITY

Introduction

This chapter provides an overview of Dominion Virginia Power's distribution system reliability. The chapter begins with a concise summary of the Commission's efforts to begin monitoring Dominion Virginia Power's distribution system reliability and describes the programs established by the Company for monitoring and improving reliability. The chapter also provides a general summary of the Company's reliability performance through the presentation and analysis of pertinent historical data.

SCC Monitoring of Reliability

By Commission Order dated August 7, 1998, in Case No. PUE960296, the Commission adopted a rate settlement agreement that required Dominion Virginia Power to submit quarterly service reliability reports on two measures of reliability typical within the electric utility industry: (1) the System Average Interruption Frequency Index ("SAIFI"), which is a measure of the average annual frequency of outages, and (2) the System Average Interruption Duration Index ("SAIDI"), which is a measure of the average annual outage time.⁷ Dominion Virginia Power expresses SAIDI values not only in minutes, but also as a service availability

⁷ SAIFI = The average number of times in a year that the typical customer is interrupted.
SAIDI = The average number of minutes in a year that the typical customer is interrupted.

percentage, which reflects the portion of the year that service is available, on average, to the customer.

The Commission Order also required that the reliability measures or indices be calculated and reported both excluding and including the impacts from major storm events; any meaningful analysis and evaluation of a utility's system reliability requires a review of both situations. The availability of reliability data that exclude the impacts from major storms facilitates evaluation of historical trends in a utility's system reliability that are not skewed by infrequent events largely beyond the utility's control. On the other hand, the availability of data that include the impacts from major storms is necessary to assess the efficacy of a utility's programs to reduce its system's vulnerability to major storms. As mentioned previously, Dominion Virginia Power classifies an event as a major storm when (1) the National Weather Service declares a severe weather warning or severe weather watch for the area, (2) significant physical damage has been sustained, and (3) more than 10,000 customers in the storm area or 10% of the customers in a local office area are without service sometime during or immediately after the event.

Dominion Virginia Power's Reliability Monitoring Program

Employees in Dominion Virginia Power's distribution operations service performance department have the responsibility for monitoring and analyzing service reliability of the distribution system. Approximately seventy employees in

this department, at the system and region level, analyze reliability information and are involved in initiating, prioritizing, and completing improvement projects.

Dominion Virginia Power uses an automated service reliability reporting system ("SRRS") to analyze historical outage information. The SRRS maintains archives of all recorded outages, including pertinent information about the cause, duration, and customers affected. SAIDI values for each local office, expressed as average outage minutes per customer, are compared to the system average and historical averages on a monthly basis. Local offices that establish a trend of performing below the system average are evaluated, using root cause analysis, for cost effective short-term and long-term reliability improvements.

The SRRS is also used to identify circuits and devices that perform below the system average during normal operating conditions. These circuits are considered candidates for reliability improvement and are analyzed using root cause analysis to identify projects that will reduce customer outage minutes, the number of customer outages, and the number of repeat outage locations. Identified projects are ranked so that the greatest impact on service reliability can be achieved with each dollar spent. In ranking the projects, consideration is also given to the effect on repeat outage locations, critical customers, multi-year reliability history, recently completed improvement projects, and storm ravaged areas. After major storms, hard hit areas experiencing outages due to trees are foot patrolled to assess the work needed to improve service reliability in those areas.

System Performance Objectives

In the 1998 rate settlement agreement mentioned previously, Dominion Virginia Power made a commitment to maintain system average reliability at levels consistent with those attained during the past decade; however, Dominion Virginia Power has stated that its overall plan is to exceed that commitment and improve reliability generally by two customer outage minutes per year (excluding major storms and over a multi-year average). Dominion Virginia Power established the 1999 SAIDI reliability goal of 126 outage minutes per customer (excluding major storm outages) by evaluating reliability in previous years and projecting the impact of reliability improvement projects scheduled to be completed in 1998 and 1999. The 2000 reliability goal is 124 outage minutes per customer (excluding major storm outages). This corresponds to an average service availability goal of 99.976⁸ percent for customers. Given the unpredictability of major storm events, the Company has not attempted to develop a goal for SAIDI that includes major storm data. Additionally, the Company has not established a goal for SAIFI.

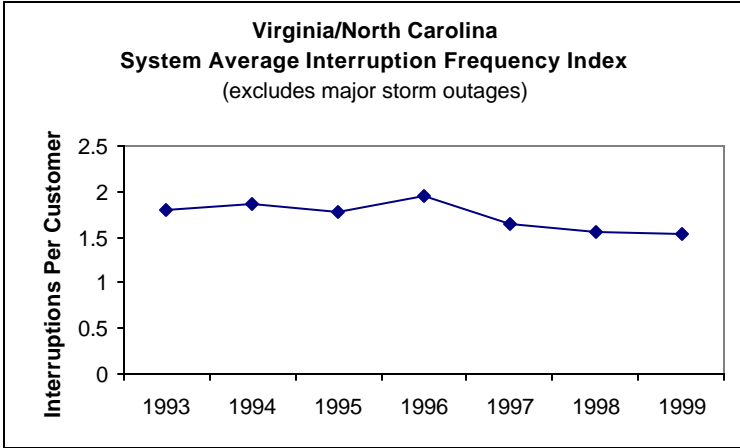
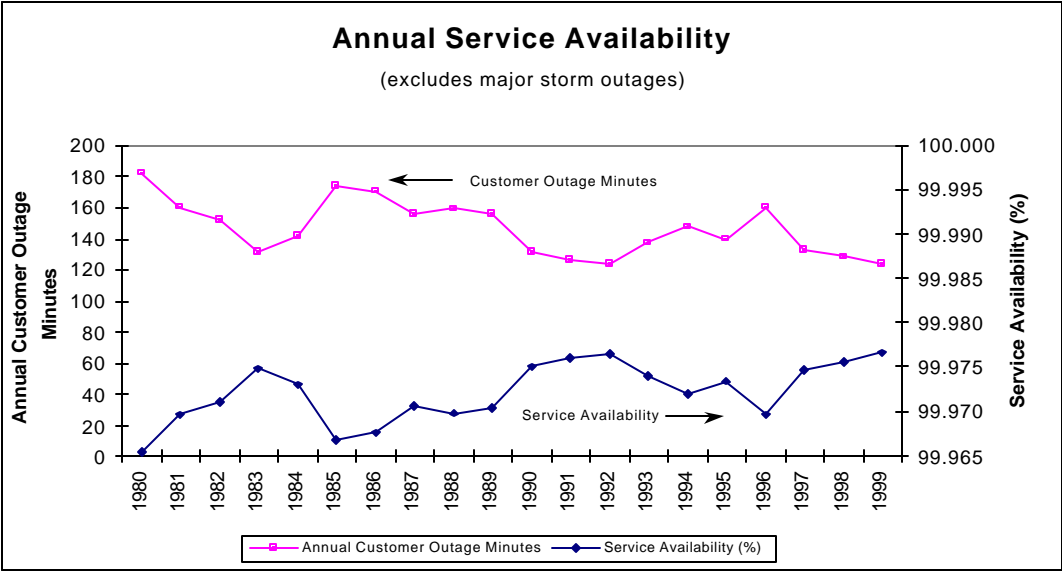
System Performance

Dominion Virginia Power's system average reliability measures, excluding major storms, reflect improving reliability trends during recent years, with reductions in both the number of devices experiencing repeat outages and the

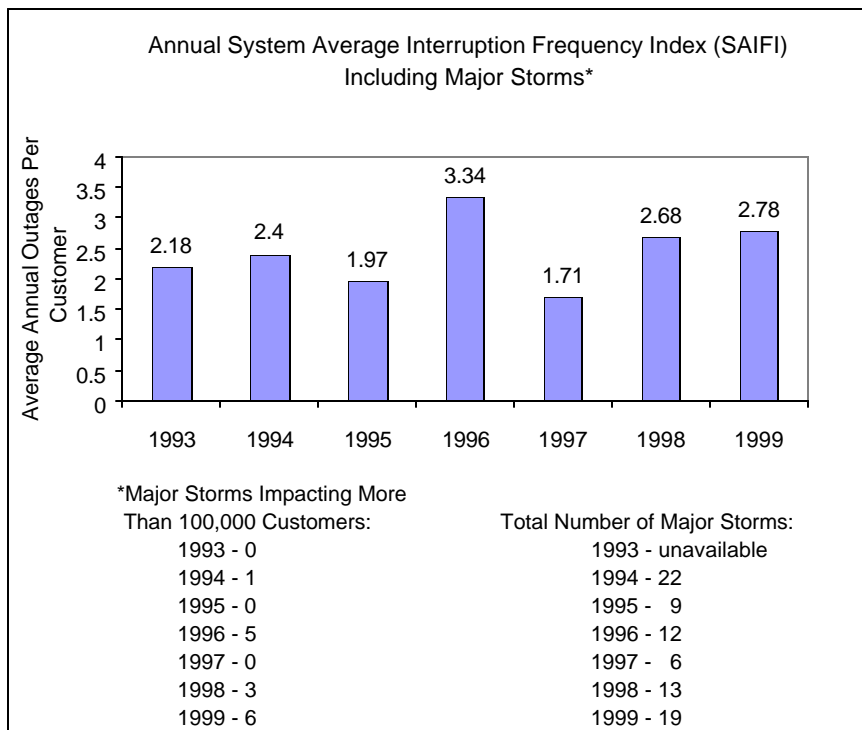
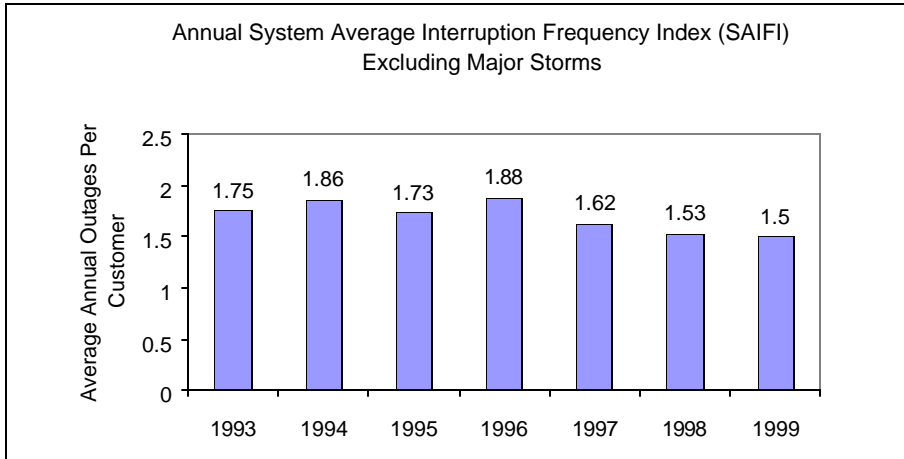
⁸ Average service availability goal = $[1.0 - (124 \text{ outage minutes} \div 525,600 \text{ minutes per year})] = 0.99976$

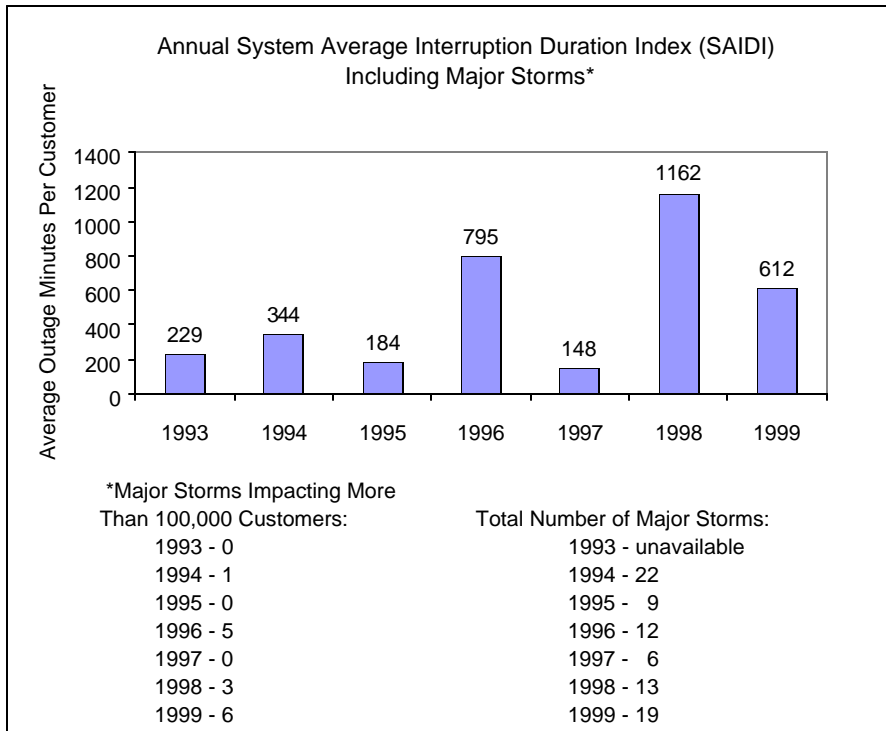
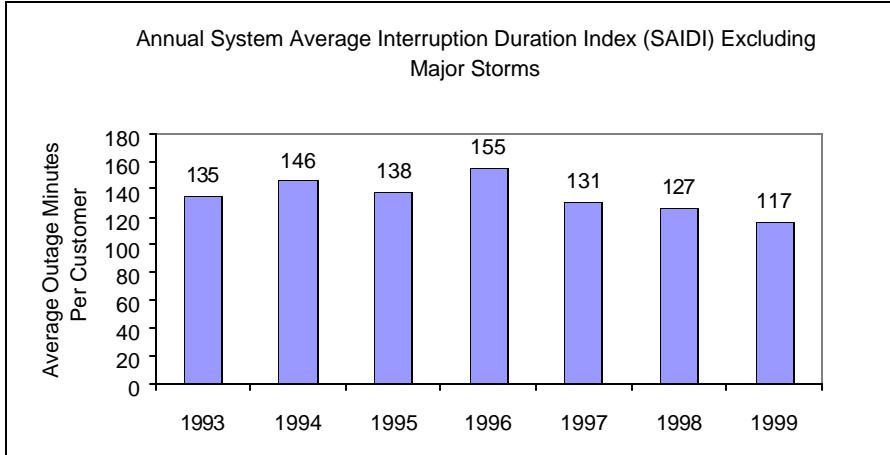
number of customer outage minutes. Since 1980, Dominion Virginia Power's annual percent service availability has trended both up and down, but has improved in recent years and remains near its historical best. The typical customer's average service availability, excluding major storms, has ranged between 99.96 and 99.98 percent since 1978, when the Company started collecting reliability data. The first chart on the following page contains line graphs that show historical annual service availability and customer outage minutes for Dominion Virginia Power/North Carolina Power beginning with 1980. Again, this information excludes major storm outages. The second chart below contains a line graph that shows that the yearly average number of customer interruptions per customer for Dominion Virginia Power/North Carolina Power – SAIFI, excluding major storms – has decreased steadily from 1.95 interruptions in 1996 to 1.53 customer interruptions in 1999.

The values of SAIDI and SAIFI, excluding major storm data, for the Virginia jurisdiction only have also improved since 1996. The Virginia jurisdiction average outage duration in 1999 as measured by SAIDI, excluding major storms, was 117 minutes per customer. The Virginia jurisdiction average outage frequency in 1999 was 1.50 outages per customer. Of course, the reliability data presented in this section applies to total system or Virginia jurisdictional averages; therefore, different local areas of the system may experience levels of reliability above or below the system averages.



The discussion so far has targeted system performance excluding the impacts of major storms. In order to provide a different perspective and to highlight the impact of major storms on system reliability, bar charts for SAIDI and SAIFI, with and without major storm data, are provided in the following four figures for the Company's Virginia jurisdiction only.





The four bar charts displayed above provide a dramatic indication of the impact of major storms on the calculation of system reliability measures. Relying solely on measures that include major storm data would muddle any evaluation of system reliability. This is because major storms do not impact a system uniformly over time but instead are likely to occur with random frequency, intensity and geographic scope (for example, see Appendix A for a list of major storms in 1999). On the other hand, ignoring major storm data could obscure changes in distribution system vulnerability to major storms, as well as underrate the powerful impact of major storms on a utility's customers. Therefore, the Staff believes there is a need to evaluate system reliability both with and without major storm data.

A review of the above charts of Dominion Virginia Power's historical values of Annual Service Reliability, SAIFI, and SAIDI indicate that reliability, excluding the impacts of major storms, has trended both up and down since 1980; however, reliability has improved steadily since 1996 and remains near its historical best. Again, this observation applies only to the overall system average, and historical best levels of reliability are not necessarily sufficient.

A review of the system-wide reliability data that include the impacts from major storms reveals that Dominion Virginia Power's system has been vulnerable to major storms. In those years when major storms have impacted Dominion Virginia Power's system, the average outage duration for a typical customer has increased significantly. However, an evaluation of the Company's distribution

system reliability should not rely exclusively on system-wide reliability indices because such calculations average the outage duration from major storms over the Company's entire customer base of approximately 2 million customers. This dilutes the apparent impact of major storms and understates the prolonged outages that certain pockets of customers may have to endure as a result of such events.

In addition to reviewing the reliability of Dominion Virginia Power's distribution system from all outage causes combined, the Staff also reviewed the impact of individual outage categories, on overall system reliability. The Company tracks eight major outage cause categories: underground material and equipment, overhead material and equipment, weather, trees, public, bulk power, miscellaneous, and company. The Staff determined that trees are a major factor in distribution system outages. In 1999 including major storm data, trees accounted for approximately 42.5 percent of customer outage minutes. Weather, the effects of which likely are exacerbated by the existence of trees, accounted for approximately 38 percent of the outage minutes. Overhead and underground material and equipment were responsible for only 9 percent of the outage minutes in 1999 when major storm data were included. Clearly, the impact on system reliability from trees in close proximity to distribution lines is significant.

Comparison With Other Utilities

Dominion Virginia Power has stated that it continually seeks to find relevant industry comparisons of standard reliability indices such as SAIDI and SAIFI, in order to compare its performance against similar utilities nationwide.

However, there are difficulties with making comparisons because the data that go into calculating these industry-accepted indices vary greatly from utility to utility. This is due to significant differences with regards to means of capturing data, major storm criteria, inclusion/exclusion of major storm outages, and even the definition of an outage.

Some utilities do not include certain types of outages (partial lights, planned outages, source outages) in the calculation of reliability indices. Another example of differences among utilities would be in their definitions of a major storm. As a result, utilities include or exclude different amounts of outage information based on their definition of a major storm. At least one major utility reportedly includes only outages where the entire distribution circuit is affected, and excludes all outages affecting only segments of a circuit (for example, outages caused by main line reclosers, tap line fuses, line transformers, and individual services); Dominion Virginia Power includes all of these events in the calculation of its reliability data.

There seems to be a general reluctance to share reliability statistics among utilities. Anonymous surveys are often done, but since the criteria used to calculate the different respondent's reliability measures are unknown, the information may be inconclusive or misleading. In the 1998 EEI Reliability Survey conducted by the Edison Electric Institute ("EEI") Distribution Committee, 41 electric utility companies provided data on distribution system reliability. Individual companies were identified by a number and only EEI has that

information. The Staff was interested primarily in the performance of other utilities from the Southeastern Electric Reliability Council ("SERC"), the Mid-Atlantic Area Council ("MAAC"), and the East Central Area Reliability Council ("ECAR"). Among the utilities that provided data to EEI, only two companies from the SERC, three companies from the MAAC, and four companies from the ECAR provided SAIDI data that excluded major storms. These nine companies had a combined average SAIDI, excluding major storms, of 114 minutes per customer, compared to a SAIDI value of 127 minutes for Dominion Virginia Power in 1998. The values of SAIDI, excluding major storms, among these nine companies ranged from a low of 46 minutes per customer for a utility in the MAAC to a high of 172 minutes per customer for a utility in the SERC.

Customer Perceptions of Performance

Dominion Virginia Power's customer survey process is separated into residential and commercial/industrial customers. Dominion Virginia Power has used Market Strategies, Inc., an independent consulting firm, to survey its residential customers twice each year through 1999.⁹ Six hundred residential customers are randomly selected for each telephone survey. The customers are asked to rank Dominion Virginia Power on a 0-to-10 scale for each of 100 questions, where 0 means Dominion Virginia Power is doing an extremely poor job, and 10 means Dominion Virginia Power is doing an extremely good job.

⁹ With the exception of 1997 when the survey was conducted four times. Beginning with 2000, Dominion Virginia Power plans to survey its customers only once a year. The survey results for 2000 were not available for this report.

Survey questions cover topics ranging from electric service reliability to billing accuracy to community involvement. Listed below are responses to questions regarding service reliability and customer service issues from the survey conducted in November 1999. The scores are indexed on a 0-to-10 scale.

<u>Questions</u>	<u>Scores</u>		
<i>How would you rate Dominion Virginia Power's performance on:</i>	Good Job (8 to 10)	Neither (5 to 7)	Poor Job (0 to 4)
• Providing reliable electric service?	67%	27%	6%
• Restoring power after interruptions?	60%	28%	12%
• Doing things right the first time?	60%	34%	6%
• Being responsive to customer needs?	55%	34%	11%

Dominion Virginia Power uses TQS Research, Inc., a firm with nationally recognized research experience, to survey its commercial and industrial customers once each year. The 1,350 largest commercial/industrial customers, including governmental accounts, are included in the telephone survey. Customers are asked to rank Dominion Virginia Power on a 1-to-10 scale for each of 50 questions, with 1 being "Very Dissatisfied" and 10 being "Very Satisfied." Listed below are results from the survey conducted in October/November 1999. Results are based on 438 responses in the "Key Accounts" category and 283 responses in the "Mid-Size Accounts" category. The scores represent the percentage of respondents that rated Dominion Virginia Power between 8 and 10.

<u>"Key Accounts" (700 largest accounts)</u>	<u>Score</u>
• Overall satisfaction with reliability.....	67%
• Overall satisfaction with Dominion Virginia Power.....	60%

<u>"Mid-Size Accounts" (Next 650 largest accounts)</u>	<u>Score</u>
• Overall satisfaction with reliability.....	78%
• Overall satisfaction with Dominion Virginia Power.....	61%

Worst Circuit Analysis

Dominion Virginia Power also maintains "worst circuits" and "worst devices" lists to improve system reliability by identifying circuits and devices that perform below system averages. Dominion Virginia Power currently maintains lists of "worst circuits" and "worst devices" ranked according to the number of outage events, number of outage events on a phase, number of customers affected, and number of customer-hours out. These lists are segmented at the system and region levels. Repeat outage reporting is used to monitor the number of protective devices (serving more than 20 customers) experiencing more than one outage in a given time frame. By comparing the performance to historical numbers at the local office level, trends can be established for each local office with respect to increases or decreases in repeat outages.

At a minimum, annual lists of Dominion Virginia Power's "worst 10 circuits" and "worst 10 devices" in each of the Company's three regions (for a system total of 30) are developed based on the total number of customer-hours out for each circuit and the total number of outages for each device. The data are compiled using outage information from the previous calendar year (excluding major storms). Root cause analysis is performed on these circuits and devices to determine the improvement projects that will reduce both the number of customers affected and the number of customer-hours out. Field inspections and patrols of the worst circuits and worst devices are also used to assess immediate repair needs, such as damaged crossarms and insulators. These inspections are often

conducted using infrared cameras to identify possible problems not visible under normal circumstances. (In some years, when the Company's budget constraints allow and there is no significant difference in reliability beyond the 10th worst circuit, more than the 10 worst circuits may be evaluated for improvement projects in a particular region.)

The "worst 10 circuits" and "worst 10 devices" lists from each region are used also to monitor the impact of improvement projects on the annual customer-hours out for each circuit and the number of repeat outages for each device. Circuits and devices can be expected to show an improvement in these measures as reliability projects are implemented. The amount of improvement varies depending on the scope of individual projects. Small projects that are implemented in the near future will have an impact sooner than larger projects that are implemented over a longer period of time. Small scope projects normally carry a year-end target date, while large projects may be broken down into segments to be implemented over several years.

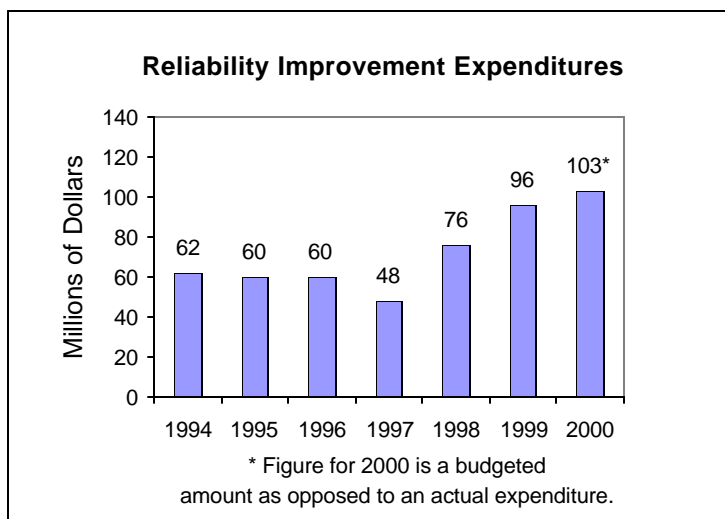
Dominion Virginia Power's worst 30 circuits represent less than two percent of the Company's distribution circuits.¹⁰ In a sampling of other state commissions that monitor their utilities' distribution reliability, one percent was the minimum percentage of circuits considered for a worst circuit analysis, but many other utilities are required to review the worst three, four, or five percent of

¹⁰ The Company also reviews the worst 30 devices for improvement projects, which could result in improvements being made to more than 30 circuits.

the distribution circuits. The Commission Staff and Dominion Virginia Power will evaluate the need for the Company to review a higher percentage of its distribution circuits and devices for its worst circuit and worst device analyses.

Improvement Projects

All identified reliability improvement projects are evaluated for cost effectiveness, number of customers impacted, and impact on service availability. The projects are then ranked according to these criteria so that the greatest impact on service reliability can be achieved with each dollar spent on improvement projects each year. In ranking the projects, consideration is also given to the effect on repeat outage locations, critical customers, multi-year reliability history, recently completed improvement projects, and storm ravaged areas. A graph of the expenditures made by Dominion Virginia Power for reliability improvement projects during the 1990s is provided below.



Maintenance Programs

In addition to monitoring and identifying projects to improve reliability, Dominion Virginia Power employs various distribution system maintenance programs. The maintenance programs include tree-trimming programs, which are discussed later in this chapter, as well as a number of equipment inspection programs. The Staff is not aware of any significant changes in the frequency or thoroughness of these programs in recent history that would adversely impact reliability.

A comprehensive line inspection (or "circuit patrol"), from substations to customers' transformers, is performed every 2 to 4 years by the Company's foresters and servicemen. Each circuit is visually checked for faulty equipment or potential hazards or any condition that could adversely affect service reliability. A main line patrol from each substation breaker to the first protective device or tie switch is performed every 2 years. Local conditions, such as intense lightning, vandalism, abnormal tree growth, and inclement weather, may result in a need for more frequent inspections. Infrared cameras may be used for inspections on main lines in order to identify possible problems not visible under normal circumstances.

In addition to circuit patrols, overhead and underground equipment and substation equipment is periodically inspected and maintained by the Company's linemen and servicemen. Overhead equipment (switches, line capacitors, pole mounted reclosers, sectionalizers, and voltage regulators), underground equipment

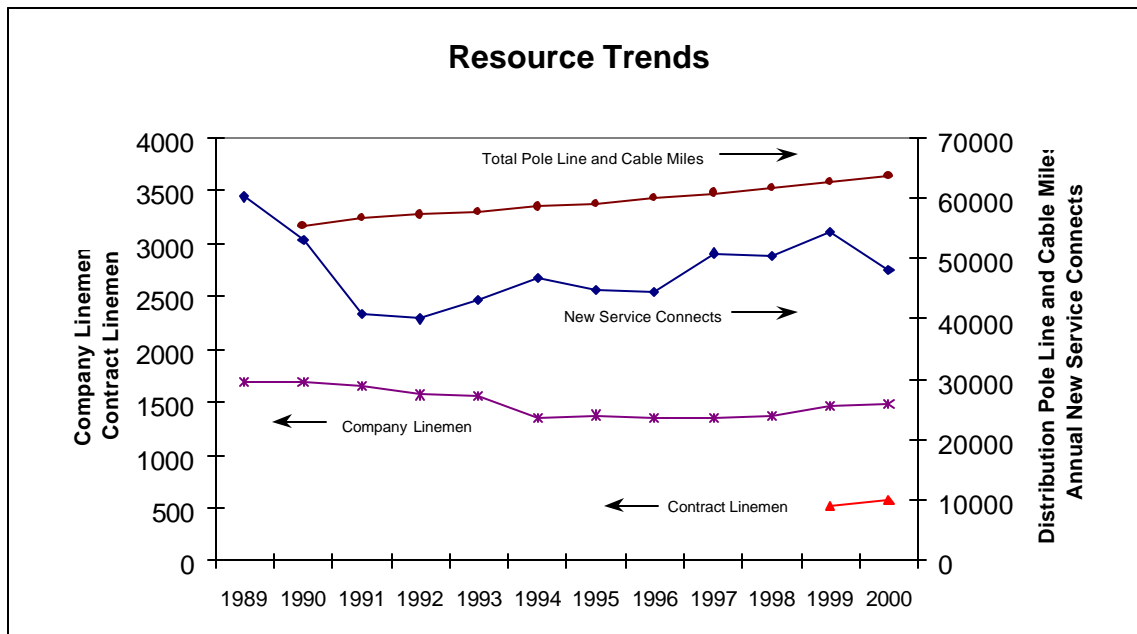
(padmounted transformers, switches, reclosers, sectionalizers, and vaults), and substation equipment (breakers and relays) are inspected at variously scheduled intervals. Maintenance may be performed on a regularly scheduled basis or as determined by inspection.

Expenditures and Resources Dedicated to Reliable Service

Concerns are sometimes expressed with respect to the adequacy of resources available for maintaining Dominion Virginia Power's distribution system and expenditures made for reliability improvements and restoration of service. The purpose of this section is to provide historical information relative to certain Company resources including distribution employees, company linemen, contract linemen, and restoration vehicles. In addition, historical trends in expenditures for service restoration, storm restoration, reliability improvements and routine tree trimming are provided as well.

While the total number of distribution employees has decreased steadily since 1989 as the Company has restructured and implemented enhancements to increase efficiency, the total number of Company linemen decreased in the early 1990s (from 1692 in 1989 to a low of 1343 in 1994) as a result of a downward trend in the number of new connects during the same period. However, as the number of new connects began to increase in 1993 the number of Company linemen remained fairly stable. Dominion Virginia Power did not begin to increase the number of Company linemen substantially until 1998. As of November 2000 Dominion Virginia Power employed 1475 linemen. Dominion

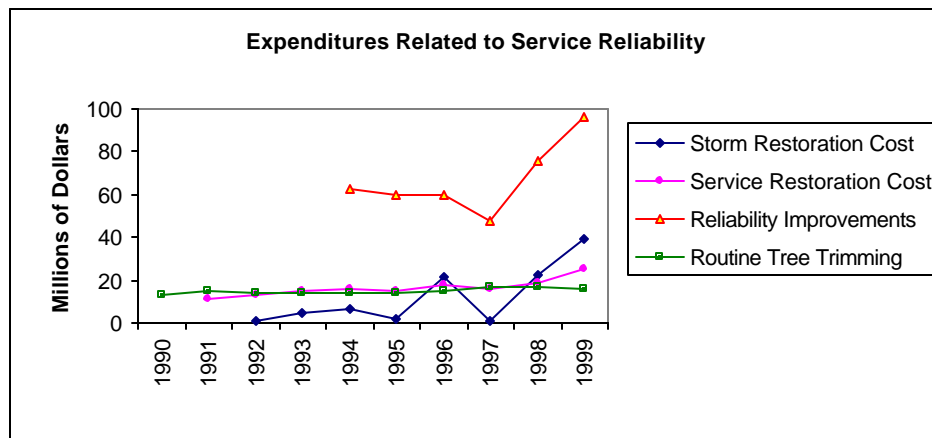
Virginia Power has indicated that it is in the process of attempting to increase the number of Company linemen; the total number of linemen authorized to be employed by the Company is 1553. Dominion Virginia Power has supplemented Company linemen with 525 contract linemen in 1999 and 571 contract linemen in 2000; however, the figures for the number of contract linemen prior to 1999 were unavailable. Therefore, the Staff cannot comment on trends in total field manpower resources. A graph of these Company resource trends relative to the number of new service connects and total distribution pole and cable line miles is provided in the figure below.



During the period that Dominion Virginia Power began to reduce the number of distribution employees and Company linemen, the Company made new capital investments in telecommunications, computer technologies, and

automation software to improve the efficiency of employees performing normal work duties and major storm restoration efforts. In addition new capital expenditures were made for the equipment necessary to restore customer service following an outage. For example, since 1994, the number of restoration vehicles has increased from 466 to 571 as of March 2000.

Of related interest are the expenditures made by Dominion Virginia Power for reliability improvements and restoration of service. From 1990 to 1996, expenditures for routine tree trimming remained stable (in nominal dollars for each year), and then increased in 1997, 1998, and 1999. Expenditures for reliability improvements decreased from 1994 to 1997 before increasing dramatically in 1998. Service restoration costs (excluding major storms) increased steadily during the 1990s, while the storm restoration costs, as expected, are dependent on the number and severity of the storms in a particular year. A graph of Dominion Virginia Power's expenditures related to service reliability is provided in the figure below.



Tree Trimming Programs for Maintaining Reliable Service

This section provides summaries of Dominion Virginia Power's routine tree trimming program and tree removal program, as well as storm clean-up and hot spot trimming. A description of the programs and expenditures associated with each program are provided. This section also includes some historical trends in tree-related reliability data.

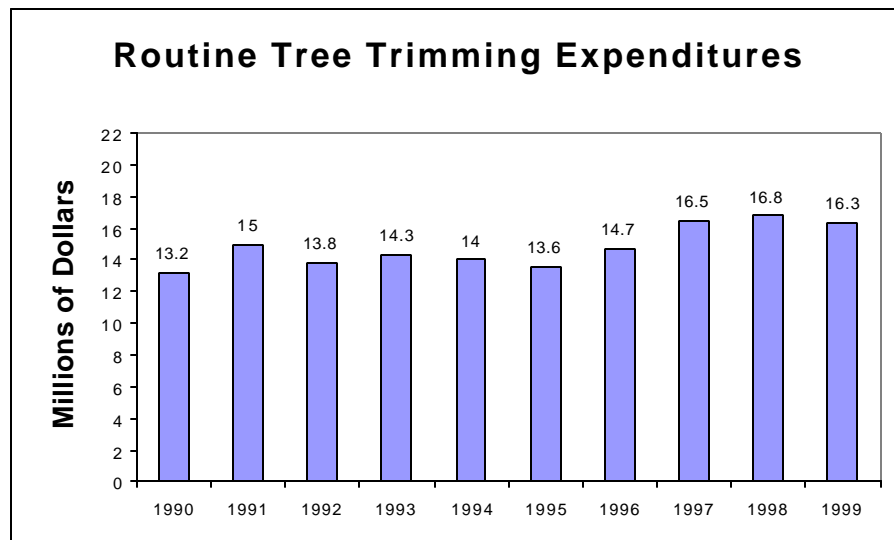
Routine Tree Trimming Program. Dominion Virginia Power routinely trims trees along the right-of-way corridors that carry a network of nearly 30,000 miles of overhead lines to their customers. Every year Dominion Virginia Power trims one-third, or approximately 10,000 miles, of the 30,000 miles with a contracted workforce of approximately 500 tree trimmers. Recently, emphasis in technology advancements has resulted in the increased working height of a tree-trimming bucket truck from 45 feet to nearly 60 feet, allowing higher clearances of the right-of-way corridor to be achieved.

Dominion Virginia Power's tree contracting strategy has also emphasized the need to stabilize the tree-trimming workforce by awarding a six-year maintenance contract to Asplundh Tree Expert Company. Past contracts have been structured to a three-year period, and by awarding a six-year contract, Dominion Virginia Power expects to minimize labor turnover in an industry that historically has experienced a high labor turnover rate. Under the new contract, Asplundh employs a workforce that receives training on Dominion Virginia Power's specifications and the SCC's tree-trimming guidelines. Dominion

Virginia Power employs fewer foresters to administer the new contract, and has scheduled fewer field inspections as a result of Asplundh's more skilled workforce. In 1997, the Company reduced the number of degreed foresters in distribution forestry from 14 to 12. The Company reduced from 21 to 17 the total number of foresters (degreed and non-degreed), all of whom are involved in field spot inspections of tree trimming. Under the existing contract, Dominion Virginia Power anticipates performing approximately 2500 inspections annually, compared to 5200 inspections under previous contracts. Additionally, added focus has been placed on establishing performance standards, such as tree-related interruptions, to track the performance of the tree-trimming program. Dominion Virginia Power believes this emphasis on performance should improve overall reliability.

Routine tree-trimming maintenance now averages about \$1,600 per mile or \$16 million per year. Prior to 1997, expenditures on routine tree trimming exhibited a slightly decreasing trend when normalized to 1999 dollars; however, expenditures on routine tree trimming increased significantly in 1997. Under the new Asplundh six-year contract, payment for mileage trimmed is based on actual time and material rates, with an annual cost cap. In the event the actual annual total cost incurred in a calendar year is less than the total annual cost cap for that year, the annual cost savings may be shared by Dominion Virginia Power and Asplundh equally. However, the sharing by Asplundh in any annual cost savings is contingent upon meeting the annual reliability target and customer complaint target. If the targets are not met, then Asplundh's percentage of any annual cost

savings is reduced in accordance with a predetermined schedule of weighted criteria. Dominion Virginia Power's annual Virginia routine tree-trimming expenditures, excluding clearing costs imposed by major storm events, in millions of dollars for 1990 through 1999 are provided in the following graph. Though not shown on the graph, the Company's budgeted expenditure for routine tree trimming in 2000 is \$16.3 million, the same amount expended during 1999.



Tree Removal Program. In addition to routine tree-trimming maintenance, right-of-way enhancement work is conducted through Dominion Virginia Power's tree removal program. The tree removal program focuses on dead tree and live danger tree removals, as well as the removal of large overhangs on circuits or segments of circuits that show poor reliability. Circuit candidates

for the tree removal program are determined by reliability groups who analyze "worst circuits" and "worst devices" outage rankings according to the number of outage events, number of customers affected, and the number of customer-hours out. These lists are segmented at the corporate and regional levels. Root cause analysis is performed annually on these circuits and devices to determine areas of focus that will reduce repeat outages and customer-hours out by administering the tree removal program.

Chronic, hard hit areas experiencing outages due to trees are foot patrolled after each major storm event to assess the work needed to preserve and improve service reliability. The right-of-way corridor is first cleared of all damaged vegetation such as broken overhangs, hanging limbs and live, leaning trees that pose an imminent outage risk. Follow-up work is performed later to remove weak wooded species such as pines, poplars, maples and sycamores. This effort not only includes trees within and adjacent to the right-of-way corridor, but may also include trees off the right-of-way that are removed with landowner consent. Select ground-to-sky sidewalling and overhang removals may also be performed. Large-scale tree removal programs may require Dominion Virginia Power to meet with the affected communities to convey the scope of the proposed improvement work.

Dominion Virginia Power's tree removal program ranges from \$7,000 to \$68,000 per mile, depending on variables such as existing right-of-way condition, truck access, canopy height, tree and limb size, traffic control, terrain, and

municipal arborist requirements and permitting. Recognizing that tree removal costs vary because each tree removal project is different, this range of costs is based on a representative sample of projects in all three of the Company's operating regions. Dominion Virginia Power anticipates a sustained increase in annual spending of \$2.5 million (through 2003 at a minimum) company-wide on the tree removal program, which is based on its reliability group's analysis of worst circuits, worst devices and repeat outages. Future expenditures on the tree removal program beyond 2003 may decrease, but expenditures on routine tree trimming are likely to increase.

Storm Clean-up and Hot Spot Trimming. In addition to the reported routine tree trimming and tree removal program expenditures, Dominion Virginia Power is responsible for tree trimming as a part of storm clean-up. Tree clean-up dollars for several of the more recent and most destructive major storm events are listed below:

1998	Hurricane Bonnie	\$1,132,382
1998	Christmas Eve Ice Storm	\$3,532,383
1999	Hurricane Floyd	\$2,720,543
2000	Super Bowl Ice Storm	\$2,000,000 (allocated amount)

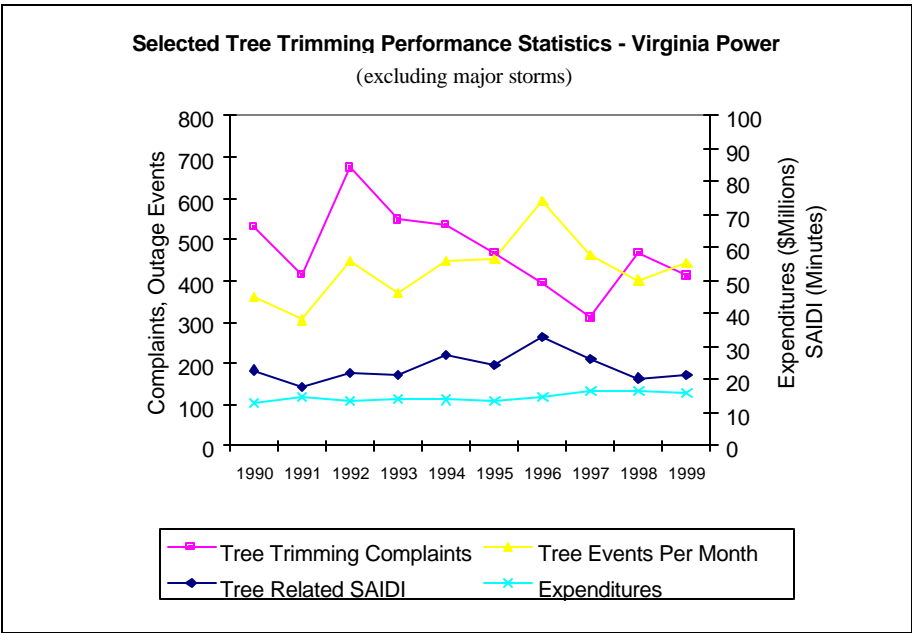
Dominion Virginia Power also performs hot spot work that includes the following:

- Removing fallen limbs from service drops.
- Providing safe tree-to-conductor clearance for customers to remove trees (to comply with NESC requirements since most private tree care companies are not qualified to work on a tree that is within ten feet of

energized wires, and sometimes customers want to remove a tree from private property that the Company would normally not remove).

- Trimming yard trees off-cycle that may not normally be trimmed hard enough so that Dominion Virginia Power complies with the SCC guidelines for not removing one-third of a tree's crown.

Tree-Related Reliability Data. In 1990 – in response to 1989 House Joint Resolution 155 – the Commission Staff issued tree trimming guidelines and began to collect and monitor annual system tree-trimming data for each jurisdictional utility, including Dominion Virginia Power. The following figure displays trends over the ten-year period 1990-1999 relative to tree-trimming-related complaints, right-of-way maintenance costs, tree-related outage events, and tree-related reliability indices. The analysis of this data provides insights into the effectiveness of Dominion Virginia Power's tree trimming programs.



Dominion Virginia Power has averaged approximately 475 tree-trimming-related complaints per year over the ten-year period 1990-1999. However, it appears that the Company has experienced a slightly downward trend in the number of complaints reported to the Company since experiencing a high of 674 complaints in 1992. It is interesting to note that as the number of complaints relative to tree trimming decreased, perhaps as a result of less aggressive trimming practices, the number of tree-related outage events has increased.

Tree-related reliability data (excluding major storms), including tree-related outages and tree-related system average interruption duration indices (SAIDI), indicate that Dominion Virginia Power's tree-related system reliability declined from 1990 to 1996, perhaps as a result of the stagnant expenditures on tree trimming discussed previously. However, since 1997 routine tree-trimming expenditures have increased by approximately \$2.4 million and tree-related reliability has improved.¹¹

Summary and Conclusions

For the three-year period 1997-1999, Dominion Virginia Power's two million customers, on average, were without power for approximately two hours per year, as a result of approximately 50,000 minor outage events per year (excluding major storms) occurring randomly throughout various small areas of Dominion Virginia Power's territory. By contrast, pockets of customers have

¹¹ In other words tree-related outage events and tree-related SAIDI have decreased, in general.

experienced poor levels of reliability that are much worse than the system average. In addition, only a few major storms each year can affect a wide portion of the Company's system, affecting large numbers of customers for significant lengths of time. However, the length of time a typical customer was impacted by the most severe storms during the period 1997-1999 was approximately 14 hours, on average. As a result of these concerns, the Commission Staff performed a review of the Company's distribution system reliability. This chapter described the Staff's investigation of Dominion Virginia Power's reliability monitoring program, analyzed measures of reliability and resources dedicated to reliable service, reviewed outage trends, and analyzed Dominion Virginia Power's tree trimming programs for maintaining reliable service.

Dominion Virginia Power has established a distribution operations performance department that has the responsibility for implementing an extensive distribution reliability-monitoring program. The Company monitors reliability indices that are typical within the electric utility industry, has made a commitment to maintain overall system average reliability at levels consistent with those attained during the past decade, and established performance objectives to improve reliability. The Company also maintains a program to evaluate the least reliable circuits and least reliable devices, and spent close to \$100 million in 1999 on reliability improvement projects. In spite of these efforts, there are small pockets of customers who continue to experience poor reliability; however, such

pockets of poor reliability may go undetected by the indices studied under the Company's current reliability program.

There are numerous examples of strategic changes in Dominion Virginia Power's approach to service reliability during the late 1990s to indicate that Dominion Virginia Power has attempted to improve service reliability, improve customer service, and control costs. Advances in telecommunications, customer tracking, computer technologies, and automation software have been used by Dominion Virginia Power to improve the efficiency of employees during both normal working conditions and major storm restoration efforts. In 1999 Dominion Virginia Power continued its efforts to improve by implementing some new technologies to reduce restoration times and improve customer communications, including a mobile dispatch data system and a geographic information system.

Dominion Virginia Power uses a three-year cycle to trim the distribution right-of-way corridors on its entire system in order to maintain system reliability. Generally, the Company's performance relative to tree trimming has been fairly consistent over the ten-year period 1990-1999. Tree-related reliability data indicate that Dominion Virginia Power's system probably became more vulnerable to tree-related outages during the period 1990 to 1996, perhaps as a result of less aggressive trimming practices reflected by a relatively flat level of expenditures on routine tree trimming. However, since 1997 annual routine tree-trimming expenditures have increased by approximately \$2.4 million over pre-1997 annual expenditures and tree-related reliability (excluding major storms) has improved

after declining from 1990 to 1996. Nevertheless, trees are still responsible for a significant percentage of interruptions on Dominion Virginia Power's system.

Dominion Virginia Power has entered into a new performance-based, long-term tree-trimming contract with Asplundh Tree Expert Company. Under the new contract, Asplundh employs a workforce that receives training on Dominion Virginia Power's specifications and the SCC's tree-trimming guidelines. Dominion Virginia Power employs fewer foresters to administer the contract, and has scheduled fewer field inspections as a result of Asplundh's more trained workforce.

In spite of Dominion Virginia Power's stated emphasis on tree trimming, some of the Company's customers have experienced extended, inconvenient tree-related outages as a result of major storms that impacted the system from 1996 to 2000. Although Dominion Virginia Power has achieved improved power restoration rates, the Staff believes that the Company should be able to adjust its tree-trimming practices to lessen the system's vulnerability to major storms.

In general, it is the Staff's position that in spite of Dominion Virginia Power's efforts to monitor and improve overall system average reliability (excluding major storms), the Company's system has become vulnerable to major storms in recent years and pockets of customers have experienced poor reliability. The Staff anticipates that Dominion Virginia Power should be able to reduce the system's vulnerability to major storms, implement corrective actions in pockets experiencing poor reliability, and continue improving overall system reliability in

2000 and beyond. In addition, the Staff plans to develop a detailed, formal program to monitor Dominion Virginia Power's distribution system reliability. The following chapter reviews some additional issues related to reliability, including a presentation of general perspectives on reliability, a discussion of the feasibility of relocating overhead facilities to underground, and a general assessment of Dominion Virginia Power's vulnerability and response to major storms.

IV. DISCUSSION AND ASSESSMENT OF SOME RELATED ISSUES

Introduction

This chapter provides a discussion and assessment of three topics related to distribution system reliability. The chapter begins with a presentation of general perspectives on reliability. The section on general perspectives is followed by a discussion of the feasibility of relocating overhead facilities to underground, with a focus on potential costs and related activities in other states. The final section presents a general assessment of Dominion Virginia Power's system vulnerability and response to major storms.

General Perspectives on Reliability

The Commission is aware that reliability of service to electric utility customers is a critical issue. Customers expect that whenever they flip the switch, their utility's electric distribution system can be relied on to provide power, and that the characteristics of the power supplied will meet the customer's needs. Therefore, problems arise when power is not reliable or when the power provided does not meet the customer's needs (for example, low-voltage conditions). Service interruptions, also commonly referred to as "outages," are of course the most recognizable service quality problem to customers.

Major storms can distort any perception of reliability. During periods when major storms occur infrequently, some customers may become accustomed to extremely high levels of reliability and develop unrealistic expectations relative to the capability of the system to withstand major storms. In addition during such

periods, it may be possible for a utility to become overly optimistic about the condition of its distribution system and the effectiveness of its tree-trimming and reliability programs. Such an attitude could lead to complacency and a distribution system that is vulnerable to major storms.

While utility companies often report their outage data on a storm-adjusted basis for better trend spotting, there is no surer way for a utility to invite scrutiny than by mishandling a major outage, especially in unusual cases. If the cause is familiar, like hurricanes or tornadoes in states prone to such calamities, the public appears more likely to be forgiving; but when an ice storm hits the Gulf Coast or a hurricane hits New England, then any problems in service restoration seem quicker to promote a reaction. Such was the case when a spate of severe ice storms and hurricanes impacted central Virginia in a period of 12 months, disrupting the Christmas holiday in one event and the Super Bowl in another.

Trees probably represent the most significant cause of outages, especially during extreme weather conditions. Tree limbs or other obstacles should not normally come in contact with power lines; trees coming in contact with overhead power lines will cause service interruptions. A successful tree-trimming program, along with a successful preventive maintenance program, should prevent many tree-related interruptions. Customer sensitivity to the relationship between trees and distribution reliability can assist the utility in reducing tree-related interruptions. Customers should avoid planting trees near transformers or underneath power lines. If a tree is touching a power line, customers should not

attempt to trim the tree, but should contact the utility to schedule a line clearing crew to perform this potentially dangerous work.

Frequently, utility efforts to protect service reliability by trimming trees come into conflict with local tree-protection ordinances or individual customers' concerns and property rights. In these cases, the proper balance between safety, reliability, conservation, and aesthetics must be sought and achieved among the parties involved. Customers concerned about trees they planted and nurtured have a right to be heard, but they must also understand the utility's responsibility to ensure the safety and reliability of service not only to that customer, but also to the community. Customer education regarding company policies and procedures can reduce such conflicts.

Feasibility of Relocating Overhead Facilities to Underground

As a result of the recent impacts of major storms on Dominion Virginia Power's system, there has been heightened interest in the feasibility of relocating overhead distribution lines to underground. Relocation of overhead facilities to underground is very rare and performed only when considered to be the most cost-effective solution. If, during Dominion Virginia Power's reliability review of worst circuits and worst devices data, the Company finds excessive and repeated damage to facilities, such as broken poles, a cost effective decision may be made to convert overhead facilities to underground as an improvement alternative.

One situation where it could be cost effective is where an overhead line with poor reliability exists in the bottom of a ravine and the adjacent right-of-way

corridor is covered with trees that tower over the line. This condition may be considered a candidate for underground conversion if other reliability improvement efforts such as tree removal are either too expensive or determined to be unsuccessful. If the cost of repeatedly replacing poles and wire due to tree damage also exceeds the cost of relocating the line underground, this location would qualify as a candidate for undergrounding.

Frequently, after major storms inflict significant damage, suggestions are made to relocate overhead distribution facilities underground in order to avoid major storm outages. However, approximately two-thirds of Dominion Virginia Power's system is overhead. The Company has indicated that the average cost of relocating underground primary distribution facilities is roughly estimated at \$500,000 per mile,¹² which would require an investment of approximately \$20 billion to relocate Dominion Virginia Power's entire overhead distribution system underground. This amount is several times the Company's current total net asset investment and would translate into several hundred dollars of additional annual charges for the average customer. To date, conventional wisdom has maintained that this option is not economically feasible. Certainly, in cases where reliability improvements have not been effective, this approach may deserve more serious consideration; however, undergrounding would not completely eliminate outages or the need for expenditures to maintain the system. For example, the worst 10

¹² The November/December 2000 issue of *Electrical World* magazine, provides the following typical figures for relocating distribution lines to underground: \$1 million per mile for 14.4 kV lines and over \$2 million per mile for 120 kV lines.

devices on Dominion Virginia Power's system in 1999 were fuses serving underground cable and the majority of the outages were attributed to cable failures.

Ontario Hydro and others studied placement of electrical systems underground in the aftermath of the January 1998 ice storm. Ontario Hydro estimated that placing cables underground in 1998 would cost about 11 billion Canadian dollars. A special committee appointed by Hydro Quebec's Board of Directors suggested that undergrounding of electrical distribution should be fostered where customers and municipalities are willing to share the extra cost. Likewise, an interagency hazard mitigation team convened in 1998 by the Federal Emergency Management Agency in Vermont recommended that the State of Vermont develop an incentive program with utility subsidies for homeowners who agree to pay the expense of burying service drops.

In Maine during the January 1998 ice storm recovery activities, some members of the public suggested that Maine's electric infrastructure would be less subject to failure if it were placed underground rather than on aerial facilities. Central Maine Power Company advised the Maine Public Utilities Commission that it studied the feasibility of underground distribution lines in 1988, and estimated that such a system would cost about 10 times the cost of the aerial system in use. Central Maine Power Company estimated that changing to an underground distribution system would cost at least \$8.5 billion in 1988, plus costs

of removal, regulators and transformers, and labor, resulting in a monthly increase of \$95 to each Central Maine Power Company customer bill.

As a result of an inquiry by the Maine Public Utilities Commission into the response by utilities in Maine to the January 1998 ice storm, the MPUC commented on the relocation of overhead facilities. The MPUC stated in summary that "placement of electric infrastructure underground may have benefits in lower outage frequency, less susceptibility to weather events, and aesthetics." However, the MPUC also noted that such a practice "would likely also raise problems from higher outage durations, higher susceptibility to flooding and excavation events, winter access and repair times." The MPUC reached the following conclusion: "...we do not believe that the advantages that could be achieved from relocating aerial facilities underground would offset likely disadvantages and costs."

In a recent survey of other state utility commissions by the Commission Staff, none of the 41 states responding had implemented a policy to relocate existing overhead facilities to underground for the purpose of improving reliability. Utilities in Maryland have been directed to investigate the feasibility of relocating overhead facilities to improve reliability, and the California Public Utilities Commission has been directed by the legislature to investigate methods to revise its outdated policy on underground lines. Some utilities in Kansas have adopted tariffs with an associated surcharge for the relocation of facilities to underground for aesthetic purposes. In a related action, South Carolina Electric &

Gas Company negotiated an "undergrounding" clause in its franchise agreement with the City of Charleston in 1996. Relocation projects, which must be approved by two-thirds of the residents in a relocation district, are funded from general utility rates (50%), the City of Charleston (35%), and residents from the affected district (15%). The Staff believes that it may be appropriate to consider relocation of overhead facilities to underground if a customer has very poor reliability on a sustained basis that cannot be corrected by additional tree trimming, even if the relocation doesn't pass a traditional cost-benefit test.

General Assessment of Dominion Virginia Power's Vulnerability and Response to Major Storms

The impacts of major storms on Dominion Virginia Power's distribution system have not been significantly different from the impacts of major storms experienced by other utilities in the eastern United States. In addition there is evidence that the Company has steadily increased its average restoration rates after major storms. While the Staff believes that Dominion Virginia Power's performance relative to recent major storms has been generally satisfactory, certain problems have been identified as a result of the Company's routine post-storm critiques, and the Company has committed to various corrective actions. However, as a result of the impact to the Company's distribution system from major storms in the past three years and evidence of customers' increased sensitivity to outages, the Staff has ongoing concerns related to the Company's distribution system reliability.

Virginia's State Climatology Office has concluded that there has been no long term increasing trend in the frequency or severity of storms on Dominion Virginia Power's territory. Likewise, the Commission Staff could not discern an increasing trend in the average outage duration from major storms. Nevertheless, there is no doubt that some of Dominion Virginia Power's customers, particularly those at the ends of circuits, have experienced multiple, lengthy outages as a result of individual severe storms. The Staff has not identified any specific evidence of gross negligence and believes that any problems with system reliability may be the result of a combination of multiple determinants. Possible causes might include an isolated random increase in frequency and severity of major storms, inadequate right-of-way maintenance in isolated areas, or a lack of resource commitment to reliability; or, there may be no identifiable underlying cause.

The Staff found no evidence that Dominion Virginia Power's distribution system design contributes to any problems with reliability. In fact in many cases, the Company has designed its system to meet or exceed industry codes and standards, which should enhance reliability. For example, the Company requires additional separation between primary and neutral conductors, uses larger crossarms than required, uses wire sizes that in many cases result in larger and stronger conductors, and designs its system for ice loading on overhead conductors that either meets or exceeds code requirements.

The Staff is concerned that expenditures on routine tree trimming may have been outpaced by the growth of trees in the heavily wooded areas of the

Company's system. Such a development probably would have gone unnoticed during the early 1990s when severe storms resulting in long outages on Dominion Virginia Power's territory were relatively infrequent, and overall system reliability was actually improving, prior to the downturn in system reliability from 1993 to 1996. In fact, although routine tree trimming expenditures have remained stable in nominal dollars, routine tree trimming expenditures prior to 1997 may have exhibited a decreasing trend when normalized to 1999 dollars. However, expenditures on routine tree trimming were up significantly in 1997, 1998, and 1999. Nevertheless, trees continue to be the cause of a substantial number of interruptions, sometimes resulting in outages of significant duration.

Dominion Virginia Power has acknowledged that service in certain areas has been inadequate, and the Company has responded with increased emphasis on routine tree trimming and tree removal programs and increased expenditures on reliability improvements, as well as increases in Company linemen and restoration vehicles in recent years.¹³ Of course, the results of such increased attention to reliability may not be immediate, as evidenced by the impacts from major storms in recent years. Furthermore, customers at the ends of major overhead circuits may never experience the high level of reliability that some customers enjoy. Customers who experience repetitive, long duration outages from multiple storms

¹³ The total number of linemen consists of company linemen and contract linemen. Due to a lack of available historical data relative to the number of contract linemen, the Staff is unable to make a statement about long term trends in the total number of linemen. There has been an increasing trend in the number of restoration vehicles since 1994, the first year for which data on restoration vehicles is available.

are likely to become hypersensitive and convinced that reliability has deteriorated. But available data show that since 1970 the average outage duration from major storms has remained fairly constant, and the occurrence of outages of four, five, or more days in Dominion Virginia Power's territory and elsewhere in Virginia and the eastern United States is not a new phenomenon.

While a definitive reason for the recently perceived system vulnerability to major storms in certain areas remains somewhat elusive, a review of the data indicate that trees were a major contributor. Trees are one of the Commonwealth's most treasured assets, and the Staff is cognizant of the need to balance a number of competing interests when trimming trees for utility line clearance. The SCC's tree-trimming guidelines require that tree-trimming practices consider "costs, safety, continuity of service, the health and vigor of affected trees, aesthetics, concerns of property owners, wildlife management, and environmental concerns." However, the Staff is concerned that in recent years a disproportionate emphasis may have been afforded aesthetics and concerns of property owners to the detriment of reliability. While the Staff is making several recommendations in an attempt to improve the Company's response and system resistance to major storms, the Staff's primary concern is that Dominion Virginia Power intensify its tree-trimming operations to adequately maintain its rights-of-way. In addition, the Staff plans to increase its reliability monitoring efforts to ensure that the actions implemented by the Company result in reliable service for all of Dominion Virginia Power's customers and mitigate system vulnerability to major storms.

Summary and Conclusions

This chapter provided a discussion and assessment of three topics related to distribution system reliability: general perspectives on reliability, the feasibility of relocating overhead facilities to underground, and Dominion Virginia Power's system vulnerability and response to major storms. The discussion on perspectives addressed the importance of reliable service to utility customers, the influence of storms on perceptions of reliability, and the relationship between trees and reliability.

A discussion on the feasibility of relocating overhead facilities to underground followed the discussion on perspectives. The relocation of overhead facilities to underground is expensive and rarely initiated. Few states have investigated the issue, but in at least two instances relocation has been recommended or implemented where customers and municipalities share the expense. The Staff believes that it may be appropriate to consider relocation of overhead facilities to underground where traditional methods to maintain reliability are unsuccessful.

The third and final section in this chapter provided a general assessment of Dominion Virginia Power's system vulnerability and response to major storms. The Staff found no evidence that Dominion Virginia Power's distribution system design contributes to the vulnerability of the system to major storms. Trees are the major contributor to outages, and the Company is responding with increased emphasis on trimming. The Staff concluded that the Company's response to recent

major storms was generally satisfactory, and the Company has initiated corrective actions where necessary as a result of routine post-storm critiques. The following and final chapter of this report presents a summary of the key findings and action items resulting from the Staff's investigation of Dominion Virginia Power's performance relative to the Super Bowl Sunday freezing rain storm and assessment of the Company's overall system reliability.

V. KEY FINDINGS AND ACTION ITEMS

- The time required for full restoration of service following the Super Bowl Sunday freezing rain storm does not appear to be abnormal, when subjected to historical comparisons, given the number of customers impacted and the extent of damage to Dominion Virginia Power's distribution system.
- The Staff agrees with the Company's prioritization plan for restoration of service following a major outage, which employs a strategy of first repairing those circuits that result in the restoration of service to the greatest number of customers. The Company adequately implemented its prioritization plan during the Super Bowl Sunday freezing rain storm.
- Dominion Virginia Power's communications with the media and the public following the Super Bowl Sunday freezing rain storm were satisfactory with the exception of some estimates of restoration times. The Company is implementing computer system enhancements as recommended by a Company task force established to improve the accuracy of customer outage information and estimated restoration times given to customers.
- A review of the outage causes associated with the Super Bowl Sunday freezing rain storm leads to the conclusion that trees were the major contributor. This finding has raised issues related to trimming of trees for adequate right-of-way clearance. Responsible trimming of trees requires a balance among multiple criteria, and the Staff believes that the Company should employ more aggressive trimming in order to meet its requirement to provide reliable service. The Staff has seen evidence that the Company has begun to address this issue. In 1997, Dominion Virginia Power increased annual spending on its routine tree-trimming program by \$2.4 million on average. In addition, the Company's system-wide, tree-removal program plan for the year 2000 addressed over 90 circuits with an estimated increase in spending of \$2.5 million.
- Where aggressive tree trimming does not provide adequate reliability, the Staff believes that Dominion Virginia Power should evaluate alternative measures, including consideration of relocating overhead facilities to underground, even if the relocation doesn't pass a traditional cost-benefit analysis.
- Dominion Virginia Power's reliability improvement projects, including the scope of its tree removal program, are based in part on the Company's annual root-cause analysis of its 10 worst circuits and 10 worst devices in each of the

Company's operating regions. The Commission Staff and Dominion Virginia Power will evaluate the need to increase the number of worst circuits and worst devices analyzed.

- During the early to mid 1990s, Dominion Virginia Power's overall system average reliability deteriorated, most likely as a result of a reduction in labor force, declining expenditures on reliability improvement projects, and flat expenditures on routine tree trimming for right-of-way maintenance. However, the Company's overall system average reliability improved during the late 1990s. The recent improvements in overall system average reliability, excluding major storms, are probably the result of several factors including (1) increases in the number of company linemen, (2) increased expenditures on routine tree-trimming and tree-removal programs, (3) implementation of a performance-based tree-trimming contract, (4) development of a systematic method to analyze the worst circuits and worst devices, leading to increased expenditures on reliability improvement projects, (5) increased investment in restoration vehicles and telecommunications and information technology, and (6) the establishment of service performance groups.
- In spite of recent improvements in Dominion Virginia Power's overall system average reliability, the Staff has become aware, as a result of numerous complaints from the public after recent major storms, of pockets of customers with poor reliability. Consequently, the Staff is developing a more formal system for monitoring reliability, focusing both on customers whose service reliability is below average and on system vulnerability to major storms. At a minimum, the Staff plans to monitor annual trends in measures of reliability, complaints relative to reliability and tree trimming, outage causes, worst circuits and worst devices, and resources dedicated to maintaining and improving reliability.

APPENDIX A
1999 DOMINION VIRGINIA POWER MAJOR STORM DATES

<u>Dates</u>	<u>Storm Type</u>	<u>Estimated Customers</u>	<u>Areas Affected</u>
1/1-1/3	Christmas Eve Ice Storm* Wrap Up	401,000	Central Virginia, W'msburg, N. Neck
1/14-1/17	Northwest Ice Storm	214,000	Northern Virginia
3/3-3/4	Wind/Chapparrel Tornado	144,900	Central Virginia
3/15	Allegheny Snowstorm	10,900	Allegheny/Shenandoah area
4/9	60 MPH Storm Front	58,700	Central Virginia
4/23-24	North-to-South Lightning/Wind	51,600	System-wide
5/22-5/25	Multi-Cell Wind/Lightning	103,800	Entire Service Territory
6/14-6/15	Alexandria Super Cell	45,700	Alexandria/Arlington only
6/29-6/30	Central Region Thundercells	69,400	Metro-Richmond and Fredericksburg only
7/7-7/8	Heatwave-Breaking Storm	68,600	Central Virginia, Tidewater, Charlottesville/Blue Ridge
7/24-7/26	System-wide watch/warn; Fredericksburg tornado	113,200	System-wide Event
7/28-7/29	Heatwave-Breaking Front 2	54,200	Central and Western Virginia; Norfolk & Peninsula
8/1-8/2	West-to-East Tornadic Front	61,800	Central and Eastern Virginia
8/11-8/12	Williamsburg SuperCell	27,400	Williamsburg
8/14-8/15	Heatwave-Breaking Front 3	79,400	Northern and Eastern Virginia
8/19-8/20	Norfolk Downburst	62,100	Norfolk area
8/29-9/5 9/4-9/5	Hurricane Dennis	270,000	Initial Impact - Tidewater only, Trek across system
9/15-9/21	Hurricane Floyd	800,000	System-wide Event
9/29-9/30	Northwest Front	54,900	Northernmost Virginia
11/2-11/3	South-to-North Wind Front	68,300	I-95 corridor

*entire storm (12/23/1998-1/3/99)