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VIRGINIA CENTER FOR COAL
AND ENERGY RESEARCH

# A Preliminary Feasibility Study of a New Electricity Transmission Line From the Virginia Coalfield to the Virginia Power System

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

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## Final Report on Virginia House Joint Resolution No. 441

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**Final Report on Virginia House Joint Resolution No. 441**

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## Executive Summary

Virginia House Joint Resolution No. 441 (February, 1991) directed the Virginia State Corporation Commission and the Virginia Center for Coal and Energy Research (VCCER) to "*study means available, prior to 1998, to 'wheel' power produced by electric power plants in southwestern Virginia*" to the Virginia Power transmission network, for purchase by Virginia Power. The Resolution directed that the VCCER study address new transmission line construction options that might be pursued "*in addition to*" the Wyoming - Cloverdale and Joshua Falls - Ladysmith transmission construction programs currently proposed by Appalachian Power Company (Apco) and Virginia Power. This report summarizes the results of the VCCER study.

The study was conducted by reviewing available information regarding the technical and economic feasibility of power line construction to various points of terminus. Where available information was not sufficient, additional information was requested from the state's two major utilities (Apco and Virginia Power) and from other sources. Load flow modeling studies were conducted by the two utilities for the purpose of evaluating the technical feasibility of specific construction alternatives.

The technical feasibility of new construction options was judged by determining the likely effects of integrating each alternative into the existing transmission system. In order to be considered technically feasible, a construction option must be able to be integrated into the existing transmission network without having a significant negative impact on that network's reliability or performance in meeting current and anticipated uses. The economic feasibility of new construction options was judged by comparing transmission line costs, on a per-kWhr-delivered basis, to the cost of moving equivalent amounts of energy by rail to eastern Virginia.

If Virginia Power is to purchase power from non-utility generators, the power must be transmitted to Virginia Power's load centers, in eastern Virginia, during peak demand periods. One way to accomplish this would be through construction of a new transmission line to provide a *direct* connection from southwestern Virginia to eastern Virginia. This option does not appear to be economically feasible under the assumptions used to guide this analysis. Factors limiting the economic feasibility of a direct connection are the long distances involved and the resultant high construction costs, the limited amounts of power generation reasonable to consider for development in southwestern Virginia prior to 1998, and Virginia Power's transmission reliability requirements.

Information provided by Apco and Virginia Power was used as the basis for determining the technical feasibility of *non-direct* new construction options, i.e. those combining new line construction and transmission through the existing system.

These options were evaluated as less-costly alternatives to a direct southwestern Virginia - eastern Virginia connection. Present, heavy loadings on the existing transmission system appear to have negative effects on the technical feasibility of all of these non-direct options. Virginia Power maintains that these current transmission loadings limit its system's ability to move additional power inputs that might be provided at Bath County or Lexington to eastern Virginia under peak load conditions. These limitations caused a number of new construction options, including direct connections from southwestern Virginia to Virginia Power in the Lexington - Bath County area and construction options which require wheeling through the Apco system, to be considered technically infeasible without further upgrades of the existing network. All construction alternatives investigated with the intention of providing increased transfer capabilities from Lexington or the Apco system to eastern Virginia were found likely to have the unintended consequence of drawing increased loadings through critical Apco system components west of Cloverdale, and therefore are considered technically infeasible at the present time.

A number of issues were identified which have the potential to influence the feasibility of power line construction, by non-utility interests, for the purpose of selling power that might be generated in southwestern Virginia to the Virginia Power system. These issues concern economic, legal, and institutional factors. Since the primary factors causing available construction options to be considered infeasible were technical, the majority of these issues did not have a major impact on these proceedings. The exception is Virginia Power's requirement that power generation contracts provide double-structure, double-circuit transmission reliability. This requirement adds substantial costs to many of the new transmission options investigated, including a direct connection from southwestern to eastern Virginia, but is justified from Virginia Power's standpoint by the need to maintain high standards of system reliability.

*For these reasons, the study concludes that construction of a new power line from southwestern Virginia, prior to 1998, to enable power to be transmitted to the Virginia Power system for purchase by that utility, does not appear to be feasible under present circumstances.*

The finding that new power line construction prior to 1998 is not feasible is dependent upon the assumptions of the analysis. If current heavy loadings on the regional transmission network were to be relieved, prior to 1998, by system upgrades or load reductions, a major technical limitation to a number of new construction options would be removed. If the amount of power generation capacity developed in southwest Virginia, prior to 1998, were substantially in excess of 500 MW, the economic feasibility of a direct connection to eastern Virginia would be enhanced through reduction of per-kWhr transmission costs. Negotiation of a lower-cost alternative to Virginia Power's double circuit - double structure transmission reliability requirement, and a southwestern Virginia power generation capacity in excess of 500 MW, would be required in order to establish an economically feasible direct-access 500-kV connection to eastern Virginia.

## Study Purpose and Approach

Virginia House Joint Resolution No. 441 (HJR 441) directed the State Corporation Commission and the Virginia Center for Coal and Energy Research (VCCER) to "*study means available, prior to 1998, to 'wheel' power produced by electric power plants in southwestern Virginia*" to the Virginia Power transmission network, for purchase by Virginia Power. The Resolution directed that the VCCER study address new transmission line construction options that might be pursued "*in addition to*" the Wyoming - Cloverdale and Joshua Falls - Ladysmith transmission construction programs currently proposed by Appalachian Power Company (Apco) and Virginia Power. This document is a report of the results of the VCCER study of the feasibility of constructing a new electric power transmission line for that purpose. A previous VCCER study demonstrated the economic benefits that could occur from construction of new electric power generation facilities in the Virginia coalfield that use locally mined coal (VCCER, 1990). A barrier to construction of such facilities is the inability of non-utility generators to gain access to transmission lines, so as to transfer power from southwestern Virginia to the Virginia Power service area.

Major factors considered by the VCCER HJR 441 study were:

1. The technical feasibility of new transmission line construction options.
2. The economic feasibility of new transmission line construction options.
3. Issues associated with ownership, regulatory approval, permitting, and economic feasibility of a new line.

Recently, questions regarding power line construction have received considerable public and political attention in Virginia. A primary focus has been the proposed transmission reinforcement program of Appalachian Power Company (Apco) and Virginia Power (VP), which involves construction of a high-capacity transmission line by each utility. The two lines are complementary in that, together, they would significantly enhance west-east power transfer capability between the two utilities. The scheduled completion date for the Apco-VP transmission reinforcement program is 1998.

These developments are important to the current study. The 1998 date specified by HJR 441 is the projected date of completion of the Apco - Virginia Power transmission reinforcement program. The approach taken here is that the feasibility of any additional transmission lines that might be proposed must be considered in light of various possible outcomes regarding the Apco - Virginia Power transmission reinforcement program: (i) construction of the proposed Apco-VP lines could be completed as scheduled; (ii) construction could be substantially delayed; or (iii) future events could prevent construction of one or both of the new lines proposed by Apco and VP.

## Research Methods

The primary method for conducting this study was to request data and information on transmission line construction, and on pertinent issues associated with such construction, from knowledgeable and experienced parties. The data and information so gathered were then analyzed and evaluated by VCCER.

Primary parties providing information included non-utility generating interests and the major utilities. The majority of the information on Virginia's transmission network, costs of power line construction, and technical implications of various construction options were provided by Appalachian Power Company (Apco), American Electric Power Service Corporation (AEP), and Virginia Power (VP). Primary non-utility generating interests contributing to these proceedings were Coastal Power Production Company, Hadson Development Corporation, and the Virginia Association of Non-Utility Power Producers. Additional information was provided by the Virginia State Corporation Commission, the Federal Energy Regulatory Commission, the Coalfield Economic Development Authority, and Carolina Power and Light. The data and information were gathered through personal interviews, telephone discussions, and written requests.

On September 1, 1991, an interim report of study findings was circulated to parties with interest in the current proceedings. That report attempted to define a preliminary information base, including the likely implications of establishing points of terminus for a power line from southwestern Virginia at various substations on the Apco-VP grid. The report also outlined some of the major issues affecting the feasibility of constructing such a power line by independent, non-utility interests. The resultant comments and feedback were utilized in the study's final phase.

On October 8, 1991, a meeting was held in Roanoke, Virginia, to discuss the technical feasibility of various power line alternatives. The meeting was hosted by Apco, and attended by representatives of Virginia Power, American Electric Power Service Corporation, Coastal Power Production Company, and Hadson Development Corporation at the invitation of VCCER. Participants of the meeting reached a consensus regarding transmission configurations that merited analysis through load flow modeling studies, in order to assess technical feasibility. Such studies were conducted cooperatively by American Electric Power Service Corporation, for Apco, and by Virginia Power. The results of those studies were provided to VCCER, but have not been independently verified or analyzed.

This report presents the results of the above investigations and analyses.

## Background Information

Parties showing interest in these proceedings are Virginia's two major electric utilities (Virginia Power and Appalachian Power Company) and potential non-utility power generation and transmission line developers. A number of companies have expressed interest in developing non-utility power production facilities in southwestern Virginia, if transmission capacity to a power purchaser were available. These include coal industry interests, companies involved in non-utility power generation ventures, and companies wishing to develop waste-coal burning and cogeneration facilities. These non-utility interests have been working since 1985 to identify a means of moving excess power which they might produce.

Virginia Power (VP) is an independent utility serving northern and eastern Virginia (Figure 1). Its service region contains areas which grew rapidly during the 1970s and 1980s, including Richmond, Tidewater, and most of Virginia's District of Columbia suburbs. Throughout this period of rapid growth, Virginia Power has been developing new power supply resources, including power purchases from other util-

ities, to meet steadily increasing demands. In the late 1980s, Virginia Power embraced non-utility generation as a means to develop needed capacity. A series of solicitations for non-utility generation were issued in the late 1980s. No bids from the southwestern Virginia coal region were contracted because of an inability to negotiate power wheeling services with Apco.

Appalachian Power Company (Apco) is one of eight operating utilities comprising the American Electric Power (AEP) System. Apco's service area includes areas in southern West Virginia and southwestern Virginia. The majority of Apco's generation consists of coal-fired units in the Kanawha and Ohio Valleys of West Virginia, which take advantage of that area's abundant coal and water resources. Apco also utilizes power surpluses produced by other utilities in the AEP system, purchasing power as needed to service its own internal load. Thus, an ability to transmit large amounts of power to Virginia from areas west of its Virginia service region are integral to Apco's operations. Apco is among the lowest-cost electric energy suppliers in the nation.

## West-East Transmission Constraints

There are existing transmission lines which extend from the southwestern coalfield (a part of the Apco service territory) to the Virginia Power service territory in eastern Virginia (Figure 1). However, according to Apco, Virginia Power, and Virginia State Corporation Commission (1991), current and anticipated demands on that system are substantial. Large quantities of power flow from west to east on a daily basis. Current west-to-east power flow demands on the system include the following:

1. Power transfers from Virginia Power's Mount Storm generating station, in northern West Virginia, and its Bath County pumped storage facility to load centers in northern and eastern Virginia.

2. Power transfers from AEP generating facilities in West Virginia and further west to Apco load centers in southern West Virginia and western Virginia, including Roanoke and Lynchburg.

3. Power transfers from the AEP system to the Virginia Power system, including bulk purchases by Virginia Power from and wheeled through AEP.

4. Power transfers from Allegheny Power System (APS) to Old Dominion Electric Cooperative (ODEC) in eastern Virginia.

5. "Loop flows" from additional west-east power transfers between other utilities located north of the Virginia Power and AEP systems.

The existence and implications of resulting west-east transmission constraints have been documented by the Staff of the Virginia State Corporation Commission in its HJR 441 study report. These constraints have been a factor in Apco's inability to provide wheeling services to non-utility generating facilities that might locate in southwestern Virginia.

## Current Apco-VP Transfer Capacity

Apco currently moves power from the western portion of its service territory to Virginia Power for purchase by that utility. Current contracts call for wheeling of 500 MW generated by units in the AEP system (the majority at Rockport, Indiana) to VP through the end of 1999, and 400 MW generated by Hoosier Energy Rural Electric Cooperative at Merom, Indiana, also through the end of 1999. The Hoosier contract has a renewal clause which automatically continues the contract unless written notice is provided in advance by either party, while AEP's contract to supply power to VP has no such clause. AEP's projections indicate that anticipated load growth within its service territory will consume its current excess power generation capacity by 1999, which would prevent renewal of the VP sales contract unless new generation facilities are developed on the AEP system.

The present capacity of the Apco system to wheel power from southwestern Virginia to the Virginia Power system, in addition to current contractual obligations, is the subject of a study being conducted by the Virginia State Corporation Commission (VSCC). The VSCC's Second Interim Report (VSCC, 1991) includes the finding that Apco's system, currently, would be able to accept commitments to wheel up to 200 to 250 MW of power from southwestern Virginia to the Virginia Power system if the entities contracting for those wheeling services were able to accept certain restrictions. These restrictions are necessary, from Apco's standpoint, due to the heavy loadings being placed on the system at present. Restrictions that would be required by Apco in any new wheeling contracts include the following:

1. In the event of heavy system loadings, wheeling services implemented through any new contracts would be curtailed prior to curtailment of Apco's native load, wheeling of power covered by existing contracts, or power sales to other utilities by AEP covered by existing contracts.

2. Apco anticipates that, as 1998 is approached, necessary curtailments of wheeling services, as defined by Condition 1 above, will become more frequent and, potentially, decrease the value of the power provided to the purchaser.

3. If the Lexington - Cloverdale 500-kV line were to go out of service, wheeling to the Virginia Power system would be curtailed for the duration of that service interruption.

The various types of power purchase agreements typically executed by Virginia Power are reviewed in Appendix A.

## The Apco-VP Transmission Reinforcement Program

Apco and Virginia Power announced their intention to construct additional transmission lines in spring 1990 (Figure 2). This announcement followed the completion of a year-long study, conducted cooperatively by the two utilities, for the purpose of finding the best solution to the west-east transmission constraint problem. Specific enhancements proposed by the two utilities include:

1. A 115 mile, 765-kV line, to be constructed by Apco, from its substation near Wyoming, West Virginia, to its substation at Cloverdale, Virginia.

2. A 102 mile, 500-kV line, to be constructed by Virginia Power, from Apco's Joshua Falls substation to Virginia Power's Ladysmith station. The new line will intersect the existing Dooms - Elmont 500-kV line, and will be connected to the existing system in two segments: (i) the western segment of the new line will be connected to the eastern segment of the existing Dooms - Elmont line, resulting in a 500-kV connection from Joshua Falls to Elmont; (ii) the eastern segment of the new line will be connected to the western segment of the existing Dooms - Elmont line, resulting in a 500-kV connection from Dooms to Ladysmith. The resultant Joshua Falls - Elmont and Dooms - Ladysmith lines will not interconnect with one another.

3. Substation improvements, and improvements in the underlying transmission network, as required to gain full benefit from the new transmission line construction.

The purposes of the transmission reinforcement program planned by AEP, as agent for Apco, and by Virginia Power were set out in a Statement of Intent, signed by officials of the two companies on March 16, 1990. The objectives of the program include enhancement of west-east power transfer capabilities. According to the Statement, those enhancements will "provide a reasonable level of capability to deliver the output of generation projects that might locate in the APCo area to meet VP's future generating needs." Subsequent statements by Apco officials indicate that 500 MW of wheeling capacity to Virginia Power will be made available to independent power producers, once the Wyoming - Cloverdale line segment is completed.

An amendment to Section 56-46.1 of the Virginia Code, passed by the 1991 Virginia General Assembly, applies to any public utilities which file applications to construct new transmission lines in Virginia during 1991 and 1992. If a proposed line is to be 500 kV or greater in size and located west of the Blue Ridge (as is Apco's proposed Wyoming - Cloverdale line), the applicant will "reasonably accommodate requests to wheel or transmit power from new electric generation facilities constructed after January 9, 1991." The Act requires that "a minimum of one-fourth of the total megawatts of the additional transmission capacity created by the construction of the proposed line" will be made available for wheeling purposes. The power line developer will be obligated to make wheeling services available, when the new line is complete, to non-utility generating interests submitting wheeling service requests within 12 months following Certification by the State Corporation Commission. Apco has stated that the wheeling capacity will be made available to power generation facilities located in both the West Virginia and Virginia portions of its service territory.

The two utilities' estimate of the incremental west-east transfer capability that would be made available by completion of the reinforcement program is approximately 2000 MW.

## Ownership Options

### Positions of the Major Utilities

Neither Apco nor Virginia Power have expressed any interest in participation in a transmission line ownership consortium.

Virginia Power's position is that they would want to be sole owner of any transmission lines constructed in the Virginia Power service territory, while they would not wish to own any line segments constructed in Apco's service territory. Virginia Power would wish to evaluate any bid to provide non-utility generation based on delivery of power to a specified point at their service area boundary. Virginia Power would evaluate that bid based on their cost to move that power from the service area boundary to a load center. They want to be in a position to determine how to integrate any new transmission line constructed in their service territory into their transmission network in a cost-effective manner, and to construct the line accordingly.

Apco's position is that they have no objections to the establishment of an independently owned and operated transmission line in their service territory, for the purpose of delivering power from contract producers in southwestern Virginia to Virginia Power. They would, however, want to maintain control over interconnections of that line with their transmission facilities.

### Non-Utility Ownership Options

Eminent domain condemnation powers would be an absolute necessity in the construction of a power line 100 - 250 miles in length. In Virginia, a private entity must incorporate as a Public Service Corporation in order to achieve the power of eminent domain. The requirements for such incorporation are contained in Section 13.1-620 of the Virginia Code. Any private entity incorporating as a Public Service Corporation in Virginia would be subject to the jurisdiction of the State Corporation Commission.

Any private party incorporating as a Public Service Corporation, in order to build an electric power line, would in all likelihood be regulated as a utility under the federal Public Utilities Holding Company Act (PUHCA). The ownership of that utility would be regulated as a holding company, under PUHCA, unless ownership were held by a consortium structured so as to avoid PUHCA regulation. PUHCA states that any entity owning or controlling ten percent or more of a utility's securities becomes a "holding company." Assuming that a consortium of corporate interests would be formed to own and operate a new electrical transmission line, consortium participants would probably choose to limit ownership shares to less than ten percent to avoid PUHCA restrictions on holding companies. The main consequence of holding company status would be restrictions on business activities other than those related to the generation of electricity. An issue to be considered would be whether or not a lender supplying in excess of ten percent of the capital would risk similar regulation, by the fact of having made the loan or if the borrower were to default on

the loan. It should be noted, however, that PUHCA amendments currently pending in Congress would, if enacted, remove many of these restrictions.

Another ownership option would be to establish a state agency or authority with the power to own and operate the line, or to empower an existing state agency or authority to do so. West Virginia legislation has created two such authorities: the Public Energy Authority (Chapter 5D, Public Energy Authority Act, West Virginia Code of 1966) and the West Virginia Economic Development Authority (Chapter 31, Corporations, West Virginia Code of 1966). Both have authority to construct electric transmission lines and to issue revenue bonds to finance the projects. Neither has been successful in launching such a project to date.

One advantage of creating or authorizing a state agency or authority to construct, own, and operate a transmission line would be that it would open avenues to financing which would not be available to non-utility corporations wishing to avoid PUHCA regulation. The legislature would have the option of relaxing or streamlining state-level permitting requirements through appropriate wording of the enabling legislation. However, a state agency or authority would remain subject to all relevant federal regulations.

One public entity that could potentially serve in an ownership capacity would be the Coalfield Economic Development Authority (CEDA). According to Charles Yates, a CEDA official, the only justification for CEDA ownership would be if that ownership would result in a number of non-utility generation plants being established in southwestern Virginia. These plants offer significant opportunities for development, both because of the jobs and coal marketing opportunities they would create, and because of the potential for energy-intensive industries to locate in association with the generating plants.

The CEDA Board would be required to consider the ownership option before the authority would be able to offer any kind of a position on ownership. The CEDA enabling legislation would need to be amended in order to allow CEDA to issue bonds to finance such a project.

**Criteria for Evaluating Feasibility**

This study evaluated the technical and economic feasibility of various transmission line alternatives.

In order for a construction option to be considered technically feasible, available information must indicate that it can be: (i) integrated into the existing transmission network without causing a significant negative impact on that system's reliability or performance; and (ii) integrated into the transmission system that would result from successful completion of the proposed Apco-VP transmission reinforcement program, also without negative impact on the system's reliability or performance.

In order to determine the economic feasibility of various construction options, we referred to a principle stated by the FERC Transmission Task Force Report (FERC, 1989): "Wheeling of power ... makes economic sense to the extent that differences in the cost of generating power at two locations is larger than the cost of transmitting power between them."

The primary difference in cost between generating power at new mine-mouth plants in southwestern Virginia, and generating it at new plants in eastern Virginia, is the cost of transporting fuel. Assuming an energy content of 25,000,000 Btu per ton of coal and a heat rate of 10,000 Btu per kWhr (the Apco system average is 9777), a $12-per-ton rail transport cost is equivalent to $.0048 per kWhr, while a $15-per-ton transport cost is equivalent to a $.0060 per kWhr transmission cost.

Additional cost savings might also be associated with a southwestern Virginia generation location, due the fact that southwestern Virginia is less developed than eastern Virginia. A $0.0075 per kWhr transmission cost figure is used as a criterion for establishing economic feasibility. Any power line construction option which results in transmission costs greater than $0.0075 per kWhr is considered to be economically infeasible by this study.

This study did not seek to evaluate the political feasibility of the various transmission configurations. However, the need to obtain permits, and the potential costs of permitting when significant environmental resources are likely to be encountered, were considered. The concentration of environmental resources in southwestern Virginia (Figure 3) would complicate the process required to permit and route any new transmission line originating in the area. Appendix C reviews information on power line environmental permitting requirements.

**Feasibility Evaluations: Available Options**

The majority of the information summarized in this section reflects input provided by representatives of Apco and Virginia Power. Although the text which follows, and the load flow modeling study report provided by the utilities (Appendix D), have been carefully reviewed by the VSCC and non-utility generating interests, the utility input was not subjected to a thorough, independent analysis. For the purposes of conducting this study, we have made assumptions which are reflected in the text which follows. These assumptions were made for the purposes of analytical convenience; they are not considered to be binding or restrictive factors.

House Joint Resolution 441 calls for a study of measures to allow wheeling of "100 megawatts or more of power." In all likelihood, it would not be economically feasible to construct a new power line of substantial length in order to transmit only 100 MW of power. Based on discussions with non-utility developers about the amount of generation capacity likely to be developed in the coalfield, this study was conducted assuming 500 MW as an amount of generation that could be potentially established in southwestern Virginia in the short term (by 1998) and, thus, was viewed as a reasonable capacity to be carried by the new line. The analysis also considers the fact that the economic feasibility of a certain transmission configurations would be enhanced if greater amounts of power could be carried.

Parties representing both utility and non-utility interests indicate that southwestern Virginia's siting and water resource limitations, and other factors, will likely limit the total amount of generation and the size of individual units constructed in southwestern Virginia, at least in the short term. Thus, we assume that, if 500 MW of generation is to be constructed in southwestern Virginia, the most likely scenario is that a few relatively small plants would be located at dispersed locations. No independently conducted studies are available to confirm this assumption.

For the purpose of determining the lengths of the various transmission lines under study, we assumed that the southwestern Virginia terminus would be located at the intersection of the Russell, Dickenson, and Buchanan county borders. This terminus is designated as SWVa in the text that follows.

We have assumed that the power delivery terminus of any new transmission line must be located at an existing 500-kV or 765-kV substation on the Apco-VP transmission network.

Virginia Power has issued transmission structure requirements for power purchases under its competitive bid solicitation program. The purpose of these requirements is to assure that Virginia Power, as the purchasing utility, will receive reliable power deliveries. Two separate circuits, each on a separate structure, are required for all transmission systems carrying power to the Virginia Power system in amounts greater than 200 MW or for distances greater than 50 miles. Thus, Virginia Power would require all transmission options discussed below to consist of dual circuits with separate structures, unless a redundant path is provided through interconnection with the Apco-VP transmission network.

Table 1 lists costs associated with many of the new transmission alternatives discussed in this report. The costs of Table 1 are for single circuit lines only. To obtain an approximate estimate of the cost of double circuit - double structure lines, the figures of Table 1 should be multiplied by 2.

## Direct Access to the Virginia Power Grid

One option for delivering power generated in southwestern Virginia would be a line running directly from the source of power to a delivery point on the Virginia Power grid. The following text evaluates potential direct-access transmission alternatives.

### SWVa - Lexington, SWVa - Bath County:

The two Virginia Power 500-kV substations located closest to the SWVa terminus are Lexington and Bath County. However, according to Virginia Power, power delivery to either of these two points would be far from optimal. The Virginia Power system's load center is in eastern Virginia, especially the heavily developed northern Virginia - Washington DC area. According to Virginia Power officials, if an additional 500 MW of generation were connected to the 500-kV system at either Bath County or Lexington, measures would need be taken to accommodate that power. The major concern would be the possibility of an outage of any one of several critical transmission facilities, which would cause heavy loading on other transmission facilities. The potential for such heavy loadings to occur is of significant concern to Virginia Power officials for two separate reasons: (i) the possibility that the voltage limits or thermal limits of one or more remaining in-service lines would be exceeded, as a result of outage; and (ii) the possibility that certain outages would also cause problems with the stability of the generating units themselves.

The outage contingency is a limitation because the major utilities' transmission systems operate at all times on a single outage contingency status, i.e. at levels

**Table 1.** Estimated costs (capital and per-kWhr, 1993 $, at various interest rates) for single-circuit[1] transmission lines of various configurations.

| Point of Terminus | Voltage | Capital Cost | Power Input | Cost at Interest Rate 10% | 13% | 16% |
|---|---|---|---|---|---|---|
| | (kV) | (Million $) | (MW) | ---- ($/kWhr) ---- | | |
| SWVa - E. Va | 500 | 202 | 500 | .0074 | .0091 | .0109 |
| | | | 870[2] | .0043 | .0053 | .0063 |
| SWVa - Clover | 345 | 127 | 500[2] | .0048 | .0059 | .0070 |
| SWVa - Lexington | 345 | 117 | 500[2] | .0044 | .0054 | .0064 |
| Lexington - Ladysmith | 500 | 103 | 500 | .0038 | .0047 | .0056 |
| SWVa - Cloverdale | 345 | 85 | 500 | .0032 | .0039 | .0047 |
| | | | 610[2] | .0026 | .0032 | .0038 |
| SWVa - | 500 | 66 | 500 | .0024 | .0029 | .0035 |
| J. Ferry | 345 | 65 | 500 | .0024 | .0029 | .0035 |
| SWVa - Broadford | 345 | 37 | 500 | .0013 | .0016 | .0020 |
| Broadford - | 500 | 54 | 500 | .0019 | .0024 | .0029 |
| J. Ferry | 345 | 71 | 500 | .0026 | .0031 | .0038 |

Notes:

1. Virginia Power currently has a double-circuit, double-structure transmission reliability requirement for power purchases in excess of 200 MW.
2. Approximate maximum power transfer capability. SWVa - Jacksons Ferry and Broadford - Jacksons Ferry 500-kV transfer capabilities exceed 1000 MW.
3. Assumptions used to calculate costs reviewed in Appendix B.

which anticipate the fact that a single outage can occur at any time, at any place. To operate the system at higher levels would be to risk the possibility that an unanticipated outage would cause an overload at another location, leading to cascading outages. This single-outage contingency mode is consistent with the reliability standards established by the North American Electric Reliability Council (NERC, 1989), a consortium of electric utilities formed to promote the reliability of the bulk electric transmission and generation network.

As a result of these concerns, Virginia Power officials state that 500 MW of additional generation connected to the 500-kV system at Bath County or Lexington

would require that an additional 500-kV line be extended from that point of connection to eastern Virginia.

SWVa - Lexington - Ladysmith:

Load flow modeling studies evaluated the technical feasibility of constructing a 182 mile, 345-kV line from SWVa to Lexington, in conjunction with a 122 mile, 500-kV line from Lexington to Ladysmith.

The load flow modeling studies indicate that the connection of a new Lexington - Ladysmith 500-kV transmission facility, in the absence of the proposed Wyoming - Cloverdale line, would result in reduced impedance (resistance to flow) between Lexington and eastern Virginia, and, thus, increased power flows on the existing, critical Apco transmission facilities west and south of Cloverdale. This result occurs for normal, all-facilities-in-service conditions, and would be exacerbated by an outage of the SWVa generating facility or interruption of transmission from the SWVa facility.

This configuration would not be acceptable to Apco, in the long term, in the absence of the Wyoming - Cloverdale line, due to the negative impact of the increased loadings on Apco's system performance.

Virginia Power found this configuration to be acceptable, from a technical standpoint. The configuration did not decrease Virginia Power's ability to import power from AEP, and other ECAR[1] utilities, and did not appear to cause other negative effects on the Virginia Power system.

In the absence of the Joshua Falls - Ladysmith line, a Lexington - Ladysmith line would provide the Virginia Power system with the benefit of a parallel path from Lexington to eastern Virginia. However, it would not relieve current power transfer constraints between Virginia Power and the AEP system. Virginia Power sees no benefit to its system from operating a Lexington - Ladysmith line in conjunction with a Joshua Falls - Ladysmith line.

If non-utility generating interests were to propose a delivery point such as Lexington or Bath County in response to Virginia Power's competitive solicitation program, Virginia Power's policy would be to consider the cost of transmission enhancements required by that delivery point in its evaluation of that bid. Virginia Power's view is that the high cost of enhancements, such as a new 500-kV line from Lexington to Ladysmith, would place a non-utility generator proposing such a delivery point at a severe disadvantage relative to other bidders not requiring such costly transmission enhancements. As discussed in the *Issues of Relevance* section below, non-utility generation interests believe that the utility's ratepayers should share the cost of improvements, such as a Lexington - Ladysmith line constructed in conjunction with a southwestern Virginia connection at Ladysmith, if those ratepayers also receive benefits from the construction.

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[1] The East Central Area Reliability Coordination Agreement (ECAR) includes 19 electric utility systems whose service areas extend from southwestern Virginia and eastern Pennsylvania to western Kentucky and northern Michigan. The AEP system is a member of ECAR.

In order to meet Virginia Power's reliability requirements, a double structure - double circuit line from SWVa to Lexington would be required. The cost of a double circuit - double structure line from SWVa to Lexington would render such a configuration economically infeasible.

If the developers of a SWVa - Lexington line were able to arrange a cost-effective alternative to a double circuit - double structure line, which would satisfy Virginia Power's reliability requirements, there is still the cost of the Lexington - Ladysmith line to be considered. The Apco-VP load flow modeling studies (Appendix D) indicate that the construction of a Lexington - Ladysmith line would cause technical problems in the Apco transmission system unless the Wyoming - Cloverdale line were completed. However, Virginia Power does not see a Lexington - Ladysmith line as complementary to Apco's Wyoming - Cloverdale construction proposal, and would resist any request that their customers bear a significant portion of Lexington - Ladysmith construction costs, as a complement to Wyoming - Cloverdale.

Thus, for a combination of technical and economic reasons, it appears that this configuration should not be considered as a feasible construction alternative.

SWVa - Valley and SWVa - Dooms:

As potential power delivery points, these locations appear to have problems similar to those of Lexington and Bath County. The major difference is they are further from SWVa but closer to Virginia Power's northern Virginia load centers. Nonetheless, according to Virginia Power officials, substantial improvements in the existing connections to eastern Virginia would be required in order for Virginia Power to accept 500 MW of power at either of these locations.

Connections from southwestern Virginia to these locations were not studied through load flow modeling. Due to the proximity of Valley and Dooms to Lexington and the likelihood that results of such studies would not differ substantially from those focused on Lexington, we conclude that a transmission line from SWVa to Valley or Dooms should not be considered a feasible alternative.

SWVa - Eastern Virginia:

If transmission facilities were to be constructed to provide a direct connection between SWVa and eastern Virginia, Virginia Power's preference would be to receive the power at any one of a number of locations along its 500-kV network. Locations mentioned as desirable delivery points include Bristers (north of Morrisville), Ladysmith, Midlothian, and Carson. Virginia Power has stated that the more northerly points may be more desirable from its perspective, since they are closer to its northern Virginia load center. The utility would wish to conduct electric power load flow modeling studies, in advance of approving any final plans, to evaluate the desirability of potential eastern Virginia power delivery points.

The load flow modeling studies conducted by AEP and VP did not study a direct connection from SWVa to eastern Virginia. Nonetheless, based on the results of the SWVa - Lexington - Ladysmith studies, both utilities agree that such a line would be acceptable, from a technical standpoint.

However, the cost of such a connection would be high, relative to the other alternatives studied (Table 1). Although the Table 1 cost figures for a SWVa - E. Va line compare favorably to the $.0075 per kWhr economic feasibility criterion for an 870-MW power transfer, two additional factors must be considered:

1. Virginia Power's reliability requirements would specify a double circuit - double structure line for this configuration. Table 1 costs are for a single-circuit line.

2. The economic feasibility of developing 870 MW of generation in the coalfields, prior to 1998, has yet to be demonstrated.

The fact that large quantities of power would need to be transmitted to lower the cost of even a single circuit line to acceptable levels would be expected to exacerbate Virginia Power's concerns regarding reliability, and make it less likely that an inexpensive alternative to a double structure - double circuit line, acceptable to Virginia Power, could be arranged.

A 765-kV SWVa - eastern Virginia construction program was not investigated in detail. Rough calculations indicate that approximately 1200 MW of southwestern Virginia generation capacity, or more, would be required to justify consideration of a 765-kV line, as an alternative capable of providing lower per-kWhr transmission costs than a fully loaded 500-kV line. This amount of power is substantially in excess of the 500 MW baseline assumption established for this study. Capital costs of a single-circuit 765-kV line to eastern Virginia would be on the order of $300 million. This cost estimate does not consider upgrades to the receiving grid that might be required to allow a 1200 MW power injection, or measures that might be required to establish double-circuit, double-structure reliability. No studies have been pursued to evaluate alternative points of terminus for a 765-kV line, or possible receiving grid upgrade costs.

Based on the above, we conclude that construction of a new, direct access line to eastern Virginia should not be considered economically feasible prior to 1998. Even if a low-cost alternative to Virginia Power's reliability standards could be negotiated by the developers, and the feasibility of developing sufficient power generation capacity to justify this line were demonstrated, the line would face substantial siting and permitting challenges. This construction would be required to cross the Blue Ridge Parkway as well as the Appalachian Trail.

SWVa - Clover:

Virginia Power is currently constructing two 393-MW coal-fired generating units at Clover, in Halifax County, as a joint venture with Old Dominion Electrical Cooperative (ODEC). Virginia Power and ODEC must extend additional transmission from Clover to the east to transmit power generated by the second unit, which is scheduled to be completed in December, 1995 (the first unit will be integrated with the existing 230-kV network). Therefore, Clover could also be a potential delivery point for power generated further west. However, the feasibility of delivering power to Clover as an interim measure, prior to 1998, must be evaluated in light of uncertainties regarding timing of completion of Clover's second unit and, hence, the additional transmission. Also, this location is further from the northern Virginia load center

than the other four eastern Virginia locations discussed above, and therefore less desirable from a Virginia Power standpoint.

Based on discussions with non-utility generating interests, we conclude that a Clover connection cannot be considered a feasible option at this time, based on a number of factors:

1. The potential high cost of constructing a double structure - double circuit line to Clover, or developing an alternative means of satisfying Virginia Power's reliability requirements.

2. Permitting difficulties likely to be encountered in crossing the Blue Ridge Parkway.

3. The technical feasibility of the line, which depends on construction of additional transmission capability between Clover and eastern Virginia. Ultimately, such a connection will need to be completed if the second unit at Clover is to come on line, but no application for the required line has yet been filed. It would be difficult to obtain financing for such a project under these circumstances.

Connection to the VP Grid, with an Apco Interconnection

The construction cost estimates of the direct-access alternatives discussed above are increased significantly by the Virginia Power requirement for a double circuit - double structure line. It has been suggested that transmission cost could be reduced if a single circuit - single structure line to a Virginia Power terminus were to be constructed in conjunction with an interconnection with the Apco system in southwestern Virginia. In essence, the connection to the Apco system would provide the redundant path required to satisfy Virginia Power's reliability concerns.

If such a configuration were to be constructed, standard utility operating procedures would dictate that the two connections be operated in parallel. That is, although both connections would be constructed so as to be able to accommodate the full loading of the southwestern Virginia generation, approximately half of the southwestern Virginia generation would be transmitted over each path during normal operations.

The reason for utilizing a parallel-path mode of operation, rather than utilizing the primary path to carry the full generation during normal operations, is to provide non-interrupted service in the event of an unplanned transmission outage along that primary path. Even the most sophisticated switching devices could not provide an instantaneous trip such that the receiving system would be transparent to an unanticipated outage of the primary transmission link.

Construction of a transmission configuration that was connected to both the Apco and VP systems through a common tie at the SWVa generating center would, in effect, provide an additional interface between the two utilities' transmission networks.

Apco sees no benefit to its system from an interconnection with any of the direct-access alternatives discussed in the preceding section. Therefore, Apco would not be willing to bear any costs of interconnecting southwestern Virginia generation

to its system for the purpose of providing backup transmission. Because of the heavy loading on its existing system, Apco would require load flow modeling studies before allowing a direct-access transmission line to interconnect with its system for any purpose.

Apco's position is that there is little difference between providing backup transmission capacity (a redundant path) and wheeling the full generation. With such a backup arrangement, Apco must be prepared to carry the entire SWVa power output at all times, because forced outages at the direct line connection to the VP system cannot be predicted. As documented in the Virginia State Corporation Commission HJR 441 report (VSCC, 1991), existing network limitations, relative to west-east power flows, limit the amount of power Apco would be able to accept from southwestern Virginia generators, for transmission to the Virginia Power grid, and the conditions under which Apco would be able to accept and transfer that power.

Furthermore, if the amount of generation established in southwestern Virginia were sufficiently small that Apco could handle the increased transmission loadings, Apco would assess wheeling rate charges as if the entire southwestern Virginia generation were being transmitted through their system. This policy is a direct result of Apco's need to reserve capacity sufficient to transmit the full southwestern Virginia generation as a necessary consequence of agreeing to provide backup-transmission, parallel-path services. Thus, the southwestern Virginia generators would have little or no incentive to invest in the primary-circuit, direct-access line, if their only option for providing the VP-required redundant-path transmission services would be through an interconnection with Apco.

SWVa - Broadford and SWVa - Lexington - Ladysmith:

Load flow modeling studies evaluated the technical feasibility of constructing a radial line from SWVa to Broadford, as a means of satisfying VP's reliability requirements, in conjunction with the SWVa - Lexington - Ladysmith option discussed above. The resulting configuration was judged acceptable, from a technical standpoint, by Virginia Power, as it satisfies that utility's reliability criteria while creating no adverse effects on operations. However, Apco judges this option technically unacceptable. This configuration increases loadings on Apco's critical facilities during normal operations, relative to both current conditions and the likely effects of SWVa - Lexington - Ladysmith, while further burdening those facilities during the unavailability of generation at the SWVa site or the removal of the SWVa - Lexington line from service.

SWVa - Ladysmith and SWVa - Jacksons Ferry:

This option was not investigated through load flow modeling studies. However, the Virginia Power and AEP transmission planners who conducted those studies noted that study results gave indications that this option might be feasible from a technical perspective. The studies suggested that this transmission configuration could be capable of delivering 500 MW of power to Virginia Power load centers, without creating technical problems for either company's transmission system, while meeting Virginia Power's reliability requirements. Load flow modeling studies to evaluate this configuration directly would need to be conducted before the above

could be concluded with certainty. However, this option is not considered to be economically feasible, in the context of this study, due to the high costs involved. These costs would include construction and maintenance of the new lines and transmission wheeling fees paid to Apco.

Transmission Through the Apco System

The closest high-capacity transmission system to the southwestern Virginia area is the Apco 765-kV Baker - Broadford - Jacksons Ferry - Cloverdale system. However, Apco maintains that heavy demands are being placed on that system at present; indeed, the consequent constraints on Apco's ability to wheel power from SWVa to the Virginia Power service area was a primary factor leading to this study, and is one reason for the Apco-VP transmission reinforcement program.

There are significant differences among the loadings on various segments of the the Apco 765-kV system (AEP, 1991). The Baker - Broadford, and the Broadford - Jacksons Ferry segments are currently experiencing the heaviest loadings, while loadings on the Jacksons Ferry - Cloverdale, Jacksons Ferry - Axton, and Cloverdale - Joshua Falls segments are considerably smaller. The above information was considered in evaluating transmission line configuration options that would interconnect with the Apco system.

SWVa - Broadford:

Broadford is the closest Apco 765-kV substation to potential locations of southwestern Virginia generation. As such, it is also a likely candidate for interconnection if the SWVa generation were to be transmitted to Virginia Power via a wheeling arrangement with Apco. According to Apco officials, an effective Broadford power delivery point may not require construction of radial lines from the plant location to Broadford. It is conceivable that, if 500 MW of power were to be developed in relatively small increments at dispersed locations, these sources could be tied into the existing 138-kV system, which are in turn connected to the 765-kV system at Broadford. Although such an arrangement would not result in the actual power generated in southwestern Virginia being loaded on to the 765-kV system at Broadford, the result would be similar.

An arrangement to wheel power from southwestern Virginia to Virginia Power through Broadford would increase loadings on the critical Broadford - Jacksons Ferry 765-kV line segment. The transmission system stresses that would result from a Broadford power delivery point are a major factor limiting Apco's ability to wheel such power under present circumstances. Thus, a Broadford power delivery point was not considered as an option by the current study, except as a potential redundant-path connection point in conjunction with a direct access VP connection.

SWVa - Jacksons Ferry:

As discussed above, the heaviest loadings on Apco's Baker - Cloverdale 765-kV line occur west of Jacksons Ferry, on the Baker - Broadford and Broadford - Jacksons Ferry segments. Typical Apco 765-kV loadings west of Jacksons Ferry are

much greater than those which occur between Jacksons Ferry and Cloverdale at present. The Wyoming - Cloverdale application package indicates that this situation is likely to continue through and beyond 1998, either with or without the transmission enhancements proposed by Apco and VP (Apco, 1991).

Load flow modeling studies evaluated the technical feasibility of constructing an 81 mile, 345-kV radial line from SWVa to Jacksons Ferry, to carry a 500-MW power transfer. The results were satisfactory, from a technical perspective, to Apco, provided that: (i) the proposed upgrade of the Cloverdale - Lexington tie between Apco and VP (as specified in the current Apco-VP reinforcement proposal) would be completed so as to be available for use when the SWVa generation comes on line; and (ii) the costs of advancing that upgrade would be borne by the developers. However, the results are not acceptable to VP, as loop flows resulting from this arrangement reduce VP's capability to import power from other utilities by more than 500 MW.

The load flow study results indicated that a 500 MW input at Jacksons Ferry, for transmission to Virginia Power, would reduce VP's capacity to import power from the Allegheny Power System by 345 MW, due to increased loadings on the Mount Storm - Meadowbrook 500-kV line. Import capability decreases, ranging from 235 MW to 255 MW, also occurred due to increased loadings on the Pruntytown - Mount Storm 500-kV line and the Dickerson - Pleasant View 230-kV line. Additional import capability reductions, due to increased loadings on lines potentially affected by Reliability Coordination Plan limits are likely, but determination of those reductions was considered beyond the scope of the current study. Import capability from Carolina Power and Light was also reduced by substantial amounts.

To summarize: a Jacksons Ferry power delivery point is a superior alternative to a Broadford power delivery point, from the standpoint of the Apco system, as available capacities north and east of Jacksons Ferry are adequate to handle an additional 500 MW transfer to Cloverdale, and would be adequate to handle an additional 500 MW transfer to the Virginia Power system if the Cloverdale - Lexington interconnection were upgraded. However, Virginia Power reports that power transfers from Jacksons Ferry to eastern Virginia load centers would cause significant technical problems on the Virginia Power system and its interfaces with neighboring utilities to the north and south, due to heavy loadings on the 500-kV segments connecting Lexington to eastern Virginia and the effects of loop flows on other critical facilities. Therefore, we conclude that this option is not technically feasible as an interim measure in the absence of the Apco-VP reinforcement program or other system enhancements.

SWVa - Jacksons Ferry and Axton - Clover:

Construction of a 500-kV Axton - Clover connection was explored in conjunction with a SWVa - Jacksons Ferry transmission line segment. Such a line would provide an additional high-capacity link between the Apco and Virginia Power systems. This option was investigated as a potential means of providing an alternative path for power flow from Jacksons Ferry to eastern Virginia, once transmission facilities between Clover and eastern Virginia are complete.

Discussions with Virginia Power officials, and with Carolina Power and Light officials, indicated that an Axton - Clover connection would be likely to cause technical

problems regardless of any new line from SWVa to Jacksons Ferry. According to these assessments, likely technical difficulties with an Axton - Clover connection include the following:

1. Because Axton - Clover does not provide a direct path from southwestern Virginia to northern Virginia, generation of 500 MW in southwestern Virginia for delivery to eastern Virginia would place further stress on the existing west-east power transfer network even if an Axton - Clover 500-kV line, and a Clover - eastern Virginia interconnection, were completed.

2. Considerable generating capacity is located in the Axton - Clover vicinity, in the Carolina Power and Light (CP&L) system as well as the Virginia Power system. CP&L has more than 3000 MW of generating capacity at Mayo and Roxboro, less than 50 miles from Axton, which will be connected to Axton through a 500-kV tie to Person (about 35 miles east of Danville) by December 1997. The existence of this generation "bubble" would add a further hindrance to flow from SWVa through Axton-Clover to northern Virginia, thereby directing the majority of the flow over other paths.

3. An Axton - Clover 500-kV connection could cause problems by providing a parallel, western path for flows from Clover to northern Virginia, allowing some of this power to flow over lines which are already heavily utilized by existing west-east transfers (i.e. Cloverdale - Lexington). This connection might also cause loadings on limiting facilities to Virginia Power's north to increase.

4. Such an interconnection provides no major benefits to Virginia Power or Apco. Apco is in the process of reinforcing its service to the Danville area by working with CP&L to construct the 500-kV interconnection from Axton to CP&L at Person. Virginia Power has no need for reinforcements in southeastern Virginia, which is one of its generating centers and also has strong connections to the CP&L system. Axton - Clover is too far south to have a major impact on west-east flow constraints between generating centers in northern West Virginia (and further west) and northern Virginia load centers.

Therefore, we conclude that this option is not technically feasible. Also, as discussed above, the timing of the Clover # 2 construction program (and the additional transmission from Clover) remains uncertain. Therefore, it is not practical to propose transmission to Clover as an interim measure to achieve power transfers to eastern Virginia.

SWVa - Cloverdale:

Although a radial, direct-access line to Cloverdale was not explored through load flow modeling studies, there is no reason to believe that the results of such studies, if conducted, would differ substantially from those discussed above for a radial line to Jacksons Ferry. Therefore, we conclude that this option is not technically feasible.

SWVa - Cloverdale or SWVa - Jacksons Ferry, and Accelerated Completion of Joshua Falls - Ladysmith:

The possibility of constructing a new line from southwestern Virginia to Cloverdale or Jacksons Ferry, in conjunction with accelerated completion of the Virginia Power Joshua Falls - Ladysmith construction program, was also investigated. Virginia Power has publicly stated that it does not intend to complete the Joshua Falls - Ladysmith construction program if Wyoming - Cloverdale is not constructed by Apco. However, Virginia Power anticipates that if their construction program were being conducted without regard for Apco's progress, the Joshua Falls - Ladysmith construction could be completed in advance of 1998, possibly as early as 1996 in the absence of unanticipated delays in permitting and right-of-way acquisition. Virginia Power officials state that they might be open to considering an accelerated schedule for the Joshua Falls - Ladysmith line, so as to complete construction in advance of Wyoming - Cloverdale, if parties benefiting from an accelerated schedule were to provide financial compensation for their added expense. Virginia Power would also be willing to consider completing Joshua Falls - Ladysmith in the event that the Wyoming - Cloverdale line were to be cancelled, but they would require a much greater financial incentive.

We investigated the possibility that power transfer from SWVa to Cloverdale or Jacksons Ferry to eastern Virginia could be accomplished through accelerated completion of the Joshua Falls - Ladysmith construction program, in the absence of Wyoming - Cloverdale. Apco states that adequate capacity exists from Cloverdale to Joshua Falls, at present, and projections indicate that this line segment will retain capacity sufficient to allow a 500-MW transfer after completion of Wyoming - Cloverdale and Joshua Falls - Ladysmith for the foreseeable future. Likewise, Virginia Power officials see an adequate margin of transfer capability available on the Joshua Falls - Elmont line, when complete, for a considerable time to come.

However, Apco and Virginia Power officials agree that accelerated construction of the Joshua Falls - Ladysmith line (i.e. in advance of Wyoming - Cloverdale) would be likely to cause problems. According to these officials, load flow modeling studies, conducted by the two utilities in planning the current reinforcement proposal, indicated that the completion of a Joshua Falls - Elmont connection (in conjunction with a Dooms - Ladysmith connection) in advance of the Wyoming - Cloverdale 765-kV line would reduce the impedance (resistance to power flow) of the transmission system between Cloverdale and eastern Virginia, resulting in an increased proportion of total west-east power flows being drawn through the heavily loaded Apco transmission facilities west of Cloverdale.

Based on these discussions, we conclude that accelerated completion of the Virginia Power Joshua Falls - Ladysmith construction program is not a technically feasible option as an interim measure to provide increased transmission capacity from southwestern Virginia to eastern Virginia.

**Issues of Relevance**

Numerous issues have been raised by various parties during the course of these investigations. Those which are most pertinent are summarized below. The listing which follows should not be considered exhaustive.

Direct Cost-Related Issues

Potential Amounts of Southwestern Virginia Generation:

This study was conducted under the assumption that 500 MW of power generation capacity might be developed in southwestern Virginia. A 1990 VCCER study indicated that available fuel resources would allow in excess of 1500 MW to be developed. However, both utility and non-utility interests recognize siting requirements, including cooling water availability, as major factors which could limit power generation development, at least in the short run. Other factors with the potential to influence the amount of generation that might be developed are air pollution permitting requirements and the availability of steam hosts for cogeneration facilities.

Virginia Power and Apco have commissioned a consultant's study of the availability of potential generating sites in southwestern Virginia. According to company officials, preliminary results confirm that there are sites in the coalfields which appear to be capable of hosting generating facilities in the 200-400 MW size range. However, the study also indicates that water resource limitations, and other site characteristics, would be likely to increase development costs. No attempt has been made to estimate the influence of site characteristics on the economic feasibility of power development at these locations.

The amount of generation capacity that is successfully developed will influence the optimal size of any new transmission line and per-unit-power costs of using that line. The 500-MW capacity estimate of this study is not substantiated by any assessment of how site availability, site development costs, or other non-fuel factors might affect generating facility development.

Virginia Power's Transmission Reliability Requirements:

According to Virginia Power and Apco, a typical transmission line operates at about 99.9 percent reliability. Thus, transmission facilities are generally far more reliable than the generating units themselves. The lack of total reliability of generating units is handled within the utility system by reserves; at any given moment, a certain percentage of total generating capacity is expected to be unavailable. The system's total generating capacity target (which includes reserves) is developed with expected generating capacity outage figures in mind.

Virginia Power requires a much higher level of reliability for transmission than for generation in its contracts with non-utility producers, as reflected by its double circuit - double structure requirement. The rationale, according to Virginia Power, is that transmission reliability and generating reliability are two completely different subjects; while generating outages are random, the times of greatest stress on the

transmission system tend to occur under peak loading conditions, when the power is needed most.

From Virginia Power's standpoint, the justification for the high-reliability requirement is that southwestern Virginia producers are competing with producers located closer to its transmission network for the right to provide Virginia Power with generating capacity. Virginia Power's customers benefit if its contract producers are able to provide a high level of transmission reliability; contractors located closer to the Virginia Power grid can provide highly reliable transmission facilities, which Virginia Power views as necessary, at lower cost. Since southwestern Virginia producers are competing with producers from the Virginia Power service area, Virginia Power officials ask why southwestern Virginia producers should not be held to the same standards.

This interpretation has a negative effect on the economics of constructing a new transmission line from southwestern Virginia. While the transmission access line required by a typical contract producer within the Virginia Power service region may range from a few miles in length to less than a mile, the line required to transmit power from southwestern Virginia, under most scenarios treated by this study, would be over one hundred miles in length. The separate circuits - separate structures requirement means that the second circuit and structure -- which in essence double the cost of the transmission access system in the absence of an Apco-VP interconnection capable of providing backup transmission -- would be required to provide uninterrupted transmission under normal circumstances less than one percent of the time.

Since a non-interconnected access line would function independently of the regional grid, contend the non-utility interests, the presumed relationship between peak regional grid loadings and outages would not hold. Thus, the non-utility interests believe the separate circuits - separate structures requirement to be an unnecessary and unreasonable mandate which works against them. They would rather see Virginia Power's reliability concerns reflected in bid evaluations and pricing.

FERC Policies Regarding Utility Wheeling Charges:

Wheeling charges by Apco (AEP) will have an impact on the economic feasibility of any new construction option which interconnects with that system, as an alternative to a direct-access transmission line to Virginia Power. These rates also have a much more direct effect on the feasibility of transmission line construction via their influence on the ability of southwestern Virginia's non-utility interests to compete effectively for Virginia Power contracts. AEP's wheeling rates are regulated by the Federal Energy Regulatory Commission (FERC).

The method used by Apco (AEP) to set wheeling rates is consistent with standard practices for all utilities regulated by FERC, and with precedents set by FERC over the past 20-30 years. Current wheeling rates charged by Apco (AEP) are not distance-based. Therefore, according to the current FERC-approved Apco policies, non-utility generators in southwestern Virginia would be required to pay wheeling rates for transmission through Apco nearly identical to rates charged by AEP for transmission by generators located in midwestern states, such as Hoosier Energy Rural Electric Cooperative. In both cases, the purchasing utility would be Virginia Power.

Currently, wheeling rates are based on the embedded cost of operating the transmission system. To calculate embedded cost, the transmission system is taken to be a discrete entity, which cannot be divided into component parts for the purpose of setting wheeling charges. The embedded cost is calculated by dividing the annual cost of owning and operating the transmission system by the "demonstrated capability" of that system (an estimate of total transmission capacity). The result is a per-unit-power-transfer rate charge which is sometimes termed as a "postage stamp" rate, as it is independent of flow path, distance, etc.

These rates are applied to power transfer transactions based on the "contract path," or a specific set of facilities that are identified in the contract as the agreed-upon basis for transmission costing. The power transfer may utilize facilities in addition to those identified as the contract path (and often does), but the contract path does constitute a convenient basis for assessing wheeling charges.

FERC is currently evaluating transmission access and pricing policies. Other methods of wheeling cost calculation have been proposed (ITCF, 1991; FERC, 1989), some of which are distance-based. For example, the MW-mile method of calculating wheeling rates would seek to identify actual flow-paths resulting from a power transfer, and assigns a rate based on the cost of system components utilized by the power transfer.[2]

AEP's FERC-approved wheeling rate for the Hoosier Energy contract, based on a 1983 filing, is $2.00 per kW-month (kW-mo), plus a $.001 per-kWhr-delivered charge to cover variable operating and maintenance costs, plus 2% compensation for power losses. If a unit generating power for transmission over the AEP system were operating at 80% of capacity, use of the above schedule would result in wheeling charges of $.0046 per kWhr delivered. According to the FERC Transmission Task Force (1989, Table 2-4), wheeling revenues for 15 major wheeling utilities in 1987 ranged from $.00031 to $.00449 per kWhr, and averaged $.0025 per kWhr. The fact that AEP wheeling rates are high, relative to these 15 utilities, indicates that AEP's transmission facilities account for a high level of investment, relative to these utilities.

Critics of the current methods for establishing wheeling charges note that, in many respects, these methods do not establish an environment which fosters development of economically efficient transmission services. For example, loop flows from current AEP-VP power transfers place stress on elements of transmission systems operated by utilities located north of the Virginia Power and Apco service territories. As evidenced by the SWVa - Jacksons Ferry modeling results, the inability of those elements to handle additional power flows is a major limitation to additional AEP-VP power transfers, at present. The contract-path method of wheeling rate charges does not provide neighboring systems with an incentive to upgrade limiting facilities, as those utilities derive no revenues from AEP-VP power transfers.

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[2] The MW-mile method would use a power flow analysis to simulate a transaction between buyer and seller, estimate the resultant power flow increment over each transmission line in the interconnected system, and multiply that flow by the line's length to obtain MW-miles of use. The method would then sum the MW-miles over all transmission lines in each transmission system, and multiply by each system's FERC-filed transmission use rate. Transmission use rates would be expressed in terms of dollars per MW-mile. There are several options that may be used to calculate transmission use rates, and total wheeling costs.

Another situation that results from contract-path wheeling rates can be illustrated by considering an alternative, where each of AEP's operating companies were required to assess embedded-cost-based wheeling charges separately. The embedded costs of each operating company are on the order of $2.00 per kW-mo, so the wheeling rate charge from Indiana would be on the order of $6.00 per kW-mo. However, the FERC-approved wheeling rate through the entire AEP system, at present, is $2.00 per kW-mo, plus delivered power charges as detailed above. If Virginia Power were importing power from a location 400 miles north of its service territory (i.e., from southern Ontario) rather than 400 miles west, the contract path would pass through a number of utility service areas and, in all likelihood, costs would be significantly greater than $2.00 per kW-mo plus delivered power charges.

Adoption of a distance-based wheeling rate formula by the FERC could either increase or decrease wheeling rates for southwestern Virginia generators seeking to use the Apco system to service Virginia Power contracts, depending on the actual formula adopted. Thus, the effect of such a change on the ability of non-utility power interests in southwestern Virginia to compete with producers in the Virginia Power service territory, and with AEP itself, is uncertain. However, it is clear that a distance-based wheeling approach would have a positive impact on the ability of southwestern Virginia interests to compete with midwestern power producers other than AEP for Virginia Power contracts. If a distance-based formula were to be adopted by FERC, which resulted in decreased charges for southwestern Virginia producers wheeling through the Apco system, the economic feasibility of transmission line alternatives which interconnect with the Apco system would be enhanced. Adoption of a distance-based wheeling rate would provide incentive to interconnect any new power line, which might be constructed by independent interests, to the Apco system at a location close to the Apco-VP interface (i.e. at Jacksons Ferry or Cloverdale, rather than at Broadford).

Improvements to Receiving Transmission Grid:

Depending on the delivery point, a 500-MW power transfer may require that enhancements be made to the existing transmission grid, to enable it to accept that power and transmit it to load centers. Another issue concerns the appropriate party to bear these costs. Virginia Power's position in bid evaluations is that the cost of any transmission enhancements required to receive power from a contract producer should be charged to that producer in evaluation of that competitive bid. The non-utility power developers disagree, stating that the full cost of of any enhancements should not be borne by the developer, reasoning that the utility's ratepayers would also benefit from most transmission enhancements. In the view of non-utility power developers, who bears what portion of transmission network enhancement costs is a matter that should be worked out in contract negotiations and/or ratemaking procedures.

The developers' views on this issue are consistent with the position of the National Independent Energy Producers (NIEP), an association of companies that generate electricity for sale to utilities. Benefits to ratepayers of new transmission facilities may include system stability, enhanced power-transfer capability, and greater system reliability. The NIEP policy is that, if the transmitting utility's system benefits from transmission enhancements, all system users should bear a propor-

tionate share of the incremental cost of the upgrade. If there is no general benefit, the developers should pay the incremental cost (Hadson Power Systems, 1991).

Benefits of Interconnections:

Apco officials state that they do not see benefits to their transmission network through interconnection with a new transmission line, given any of the alternatives discussed above. Therefore, they would not bear any costs of interconnection, and they would not be willing to credit independent power line developers for such benefits in the context of a contract for backup transmission services.

The developers contest this view, stating their opinion that Apco's transmission system could benefit from appropriate interconnections, given that many of the route alternatives discussed above would provide parallel paths to existing Apco lines and/or provide improved interconnections between Apco and the Virginia Power system.

## Non-Direct-Cost Issues

Need:

Before construction of a power line can begin, a Certificate of Public Convenience and Necessity must be obtained from the State Corporation Commission. To grant the Certificate, the Commission must find that the line is needed, and that the route will minimize adverse effects on the environment.

Non-utility developers interested in constructing generation facilities in the Virginia coalfield have been unable to obtain long-term wheeling services to date. While the Apco-VP transmission reinforcement program proposes to provide such services, the earliest that these lines could be available is 1998. It is possible that the approval process will delay completion of the line beyond 1998, or prevent its construction. In this view, growing opposition to the location of generation facilities in eastern Virginia, coupled with the economic development needs of southwestern Virginia, further support the need for new transmission facilities. The establishment of a power generation industry in southwestern Virginia would bring new jobs and investment to that area.

Opponents of Apco's Wyoming - Cloverdale 765-kV line have questioned whether or not such a line is actually needed to serve future electric power demands, as Apco contends. Should a major transmission line project be proposed strictly for the purpose of serving non-utility generators in southwestern Virginia, the line's developers would also have to face questions related to need. Opponents of the line could be expected to contend that construction of generating plants in eastern Virginia presents a reasonable alternative to the line, which serves the public need for power generation while creating a lesser impact on the environment. Opponents of a new line from the coalfields could also point to the utilities' study which concludes that the Wyoming - Cloverdale and Joshua Falls - Ladysmith lines is the most effective option for achieving system improvement.

Use of Resources:

The position taken by Apco and Virginia Power personnel providing input to this study is that the most cost effective action to provide additional transmission capacity between the Virginia coalfield and the Virginia Power grid is the transmission reinforcement program proposed by Apco and Virginia Power. They maintain that these new lines were proposed after a year-long study, based on load flow analyses which evaluated and compared numerous possible transmission line routes under a variety of conditions. If completed, the new lines will provide wheeling capacity available for use by non-utility generators in the Apco service territory while serving the primary purpose of enhancing capabilities of the existing transmission grid.

Non-utlity developers acknowledge that the Apco-VP transmission reinforcement proposal is one factor that needs to be considered in the context of the current study. However, the feasibility of constructing a new line from the coalfields needs to be examined in the context of uncertainties regarding eventual completion of the Apco - Virginia Power program. Should the proposed Apco - Virginia Power lines be substantially delayed or cancelled, a new line from the coalfields may represent the only opportunity available to develop a power generation industry in southwestern Virginia.

Eminent Domain:

The power of eminent domain is attached to qualified Public Service Corporations by Section 56-49 of the Virginia Code. This right is linked to the Certificate of Public Convenience and Necessity, which a Public Service Corporation may obtain upon valid application to the VSCC. A Certificated Public Service Corporation is authorized to use the power of eminent domain to acquire lands needed to serve the public. The power of eminent domain would be a necessity for most (if not all) new power line construction options considered in this report.

As far as the current study is concerned, the issue is: should a power line being constructed to deliver power from non-utility producers be interpreted as serving the public, and eligible to achieve eminent domain condemnation powers?

The developers cite case law as evidence that an independently owned and operated transmission line would meet the public service test, and therefore qualify as a valid use of eminent domain authority. The Virginia Supreme Court case *Peck Iron and Metal Company vs. Colonial Pipeline Company* (206 Virginia 711) established a three-level test to determine if eminent domain authority may be exercised by a Public Service Corporation. According to this test, the need for the facility must be demonstrated and the taking must serve a public use. The developers contend that, under the criteria established by this case, the use of an independently owned and operated transmission line would meet the public use requirement if all entities desiring to transmit electricity over the facilities were permitted to do so at FERC-approved rates, subject to capacity limitations.

VSCC Approval:

The Code of Virginia prohibits "operation" by utilities attempting to duplicate services being provided by a Certificated utility within the service area where that Certificated utility is authorized to provide those services, unless the service of that Certificate holder is inadequate and cannot be cured. According to Virginia State Corporation Commission (VSCC) staff, the VSCC would not be likely to interpret the construction and use of an independently owned transmission line as violating the exclusive limitations implied by Certification, unless the transmission line enterprise attempted to distribute power. However, the "host" utility could provide a substantial barrier to VSCC approval if it were to contend that the proposed facility would interfere with its ability to serve its customers, and present substantive evidence to that effect.

Electromagnetic Field (emf) Effects:

The health effects of electromagnetic fields are a major issue of concern to citizens living and working in areas likely to be affected by new power line construction. This becomes an issue of relevance to these proceedings to the effect that public policies influence the tradeoffs between rail transport of coal and transmission of electric power. Scientific literature assessing the health effects of emf were recently reviewed by the U.S. Office of Technology Assessment. Their conclusions of that study were quoted by the FERC's Transmission Task Force Report:

> "In our view, the emerging evidence no longer allows one to categorically assert that there are no risks. But it does not provide a basis for asserting that there is a significant risk. If exposure to fields does turn out to pose a health risk, it is unlikely that high voltage transmission lines will be the only source of concern. Power frequency fields are also produced by distribution lines, wall wiring, appliances, and light fixtures. These non-transmission sources are much more common than transmission lines and could play a far greater role than any transmission lines in any public health problems" (quoted in FERC, 1989, pages 52-53).

Coalition Financing:

If a coalition of non-utility generation ventures were required to finance a new transmission line, and if the ability of each venture to market power is dependent on the new line, financial difficulties of one party could throw the entire project into jeopardy. This type of situation could make it difficult for involved parties to obtain financing for generation, as well as for transmission line construction.

The Potential to Establish "Interim" Transmission Facilities:

The preamble to House Joint Resolution 441 refers to the fact that "*the present economic development needs of southwestern Virginia establish the need to study what can be done in the near future to enable power to be 'wheeled' from power plants in southwestern Virginia earlier than 1998 ...,*" with 1998 being the date of

scheduled completion of the transmission reinforcement program scheduled by Apco and Virginia Power. The utilities suggest that there are at least two major factors which will work against completion of any of the alternatives discussed in this report, as "interim" measures prior to 1998:

1. The time requirements of building a transmission line: The shortest of the power line alternatives discussed above is 125 miles. A project of this magnitude is a substantial undertaking. Under the best of circumstances, such a project could be expected to take at least five years (including engineering and design, permitting, and construction), once the decision has been made to move forward. A five-year completion schedule would assume no major permitting problems. Thus, given the significant capital requirements, other issues discussed above, and the fact that much work would need to be done prior to initiating engineering and design activities, such a line could be completed prior to 1998 only under the most favorable conditions. Thus, such a line would prove to be significant as an interim measure only if the Apco-VP transmission reinforcement program was itself delayed substantially beyond 1998. As the utility's power planners point out, the Apco-VP transmission reinforcement program has a 1-to-2 year head start over any other transmission alternative.

2. Anticipated contract purchases by Virginia Power: Assuming all plants under development come on line as expected, the most recent projections by Virginia Power (March 1991) show 1997 as an anticipated on-line date for baseload generating capacity and 1995 as an anticipated on-line date for peaking generating capacity. More recently, public statements by Virginia Power, calling attention to Virginia's continuing economic slowdown, indicated an expectation of at least a one year delay in the baseload purchase schedule.

   If the power line were to be constructed to deliver power produced by a "Qualifying Facility" (as defined by PURPA), Virginia Power would be required to purchase that power regardless of its solicitation schedule. However, the "avoided cost" payments required under such an arrangement would likely be less than typical rates of compensation achieved by successful bidders in Virginia Power solicitations.

## Conclusions

The study concludes that construction of a new power line from southwestern Virginia, to enable power to be transmitted to the Virginia Power system for purchase by that utility on an interim (pre-1998) basis, should not be considered as a feasible venture under present circumstances.

If Virginia Power is to purchase power from non-utility generators at competitive rates, that power must be able to be transmitted to Virginia Power load centers in eastern Virginia during peak demand periods. Because of the long distances involved, the limited amounts of power generation considered to be developable in southwestern Virginia prior to 1998, and Virginia Power's transmission reliability requirements, a new, direct power line from southwestern Virginia to eastern Virginia does not appear economically feasible at the present time.

If the amount of power generation capacity that could, potentially, be developed in southwestern Virginia, prior to 1998, were substantially in excess of 500 MW, the economic feasibility of a direct connection to eastern Virginia would be enhanced through reduction of per-kWhr transmission costs. However, the capacity of a 500-kV line to eastern Virginia is not sufficient to justify such construction, on economic grounds, given Virginia Power's requirement that double circuit - double structure transmission reliability be provided. Negotiation of a lower-cost alternative to Virginia Power's transmission reliability requirement, and a southwestern Virginia power generation capacity in excess of 500 MW, would be required in order to establish an economically-feasible direct-access 500-kV connection to eastern Virginia that could compete favorably with the cost of moving coal by rail to eastern Virginia generating facilities.

According to information provided by Apco (AEP) and Virginia Power, current loadings on the existing transmission system have negative effects on the technical feasibility of all alternatives to a direct southwestern Virginia - eastern Virginia connection which were considered by this study. Current, heavy loadings on the Virginia Power transmission system limit that utility's ability to move additional power inputs that might be provided at locations near Bath County and Lexington to eastern Virginia under peak load conditions. This result is likely to occur if the power input is provided through a direct connection to the southwestern Virginia generation or if it is wheeled through the Apco system, given current transmission configurations. All construction alternatives investigated with the intention of providing increased transfer capabilities from Lexington or the Apco system are considered by Apco as likely to have the unintended consequence of drawing increased loadings through critical Apco system components west of Cloverdale. Therefore, these alternatives cannot be considered technically feasible according to criteria utilized in this study. If developments were to take place, prior to 1998, to relieve current heavy loadings on the Apco-VP transmission network, a major technical limitation to a number of new construction options would be removed.

Various parties concerned with these proceedings raised numerous issues regarding economic, legal, and institutional factors influencing the feasibility of new transmission line construction by non-utility interests. The primary factors which prevent the majority of the new construction options from being considered feasible are technical. Therefore, these issues did not have a major influence on the study. Should conditions change in future years, however, so that new transmission construction from southwestern Virginia becomes a viable alternative, certain of these issues could play major roles in determining the economic feasibility of new construction ventures. Major cost-related issues of this nature are Virginia Power's transmission reliability requirements, FERC policies governing wheeling rates charged by Apco, and the issue of who should pay for receiving-grid improvements required by power inputs of non-utility generators.

## Future Prospects

Under present circumstances, each of the power line construction options investigated appears to be infeasible for economic reasons, technical reasons, or both, prior to 1998. However, when viewed over a longer term, prospects appear considerably brighter. Although HJR 441 established 1998 as a target date for establishing interim transmission facilities, this date would probably have proven to be optimistic even if a feasible construction alternative had been identified.

Looking at the longer term: Both the Hoosier Energy and the AEP contracts to provide power to Virginia Power expire at the end of 1999. Although the Hoosier Energy contract has an automatic renewal clause, the AEP contract does not. Virginia Power has no plans, at present, to replace the power currently being purchased through these contracts with its own generation. If one or both of those contracts is not renewed, an increment of transmission capacity could become available.

If the FERC were to allow wheeling rates to be calculated using distance-based formulas, southwestern Virginia interests would have a competitive advantage relative to midwestern bidders on Virginia Power contracts. Such a change is being advocated by some utilities, including Virginia Power, on economic efficiency grounds.

If the Apco-VP transmission reinforcement program is completed, this will also open up transmission capacity from southwestern Virginia to Virginia Power. It is also possible that future improvements to neighboring transmission systems will open up additional west-east transfer capacity, and remove some of the technical constraints to the new construction options described in this report.

If such events occur, opening the door for development of substantial amounts of generation in southwestern Virginia, a new power line to connect southwestern Virginia to Jacksons Ferry should be investigated.

AEP officials state that, in general, the closer the non-utility generation interconnection to the Apco-VP interface, the greater the wheeling capacity of the Apco system. Therefore, a direct-access Jacksons Ferry interconnection would potentially increase Apco's ability to transfer power to the Virginia Power system, in comparison to a Broadford interconnection. According to AEP officials, this result would be likely regardless of the completion of the Apco-VP transmission reinforcement proposal. As documented in this report, based on current transmission configurations, a Jacksons Ferry power input would allow the Apco system to carry greater amounts of power to the Virginia Power interface than would a power input at Broadford. AEP officials also state their expectation that, if the Apco-VP reinforcement program is completed, a connection in the vicinity of Jacksons Ferry would allow the AEP system to transmit power to Virginia Power in amounts greater than the 500 MW currently committed.

At present, major technical limitations to this construction option occur due to its effects on the Virginia Power system. Current constraints on the Virginia Power system's ability to transfer power from the Apco interface to eastern Virginia would need to be relieved, through completion of the Apco-VP reinforcement program or through other means, before a new transmission line to Jacksons Ferry could be considered technically feasible. A major factor influencing the economic feasibility

of a SWVa - Jacksons Ferry construction program would be the wheeling rate charged by Apco for transmission from Jacksons Ferry.

If future developments were to allow such a construction program to be considered feasible, developers might wish to consider establishing Broadford as a collection point for the output of dispersed generation facilities. Transmission of all or part of this generation to Broadford could potentially be accomplished through connections to the Apco 138-kV system. A new transmission line might then interconnect with the Apco system at both Broadford and Jacksons Ferry, thereby satisfying Virginia Power's reliability requirements. Such an arrangement might also allow portions of the new line to be established on a right-of-way directly adjacent to the existing Broadford - Jacksons Ferry 765-kV corridor, thereby minimizing environmental impacts.

Additional studies would be necessary to establish the technical feasibility of this option. If it did prove technically feasible to establish a new line as described above, an additional advantage would result from the fact that the success of individual generation ventures would not be dependent upon successful financing of the new line. A connection to the Apco system at Broadford could still be available for a limited amount of power if the venture to establish a new line were to fail due to financial difficulties or for any other reason.

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This report was prepared by Carl Zipper and John Randolph of the Virginia Center for Coal and Energy Research, with the assistance of Saifur Rahman of the Bradley Department of Electrical Engineering at Virginia Polytechnic Institute and State University. David Holladay prepared Appendix C and Figures 2 and 3. Glenn Ross, of Virginia Power, prepared the *Typical Utility Purchase Agreements* and *Typical Non-Utility Generation Projects* section of Appendix A. The Electric Transmission Lines map attached to this report was prepared by the staff of the Virginia State Corporation Commission.

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## Appendix A: Power Purchase Arrangements - Virginia Power

Voluntary power purchase agreements are executed by utilities for two reasons:

1. To lower the overall cost of energy provided by that utility to its customers.
2. To bring additional power into the system during periods when, in the absence of such a purchase, demands would exceed power supplies.

Utilities are also required by the Public Utility Regulatory Policies Act (PURPA) to purchase power produced by non-utility generating facilities which meet criteria defined by the Act.

Purchased power must be integrated into the purchasing utility's dispatch system. That is: at any given moment in time, a utility is making decisions on how to utilize available power supply resources to meet system demands reliably, and at least cost. Generally speaking, the utility will seek to make use of its lowest-cost sources of power during periods of low demand. Typically, these will be hydroelectric generating stations and large, coal-fired base-load units, which must run continuously in order to operate at highest efficiencies. As demands on the system increase, additional power-supply increments are brought on-line at progressively increasing costs. In addition to supply costs, other factors will influence a utility's dispatch decisions. Among these is available transmission capacity from sources of generation to load centers.

### Cost Components of Common Power Purchase Contracts

Typical power purchase agreements have energy cost and capacity cost components.

Energy costs are determined based on the number of kWhrs supplied to the power purchaser under the contract agreement. Energy costs have two major components: the fuel cost, and variable non-fuel costs of owning, operating, and maintaining the generating plant.

Capacity costs represent the fixed cost to the operator of owning, operating, and maintaining the generating plant. These costs are paid over the life of the contract, and are independent of the amount of electrical energy supplied.

Payments to the power supplier by the purchasing utility are calculated as the sum of the contractually-defined energy cost and the capacity cost.

### Typical Utility Purchase Agreements

Long-term unit capacity purchases

Virginia Power ("the Company") has executed purchase agreements for 500 MW from AEP and 400 MW from Hoosier Energy Rural Electric Cooperative through December 31, 1999. The components of the AEP purchase are 455 MW from the coal-fired Rockport unit 1, and 45 MW from AEP system power. The Hoosier purchase is for a portion of the capacity of the Merom coal units. Both purchases have minimum take provisions, and energy costs are priced at actual cost plus 10% ($20-$30/MWhr total average energy cost). Capacity costs for the Rockport purchase are currently

$10-$11/kW-mo and decline over the life of the contract. Hoosier capacity costs including transmission are $9.15/kW-mo (fixed over the contract term).

Other capacity purchases

These purchases include daily, weekly, monthly, and seasonal, short-term, and limited-term purchases. These purchases are made under the service schedules of existing utility interconnection and operating (I&O) agreements. Generally 100-500 MW of capacity is reserved under these agreements. The selling utility makes this reserved capacity available to the buyer after meeting its own load requirements. Energy scheduling is at the discretion of the buyer after meeting its own load requirements. Normally, energy is billed at actual production cost plus 10%. These energy costs may range from $20-$80/MWhr depending on the type unit dispatched to provide the energy. Dispatch cost is based on the selling utility's estimate of production costs. Capacity (reservation) costs are normally in the $5-$8/kW-mo range.

Hourly economy and emergency purchases

Economy purchases are hourly, as-available purchases based on a split-the-savings costs of the two utilities. These purchases may be discontinued at any time at the discretion of the seller. There are no capacity costs associated with these hourly purchases. Energy costs are generally in the $20-$30/MWh range. Emergency purchases are made when a utility cannot meet load or maintain adequate reserves. Normally, there are no capacity costs associated with these purchases and energy costs are generally in the $30-$80/MWhr range. All the Company's interconnected utilities maintain reserve capacity and mutually support each other during emergency conditions.

**Typical Non-Utility Generation Projects**

Bid solicitation projects

These are non-utility generators with which the Company has executed contracts as a result of the Company's 1986, 1988, and 1990 capacity bid solicitations. These projects are dispatched by the Company in the same general manner as the Company's own units. The capacity payments to these projects range from $5-$15/kW-mo. Energy costs range from $15-$30/MWhr. The total payment (capacity and energy) generally reflects the generating technology of the project. Peaking projects (combustion turbines) have low capacity and high capacity payments and relatively low energy payments. Most of these projects have a steam host and are Qualifying Facilities under PURPA.

Qualifying Facility purchases

The Company is required by law under the PURPA to purchase capacity and energy from Cogenerators and Small Power Producers (Qualifying Facilities-QFs). Both energy and capacity payments are based on the administratively determined avoided costs which are included in the Company's jurisdictional tariffs. Generally, capacity costs range from $4-$15/kW-mo and energy costs range from $2-$25/MWh. These projects have very limited dispatch provisions. As a result, they are base-loaded at the discretion of the project operator.

## Appendix B: Methods for Calculating Transmission Line Costs

The results of preliminary cost calculations are listed in Table 1, in the text. These costs were calculated based on information provided by Apco and Virginia Power. The assumptions of these cost estimates are as follows:

- The basis for the calculations are direct labor, materials, and right-of-way purchase costs per mile of power line, for lines of various voltages, provided by Apco and Virginia Power.
- Interconnection costs (labor and materials) are estimated according to figures provided by Apco and Virginia Power, in most instances. For those interconnections for which interconnection cost figures were not provided, interconnection cost was estimated at $10 million per terminus. These costs are assessed only at an interconnection with the Apco or VP grid.
- Total capital costs are calculated as labor, materials, and right-of-way purchase costs, plus 28.9% for corporate overhead and a 10% contingency. Capital costs are depreciated over a 50-year period.
- Annual maintenance expenditures are estimated at 1.5% of capital costs.
- Annual property taxes for structures estimated at 1% of capital.
- Power line mileage is estimated as the straight line mileage between two points of terminus, plus 15%.
- Generating plant capacity factor is assumed at 80%; transmission system availability is assumed at 99.9%.
- Transmission power losses are calculated according to figures provided by Apco.
- The cost of transformers at the power plant (to step plant output voltages up to the transmission line voltage) are not considered as transmission line costs.
- All costs are calculated using 1993 dollars; inflation was not considered in the analysis (i.e., the analysis assumes that inflation of all costs considered will occur at identical rates.).

Costs were calculated for interest rates of 10, 13, and 16 percent. The 10 percent figure approximates the rates of return approved for Apco and Virginia Power by the Virginia State Corporation Commission, while the 13 percent approximates the return on equity approved by the VSCC for the two utilities. The FERC Transmission Task Force Report (1989) uses 16 percent to estimate the cost of capital in its calculations of transmission line capacity costs (Table 2-5).

The costs of Table 1 are approximate. Inaccuracies include lack of consideration of actual routing barriers and distances, and lack of terminus-specific interconnection costs. There is also some uncertainty regarding whether or not an independent company, possibly a company formed specifically for the purpose of constructing a transmission line, would require the same level of corporate overhead assessment as a major utility. These costs include only the power line itself; they do not include any costs that might be required to reinforce the transmission system at the receiving

end. Also, as noted in Table 1, these costs are for single circuit transmission lines. In order to meet the Virginia Power interconnection requirements, a double-structure, double circuit line would be required. This would require a doubling of these costs, or that an arrangement be made with Apco and Virginia Power for backup transmission services.

As a point of reference for the capital cost totals, the total estimated capital cost of the transmission reinforcement program proposed by Apco and Virginia Power (including all power line construction, substation improvements, and associated improvements to the receiving grid) is $409 million (1998 dollars).

According to Virginia Power officials, recent, long-term unit power purchase agreements have been executed by the utility at energy costs ranging from $.020-.025 per kWhr, and capacity costs in the neighborhood of $5 per kW-mo. Assuming a unit capacity factor of 75% (the purchase costs cited here are higher than power generation costs at some of the older coal-fired baseload units on the Virginia Power system, so these higher-cost units would be dispatched to operate at lower capacities), the total contract price comes to $0.025 to $0.030 per kWhr.

**Table B-1.** Assumptions used to calculate costs of single circuit electric power transmission lines of various configurations.

| Point of Terminus | Voltage | Distance[1] | Power Transfer | Power Loss | Connect Cost[2] | Construct Cost[4] |
|---|---|---|---|---|---|---|
| | (kV) | (Miles) | (MW) | (%) | (Million $) | ($/Mile) |
| SWVa - E. VA | 500 | 250 | 500<br>870 | 1.6<br>2.8 | 5 | 478,000 |
| SWVa - Clover | 345 | 180 | 500 | 4.4 | 12 | 374,000 |
| SWVa - Lexington | 345 | 160 | 500 | 3.8 | 12 | 384,000 |
| Lexington - Ladysmith | 500 | 105 | 500 | 0.7 | 17 | 478,000 |
| SWVa - Cloverdale | 345 | 125 | 500<br>610 | 3.0<br>3.7 | 5[3] | 384,000 |
| SWVa - J. Ferry | 345<br>345<br>500 | 70 | 500<br>820<br>500 | 1.6<br>2.8<br>0.4 | 15<br>15<br>6 | 384,000<br>384,000<br>501,000 |
| SWVa - Broadford | 345 | 25 | 500 | 0.6 | 15 | 384,000 |
| Broadford - J. Ferry | 500<br>345 | 45 | 500<br>500 | 0.3<br>0.9 | 12<br>30 | 501,000<br>384,000 |

Notes:

1. Straight line distances. Construction costs are estimated by adding 15% to this figure.
2. Connect costs include breakers, transformers, and associated requirements at one end only (Apco-VP interconnection) for radial lines. Broadford-J. Ferry connect costs include interconnections at both the Broadford and the Jacksons Ferry substations. Connect costs do not include costs associated with necessary upgrades to the receiving grid.
3. Includes cost to tie into existing transformer at Cloverdale, plus estimate of cost to advance upgrade of Cloverdale substation as planned by transmission reinforcement program.
4. Variations in per-mile construction estimates for lines of identical voltages result from higher anticipated construction costs in western Virginia due to mountainous terrain. These costs include right-of-way acquisition.

**Table B-2: An example of a transmission cost calculation.**

Example: 345 kV line from SWVa to Jacksons Ferry:

| | | | |
|---|---|---|---|
| Straight Line Miles: | 70 | | |
| Tortuosity Factor: | 15.0% | | |
| Power Line Miles: | 80.5 | | |
| Design & Construct, per mile: | $384,000 | | |
| Corporate Overhead: | 28.9% | | |
| Contingency: | 10.0% | | |
| Total Cost per Mile | $544,474 | | |
| Interconnect - Labor & Mat: | $15,000,000 | | |
| Corporate Overhead: | 28.9% | | |
| Contingency: | 10.0% | | |
| Total Interconnect Cost: | $21,268,500 | | |
| Total Capital Cost: | $65,098,625 | | |
| Input Power: | 500 MW | | |
| Power Loss: | 0.9% | | |
| Delivered Power: | 495 MW | | |
| Interest Rate: | 10.00% | 13.00% | 16.00% |
| Depreciation Period (years): | 50 | | |
| Annual Cost of Capital: | $6,565,794 | $8,481,639 | $10,422,018 |
| Annual Maintenance as % of total capital: | 1.5% | 1.5% | 1.5% |
| Annual Property Tax as % of total capital: | 1.0% | 1.0% | 1.0% |
| Annual Cost: | $8,193,259 | $10,109,104 | $12,049,484 |
| Hours per Year: | 8760 | | |
| Power Gen. Capacity Factor: | 80.0% | | |
| Trans. Capacity Factor: | 99.9% | | |
| Power Delivery (kWhr/year): | 3,444,488,064 | | |
| TRANSMISSION COST: per kWhr | $.0024 | $.0029 | $.0035 |

Formula for calculating annual cost of capital:

$$A = \frac{C*r*[(1+r)^{**}t]}{[(1+r)^{**}t]-1}$$

A = Annual cost of capital
C = Capital cost, total
t = Time, years to recover capital
r = Annual interest rate

## Appendix C: Environmental Permitting Requirements

Examples of Possible Permitting Requirements For a New Power Transmission Line From the Virginia Coalfields to the Virginia Power System

**Resource** Blue Ridge Parkway

**Agency** UDSI National Park Service
Blue Ridge Parkway
200 BB&T Building
One Pack Square
Ashville, NC 28801

**Permit Required** Right of Way Permit

**Permit Information:** Before issuing the right of way permit, an Environmental Impact Statement (EIS) in compliance with the National Environmental Policy Act (NEPA) will be necessary. This process is costly and time consuming. For example, the Forest Service EIS for the proposed APCO Wyoming to Cloverdale project is estimated to cost $1 million and take two years to complete. In another instance, an APCO right of way application to cross the Blue Ridge Parkway for the Jacksons Ferry to Axton 765 kV transmission line resulted in an in-depth 457-page EIS from the Park Service. It is uncertain whether the NPS would want a separate EIS, or would work in conjunction with other affected federal agencies. Specific reference to rights of way for National Park Service lands may be found in Part 14, Title 36 of the Code of Federal Regulations.

**Resource** Appalachian National Scenic Trail

**Agency** USDI National Park Service
Appalachian Trail Project Office
Harper's Ferry, WVA 25425

**Permit Required** Right of Way Permit

**Permit Information:** Since the Appalachian Trail is administered by the National Park Service, the application for right of way will be similar to that for a project crossing the Blue Ridge Parkway. The same 36 CFR Part 14 regulations apply to right of way across the trail and the proposal would invoke the NEPA process. Close scrutiny by the Appalachian Trail Project Office, Appalachian Trail Conference, recreation users and the public should be expected. According to NPS guidelines (36 CFR Part 14): Permit applications "shall be consistent with applicable legislation, Federal regulations and administrative policies, and based upon a determination that public health and safety, environmental and scenic values, natural and cultural resources, scientific research, implementation of management responsibilities, proper allocation and use of facilities, and the avoidance of conflict among visitor use activities, will not be adversely impacted."

**Resource** Jefferson National Forest

**Agency** USDA Forest Service
Jefferson National Forest
210 Franklin Road, SW
Roanoke, VA 24001

**Permit Required** Special Use Permit

**Permit Information:** Power transmission lines are not permitted in National Forest Wilderness Areas, and almost certainly would not be permitted in the Mount Rogers National Recreation Area. As for the other areas of the forest, the Jefferson National Forest Land and Resource Management Plan (1985) states that special use permits will only be issued "under the following conditions: when legally mandated, when needed in the public interest and cannot be met on non-federal land, and when National Forest programs/activities will be enhanced." These issues would be addressed in an EIS. As is the case with the Blue Ridge Parkway, the EIS would be costly and time consuming, and may be studied in conjunction with other federal agencies.

**Resource** State Wildlife Management Areas

**Agency** Commonwealth of Virginia
Department of Game and Inland Fisheries
4010 West Broad Street
Box 11104
Richmond, VA 23230

**Permit Required** Easement

**Permit Information:** No specific permit is required to cross Wildlife Management Areas, but an easement must be purchased from the State of Virginia. While this process is fairly simple, the difficulty with crossing Wildlife Management Areas could come from federal review. The U.S. Fish and Wildlife Service will study threatened and endangered species which exist in the proposed corridor, and especially in the right of way across the Wildlife Management Area. The Endangered Species Act is very powerful legislation which could halt or significantly alter the proposal. The USFWS review may be coupled with an EIS involving other affected federal agencies.

**Resource** State Parks and Recreation Areas

**Agency** Commonwealth of Virginia
Department of Conservation and Recreation
Division of State Parks
203 Governor Street
Richmond, VA 23219

**Permit Required** Easement

**Permit Information:** No specific permit is required to cross State Parks, but an easement must be purchased from the State of Virginia. Easements to Public Service Corporations are covered in the Code of Virginia, Title 10.1, Section 110. According to the provisions of Section 110, easements are allowed "provided that the easement is consistent with and not in derogation of the general purpose for which the land or other property is held. With this in mind, the Department of Conservation and Recreation would take a critical look at a power line proposal across a State Park.

**Resource** State Waters

**Agency** Commonwealth of Virginia
Marine Resources Commission
2600 Washington Avenue
P.O. Box 756
Newport News, VA 23607-0756

**Permit Required** Joint Permit Application

**Permit Information:** For most state and federal water related permits, a Joint Permit Application is available from the Virginia Marine Resources Commission (VMRC). The application is distributed by the VMRC to the Army Corps of Engineers, the Tennessee Valley Authority, Commonwealth of Virginia, and local wetland boards. The Army Corps of Engineers handles public notice and public review and comment for the project. These comments are distributed to the agencies which use the application. The Joint Permit Application is used to acquire permits for navigable stream crossings, projects affecting state scenic rivers, wetlands and other state waters. The VMRC suggests that the applicant still needs to contact the involved agencies to make sure permit requirements are fulfilled. The applicant should also contact local health departments and building officials which might not use the joint application.

**Resource** Virginia Natural Area Preserves

**Agency** Commonwealth of Virginia
Department of Conservation and Recreation
Division of Natural Heritage
203 Governor Street
Richmond, VA 23219

**Permit Required** N/A

**Permit Information:** No permit is available. Natural Area Preserves are dedicated to the State for preservation and are protected from taking for utility corridors.

**Resource** Historic Resources

**Agency** Commonwealth of Virginia
Department of Historic Resources
211 Governor Street
Richmond, VA 23219

**Permit Required** Architectural and Archaeological Resource Investigation

**Permit Information:** Architectural Resource Investigations and Archeological Resource Investigations will be required at tower sites and along the right of way. Since these investigations are undertaken after right of way and tower sites are decided, it is difficult to proactively avoid all historic resources, and mitigation measures could require last minute alteration of routes.

**Additional Considerations Regarding Environmental Permitting:**

1. Power line applications filed with the Virginia State Corporation Commission must comply with requirements set forth in the VSCC publication *Guidelines of Minimum Requirements for Transmission Line Applications Filed Under Virginia Code Section 56-46.1 and the Utility Facilities Act.* These guidelines contain a number of requirements designed to minimize adverse environmental impacts.

2. Any conversion of lands whose current use was funded through federal Title 10 Land and Water Conservation Fund must be reviewed by the Virginia Department of Conservation and Recreation, and the National Park Service. Such lands typically include parklands and recreation areas. Relevant statutes are Section 6(f)(3) of the Land and Water Conservation Act, and 36 CFR Part 59. The process is defined in the Land and Water Conservation Fund Manual, which can be obtained from the Virginia Department of Conservation and Recreation. The 6(f)(3) conversion process can result in the need to file an EIS.

Appendix D

Report on Load Flow Modeling Analysis

# Technical Assessment of Alternative Transmission Configurations to Integrate Generation in the Southwest Virginia Coal Fields into the VP and APCo Transmission Systems

Prepared by Virginia Power and by
AEP Service Corporation, on Behalf of
Appalachian Power Company, at the Request of the
Virginia Center for Coal and Energy Research

November 1991

## I. Introduction

Virginia House Joint Resolution No. 441 directed the State Corporation Commission and the Virginia Center for Coal and Energy Research (VCCER) to "study the means available prior to 1998, to wheel power produced by electric power plants in southwestern Virginia" to the Virginia Power transmission network, for purchase when needed by Virginia Power. In response to that legislation, the VCCER is examining the feasibility of constructing a new electric power transmission line for that purpose. Two interim reports documenting the progress of that study have been prepared.

The VCCER investigators have consulted, during the course of their study, with representatives of Appalachian Power Company (APCo) and Virginia Power (VP) to gather information about the performance of the two companies' transmission systems and to obtain conceptual assessments regarding the technical feasibility of alternative transmission configurations conceived by the VCCER. To provide initial assessments of the alternative transmission configurations, the electric utilities offered to conduct power system simulation studies of several alternative transmission configurations agreed to by the parties involved in the VCCER study. To that end, the VCCER prepared a list of seventeen alternative transmission configurations and organized a meeting among the parties to discuss the alternatives and to decide which transmission configurations should be evaluated.

A meeting was held on October 8, 1991 in Appalachian Power Company's office in Roanoke. In attendance were representatives of the Virginia Center for Coal and Energy Research, Appalachian Power Co./American Electric Power Service Corp. (APCo/AEPSC), Virginia Power, Coastal Power Production Co., Hazel and Thomas, P.C., and Hadson Development Corp. The feasibility of the alternative transmission configurations contemplated by the VCCER were discussed and several were selected for evaluation by the utilities. All of the configurations were conceived solely to deliver the output of new generating capacity located generally in southwest Virginia to the VP system.

This report describes and summarizes the results of load flow simulation studies conducted jointly by AEPSC, on behalf of APCo, and by VP to assess the technical characteristics of three alternative transmission configurations.

## II. Description of Alternative Transmission Configurations

Two alternative transmission configurations for study were defined at the meeting of October 8, 1991. The first contemplates the construction of a 182 mile (estimated) 345 kV transmission line from the southwestern Virginia coal fields to Virginia Power's Lexington substation together with a 122 mile (estimated) 500 kV transmission line from Lexington to Virginia Power's Ladysmith substation. Because of physical constraints at Lexington substation, foreclosing future extensive expansion of the 500 kV switchyard, a new 345/500 kV substation (West Lexington) located in close proximity to Lexington

substation was assumed in the simulation studies to integrate the new 345 kV and 500 kV transmission lines with the existing Lexington (VP) to Cloverdale (APCo) 500 kV interconnection.

The second alternative includes all of the transmission facilities of Alternative One but with a second 345 kV transmission line (approximately 28 miles) from the southwestern Virginia coal fields connected to APCo's Broadford 765 kV substation via a 345/765 kV transformer located at the Broadford substation.

A third alternative, as described in a letter dated October 18, 1991 from C. Zipper of the VCCER to study participants, contemplates the construction of an 81 mile (estimated) 345 kV transmission line from the southwestern Virginia coal fields connected to APCo's Jacksons Ferry 765 kV substation via a 345/765 kV transformer at the Jacksons Ferry substation.

The three alternative transmission configurations are illustrated in Exhibits 1, 2 and 3. The new transmission lines and their associated transformers are identified by the dashed lines. A 500 MW generating plant, located in the southwestern Virginia coal fields, was assumed to be developed in conjunction with the three alternative transmission concepts.

## III. Load Flow and Transfer Capability Study Procedures

A general framework for the study was established jointly by VP and AEPSC. AEPSC planning engineers conducted load flow simulation studies of the proposed configurations, primarily to assess the effects on APCo area performance. Virginia Power planning engineers conducted linear load flow studies to assess the effects of the proposed configurations on the ECAR to VP transfer capability. Computer output and other relevant material for the two parts of the study were available to AEPSC and VP so that each could review the information and assess the impact on their respective transmission systems. Furthermore, the companies agreed that their analysis would focus primarily on the impact that the proposed transmission configurations would have on the performance of their respective systems without the APCo/VP reinforcement program in place.

This framework recognized the limited time available to conduct the studies as well as the availability of manpower in each company that could be dedicated to this study.

### A. AEPSC Study Procedure for Load Flow Simulation Studies of Alternative Transmission Configurations

The three alternative transmission configurations were modeled by AEPSC in the 1998/1999 winter peak and winter shoulder-peak load flow base cases developed by APCo/AEPSC for use in connection with APCo's Application for Approval and Certification of Electrical Transmission Lines as documented in Volume II, Section IV of that Application. Although 1998 load flow cases were used, the results of the simulation studies are also representative of

the performance of the system that could be expected in the mid-1990s -- the time frame contemplated for development of the SWVa generating plant and associated transmission facilities. Exhibits 4-6 show the 1998/99 winter peak base case power flow conditions for the three alternatives examined.

The load flow base cases for each alternative were examined to identify how the new SWVa generating plant and related transmission affected the magnitude of power flows on the VP and APCo systems and the consequent changes in power flow patterns across the interconnected system. Also, a limited set of simulations of single and overlapping transmission outages, including the outage of the SWVa generating plant which would leave the new SWVa plant transmission outlets in-operation, was examined to identify the effects on the performance of the APCo and VP transmission systems. This part of the study focused on identifying added burdens or relief provided to the APCo transmission system by comparing the results of these simulations to the results of similar simulations, without the new SWVa generating plant, as documented in Section IV of APCo's Application. VP also reviewed the results of these simulations so as to assess how the SWVa generating plant and transmission facilities might affect the operation of their system.

B. VP Study Procedure for Transfer Capability Assessment

The three alternative transmission configurations were modeled by VP in the load flow base cases used for the APCo/VP joint interconnection study. The base case conditions included 1998 summer peak and off-peak and 1998/99 winter peak and off-peak conditions, all initially without the joint reinforcement program proposed by APCo and VP. The base transfer levels were the same as those modeled in the joint VP/APCo planning study.

Through the linear load flow method, the ECAR to VP First Contingency Incremental Transfer Capability was calculated for each load level condition and for each of the SWVa generating plant transmission configurations. The results of those calculations were then compared to the appropriate transfer capabilities without the SWVa generating plant and related transmission to assess whether the transfer capability increased or decreased as a result of the addition of the SWVa facilities.

The studies were repeated with the APCo/VP reinforcement program in service for 1998 summer peak conditions to assess the effects of the alternative SWVa generating plant developments on transfer capability following the completion of the joint reinforcement program.

## IV. Summary of Analyses of Performance of Alternative Transmission Configurations

The following presents a summary of the results of the studies conducted by VP and AEPSC for each of the SWVa generating plant transmission alternatives. These results are all based on models without the APCo/VP reinforcement program.

### A. Alternative One - 500 MW SWVa generating plant connected to Lexington and a new Lexington-Ladysmith 500 kV line

- This alternative requires extensive EHV transmission construction including approximately 182 miles of 345 kV transmission; 122 miles of 500 kV transmission; and 345/500 kV transformer capacity and necessary substation development, switchgear and related terminal facilities to integrate the new transmission into the existing VP transmission grid.

- About 4% (20 MW) of the SWVa generating plant output is consumed, in the form of transmission losses, in the SWVa-Lexington 345 kV transmission line, effectively resulting in 480 MW of generation delivered to VP.

- An outage of the 182 mile SWVa-Lexington 345 kV line or a 345/500 kV transformer phase at Lexington will result in the isolation of the SWVa generating plant forcing the plant out-of-operation until such time that the line or transformer are restored to operation.

- The net effect of the new generation and transmission generally results in an increase in power flows on the existing critical APCo transmission facilities, many of which are already heavily loaded. An outage of the SWVa generating plant, with the SWVa transmission facilities remaining in service, exacerbates this situation. These results are due to the connection of the SWVa transmission facilities into W. Lexington, which reduces the impedance of the APCo-VP transmission path.

- Cloverdale 345/500 kV transformer overloads, resulting from single and overlapping facility outages during shoulder-peak periods, are reduced but continue to persist even when the SWVa generating plant and related transmission facilities are added.

- The ability of Virginia Power to import power and energy from ECAR was unchanged by the new SWVa generating plant development.

- This alternative does not meet Virginia Power's minimum transmission requirement of providing two transmission outlets from non-utility generation plants located more than 50 miles distant from the VP transmission grid.

B. Alternative Two - 500 MW SWVa generating plant connected to Broadford and Lexington and a new Lexington-Ladysmith 500 kV line

- This alternative requires extensive EHV transmission construction including approximately 210 miles of 345 kV transmission; 122 miles of 500 kV transmission; and necessary substation development, switchgear and related terminal facilities to integrate the new transmission into the existing VP transmission grid at Lexington and Ladysmith and APCo transmission grid at Broadford including 345/500 kV transformer capacity at Lexington and Broadford.

- Because nearly 50% of the SWVa generating plant output is wheeled to VP through the APCo system, a transmission service arrangement with APCo would be required.

- About 1.4% (7 MW) of the SWVa generating plant output is consumed, in the form of transmission losses, by the two transmission outlets.

- The new facilities generally result in an increase in power flows on the existing critical central/ eastern APCo transmission facilities, many of which are already heavily loaded. Furthermore, an outage of the 182 mile SWVa-Lexington 345 kV line or a 345/500 kV transformer phase at Lexington will result in the full output of the SWVa plant being delivered to Broadford substation thereby substantially burdening the already heavily loaded central/eastern APCo interface transmission facilities.

- The new facilities will result in a slight reduction of the power flows on the APCo north/south transmission facilities during normal, all facilities in-service conditions. However, an outage of the SWVa generating plant, with the new transmission in operation, will result in a substantial increase in the loadings on the APCo north/south interface.

- Cloverdale 345/500 kV transformer overloads, resulting from single and overlapping facility outages during shoulder-peak periods, are reduced (in a lesser amount than in Alternative One) but continue to persist even when the SWVa generating plant and related transmission facilities are added.

- This alternative would meet Virginia Power's minimum transmission requirement of providing two transmission outlets from non-utility generation plants located more than 50 miles distant from the VP transmission grid.

- The ability of Virginia Power to import power and energy from ECAR was about the same with or without the new SWVa generating plant development.

C. Alternative Three - 500 MW SWVa generating plant connected to Jacksons Ferry

- This alternative requires the construction of an estimated 81 miles of 345 kV transmission and 345/500 kV transformer capacity and necessary substation development, switchgear and related terminal facilities to integrate the new line into APCo's transmission grid at Jacksons Ferry.

- All of the SWVa generating plant output must be wheeled to VP through the APCo system. Therefore, a transmission service arrangement with APCo would be required.

- About 1.8% (9 MW) of the SWVa generating plant output is consumed, in the form of transmission losses, by the SWVa-Jacksons Ferry line.

- An outage of the SWVa-Jacksons Ferry 345 kV line or a 345/500 kV transformer phase at Jacksons Ferry will result in the isolation of the SWVa generating plant forcing the plant out-of-operation until such time that the line or transformer are restored to operation.

- The new facilities generally result in a decrease in power flows on the existing APCo north/south and central/eastern interface transmission facilities for normal, all facilities in-service conditions.

- Cloverdale 345/500 kV transformer overloads, resulting from single and overlapping facility outages during shoulder-peak periods, are increased significantly when the SWVa generating plant and line to Jacksons Ferry are added.

- VP's import capability on its western and northern interface with APCo and APS was decreased by 345 MW due to increased loading on the Mt. Storm-Meadow Brook 500 kV line. Import capability decreases, ranging from 255 MW to 235 MW, were also evident due to increased loading on the Pruntytown-Mount Storm 500 kV line and the Dickerson-Pleasant View 230 kV line.

- This option increased the loading on the APS/VP Pruntytown-Mount Storm and APS's Hatfield-Black Oak 500 kV lines. Increased loading on these lines will magnify the reduced import capability when the RCP limits are applied by APS. The determination of the RCP reduction in import capability was beyond the scope of this study.

- VP's import capability on its southern interface with CP&L was decreased by 820 MW due to increased loading on the Clover 500/230 kV transformer or the Halifax-Person 230 kV line. Import capability was also decreased by 775 MW due to increased loading on the Clover-Halifax 230 kV line.

- This alternative does not meet Virginia Power's minimum transmission requirement of providing two transmission outlets from non-utility generation plants located more than 50 miles distant from the transmission grid.

## V. Conclusion

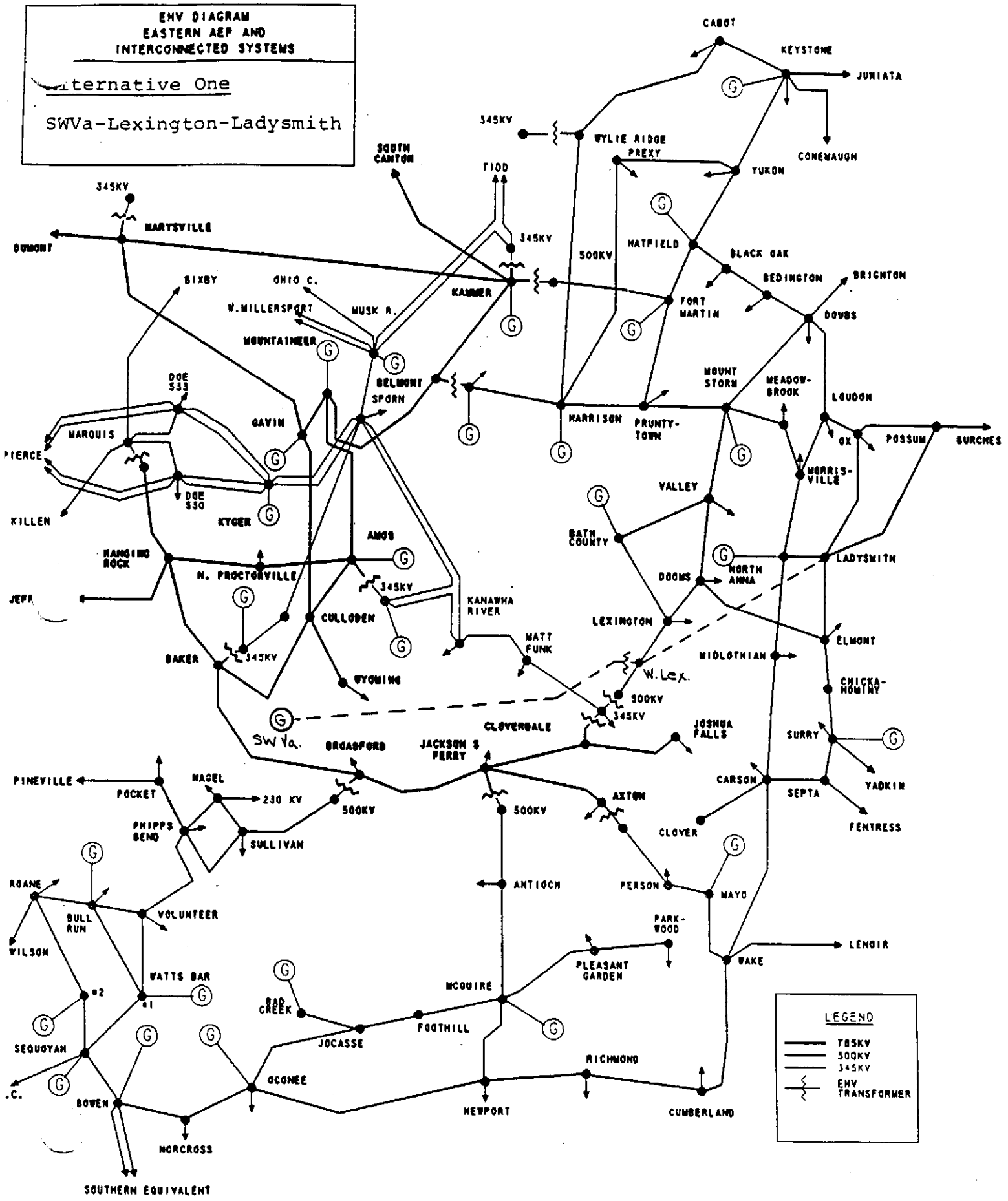
The analysis of the transmission plans reported herein represents a technical assessment of several alternatives to transmit power from southwest Virginia to Virginia Power. Neither VP nor APCo endorses any one of these plans. Plans characterized in this section as "viable" are those that are judged to have no significant deleterious impact on the reliability and performance of the VP and/or APCo system; the "viable" plans do not necessarily provide any benefit to that company or its customers.

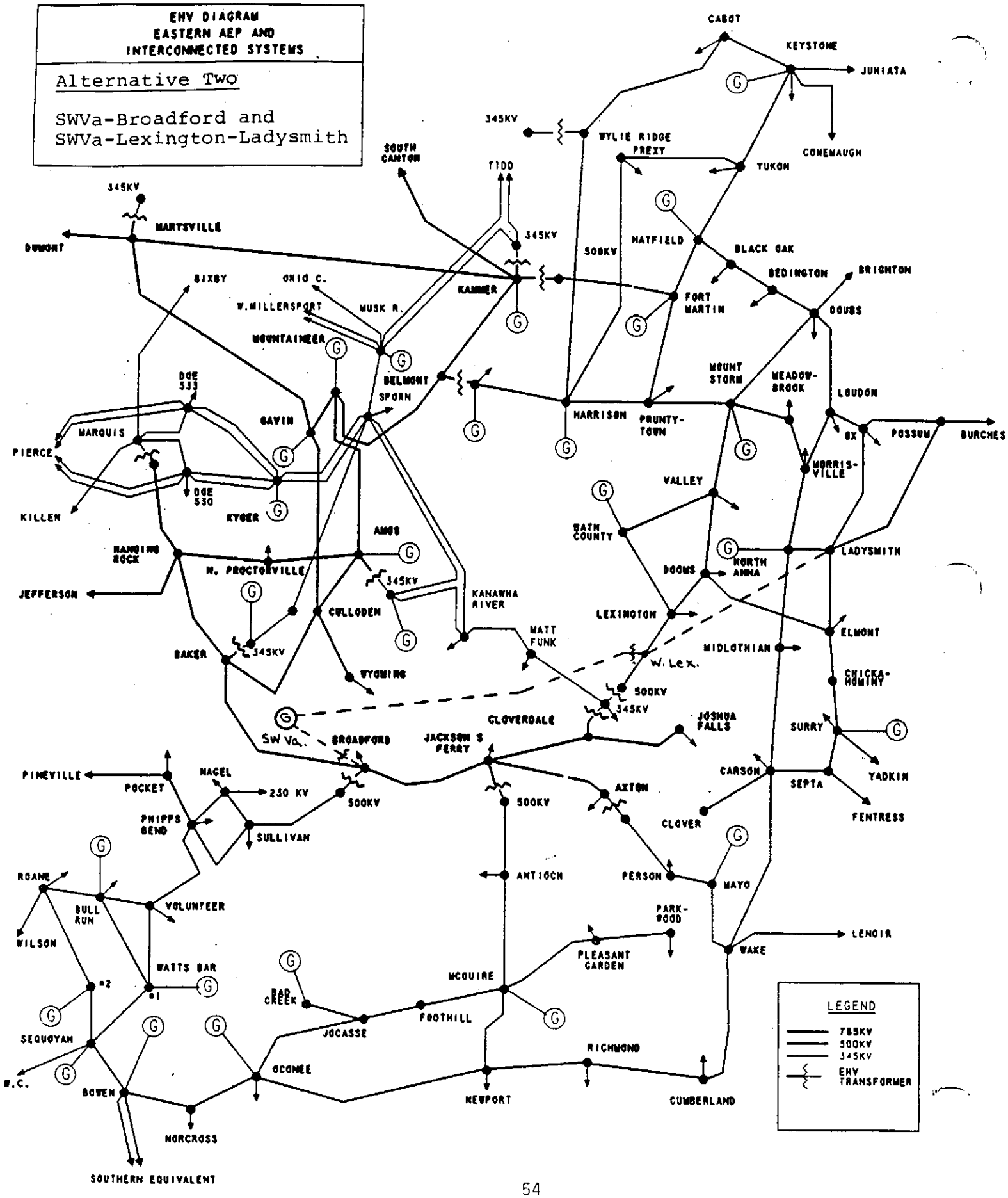
Alternative One (SWVa-Lexington-Ladysmith) would have some negative impacts on APCo, even though it is technically viable from VP's perspective. VP notes that this plan does not comply with VP requirements for two plant outlets. APCo believes that the negative impact of this plan on APCo system performance could be eliminated by connecting the SWVa site directly to Ladysmith via a 500 kV transmission line without an intermediate tie to W. Lexington. This modified configuration should be viable even after the completion of the APCo/VP reinforcement program.

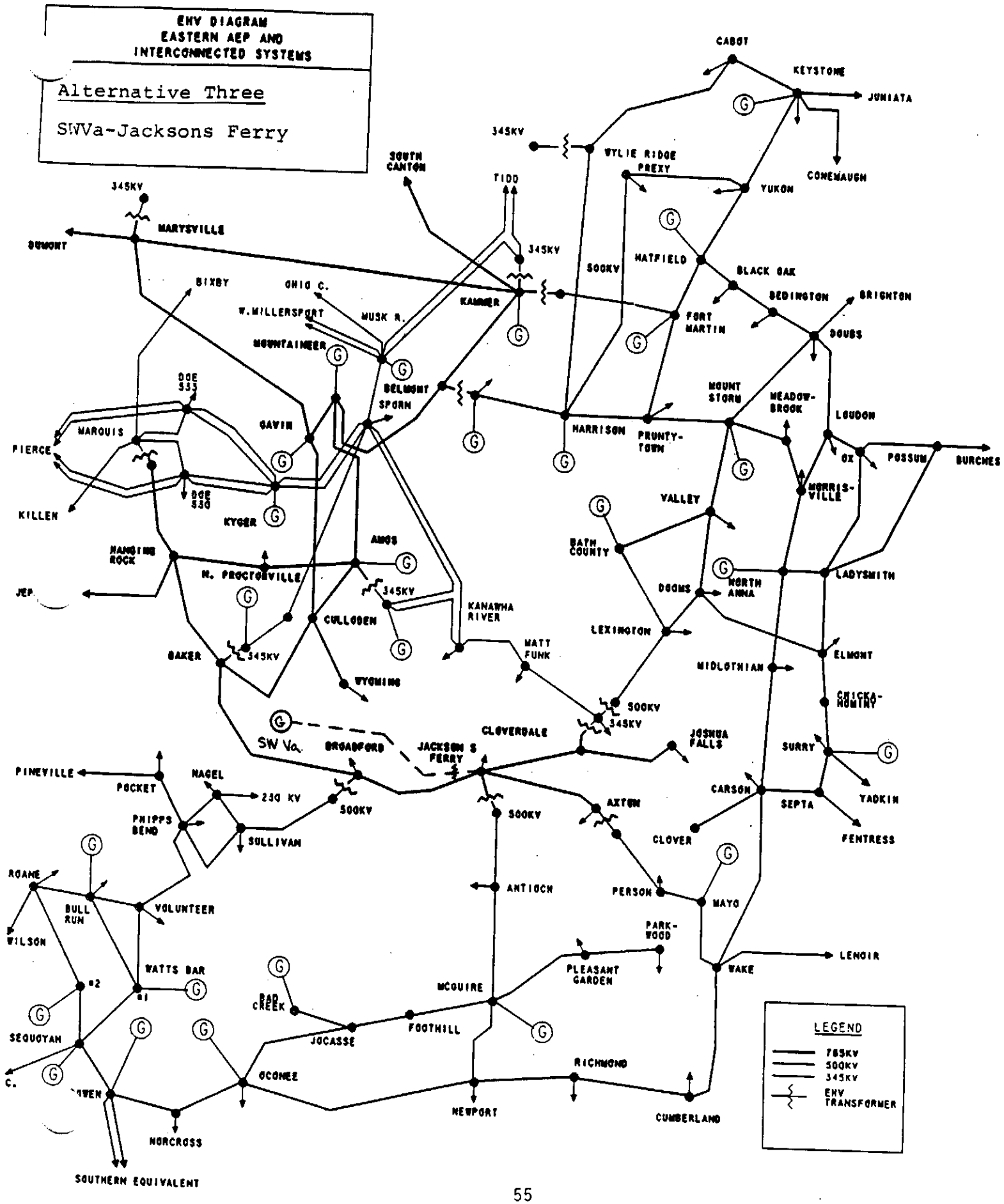
Alternative Two (SWVa-Lexington-Ladysmith plus SWVa-Broadford) is technically viable from VP's perspective, and this plan addresses VP's requirements for two plant outlets. APCo judges this plan to be unacceptable as a result of the connection at Broadford. This connection increases the stress on APCo's critical interfaces during a variety of operating conditions normally anticipated in day-to-day operation such as the unavailability of generation at the SWVa site or the removal from service of the SWVa-Lexington line. Additional analyses would be required to determine the impact of this plan after the APCo/VP reinforcement program is completed.

Alternative Three (SWVa-Jacksons Ferry), as studied, has a negative impact on the Cloverdale-Lexington interconnection. However, if the Cloverdale-Lexington tie between APCo and VP is reinforced (addition of the Cloverdale 765/500 kV transformer and upgrade of the Cloverdale-Lexington 500 kV line) as part of this plan, then the modified plan would be technically viable from APCo's perspective. In addition, APCo would require a transmission service arrangement to wheel the SWVa generating output to the VP system. VP judges this plan to be unacceptable because VP's import capability will be reduced by more than the 500 MW of generation added. VP is opposed to any plan of transmission improvements or generation additions that will lower the already restrictive transfer capability of the existing transmission system. The performance of this plan after the APCo/VP reinforcement program is completed in terms of whether additional wheeling capacity is available for more than 500 MW of generation would need to be studied carefully.

In summary, the load flow studies have confirmed the concerns expressed by APCo and VP representatives that were documented in VCCER's second interim report. None of the plans, as studied, are viable from both APCo's and VP's perspective. However, Alternative One as modified by removing the connection at W. Lexington and connecting the SWVa site directly to Ladysmith via a 500 kV transmission line would be viable from a technical perspective.


EHV DIAGRAM
EASTERN AEP AND
INTERCONNECTED SYSTEMS
Alternative One
SWVa-Lexington-Ladysmith
CABOT
KEYSTONE
JUNIATA
CONEMAUGH
345KV
WYLIE RIDGE
PREXY
YUKON
SOUTH CANTON
TIDD
345KV
500KV
HATFIELD
BLACK OAK
BEDINGTON
BRIGHTON
DOUBS
FORT MARTIN
KAMMER
OHIO C.
W.MILLERSPORT
MUSK R.
MOUNTAINEER
BELMONT
SPORN
MOUNT STORM
MEADOW-BROOK
LOUDON
HARRISON
PRUNTY-TOWN
345KV
BIXBY
BUMONT
MARYSVILLE
DOE 533
DOE 530
MARQUIS
GAVIN
PIERCE
KILLEN
KYGER
VALLEY
MORRIS-VILLE
OX
POSSUM
BURCHES
BATH COUNTY
HANGING ROCK
N. PROCTORVILLE
AMOS
345KV
DOOMS
NORTH ANNA
LADYSMITH
JEFF
KANAWHA RIVER
CULLODEN
LEXINGTON
ELMONT
MIDLOTHIAN
MATT FUNK
W.Lex.
BAKER
345KV
WYOMING
500KV
CHICKA-HOMINY
345KV
SW Va.
CLOVERDALE
JOSHUA FALLS
SURRY
BROADFORD
JACKSON'S FERRY
PINEVILLE
POCKET
NAGEL
230 KV
500KV
AXTON
CARSON
SEPTA
YADKIN
PHIPPS BEND
SULLIVAN
CLOVER
FENTRESS
ROANE
BULL RUN
VOLUNTEER
ANTIOCH
PERSON
MAYO
WILSON
PARK-WOOD
LENOIR
WATTS BAR
#2
#1
BAD CREEK
MCGUIRE
PLEASANT GARDEN
WAKE
SEQUOYAH
JOCASSE
FOOTHILL
RICHMOND
OCONEE
NEWPORT
CUMBERLAND
BOWEN
MCRCROSS
SOUTHERN EQUIVALENT
LEGEND
765KV
500KV
345KV
EHV TRANSFORMER


EHV DIAGRAM
EASTERN AEP AND
INTERCONNECTED SYSTEMS
Alternative Two
SWVa-Broadford and
SWVa-Lexington-Ladysmith
CABOT
KEYSTONE
JUNIATA
CONEMAUGH
345KV
WYLIE RIDGE
PREXY
YUKON
SOUTH CANTON
TIDD
345KV
500KV
HATFIELD
BLACK OAK
BEDINGTON
BRIGHTON
DOUBS
FORT MARTIN
KAMMER
345KV
MARYSVILLE
DUMONT
SIXBY
OHIO C.
W. MILLERSPORT
MUSK R.
MOUNTAINEER
BELMONT
SPORN
DGE 533
DGE 530
MARQUIS
PIERCE
KILLEN
KYGER
GAVIN
HARRISON
PRUNTY-TOWN
MOUNT STORM
MEADOW-BROOK
LOUDON
OX
POSSUM
BURCHES
MORRIS-VILLE
VALLEY
BATH COUNTY
RANGING ROCK
N. PROCTORVILLE
AMOS
345KV
JEFFERSON
DOOMS
NORTH ANNA
LADYSMITH
KANAWHA RIVER
LEXINGTON
ELMONT
MIDLOTHIAN
W. Lex.
CHICKA-HOMINY
CULLODEN
MATT FUNK
BAKER
345KV
WYOMING
500KV
345KV
SW Va.
BROADFORD
JACKSON'S FERRY
CLOVERDALE
JOSHUA FALLS
SURRY
YADKIN
PINEVILLE
POCKET
NAGEL
230 KV
500KV
PHIPPS BEND
SULLIVAN
CARSON
SEPTA
FENTRESS
AXTON
CLOVER
500KV
ANTIOCH
PERSON
MAYO
ROANE
BULL RUN
VOLUNTEER
WILSON
PARK-WOOD
LENOIR
WAKE
PLEASANT GARDEN
WATTS BAR
#2
#1
BAD CREEK
MCGUIRE
FOOTHILL
JOCASSE
SEQUOYAH
B.C.
OCONEE
BOWEN
NORCROSS
SOUTHERN EQUIVALENT
NEWPORT
RICHMOND
CUMBERLAND
LEGEND
765KV
500KV
345KV
EHV TRANSFORMER


EHV DIAGRAM
EASTERN AEP AND
INTERCONNECTED SYSTEMS
Alternative Three
SWVa-Jacksons Ferry
CABOT
KEYSTONE
JUNIATA
345KV
WYLIE RIDGE
PRSXY
CONEMAUGH
YUKON
SOUTH CANTON
TIDD
345KV
MARYSVILLE
DUMONT
500KV
HATFIELD
BLACK OAK
BIXBY
OHIO C.
KAMMER
BEDINGTON
BRIGHTON
W. MILLERSPORT
MUSK R.
FORT MARTIN
DOUBS
MOUNTAINEER
DOE 533
BELMONT
SPORN
MOUNT STORM
MEADOW-BROOK
LOUDON
MARQUIS
GAVIN
HARRISON
PRUNTY-TOWN
PIERCE
OX
POSSUM
BURCHES
DOE 530
KILLEN
KYGER
VALLEY
MORRIS-VILLE
HANGING ROCK
AMOS
BATH COUNTY
N. PROCTORVILLE
345KV
DOOMS
NORTH ANNA
LADYSMITH
JEP
KANAWHA RIVER
CULLODEN
LEXINGTON
BAKER
345KV
MATT FUNK
ELMONT
MIDLOTHIAN
WYOMING
500KV
345KV
CHICKA-HOMINY
SW Va.
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SURRY
PINEVILLE
POCKET
NAGEL
230 KV
500KV
CARSON
SEPTA
YADKIN
PHIPPS BEND
SULLIVAN
500KV
AXTON
CLOVER
FENTRESS
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#1
POD CREEK
MCGUIRE
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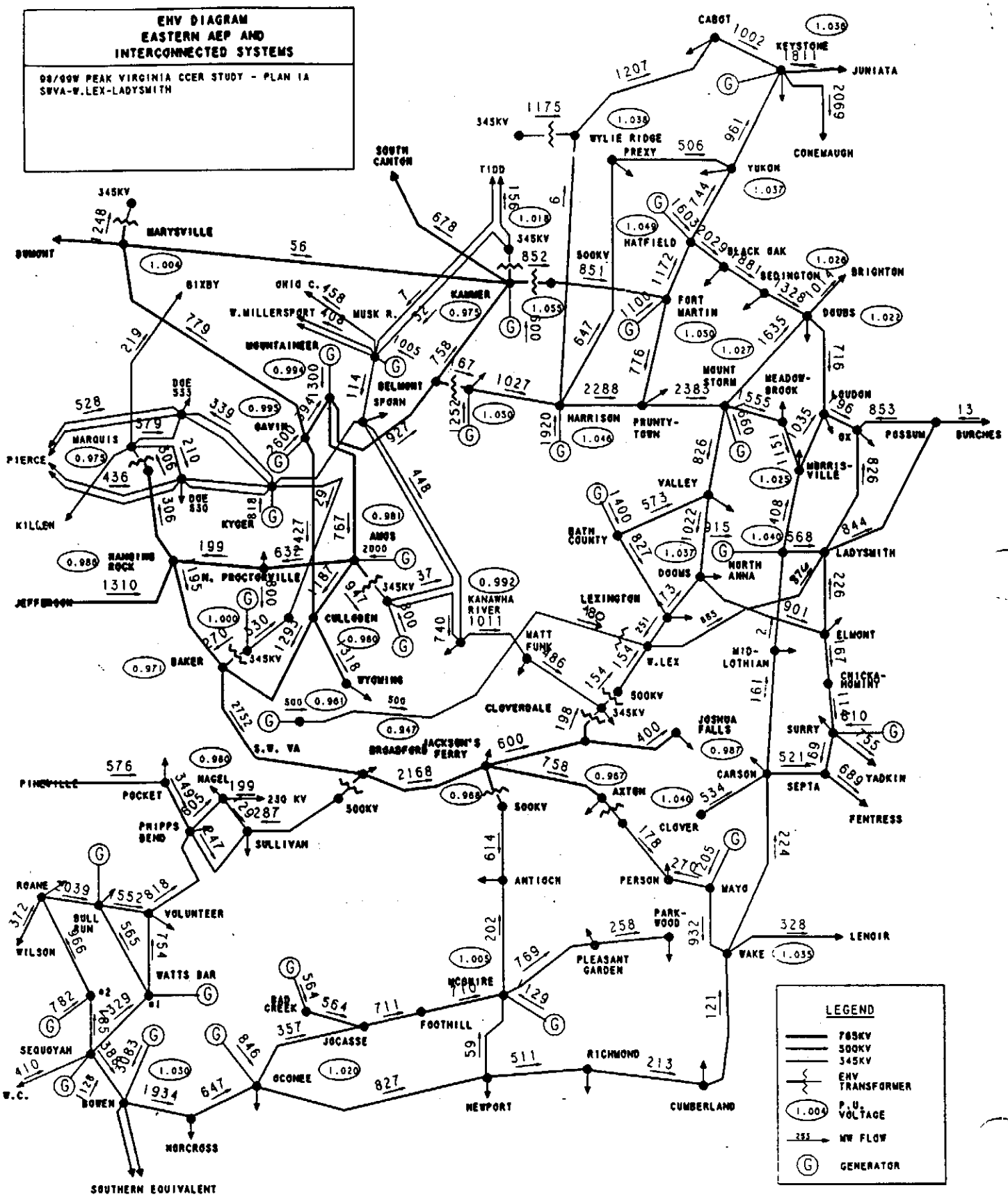
LENOIR
SEQUOYAH
JOCASSE
FOOTHILL
OCONEE
RICHMOND
NEWPORT
CUMBERLAND
NORCROSS
SOUTHERN EQUIVALENT
LEGEND
765KV
500KV
345KV
EHV TRANSFORMER


EHV DIAGRAM
EASTERN AEP AND
INTERCONNECTED SYSTEMS
98/99W PEAK VIRGINIA CCER STUDY - PLAN 1A
SWVA-W.LEX-LADYSMITH
CABOT
KEYSTONE
JUNIATA
CONEMAUGH
WYLIE RIDGE
PREXY
YUKON
SOUTH CANTON
TIDD
MARYSVILLE
DUMONT
BIXBY
OHIO C.
W.MILLERSPORT
MUSK R.
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W.LEX
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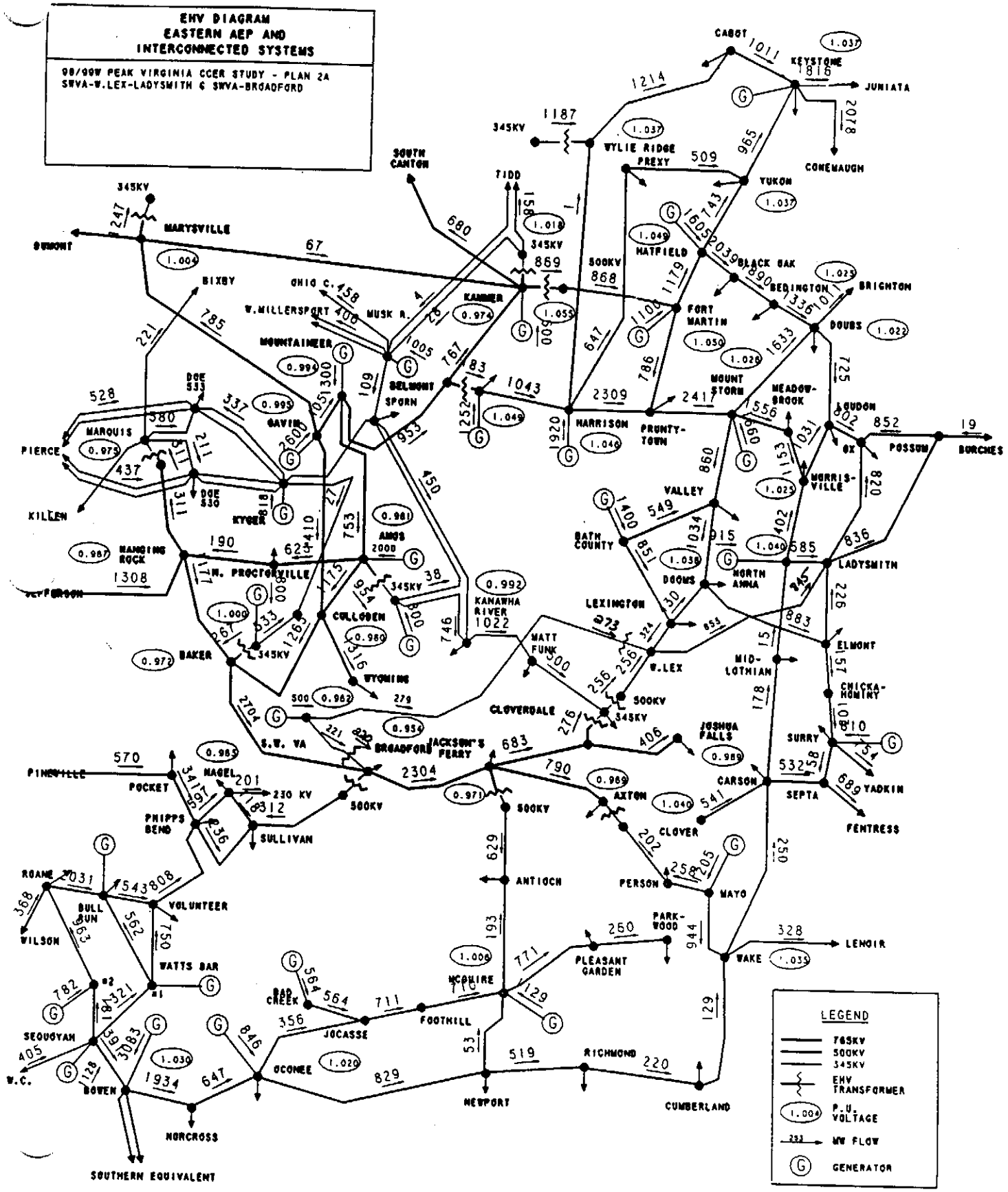
JOSHUA FALLS
SURRY
JACKSON'S FERRY
BROADFORD
AXTON
CARSON
SEPTA
YADKIN
FENTRESS
PINEVILLE
POCKET
NAGEL
230 KV
PHIPPS BEND
SULLIVAN
CLOVER
ROANE
BULL RUN
VOLUNTEER
WILSON
WATTS BAR
ANTIOCH
PERSON
MAYO
PARK-WOOD
LENOIR
WAKE
PLEASANT GARDEN
MCGUIRE
FOOTHILL
JOCASSE
BAD CREEK
SEQUOYAH
BOWEN
OCONEE
NEWPORT
RICHMOND
CUMBERLAND
NORCROSS
SOUTHERN EQUIVALENT
LEGEND
765KV
500KV
345KV
EHV TRANSFORMER
P.U. VOLTAGE
MW FLOW
GENERATOR


EHV DIAGRAM
EASTERN AEP AND
INTERCONNECTED SYSTEMS
88/89W PEAK VIRGINIA CCER STUDY - PLAN 2A
SWVA-W.LEX-LADYSMITH & SWVA-BROADFORD
CABOT
KEYSTONE
JUNIATA
CONEMAUGH
345KV
WYLIE RIDGE
PREXY
SOUTH CANTON
TIDD
YUKON
MARYSVILLE
SUMMIT
BIXBY
OHIO C.
W.MILLERSPORT
MUSK R.
KAMMER
MOUNTAINEER
HATFIELD
BLACK OAK
BEDINGTON
BRIGHTON
FORT MARTIN
DOUBS
DOE 533
DOE 530
MARQUIS
PIERCE
KILLEN
KYGER
GAVIN
BELMONT
SPORN
HARRISON
PRUNTY-TOWN
MOUNT STORM
MEADOW-BROOK
LOUDON
OX
POSSUM
BURCHES
MORRIS-VILLE
VALLEY
BATH COUNTY
DOOMS
NORTH ANNA
LADYSMITH
HANGING ROCK
N. PROCTORVILLE
AMOS
KANAWHA RIVER
LEXINGTON
MATT FUNK
W.LEX
MID-LOTHIAN
ELMONT
CHICKA-HOMINY
SURRY
SEPTA
YADKIN
FENTRESS
CARSON
AXTON
CLOVER
JOSHUA FALLS
CLOVERDALE
S.W. VA
BROADFORD
JACKSON'S FERRY
BAKER
WYOMING
CULLODEN
PINEVILLE
POCKET
NAGEL
230 KV
500KV
PHIPPS BEND
SULLIVAN
ROANE
BULL RUN
VOLUNTEER
WILSON
WATTS BAR
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765KV
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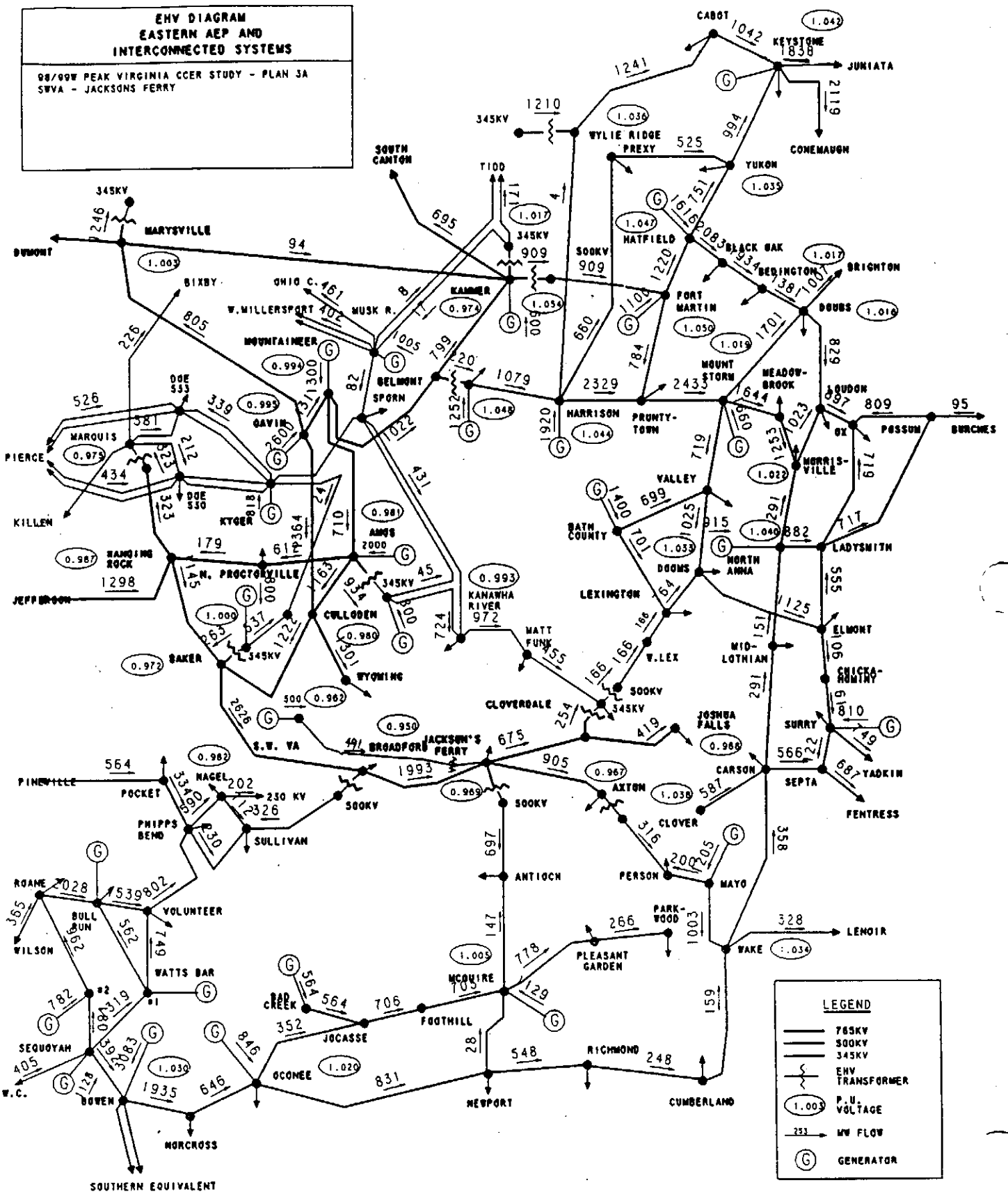
GENERATOR


EHV DIAGRAM
EASTERN AEP AND
INTERCONNECTED SYSTEMS
98/99W PEAK VIRGINIA CCER STUDY - PLAN 3A
SWVA - JACKSONS FERRY
CABOT
KEYSTONE
JUNIATA
CONEMAUGH
WYLIE RIDGE
PREXY
YUKON
SOUTH CANTON
TIDD
HATFIELD
BLACK OAK
BEDINGTON
BRIGHTON
DOUBS
MARYSVILLE
DUMONT
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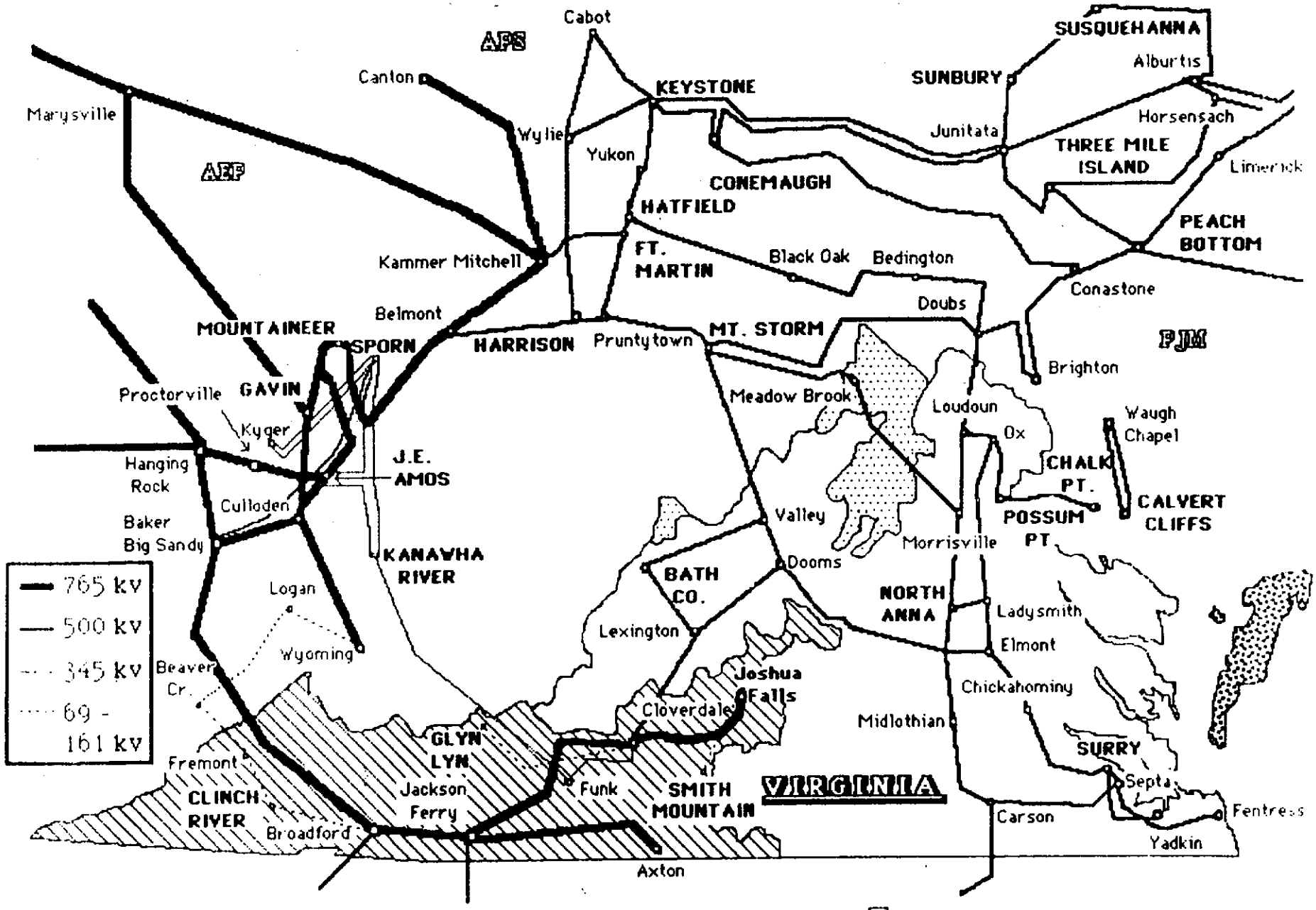
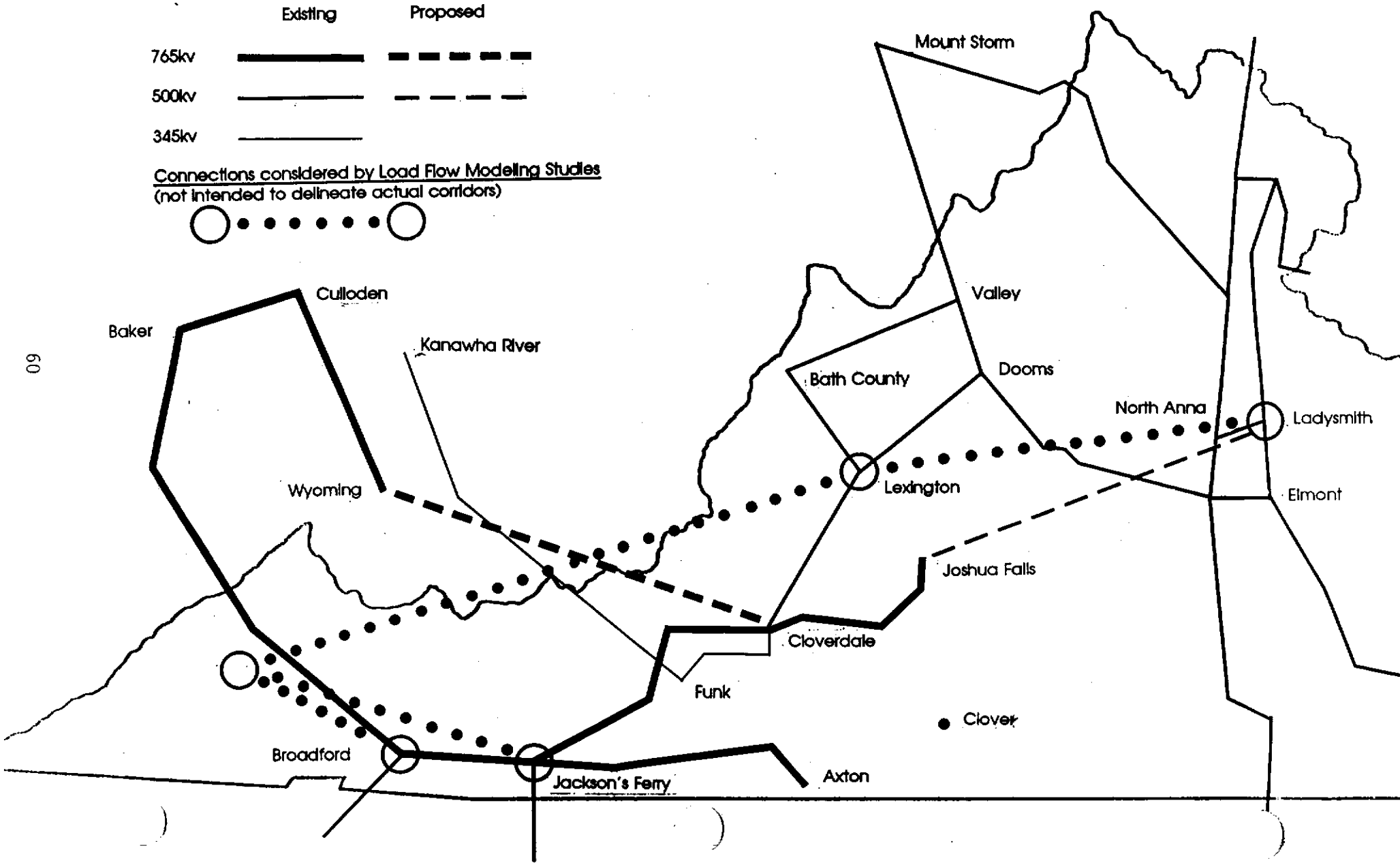
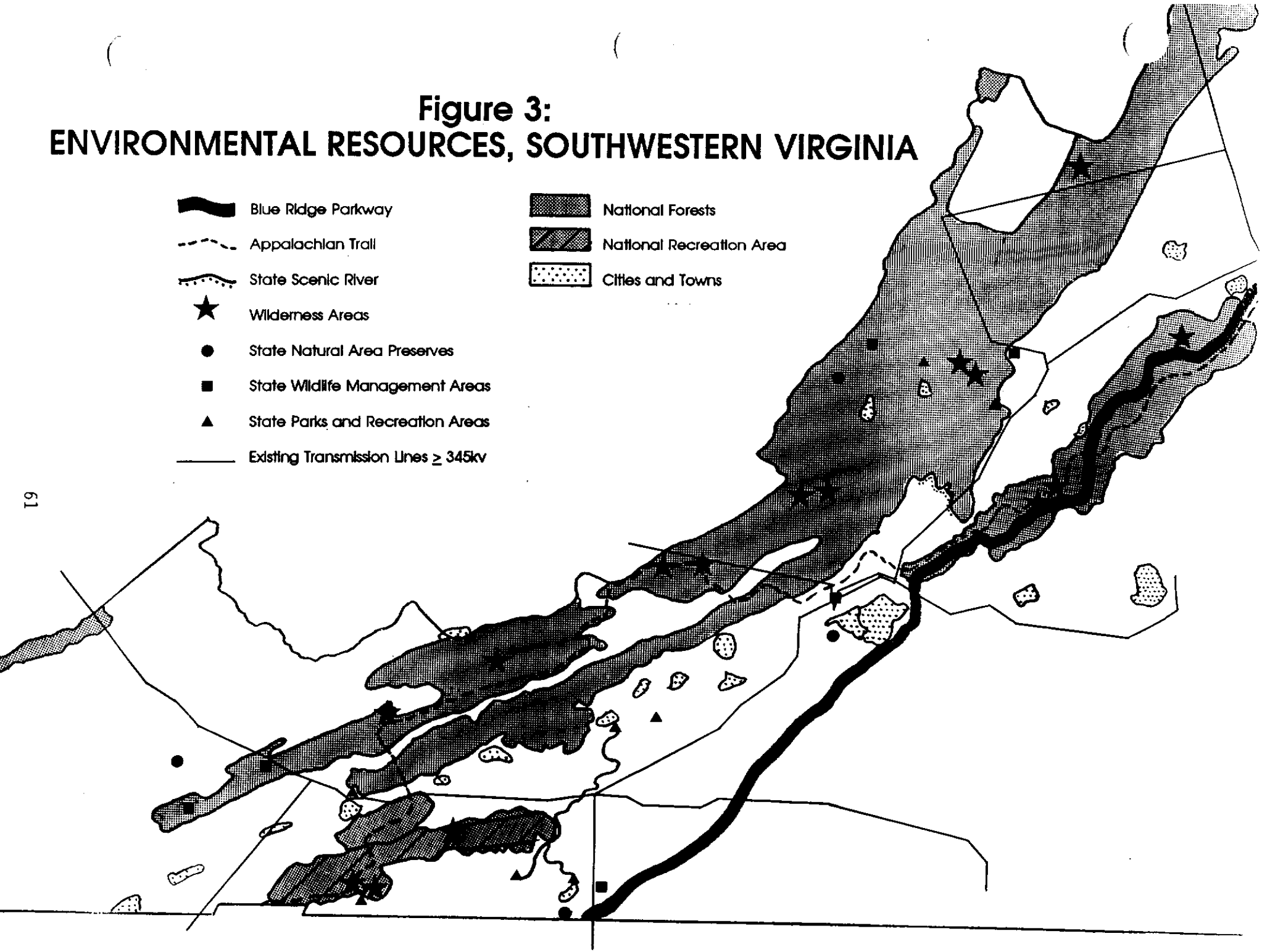
# Figure 1:
# ELECTRIC TRANSMISSION LINES



# Figure 2:
# POWER TRANSMISSION LINES, VIRGINIA AND ADJACENT AREAS



# Figure 3:
# ENVIRONMENTAL RESOURCES, SOUTHWESTERN VIRGINIA



# GENERAL ASSEMBLY OF VIRGINIA--1991 SESSION

## HOUSE JOINT RESOLUTION NO. 441

*Requesting the State Corporation Commission and the Virginia Center for Coal and Energy Research to study means available, prior to 1998, to "wheel" power produced by electric power plants in Southwest Virginia.*

Agreed to by the House of Delegates, February 22, 1991
Agreed to by the Senate, February 21, 1991

WHEREAS, in March 1990, Virginia Power and Appalachian Power Company (APCO) announced joint plans to construct a series of new high-voltage power lines in Virginia and West Virginia; and

WHEREAS, one such power line would originate at Wyoming, West Virginia, and end near Roanoke, Virginia, and another would originate near Lynchburg and end at North Anna, Virginia; and

WHEREAS, Virginia Power and APCO anticipate, if all contingencies are met, that these new lines will increase the east-west electricity transmission capacity available through Virginia by 2000 megawatts or more; and

WHEREAS, Virginia Power and APCO indicate that if the proposed lines are built, a portion of this increased transmission capacity could be used to "wheel" power from proposed electric power plants constructed in Southwest Virginia; and

WHEREAS, APCO and Virginia Power indicate that the Allegheny Power System (APS) and Pennsylvania Jersey Maryland (PJM) power pool must also enhance their electricity transmission systems for the projected increases in transmission capacity, upon which the promised "wheeling" services from Southwest Virginia depend, to be fully realized; and

WHEREAS, the proposed lines may not be constructed until approved by the Virginia State Corporation Commission, the State of West Virginia and the appropriate federal agencies; and

WHEREAS, the Virginia Center for Coal and Energy Research reported in May 1990, that each 100 megawatts coal-fired electric power generation facility constructed in the Virginia coalfields would produce $137 million in capital investment, 125 construction jobs, $1.32 million in annual operating plant wages, $750,000 annually in property taxes, secure jobs for substantial numbers of coal miners, power plant operators and service industry personnel, and significantly increase Virginia coal sales; and

WHEREAS, numerous private, nonutility developers desire to construct power plants ranging in size from 100 megawatts to 400 megawatts each in Southwest Virginia; and

WHEREAS, Virginia Power and APCO are also considering siting new electric power plants in Southwest Virginia; and

WHEREAS, APCO and Virginia Power estimate the increased capacity created by the proposed lines to "wheel" power from such power plants in Southwest Virginia will be available in 1998, but recognize that the actions required of APS and the PJM power pool and the approvals required from state and federal agencies could cause the increased "wheeling" capacity to not be available until later than 1998; and

WHEREAS, if approved, constructed and used for the purposes proffered by Virginia Power and APCO, the proposed electricity transmission lines represent a positive, long-term solution to the need to "wheel" power from Southwest Virginia power plants; and

WHEREAS, the present economic development needs of Southwest Virginia establish the need to study what can be done in the near future to enable power to be "wheeled" from power plants in Southwest Virginia earlier than 1998; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the State Corporation Commission, with the support of the Virginia Center for Coal and Energy Research, is hereby requested to study what steps could be implemented in the near future to enable 100 megawatts or more of power, prior to 1998, to be "wheeled" from electric power plants built in Southwest Virginia. The study should include, but need not be limited to, an examination of: (i) how much transmission capacity currently existing on the transmission system serving Southwest Virginia could feasibly be allocated for such a purpose, and (ii) what enhancements could be made for such a purpose to the existing Southwest Virginia transmission system; and, be it

RESOLVED FURTHER, That the Virginia Center for Coal and Energy Research, with comment and review by the State Corporation Commission, examine the feasibility, in addition to the lines proposed by Virginia Power and APCO, of constructing a new electricity transmission line directly from the Virginia coalfields for such a purpose; and, be it

RESOLVED FINALLY, That Virginia Power and APCO are hereby requested to fully cooperate with the State Corporation Commission and the Virginia Center for Coal and Energy Research in the conduct of these studies and to provide any information requested by the Commission or the Center which is necessary to complete such studies. The Commission and the Center shall take all necessary steps to protect the confidentiality of any proprietary information provided by Virginia Power and APCO for this purpose.

The Commission and the Center should present two interim reports each on their respective studies to both the Virginia Coal and Energy Commission and the Virginia Coalfield Economic Development Authority by June 1, 1991, and September 1, 1991.

The Commission and the Center shall complete their work in time to submit their findings and recommendations to the Governor and the 1992 Session of the General Assembly as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.