PJM
Import Capability Study Procedure Manual

February 24, 2001

Table of Contents

1.0: INTRODUCTION 1

2.0: STUDY OBJECTIVES 1

3.0: STUDY SCOPE 1

4.0: GENERAL PROCEDURES AND ASSUMPTIONS 2

5.0: BASE CASE 2

5.1: POWER FLOW MODEL 2
5.2: TRANSFERS WITHIN EXTERNAL SYSTEMS 3
5.3: LOAD MODEL 3
5.4: NYPP/PJM PHASE ANGLE REGULATOR (PAR) SETTING 3

6.0: DISCRETE OUTAGE SCENARIOS 4

7.0: STUDY CRITERIA 4

7.1: EQUIPMENT LOADING (THERMAL) CRITERIA 5
7.2: VOLTAGE CRITERIA 5

8.0: GENERAL METHODOLOGY 5

8.1: EXTERNAL SYSTEMS' EXPORT METHODOLOGY 5
8.2: LINEAR ASSESSMENT 6
8.3: STUDY PROCEDURE 6
8.4: STUDY GUIDELINES 7
8.5: VOLTAGE ASSESSMENT 9

APPENDIX I ESTABLISHED OPERATING PROCEDURES 10

APPENDIX II PJM REACTIVE ANALYSIS - CRITERIA AND METHODOLOGY 11

APPENDIX III APS/PJM/VP RELIABILITY COORDINATION PLAN - VOLTAGE LIMITATION 13

APPENDIX IV PJM CAPACITY DEFICIENCY SCENARIO UNIT SELECTION 16

APPENDIX V PJM LOAD FORECAST 17

1.0: Introduction

In 1994 the defunct Capacity and Transmission Planning Subcommittee assessed the various components of the methodology for conducting PJM Import Capability Studies (PICS). The assessment concentrated on the realistic representation of emergency operating conditions to ensure results that realistically simulate system conditions during capacity emergencies. Results and recommendations from this assessment were incorporated into the formation of this document, the PICS Procedure Manual of July 1994.

While the scope of work may vary from study to study, the objectives and procedures will remain relatively unchanged. This Procedure Manual will serve as a general guideline to the study teams, help maintain study consistency, and will help bring new participants quickly up to speed. This document should in no way diminish the role of the study teams to bring forth any comments and suggestions that may be incorporated into future revisions of this manual.

PJM requirements specify that generation and transmission resources are to be coordinated so that the probability of load being greater than deliverable capacity resources shall not be greater, on average, than one day in ten years. Among the factors considered in the annual calculation of the probability of load exceeding generation are the characteristics of the loads, the probability of error in load fore-cast, the scheduled maintenance requirements for PJM generating units, the forced outage rates of PJM generating units, and the effects of connections to other systems.

PJM performs a yearly PJM Import Capability Study to determine the assistance available from the interconnected system during a PJM capacity deficiency and uses this value in the above calculation. PJM preserves this benefit of interconnected operations through CBM.

2.0: Study Objectives

The goal of PIC Studies is to establish the PJM Capacity Emergency Transfer Limit (CETL) which is the amount of emergency power that can be reliably transferred to PJM from adjacent regions in the event of a PJM generation capacity deficiency. These transfer limits are used to determine the PJM Tie Benefit that is subsequently used in the establishment of the PJM Reserve Requirement. It is also widely used as part of the process to determine the impact on the PJM import capability due to a major facility addition or other system enhancement.

3.0: Study Scope

The study consists of determining the CETL for simultaneous emergency imports from external systems for a specific year. This transfer analysis considers only the bulk power system as potentially limiting. Underlying network constraints are considered local load limitations.

This assessment is repeated for various system conditions, such as transmission enhancements, to determine sensitivity results.

The study scope is restricted primarily to the appraisal of interregional transfers under steady-state conditions. The study team does not normally conduct appraisals of stability performance. When such a need arises, a separate study scope shall be provided.

4.0: General Procedures and Assumptions

The PJM Planning Committee shall approve general guidelines for study procedures and assumptions including:

1. External firm base transfers and commonly occurring economy transfers that should be modeled;
2. Upper test levels of emergency imports into PJM;
3. Generation outage scenarios; and
4. A tentative work schedule.

Using these general guidelines, the study team will establish a work plan to meet the required schedule. From the base case, different generation outage cases are developed and linear analysis performed to establish emergency import capabilities based on thermal considerations. These transfer capabilities are then checked against reactive limitations and revised as required. The combined results are tabulated and submitted to the PC for review. When all results are finalized, exhibits and tables are prepared for attachments to the final report. Detailed study procedures are discussed in the following sections.

5.0: Base Case

5.1: Power Flow Model

External generation committed as PJM Installed Capacity will be on-line and serving PJM load during the PICS analysis. Conversely, internal generation not committed as PJM Installed Capacity will be on-line and serving external load during the PICS analysis.

The nature of a PICS requires an extensive review of generation and transmission systems in the regions adjacent to PJM. The network model must be of sufficient detail to allow for the testing of transmission limits within PJM and on the PJM interfaces with adjacent regions and also to permit proper evaluation of limits within adjacent regions. In addition, the participation of large amounts of adjacent regions' generation requires an extensive model so that realistic generation models can be used. Furthermore, the combination of large emergency transfers from adjacent regions to PJM and large transfers within and between those regions creates a competing uses problem.

The Allegheny Power System's (APS) Reliability Coordination Plan (RCP) has been the most-limiting, external-to-PJM operating restriction that affects PJM imports. Since this plan was adopted in response to voltage problems at Black Oak and Bedington 500 kV busses, ECAR transfers to PJM and Virginia Power (VP) have at times been curtailed. In order to test for RCP limits in PIC studies, it has become increasingly important to possess an extensive and detailed model not only of the Allegheny Power System where the limits occur, but also of the areas adjacent to APS (Eastern ECAR, Northern VACAR) which also contribute to the problem.

NPCC has been a major supplier of emergency power to PJM in the past, and increased transfers between OH and MECS/NYPP/AEP and between HQ and NYPP/NEPOOL/NB/NS, due to their large potential impact on PJM transfers, require expanded representation of those areas, too.

For these reasons, PIC studies should be conducted using either the full size version of the NERC/MMWG load flow base cases or an available MEN/VEM load flow base that has an expanded PJM model incorporated.

5.2: Transfers within External Systems

Modeling of transfers within external systems in PICS has revolved around the assumption that PJM is experiencing a capacity emergency and the adjacent regions are all able to help to the extent of their installed reserves. Because of this assumption, modeled transfers between regions outside PJM have been restricted to firm purchases reported in EIA-411. This practice assumes that formal economy transactions between outside regions will be curtailed in the event of a capacity emergency. It also assumes that no areas outside PJM are also experiencing a capacity emergency; however some external systems would be in a capacity emergency without their non-firm purchases and it is questionable whether these "economy" transfers would be curtailed. Furthermore, it has been demonstrated that these external systems can have an emergency at the same time as PJM. In conclusion, care should be taken to model all transfers whose curtailment could not be depended on during a PJM capacity deficiency.

5.3: Load Model

Modeling of loads in PIC studies assumes that higher than forecast loads coupled with high generating capacity outages will put PJM into a capacity emergency. For PJM company loads, the study team should use Load Analysis Subcommittee (LAS) prepared loads that reduce the forecast demand by any type of load reductions or load management. This information can be found in the LAS Load Report in Tables B-9 on line 6. Table 1 in Appendix V provides an example of this table. These loads should be increased by the appropriate factor that will convert PJM weather normalized peak loads to LAS 90/10 peak loads for the year studied (Appendix V, Table 2). The resultant company loads should then be reduced to reflect diversity in the companies' peak loads so that the sum of the company loads equals the PJM Pool 90/10 peak load. The portion of any company's load that is above its LAS Load Report Tables B-9 line 4 load shall be modeled as uncompensated load with an eighty percent power factor. This methodology is consistent with reactive planning practices for compensating forecast peak loads.

Capacitors should be modeled for the busses represented in the base case and for those one voltage level below in the same substation.

5.4: NYPP/PJM Phase Angle Regulator (PAR) Setting

The flow on the 345 kV Ramapo PARs shall be maximized in PICS. This means that the maximum flow of 1000 MW into PJM should be held when possible within the angular limits of the PARs.

The PARs between Public Service Electric & Gas Company (PSE&G) and the Consolidated Edison Company (Con-Ed) shall also be maximized at the contract limit. During normal system conditions PSE&G receives 1,000 MW from NYPP at Waldwick and delivers it to Con-Ed at Farragut and Goethals. During PJM emergencies, contracts allow for PJM emergency use of 700 MW of this power by curtailing the delivery at Farragut and Goethals to 300 MW. In some instances because of high generation in SENY, PSE&G may be unable to deliver the 300 MW to

Con-Ed. When this occurs, it can be assumed that Con-Ed does not need the 300 MW from PSE&G and consideration can be given to allowing 1,000 MW net to PSE&G.

6.0: Discrete Outage Scenarios

PIC Studies should test a variety of different possible capacity deficiency scenarios for the purpose of obtaining a bandwidth of PJM CETLs. A wide range of CETLs is possible depending on how the PJM capacity deficiency is represented. All outage scenarios shall outage units only within boundaries PJM that have been committed as PJM Installed Capacity.

There are practical limitations to the number of scenarios that can be tested in a reasonable amount of time. The study team must try to cover all the eventualities by modeling different scenarios that attempt to stress the different interfaces between PJM and the adjacent regions. To try to cover all the requirements listed above, each of the capacity deficiency scenarios should attempt to model a different combination of contributing causes:

- Model one scenario that represents a uniform capacity deficiency in each PJM company based on EFOR. This will be similar to the VEM/MEN method.
- Model at least three scenarios that stress each of the different PJM regions (Western, Southwestern, and Eastern regions). When developing these scenarios, start from the uniform capacity deficiency scenario and outage capacity so that at a representative PJM base import level nearly 25% of installed capacity is out of service in the stressed region.

The three PJM capacity regions, western, southwestern, and eastern are defined as follows:

> *Eastern:* Capacity located east of the PJM eastern interface;
>
> *Southwestern:* Capacity located west of the PJM eastern interface and south of the Pennsylvania/Maryland border; and
>
> *Western:* Capacity located west of the PJM eastern interface and north of the Pennsylvania/Maryland border.

Appendix IV: PJM Capacity Deficiency Scenario Unit Selection, provides an example calculation method of choosing units to outage in the three regions for the four capacity deficiency scenarios.

7.0: Study Criteria

Emergency import capabilities are determined with observance of the *MAAC Reliability Principles and Standards Section 7B*. The security criteria applied are normally restricted to equipment loading and voltage constraints. Appraisals of stability limitations are done under the scope of a different study. The MAAC region is not currently limited by stability criteria.

7.1: Equipment Loading (Thermal) Criteria

The bulk electric supply system shall be operated in such a manner so that all transmission equipment loadings are within normal continuous ratings on a pre-contingency basis, and within applicable emergency ratings following a contingency. In PJM the applicable short time ratings of transmission lines and transformers are generally applied. It should be noted that PJM tie line ratings are based on the more restrictive sets if there exists different ratings between PJM and its neighboring region. The study team should monitor critical and commonly occurring thermal limitations in external systems and should be guided in their selection by limits found in the MEN and VEM reports.

The study team should keep an up-to-date list of monitored elements whose pre- and post-contingency ratings are to be observed in linear analysis. Single contingencies involving critical transmission elements of 230 kV and above should be simulated. Depending on the nature and conditions of the study, other contingencies and critical facilities may also need to be considered. The study team is encouraged to bring forth any additional contingencies that could be incorporated in future revisions of this Manual. Further established operating procedures, which are deemed to have an impact on equipment loading, are also considered and simulated as required. Appendix I provides a summary of these procedures.

7.2: Voltage Criteria

The pre-contingency voltage on all PJM 500 kV busses must be at or above 1.0 per unit and the minimum post single contingency voltage must be at or above 0.95 per unit.

Maximum power transfers across critical interfaces within PJM are established to ensure reliable operation. In general, PJM transfer limits are set to a transfer level coinciding with either a 200 MW transfer backoff from the last convergent case or a 5% voltage drop at certain busses, whichever is more restrictive. Appendix II more clearly explains the PJM voltage criteria and methodology.

The integrity of the APS bulk transmission system is maintained through their RCP by controlling the precontingency flows on critical circuits so as to preclude voltage collapse on a postcontingency basis. Appendix III explains the APS RCP criteria and methodology in detail.

8.0: General Methodology

8.1: External Systems' Export Methodology

External systems' export participation should be limited to those areas adjacent to PJM and include parts of ECAR, NPCC and SERC. Capacity participation percentages of these regions shall be approved by the Planning Committee (PC).

The participating companies within these regions shall be:

ECAR: AEP, APS, & CAPCO

NPCC: NYPP, OH, & HQ (2000 MW)

SERC: the VACAR companies

CETLs are based on and to a large extent determined by the amount of emergency power that each adjacent pool can be expected to provide to PJM. In past PICS, a given region's proportion of the total transfer, or its participation level, was determined solely by its proportion of the total reserves of the three adjacent regions. In more recent PICS, this practice was modified by assuming high availability of reserves for one region while other regions had a low availability. Unfortunately, this modification still did not address the problem of "bottled" reserves. Bottled reserves are reserves unavailable for transfer due to transmission or other limitations. These limits arise from the nature of the interconnections between regions and subregions and are also a reflection of the way in which those systems are operated. Each of the three regions that tie to PJM has special characteristics that affect its ability to provide emergency power.

The capacity participation of the adjacent regions should not be based solely on the reserve capacity in those regions. It should be restricted to the amount of power that the regions can reliably transfer to PJM and capped at their reserve capacity level. Each region's participation should be determined by ac and linear analysis of adjacent region and PJM limitations. The final participation of each region should be based on the value obtained through an analysis of maximum simultaneous transfers to PJM. This would reflect the way the system is actually operated and assumes sufficient time for generation adjustment in external systems to benefit PJM. The maximized simultaneous values of CETL resulting from all the scenarios studied will be forwarded to the PJM PC for their approval and use.

8.2: Linear Assessment

The ability of the bulk power system to transfer from one area to another is often constrained by the thermal capability of transmission elements or established interface flow limits for various normal and contingency conditions. To efficiently determine the thermal and interface flow limitation for various transfers a linear load flow solution can be used. Linear load flow, dc load flow, is a non-iterative numerical technique for the approximate but rapid calculation of load flow solutions. By ignoring reactive power flow and changes in voltage magnitudes, numerous contingencies can be rapidly evaluated.

8.3: Study Procedure

Listed below is the procedure that should be used by the study team to determine the PJM CETL:

8.3.1: Establish a Base Condition

An evaluation of emergency import capability is based on a simulation of the power system performance. The power system model represents a single "snapshot" of the condition of the system. Different patterns of demand and generation cause variation in emergency import capabilities on an hour-by-hour basis. The CETL determined in the study should therefore be considered as a representative rather than a definitive value.

The model used is developed from the NERC/MMWG seasonal base cases or an available MEN/VEM load flow case with an expanded PJM representation. This case is modified to include additional contracted transfers plus a number of significant economy transactions that may occur on the system. If required, other changed cases may also be developed for sensitivity testing of specific system enhancements that are not already modeled in the base case.

8.3.2: Develop Outage and Monitored Line Lists

Lists of contingencies (line, transformer and generator trips) along with a list of crucial lines, transformers, and interfaces to be monitored are maintained by the PJM OI. The lists should be reviewed at the beginning of each study for completeness and accuracy.

8.3.3: Develop Generation Dispatches for each Regional Transfer to be Simulated

The dispatch methodology is based on an emergency demand scenario. An emergency situation is simulated in which critical PJM generating facilities are unexpectedly outaged while higher-than-expected loads are encountered, causing PJM to request emergency power from neighboring systems. In response to the request the neighboring systems increase their generation in order to meet PJM's deficiency. The exporting systems should pick up generation according to economics, while PJM reduces generation at certain plants in order to represent a pessimistic but realistic emergency transfer scenario. PJM generation shall be discretely reduced in proportion to the dispatched generation in the sub-areas. Care must be taken when reducing generation on or near the interface between PJM and a neighboring system so as not to distort the results of the study.

8.3.4: Calculate the CETL

Each of the discrete outage scenario's CETLs is calculated for simultaneous emergency imports to PJM from ECAR, NYPP and VACAR.

8.4: Study Guidelines

8.4.1: Local Limits

A local limit is a facility that has an outage transfer factor (OTF) of less than 2%. Usually a facility with a low transfer response shows up to be limiting because it is heavily loaded in the base case and not as a result of transfers. The 2% OTF cutoff is a guideline and not a rigid value. During base case preparations, care should be taken that internal generation is not dispatched to bring local limits close to their rated capability. The owner of the facility in question should be consulted on whether the limitation needs to be considered as a limit or if a local generation adjustment can be employed to alleviate the loading on the facility. For transfers that are limited by pre-contingency operation, the 2% cutoff applies to the transfer distribution factor.

8.4.2: Operating Procedures

When an operating procedure is identified, a verification case should be run with the operating procedure in effect to determine if additional limits to the transfers are identified. The table of limitations should clearly show whether an operating procedure was in effect in order to obtain the noted CETL.

Appendix I provides a list of operating procedures that are currently employed. Application of an operating procedure that is not documented herein is subject to the review and approval of the PC.

If an element for which operating procedures exist limits a transfer, then the limitation may be removed by applying the operating procedures. These procedures usually include opening a restrictive line or automatic opening of overloaded circuit.

For example, the East Sayre to North Waverly 115 kV circuit could open automatically under an actual overload condition. If PJM is limited by this circuit following the loss of, say, the East Towanda to Hillside 230 kV circuit, then the limit may be removed providing that the opening of the overloaded circuit does not result in reducing the CETL to level below that of no automatic operation.

With the operating procedures applied, other elements may become limiting, perhaps at a transfer level that would preclude the application of such procedures. Regardless of the outcome, the operating procedures must be simulated to duly assess their overall impacts. An example will serve to illustrate the CETLs to be determined when operating procedures are applied.

Example Operating Procedures

Case	Import Limit (MW)	Limiting Facility	Contingency/Operating Procedure
#1	2000	E. Sayre-N. Waverly	E. Towanda-Hillside
#2	2200	Laurel Lake-Goudey	E. Towanda-Hillside and auto-opening of E. Sayre-N. Waverly
#3	1900	Laurel Lake-Goudey	E. Towanda-Hillside and auto-opening of E. Sayre-N. Waverly

In case #2 transfer capability is improved and the operating procedure can be applied to remove the limit imposed by the East Sayre to North Waverly circuit. In case #3 the operating procedure does not improve transfer capability and therefore should not be applied. The CETL reverts back to 2,000 MW with the East Sayre to North Waverly line remaining as the limiting element.

Occasionally, the application of an operating procedure may result in a higher transfer that is now limited by another element for which operating procedures also exist. The current practice is not to perform simulation of subsequent line openings to assess the cascading effects.

8.5: Voltage Assessment

At present, two sets of voltage-based transfer limits are known to have an impact on the interregional transfers examined in PIC studies:

1. PJM West, Central and East Interface Limits, and
2. RCP Limits

Voltage assessment is performed using ac analysis and needs only to be performed at the first limit obtained from thermal analysis. Recognized contingencies are then applied, and pre- and post-contingency voltages at critical busses are checked against the applicable criteria. If all voltage criteria are satisfied, the CETL shall be the thermal limit. Otherwise, transfers are reduced until all voltage criteria are satisfied, and the reactive limit shall replace the thermal limit as the CETL.

Appendices II and III provide descriptions of the methods with which the PJM transfer limits and the RCP limits are determined.

Appendix I
Established Operating Procedures

There exist established operating procedures that would be employed under the appropriate set of conditions to alleviate potential limits. These procedures take the form of opening lines (depending on system conditions), adjusting PAR settings, or recognizing the operating characteristics of protection systems. In situations where it is considered appropriate to assume the opening of a facility, the transfer limit shall be recalculated as a multiple event with the critical contingency and the operating procedure taken together.

Known operating procedures that could affect the interregional transfer are:

- If system conditions permit, certain GPU/NYPP and GPU/ECAR 115 kV and 138 kV facilities may be opened at the discretion of the system operator if they impose a limit on PJM, NYPP, or ECAR operations. These facilities are Tiffany-Goudey, Laurel Lake-Goudey, Carroll-Germantown, Grand Point-Roxbury, Garrett-Garrett Tap, and Social Hall-East Blairsville lines. Opening of these lines must not create an actual or contingency overload elsewhere.
- Overcurrent relays are installed on the Warren-Falconer, North Waverly-East Sayre, and Burma-Piney 115 kV lines. These lines would open automatically when overloaded.
- When the Cedar Grove-Clifton K 230 kV circuit poses a limit to emergency transfers, flows on this line can be relieved through PAR adjustment or generation redispatch in Northern PSE&G.

Appendix II
PJM Reactive Analysis - Criteria and Methodology

Background

The PJM Power Pool currently performs off-line ac load flow analysis to determine transfer interface limits for use in real-time system operations. The reactive limit criterion allows PJM to be operated reliably for those situations in which PJM west-to-east transfer become significant enough to warrant a consideration of voltage-based constraints in pool operation. The west-to-east transfers originate from three sources: intra-PJM generation dispatch, inter-pool economy energy transfers (predominantly from systems west of PJM), and inadvertent transmission loop flows. The continuous existence of one or more of these transfers presently requires that PJM constantly develop and impose voltage-based interface limits.

Three limit indicators ("transmission line cut-sets" or "transfer interfaces") are developed in the PJM reactive limit analysis. These indicators include the following PJM 500 kV transmission line cut-set MW flow summations:

Western Transfer Interface Indicator

Keystone - Juniata
Conemaugh - Juniata
Conemaugh - Hunterstown
Doubs - Brighton

Central Transfer Interface Indicator

Keystone - Juniata
Conemaugh - Juniata
Conastone - Peach Bottom

Eastern Transfer Interface Indicator

Wescosville - Alburtis
Juniata - Alburtis
TMI - Hosensack
Peach Bottom - Limerick
Peach Bottom - Keeney

These transfer interfaces' indicators are composed of MW line flows that are pre-contingency values, not post-contingency flows nor any combination of pre- and post-contingency flows.

The reactive limit criteria ensure that PJM is operated so that no single-contingency loss of generation or transmission within or outside PJM will cause a voltage deviation greater than 5% at any PJM 500 kV facility. The transfer interfaces are monitored and controlled to remain at or below the pre-determined transfer limits. The transfer limits are considered by system operations to be normal or long-term ratings for the line summations, and hence are monitored and controlled as a single facility with a single normal or pre-contingency rating that applies to the cut-set.

Interpretation of Reactive Limits

Each interface's voltage drop curve is used to evaluate the limiting transfer interfaces. Transfers are reduced 200 MW from the last convergent point on the voltage drop curve. The lowest of either the 200 MW back-off transfer value or the transfer interface value corresponding to the 5% voltage-drop point is deemed to be the initial limit estimate for the particular transfer interface.

The interface that has the lowest west-to-east PJM import value is the reactive-limiting transfer interface and the corresponding PJM import value is the reactive import limit. This import value is an approximation of one time snapshot used by planners and operators to compare with other similar values, determined for varying assumed system conditions, in the evaluation of system operating conditions and potential system enhancements.

Load Flow Assumptions

The critical load flow assumptions shall include but not be limited to the following:

- bus loads are modeled as constant P and Q in both the pre-contingency and contingency cases;
- LTC transformers that can regulate in the pre-contingency case are fixed in the contingency case;
- generators which regulate voltage at a remote bus in the pre-contingency case shall be set to regulate their terminal bus at the pre-contingency voltage level in the contingency case; and
- PARs will be set at a fixed angle in the contingency case, i.e., the PARs shall not be allowed to readjust to hold their desired MW or MVAR flows.

For PJM generator contingencies, the inertial increase of on-line generators shall be used to pick up the amount of generation outaged. This modeling is used in planning studies that assess transfer limit values and economic import capabilities, and will ensure consistency of results among planning and operating studies.

Appendix III
APS/PJM/VP Reliability Coordination Plan - Voltage Limitation

Prevailing west-to-east economic transfers have resulted in heavy loading on 500 kV facilities along the interface between APS, VP, and Western PJM. The APS/PJM/VP Reliability Coordination Plan (RCP) has been jointly developed and implemented by APS, PJM, and VP to monitor key line loadings and maintain secure voltage levels at critical busses, including Bedington, Black Oak, and Conemaugh 500 kV.

The RCP is designed to ensure reliable operation of the bulk power system following critical single contingencies in the APS, PJM, and VP systems. In the RCP voltage analysis, single contingency limits are developed for specific facilities and applied to operations in a way similar to short-term or 4-hour thermal ratings. ac load flow analysis is used to predict the post-contingency line loading versus post-contingency voltage performance at these facilities. Four action levels, Levels I through IV, are defined to specify the point at which additional west-to-east transfers are to be prohibited or ongoing transfers are to be curtailed. These action levels are derived from the post-contingency voltage versus line flow curves described in detail below, and designated actions that improve operating conditions are specified in the following manner:

> Level I, Controlled Loading Level is the operating level determined by the initiating control area where the increase in transfers should be controlled in anticipation of a deteriorating reactive or thermal situation.
>
> Level II, Small Block Curtailments is the operating level that will result in marginally acceptable post-contingency operation while anticipating increased transmission loading. Transfers are frozen or may be curtailed up to 500 MW per pass in anticipation of a deteriorating reactive or thermal situation.
>
> Level III, Large Block Curtailments is the operating level that will result in the minimum acceptable post-contingency operation. Curtailments may be up to 1,000 MW per pass.
>
> Level IV-A, Emergency Operations is the operating level where probable voltage collapse or cascading thermal overloads will result if a critical single contingency should occur.
>
> Level IV-B, Emergency Load Shed is the operating level that analysis has shown can result in imminent voltage collapse or cascading thermal overloading. A critical contingency has occurred and load shedding by APS, PJM, and VP should be initiated immediately to avoid a system collapse.

Participating control areas must reduce their imports within a reasonable time, 20 minutes, using all available means, including emergency procedures such as voltage reduction, interruptible curtailments, starting of combustion turbines, and load shedding. Upon notification of load shedding by either PJM or VP, APS will also shed load to maintain system reliability.

Level IV-A should only be experienced after the occurrence of a less critical contingency or when curtailments were not of sufficient magnitude in previous levels.

RCP Level II limits should be applied to establish transfer capabilities. This is consistent with the methodology employed by the VEM and MEN Study Committees in their operating studies and PJM's current approach to determine interregional transfer levels.

Development of the post-contingency curves involves plotting the post-contingency MW line flow versus post-contingency voltage for a specified set of circumstances involving 1/ a contingency, 2/ a limiting facility, which is the voltage at a bulk power, 500 kV bus that is particularly sensitive to changes in west-to-east transfers for the contingency, and 3/ the post-contingency MW flow of a transmission line that is connected to the limiting facility bus. Table III-1 is a list of associated contingencies and limiting facilities that are presently used in RCP analysis.

When a curve has been sufficiently developed (i.e., a voltage decay appears as line loading increases) for each transfer studied, a point is found on the curve where voltage collapse appears imminent or where the curve becomes especially steep or vertical. From this point a 50 MW safety margin in post-contingency line flow is determined and labeled as Level IV. From Level IV additional 50 MW operating margins are determined and labeled Levels III, II, I so that a Level I would correspond to a line flow that is backed-off 200 MW from the apparent point of voltage collapse.

In APS system operations, each limiting facility will have a post-contingency MW flow limit that is specific to each contingency for which the facility is monitored.

One assumption made when developing the RCP limits is that PJM and VP import power from ECAR in a two-to-one ratio (i.e., for every 2 MW PJM import, VP imports 1 MW). Interregional transfers are varied in accordance with economic dispatches. A final assumption is that the base case transfers normally include economic transfers, and the RCP analysis represents a snap shot of incremental transfer under a given set of system operating conditions that an operator may expect to see on any given summer or winter day.

The critical load flow assumptions shall include but not be limited to the following:

- bus loads are modeled as constant P and Q in both the pre-contingency and the contingency cases,
- LTC transformers shall be allowed to regulate in both the pre-contingency and the contingency cases,
- generators shall be allowed to regulate voltage at remote busses in both the pre-contingency and the contingency cases, and
- PARs shall be allowed to readjust to hold their desired MW or MVAR flows in both the pre-contingency and the contingency cases.

Monitored Facilities

Line Flows	Bus Voltages
Hatfield-Black Oak 500 kV	Bedington 500 kV Black Oak 500 kV
Black Oak-Bedington 500 kV	Bedington 500 kV Black Oak 500 kV
Mt. Storm-Meadowbrook-Morrisville 500 kV	Meadowbrook 500 kV

Contingencies

Mt. Storm-Meadowbrook-Morrisville 500 kV

Mt. Storm-Doubs 500 kV

Pruntytown-Mt. Storm 500 kV

Conemaugh-Hunterstown-Conastone 500 kV

Table III-1: RCP Analysis Monitored and Contingency Facilities

Depending on the nature and conditions of the study, other contingencies and critical facilities may also need to be evaluated.

Appendix IV
PJM Capacity Deficiency Scenario Unit Selection

Worksheet A illustrates one way to choose capacity within a region to model the different capacity deficiency scenarios. The suggested procedure is as follows:

Required Inputs: Unit, capacity, unit-type, and EFOR.

1. Capacity is grouped into the three capacity regions: eastern, southern, and western. Capacity is further segregated into the three unit-type subgroups within the regions: nuclear, steam, and all remaining unit-types. Capacity should be sorted by descending EFOR or unit-size within the subgroups.
2. Capacity is summed by region and by subgroup within each region.
3. EFOR capacity is calculated by taking the product of each unit's capacity and EFOR.
4. The amount of capacity to outage is determined for the base case. For example, if the PJM installed capacity and load are 60,000 and 50,000 MW respectively, and the base interchange is 1000 MW out, then the on-line capacity target value is equal to 50,000 + 1000 = 51,000 MW. The amount of capacity that must be outaged to meet this capacity target is equal to 60,000 - 51,000 = 9,000 MW.
5. The uniform capacity deficiency target value is obtained by uniformly scaling the EFOR capacity value subgroup totals until their sum equals the desired outage target.
6. Capacity is selected for outaging within each subgroup to approximate the subgroup capacity outage target. As previously described, 1/ a capacity deficiency is more likely to occur through the unavailability of a relatively small number of large units rather than a very large number of small units, and 2/ the probability of losing units with high historical unavailability is greater than that of losing units with low historical unavailability; therefore outage the larger units within each subgroup, and choose those units with higher EFORs to remain consistent with these phenomena.
7. Once a generator has been placed on out-of-service status, it must also be out-of-service at higher PJM imports levels.
8. High-regional capacity deficiency scenarios are developed from the uniform capacity deficiency scenario by outaging additional capacity in the region to be stressed. Capacity should be outaged so that approximately 25% of the stressed region's installed capacity is out-of-service in the base case. The unit selection procedure is the same as used for the uniform capacity deficiency scenario.

Appendix V
PJM Load Forecast

Table B-9 and PJM Unrestricted Peak Load Forecast

POTOMAC ELECTRIC COMPANY
1996 PJM Load Forecast Report
Table B-9f: Impact of Load Management and Non-Utility Generation
February 1996

	1998
(1) Peak Excluding Load Management & NUG	6385
(2) Owner Retained NUG	2
(3) Load Reductions	532
(4) PJM Accounting Peak: (1) - (2) - (3)	5851
(5) Load Management Delegated to PJM	291
(6) Actual Expected Peak: (4) - (5)	**5560**

Table 1. 1996 PJM Load Forecast Report Table B-9f

Year	90/10 Low	Weather Normalized Peak	90/10 High
1998	46107	**48363**	**50619**

Table 2. PJM 1995 Unrestricted Peak Load Forecast