OHIO VALLEY ELECTRIC CORPORATION

2016 TRANSMISSION PLAN

Prepared On OVEC's behalf by:
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Foreword

American Electric Power (AEP) completed this Transmission Performance Appraisal on behalf of the Ohio Valley Electric Corporation (OVEC)

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Executive Summary

The Ohio Valley Electric Corporation (OVEC) system in the near-term planning horizon is projected to meet the requirements of both OVEC planning criteria and the applicable NERC Transmission Planning Standards.

Steady State studies examined performance of the planned OVEC system at the projected summer peak load levels and planned systems of 2017 and 2021, and 2021 Spring Light Load conditions. A sensitivity analysis examined 2021 summer peak load performance assuming that several generators in the area were retired or otherwise unavailable. Results of these studies identified outage conditions which could overload elements of several OVEC tielines to neighboring systems. The limiting elements are owned by the other systems. OVEC will communicate these results to the facility owners for their consideration. In addition, transfer capability analysis was used to examine incremental transfer capabilities for transfers into, out of, and across the OVEC system.

Short Circuit studies were carried out in 2015, reflecting known changes in the vicinity of the OVEC system. It was determined that the highest anticipated breaker duties are approximately 89% of capability. Based on a comparison of network topology changes between the models used in the 2015 assessment and those used in this 2016 assessment, the 2015 Short Circuit study is deemed to still be valid. The results of the previous studies are provided for reference in Appendix D. Replacement of the last antiquated bulk oil breaker at Kyger Creek was completed in 2016. Replacement of older Air Blast breakers at Clifty Creek with modern SF6 breakers of similar interrupting capabilities also began in 2016.

Previous studies of the stability performance of the Clifty Creek and Kyger Creek plants have been determined to still be valid. These studies indicated that performance meets the requirements of the NERC TPL standards. The previous assessments are provided for reference in Appendix E for Kyger Creek and Appendix F for Clifty Creek.

In light of the results documented in this 2016 assessment, the existing and planned OVEC system is expected to meet the NERC TPL standards without any additional transmission reinforcements or upgrades through 2026.

Introduction

This report provides an assessment of the OVEC transmission system as required by the NERC Transmission Planning Standards. This assessment, and the studies it documents, is also an integral part of the open planning process instituted in response to FERC Order 890.

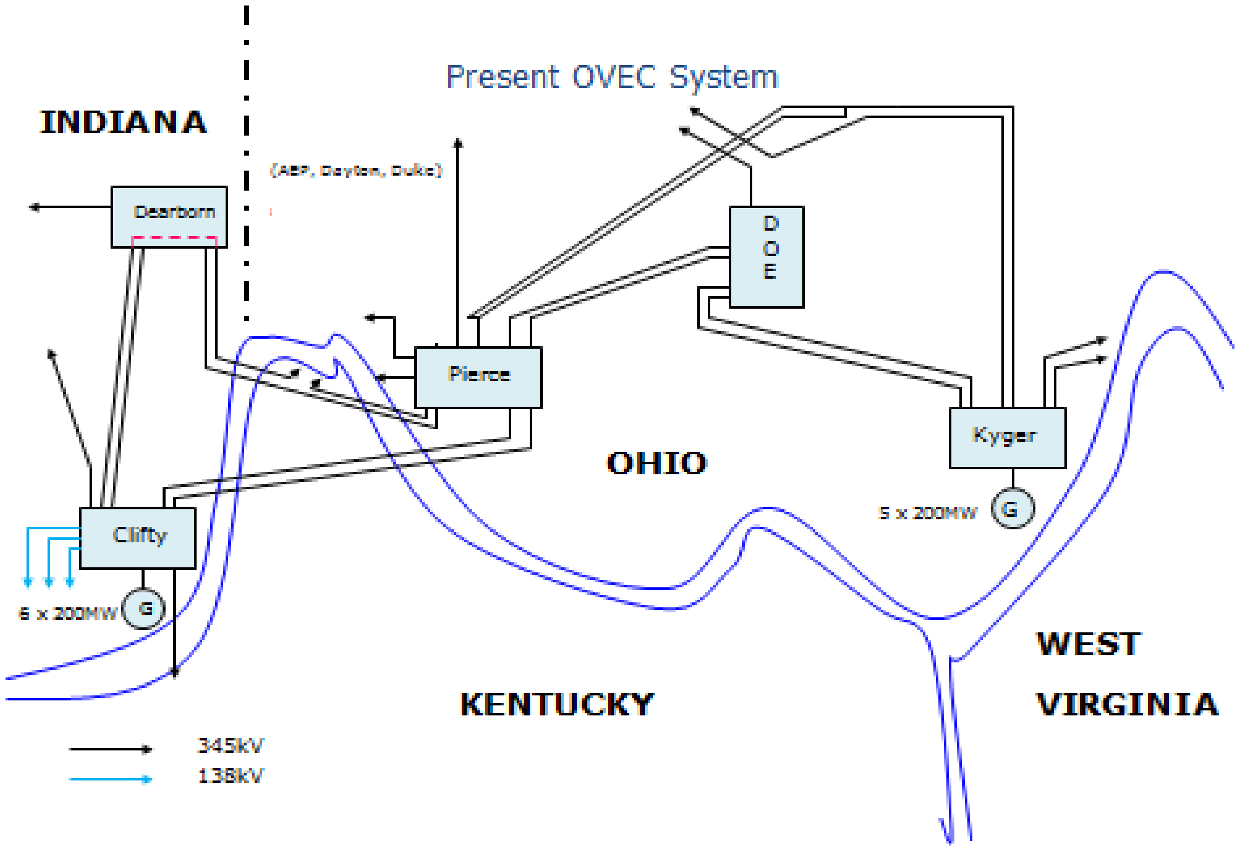
System Description

The Ohio Valley Electric Corporation (OVEC) and its subsidiary, Indiana-Kentucky Electric Corporation (IKEC), were organized and their transmission systems constructed in the years 1952-1956. OVEC/IKEC was formed by 15 investor-owned electric utility companies (Sponsors) for the express purpose of supplying the electric power requirements of a single retail customer, the U.S. Department of Energy's (DOE) uranium enrichment project (Project) located near Portsmouth, Ohio. Due to the highly critical nature of the DOE load, stringent design criteria were adopted for planning and constructing the OVEC/IKEC System.

The entire OVEC/IKEC System is considered to be part of the bulk electric system, as it is primarily an EHV network. The system map, showing the configuration as presently planned to exist through the end of the 10 year planning horizon, appears below. The only non-EHV transmission facilities are 138 kV facilities associated with interconnections to the systems of several Sponsors. The OVEC system is highly interconnected. Interconnecting facilities consist of eight 345 kV lines, the high-side connections to four neighboring system 345/138 kV transformers, and three 138 kV lines. The strong internal EHV network and number of interconnections relative to the size of the system precludes a need to analyze sub areas within OVEC, or to use more detailed models than are used in regional studies.

The minimal DOE load today is served from the remaining DOE-owned 345 kV station (DOE X530) within the Project's boundaries. Two double-circuit tower 345kV lines and one single-circuit 345 kV line from OVEC/IKEC and Sponsors' stations supply this station. A second, similar station (DOE X533) was removed from service in November 2008. Reconnection of the lines (bypassing the former station site) was completed in December 2010. The OVEC/IKEC System has eleven generating units located at two plants with a total capacity of about 2200 MW. Prior to September 2001, a portion of the OVEC generation was delivered to the DOE load based on the demand established in OVEC/IKEC's contract with DOE, and any remaining generation was sold to the Sponsors on an ownership participation basis. Since September 2001, all generation, with the exception of required operating reserves, has been made available to the Sponsors. Considering the strength of the generation and transmission system compared with the total load served and the transfers incurred in real time, it is reasonable to assume that OVEC does not require additional reactive compensation.

Ohio Valley Electric Corporation 2016 Transmission Plan



Review of Recent Operating Conditions and System Changes

As outlined in Attachment M of the OVEC Tariff, the following factors are to be addressed in developing the OVEC transmission plan:

- Review of recent operating conditions, such as NERC Transmission Loading Relief events or MISO and PJM LMP binding constraints that may indicate developing reliability concerns on the OVEC system
  - *Recent congestion has generally been associated with multiple prior outages of other facilities*

- Requests for connection to OVEC facilities
  - *None*

- Requests for service into, out of, or through the OVEC Transmission system
  - *None*

- Projections of future load or generation changes within OVEC
  - *Minimal*

- Projections of OVEC major transmission equipment or systems approaching end-of-useful life
  - *The Clifty Creek 345 kV station is the only station containing OVEC/IKEC-owned BES circuit breakers other than modern SF6 "puffer" designs. IKEC-owned equipment at this station as of 1/1/2016 included 17 high pressure Air Blast circuit breakers. Although this equipment has adequate interrupting capability, the age, design and operating characteristics pose increasing concerns about O&M costs, availability of parts, and associated declining availability of the breakers for service. Gradual replacement of these breakers is anticipated in the coming years, prioritized based on individual breaker condition as well as budget constraints and coordination with unit outage schedules.*

New Facilities

Replacement of antiquated circuit breakers and associated relays and controls at Kyger Creek was completed in 2016. In addition, one 345 kV air blast circuit breaker was replaced at Clifty Creek.

Abnormal Conditions

No extended periods of abnormal conditions are expected on the OVEC system.

Study Base Cases

Assumptions

The primary analyses for this assessment were based on power flow models derived from the ERAG/MMWG 2015 library models of projected conditions for 2021 Summer near term peak load and 2021 Spring light load conditions. These models represent Eastern Interconnection systems, particularly those of RF members, including OVEC and adjacent transmission systems, as planned for the 2021 Summer period in early to mid-2015. This represents the latter portion of the near term (Years 1-6) planning horizon.

Analysis of system performance with neighboring system plans not yet finalized at the time the OVEC analysis is performed will be an ongoing process as plans in adjacent systems continue to evolve.

Additional analyses were performed to provide context and provide a basis for assessing other load levels, time periods and generation dispatch. Studies based on the 2017 Summer peak load model provide a reference point based on year-one conditions. As the known system improvements and generator retirements affecting the OVEC area are represented in the 2021 Summer model, and no emerging issues involving OVEC-owned facilities appeared in any of the near term analyses, previous studies of the long term planning period were deemed to still be valid. Based on the system plans known at this time, performance for the longer term (6-10 year) planning horizon is anticipated to be similar to that identified in the 2021 analysis.

2017 Summer Peak model

- The initial base case model for the 2017 peak load studies was derived from the 2017 summer peak model contained in the 2015 series ERAG-MMWG library. The model used for the OVEC studies is similar to the base case used in ReliabilityFirst 2017 Summer studies conducted in 2016, with the exception of correction of an impedance error corrected in south-central Ohio prior to finalizing the OVEC studies.

2021 Summer Peak Planning horizon models:

- The initial base case models for the 2021 peak load studies were derived from the 2021 summer peak model contained in the 2015 series ERAG-MMWG library. Because the OVEC Transmission system consists entirely of 345 kV and 138 kV facilities, the OVEC system is fully represented in the MMWG power flow models. There are no additional OVEC transmission facilities expected to be in service for the planning horizon that were not represented in the ERAG/MMWG models. For OVEC, key assumptions for all peak load models consist of an area load of 35 MW and a total generation of 2,000 MW delivered to the OVEC owners. In determining the level of OVEC interchange to be modeled, it is assumed that the equivalent of one of the eleven OVEC generators is not available. Because the OVEC generation units are all of similar size, age, and operating history, the assumption is made that they will all be dispatched at similar levels.

2021 Spring Light Load Condition

The 2021 ERAG/MMWG Light Load model was reviewed and compared to the 2021 Summer peak model. No major topology differences were identified in the vicinity of OVEC. RF member systems had the opportunity to review and update this model in the first half of 2016 in preparation for the Transmission System Performance Subcommittee study of this period

2026 Summer Peak Load.

The 2026 ERAG/MMWG Summer peak load model was reviewed and compared to the 2021 Summer peak model. Since no major topology differences were identified in the vicinity of OVEC, no further analysis was performed.

Sensitivity Studies

2021 Summer Peak with retirement of additional nearby generators

Due to the uncertainties introduced by various proposals to implement further reductions in allowable power plant emissions, a sensitivity scenario was developed based on postulated retirement of additional coal-fired units in several neighboring systems in the PJM RTO. The units selected, while generally newer than units retired in 2010-2016, are among the older coal units remaining in these systems, but were primarily selected based on proximity to OVEC. The generation removals were balanced by scaling generation up throughout the PJM market.

Removed Generation:

Unit	MW dispatched in 2021 SP model
Cardinal 1	585
Conesville 4	780
Miami Ft 7	510
Stuart 1	575

Transfer Capability Analysis (FCITC)

The PTI/Siemens PSS/E and/or MUST analysis tools were used to screen for violations of performance criteria under various outage conditions. MUST was also used to determine First Contingency Incremental Transfer Capabilities (FCITCs) for 12 different transfer directions expected to affect flows into, out of or through the OVEC system. These FCITCs are not an indication of the transmission network capability to accommodate a specific transfer or transmission service request. However, they serve as a surrogate for a variety of possible operating conditions, and provide a means to evaluate the strength of the system as it is stressed by these varied conditions. The following transfer directions were studied:

From	To	2017 Summer Peak Load FCITC (MW)	2021 Summer Peak Load FCITC (MW)	Limit
OVEC	Sponsors*	100+	2000+	None
Sponsors*	OVEC	100+	200+	None
LGEE	DEO&K	250	300+	Trimble Co – Clifty Creek 345 kV
DEO&K	LGEE	2000+	2000+	None
LGEE	AEP	100+	300+	None
AEP	LGEE	2000+	2000+	None
EKPC	DEO&K	1000+	1000+	None
EKPC	DAY	1000+	1000+	None
TVA	ITC	100+	300+	None
ITC	TVA	4000+	4000+	None
AMIL	DVP	100+	4000+	None
DVP	AMIL	4000+	4000+	None
AMIL	PJM	100+	4000+	None

+ Not limited by transmission conditions at the value given (Generation Capacity Limit or tested transfer level)
*The deliveries involving the OVEC Sponsoring companies are allocated in the following manner:

AEP 61.47% (Includes Buckeye share) FE 4.85% SIGE 1.5% METC 6.65% (Peninsula share)
AP 3.5% DAY 4.9% LGEE 8.13%

Steady State Analysis Results

Results of the studies performed for the 2016 Assessment are documented in Appendix C. To summarize, the following base cases were used to simulate single and "double" contingencies corresponding to the NERC Planning Event categories P1 – P7:

- 2017 Summer Peak
- 2021 Spring Light Load
- 2021 Summer Peak
- 2021 Summer Peak, additional generation retirements

The results shown identify potential overloads on 3 OVEC tielines to neighboring systems. In each instance, the identified loading levels remain below the capability of the OVEC-owned facilities associated with the circuit. Therefore, OVEC will communicate these results to the facility owners, but is not responsible for any upgrades at this time.

Short Circuit Assessment

Studies performed in 2015 evaluated the expected short circuit interrupting duties relative to the capability of the planned circuit breakers, following completion of the Kyger Creek breaker replacements. The last remaining (of the 17 original) 330/345 kV breakers at Kyger Creek was replaced during a scheduled outage of the associated generating unit. The studies in 2015 showed that no OVEC circuit breakers are expected to be called upon to interrupt fault currents in excess of their capability. Eighteen breakers were found to have interrupting duties above 80% of their capability, with the highest at 89.2% of capability. The detailed studies are documented in Appendix D.

Note that the 2015 study results were expected to be somewhat conservative (i.e., overstate the actual fault currents to be reasonably expected going forward.) This is because some retired generating units in neighboring systems were still modeled as in service. Under the terms of the applicable tariff, the owner of a unit that has requested deactivation has up to one year after the actual deactivation date to apply to reuse their connection rights. To prevent "overselling" connection rights, the impact of the retiring units needed to be included until those rights expired. Review of the posted queue requests for Indiana, Kentucky, Ohio and West Virginia shows no requests have been made to re-use rights of retiring units connected within 3-5 buses of the OVEC system. For the units that retired prior to the Fall of 2015, those rights have now expired. Furthermore, comparison of the powerflow models used in the studies run during the 2015 effort to those run during the 2016 shows no major transmission topology changes within 3-5 buses of the OVEC system. Therefore, the 2015 studies are adequate to support the conclusion that the short circuit duties on the OVEC system will remain within the interrupting capabilities of the existing or planned circuit breakers.

Stability Studies and Results

Studies were performed in late 2011 to evaluate the stability performance of the Clifty Creek plant during the outages needed to retire the Dearborn CBs DA and DD, and applying the requirements of the proposed TPL-001-2. The plant performance was found to meet the requirements of both the OVEC Transmission Testing Criteria and NERC Reliability Standards. The studies were documented in a separate report, provided as Appendix F. Analysis of the stability performance of the Kyger Creek plant was completed in 2010 and remains valid. It is provided for reference as Appendix E.

Operating Procedures/Special Protection Systems

OVEC has no Special Protection Systems. Operating procedures exist to reduce flows through the Clifty Creek-Carrolton 138 kV tieline between OVEC and KU. They are described in Part 5 of the OVEC response to FERC Form 715, and reproduced in Appendix B of this report.

Appendices

Appendix A – Testing Criteria

(Excerpt from the OVEC response to FERC FORM 715 - ANNUAL TRANSMISSION PLANNING AND EVALUATION REPORT)

4. TRANSMISSION TESTING CRITERIA

4.1 Steady State Testing Criteria

The planning process for OVEC/IKEC's transmission network embraces two major sets of testing criteria to ensure reliability. The first set includes all significant single and double contingencies (NERC Categories B and C.) The second set includes more severe multiple contingencies (NERC Category D) and is primarily intended to test the potential for system cascading.

For OVEC/IKEC transmission planning, the testing criteria are deterministic in nature; these outages serve as surrogates for a broad range of actual operating conditions that the power system will have to withstand in a reliable fashion. In the OVEC/IKEC transmission system, thermal and voltage performance standards are usually the most constraining measures of reliable system performance. Each type of performance requirement is described in the following discussion. Table 1 below documents the performance criteria for all transmission facilities under normal and contingency conditions.

4.1.1 Single and Double Contingencies

Contingencies include the forced or scheduled outage of generating units, transmission circuits, transformers, or other equipment. In general, a single contingency is defined as the outage of any one of these facilities. Due to the interconnected nature of power systems, testing includes outages of facilities in neighboring systems. A single facility is defined based on the arrangement of automatic protective devices. Generally, double circuit tower outages, breaker failures, station outages, common right-of-way outages, and other common-mode failures have substantially lower probabilities of occurrence than the outage of a single transmission facility and are, therefore, not considered single contingencies.

Double contingencies, being a more severe test of system performance, are used as a surrogate for the significant uncertainties that are inherent in the planning process. A double contingency can be defined as an outage of any two facilities. Double contingencies can be categorized by industry standards as either N-2 (an overlapping outage of two facilities with no corrective action following the first contingency) or N-1-1 (this category allows system adjustments after the initial outage). Double contingency analyses are also frequently applied in facility planning studies. These tests provide additional insight regarding the need for transmission system enhancements.

Operational planning studies may consider up to two key outages in effect prior to the next (third) contingency. It is assumed that all operator adjustments required for the prior outages have been implemented. The number of prior outages depends on the strength of the transmission system and the number of variables to be considered in developing effective operating guidelines. Clearly, as the number of concurrent contingencies increases, it will become increasingly difficult to meet the required performance limits (see Section 3), even with special operating procedures.

The number of outages actually occurring on the system can exceed the number assumed for study purposes. Operational planning engineers can evaluate those conditions, as needed.

4.1.2 Extreme Contingencies

The more severe reliability assessment criteria required in NERC Reliability Standards are primarily intended to prevent uncontrolled area-wide cascading outages under adverse but credible conditions. OVEC/IKEC, as a member of ReliabilityFirst, plans and operates its transmission system to meet the criteria. However, new facilities would not be committed on the basis of local overloads or voltage depressions following the more severe multiple contingencies unless those resultant conditions were expected to lead to widespread, uncontrolled outages.

In operational planning studies, the purpose of studying multiple contingencies and/or high levels of power transfers is to evaluate the strength of the system. Where conditions are identified that could result in significant equipment damage, uncontrolled area-wide power interruptions, or danger to human life, IROL operating procedures will be developed, if possible, to mitigate the adverse effects. It is accepted that the defined performance limits could be exceeded on a localized basis during the more severe multiple contingencies, and that there could be resultant minor equipment damage, increased loss of equipment life, or limited loss of customer load. Normally, operating procedures to mitigate uncontrolled area-wide power interruptions are only used on an interim basis until facility additions can be put in place to restore acceptable reliability levels.

4.2 Stability Testing Criteria

The Appendix B Stability Disturbance Testing Criteria specify the disturbance events for which stable operation is required of all BES connected generation, including renewable generation.
The disturbance events specified in testing criteria A through E of Appendix B are applicable to planning and operational planning studies. These disturbance events correspond to the NERC Category B2, B3, C3, C7 and C8 contingencies listed in Table 1 of NERC TPL standards 001 through 004. The disturbance events specified in criteria F

and G of Appendix B may also be applied in operational planning studies when a long-term facility outage is anticipated. Testing with disturbance events other than those specified in Appendix B may be performed in planning and operational planning studies where applicable. Examples of such testing include common-failure mode disturbances such as double circuit tower faults (NERC Category C5) or bus faults (NERC Category C9) that result in the outage of multiple facilities at a location. On the OVEC/IKEC transmission system, NERC Category C1, C2, and C9 contingencies are generally either of the same or less severity than the A criterion (Appendix B) breaker failure events that result in tripping the same facilities.

4.3 Power Transfer Testing Criteria

The power transfer capability between two interconnected systems (or sub-systems) with all facilities in service or with one or two critical components out of service, indicates the overall strength of the network. Many definitions of power transfer capability are possible, but uniformity is highly desirable for purposes of comparison. Furthermore, transfer capability, however defined, is only accurate for the specific set of system conditions under which it was derived. Therefore, the user of this information needs to be aware of the conditions under which the transfer capability was determined and those factors that could significantly influence the capability.

OVEC/IKEC has adopted the definitions of transfer capability, published by NERC in "Transmission Transfer Capability", dated May 1995. The most frequently used transfer capability definition is for First Contingency Incremental Transfer Capability (FCITC) and is quoted below from the referenced NERC publication:

<u>First Contingency Incremental Transfer Capability</u>

> "FCITC is the amount of power, incremental above normal base power transfers, that can be transferred over the transmission network in a reliable manner, based on the following conditions:
>
> 1. For the existing or planned system configuration, and with normal (pre-contingency) operating procedures in effect, all facility loadings are within normal ratings and all voltages are within normal limits.
>
> 2. The electric systems are capable of absorbing the dynamic power swings, and remaining stable, following a disturbance that results in the loss of any single electric system element, such as a transmission line, transformer, or generating unit, and
>
> 3. After the dynamic power swings subside following a disturbance that results in the loss of any single electric system element as described in 2 above, and after the operation of any automatic operating systems, but before any post-

contingency operator-initiated system adjustments are implemented, all transmission facility loadings are within emergency ratings and all voltages are within emergency limits."

First Contingency Total Transfer Capability (FCTTC) is similar to FCITC except that the base power transfers (between the sending and receiving areas) are added to the incremental transfers to give total transfer capability. ECAR has adopted guidelines for interpreting and applying the NERC transfer capability definitions, and OVEC/IKEC uses these guidelines in its internal studies as well.

While the first contingency transfer capabilities are the most frequently used measure of system strength, transfer capabilities also can be calculated for "no contingency" and "second contingency" conditions.

Available Transfer Capability

In April 1996 the Federal Energy Regulatory Commission issued two rules -- Orders No. 888 and 889. Two aspects of these rules are "open access" to the transmission systems of integrated utilities and the posting of available transfer capability. The ability of a transmission system to permit power transfers is defined by several terms, namely:

Firm Available Transfer Capability (ATC)
Firm Total Transfer Capability (TTC)
Non-firm ATC
Non-firm TTC
Transmission Reliability Margin
Capacity Benefit Margin

The ATC/TTC values provide an indication of the ability of the transmission system to support transfers. Firm ATC is the level of additional transfer capability remaining in the physical network for further commercial activity over and above existing commitments for future time periods. The ATC/TTC values are calculated for transactions in both directions between OVEC/IKEC and directly connected control areas and for selected commercially viable through paths across the OVEC/IKEC System. ATC values are the lesser of network capability or contract path capacity (i.e., the total capability of interconnections to a neighboring control area). Firm TTC is determined by adding firm schedules and/or reservations to the ATC values.
Non-firm ATC are calculated in a manner similar to that used to calculate the firm values, except that both firm and non-firm transactions are included in the calculations.
TRM is the amount of transfer capability which may be reserved to ensure that the transmission network is secure under a range of uncertainties in operating conditions. These uncertainties include generation unavailability, load forecast error, load diversity, unknown outages in neighboring systems, and variations in generation dispatch. The TRM is applied directly to facility ratings for calculations of firm ATC/TTC by adjusting

the thermal rating of the critical facility(ies) down to 95% of the seasonal emergency capability. TRM is applied only to firm ATC calculations.

CBM is the amount of transfer capability reserved by Load Serving Entities to ensure access to generation from interconnected systems to meet generation reliability requirements. The total OVEC/IKEC CBM value is based upon generation reserve requirements. CBM is subtracted as a fixed MW amount from the firm OVEC/IKEC TTC import capability. The CBM is allocated among OVEC/IKEC's interfaces and the amount allocated to individual interfaces is based upon the lowest of: 1) the estimated long term generation reserve of the adjoining control area, 2) the transmission interconnection capability with each of the adjoining control areas, and 3) the FCTTC with each of the adjoining control areas.

At present, the TRM and CBM for the OVEC System have been reduced to zero.

OVEC/IKEC methodologies to calculate these values are consistent with the "NERC Available Transfer Capability" and the "ECAR TTC/ATC Calculation/Coordination" documents.

Appendix B – Special Procedures & Contingencies

(Excerpt from the OVEC response to FERC FORM 715 - ANNUAL TRANSMISSION PLANNING AND EVALUATION REPORT)

A. SPECIAL PROCEDURES

This section describes operating procedures that have been developed to mitigate problems identified on the transmission system and special modeling techniques used in the assessment of OVEC/IKEC system performance. Unless otherwise stated, these operating procedures are anticipated to be applicable indefinitely. As a result, they should be modeled in screening studies that evaluate future system performance. The procedures described herein generally are implemented to reduce facility loadings to within equipment thermal capabilities or to insure that adequate voltage levels or steady state stability margins are maintained.

Clifty Creek-Carrolton 138 kV (OVEC-KU)

Past operating experience indicates that the Clifty Creek – Carrolton 138 kV tieline between OVEC and KU may become heavily loaded anticipating loss of either Ghent Unit 1 (KU) or Spurlock-N. Clark 345 kV (EKPC). Loading concerns would likely occur during periods of high north-to-south transactions, especially if these transfers coincide with high output at Trimble County (KU) and reduced output at other LGE or KU plants. If necessary, OVEC has agreed to open the Clifty Creek 345/138 kV transformer T-100A at the request of the MISO Reliability Coordinator to relieve the loading concerns.

The areas of concern described above are those identified in the most recent performance appraisals conducted, based on the best available knowledge of interconnected system development, and expected operating conditions. The results of appraisals assuming different system conditions can be considerably different.

B. CONTINGENCY LIST

The following is a description of the contingencies that have been simulated in recent appraisals of the OVEC/IKEC system performance, to meet the requirements of the NERC Reliability Standards. This list is not exhaustive, but is designed to screen OVEC/IKEC system performance to verify that reliability criteria are being met and that OVEC system performance will not cause widespread cascading of the interconnected network.

Single Contingencies

Each 300 kV or higher branch within OVEC or the systems of OVEC's immediate neighbors (AEP, Duke Energy Ohio & Kentucky, Dayton, and LGEE). For those neighbors connected to Clifty Creek 138 kV, each 100 kV or higher branch in the zones connected to Clifty Creek.
Each tieline from the portion of the system comprised of the areas and zones described above

The OVEC stations (and DOE-owned stations within the OVEC Balancing Authority area) are primarily of the "breaker and a half" configuration. Therefore, single contingencies can generally be represented by individually removing each branch or generator represented in the powerflow model. Exceptions from this statement include the following:

- Clifty Creek 345/138 kV transformation – The in-service Clifty Creek transformer T-100A does not have automatic switching between the transformer and the 138 kV bus. Forced outages of this transformer also de-energize the Clifty Creek 138 kV bus, opening the ties to Carrolton(KU), Northside(LGE) and Miami Fort(DEO&K) until the transformer low-side disconnect can be manually opened and the bus restored.

- Dearborn(OVEC)-Tanners Creek(AEP) 345 kV bus extension – The 345 kV tie between these adjacent OVEC and AEP stations is protected as a bus extension rather than a transmission line. Normal clearing of a fault on the tie or the #1 Tanners Creek bus will also trap the Tanners Creek

(AEP) – East Bend (DEO&K) tie, as well as the Dearborn-Clifty Creek #1 and Dearborn – Pierce circuits.

The OVEC/IKEC generators are cross-compound machines. Future modeling refinements to increase compatibility between steady state and dynamics models will have each shaft represented individually. Representing a change in dispatch or status of a single unit will require changes to both HP and LP machines in the model.

One additional outage scenario that does not directly correspond to any of the contingencies required by the NERC TPL Reliability Standards should be included in contingency simulations testing the OVEC/IKEC transmission system:

- FGD systems at both Clifty Creek and Kyger Creek plants create the possibility that some common-mode FGD equipment trips could remove up to 3 units at either plant. This exposure does not match any of the contingencies required by the NERC TPL Standards, therefore OVEC does not consider that issues identified for these outages would require mitigation. However, performance for such outages should be evaluated for risks and consequences.

Multiple Contingencies

All combinations of branches connected to any OVEC bus, or two layers out from any OVEC bus, augmented by any branches identified in the Single Contingency analysis above. Similar to the discussion in the Single contingency section, the "breaker and a half" configuration present at most OVEC stations means that power flow analysis simulating NERC Category P2 contingencies removes no additional facilities than an associated P1 contingency. Similarly, (neglecting, for screening purposes, the manual system adjustments allowed between the individual "Category P1" contingencies contained in NERC Category P3 or P6 contingencies) powerflow simulation of most types of NERC Category P3-P7 contingencies on the OVEC system can be simulated by simply removing individual branches two at a time. NERC Extreme Event contingencies resulting in complete station outages are also regularly tested. Most common power system analysis tools provide options to easily simulate these outages.

Appendix D

Results

The PowerGEM Transmission Adequacy & Reliability Assessment (TARA) tool was used for the steady-state analysis in the studies conducted for the 2016 OVEC Transmission Assessment. The TARA output format is in a significantly different format than that used in previous years. A single table contains the Planning Event results for all of the N-0, N-1 and N-1-1 simulation results based on a given scenario (year, season, load level, etc.) In the absence of any results identifying overloads on OVEC-owned equipment, there is no need to further categorize the different performance requirements of each of the P0 – P7 contingency categories contained in the Planning Events portion of Table 1 of TPL-001-4. Results are shown for facilities where the "Final AC Loading" is equal to or greater than 100% of the applicable rating.

As discussed in the Contingency List portion of Appendix B (and neglecting for screening purposes the manual system adjustments allowed between the individual "Category P1" contingencies contained in NERC Category P3 or P6 contingencies) steady-state simulation of most NERC Category P3-P7 contingencies on the OVEC system can be simulated by simply removing individual branches two at a time. While TARA has the capability to performing system adjustments between N-1 and the second step in an N-1-1 simulation, this feature was not used for the simulations documented here, so the results also apply to the more severe contingency categories, including parts of the Extreme Events portion of TPL-001-4 Table 1. Extreme Events applicable to the OVEC system that are not addressed by the N-1-1 analysis include Types 2c (Loss of a switching station or substation) and 2d (Loss of all generating units at a generating station.) Type 2c is deemed to be more severe for the OVEC system, since the loss of a substation at a power plant would include the loss of the generation as well as weakening the remaining system. Results of simulations of Extreme Event Type 2c contingencies are tabulated separately from the Planning Event results.

Appendix D

Appendix C
2017 Summer Peak

Loadflow Case: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\OVEC 2016 Assessment 2017 SP base.raw
Study Data File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec_16compl_inertia_kvrange.sub
Contingency File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec+adjacent_singles_16 assess_inertia-kvrange.con (total 1761 contingencies)/ First-Level Contingency File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec+adjacent_singles_16 assess_inertia-kvrange.con (total 1761 contingencies)
Monitor File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\OVEC combo 2016.mon (90.0% loading cutoff)
Exclude File: not provided
Solution Options (Pre/Post Contingency): Shunts[All Enabled/All Enabled] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/Adjusted] Area Interchange [Disabled/Disabled]

Fir	First Level Scenario*	Monitored Facility	Areas	Rate Base (M	Rate Cont (MVA)	Cont Name**	AC Base Flow (MV	AC Cont Flow (MVA)	Orig Case Cont AC	Final AC %Load	Fr Base Volt	Fr Cont Volt	To Base Volt	To Cont Volt
	uj06CLIFTY 345FGD123	248000 06CLIFTY 345 324114 7TRIMBLE 345 1	206/363	1134	1370	05JEFRSO 765 - 05ROCKPT 765 - 1	948.1	1425.9	93.94	104.08	1.02	1.02	1.0203	1.0203
	uj06CLIFTY 345FGD456	248000 06CLIFTY 345 324114 7TRIMBLE 345 1	206/363	1134	1370	05JEFRSO 765 - 05ROCKPT 765 - 1	948.1	1425.9	93.94	104.08	1.02	1.02	1.0203	1.0203
	05JEFRSO 765 - 05ROCKPT 765 - 1	248000 06CLIFTY 345 324114 7TRIMBLE 345 1	206/363	1134	1370	Base Case	1287.1	-	72.07	113.5	1.02	-	1.0203	-
	05JEFRSO 765 - 05ROCKPT 765 - 1	248000 06CLIFTY 345 324114 7TRIMBLE 345 1	206/363	1134	1370	uj06CLIFTY 345FGD123	1287.1	1426	69.19	104.09	1.02	1.0202	1.0203	1.0203
	05JEFRSO 765 - 05ROCKPT 765 - 1	248000 06CLIFTY 345 324114 7TRIMBLE 345 1	206/363	1134	1370	uj06CLIFTY 345FGD456	1287.1	1426	69.19	104.09	1.02	1.0202	1.0203	1.0203
	05JEFRSO 765 - 05ROCKPT 765 - 1	248000 06CLIFTY 345 324114 7TRIMBLE 345 1	206/363	1134	1370	249500 08AMO 345 249530 08EDWDSP 345 1	1287.1	1381.9	65.97	100.87	1.02	1.02	1.0203	1.0203
	05JEFRSO 765 - 05ROCKPT 765 - 1	248000 06CLIFTY 345 324114 7TRIMBLE 345 1	206/363	1134	1370	08TRIMBL 345 - 7GHENT 345 - 1	1287.1	1373.7	69.2	100.27	1.02	1.02	1.0203	1.0203
	08TRIMBL 345 - 7GHENT 345 - 1	248000 06CLIFTY 345 324114 7TRIMBLE 345 1	206/363	1134	1370	05JEFRSO 765 - 05ROCKPT 765 - 1	948	1373.5	93.94	100.26	1.02	1.02	1.0203	1.0203
	05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249754 08HEHIDN 138 249877 08WILM J 138 1	111.1	145.2	70.59	112.52	1.0241	1.0212	0.9789	0.964
	05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 249754 08HEHIDN 138 1	111.1	144.3	70.17	111.83	1.0241	1.0213	0.9789	0.9651
	05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 250057 08M.FORT 138 1	111.1	139.6	67.99	108.24	1.0241	1.0222	0.9789	0.9713
	05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	248831 07HUBBL8 138 249691 08BATESV 138 1	111.1	129.1	66.86	100.07	1.0241	1.0225	0.9789	0.9692
	243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249754 08HEHIDN 138 249877 08WILM J 138 1	111.2	145.2	70.59	112.53	1.0241	1.0211	0.9788	0.9638
	243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 249754 08HEHIDN 138 1	111.2	144.3	70.17	111.84	1.0241	1.0213	0.9788	0.9649
	243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 250057 08M.FORT 138 1	111.2	139.6	67.99	108.25	1.0241	1.0222	0.9788	0.9711
	243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	248831 07HUBBL8 138 249691 08BATESV 138 1	111.2	129.1	66.86	100.08	1.0241	1.0225	0.9788	0.9691
	248831 07HUBBL8 138 249691 08BATESV 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	86.3	129.1	86.17	100.06	1.0246	1.0223	0.984	0.9666
	248831 07HUBBL8 138 249691 08BATESV 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	86.3	129.1	86.16	100.04	1.0246	1.0223	0.984	0.9668
	249500 08AMO 345 249530 08EDWDSP 345 1	248000 06CLIFTY 345 324114 7TRIMBLE 345 1	206/363	1134	1370	05JEFRSO 765 - 05ROCKPT 765 - 1	903.8	1381.9	93.94	100.87	1.02	1.02	1.0203	1.0203
	249532 08TRIMBL 345 324114 7TRIMBLE 345 1	248000 06CLIFTY 345 324114 7TRIMBLE 345 1	206/363	1134	1370	05JEFRSO 765 - 05ROCKPT 765 - 1	948	1373.5	93.94	100.26	1.02	1.02	1.0203	1.0203
	249736 08GRDALE 138 249754 08HEHIDN 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	90.5	144.3	86.17	111.84	1.0244	1.0213	0.9841	0.9649
	249736 08GRDALE 138 249754 08HEHIDN 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	90.5	144.3	86.16	111.83	1.0244	1.0213	0.9841	0.9651
	249736 08GRDALE 138 250057 08M.FORT 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	87.7	139.6	86.17	108.24	1.0247	1.0222	0.9865	0.9711
	249736 08GRDALE 138 250057 08M.FORT 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	87.7	139.6	86.16	108.24	1.0247	1.0222	0.9865	0.9714
	249754 08HEHIDN 138 249877 08WILM J 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	91.1	145.2	86.17	112.53	1.0243	1.0211	0.9837	0.9638
	249754 08HEHIDN 138 249877 08WILM J 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	91.1	145.2	86.16	112.52	1.0243	1.0212	0.9837	0.964
	324105 7GHENT 345 324109 7NAS 345 1	248009 06CLIFTY 138 324227 4CARROLT 138 1	206/363	166	210	324253 4GHENT 138 324287 4NAS TP 138 1	66.1	236.1	25.55	112.41	1.0236	0.9925	1.0028	0.8992
	324253 4GHENT 138 324287 4NAS TP 138 1	248009 06CLIFTY 138 324227 4CARROLT 138 1	206/363	166	210	324105 7GHENT 345 324109 7NAS 345 1	53.6	236.1	31.5	112.41	1.0241	0.9925	1.0049	0.8992

* Absence of an entry labeled (Base Case) indicates that there were no N-0 violations
** Absence of an entry labeled (Base Case) indicates that there were no N-1 violations

Latest available rating information:
Clifty Creek-Trimble County 345 kV overall ratings SN/SE 1134/1451 MVA, OVEC facilities minimum 1410/1762 MVA
Clifty Creek-Miami Ft 138 kV overall ratings SN/SE 112/129 MVA, OVEC facilities minimum 223/290 MVA
Clifty Creek-Carrollton 138 kV overall ratings SN/SE 166/210 MVA, OVEC facilities minimum 205/284 MVA

2021 Summer Peak

Loadflow Case: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\OVEC 2016 Assessment 2021SP base.raw
Study Data File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec_16compl_inertia_kvrange.sub
Contingency File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec+adjacent_singles_16 assess_inertia-kvrange.con (total 1767 contingencies)/ First-Level Contingency File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec+a
Monitor File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\OVEC combo 2016.mon (90.0% loading cutoff)
Exclude File: not provided
Solution Options (Pre/Post Contingency): Shunts[All Enabled/All Enabled] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/Adjusted] Area Interchange [Disabled/Disabled]

First Level Scenario *	Monitored Facility	Areas	Rate Base (MV	Rate Cont (MV	Cont Name	AC Base Flow (MV	AC Cont Flow (M	Orig Case Cont AC	Final AC %Load	Cont MV Flow	Fr Base Volt	Fr Cont Volt	To Base Volt	To Cont Volt
05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249754 08HEHIDN 138 249877 08WILM J 138 1	106.3	137	65.67	106.23	140	1.0245	1.0215	0.9801	0.9629
05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 249754 08HEHIDN 138 1	106.3	136.1	65.25	105.51	139	1.0245	1.0217	0.9801	0.9641
05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 250057 08M.FORT 138 1	106.3	131.3	63	101.78	134.3	1.0245	1.0226	0.9801	0.9705
243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249754 08HEHIDN 138 249877 08WILM J 138 1	106.3	137.1	65.67	106.24	140	1.0245	1.0215	0.98	0.9627
243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 249754 08HEHIDN 138 1	106.3	136.1	65.25	105.53	139.1	1.0245	1.0217	0.98	0.9638
243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 250057 08M.FORT 138 1	106.3	131.3	63	101.79	134.3	1.0245	1.0226	0.98	0.9703
249736 08GRDALE 138 249754 08HEHIDN 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	84.2	136.1	82.42	105.52	139.1	1.0246	1.0217	0.9837	0.9638
249736 08GRDALE 138 249754 08HEHIDN 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	84.2	136.1	82.42	105.51	139	1.0246	1.0217	0.9837	0.9641
249736 08GRDALE 138 250057 08M.FORT 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	81.3	131.3	82.42	101.79	134.3	1.0249	1.0226	0.9861	0.9703
249736 08GRDALE 138 250057 08M.FORT 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	81.3	131.3	82.42	101.78	134.3	1.0249	1.0226	0.9861	0.9705
249754 08HEHIDN 138 249877 08WILM J 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	84.7	137.1	82.42	106.24	140	1.0245	1.0215	0.9832	0.9627
249754 08HEHIDN 138 249877 08WILM J 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	84.7	137	82.42	106.23	140	1.0245	1.0215	0.9832	0.9629
324105 7GHENT 345 324109 7NAS 345 1	248009 06CLIFTY 138 324227 4CARROLT 138 1	206/363	166	210	324253 4GHENT 138 324287 4NAS TP 138 1	69.6	243.6	27.49	116	219.2	1.0238	0.9916	1.0014	0.8947
324253 4GHENT 138 324287 4NAS TP 138 1	248009 06CLIFTY 138 324227 4CARROLT 138 1	206/363	166	210	324105 7GHENT 345 324109 7NAS 345 1	57.7	243.9	33.16	116.12	219.2	1.0242	0.9915	1.0032	0.8941

* Absence of an entry labeled (Base Case) indicates that there were no N-0 violations
** Absence of an entry labeled (Base Case) indicates that there were no N-1 violations

Latest available rating information:
Clifty Creek-Trimble County 345 kV overall ratings SN/SE 1134/1451 MVA, OVEC facilities minimum 1410/1762 MVA
Clifty Creek-Miami Ft 138 kV overall ratings SN/SE 112/129 MVA, OVEC facilities minimum 223/290 MVA
Clifty Creek-Carrollton 138 kV overall ratings SN/SE 166/210 MVA, OVEC facilities minimum 205/284 MVA

2021 Spring Light Load

Loadflow Case: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\OVEC 2016 Assessment 2021LL based on ERAG-MMWG.raw
Study Data File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec_16compl_inertia_kvrange.sub
Contingency File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec+adjacent_singles_16 assess_inertia-kvrange.con (total 1767 contingencies)/ First-Level Contingency File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec+ad
Monitor File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\OVEC combo 2016.mon (90.0% loading cutoff)
Exclude File: not provided
Solution Options (Pre/Post Contingency): Shunts[All Enabled/All Enabled] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/Adjusted] Area Interchange [Disabled/Disabled]

First Level Scenario	Monitored Facility	Area	Rate Base (MVA)	Rate Cont (MVA)	Cont Name	AC Base Flow (MW)	AC Cont Flow (MW)	Orig Case Cont AC	Final AC %Loading	Base MW Flow	Cont MW Flow	Fr Base Volt	Fr Cont Volt	To Base Volt	To Cont Volt
*** No Branch Flow Violations Found ***															

2021 Summer Peak – postulated additional generation retirements

Loadflow Case: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\OVEC 2016 Assessment 2021SP retirement sensitivity.raw
Study Data File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec_16compl_inertia_kvrange.sub
Contingency File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec+adjacent_singles_16 assess_inertia-kvrange.con (total 1767 contingencies)/ First-Level Contingency File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec+a
Monitor File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\OVEC combo 2016.mon (90.0% loading cutoff)
Exclude File: not provided
Solution Options (Pre/Post Contingency): Shunts[All Enabled/All Enabled] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/Adjusted] Area Interchange [Disabled/Disabled]

First Level Scenario *	Monitored Facility	Area	Rate Bas (MV	Rate Cont (MV	Cont Name **	AC Base Flow (MV	AC Cont Flow (MV	Orig Case Cont AC %Loadi	Final AC %Loadi	Base MW Flo	Cont MW Flo	Fr Cont Volt	To Base Volt	To Cont Volt
05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249754 08HEHIDN 138 249877 08WILM J 138 1	116	151	73.28	117.03	118.8	154	1.0206	0.9772	0.9606
05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 249754 08HEHIDN 138 1	116	150.1	72.86	116.32	118.8	153.1	1.0207	0.9772	0.9617
05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 250057 08M.FORT 138 1	116	145.3	70.62	112.63	118.8	148.4	1.0217	0.9772	0.9682
05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	248831 07HUBBL8 138 249691 08BATESV 138 1	116	134.6	69.56	104.34	118.8	137.5	1.022	0.9772	0.9658
05TANNER-08M.FTHS-08MFTM9-345-138	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	248831 07HUBBL8 138 249914 08WEISBG 138 1	116	133.6	68.56	103.53	118.8	136.5	1.0222	0.9772	0.9673
243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249754 08HEHIDN 138 249877 08WILM J 138 1	116.1	151	73.28	117.04	118.8	154	1.0205	0.977	0.9603
243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 249754 08HEHIDN 138 1	116.1	150.1	72.86	116.33	118.8	153.1	1.0207	0.977	0.9615
243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	249736 08GRDALE 138 250057 08M.FORT 138 1	116.1	145.3	70.62	112.64	118.8	148.4	1.0217	0.977	0.968
243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	248831 07HUBBL8 138 249691 08BATESV 138 1	116.1	134.6	69.56	104.34	118.8	137.5	1.022	0.977	0.9656
243233 05TANNER 345 249568 08M.FTHS 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	248831 07HUBBL8 138 249914 08WEISBG 138 1	116.1	133.6	68.56	103.54	118.8	136.5	1.0222	0.977	0.9671
248831 07HUBBL8 138 249691 08BATESV 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	89.7	134.6	89.96	104.34	91.9	137.5	1.022	0.9837	0.9656
248831 07HUBBL8 138 249691 08BATESV 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	89.7	134.6	89.95	104.33	91.9	137.5	1.022	0.9837	0.9658
248831 07HUBBL8 138 249914 08WEISBG 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	88.4	133.6	89.96	103.54	90.6	136.5	1.0222	0.9838	0.9671
248831 07HUBBL8 138 249914 08WEISBG 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	88.4	133.6	89.95	103.53	90.6	136.5	1.0222	0.9838	0.9673
249501 08BATESV 345 324105 7GHENT 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	92.4	131.4	89.96	101.83	94.6	134.3	1.0227	0.9867	0.9736
249501 08BATESV 345 324105 7GHENT 345 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	92.4	131.3	89.95	101.82	94.6	134.3	1.0227	0.9867	0.9737
249736 08GRDALE 138 249754 08HEHIDN 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	94	150.1	89.96	116.33	96.2	153.1	1.0207	0.9826	0.9615
249736 08GRDALE 138 249754 08HEHIDN 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	94	150.1	89.95	116.32	96.2	153.1	1.0207	0.9826	0.9617
249736 08GRDALE 138 250057 08M.FORT 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	91.1	145.3	89.96	112.64	93.3	148.4	1.0217	0.9851	0.968
249736 08GRDALE 138 250057 08M.FORT 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	91.1	145.3	89.95	112.62	93.3	148.4	1.0217	0.9851	0.9682
249754 08HEHIDN 138 249877 08WILM J 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	94.5	151	89.96	117.04	96.8	154	1.0205	0.9822	0.9603
249754 08HEHIDN 138 249877 08WILM J 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	94.5	151	89.95	117.03	96.8	154	1.0206	0.9822	0.9605
249877 08WILM J 138 249914 08WEISBG 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	88.1	133.1	89.96	103.16	90.3	136	1.0222	0.9836	0.9668
249877 08WILM J 138 249914 08WEISBG 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	88.1	133.1	89.95	103.15	90.3	136	1.0222	0.9836	0.967
324105 7GHENT 345 324109 7NAS 345 1	248009 06CLIFTY 138 324227 4CARROLT 138 1	206/363	166	210	324253 4GHENT 138 324287 4NAS TP 138 1	69.5	242.5	26.9	115.47	68.7	218	0.9914	1.0014	0.8947
324253 4GHENT 138 324287 4NAS TP 138 1	248009 06CLIFTY 138 324227 4CARROLT 138 1	206/363	166	210	324105 7GHENT 345 324109 7NAS 345 1	56.5	242.7	33.1	115.59	54.6	218	0.9912	1.0032	0.8941
249501 08BATESV 345 249691 08BATESV 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	243233 05TANNER 345 249568 08M.FTHS 345 1	92.4	131.4	89.96	101.83	94.6	134.3	1.0227	0.9868	0.9737
249501 08BATESV 345 249691 08BATESV 138 1	248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	05TANNER-08M.FTHS-08MFTM9-345-138	92.4	131.3	89.95	101.82	94.6	134.3	1.0227	0.9868	0.9739

* Absence of an entry labeled (Base Case) indicates that there were no N-0 violations
** Absence of an entry labeled (Base Case) indicates that there were no N-1 violations

Latest available rating information:
Clifty Creek-Trimble County 345 kV overall ratings SN/SE 1134/1451 MVA, OVEC facilities minimum 1410/1762 MVA
Clifty Creek-Miami Ft 138 kV overall ratings SN/SE 112/129 MVA, OVEC facilities minimum 223/290 MVA
Clifty Creek-Carrollton 138 kV overall ratings SN/SE 166/210 MVA, OVEC facilities minimum 205/284 MVA

2021 Summer Peak – station outages

Loadflow Case: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\OVEC 2016 Assessment 2021SP base.raw
Study Data File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\ovec_16compl_inertia_kvrange.sub
Contingency File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\subdbl_cont_bus_16.con (total 46 contingencies)
Monitor File: U:\JHR_02-20-2013\JHR\OVEC\2016\annual assessment\models\other input files\OVEC combo 2016.mon (80.0% loading cutoff)
Exclude File: not provided
Solution Options (Pre/Post Contingency): Shunts[All Enabled/All Enabled] PAR[Adjusted/Fixed] XFMR Tap[Adjusted/Adjusted] Area Interchange [Disabled/Disabled]

Monitored Facility	Areas	Rate Base (MVA	Rate Cont (MVA	Cont Name	Base Flow (MV	Cont Flow (MV	Final AC %Lo	Radial Index	Base MW Flo	Cont MW Flow	Fr Base Volt	Fr Cont Volt	To Base Volt	To Cont Volt
248009 06CLIFTY 138 324227 4CARROLT 138 1	206/363	166	210	BUS:324105 7GHENT 345	46.3	184.5	87.84	0.54541	44.5	186.7	1.0254	1.018	1.0079	0.9817
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	BUS:243233 05TANNER 345	74.1	109.3	84.77	0.17393	75.9	112	1.0254	1.0243	0.9892	0.9792
248009 06CLIFTY 138 250057 08M.FORT 138 1	206/212	129	129	BUS:249568 08M.FTHS 345	74.1	106.3	82.41	0.17237	75.9	108.9	1.0254	1.0245	0.9892	0.9801

Note: No loadings above 100% of ratings, no voltage violations

Appendix D

Ohio Valley Electric Corporation

2016 Short Circuit Assessment

(based on studies conducted in 2015)

East Transmission Planning
November 2016

AEP AMERICAN® ELECTRIC POWER

AEP: America's Energy Partner℠

The 2016 OVEC Short Circuit Assessment

The OVEC short circuit assessment is based on studies conducted in 2015. Based on the limited topology changes and lack of generation additions in close proximity to OVEC, the studies conducted in 2015 remain valid. Those studies were performed using v12.4 of the Aspen OneLiner™ program including the ASPEN Breaker Rating Module™. The study was based on the latest available AEP/PJM model at the time the study was conducted with the OVEC circuit breaker data* added.

The results of the study are summarized in the tables included as **Attachment A**. Those studies show that no OVEC circuit breakers are expected to be called upon to interrupt fault currents in excess of their capability. Twenty-seven breakers were found to have interrupting duties above 80% of their capability, with the highest at 87.5% of capability. The lowest margins were found at Pierce.

Note that these results are expected to be somewhat conservative (i.e., overstate the actual fault currents to be reasonably expected.) This is because some of the generating units already retired or expected to be retired in neighboring systems may still be modeled as in service. Under the terms of the applicable tariff, the owner of a unit that has requested deactivation has up to one year from the actual date of deactivation to apply to reuse their connection rights. To prevent "overselling" connection rights, the impact of the retiring units needs to be included until those rights have expired.

*Breaker characteristics utilized for Circuit Breakers located within the OVEC Balancing Authority Area, but owned by others, reflect the best information available at the time of this study. Results documented here are provided for the benefit of the equipment owner to make their own determination as to the adequacy of the breaker interrupting capabilities. The equipment owner bears ultimate responsibility to ensure that the equipment continues to be suitable for the application, including any applicable NERC Reliability Standard Compliance requirements.

BUS	BREAKER	DUTY %	DUTY MPS	BREAKER CAPABILITY	MOMENTARY DUTY %	MOMENTARY DUTY AMPS	MOMENTARY BREAKER CAPABILITY	ISC	X/R
06CLIFTY 138.kV	AC	41.9	16764.3	40000	23.9	24835	104000	15057.5	41.7
06CLIFTY 138.kV	AD	38.2	15289.6	40000	21.6	22459.2	104000	13567.8	45.1
06CLIFTY 138.kV	AE	43.4	17358.6	40000	24.8	25831	104000	15692.1	40.1
06CLIFTY 345.kV	A	83.5	53435.1	64000	49.4	82161.8	166400	49025.5	27.5
06CLIFTY 345.kV	B	83.5	53435.1	64000	48	79849.8	166400	49025.5	27.5
06CLIFTY 345.kV	C	79.9	51106.7	64000	49.4	82161.8	166400	51106.7	27
06CLIFTY 345.kV	D	83.5	53435.1	64000	49.4	82161.8	166400	49025.5	27.5
06CLIFTY 345.kV	DL	89.2	51106.9	57300	55.1	82162.1	148980	51106.9	27
06CLIFTY 345.kV	DL1	89.2	51106.9	57300	55.1	82162.1	148980	51106.9	27
06CLIFTY 345.kV	DL2	89.2	51106.7	57300	55.1	82161.8	148980	51106.7	27
06CLIFTY 345.kV	E	83.5	53435.1	64000	48	79849.8	166400	49025.5	27.5
06CLIFTY 345.kV	F	79.9	51106.7	64000	49.4	82161.8	166400	51106.7	27
06CLIFTY 345.kV	G	83.3	53297.7	64000	49.4	82161.8	166400	48883.3	27.6
06CLIFTY 345.kV	H	83.3	53297.7	64000	47.9	79688.6	166400	48883.3	27.6
06CLIFTY 345.kV	I	79.9	51106.7	64000	49.4	82161.8	166400	51106.7	27
06CLIFTY 345.kV	J	79.9	51106.7	64000	49.4	82161.8	166400	51106.7	27
06CLIFTY 345.kV	K	79.3	50776.6	64000	48	79830.4	166400	46332.6	28.4
06CLIFTY 345.kV	L	79.9	51106.7	64000	49.4	82161.8	166400	51106.7	27
06CLIFTY 345.kV	M	79.9	51106.7	64000	49.4	82161.8	166400	51106.7	27
06CLIFTY 345.kV	N	77.8	49813.4	64000	48.2	80175.6	166400	49813.4	27.4
06CLIFTY 345.kV	O	79.9	51106.7	64000	49.4	82161.8	166400	51106.7	27
06CLIFTY 345.kV	P	79.9	51106.7	64000	49.4	82161.8	166400	51106.7	27
06CLIFTY 345.kV	Q	79.9	51106.7	64000	49.4	82161.8	166400	51106.7	27
06CLIFTY 345.kV	R	81.1	51106.7	63000	50.2	82161.8	163800	51106.7	27
06CLIFTY 345.kV	S	81.1	51106.9	63000	50.2	82162.1	163800	51106.9	27
06CLIFTY 345.kV	T	81.1	51106.9	63000	50.2	82162.1	163800	51106.9	27
06DEARBN 345.kV	DB	85.6	42796.2	50000	50.9	66158.7	130000	42577.6	18.1
06DEARBN 345.kV	DC	85.4	42707.6	50000	50.8	66035.8	130000	42506.6	18.1

06DOE530 345.kV	212	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	215	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	218	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	222	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	225	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	228	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	242	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	245	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	248	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	252	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	255	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	258	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	262	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	265	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	268	76.7	30488.9	39762	44.9	38649.2	86164	23693.6	33.8
06DOE530 345.kV	272	61	31698	52000	37.2	38649.2	104000	23693.6	33.8
06DOE530 345.kV	275	61	31698	52000	37.2	38649.2	104000	23693.6	33.8
06DOE530 345.kV	278	61	31698	52000	37.2	38649.2	104000	23693.6	33.8
06DOE530 345.kV	282	61	31698	52000	37.2	38649.2	104000	23693.6	33.8
06DOE530 345.kV	285	61	31698	52000	37.2	38649.2	104000	23693.6	33.8
06KYGER 345.kV	A	79.1	39552.1	50000	48.5	63113.8	130000	39552.1	24.4
06KYGER 345.kV	AA	79.1	39552.1	50000	48.5	63113.8	130000	39552.1	24.4
06KYGER 345.kV	B	75.8	37917	50000	46.5	60504.6	130000	37917	23.4
06KYGER 345.kV	BB	79.1	39552.1	50000	48.5	63113.8	130000	39552.1	24.4
06KYGER 345.kV	C	79.1	39552.1	50000	48.5	63113.8	130000	39552.1	24.4
06KYGER 345.kV	D	80.9	40426.8	50000	48.5	63113.8	130000	37883	24.4
06KYGER 345.kV	E	80.9	40426.8	50000	46.8	60794.5	130000	37883	24.4
06KYGER 345.kV	F	79.1	39552.1	50000	48.5	63113.8	130000	39552.1	24.4
06KYGER 345.kV	G	80.9	40426.8	50000	48.5	63113.8	130000	37883	24.4
06KYGER 345.kV	H	80.9	40426.8	50000	46.8	60794.5	130000	37883	24.4
06KYGER 345.kV	I	79.1	39552.1	50000	48.5	63113.8	130000	39552.1	24.4
06KYGER 345.kV	J	79.1	39552.1	50000	48.5	63113.8	130000	39552.1	24.4

06KYGER 345.kV	K	79.1	39552.1	50000	48.5	63113.8	130000	39552.1	24.4
06KYGER 345.kV	L	79.1	39552.1	50000	48.5	63113.8	130000	39552.1	24.4
06KYGER 345.kV	M	79.8	39878.2	50000	48.5	63113.8	130000	37182.6	25.1
06KYGER 345.kV	N	79.8	39878.2	50000	46.8	60834.2	130000	37182.6	25.1
06KYGER 345.kV	O	79.1	39552.1	50000	48.5	63113.8	130000	39552.1	24.4
06KYGER 345.kV	P	79.1	39552.3	50000	38.5	63114.1	163800	39552.3	24.4
06KYGER 345.kV	Q	79.1	39552.3	50000	38.5	63114.1	163800	39552.3	24.4
06PIERCE 345.kV	1424	77.8	38896.3	50000	46.6	60626.5	130000	38896.3	18.7
06PIERCE 345.kV	A	77.8	38896.3	50000	46.6	60626.5	130000	38896.3	18.7
06PIERCE 345.kV	C	73.6	36790.7	50000	43.2	56129.4	130000	36790.7	14.5
06PIERCE 345.kV	D	73.6	36790.7	50000	43.2	56129.4	130000	36790.7	14.5
06PIERCE 345.kV	E	74.3	37126.3	50000	44.2	57433	130000	37126.3	17.4
06PIERCE 345.kV	F	74.1	37070.7	50000	43.8	57000.3	130000	36511.6	19
06PIERCE 345.kV	G	73.6	36790.7	50000	43.2	56129.4	130000	36790.7	14.5
06PIERCE 345.kV	H	74.9	37445.9	50000	44.4	57679	130000	37002.7	18.7
06PIERCE 345.kV	I	74.9	37445.9	50000	44.4	57679	130000	37002.7	18.7
06PIERCE 345.kV	J	73.9	36938.6	50000	43.7	56808.3	130000	36394.8	19
06PIERCE 345.kV	K	74.2	37114.9	50000	44	57169.1	130000	36675.6	18.7
06PIERCE 345.kV	L	74.2	37114.9	50000	44	57169.1	130000	36675.6	18.7
06PIERCE 345.kV	M	73.2	36612.1	50000	43.3	56306.1	130000	36073	19
06PIERCE 345.kV	P	74.3	37126.3	50000	44.2	57433	130000	37126.3	17.4
06PIERCE 345.kV	Q	62.5	31250.4	50000	36.7	47760.8	130000	30438.2	20.1
06PIERCE 345.kV	R	71.5	35774.4	50000	42	54578.9	130000	35774.4	14.5

Appendix E

Ohio Valley Electric Corporation Stability Assessment Template
Indiana-Kentucky Electric Corporation TPL-001-0.1, TPL-002-0, TPL-003-0, TPL-004-0
Electrical Operations – Record

A stability study of an existing generating plant connected to the OVEC system is not needed unless the answer to at least one of the following statements is “YES”:

1. The impedance or configuration of the transmission network in the vicinity of a generating plant connected to the OVEC system has been modified by addition, removal, or other change so as to weaken the transmission system in the vicinity of the generating plant.

YES NO _ X

2. Changes have been made to the steady-state or stability modeling or MW capability of any generating unit(s) so as to decrease the stability of the unit(s).

Is a stability study needed based on 1 or 2 above?

YES NO __X

YES NO __X____

This assessment was completed for the period listed and completed the individual named below.

2016 - 2021
Dates covering this assessment

Robert J. O’Keefe
Name

November 28, 2016
Date of assessment

Stability Assessment Template

TPL-001-0.1, TPL-002-0, TPL-003-0, TPL-004-0

Version History

REVISION	DATE	REVISED/REVIEWED BY	PURPOSE
1.0	08/30/10	JHR, GWB, RJM, SRC, JAD	Original Issue
1.1	11/25/15	RJO, JHR, SRC	Clarifying text added to items 1&2

Stability Assessment Template

TPL-001-0.1, TPL-002-0, TPL-003-0, TPL-004-0

Version History

REVISION	DATE	REVISED/REVIEWED BY	PURPOSE
1.0	08/30/10	JHR, GWB, RJM, SRC, JAD	Original Issue
1.1	11/25/15	RJO, JHR, SRC	Clarifying text added to items 1&2

Ohio Valley Electric Corporation

Kyger Creek Plant

Stability Performance Study

Of Final DOE Station Configurations

Advanced Transmission Studies and Technologies
September 2010

AEP: America's Energy Partner SM

1. INTRODUCTION

This study was undertaken to evaluate the stability performance of Ohio Valley Electric Corporation's (OVEC) Kyger Creek Plant following permanent changes to transmission interconnections at the Department of Energy's (DOE) X530 and X533 345 kV Stations. These changes are expected to be placed in service during the 4th quarter of 2010.

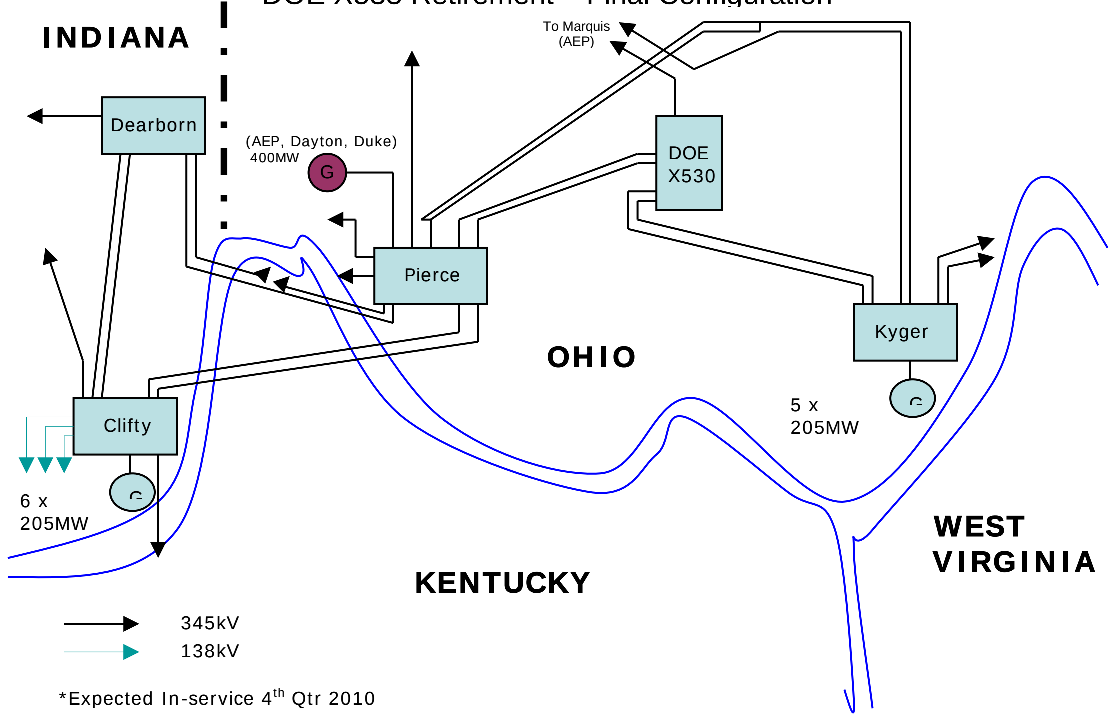
2. OVERVIEW OF GENERATION/TRANSMISSION FACILITIES

The generation capability at the Kyger Creek Plant is 1,025 MW winter net and is the sum of five similar units each rated at 205 MW winter net.

The final transmission configuration in the vicinity of DOE's X530 and X533 345 kV stations that was the subject of this study is as follows: Kyger Creek – X533 circuit 1 of the 345 kV double circuit tower (DCT) line is now routed directly to Marquis 345 kV from the X533 site (also utilizing the former X533-Marquis line, but without the series reactor) and Kyger Creek – X533 circuit 2 now connects to X533 – Pierce DCT line as a 6-wire DCT line from the X533 site to Pierce 345 kV Station. The X530 345 kV Station has been returned to the configuration that existed prior to the start of construction at Marquis and the 2008 interim reconfigurations.

The final configuration is also shown in Figure 1. The X533 Station no longer exists as a station and the entire DOE load of approximately 35 MW is now served from the X530 Station.

Figure 1
DOE X533 Retirement – Final Configuration*



3. TESTING CRITERIA

AEP / OVEC transient stability criteria for 345 kV connected generation facilities shown in Table 1 below specify the conditions and events for which stable operation is required (see OVEC FERC Form 715 filing, Part 4). In addition, satisfactory damping of generator post-disturbance power oscillations is required.

These testing criteria are applied in time domain simulations to evaluate the stability performance of a generation facility. For each disturbance, the resulting transmission system response is simulated and then analyzed to assess the impact of the disturbance scenarios on the proposed generators and the surrounding system. A one cycle margin to instability is present in the stability results designated as acceptable reported in this study.

Although beyond the scope of the AEP / OVEC stability testing criteria, a double circuit tower (DCT) line outage was considered in this study as a valid and credible fault disturbance scenario.

TABLE 1

AEP / OVEC Stability Testing Criteria for 345 kV Connected Generation

Prefault System Condition		Fault Disturbance Scenario
All Transmission Facilities in Service	2A	Permanent single phase to ground fault with breaker failure. Fault clearing by backup breakers.
	2B	Permanent three phase to ground fault with unsuccessful HSR if applicable. Fault cleared by primary breakers.
	2C	Three phase line opening without fault.
One Transmission Facility Out	2D	Permanent three phase to ground fault with unsuccessful HSR, if applicable. Fault cleared by primary breakers.
	2E	Three phase line opening without fault.
Two Transmission Facilities Out	2F	Temporary three phase to ground fault with successful HSR, if applicable.
	2G	Three phase line opening without fault.

Where,
Criteria 2A = NERC TPL Table 1 Category C6-9
Criteria 2B = NERC TPL Table 1 Category B1-3
Criteria 2C = NERC TPL Table 1 Category B1-3
Criteria 2D = NERC TPL Table 1 Category C3
Criteria 2E = NERC TPL Table 1 Category C3

The DCT line outages simulated in this study may be considered as a combination of NERC Category C3 and C5 contingencies. In this study, a prior outage of a DCT line is followed by another DCT line outage. The other NERC TPL category contingencies are either not applicable or would be less severe.

4. STUDY SCOPE and DATA

With reference to the above stability testing criteria, and in consideration of double circuit tower (DCT) faults and outages, the cases to be simulated were determined and are listed in Table 2 below. These cases all involved three-phase primary cleared faults or non-fault initiated tripping. Phase-to-ground delayed clearing faults were not simulated due to the station configuration at Kyger Creek 345 kV which is such that outage of further transmission elements does not occur, thus making these disturbance scenarios less severe.

Unsuccessful high speed reclosing (HSR) of faulted transmission lines was simulated in all three-phase fault cases. All primary fault clearing was assumed to be 3.5 cycles from fault initiation. The Kyger Creek Plant was dispatched at its winter net capacity of 1,025 MW unless otherwise indicated. The AEP 2009 series BCD 2015 Summer ERAG / MMWG base case was used in this study.

5. STUDY RESULTS

The study results for each stability simulation case are indicated in Table 2 below.

Each case consists of a prior double circuit tower (DCT) outage out of the Kyger Creek 345 kV Station followed by three-phase fault and trip, or non-fault initiated trip, of a second DCT. The Kyger Creek Plant is thus connected by one remaining DCT post-contingency in each case. Each of these cases is beyond the severity of the stated stability criteria in Section 3 above. The acceptable stability results from these cases indicate that less severe cases consistent with the criteria would also have acceptable stability.

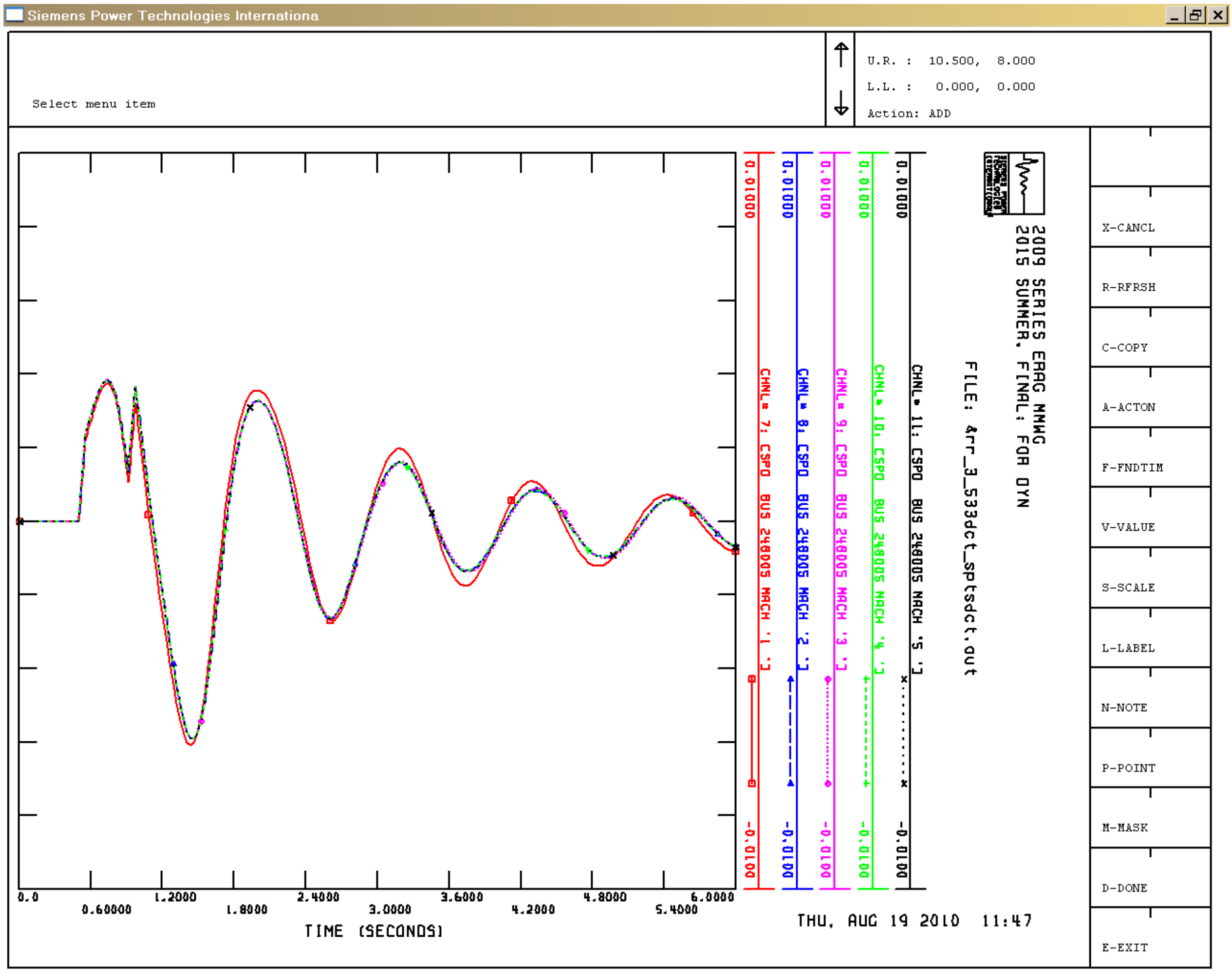
Plots of the dynamic simulation cases with three-phase faults are attached below.

6. CONCLUSION

The Kyger Creek Plant exhibits acceptable stability with the final configuration at DOE's X530 and X533 345 kV stations for Criteria 2A through 2E without a need for curtailment.

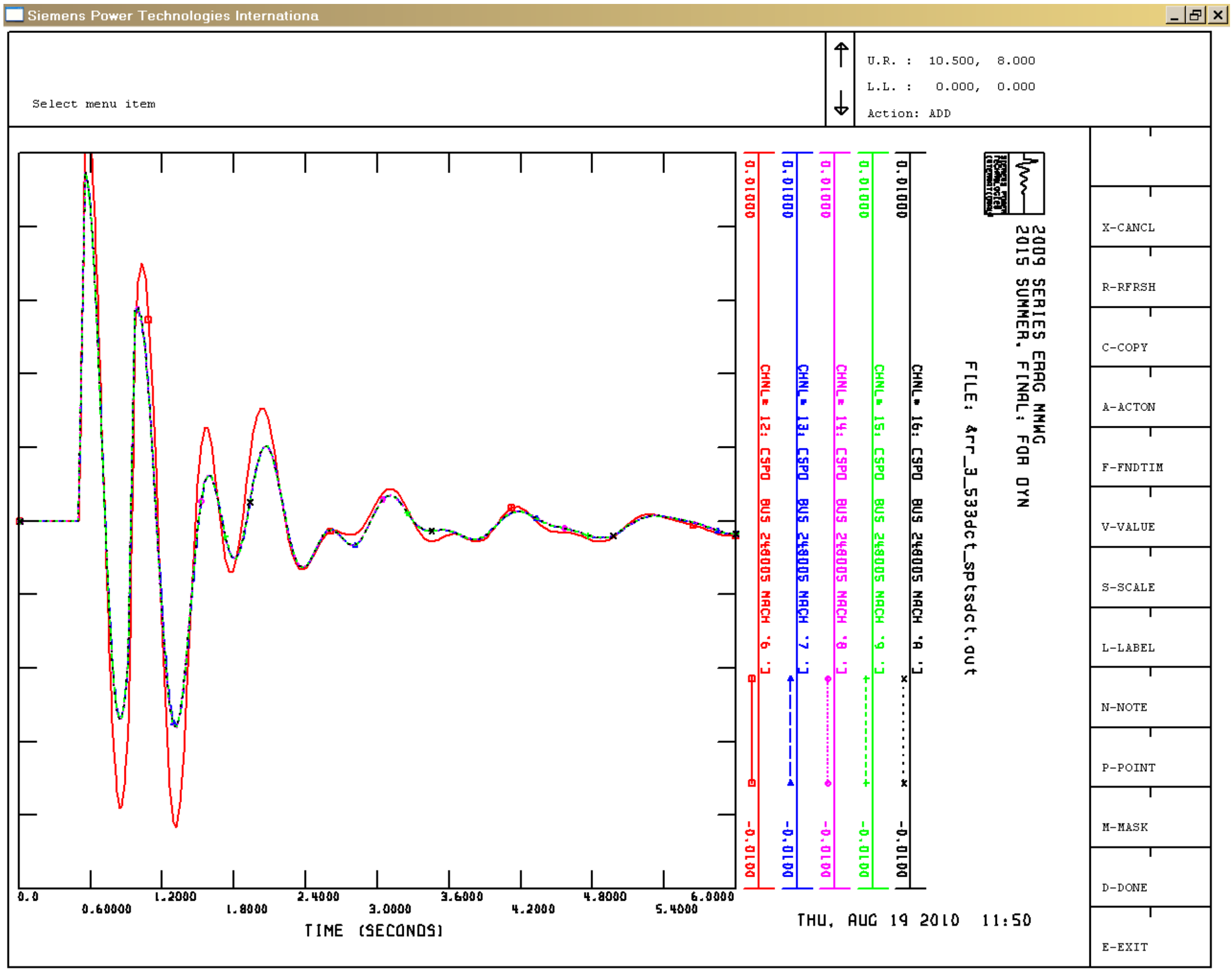
TABLE 2

Case Number	Prior Outage	Outaged Line	MW	Fault Type	Result
Case 1	Kyger Ck – X533 345 kV DCT	Kyger Ck – Sporn / Tristate 345 kV DCT	1025	3 Phase w/ HSR	Stable
Case 2	Kyger Ck – X533 345 kV DCT	Kyger Ck – Sporn / Tristate 345 kV DCT	1025	No Fault	Stable
Case 3	Kyger Ck – X530 345 kV DCT	Kyger Ck – Sporn / Tristate 345 kV DCT	1025	3 Phase w/ HSR	Stable
Case 4	Kyger Ck – X530 345 kV DCT	Kyger Ck – Sporn / Tristate 345 kV DCT	1025	No Fault	Stable
Case 5	Kyger Ck – X530 345 kV DCT	Kyger Ck – X533 345 kV DCT	1025	3 Phase w/ HSR	Stable
Case 6	Kyger Ck – X530 345 kV DCT	Kyger Ck – X533 345 kV DCT	1025	No Fault	Stable



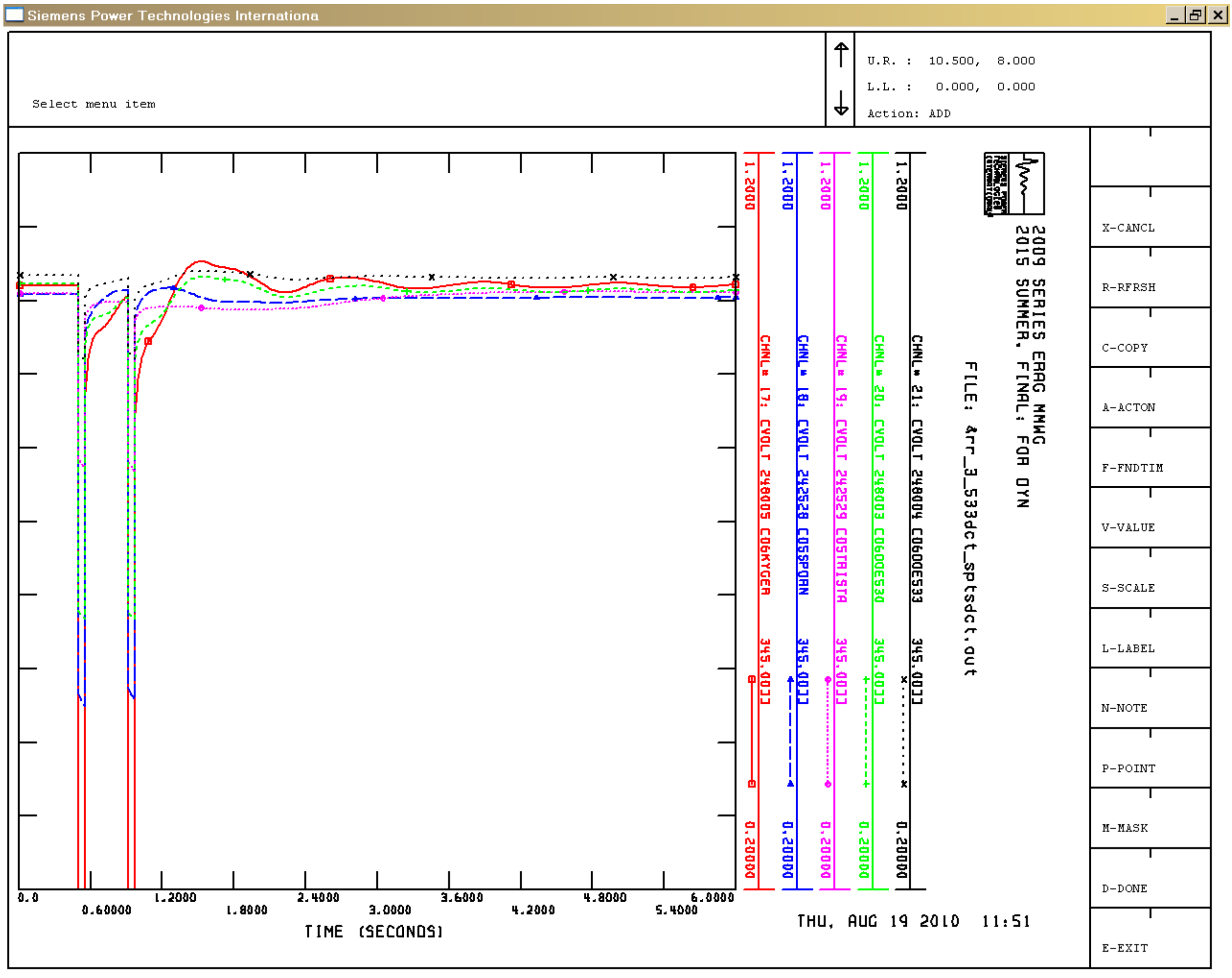
Kyger Creek Plant Per Unit Speeds

Case 1 – Prior outage of Kyger Creek – X533 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



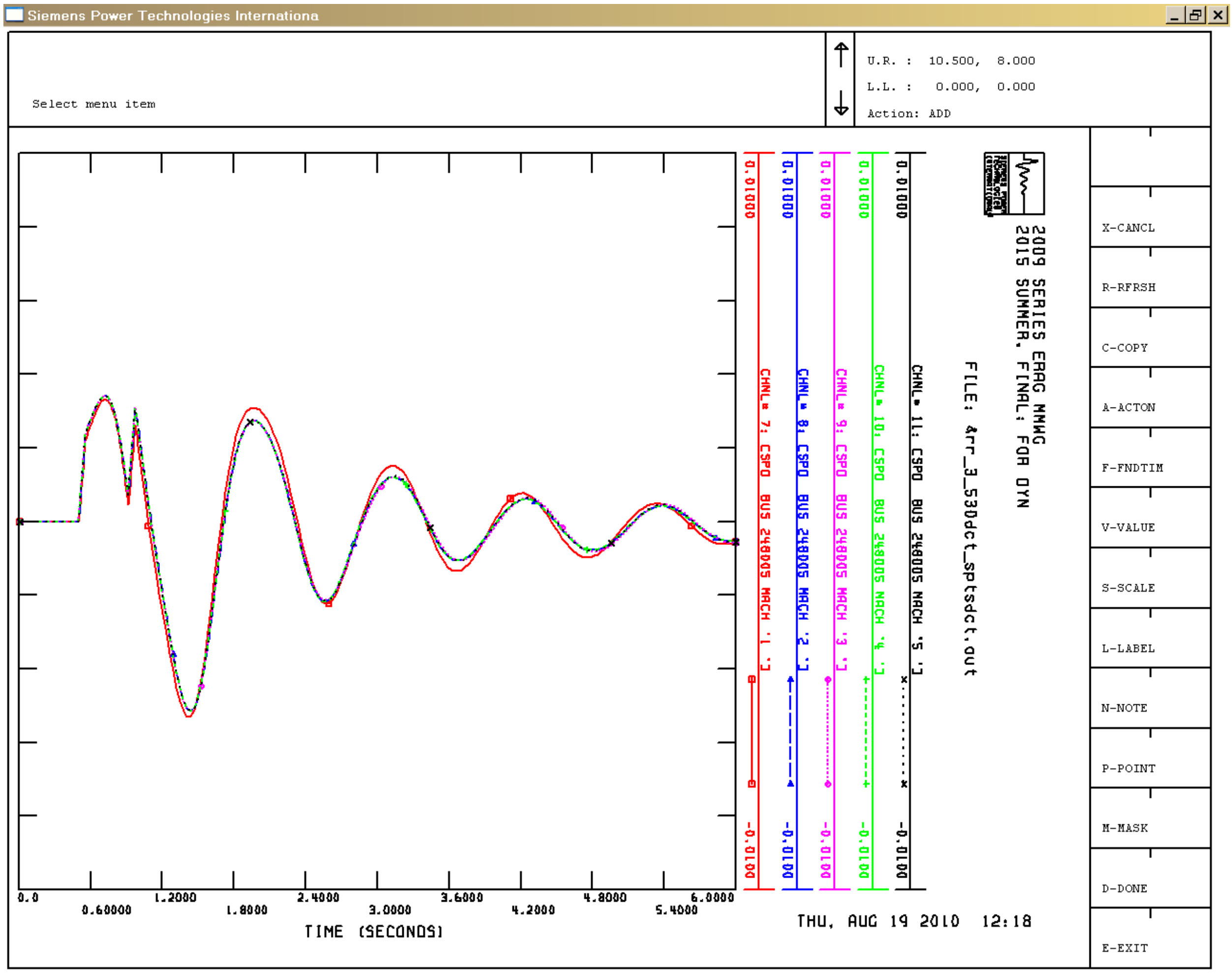
Kyger Creek Plant Per Unit Speeds

Case 1 – Prior outage of Kyger Creek – X533 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



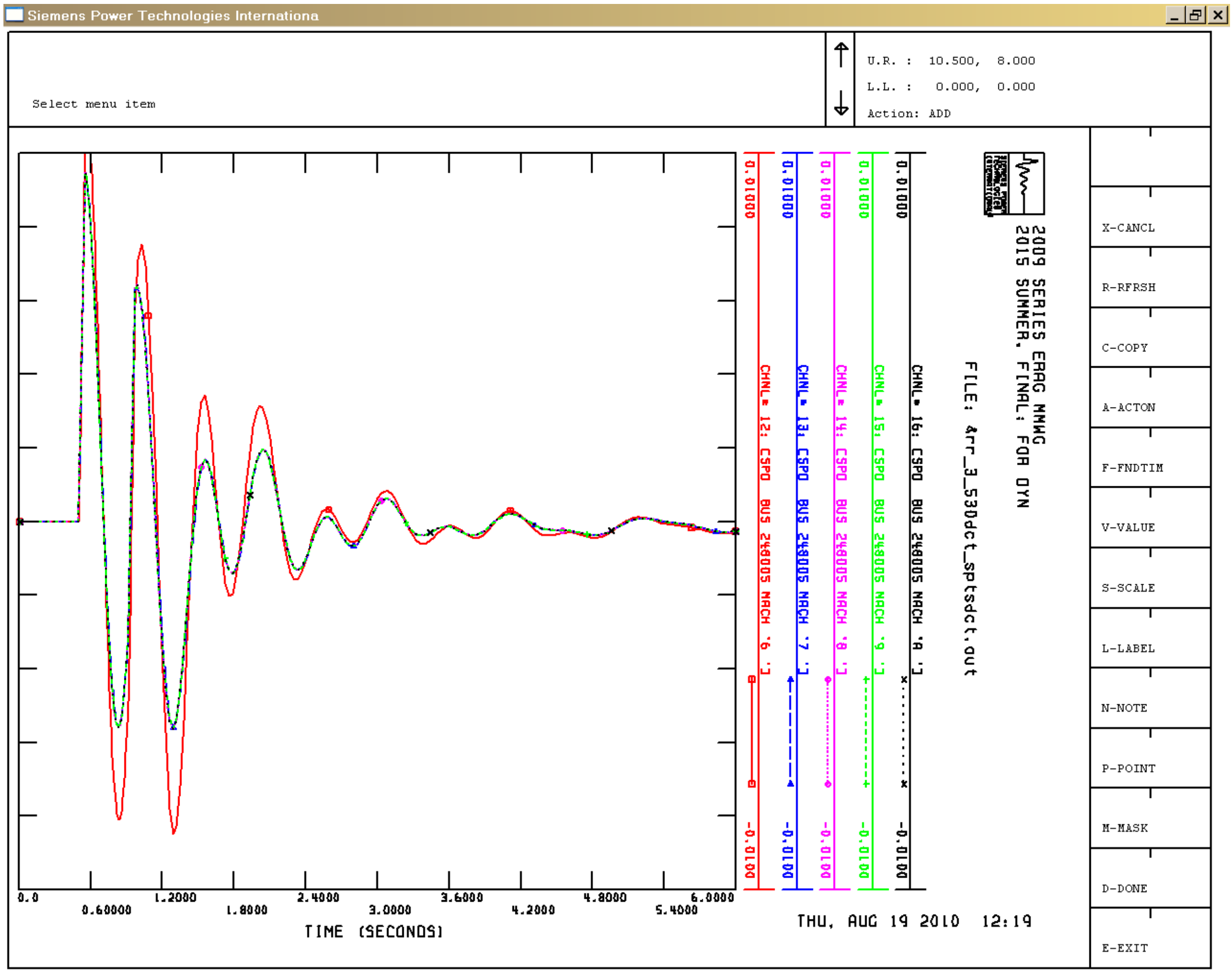
Per Unit Station Voltages

Case 1 – Prior outage of Kyger Creek – X533 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



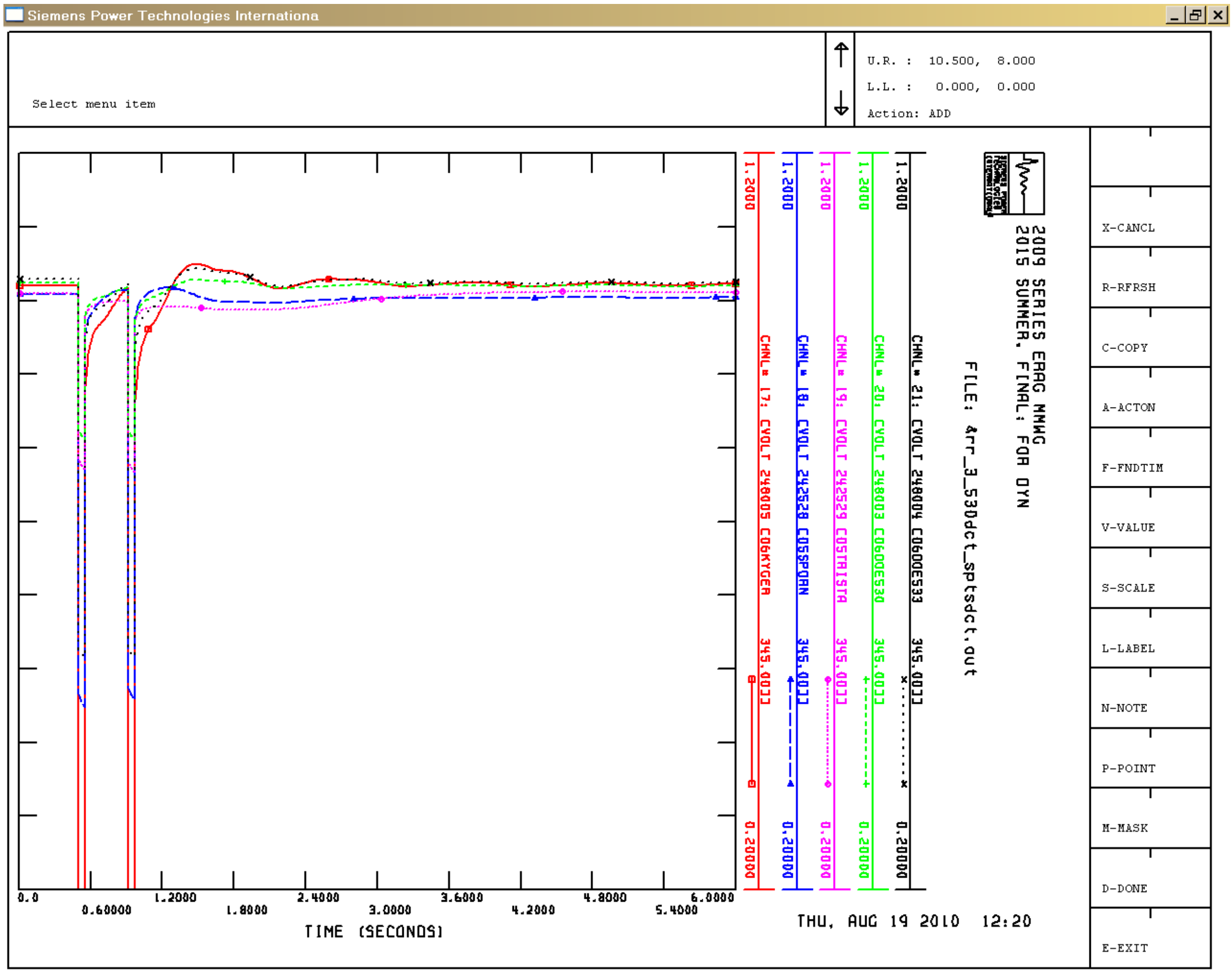
Kyger Creek Plant Per Unit Speeds

Case 3 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



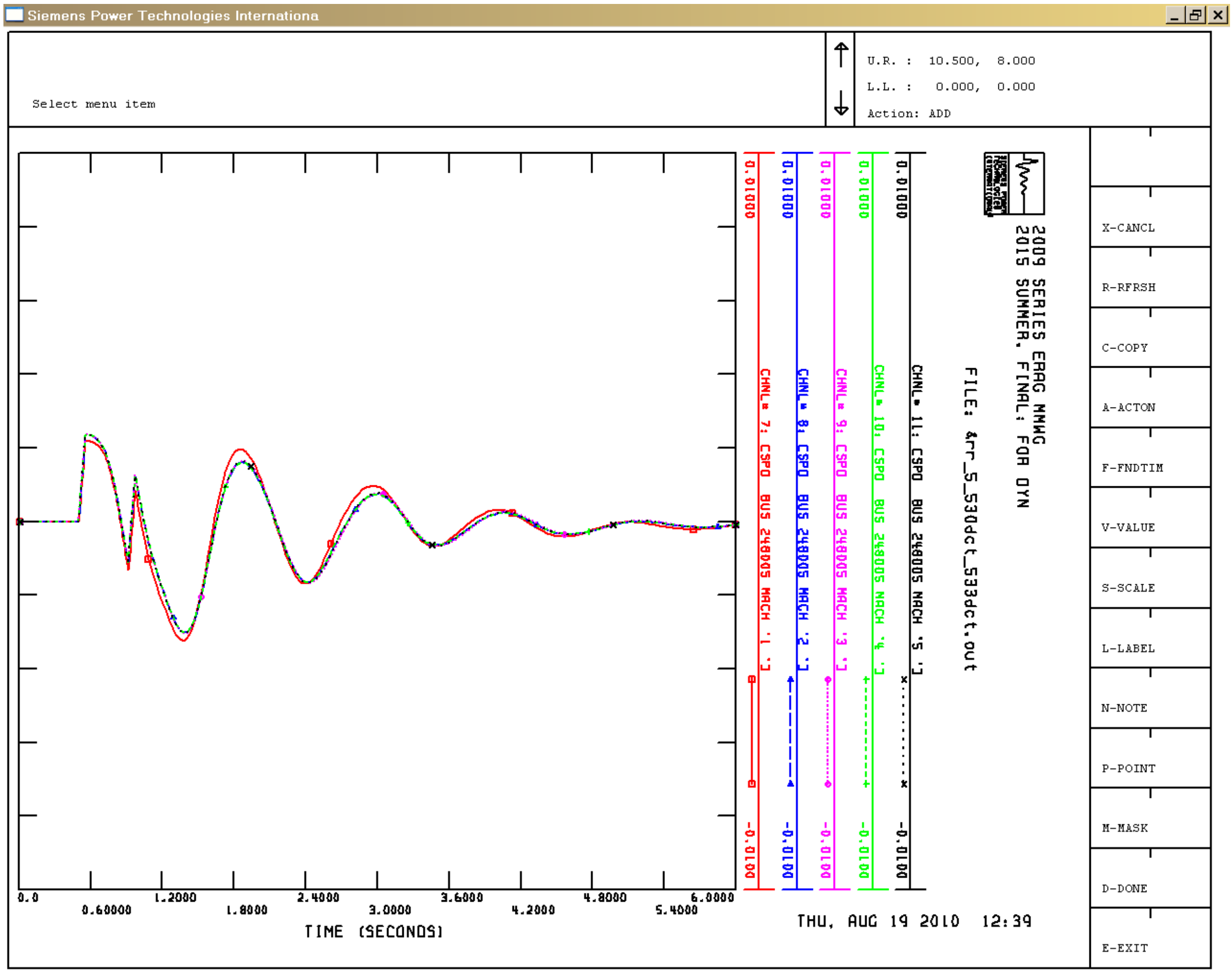
Kyger Creek Plant Per Unit Speeds

Case 3 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



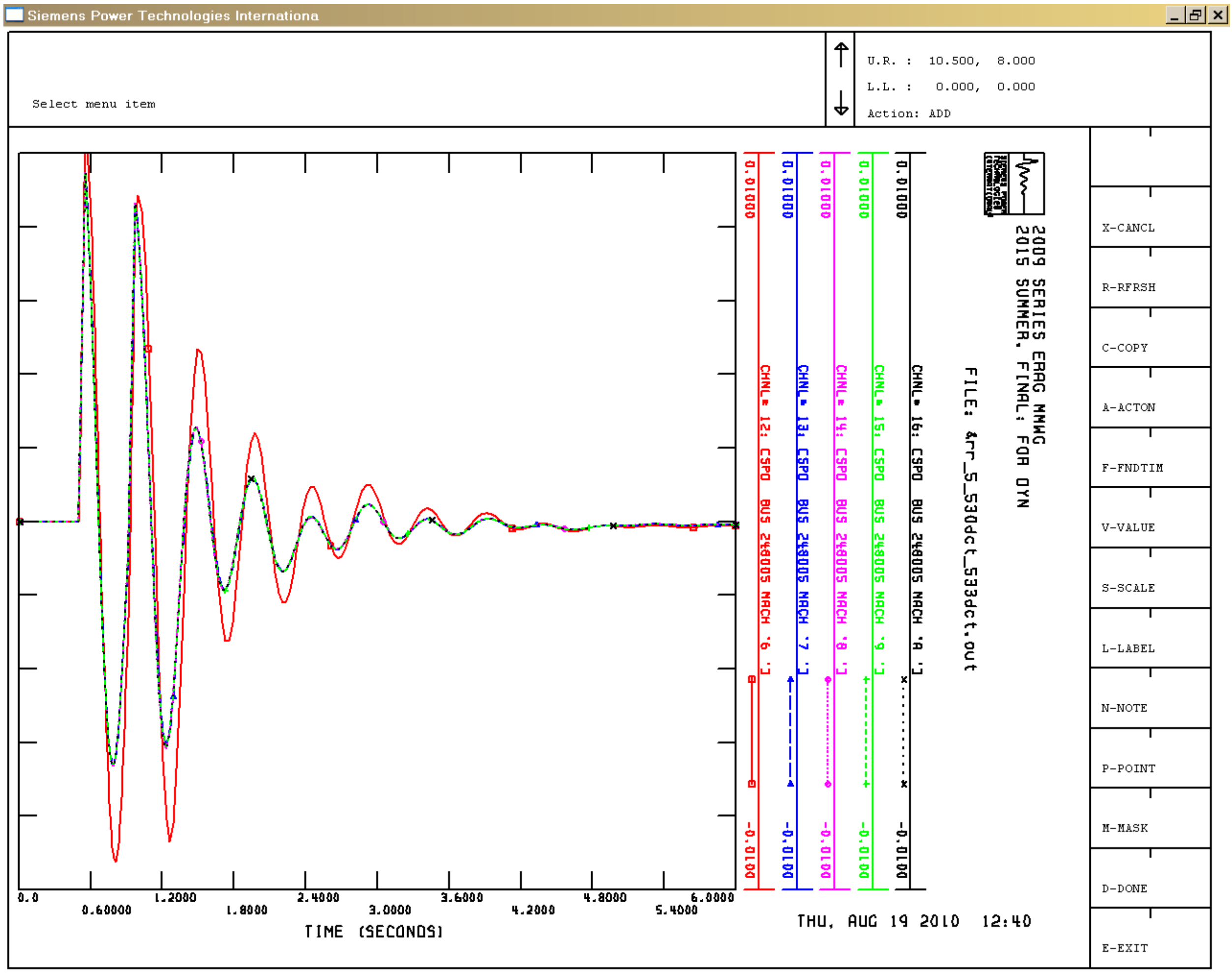
Per Unit Station Voltages

Case 3 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – Sporn/Tristate 345 kV DCT with unsuccessful HSR.



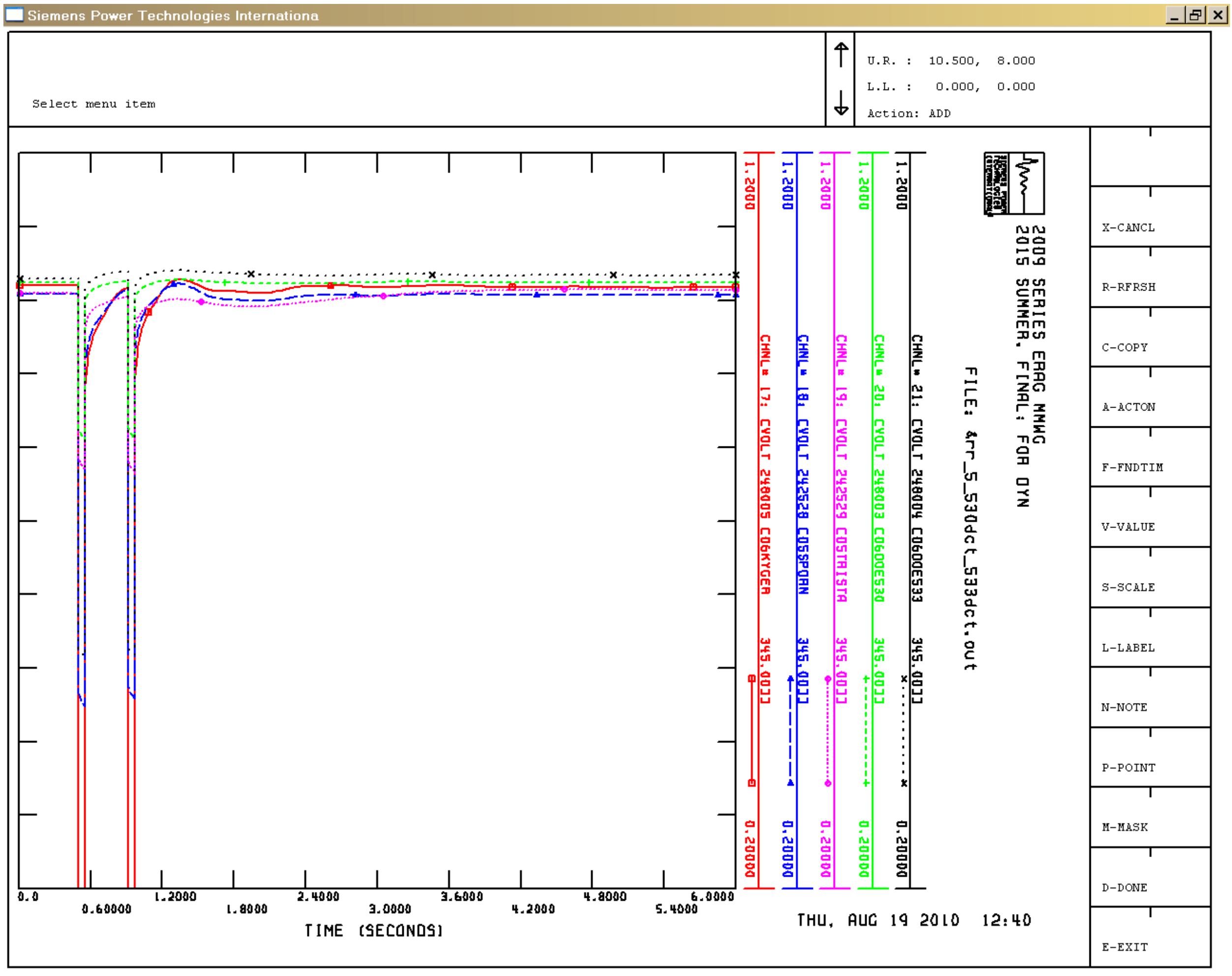
Kyger Creek Plant Per Unit Speeds

Case 5 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – X533 345 kV DCT with unsuccessful HSR.



Kyger Creek Plant Per Unit Speeds

Case 5 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – X533 345 kV DCT with unsuccessful HSR.



Per Unit Station Voltages

Case 5 – Prior outage of Kyger Creek – X530 345 kV DCT. Fault and trip Kyger Creek – X533 345 kV DCT with unsuccessful HSR.

Appendix F

Ohio Valley Electric Corporation

Clifty Creek Plant

Stability Performance Study

Advanced Transmission Studies and Technologies

December 2011

AEP: America's Energy Partner℠

7. INTRODUCTION

This study was undertaken to evaluate the stability performance of Ohio Valley Electric Corporation's (OVEC) Clifty Creek Plant. The study was conducted in accordance with the August 2011 NERC Board approved NERC TPL-001-2 standard.

8. OVERVIEW OF GENERATION/TRANSMISSION FACILITIES

The generation capability at the Clifty Creek Plant is 1,230 MW winter net and is the sum of six similar units each rated at 205 MW winter net. This study considered the planned temporary outages of Clifty Creek – Dearborn – Buffington 345 kV line sections in late 2011 through early 2012 that were necessary for removal of Dearborn circuit breakers DA and DD, though this outage is not within the planning horizon.

9. TESTING CRITERIA

NERC TPL-001-2 Table 1 specifies the system conditions and disturbance events for which stable operation is required. In addition, satisfactory damping of generator post-disturbance power oscillations is required.

The Table 1 testing criteria are applied in time domain simulations to evaluate the stability performance of a generation facility. For each disturbance, the resulting transmission system response is simulated and then analyzed to assess the impact of the disturbance scenario on the proposed generators and the surrounding system. A minimum one cycle margin to instability is present in the stability results designated as acceptable reported in this study.

Some of the NERC TPL-001-2 Table 1 category contingencies are either not applicable or would be less severe and are omitted from this study. Specifically, P1 contingencies are less severe than P6 contingencies (P6 is the same as P1 under a prior outage condition) which, if stable, demonstrate compliance with P1. Due to the configuration of Clifty Creek 345 kV Station, P2 bus section and circuit breaker faults are equivalent in severity to line faults because these disturbance scenarios would not remove any more transmission facilities than would P1 contingencies and may remove a generating unit. P3 prior generation outages would be less severe due to the fact that stability studies test the ability of the transmission system under contingency outages to absorb generation and a condition of less generation would be more stable. P4 stuck breaker contingencies with backup fault clearing are less severe than P6 three-phase fault cases under a prior outage condition because, also due to the configuration of Clifty Creek 345 kV Station, these disturbance scenarios would result only in the removal of one transmission facility.

P6 and P7 criteria are combined in this study by simulating the three-phase fault and tripping of double circuit tower lines on top of the prior outage of another transmission facility. These are the type of disturbance scenarios that produce the most severe stability tests on the Clifty Creek Plant due to the most severe fault type (3-phase) and the most transmission facilities removed. The prior outage cases are not followed by any system adjustments and so also qualify as Type 1 stability extreme disturbances in TPL-001-2 Table 1.

For the purposes of post-fault transient voltage criteria required by TPL-001-2 R5, this study assumes that transient voltage dips at the transmission station above 40 percent voltage for 2.5 seconds are acceptable. The magnitude and duration of post-fault transient voltage dips is closely associated with proximity to instability of conventional generation and transient voltage dips that do not lead to instability are acceptable for conventional generating plants and should not otherwise result in tripping of the generator or plant auxiliary load. Therefore, where instability of the subject generating plant is approached in any of the cases included in this study, either a clearing time margin or a MW dispatch margin is applied instead.

10. STUDY SCOPE and DATA

With reference to the above stability testing criteria, and in consideration of double circuit tower (DCT) faults and outages, the cases to be simulated were determined and are listed in Table 1 below. These cases involved three-phase primary cleared faults or non-fault initiated tripping. Phase-to-ground delayed clearing faults at Clifty Creek 345 kV Station were not simulated due to the station configuration that is such that outage of further transmission elements does not occur, thus making these disturbance scenarios less severe. Phase-to-ground delayed clearing faults were considered at remote ends of lines emanating from Clifty Creek Station.

Base cases applied in this study were the 2010 series ERAG / MMWG 2012 Summer Peak Load and 2016 Light Load cases in accordance with TPL-001-2 R2.4.1 and R2.4.2, respectively. All ERAG / MMWG dynamic base cases include modeling of automatic dynamic control devices relevant to the Clifty Creek area in accordance with TPL-001-2 R4.3.2. The 2012 Summer Peak Load case was studied with Clifty Creek – Dearborn #2 – Buffington 345 kV line sections out of service due to the Dearborn Bus 2 bypass project, though this is not a planning horizon condition for TPL purposes.

Dynamic load representation, in accordance with TPL-001-2 R2.4.1, was applied as a sensitivity variable in the 2012 Summer Peak case. The PSS/E CLODAR model was applied to the study area (OVEC, AEP, LGEE, HE, DEM areas) with the following percentages:

Large motor	20 p
Small motor	40
Transformer exciting current	3
Discharge lighting	5
Constant power	2
Constant current	30
Distribution equivalent R + jX percent on load MW per unit base	4

The Clifty Creek Plant was dispatched at its winter net capacity of 1,230 MW unless otherwise indicated. Other nearby generating plants at Trimble County (LGEE) and Buckner (IPP) were also dispatched at their winter net MW capacities.

Unsuccessful high speed reclosing (HSR) of faulted transmission lines was simulated in three-phase fault cases inclusive to the OVEC system in accordance with TPL-001-2 R4.3.1.1. All primary fault clearing was assumed to be 3.5 cycles from fault initiation and backup or delayed clearing was assumed to be 15.0 cycles from fault initiation. Failure of a primary protection system(s) may cause up to a 30-cycle delayed fault clearing at the remote end of a line.

In all stability simulations in this study, the PSS/E simulation option “Scan circuits against generic relay zones” was turned on in accordance with TPL-001-2 R4.3.1.3.

Sensitivity conditions as required by TPL-001-2 R2.4.3 for both peak load and light load base cases considered the redispatch of generation on or in the vicinity of the OVEC system. Specifically, the Kyger Creek and Sporn generating plants were turned off and Tanners Creek and Lawrenceburg generating plants (one station away from Dearborn) were turned on and dispatched to their winter net MW capability.

11. STUDY RESULTS

The study results for each stability simulation case are indicated in Table 1 below. The results of cases simulated on peak load and light load conditions, as well as the sensitivity variable cases and non-fault initiated outage cases, are all the same as far as the their stability is concerned. The acceptable stability results from these cases in recognition of TPL-001-2 R4.1.1, 4.1.2, and 4.1.3 indicate that less severe cases consistent with TPL-001-2 criteria would also have acceptable stability.

No generic relay scan alarms were observed on any non-faulted lines in any of the cases included in this study (TPL-001-2 R 4.3.1.3). No generators are expected to trip during faults due to lack of low voltage ride-through capability (TPL-001-2 R4.3.1.2).

Plots of a representative sample of the dynamic simulation cases involving three-phase and phase-to-ground faults are attached below.

12. CONCLUSION

The Clifty Creek Plant exhibits acceptable stability performance under all credible contingencies consistent with NERC TPL-001-2 without a need for generation curtailment.

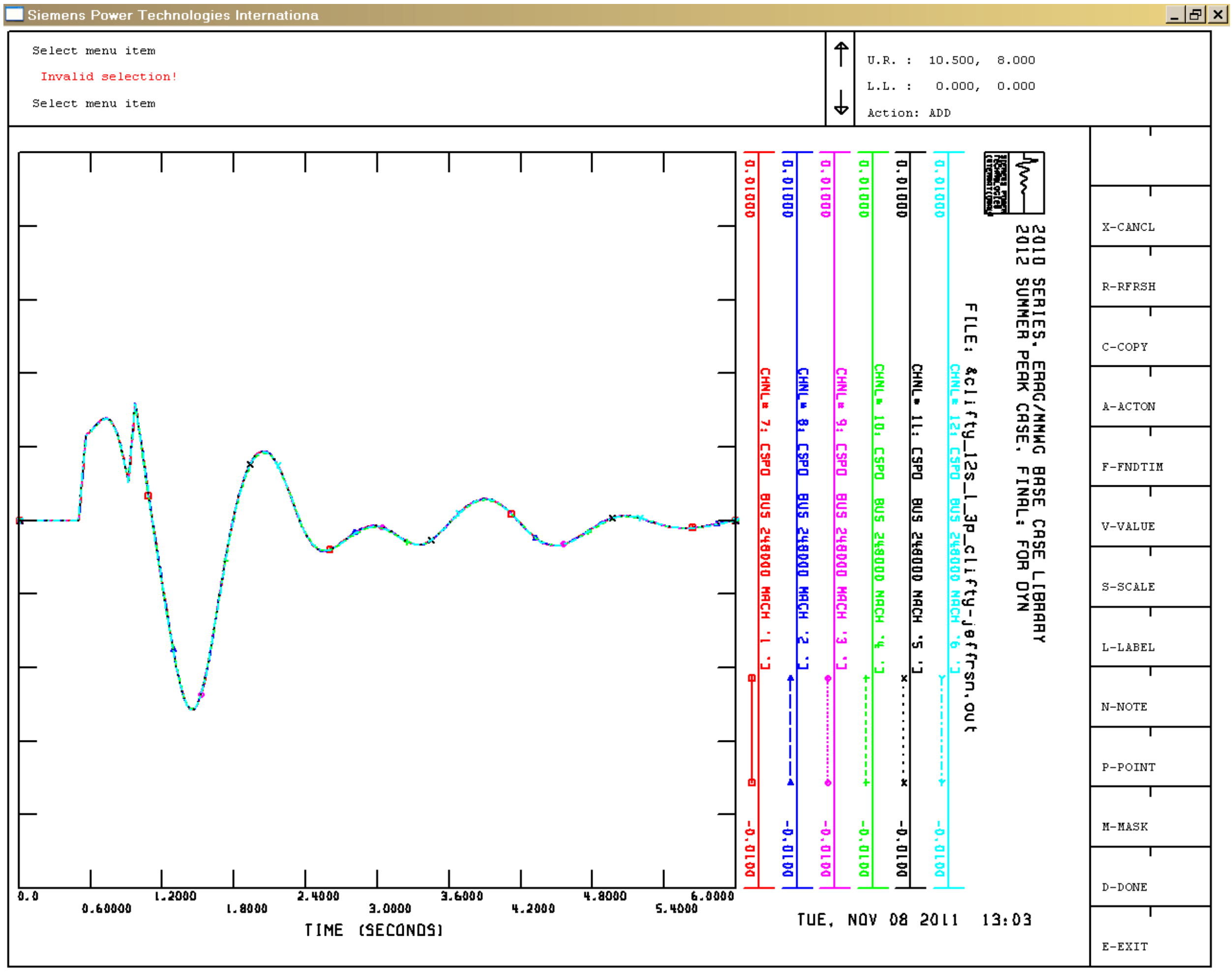
Table 1 – Clifty Creek Plant Stability Study Cases

	Prior Outage *	Outaged Facility	NERC Category	Fault Type **	Result
Case 1	Clifty Creek – Jefferson 345 kV	Clifty Creek – Pierce 345 kV DCT	P6-P7	3 Phase w/ unsuccessful HSR	Stable
Case 2	Clifty Creek – Jefferson 345 kV	Clifty Creek – Dearborn 345 kV DCT	P6-P7	3 Phase w/ unsuccessful HSR	Stable
Case 3	Clifty Creek – Jefferson 345 kV	Clifty Creek – Trimble Co 345 kV	P6	3 Phase No HSR	Stable
Case 4	Clifty Creek – Jefferson 345 kV	Buckner – Middletown 345 kV DCT	P6-P7	3 Phase No HSR	Stable
Case 5	Clifty Creek – Trimble Co 345 kV	Clifty Creek – Pierce 345 kV DCT	P6-P7	3 Phase w/ unsuccessful HSR	Stable
Case 6	Buckner – Middleton 345 kV	Clifty Creek – Pierce 345 kV DCT	P6-P7	3 Phase w/ unsuccessful HSR	Stable
Case 7	None	Dearborn – Clifty Creek 345 kV #1 Remote End Fault @ Dearborn	P5	1 Phase-to-ground w/ relay failure	Stable

Case 8	None	Clifty Creek 345 kV Station Bus 1 or 2	Extreme Event	3 Phase w/ 3 Phase delayed	Unstable, No Cascading

* The prior outage cases listed above (1 through 6) are not followed by any system adjustments and so also qualify as Type 1 stability extreme disturbances in TPL-001-2 Table 1.

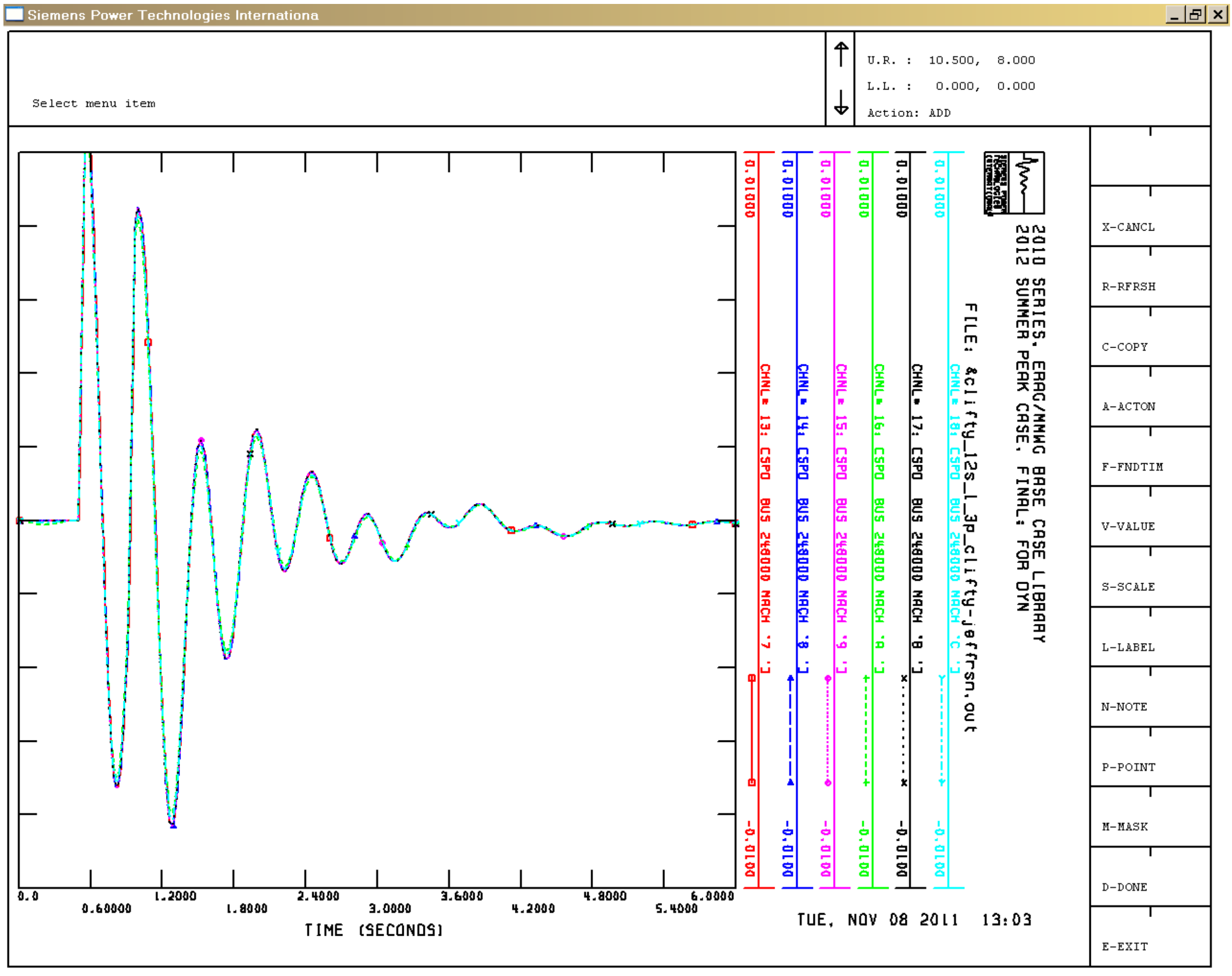
** A representative sample of non-fault initiated outages was also considered per TPL-001-2 P2.1.



Clifty Creek Plant LP Generator Speeds

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

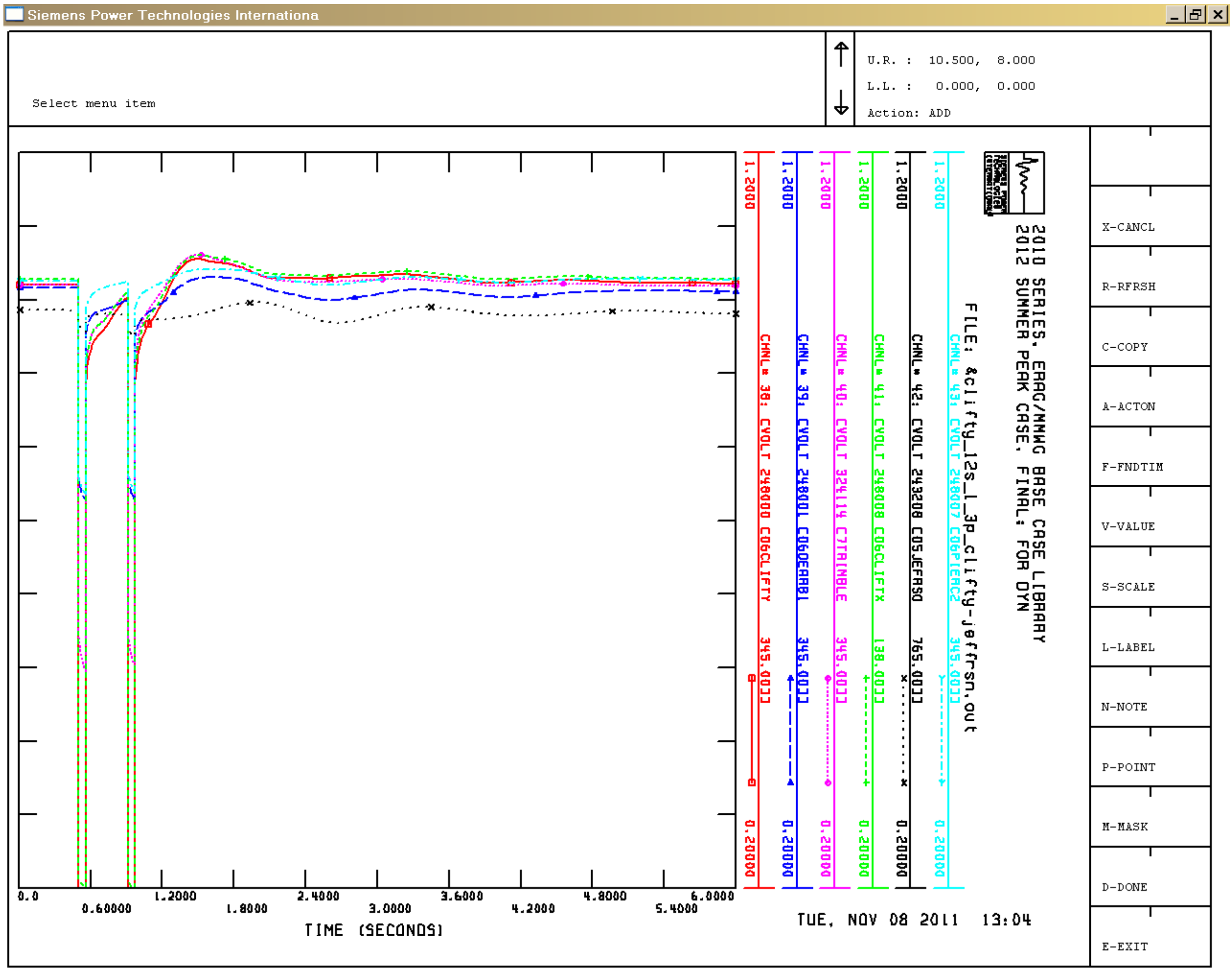
2012S Base Case



Clifty Creek Plant HP Generator Speeds

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

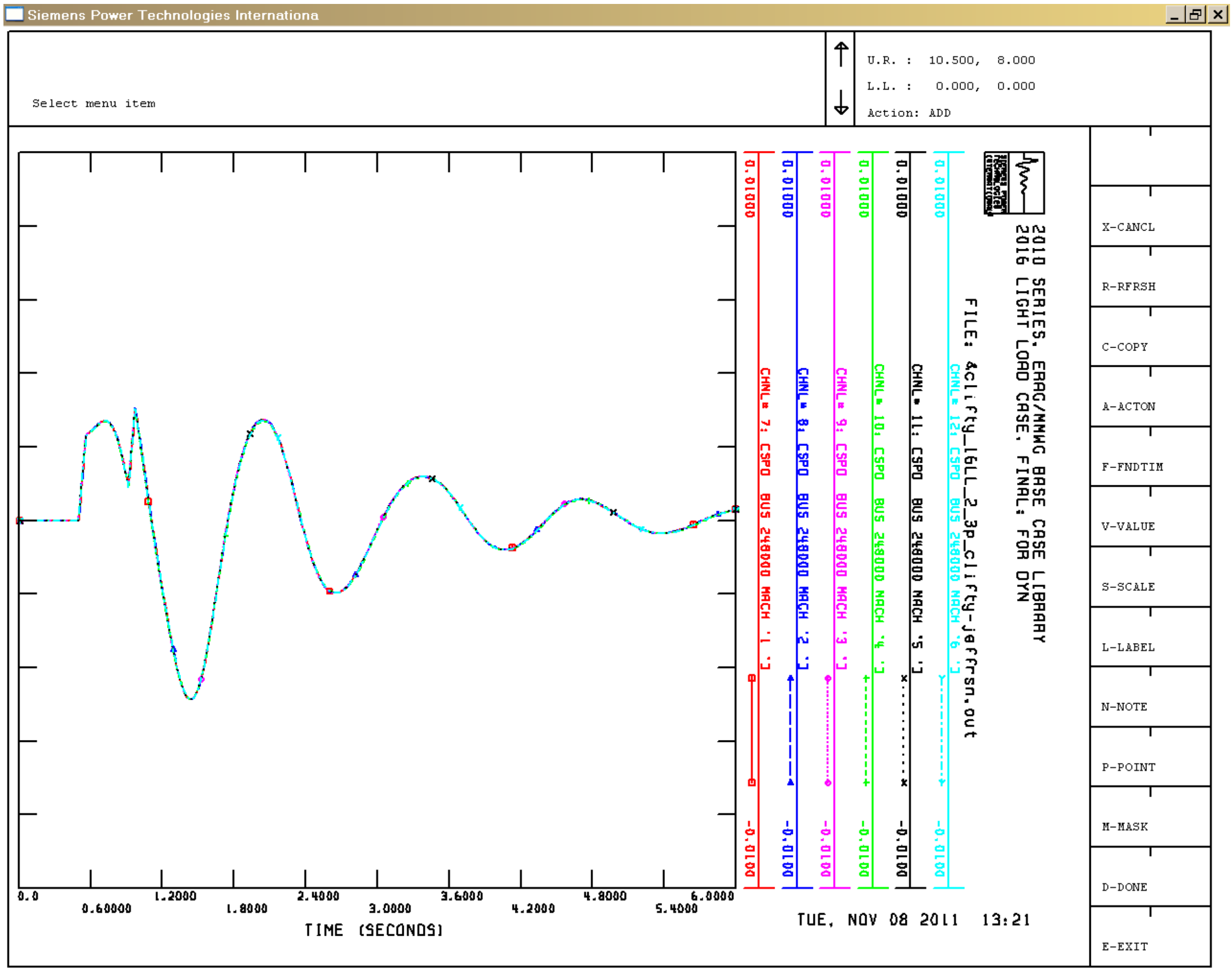
2012S Base Case



Clifty Creek, Dearborn, Trimble County, Jefferson, Pierce Station Voltages

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

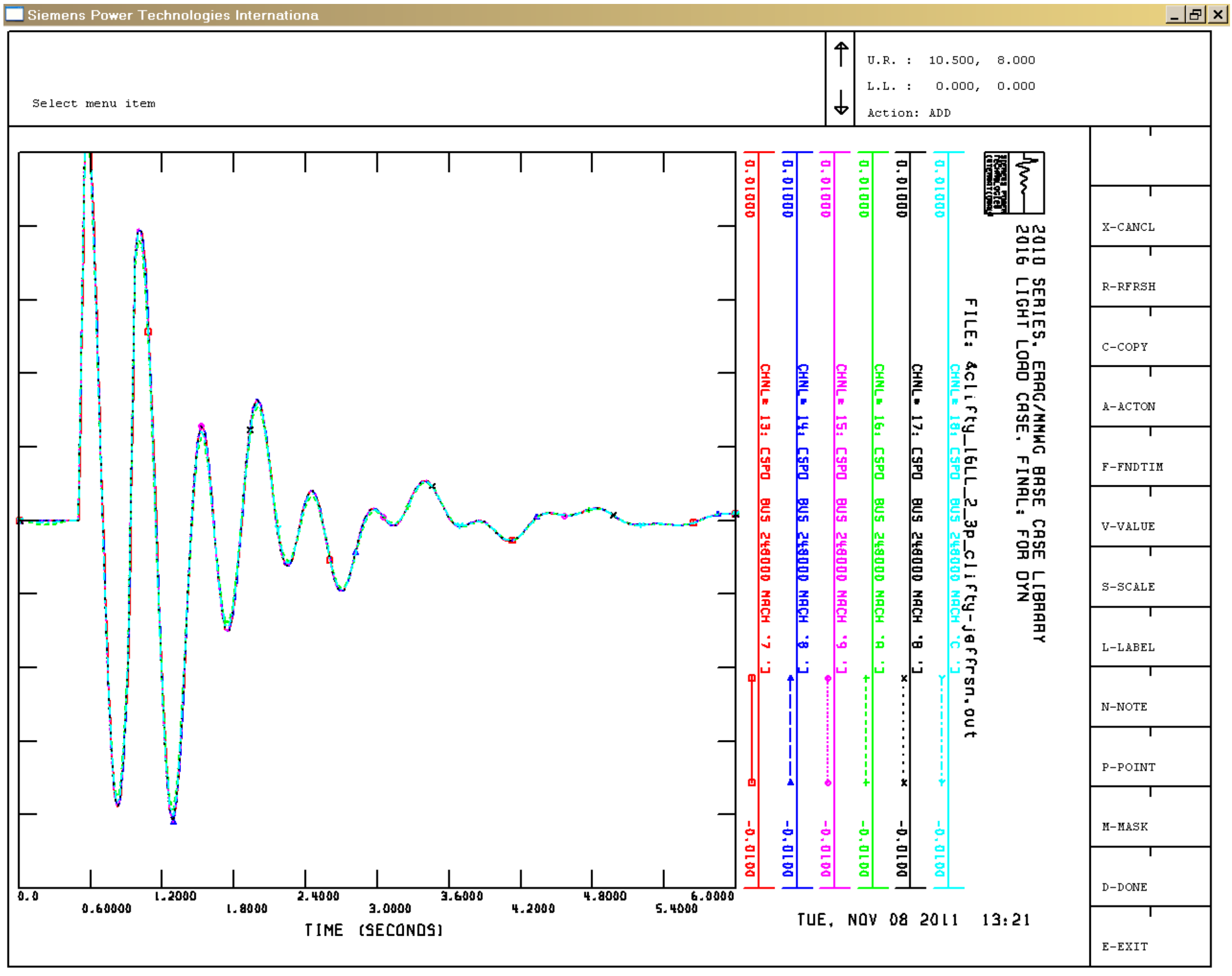
2012S Base Case



Clifty Creek Plant LP Generator Speeds

Case 2: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Dearborn 345 kV DCT with unsuccessful HSR.

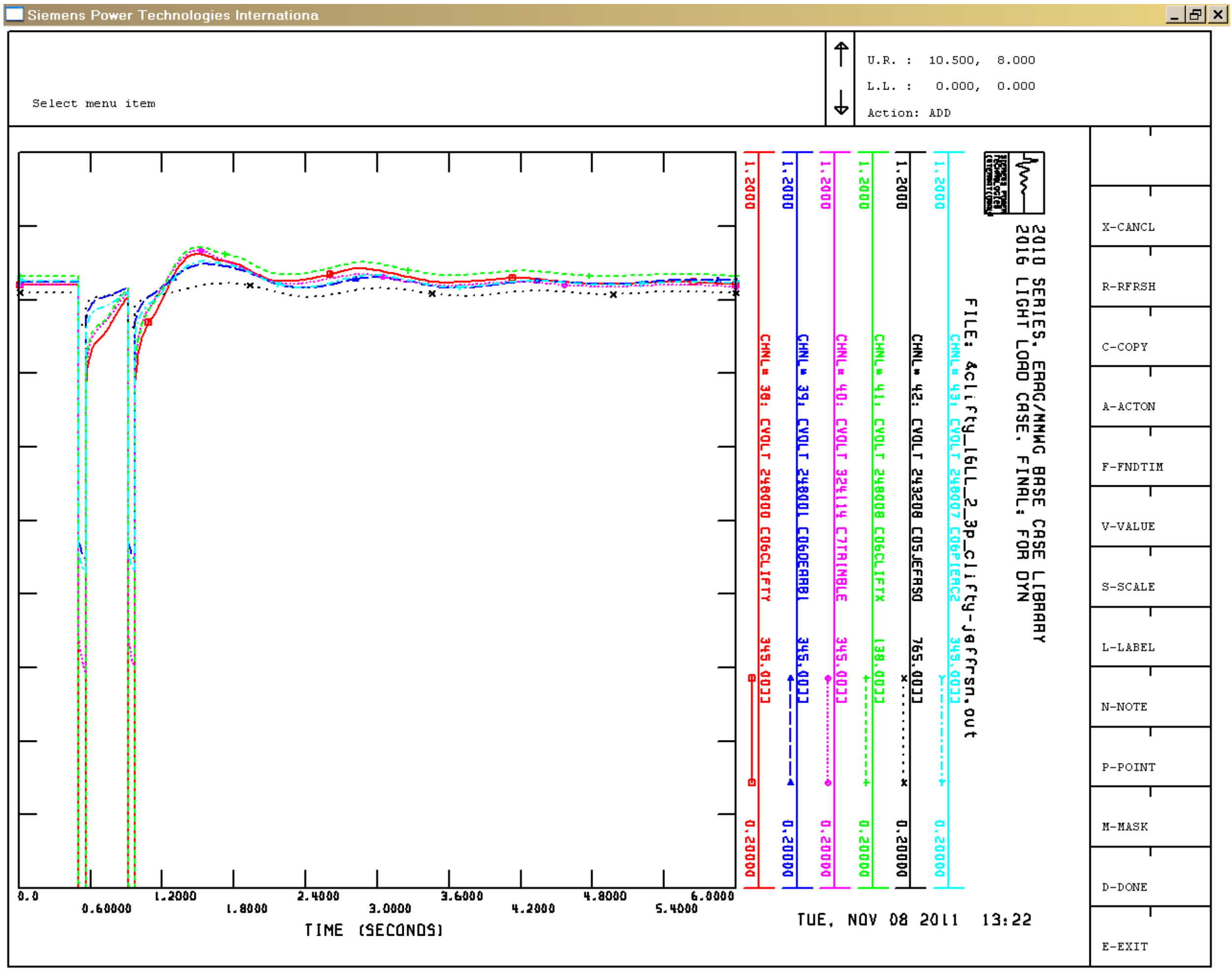
2016LL Base Case



Clifty Creek Plant HP Generator Speeds

Case 2: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Dearborn 345 kV DCT with unsuccessful HSR.

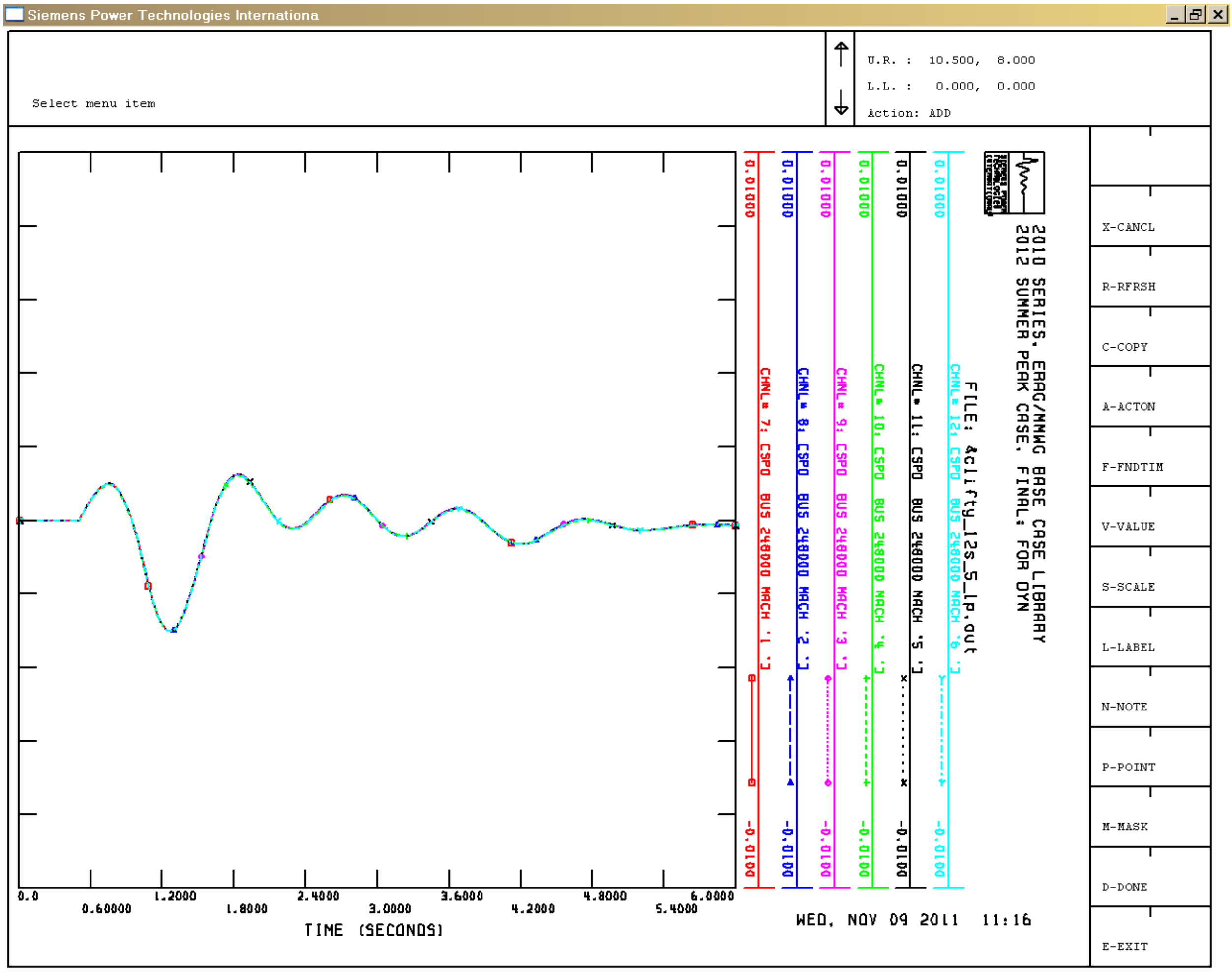
2016LL Base Case



Clifty Creek, Dearborn, Trimble County, Jefferson, Pierce Station Voltages

Case 2: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Dearborn 345 kV DCT with unsuccessful HSR.

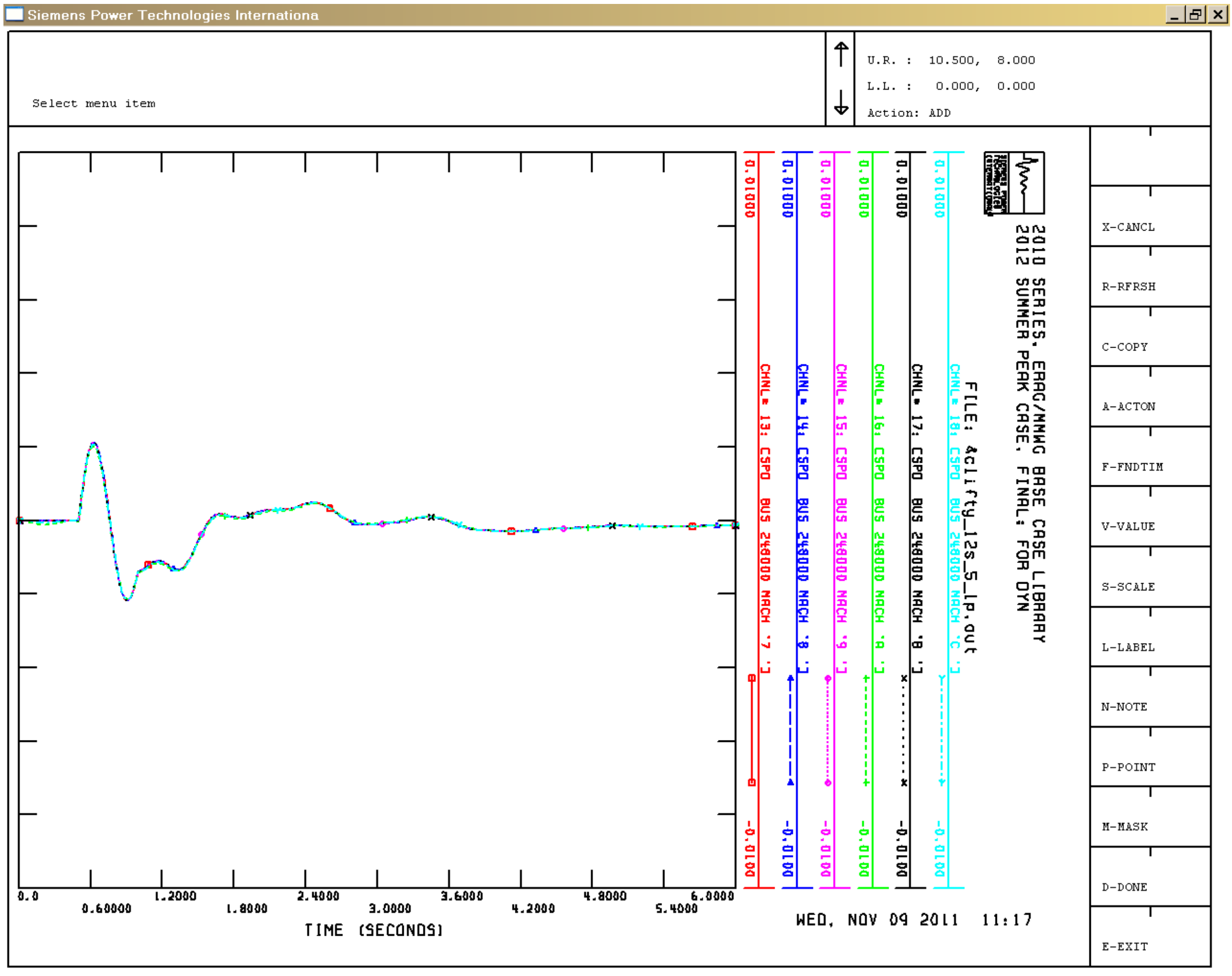
2016LL Base Case



Clifty Creek Plant LP Generator Speeds

Case 7: No prior outage. Remote end phase-to-ground fault, relay failure, and delayed trip of Clifty Creek – Dearborn 345 kV #1.

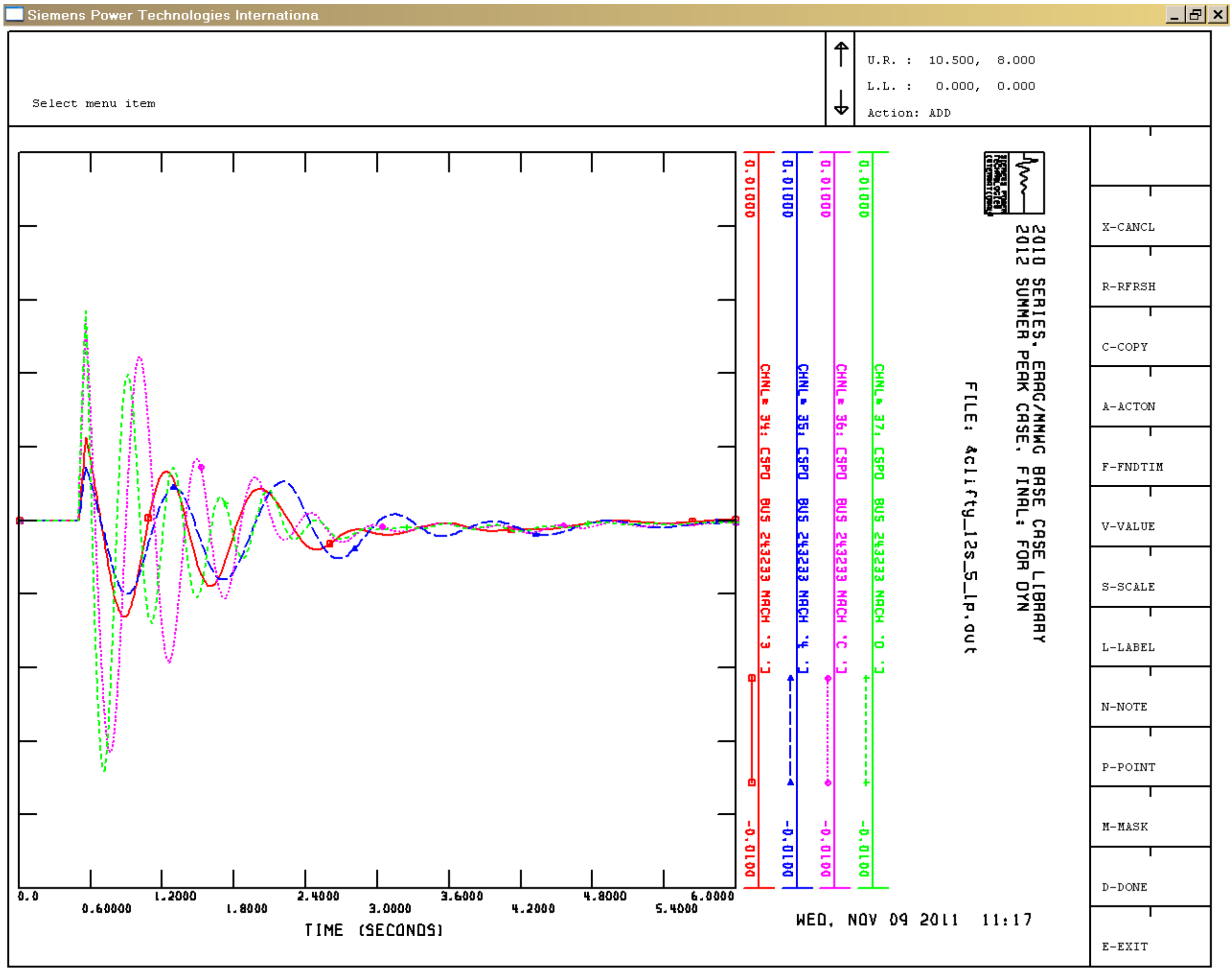
2012S Base Case



Clifty Creek Plant HP Generator Speeds

Case 7: No prior outage. Remote end phase-to-ground fault, relay failure, and delayed trip of Clifty Creek – Dearborn 345 kV #1.

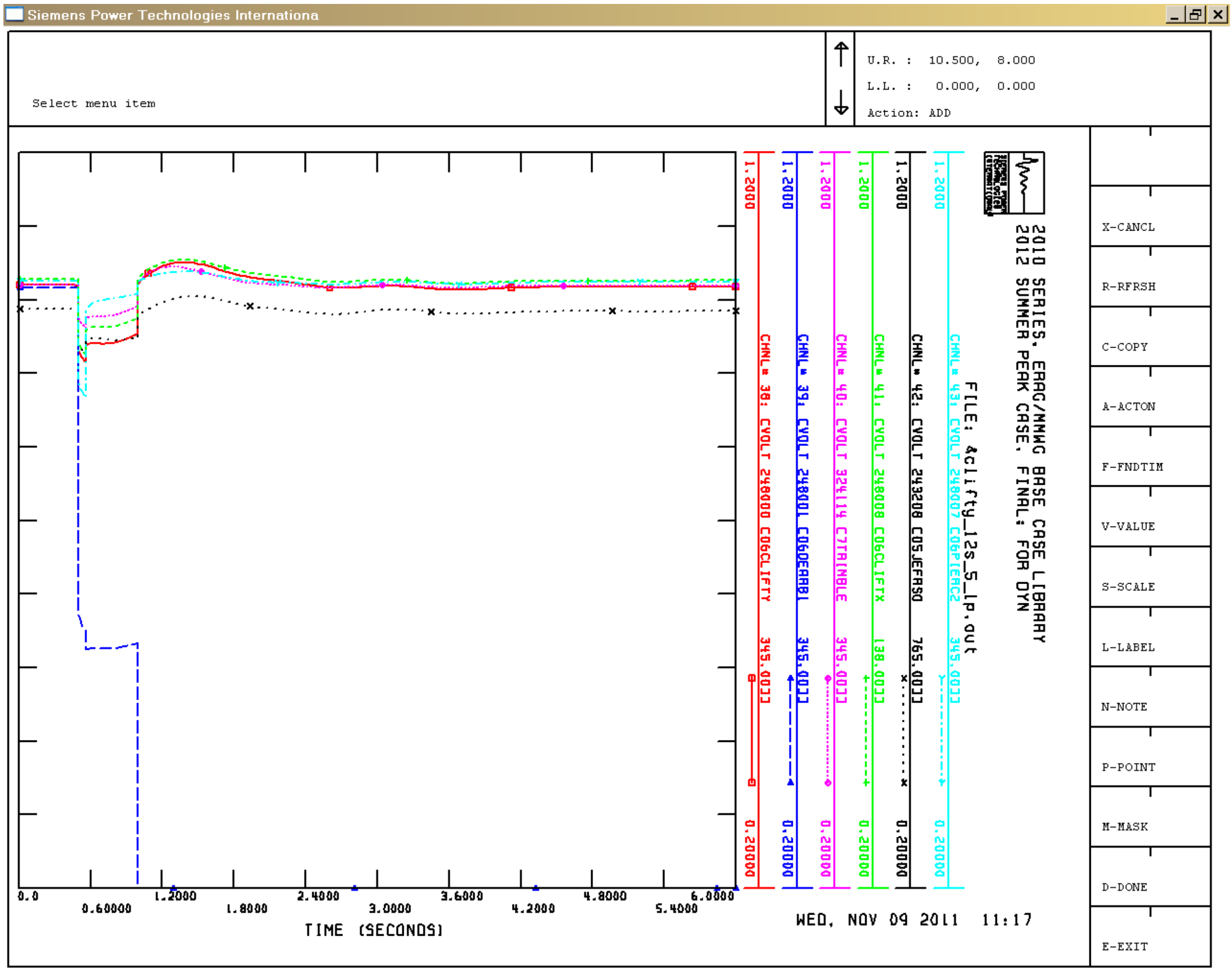
2012S Base Case



Tanners Creek 3 and 4 Generator Speeds

Case 7: No prior outage. Remote end phase-to-ground fault, relay failure, and delayed trip of Clifty Creek – Dearborn 345 kV #1.

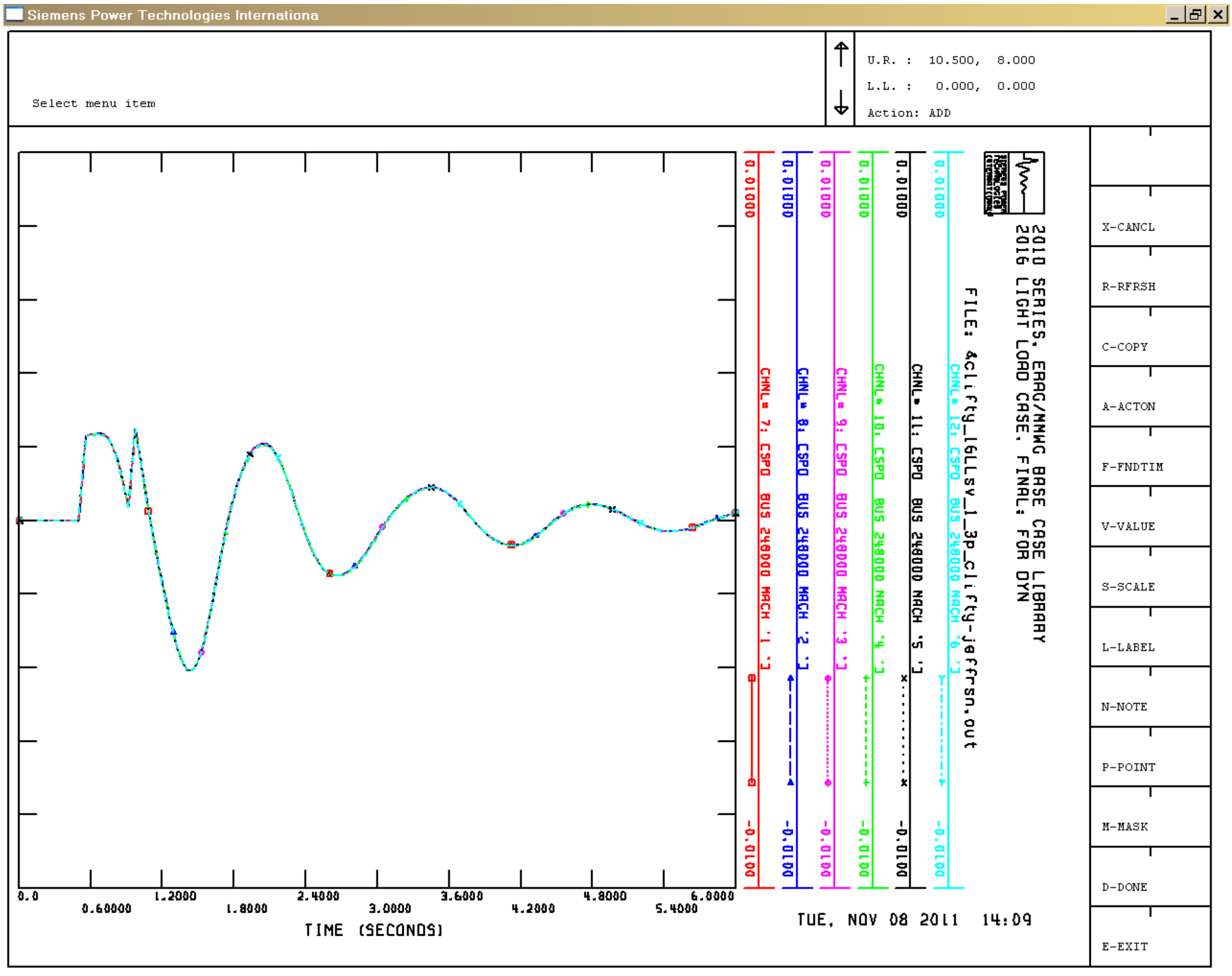
2012S Base Case



Clifty Creek, Dearborn, Trimble County, Jefferson, Pierce Station Voltages

Case 7: No prior outage. Remote end phase-to-ground fault, relay failure, and delayed trip of Clifty Creek – Dearborn 345 kV #1.

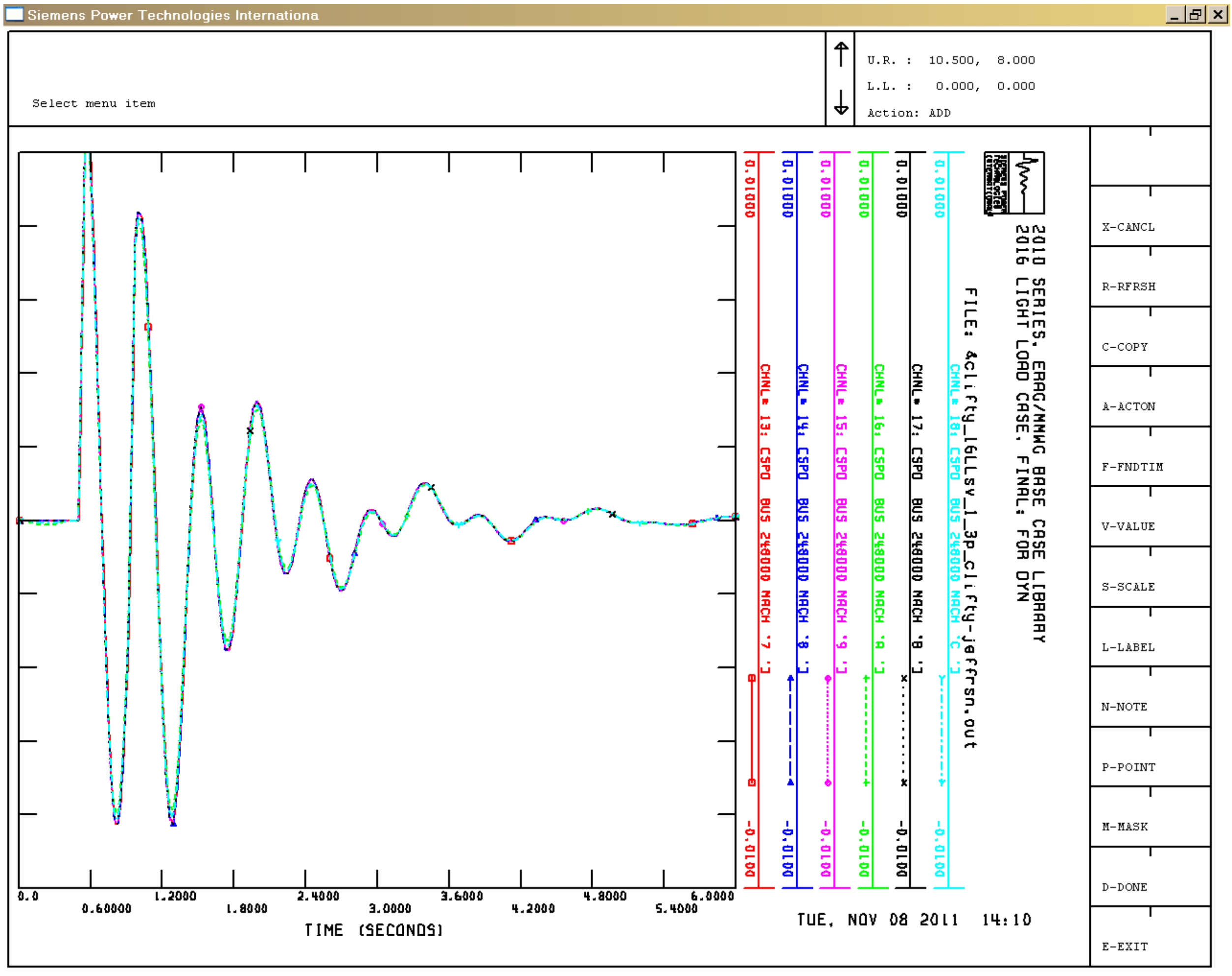
2012S Base Case



Clifty Creek Plant LP Generator Speeds

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

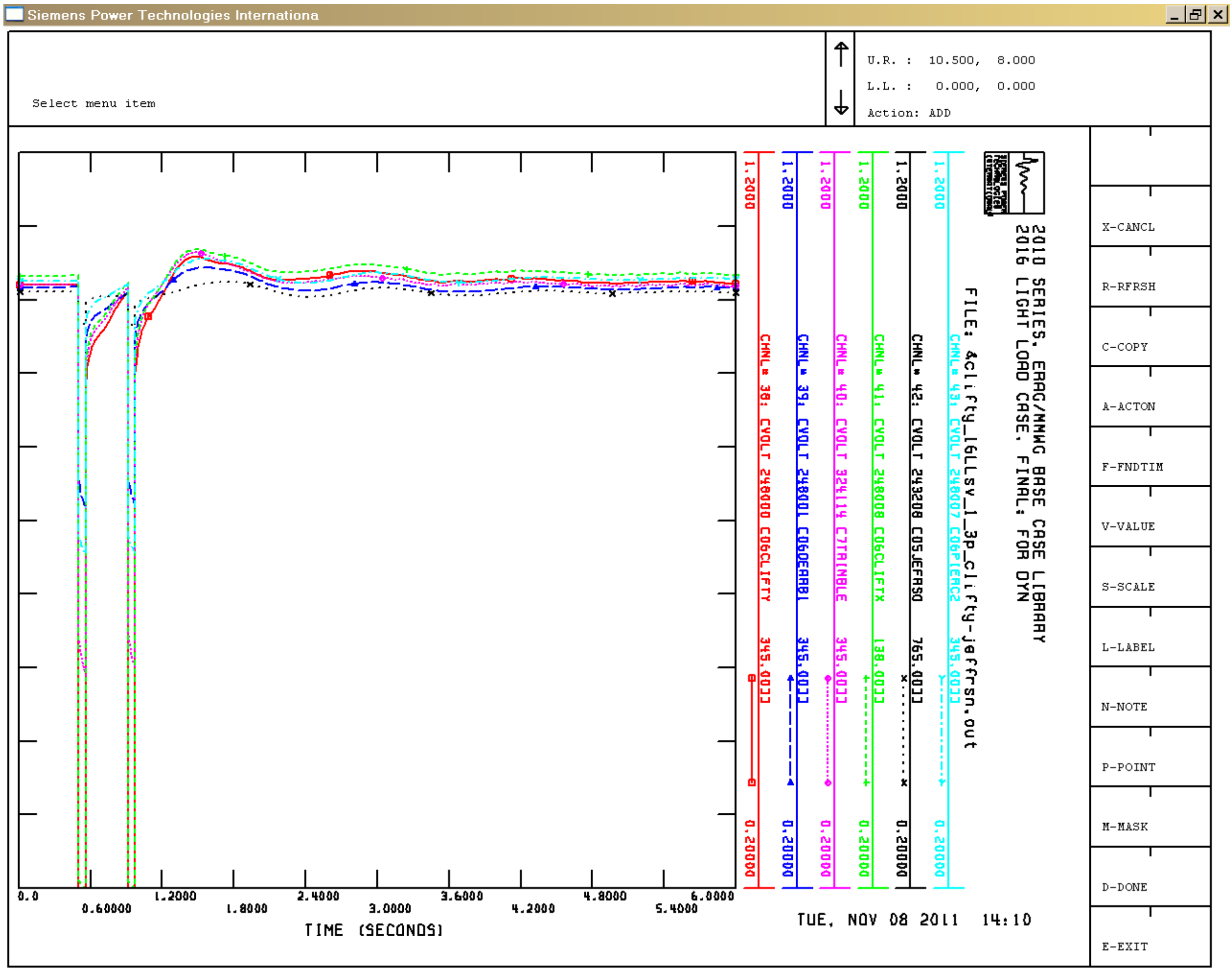
2016LL Base Case with generation dispatch sensitivity



Clifty Creek Plant HP Generator Speeds

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

2016LL Base Case with generation dispatch sensitivity



Clifty Creek, Dearborn, Trimble County, Jefferson, Pierce Station Voltages

Case 1: Prior outage of Clifty Creek – Jefferson 345 kV. Fault and trip Clifty Creek – Pierce 345 kV DCT with unsuccessful HSR.

2016LL Base Case with generation dispatch sensitivity