Connection Study Requirements

Document Release R1

Released: September 20, 2010

The Customer shall comply with all the applicable requirements in this document when performing connection studies to produce the engineering study report. AESO will review the engineering study report to ensure all the AESO requirements are met before accepting the proposed customer connection.

Table of Contents

1 Introduction

The study requirements provided in this document are intended to be used by the AESO customers who propose connecting a new facility or modifying an existing facility within the Alberta Interconnected Electric System (AIES). The AESO engineers will review the customer connection studies documented in the engineering study report based on the following given requirements and guidelines presented in this document. The AESO will review the customer engineering study report to ensure completeness of the studies and its compatibility with the AESO long term transmission development plans before endorsing the proposed customer connection.

In case of any ambiguities in the study requirements, guidelines, application of the Alberta Reliability Standards[1] and Transmission Reliability Criteria and AESO standards, the AESO will determine the proper method to be applied based on the system needs and each specific connection study.

[1] At the time this document was developed Alberta Reliability Standards (ARS) was under development. The ARS must be applied when in effect.

2 Project Classification

From the study perspective all connection projects can be classified into two categories based on the complexity of the project and constraints in the area where the proposed customer upgrades or new facility will be connected:

- Level one projects are more complex projects that could affect system operation, existing customers, or require the implementation of mitigation measures, e.g. Remedial Action Schemes (RAS). Consequently, upon completion of level one projects, applicable AESO documents such as Authoritative Documents (AD) and/or other operational procedure and information documents may need to be revised.

- Level two projects are relatively less complex projects which based on the previous understanding of the system will likely not cause any adverse impact on the system operation or violation of the AESO Reliability Criteria.

The AESO will determine the project level at the start and will reserve the right to change the project level based on the study outcomes, e.g. study results for a level two project indicate that existing operating limits may be affected and therefore the project classification should be changed to level one.

3 Study Stages

Comprehensive engineering study stages are outlined below. Descriptions of the stages are provided in the subsections 3.1 to 3.8. All applicable study stages and their order shall be identified in the study scope document and acknowledged by the AESO. The customer can decide on the need and details of sensitivity studies to be performed at a later stage, mainly based on the system requirements and study results obtained from power flow and transient stability analysis. The AESO will review and apply any necessary modifications to the study stages to be completed and identified sensitivity studies based on the complexity of the project, connection area, system requirements and any study results obtained.

- Stage 1) Preparing study scope including disclosure of all study assumptions and methodology;
- Stage 2) Conducting power flow studies to check voltage deviation and thermal overloads. Voltage stability analysis will be considered at this stage;
- Stage 3) Conceptually designing proper mitigation measures for any identified power flow problems including thermal overloads, unacceptable voltage dip/rise, and inadequate voltage stability margin;
- Stage 4) Conducting power flow sensitivity studies;
- Stage 5) Conceptually designing or modifying mitigation measures for any power flow problems identified during sensitivity studies;
- Stage 6) Conducting short circuit analysis;
- Stage 7) Conducting transient stability analysis;
- Stage 8) Conceptually designing proper mitigation measures for any identified dynamic stability problems;
- Stage 9) Conducting transient sensitivity studies;
- Stage 10) Conceptually designing or modifying mitigation measures for any dynamic stability problems identified in Stage 9;
- Stage 11) Conducting motor starting studies where applicable;
- Stage 12) Conceptually designing proper mitigation measure for any identified motor starting issues;

Stage 13) Conducting restoration studies for the proposed generating facilities only. Section 9 of this document provides details for such studies;

Stage 14) Conceptually designing proper mitigation measure to any identified restoration problems;

Stage 15) Repeating stages 2 to 14 for any other alternative connection plan;

Stage 16) Producing an engineering report signed and stamped by a Professional Engineer registered within the province of Alberta.

Communication between the customer and the AESO throughout the connection studies is advised particularly in the case of level one projects or at any study stage where the customer identifies an issue requiring mitigation plans (level one or two projects). Ongoing dialog will help to ensure the following:

- Early identification of any obstacles in the project and timely resolution of the issue;
- All parties involved will remain committed to the same objectives which include compliance with the AESO Reliability Criteria and thorough connection analysis;
- Engineering of proper sensitivity tests and feasible mitigation measures if needed.

For level one projects, the customer is recommended to seek AESO's review upon completion of various study stages (power flow, short circuit or transient stability analysis) and prior to conceptually devising any mitigation plans to improve system performance. Ongoing communication for complex projects will assist the AESO to support the completeness of the studies.

3.1 Study Scope

Study scope should include in details the following data:

1. Customer facility (generation, load, transformer, line, etc.) and objective;
2. Study assumptions which will be used to perform all necessary studies;
3. Study stages to be completed as part of the connection analysis;
4. Criteria, requirements, standards, rules and guidelines requested by the AESO to be applied when performing connection studies;

5. Study methodology including software to perform the applicable studies, potential connection alternatives and sensitivity tests to be considered;

6. List of scenarios and contingencies to be considered;

7. Study timelines and deliverables;

8. Key engineers involved in performing and reviewing the connection studies.

Study scope shall be drafted using the AESO Connection Study Scope template and reviewed by the AESO prior to performing connection studies. The AESO can propose changes to the scope document to incorporate all requirements and scenarios that must be considered as part of the studies. Also, the AESO may require additional criteria and standards to be applied depending on the complexity of the project, and constraints of the connection area.

All contingencies that can potentially affect system reliability as well as established system limits must be considered. Study results obtained mainly from power flow and transient stability analysis should be considered to determine system conditions and contingencies for which sensitivity studies are required. AESO can modify the scenarios (i.e. system conditions) and contingency list based on the results obtained from planning studies.

3.2 Power Flow Analysis

Once the study scope, base cases and assumptions are discussed and agreed upon by the customer and AESO, the customer can perform power flow analysis leading to development of the engineering study report. When performing power flow studies PSS/E or PSAT[2] software tools with full Newton-Raphson method[3] shall be employed. Other industry recognized software may also be acceptable subject to approval from the AESO.

Various system conditions and contingencies as identified in the study scope should be investigated to determine system response. Contingencies must be considered to be permanent outages which cannot be returned to service within the time frame required for manual system adjustments.

All outages must be modeled based on the actual bus configurations, breaker types and locations. The AESO will review and provide direction on how to properly model contingencies when customer does not have access to such data.

[2] The version of the tool used to conduct studies should be consistent with the version AESO has employed in house to allow adoptability and ease of cooperation between the AESO and the customer.
[3] Some industry standard tools employ decoupled or fast decoupled power flow method to perform voltage stability analysis (i.e. PV studies). Such methods can be applied when performing PV studies.

Starting with all related facilities in-service[4] and following any contingency types described in the AESO Reliability Criteria, the system must demonstrate acceptable performance:

- All facilities must be operating within their facility seasonal ratings with no thermal overloads;
- Alberta system operating limits must be respected including minimum acceptable voltages, voltage stability margins and angular stability;
- System instability, cascading outage(s), and uncontrolled load or generation shedding must not occur.

Table 1 in Appendix A illustrates NERC/WECC planning Standards adopted into the AESO Reliability Criteria. The AESO may require additional planning and operations criteria, standards and guidelines to be applied depending on the study scope and results obtained from the completed connection study stages.

The summer/winter thermal rating of any transmission element based on 100% static thermal rating shall not be exceeded under normal operating conditions with all transmission elements in-service. All contingencies that result in violation of thermal rating of any transmission line, even if the violation is lower than emergency rating of the element, should be indicated to and discussed with the AESO.

Power-Voltage (PV) stability analysis is required as part of the connection studies for system normal and post contingency. Steady state voltage stability margin is required with the system load or cut-plane transfer (whichever applicable) modeled at a minimum of 105% of the peak operating point for system normal conditions (Category A) and following single outage (Category B) events. For multiple outages (Category C) steady state voltage stability is required with the system load or cut-plane transfer (whichever applicable) modeled at a minimum of 102.5% of the expected peak.

Voltage stability margin must be respected with the Under-Load Tap Changer (ULTC) transformers taps locked (short time frame) and stepping (longer time period). Also automatic switching of capacitor banks and/or reactors should not be allowed when performing PV analysis. For all power flow solutions area interchange control must be disabled and VAR limits of generators and SVCs applied automatically.

The Alberta transmission system must be capable of steady state operation within acceptable voltage ranges as provided by the applicable AESO documents during

[4] As identified in the AESO Reliability Criteria, the most critical generator, i.e. the unit that will cause the greatest stress on the component of the AIES being studied, can be assumed out of service due to commercial or maintenance reasons. Under this condition where the system operation is normal with the most critical generator out of service, Category B events (i.e. single element out of service) will be studied. This condition is referred to as N-G-1 criteria.

normal (i.e. all transmission elements in-service) and abnormal (i.e. following a Category B or C contingency) conditions. Acceptable post contingency voltage deviation at the Point of Delivery (PoD) is provided in the AESO Reliability Criteria. Appendix A, Table 2 illustrates the AESO steady-state voltage deviation standards:

- Following a single contingency voltage deviation shall not exceed +/- 10% of the pre-contingency voltage within the first 30 seconds of simulation;
- Following a single contingency and post auto control actions (e.g. ULTC transformers are tapped) voltage deviation shall not exceed +/- 7% of the pre-contingency voltage;
- Following a single or multiple contingencies, i.e. Category B or C events, voltage deviation shall not exceed +/- 5% of the pre-contingency voltage after operator manual control and when steady state conditions are restored.

Voltage deviation must be calculated based on the pre-contingency voltage level at the PoD bus as a reference. ULTC transformers shall be kept locked for the 10% voltage deviation evaluations. Also, automatic switching of capacitor banks and/or reactors shall not be allowed for 10% or 7% voltage deviation evaluations. Manual voltage control actions should be practical to be completed within 30 minutes.

The customer is recommended to consult with the AESO at an earlier stage if any system issues are identified as part of the power flow studies that can affect system operation (e.g. deteriorate existing constraints or violate Reliability Criteria) and may require mitigation measures such as RAS.

3.3 Short Circuit Analysis

Worst case scenario should be assumed in preparation for the short circuit analysis as discussed and agreed upon with the AESO. Analysis should be performed using PSS/E or PSAT tools. Other industry recognized software may also be acceptable subject to approval from the AESO.

When performing short circuit analysis and reporting the results the following requirements must be considered:

- Use prevailing system conditions for initial fault calculations with consideration of worst case fault conditions (e.g. area generators online);
- Include three-phase faults and single line to ground faults;
- Use polar coordinates and physical values to report results.

Further sensitivity analysis may be required by the customer in co-operation with the transmission facility owner(s) should the primary analysis indicate a potential to exceed or approach existing rated fault duty of transmission equipment.

3.4 Transient Stability Analysis

Prior to conducting transient stability analysis all study assumptions including the following data must be reviewed and acknowledged by the AESO as part of the study scope document:

- List of contingencies to be considered; in addition to the contingencies identified in the scope document other contingencies may be deemed necessary to be investigated based on the power flow study results if such studies were performed earlier.

- Fault clearing time for each transmission element; it is necessary to obtain fault clearing times for the contingencies from the area TFO prior to conducting any transient stability analysis.

- Load model; assumptions related to load model, motor loads, and natural load relief due to motor protection schemes should be discussed and agreed upon by the AESO.

- Reference generator; angular stability of all related generators to be determined with reference to this generator.

Transient stability analysis should be performed using PSS/E or TSAT; versions used should be compatible with the AESO in-house version for ease of cooperation. Other industry recognized software may also be acceptable subject to approval from the AESO.

For all Category B or C contingency analysis, the AESO requests that a bolted three-phase to ground fault to be applied first as this is a worse case compared to a single line to ground fault (SLG). However, SLG fault can be tested if simulation results indicate instability following a three phase fault. Type and location of applied fault must be documented in the engineering study report.

All contingencies must be modeled based on the actual bus configurations, breakers types and locations. The AESO will review and provide direction on how to properly model contingencies when customer does not have access to such data.

Dynamic stability of the AIES must be maintained following a single contingency (Category B) or multiple contingencies (Category C) with all generators remaining stable. Also following single or most[5] multiple contingencies the AIES must remain connected to the WECC system. Any violations must be documented in the engineering study report.

All simulated contingencies that trigger any of the existing automatic and/or manual protection schemes must be indicated when presenting the transient stability analysis results to the AESO. Under Frequency Load Shedding (UFLS) and Under Voltage Load Shedding (UVLS) schemes are examples of the automatic protection schemes that if triggered must be indicated to the AESO.

The customer is recommended to consult with the AESO at an earlier stage if any system issues are identified as part of the transient stability analysis that can affect system reliability and may require mitigation measures such as RAS.

3.5 Sensitivity Studies

Sensitivity studies require perturbation of key study assumptions to ensure the study results obtained from power flow and/or transient stability analysis are robust. Key study assumptions are parameters that can affect study results and area operation such as assumed intertie flow.

Based on the results obtained from earlier power flow and/or transient stability analysis, sensitivity studies can be determined by the customer. Since the nature of these studies is highly relevant to the earlier analysis, it is sometimes impractical to identify the need or details of the sensitivity tests in the study scope document. Therefore, these studies can be added as necessary to the scope document at a later stage. The customer is recommended to discuss all aspects of the sensitivity tests in detail with the AESO prior to conducting such studies.

When sensitivity studies are determined, the study scope shall be updated to incorporate details of the studies including but not limited to the following:

- Study assumptions including system conditions, generation dispatch, load level, reactive resources, and other relevant data that can affect study results;
- Study methodology;
- List of contingencies and system scenarios to be investigated.

The AESO can propose additional sensitivity studies identified by the customer based on the reported study results.

[5] Related multiple contingencies that may impact Alberta electric system connection to the rest of the WECC system will be outlined in the study scope document.

3.6 *Motor Starting Studies*

When the customer facilities include installation of motors, the customer must perform motor starting studies to evaluate the potential impacts of motor starting operations on the surrounding system. The study results should illustrate the following:

1. Expected voltage drop in the surrounding system during motor starting;
2. Flicker impacts of motor starting over time.

The customer must provide details of study assumptions, motor model and software used to perform the studies. Also, the type of motor starting equipment and/or starting methodology that would be implemented must be specified when providing the study results.

All study assumptions, results, and motor starting methodology shall be reviewed and acknowledged by the AESO. The customer must comply with the AESO Voltage Fluctuations (Flicker) standards provided in Generation and Load Standards document.

3.7 Mitigation Measures

The customer facility upgrades or connection should not adversely impact system reliability and/or the existing constraints. The facility connection or upgrades must meet the requirements of the AESO Reliability Criteria, standards, and rules as established in the scope document. The AESO must be informed of any adverse impact on system reliability prior to system or customer mitigation plans being implemented. Appropriate mitigation measures must be devised if needed based on the results obtained from power flow and/or transient stability analysis to negate the impact of the customer connection on system reliability.

Depending on the connection area, Remedial Action Schemes could be considered to facilitate customer connection when system development cannot be implemented in time and/or frequency of RAS triggering event is foreseen to be very low. However, as there are already numerous manual and automated schemes installed on the system, the customer must consider the existing protection schemes as outlined in the study scope document prior to proposing any new RAS in the connection area.

Operation of the existing and proposed schemes in studies may require manual steps in the simulations to evaluate system performance. The consequence of RAS failure must also be considered when performing such studies. Miscoordination and complexity of too many schemes may be a real-time concern. Hence all applied mitigations measures must be acceptable practical solutions to facilitate reliable system operation.

The customer must devise any mitigation measures required for facility connection or upgrades in coordination with the AESO to ensure system reliability is maintained and also related ADs, and/or other operational procedure and information documents are revised in a timely manner.

3.8 Engineering Study Report

The customer shall use the Engineering Study Report template provided by the AESO to report all study assumptions, methodology, results and analysis including any modifications made in the study scope. The report should be populated and submitted to the AESO for review whenever the customer seeks consultation with the AESO throughout the studies.

Boundary conditions are studied conditions that result in acceptable performance within a set of assumptions on load, generation, interchange, equipment ratings and transmission configuration. If conditions beyond the boundaries are not studied they are automatically outside boundary conditions. Boundary conditions can affect Alberta operating limits. Therefore, customer must clearly declare all the boundary conditions considered in connection studies in the engineering study report.

A registered Professional Engineer within the province of Alberta shall sign and stamp the complete engineering study report on behalf of the customer. The engineering study report must be submitted to the AESO to be reviewed for the following:

- Sufficient studies are performed to analyze customer proposal under known system conditions;
- Customer connection proposal fits AESO long term transmission development plans;
- Adequate amount of information is enclosed in the engineering study report.

4 Study Assumptions and Modeling

For all the customer connection studies, the AESO will provide generic power flow base cases and appropriate dynamic data in PSS/E format used by the AESO engineers. The customer study engineers must generate suitable study cases by applying specific assumptions for the connection studies. All changes applied in the generic Base Case to produce study cases must be documented by comparing the cases[6]. All applied modifications in topology and/or parameters must be justified in the comparison file and acknowledged by the AESO prior to the study cases being used for connection studies. All study files, such as single line (slider) diagrams, contingency modeling, and idev response files, should be developed by the customer[7]. All developed study cases and files shall be made available to the AESO when requested.

The transmission facility owner (TFO) in the connection area must review all the applied study cases and support that equipment information and topology provided in the study cases are appropriate and suitable when performing the studies. All engineers performing the connection studies have a level of duty to review the study cases used to ensure that they are appropriate and accurate for the work being performed. The AESO must be informed if any potential imprecision are noted in the given AESO generic power flow Base Cases or dynamic data.

Nominal transmission voltages for different TFOs in Alberta are:

- 69kV Altalink and ENMAX, 72kV ATCO and EPCOR;
- 138kV Altalink, ENMAX and EPCOR, 144kV ATCO;
- 240kV Altalink, ENMAX, EPCOR and ATCO;
- 500kV Altalink, ENMAX, EPCOR and ATCO.

AESO converts all the 72kV voltages to 69kV and 144kV to 138kV in the AESO base cases. Associated equipment ratings are converted accordingly.

Any changes in the load levels, generation dispatch, capacitor banks/reactors switching, voltage and intertie levels to create a complete worst case set of scenarios for investigation must be indicated in the study scope and acknowledged by the AESO before such modifications are applied.

[6] Compare the power flow study cases with the generic AESO Base Case in PSS/E, PSAT or other industry tools as approved by the AESO.

[7] The AESO will share any applicable slider diagrams, contingency and idev response files if such files are readily available due to past AESO planning studies. However, the AESO will not develop any of the study files for the connection study purposes.

For the connection studies leading to NID application, all projects (customer or system) at the NID stage will be included in the study assumptions. Projects (customer or system) may affect one another especially in constrained areas. AESO will post updated Auxiliary Data Archive files on its website as required. The customer is requested to verify all study results based on the most relevant data and present updated results to the AESO prior to finalizing engineering study report for the NID application and/or connection project.

4.1 Load

Assumptions regarding high and/or low ranges of the AESO load forecast must be applied to the study base cases prepared for the connection studies to simulate worst case system conditions. Also worst case power factor based on the historic load data must be applied.

For the purpose of power flow analysis, loads shall be modeled as constant MVA load. However, the amount of motor load modeled is significant to the outcome of transient stability analysis. Typically the AESO assumes 70% of the load to be motors (40% large motors and 30% small motors) in north regions of the AIES, i.e. areas 17 to 23, 25, 27 and 28. Basic motor load modeling in dynamic simulations shall be at least 20% induction motors in all other areas. The remaining load is modeled as constant current for active power, and constant impedance for reactive power. Depending on the connection area and system load make up, the AESO may require additional analysis with different proportions of motor loads.

Assumptions on the amount of static load to be converted to motors for transient stability analysis must be indicated in the study scope document and accepted by the AESO prior to conducting such studies. The load response to frequency and voltage changes should be correctly modeled as well (e.g. UFLS / UVLS settings).

4.2 Generation

In an area where multiple generators exist, a range of possible generation levels up to units Maximum Authorized MW (MAM) may need to be considered when performing studies. All assumptions made on generation dispatch and market practice must be clarified in the study scope document and acknowledged by the AESO. Sensitivity studies may be identified to test affect of various generation levels and dispatch patterns on the study results.

When connecting a new generator(s), the customer shall declare the following:

- The maximum gross active power that can be produced under optimal conditions at the generator terminal;

- The reactive power capability at the generator terminals when the generating unit is operating at its maximum MW capacity as identified above;

- The minimum stable active power generation level that the generator can be continuously operated at without becoming unstable;

- The maximum and minimum continuous reactive power capability of the generator;

- Station Service Load (SSL);

- The maximum active power generation at the point of connection to the Alberta grid.

MAM means (i) for a generating unit, the maximum quantity (MW) that the generating unit is authorized by the ISO to deliver to its generator terminal; or (ii) for generating facilities with a collector bus, the maximum quantity (MW) that the generating units are authorized by the ISO to deliver to the its collector bus[8].

The Maximum Capability (MC) for a generating asset is the maximum quantity (MW) that the generating asset is physically capable of providing under optimal operating conditions for that asset while complying with all applicable ISO Rules and terms and conditions of the ISO tariff[9]. If part way through the analysis the customer decides to increase the maximum gross or net generation level (i.e. MAM or MC), then available options to the customer are:

- To continue the studies with the original assumptions and start a new project for the increased level; or

- To perform all the applicable studies based on the increased generation level.

Connection studies must show that the proposed generator(s) comply with the applicable AESO Interconnection Requirements including and not limited to:

- Generator/Load Requirements,

- Wind Power Technical Requirements.

[8] AESO is currently consulting with the industry for the definition of MAM. The final definition will be published at the AESO website: http://www.aeso.ca/rulesprocedures/9072.html (ISO Rules, Part One, Definitions). The Connection Study Requirements document will be revised when the final definition is available.
[9] The definition of the MC can be found on the AESO website: http://www.aeso.ca/rulesprocedures/9072.html (ISO Rules, Part one, Definitions).

The customer must commit to verify all study results based on WECC test report for the new generator(s) following connection to the Alberta grid. In case WECC test results indicate a lower maximum active power than the requested MAM and/or MC levels then the following options are available to the customer:

- Generator data model must be modified to reflect the requested MAM and/or MC levels and signed and stamped by a registered Professional Engineer within the province of Alberta; Or
- Generator to operate within the WECC results.

4.3 Equipment Rating

All existing and new equipment ratings based on 100% static thermal rating must be respected when conducting connection studies.

4.4 Dynamic Models

The customer must represent proposed equipment with the best model available including turbine governors, power system stabilizers (PSS), excitation system and its limiters, static VAR compensators (SVC), wind turbines and all other relevant dynamic representation of the proposed facilities.

The customer shall not disregard any dynamic model provided in the AESO dynamic file which represents other equipment or schemes in the system. The AESO must be notified if any particular equipment model causes error or improper simulation interruption. Depending on the study scope, the dynamic model(s) may be modified following the AESO approval.

4.5 Protection Fault Clearing Time

It is critical for the customer to obtain fault clearing times from the area TFO when conducting transient stability analysis as part of the connection studies. Protection fault clearing times that do not meet the AESO protection standards and/or can cause potential dynamic stability issues may drive protection upgrades and must be discussed with the AESO once identified. The AESO may request additional studies using a range of protection fault clearing times to ensure system performance results are robust.

5 Performance Standards

At the beginning of the project, the AESO will specify all criteria, standards, and guidelines as well as the AESO rules and practice (market or otherwise) which must be applied when performing connection studies.

The AESO's agreement is necessary on "Operator adjustment" period to prepare the system for the next worst contingency and maintain system stability. All control actions in response to the contingencies to ensure reliable system operation shall be practical to complete within 30 minutes for both steady state voltage stability and thermal limits. Control actions in response to contingencies shall also consider whether a faster response is necessary to address facility specific limits.

6 Authoritative Documents (ADs)

All the AESO Authoritative Documents that can have potential impact on the customer facility connection or upgrades must be identified in the study scope document. The customer must understand the impact of the developed ADs and apply the considerations when performing connection studies.

7 Application of New or Non-Traditional Technology

When the customer connection encompasses new technologies in the AIES (e.g. nuclear, permanent magnet generators), the customer should provide detailed information to the AESO on how these additions are expected to perform and to be integrated into system operations as such information becomes available.

8 Maintenance and Outage Planning

All facilities will need to be out of service at some point due to forced outage or planned maintenance. Consequently, the impact of transmission elements being out of service for maintenance should be known. Similarly, the impact of assumed base loaded generators being out of service should be known.

Furthermore, if significant outages are required to convert, upgrade, or construct new facilities, the work should be staged such that periodic updates are available to the AESO for approval. The updates must include the study results of every project phase during various planning and construction phases.

9 System Restoration

System restoration studies are required by all customers who are interested to connect a new generator(s) to the Alberta transmission system with an aggregate generating capacity of greater than 40MW within the customer facility. All distribution connected power plants and wind power plants are excluded from such studies.

Restoration studies must verify that customer proposed generating facility is capable to start up from a system significantly different than normal operating conditions, i.e. restoration condition or event.

The AESO will provide all base cases and dynamic models required for the restoration studies. Through detailed motor starting analysis, the restoration studies must verify that the new generating facility can start up and synchronize to the system as provided in the restoration base case. All equipment limits (existing and new) including the proposed generation plant limits (e.g. low voltage motor protection settings) must be respected during the restoration studies. Any violation of these limits must be mitigated and their validity proven to the AESO.

10 Verification of Study Results

Assumptions made on proposed equipment must be verified once the customer facilities are in-service and new or finalized project data is available, e.g. WECC generator test report or finalized motor model. All discrepancies between study assumptions and actual data must be indicated to the AESO before closing off the project.

The customer must verify connection studies using actual data set to validate the earlier results and reconcile any differences. Mitigation measures should be considered if final study results indicate any power flow or transient stability concerns prior to closing off the connection project.

11 Study Timeline and Deliverables

The customer must inform the AESO with their study plans, timelines and updates. Such timeline and deliverables should be clearly identified in the study scope document.

Projects may affect one another especially in the constrained areas. The AESO should be informed periodically on the progress of the connection studies, timelines and decisions made by the customer with regard to the connection project. The customer must inform the AESO at the earliest of any major changes such as canceling or delaying the project.

12 Development of Alternatives

The customer shall coordinate with the AESO to ensure that the connection plans are not deteriorating existing system constraints and affecting system plans that are in progress in the area. If there is a correlation, the customer and the AESO must work together to devise a mitigation plan or revise the connection plans to ensure system reliability is maintained.

When a customer NID application is dependant on a system NID application, the AESO and the customer should consider developing other plans or mitigation measures if system projects are delayed in construction and commissioning stages.

Customer facility connection or upgrades shall not adversely impact the existing system reliability or violate the AESO Reliability Criteria. When developing connection alternative plans, priority must be given to the outcome of study results. Consequently an alternative with the least cost and impact on the system reliability should be considered for proposal.

Appendix A

Table 1: Transmission System Standards – Normal and Contingency Conditions

Category	Contingencies		System Limits or Impacts				
	Initiating Event(s) and Contingency Element(s)	Elements Out of Service	Thermal Limits	Voltage Limits	System Stable	Loss of Demand or Curtailed Firm Transfers	Cascading[c] Outages
A - No Contingencies	All Facilities in Service	None	Applicable Rating[a] (A/R)	Applicable Rating[a] (A/R)	Yes	No	No
B – Event resulting in the loss of a single element.	Single Line Ground (SLG) or 3-Phase (3Ø) Fault, with Normal Clearing: 1. Generator 2. Transmission Circuit 3. Transformer Loss of an Element without a Fault.	 Single Single Single Single	 A/R A/R A/R A/R	 A/R A/R A/R A/R	 Yes Yes Yes Yes	 No[b] No[b] No[b] No[b]	 No No No No
	Single Pole Block, Normal Clearing[f]: 4. Single Pole (dc) Line	Single	A/R	A/R	Yes	No[b]	No
C – Event(s) resulting in the loss of two or more (multiple) elements.	SLG Fault, with Normal Clearing[f]: 1. Bus Section 2. Breaker (failure or internal fault)	Multiple Multiple	A/R A/R	A/R A/R	Yes Yes	Planned/Controlled[d] Planned/Controlled[d]	No No
	SLG or 3Ø Fault, with Normal Clearing[f], Manual System Adjustments, followed by another SLG or 3Ø Fault, with Normal Clearing[f]: 3. Category B (B1, B2, B3, or B4) contingency, manual system adjustments, followed by another Category B (B1, B2, B3, or B4) contingency	Multiple	A/R	A/R	Yes	Planned/Controlled[d]	No
	Bipolar Block, with Normal Clearing[f]: 4. Bipolar (dc) Line Fault (non 3Ø), with Normal Clearing[f]: 5. Any two circuits of a multiple Circuit towerline[g]	Multiple Multiple	A/R A/R	A/R A/R	Yes Yes	Planned/Controlled[d] Planned/Controlled[d]	No No
	SLG Fault, with Delayed Clearing[f] (stuck breaker or protection system failure): 6. Generator 8. Transformer 7. Transmission Circuit 9. Bus Section	Multiple Multiple	A/R A/R	A/R A/R	Yes Yes	Planned/Controlled[d] Planned/Controlled[d]	No No
D[e] – Extreme event resulting in two or more (multiple) elements removed or cascading out of service	3Ø Fault, with Delayed Clearing[f] (stuck breaker or protection system failure): 1. Generator 3. Transformer 2. Transmission Circuit 4. Bus Section 3Ø Fault, with Normal Clearing[f]: 5. Breaker (failure or internal fault) Other: 6. Loss of towerline with three or more circuits 7. All transmission lines on a common right-of-way 8. Loss of a substation (one voltage level plus transformers) 9. Loss of a switching station (one voltage level plus transformers) 10. Loss of all generating units at a station 11. Loss of a large load or major load center 12. Failure of a fully redundant special protection system (or remedial action scheme) to operate when required 13. Operation, partial operation, or misoperation of a fully redundant special protection system (or remedial action scheme) in response to an event or abnormal system condition for which it was not intended to operate 14. Impact of severe power swings or oscillations from disturbances in another Regional Council.	Evaluate for risks and consequences. • May involve substantial loss of customer demand and generation in a widespread area or areas. • Portions or all of the interconnected systems may or may not achieve a new, stable operating point. • Evaluation of these events may require joint studies with neighboring systems.					

Footnotes to Table I.

a) Applicable rating (A/R) refers to the applicable normal and emergency facility thermal rating or system voltage limit as determined and consistently applied by the system or facility owner. Applicable ratings may include emergency ratings applicable for short durations as required to permit operating steps necessary to maintain system control. All ratings must be established consistent with applicable NERC Planning Standards addressing facility ratings.
b) Planned or controlled interruption of electric supply to radial customers or some local network customers, connected to or supplied by the faulted element or by the affected area, may occur in certain areas without impacting the overall security of the interconnected transmission systems. To prepare for the next contingency, system adjustments are permitted, including curtailments of contracted firm (non-recallable reserved) electric power transfers.
c) Cascading is the uncontrolled successive loss of system elements triggered by an incident at any location. Cascading results in widespread service interruption which cannot be restrained from sequentially spreading beyond an area predetermined by appropriate studies.
d) Depending on system design and expected system impacts, the controlled interruption of electric supply to customers (load shedding), the planned removal from service of certain generators, and/or the curtailment of contracted firm (non-recallable reserved) electric power transfers may be necessary to maintain the overall security of the interconnected transmission systems.
e) A number of extreme contingencies that are listed under Category D and judged to be critical by the transmission planning entity(ies) will be selected for evaluation. It is not expected that all possible facility outages under each listed contingency of Category D will be evaluated.
f) Normal clearing is when the protection system operates as designed and the fault is cleared in the time normally expected with proper functioning of the installed protection systems. Delayed clearing of a fault is due to failure of any protection system component such as a relay, circuit breaker, or current transformer (CT), and not because of an intentional design delay.
g) System assessments may exclude these events where multiple circuit towers are used over short distances (e.g., station entrance, river crossings) in accordance with Regional exemption criteria

Table 2: Acceptable Post Contingency Voltages

	Time Period		
	Post-Transient (Up to 30 sec)	**Post Auto Control (30 sec to 5 min)**	**Post Manual Control (Steady State)**
Allowable Voltage Deviation @ LV bus	± 10%	± 7%	± 5%