Connection to Series Compensated Line
Assessment Guideline

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Assessment Guideline

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Executive Summary

Purpose and Scope

The AESO has developed the Connection to Series Compensated Line Assessment guideline to address emerging reliability challenges in the Alberta Interconnected Electric System (AIES). This guideline:

- Help market participants (MPs) understand the operational challenges and risks associated with connecting the proposed facilities to the existing series compensated lines in the AIES
- Lists the assessments required by the AESO and the possible assessments required by transmission facility owners (TFOs)
- Provides transparency and guidance on how to conduct the applicability, pre-screening, screening and detailed study by the responsible entity and how to provide the detailed study report to the AESO
- Defines a standardized, risk-based approach for assessing some concerning phenomena, including assessment scope, study methodologies, inputs, assumptions, performance criteria, reporting requirements and mitigation options

Rationale

The series compensated line creates complex, nonlinear and time-varying electrical conditions. New facilities (e.g., load or generating facilities) to connect to existing series compensated lines will trigger a list of reliability and stability challenges including:

- System reliability related:
  - Sub-synchronous oscillation (SSO)
- Reliable and safe operation of transmission facilities related:
  - Steady-state voltage levels and voltage fluctuations that may affect the selection of basic insulation levels
  - Abnormal voltages during grid faults including transient overvoltages
  - Stability and dynamic voltages of the power system with overcompensated lines
  - Transient recovery voltages of circuit breakers
  - Ferroresonance
  - Harmonics
  - Protection challenges and strategies

Performance Criteria

The following performance criteria apply to the connection to series compensated lines assessments:

- MPs shall conduct SSO assessment to ensure the facility shall not introduce or exacerbate any form of SSO under any credible operating condition
  - Any mitigation measures required to eliminate or adequately damp identified SSO phenomena shall be implemented as a condition of connection
  - For this assessment, AESO's "Sub-synchronous Oscillations Assessment Guideline" shall be referred for detailed analysis
- For the assessments related to reliable and safe operation of transmission facilities, TFOs will determine the performance criteria

Application

For connection projects to the existing series compensated lines, the AESO will identify the assessment requirements and specify the associated technical studies in the functional specification (FS). MPs and TFOs must comply with the FS and demonstrate meeting performance criteria prior to energization.

MPs and TFOs are expected to apply this guideline when conducting and submitting the connection to series compensated lines assessments to the AESO, and to implement any required mitigation measures.

1. Connection to Series Compensated Line Introduction

1.1 Background

The connection to series compensated line assessment is an operational requirement new to the industry in Alberta. This topic is currently not included in any AESO Authoritative Documents. MP projects that have been identified as high-risk through the applicability, pre-screening criteria or screening steps will be required to conduct detailed study, providing the AESO with evidence of meeting an operational requirement, which will be documented in a project's functional specification.

This guideline was developed to indicate what studies are commonly required and what mitigation are available to consider when a customer connection project proposes a connection to a series compensated line in the AIES. This information will help MPs understand the operational challenges and risks associated with connecting their facilities to series compensated lines. The guideline includes a section on the theory of series compensation. While series compensation provides operational flexibility, it also introduces reliability complexities, outlined in the Issues Related to Series Compensation section.

The AESO lists possible studies to be conducted by either MP or by transmission facility owner (TFO) below demonstrating adherence to the operational requirements in the AESO's functional specification:

- One or multiple of sub-synchronous oscillation (SSO)[1] assessments to be conducted by the MP subject to the technology to connect:
  - Sub-Synchronous Resonance (SSR)
  - Power Electronic Device Interactions (PEDI)
- The assessments are commonly required and conducted by TFO, including but not limited to:
  - Fundamental Frequency Overvoltage (FFOV)
  - Fault Current, Bypass Current, Swing Current and Temporary Overvoltage Analysis
  - Stability and Dynamic Voltage Performance
  - Harmonic Impact Assessment
  - Transient Recovery Voltage (TRV) and Breaker Capability Analysis
  - Ferroresonance Risk Evaluation
  - Metal Oxide Varistors (MOV), bypass breaker and damping circuit assessment

For SSO assessments to be conducted by a MP, please refer to the AESO's *Sub-synchronous Oscillations Assessment Guideline*. For the assessments to be conducted by TFOs, the AESO will

[1] CIGRE WGC4/B4.52 "Guidelines for subsynchronous Oscillation Studies in Power Electronic Dominated Power System", TB 909, June 2023.

rely on the TFOs to follow industry practice to conduct the assessments and propose the mitigation solutions.

This guideline is not authoritative and for information purposes only.

1.2 Roles and Responsibilities

This section outlines the high-level roles and responsibilities of various tasks in the study. All the parties can reach out AESO's project manager for details.

Table 1: RACI Chart for Connection to Series Compensated Lines

Note: R – Responsible; **A** – Accountable; **C** – Consult; **I** – Inform

Deliverable	AESO	Transmission Facility Owner (TFO)	Generation Facility Owner (GFO)	Market Participant (MP)
Applicability and Pre-Screening (Earliest Connection Process Stage: Stage 1)				
Conduct Pre-Screening	A/R	I	I	I
Screening Assessment (Earliest Connection Process Stage: Stage 2)				
The screening is required for SSO studies. Please refer to RACI chart for Screening in AESO's SSO Assessment Guideline				
Detailed Study (to be conducted by MP) (Earliest Connection Process Stage: Stage 3)				
Please refer to RACI chart for detailed study in AESO's SSO Assessment Guideline				
Detailed Study (to be conducted by TFO) (Earliest Connection Process Stage: Stage 3 but prior to facility energization)				
Provide models data for the facility	R	A/R	R	R
Performs the screening B assessment and identify the need for further investigation	C	A/R	C	C
Result Acceptance and Mitigation Recommendation (Earliest Connection Process Stage: Stage 3 but prior to facility energization)				
Review and accept study results	A/R	I	I	I

Deliverable	AESO	Transmission Facility Owner (TFO)	Generation Facility Owner (GFO)	Market Participant (MP)
Review proposed mitigation plan	A/R	C	R	R
Accept the mitigation strategy and update the functional specification (FS) accordingly with related requirements	A/R	I	I	I

Note:

Responsible (R) = “the doer”. Those who do work to achieve the task. There can be multiple resources responsible. The act of approving a deliverable can be categorized under the responsible party.

Accountable (A) = “the buck stops here”. The resource ultimately answerable for the correct and thorough completion of the task There can only be one “A” specified for each task.

Consulted (C) = “in the loop”. Those whose opinions are sought. Those who have special knowledge or expertise needed to make decisions or solve problem. Two-way communication.

Informed (I) = “in the picture”. Those who are kept up to date on progress and decisions (once made). May be impacted by decision but are not active in final decision. One-way communication.

1.3 Applicability

This guideline applies to projects directly connected to series compensated lines, including:

- power electronic based generating facilities, including aggregated generating facilities or energy storage resources (e.g., battery energy storage systems [BESS])
- conventional generating facilities (e.g., synchronous generators)
- Industrial load facilities (e.g., large-scale data centre load)

The AESO will include the study requirements in project’s functional specification if the project is applicable.

1.4 Pre-Screening

The AESO provides the guidance about pre-screening for SSO only. Please refer to pre-screening steps in AESO’s SSO Assessment Guideline. For TFO led studies, please contact the TFO for pre-screening details.

1.5 Screening Assessment

The AESO provides the guidance about screening for SSO only. Please refer to screening steps in AESO's SSO Assessment Guideline. For TFO led studies, please contact the TFO for screening details.

1.6 Detailed Study

The AESO provides the guidance about detailed study for SSO only. Please refer to detailed study steps in AESO's SSO Assessment Guideline. For TFO led studies, please contact the TFO for study details. Furthermore, the AESO suggests MPs to present the detailed study results using the study report template in Appendix A.

1.7 Result Acceptance and Mitigation Implementation

The market participant shall submit the study report and the proposed mitigation solution, which must be accepted by the AESO before the in-service date of project. The AESO shall review the study report within reasonable time. The AESO may comment on the report and ask the MP to respond prior to our acceptance. The AESO may revise the project's functional specification according to the study result or proposed mitigation solution. Any delay on the study report submission may result in a delay of project energization.

1.8 Energization Requirements

The AESO authorizes the project to connect to the AIES and achieve energization when the project meets all the AESO's energization checklist requirements, outlined in the 100-day and 30-day energization packages. The required study report will be included in the energization checklist. The AESO encourages the market participant to check with AESO's project manager to fully understand how to meet the energization requirements.

2. Theory of Series Compensated Line

2.1 Background

Series compensation is a crucial technology in modern power transmission systems, enhancing both steady-state and dynamic performance. This document provides an overview of series compensation, examining its evolution, applications, control strategies and practical implementations. The discussion extends from traditional mechanically operated switches to advanced power electronic devices, highlighting their role in improving system reliability and operational efficiency.

Series capacitors, a key component of series compensation, are widely deployed in high voltage alternating current (HVAC) transmission systems to optimize power flow and enhance grid stability. These systems, characterized by long-distance transmission lines interconnecting major generation and demand centers, often face limitations due to high line reactance. Additionally, the inherent characteristics of meshed networks, governed by Kirchhoff's laws, can lead to power flow imbalances, loop flows and network congestion. By partially compensating line reactance, series capacitors mitigate these issues, increasing transmittable power and improving power flow control.

Variable series compensation, a fundamental aspect of flexible alternating current transmission systems (FACTS), plays a pivotal role in modern power grids. It enables dynamic power flow control, minimizes the impact of disturbances, and enhances system stability by reducing traditional stability margin requirements. As the power sector transitions toward a fully decarbonized future, the flexibility offered by series FACTS, supported by advancements in power electronics, will be essential in ensuring a resilient and efficient transmission network.

2.2 Series Compensation with Series Capacitors

Series capacitive compensation is a well-established technology widely applied in transmission systems to enhance power transfer capability and system stability. Fixed series compensation (FSC) remains the most widely deployed series compensation solution. The fundamental principle involves inserting a series capacitor into the transmission line to reduce its effective inductive reactance, thereby increasing synchronizing power and improving steady-state stability. This results in an apparent reduction in the line reactance, expressed as:

$X_e = X_L - X_C$

where X_L is the inductive reactance of the line, and X_C is the reactance of the series capacitor. The reduction in reactance leads to an increase in transmitted power, given by:

$$P_e = \frac{V_A V_B}{X_L - X_C} \sin\delta \approx \frac{V^2}{X_L(1-k)} \sin\delta$$

where V_A and V_B are the voltage magnitudes at the sending and receiving ends, $k = X_C / X_L$ represents the degree of compensation, and δ is the voltage phase angle difference between the two buses. The reactive power injected by the capacitor depends on the compensation level and can be approximated as:

$$Q_e \approx 2\frac{V^2k}{X_L(1-k)^2}(1-\cos\delta)$$

By increasing the compensation level k, active power transfer improves, but at the cost of a significant rise in reactive power. In summary, several key benefits include:

- Enhanced transmission capacity by reducing impedance-related constraints
- Flexible power flow control in meshed networks
- Improved voltage profile by compensating reactive power demand
- Greater angular stability by increasing synchronizing torque
- Damping of power oscillations to mitigate transient instability
- Optimized utilization of parallel transmission corridors

However, while series compensation enhances system performance, it also introduces operational challenges, which will be further explained in Section 2.

2.3 Series Compensation with FACTS

The introduction of FACTS technology has transformed power transmission by providing dynamic, real-time control of network parameters. FACTS-based series compensation solutions utilize power electronic devices to overcome the limitations of traditional fixed series capacitors, offering enhanced flexibility, stability and efficiency in modern grids.

Several key FACTS-based series compensators include:

- **Thyristor-Controlled Series Capacitor (TCSC):** A capacitor bank equipped with thyristor-controlled reactors to provide continuously adjustable compensation
- **Thyristor-Switched Series Capacitor (TSSC):** Similar to TCSC but with discrete switching instead of continuous control
- **GTO-Controlled Series Capacitor (GCSC):** Uses gate turn-off thyristors (GTOs) for rapid switching of the series capacitor
- **Static Synchronous Series Compensator (SSSC):** A voltage-sourced converter that injects a controllable series voltage independent of line current
- **Distributed Static Synchronous Series Compensator (DSSC):** A modular version of SSSC, offering decentralized compensation across multiple points on a transmission line

Compared to FSC, FACTS-based series compensation provides several advantages:

- **Dynamic Power Flow Control:** Unlike fixed capacitors, FACTS devices can modulate impedance in response to grid conditions, preventing congestion and optimizing line loading
- **Damping of Power Oscillations:** By actively responding to disturbances, FACTS controllers mitigate electromechanical oscillations, reducing the need for conservative stability margins
- **Voltage and Stability Support:** FACTS compensators enhance both steady-state and transient stability, ensuring greater grid resilience during contingencies

- **Mitigation of SSR (Sub-Synchronous Resonance) and Other Harmful Resonances:** Advanced controllers integrated into TCSC and SSSC can detect and suppress SSO, reducing the risks of SSR

As the power grid transitions toward higher levels of renewable energy integration and decentralized generation, the role of FACTS-based series compensation is expected to grow. The increasing penetration of variable renewable generation introduces greater grid volatility, requiring advanced real-time control solutions to maintain stability. FACTS devices provide the necessary flexibility to regulate voltage profiles, adjust power flows, and support weak grid conditions.

Currently, there is no permanently installed FACTS-based series compensator within the AIES. However, given the ongoing shift toward decarbonization, the adoption of series FACTS compensation will likely be essential to enhance grid flexibility and resilience. Power electronics advancements will further enable more efficient, scalable and adaptive compensation solutions to meet future operational challenges.

3. Issues Related to Series Compensation

3.1 Market Participant Studies Related to Series Compensation

Fixed series compensation of transmission lines is commonly employed in power systems to enhance transfer capability and transient stability. However, the increasing integration of power electronic-based renewable energy sources has significantly altered power system dynamics, leading to new oscillation phenomena that pose substantial risks to system stability. Therefore, facility owner must conduct comprehensive technical studies on various types of oscillations.

Sub-synchronous interactions (SSI) encompass various oscillatory behaviours within the 5-60 Hz frequency range, classified into SSR and PEDI, depending on the interaction mechanism. SSR primarily arises from interactions between a series-compensated transmission system and a large steam turbine generator. PEDI is associated with the interaction between a series-compensated line and other power electronic control devices across the network (e.g., SC–IBR, SC–HVDC, SC–FACTS, SC-BESS, or large electronic-based loads).

The evolving power grid requires an updated framework for understanding and mitigating these emerging oscillations. By systematically categorizing these phenomena, we can evaluate their interdependencies and potential risks, ensuring the safe operation of modern power systems. The key study objectives for different technical aspects of series-compensated systems are outlined below.

3.1.1 Sub-Synchronous Resonance

SSR is a phenomenon in which energy exchanges between a generator and a series-compensated transmission network at sub-synchronous frequencies. This oscillatory energy interchange may be lightly damped or undamped, potentially leading to increased fatigue or catastrophic failure of generator turbine shafts.

The electrical network has a natural resonant frequency given by:

$$f_n = f_0 \sqrt{\frac{X_C}{X_L}}$$

where X_L is the total network reactance, including transmission line reactance, generator step-up transformer reactance, generator subtransient reactance and system equivalent reactance, while X_C represents the series capacitor reactance. As series capacitor reactance is a fraction of transmission line reactance, the resonant frequency f_n is always lower than the nominal system frequency f_0, giving rise to sub-synchronous resonance.

Three distinct aspects of SSR analysis have been identified:

- Induction generator effect (IGE) results from the apparent negative resistance characteristic of generators at frequencies below the system synchronous frequency

  - At a resonant electrical frequency defined by the combined inductance and capacitance characteristics of the system, this apparent negative resistance may exceed the network resistance
  - Such a condition will result in self-excitation of oscillatory currents at the natural frequency
- Torsional interaction (TI) may occur when the electrical resonant frequency is near the complement of a torsional resonant frequency of a turbine-generator torsional mode f_m (i.e., $f_n = f_0 - f_m$)
  - Under these conditions, a small voltage induced in the armature by rotor oscillation can result in a large sub-synchronous current
  - When the net circuit resistance is positive, this current will produce an oscillatory component of rotor torque which is phased to enhance the rotor oscillation
  - When this torque is larger than that resulting from mechanical damping, the coupled electro-mechanical system will experience growing oscillations
- Torque amplification (TA) analysis is the study of the response of turbine-generator shaft systems to large amplitude disturbances such as faults in the transmission system
  - When the transmission system contains series capacitors, the transient electrical torque may contain large amplitude frequency components close to resonant frequencies of the shaft system
  - This can result in high shaft torques which may seriously damage the turbine-generator unit

3.1.2 Sub-Synchronous Torsional Interaction

SSTI usually occurs between series-compensated transmission lined and the conventional generator’s shaft turbines due to the negative damping from the power electronic controller at sub-synchronous frequencies. It can amplify the undamped oscillations in the generator’s mechanical torsional modes.

SSTI results from control interactions. If the control of devices, such as SVCs, STATCOMs and VSC-based HVDC systems were tuned properly, it can enhance torsional damping and mitigating the risk of instability. However, in poorly coordinated systems, negative damping effects may lead to un-damped oscillatory growth, necessitating proper controller tuning and damping measures.

3.1.3 Power Electronic Device Interaction

PEDI arises from the interaction between power electronic devices and series-compensated transmission systems. Unlike SSR and SSTI, PEDI does not involve mechanical shaft systems but results from the dynamic behaviour of power electronic controllers.

Interactions between IBRs, FACTs, BESS, HVDC links, or large electronic-based load, and series-compensated networks can lead to uncontrolled oscillations. These oscillations tend to grow rapidly due to the high-speed response of power electronics, potentially causing severe over-voltages, current distortions and protective device misoperations.

PEDI can result in severe over-voltages, current distortion, tripping of additional transmission facilities, and damage to the control circuits. Usually type-3 WTGs rotor side converter current control loop was the primary cause of the SSCI problem. The overall controller response can introduce negative damping, resulting in instability.

3.2 TFO Studies Related to Series Compensation

To ensure the reliable operation of series-compensated networks, TFOs must conduct comprehensive technical studies. These studies primarily focus on assessing the impact of series compensation on individual components and local system performance. The key study objectives for different technical aspects of series-compensated systems are outlined below.

3.2.1 Fundamental Frequency Overvoltage

This study evaluates the FFOV and voltage profile under normal operating conditions of the series compensation system. The objective is to determine the maximum and minimum protection voltage levels, ensuring proper coordination of protection schemes and voltage control mechanisms.

3.2.2 Fault Current, Bypass Current, Swing Current and Temporary Overvoltage Analysis

Assessing fault current, bypass current, and temporary overvoltage levels is critical for ensuring the stability and protection of series-compensated lines. This study involves analyzing:

- Balanced and unbalanced faults under various system configurations
- Bypass current characteristics to evaluate protection system performance
- Swing current analysis (as defined in Institute of Electrical and Electronics Engineers [IEEE] 824) to assess the impact of power swings on the compensated lines

3.2.3 Stability and Dynamic Voltage Performance

While series compensation enhances system stability and power transfer capability, a high compensation degree can introduce risks such as low damping of electromechanical oscillations. This study investigates:

- Transient stability following grid disturbances
- Damping characteristics of system oscillations
- Dynamic voltage behaviour to identify potential instabilities or voltage fluctuations

3.2.4 Harmonic Impact Assessment

Series compensation can introduce harmonic distortions into the network. This study aims to:

- Analyze harmonic impedance, current, and voltage from the 2nd to 50th harmonic order under various operating conditions
- Identify potential harmonic resonance conditions

- Recommend mitigation measures such as harmonic filters or tuning capacitor banks if necessary

3.2.5 Transient Recovery Voltage and Breaker Capability Analysis

To ensure reliable switching operations of the new and existing breakers at the terminals of or electrically nearby the series compensated lines, this study evaluates:

- TRV characteristics following fault clearing or switching operations
- Circuit breaker capabilities, ensuring they can handle TRV levels and operate within their design limits
- The need for special protection schemes, such as controlled switching or TRV suppression techniques

3.2.6 Ferroresonance Risk Evaluation

Ferroresonance can occur in series-compensated systems, particularly in tapped substations or at transmission line terminals. This study examines:

- The potential for ferroresonance conditions under various system configurations
- The impact on transformers, capacitors and other reactive components
- Possible mitigation strategies

Appendix A: GRIP Overview

Introduction

The Alberta Interconnected Electric System (AIES) is undergoing a period of grid transformation driven by multiple factors, including the increasing integration of inverter-based resources (IBRs) such as wind and solar, changes in system topology, and evolving operating conditions. Collectively, these factors present the following challenges to the Alberta Electric System Operator (AESO):

- High penetration of IBR, which can reduce system capability to manage and maintain frequency stability, system strength and operational flexibility
- Restrictions on the availability of reliability support through interties due to weak connectivity with the Western Interconnection, where excessive reliance on external resources increases the risk of intertie tripping
- Increasing operational limitations associated with newly energized facilities
- An increase in reliability-related phenomena observed during real-time operations

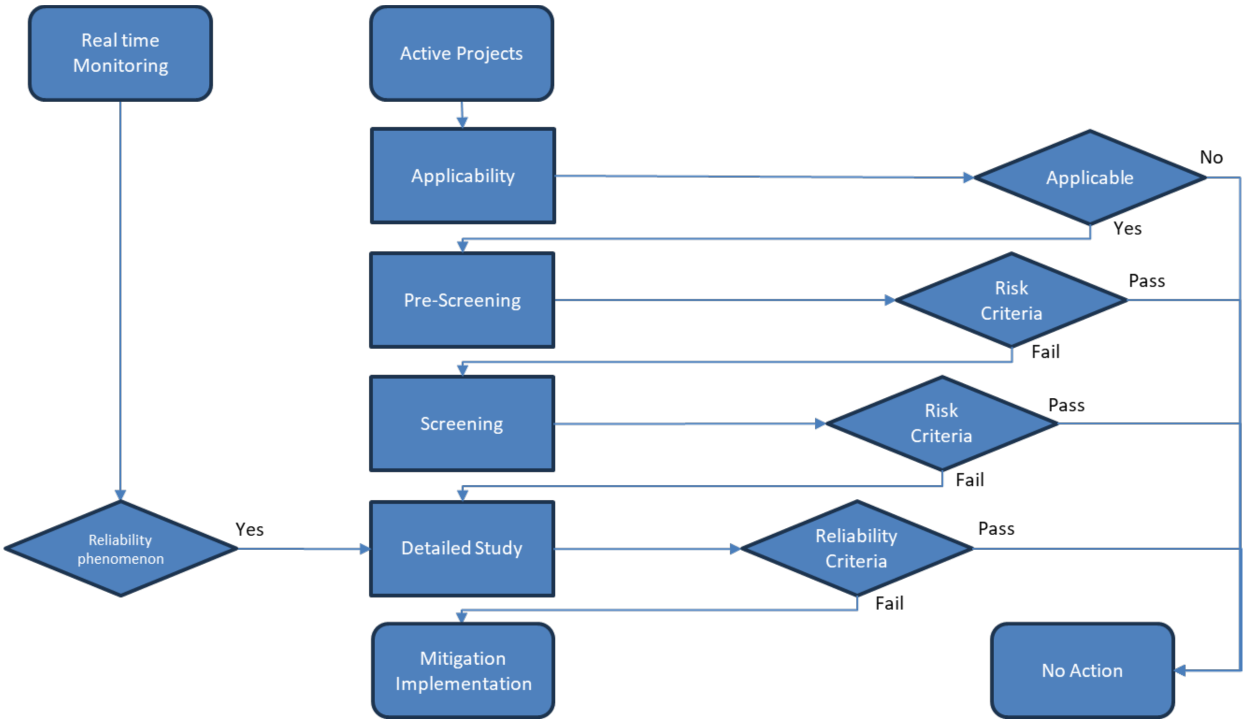
As a result of these emerging AIES reliability challenges, the AESO has identified several areas where performing Grid Readiness, Integration and Performance (GRIP) Requirements would be beneficial. System reliability is also heavily dependent on how market participants (MPs) conduct technical assessment and design the facility accordingly to meet connection requirements prior to energization. Therefore, we have created standard guidelines on how to conduct GRIP. We have adopted a risk-based approach, which considers the risk to the reliability of the AIES using project information, beginning with high-level screening assessments for all active connection projects and, where necessary, proceeding to more detailed studies. These studies may identify potential mitigation measures to be implemented during the connection process. This approach seeks to strike the right balance between moving efficiently through the connection process and exercising the due diligence required to ensure system reliability.

AESO's Risk-Based Assessment Approach

The AESO's process for GRIP uses a risk-based framework, as shown in Figure A1, which consists of:

- Applicability
- Pre-screening
- Screening
- Detailed study, report and submission
- Result acceptance
- Mitigation implementation

Figure A1: Risk-Based Assessment Approach



The phases of this process occur at different points throughout the AESO's Connection Process. For topics related to AESO Authoritative Documents, MPs are responsible for completing applicability, pre-screening and screening steps independently, and are encouraged to use the approach and methodology outlined in this guideline. In all other cases, the AESO will conduct these initial steps. These steps will determine whether a facility requesting system access can be excluded from further analysis or requires further study as a high-risk project. Projects identified as high risk will include a detailed study requirement in the project's functional specification. This guideline provides details on the recommended approach for conducting detailed studies. Upon receiving the detailed study, the AESO will work with MPs to review and comment on the report in accordance with this guideline. We may revise project's functional specification if the report results in changes to a project's scope of work.

Applicability

The objective of applicability phase identifies projects requiring further assessment using applicability criteria based on accessible project information available early in the customer connection process such as, facility size, type and technology.

Once a project meets the applicability criteria it will move to the next relevant step following the guideline. MPs have the option to skip the pre-screening or screening steps and move directly to the detailed study or mitigation steps.

Pre-screening

The objective of pre-screening is to conduct a further assessment once the preferred connection alternative is selected. At this stage, the project details such as point of connection, nearby facilities and project scope are known, which are used to help identify potential high-risk projects. This information helps the MP and the AESO understand the risk of meeting operational requirements.

Screening

The objective of screening is to conduct a further assessment when more detailed technical information on MPs proposed facility becomes known. This guideline introduces a technical evaluation to assess whether a project qualifies as high-risk. Projects identified as high-risk move to the detailed study stage. The AESO will include the detailed study requirement and report submission requirement in functional specification for high-risk projects.

Detailed Study, Report and Submission

The objective of the detailed study is to demonstrate compliance with the AESO's operational requirements through advanced calculations or simulation outlined in this guideline prior to project energization. To conduct this work, the responsible entity will require detailed project information and models, usually in the later stages of the customer connection process. The AESO will identify and include the detailed study and report submission requirements in the functional specification for the high-risk projects.

Mitigation

The detailed study report may identify a reliability issue. When this occurs, the MP must consider a mitigation solution and consult with the AESO on the proposed approach. The detailed study will then need to be revised to confirm the effectiveness of the proposed mitigation.

As indicated above, a responsible entity has the option to skip the screening steps and proceed directly to the detailed study. Further, if the responsible entity is aware the detailed study will indicate a reliability issue or potential non-compliance, the responsible entity may proceed with proposing a mitigation solution to the AESO.

Result Acceptance

Upon submission of the detailed study report, the AESO will follow this guideline to review and comment on the report within a timely manner. The responsible entity of the detailed study will be responsible to address all AESO comments and authenticate the study report. The detailed study must be completed prior to the project energization, preferably 100 days prior to the project energization.

It is important to note that this guideline is meant to assist the AESO in understanding and mitigating the risks to reliability of the AIES. This risk-based assessment is not conclusive and if the reliability phenomenon is observed in real-time, we will work with the MP on real-time mitigation measures. Furthermore, project changes, accepted through the AESO's Project Change Proposal process may trigger the need for additional applicability, pre-screening, screening and detailed study.

Appendix B: Detailed Study Report Template

It is encouraged that a study report will be written based on the template below to present your relevant study, analysis, or findings for a specific study topic. Following AESO's study guidelines on the specific study topic can help the AESO to review your study report in an efficient and effective manner. This template can also be used for the report to present screening results if required.

1.0 Title Page

This section shall include report title, project number, author/reviewer/approvers names, date of submission and Association of Professional Engineers and Geoscientists of Alberta (APEGA) authentication.

2.0 Executive Summary

This section will provide a summary of the study report, including main objectives, study methodology, key findings, recommendations, mitigation if required, etc.

3.0 Table of Contents

This table will list sections and subsections with page numbers in the report.

4.0 Introduction/Objective

This section will outline the background information on a specific topic, and study purpose, objective and its scope.

5.0 Methodology and Scenarios

This section will elaborate on the study approach and list the scenarios to study. Other key information such as simulation software and its version, data collection methods, analysis or evaluation techniques should be included. Please check with AESO's corresponding study guideline to use the recommended methodology and scenarios.

6.0 Criteria (if applicable)

This section will define the basis for judgement and decision-making in the report, including applicable standards, justification for selecting these criteria, application of criteria, etc.

7.0 Inputs Data and Assumptions

This section will define the information, variables and underlying assumptions in the report, including raw data and key variables, credible assumptions made in the study. Please check with AESO's corresponding study guideline to use the recommended inputs and assumptions.

8.0 Simulation Results Analysis

This section will demonstrate the key outcomes from the study, including overview of the simulation, data presentation using tables, graphs or charts, and interpretation of expected or unexpected results. Please check AESO's corresponding study guideline to use the recommended way to present simulation results if defined.

9.0 Mitigation/Correction Actions (if applicable)

This section will explore solutions or measures to address risks identified in the study report and proposes the mitigation/corrective actions which shall be implemented prior to the project energization. If the mitigation requires another study to confirm the effectiveness, the separate study report can be submitted to the AESO.

10.0 Conclusion

This section will summarize the main takeaways, interpret the implications of the findings and provide the final thoughts to support the decision-making.

11.0 References

The section will list all sources cited in the study report.

12.0 Appendices

This section will provide some additional information that supports the study report. It can include raw data, diagrams, detailed calculations, etc.

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