AESO DER ROADMAP INTEGRATION PAPER

DER Commissioning and Testing Recommendations

AUGUST 2022

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Introduction

As discussed in the *AESO Distributed Energy Resources (DER) Roadmap*[1], the growth of distributed energy resources (DERs) and their integration with the Alberta interconnected electric system (AIES) will drive significant changes for the AESO, distribution facility owners (DFOs), transmission facility owners (TFOs), market participants, and consumers in Alberta. As DER penetration continues to grow, the increasing complexity and scale of power systems in Alberta may present reliability challenges concerning AIES operations and coordination of planning between the distribution and transmission systems. These challenges include defining the necessary tests to confirm that all relevant equipment and systems meet a range of technical and functional requirements under various operating conditions. This includes commissioning activities, production tests, periodic field tests, and other ad-hoc testing.

As discussed in greater detail in a separate AESO DER Roadmap Integration Paper[2], the Institute of Electrical and Electronics Engineers (IEEE)[3] and Canadian Standards Association (CSA) have each published recommended standards for the interconnection of DERs, which: (i) contemplate new measures for DER-related frequency ride-through (FRT) and voltage ride-through (VRT) based on different scopes and electric system impacts[4]; and (ii) emphasize different levels of performance[5] depending on the level of DER penetration and type of DER technology ("industry standards"). The industry standards are not binding requirements unless adopted by an implementing agency (regulatory body, DFOs or TFOs). The voluntary nature of the industry standards has given rise to questions from Alberta's industry participants, particularly DFOs and TFOs, regarding the selection and adoption of the requirements set out in the industry standards for purposes of establishing DFOs' distribution system-level DER interconnection requirements in Alberta.

Whereas other documents in the AESO DER Roadmap Integration Papers series examine and recommend the adoption by DFOs of certain industry standards relating to functional and technical requirements to ensure the continued reliability of the AIES, this document defines the necessary tests and procedures to confirm that the recommended functional and technical requirements are met. Similar to other papers in the series, this document sets out the AESO's recommendations only; should the AESO determine that AESO requirements are necessary in the future, these will be addressed through the applicable processes for developing ISO rules and Alberta reliability standards.

Background and Purpose

The AESO's legislative duties include directing the safe, reliable and economic operation of the AIES[6]. Given its central role in ensuring the reliability of the AIES, the AESO developed the *AESO DER Roadmap*, which is being advanced in collaboration with stakeholders, to explore and manage the challenges and

[1] AESO Distributed Energy Resources (DER) Roadmap (June 2020), available on the AESO website.

[2] AESO DER Roadmap Integration Paper – DER Ride-Through Performance Recommendations (originally published in March 2021), available on the AESO website.

[3] IEEE Standard 1547-2003, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems

[4] The IEEE and CSA standards emphasize the impacts that DERs may have on the transmission system and distribution systems, respectively. For further details, see the *AESO DER Roadmap Integration Paper – DER Ride-Through Performance Recommendations*.

[5] *I.e.*, "categories" or "grades".

[6] Electric Utilities Act, Section 17(h).

opportunities associated with the transformation of the AIES.

In July 2019, the AESO established the Technical Performance Exploration Group (TPEG)[7], consisting of technical experts from utilities across Alberta, including DFOs and TFOs, to exchange ideas, discuss DER-related topics, and proactively prepare for a future state with higher DER penetration and potentially rapid growth in DERs. The TPEG focuses on:

- facilitating a common understanding of the overall impacts on the reliable operation and planning of the AIES due to DER integration;
- developing consensus on the future state of DER technical performance;
- proposing recommendations to close any gaps identified between the current and desired future states; and
- supporting the coordination of stakeholders' implementation of recommendations relating to the technical interconnection of DERs in Alberta.

The TPEG's scope of work excludes matters relating to policy and the regulatory framework in Alberta, the electricity market impact of DERs, and various other technical aspects related to DER integration and operation, including modelling, forecasting, and DER management systems (DERMS).

This AESO DER Roadmap Integration Paper:

- provides an update to stakeholders, including DFOs, TFOs, DER proponents and owners (herein simply referred to as "DER owners"), the Alberta Utilities Commission, and other interested parties, about the results of the TPEG's work;
- addresses the commissioning and testing aspects of the technical requirements for DERs;
- provides an overview of Alberta DFOs' existing commissioning and testing requirements and a review of various jurisdictions outside of Alberta,
- sets out the AESO's recommended approach, developed in collaboration with the TPEG, for managing commissioning and testing requirements in the future.

This document is also intended to assist interested parties in assessing the potential impacts that the AESO's recommendations may have on them, including current or planned projects, facilities, and services.

Overview of Industry Standards

The following provides an overview of the industry standards regarding commissioning and testing of DERs.

IEEE Standard 1547.1–2020

In April 2018, IEEE published the "base standard" IEEE Standard 1547–2018 – *Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces* (IEEE Standard 1547-2018), which, compared to the previous IEEE Standard 1547 version of 2003, significantly enhances and expands the required levels of performance and functional capability for DERs connecting specifically to primary and secondary distribution systems. The advanced capabilities of modern DERs connecting to electric systems, especially inverter-based DERs, are reflected in this new standard. However, the testing procedures for dealing with the new DER capabilities were not

[7] The TPEG membership list is provided in Appendix A.

updated and readily available in IEEE Standard 1547–2018.

In March 2020, IEEE published IEEE Standard 1547.1-2020 – *IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces* (IEEE Standard 1547.1-2020). This is a "test standard", which contains conformance test and evaluation procedures to establish and verify compliance with the technical requirements set out in IEEE Standard 1547–2018, thus providing a means for manufacturers, utilities, and independent testing agencies to confirm the suitability of DERs for interconnection with a distribution system. Wherever necessary, IEEE Standard 1547.1-2020 is structured to align with IEEE Standard 1547–2018. IEEE Standard 1547-2018 provides three progressive capability levels (categories) to ensure that DERs do not negatively impact electric system performance when a fault occurs. These three categories are as follows:

Category I – This is an "entry level" of compliance compatible with most "bulk power system"[8] (BPS) needs and therefore reasonably attainable for by DER technologies that are in common use today. This level is suitable for low levels of DER penetration.[9]

Category II – This level of performance covers all BPS reliability needs and is coordinated with the existing NERC Standard PRC-024-2 – *Generator Frequency and Voltage Protective Relay Settings*, developed to avoid adverse tripping of BPS generators during system disturbances. This level of performance is attainable by inverter-based resources.

Category III – This is an enhanced level of performance where DER operation becomes important for the distribution system. It provides the highest disturbance ride-through capabilities, which are attainable by inverter-based resources where high levels of DER penetration or high variability in output are expected, or where momentary cessation requirements are seen as a desirable solution for coordinating with distribution system protection and control and safety.

CSA C22.3 No. 9:20

CSA C22.3 No. 9:20, *Interconnection of distributed energy resources and electricity supply systems* (CSA C22.3 No. 9:20) was published in January 2020. It specifies the technical requirements for the interconnection of DERs with distribution systems up to voltage levels of 50 kV line-to-line at the point of common coupling. This standard specifies the minimum requirements for personnel safety, service continuity, and protection of property. It is generally in-line with IEEE Standard 1547-2018 and the then-draft IEEE Standard 1547.1-2020, although it does not address transmission system impacts or upgrades due to DER integration. Section 8 of C22.3 No. 9:20, Interconnection Tests, provides a comprehensive list of tests and test conditions under which DERs, especially inverter-based DERs, are tested.

CSA C22.3 No. 9:20 requires that the distribution wires owner specify the applicable grade of DER system interconnection capability, either a "baseline" or "supplemental" grade, based on the assessed level of DER penetration (*i.e.*, baseline for "low" penetration levels, and supplemental for "high" penetration levels), and the DER technology (*i.e.*, inverter-based, synchronous or induction). Penetration levels[10] are determined

[8] As contemplated in IEEE Standard 1547-2018.

[9] Note that IEEE Standard 1547-2018 does not clearly define or prescribe levels of DER penetration.

[10] In CSA C22.3 No. 9:20, "penetration level" (*e.g.*, "high" or "low") refers to the aggregate capacity of a DER connecting to a particular distribution feeder. This CSA standard intentionally uses qualitative measures (*i.e.*, high/low DER penetration) instead of quantitative measures. Further, the distribution wires owner defines the aggregate

by the distribution wires owner.

UL 1741 SA

In 2016, the Underwriters' Laboratories published standard UL 1741 Supplement A (SA) – *Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources*, which specifies the testing methods to evaluate compliance with electric utilities' source requirement documents (SRDs) for limits and parameter settings. This is primarily a product safety standard that lays out the manufacturing (including software) and product testing requirements with the goal of producing inverters more capable of riding through distribution and transmission system excursions or even actively managing system reliability functions. Products that meet this requirement can be called "Grid Support Inverters", "Smart Inverters" or "Advanced Inverters".

The upcoming UL 1741 Supplement B (SB) will directly refer to IEEE Standard 1547.1–2020 and is expected to be the only manufacturer's test procedure to certify IEEE Standard 1547-2018 compliance.

Current Commissioning and Testing Requirements in Alberta

In Alberta, the current ISO rules contain higher-level provisions applicable only to large DERs, usually with a capacity of 5 MW and higher, and generally stipulate the need for commissioning and testing, requireSCADA visibility for generation dispatch, and require the provision of modelling data for purposes of the AESO's system studies. The AESO may also, as conditions for interconnection, specify in a functional specification that certain protection schemes be available on the transmission system or on the DER. These protection schemes include telecommunication systems, transfer trips, or remedial action schemes. In these cases, the AESO relies on the TFO, the DFO, and the DER owner to coordinate closely to meet the protection requirements. The AESO also relies on the TFO, the DFO, and the DER owner to carry out the necessary commissioning activities and testing to confirm compliance with the AESO's requirements.

In addition to the ISO rules, which are limited in scope and applicability, each DFO in Alberta develops and maintains detailed interconnection technical requirements, including the associated commissioning and testing requirements, for all DERs installed within its own service area. A high-level comparison of the current commissioning and testing requirements of the major Alberta DFOs is provided in ***Appendix B***. Although these requirements differ slightly in scope and detail, there are commonalities between them.

- A DER owner must provide the incumbent DFO with advance notice of the scheduled commissioning activities before energization and startup of the testing plans and procedures.
- A DER owner is solely responsible for the inspection, testing, and calibration of its equipment at the point of common coupling, generally defined as the point of connection where electricity flows between the DFO's distribution system and the DER.
- The incumbent DFO has the right to witness any part of the commissioning activities and tests, may request additional testing, and may conduct its own testing.
- Deficiencies found during commissioning activities must be mitigated or corrected by the DER owner prior to the actual interconnection and operation of the DER.
- All commissioning tests and test results must be recorded and retained by the DER owner, and must be provided to the DFO immediately upon completion of the activities and tests, or provided

capacity for each feeder or section of its distribution system, which in turn indicates whether the DER penetration level is high or low.

to the DFO upon request.

- IEEE Standard 1547, CSA 22.3 No.9:20, and UL 1741 SA are the three common standards to be enforced by DFOs and followed by DERs for commissioning and testing.

Jurisdictional Review

In this non-exhaustive jurisdictional review pertaining to DER commissioning and testing requirements, the AESO examined only publicly available materials—portions of which are summarized below—of certain Canadian utilities and a variety of independent system operators (ISOs) and regional transmission organizations (RTOs) in North America. ISOs and RTOs in the United States are responsible for managing the transmission system in different geographic regions of the country, and these regions may encompass multiple states. Some ISOs and RTOs have issued guidelines and recommendations regarding the interconnection of DERs to the distribution system that may be superseded by a requirement established by some other relevant authority, referred to as an Authority Governing Interconnection Requirements.[11] Notably, the characteristics of the various jurisdictions' power systems may differ, and the DER penetration levels and growth rates vary substantially depending on the regions. Therefore, reliability needs may differ from region to region. The AESO's jurisdictional review provides a summary for information and reference purposes only; it is not exhaustive and is not determinative of the approach that should apply in Alberta.

The North American Electric Reliability Corporation (NERC), responsible for developing and enforcing reliability- and security-related standards for the BPS, is contemplating the development of a set of guidelines related to modeling and assessments.[12]

BC Hydro

A DER owner is responsible for the inspection, testing, and calibration of all equipment up to the point of interconnection. BC Hydro can choose to witness the tests or require additional tests to be performed. BC Hydro requires that all tests comply with IEEE Standard 1547.1-2020. If a deficiency is found during commissioning and testing, it must be corrected before the DER is approved for operation. BC Hydro also requires that DER commissioning and testing reports be signed and sealed by qualified professional engineers. Although BC Hydro does not require regular submissions of commissioning and testing reports, the DER must provide these reports to BC Hydro upon request.[13]

Manitoba Hydro

In Manitoba, all commissioning tests must be coordinated with Manitoba Hydro. IEEE Standard 1547.1 must be followed for all tests.[14] Manitoba Hydro sends a representative to witness the tests, during all or a

[11] IEEE Standard 1547-2018 introduces and defines the concept of an Authority Governing Interconnection Requirements. IEEE Standard 1547-2018 is available on the IEEE website at https://standards.ieee.org/standard/1547-2018.html

[12] NERC, *Distributed Energy Resources Connection Modeling and Reliability Considerations* (February 2017), available at https://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/Distributed_Energy_Resources_Report.pdf

[13] BC Hydro, *60 kV to 500 kV Technical Interconnection Requirements For Power Generators* (June 2, 2014), available at https://app.bchydro.com/content/dam/BCHydro/customer-portal/documents/transmission/tgi/technical-interconnection-requirements-for-power-generators-r14-2014-06.pdf

[14] Manitoba Hydro, *Technical Requirements For Connecting Distributed Resources To The Manitoba Hydro Distribution System* (January 2011), available at https://www.hydro.mb.ca/accounts_and_services/generating_your_own_electricity/pdf/drip_technical_requirements.pdf

portion of the commissioning process.

Nova Scotia Power

In 2020, Nova Scotia Power published its *Interconnection Requirements for Generating Facilities >100 kW Connected to Distribution Systems Rated ≤ 26.4 kV*.[15] The utility generally requires that CSA C22.3 No.9:20 be followed for most of the interconnection tests, with the remainder being based on IEEE Standard 1547–2018.

Toronto Hydro

A DER owner must give Toronto Hydro at least 15 days advance written notice before commissioning. Toronto Hydro may send personnel to witness the commissioning and testing of the connection of any DER greater than 10 kW. Toronto Hydro also requires submissions of commissioning test report which must be certified by Professional Engineers. All DERs must comply with IEEE Standard 1547 and CSA C22.2 No.257 and C22.3 No.9:20.[16]

Northeast Power Coordinating Council (NPCC)

NPCC does not have jurisdiction over the interconnection of DERs. In its DER guidance document *Distributed Energy Resources (DER) Considerations to Optimize and Enhance System Resilience and Reliability*, NPCC recommends that member states or provinces adopt IEEE Standard 1547 and 1547–2020 for technical requirements for DERs, including commissioning and testing.[17]

Midcontinent Independent System Operator (MISO)

MISO does not have jurisdiction over the interconnection of DERs, which fall under the jurisdiction of the relevant distribution provider and, as applicable, the state public utility commission or electric cooperative governing board. However, MISO published a guideline *IEEE Standard 1547 Implementation – Recommendations on Requirements Impacting Transmission Systems*, in which MISO encouraged distributors in the MISO region to adopt IEEE Standard 1547 for DER connections, including commissioning and testing requirements.[18]

ISO New England (ISO-NE)

ISO-NE is currently working with the Massachusetts Technical Standards Review Group on full

[15] Nova Scotia Power, *Interconnection Requirements for Generating Facilities >100 kW Connected to Distribution Systems Rated ≤ 26.4 kV* (August 14, 2020), available at https://www.nspower.ca/docs/default-source/pdf-to-upload/interconnection-requirements-generating-facilities-above-100kw.pdf?sfvrsn=fc0424ee_12

[16] Toronto Hydro, *Toronto Hydro – Distributed Generation Requirements* (January 1, 2011) available at https://www.torontohydro.com/documents/20143/85785/conditions-of-service-reference-3-dg-requirements.pdf/9b8d1c8c-b06f-1d19-c376-1e42907031b3

[17] NPCC, *Distributed Energy Resources (DER) Considerations to Optimize and Enhance System Resilience and Reliability* (Version 2, approved November 20, 2020), available at https://www.npcc.org/content/docs/public/program-areas/standards-and-criteria/der-forum/2020/der-v2-11-20-2020.pdf

[18] MISO, *MISO Guideline for IEEE Std 1547-2018 Implementation Recommendations on Requirements Impacting Transmission Systems* (November 2019), available at https://cdn.misoenergy.org/MISO%20Guideline%20for%20IEEE%20Std%201547388042.pdf

implementation of IEEE Standard 1547-2018.[19] An SRD[20] was developed as an interim solution for inverter-based solar PV projects. According to the SRD, all applicable inverter-based applications shall:

- Be tested and certified per UL 1741 SA as a grid support utility interactive inverter
- Have the voltage and frequency trip settings
- Have the abnormal performance capabilities (ride-through)
- Comply with other grid support utility interactive inverter functions statuses

California ISO (CAISO)

CAISO directly or indirectly manages the largest rollout of DERs in North America in the California ISO balancing area. California's Electric Tariff Rule 21 (Rule 21) is a tariff that describes the interconnection, operating and metering requirements that must be satisfied for generation facilities to be connected to a utility's distribution system.[21] Rule 21 primarily follows the IEEE Standard 1547 and UL 1741 standards for DER commissioning and testing.

In Rule 21, a proponent or owner of a DER is responsible for testing its facilities and associated interconnection facilities to ensure compliance with the safety and reliability provisions prior to operating in parallel with a transmission or distribution system. Generally speaking, the incumbent distribution utility requires little or no additional tests if the DER equipment is certified by an accredited lab to meet UL 1741 SA. For interconnections with non-certified DER equipment, it is up to the incumbent distribution utility to accept a testing plan. Alternatively, the DER owner and the distribution utility may agree to have the distribution utility conduct the required testing at the DER owner's expense.

AESO's Proposed Approach to DER Commissioning and Testing

Based on its observations and analyses of the existing Alberta DFOs' terms and conditions as well as other jurisdictions in North America, the AESO proposes the following approach to commissioning and testing requirements for DERs:

1. At the present time, the AESO does not see a need to develop province-wide recommendations to address the commissioning and testing requirements for all DERs. In the AESO's view, the existing DFOs' requirements for commissioning and testing are comprehensive, inclusive, and consistent with industry practice. The AESO will continue to rely on DFOs (and, in some cases, the TFOs) and the DER owners to coordinate and carry out all commissioning activities and applicable tests.
2. The AESO will continue to use AESO functional specification documents to specify any exceptional technical requirements, including commissioning and test requirements, for DERs that may have significant impacts on the AIES. The AESO functional specification will identify the responsible parties for tests and the provider for test results and reports.
3. The AESO will continue to monitor the impact of DERs on the AIES and will decide, in the future, if new

[19] See https://www.iso-ne.com/static-assets/documents/2018/02/a2_implementation_of_revised_ieee_standard_1547_presentation.pdf

[20] See https://www.iso-ne.com/static-assets/documents/2018/02/a2_implementation_of_revised_ieee_standard_1547_iso_source_document.pdf

[21] Available on the CPUC website at https://www.cpuc.ca.gov/General.aspx?id=3962

or amended authoritative documents are required. As previously discussed, should the AESO determine that AESO requirements are necessary in the future, these will be addressed through the applicable processes for developing ISO rules and Alberta reliability standards.

Appendix A – TPEG Membership

TPEG Member
AESO
AltaLink
ATCO
City of Lethbridge
City of Medicine Hat
City of Red Deer
ENMAX Power
EPCOR
FortisAlberta

Appendix B – Comparison of Alberta DFOs' Commissioning and Testing Requirements

	FortisAlberta[22]	ATCO[23]	ENMAX[24]	EDTI[25]
General Requirements				
Responsible party for tests	DER	DER	DER	DER
Advance notice time before commissioning	30 days	≥ 2 weeks	≥ 2 weeks	≥ 2 weeks
Main standards for inspection, calibration, commissioning and testing for equipment and systems	IEEE Std 1547.1-2020 CSA C22.3 No.9-20 UL 1741	IEEE Std 1547.1-2005 CSA C22.3 No. 9-08 UL 1741	IEEE Std 1547.1-2005 CSA 22.3 No.9-08 UL 1741 SA	IEEE Std 1547 CSA C22.3 No. 9-08 UL 1741
Testing Requirements				
Mandatory tests	▪ type test ▪ commissioning test ▪ production test ▪ verification test	▪ type test ▪ commissioning test ▪ production test ▪ verification test	▪ type test ▪ commissioning test ▪ production test ▪ verification test	▪ type test ▪ commissioning test ▪ periodic test ▪ verification test
Tests to be performed upon request	▪ verification tests performed annually if transfer trip is required		▪ verification test – coordinated with DFO ▪ DFO can request additional tests	▪ DFO can request additional tests
Reporting Requirements				
How a DER provides testing reports to DFO	test reports must be provided upon request	test reports be provided upon request	test reports must be provided upon request	• commissioning test reports must be provided • other reports provided upon request
Testing reports retention period	unspecified	unspecified	unspecified	unspecified

[22] FortisAlberta Technical Interconnection Requirements for DER 150 kW and Greater, Version 2.0, available at the FortisAlberta website.

[23] Standard for the Interconnection of Generators to ATCO Electric's Distribution system and Inverter based Distributed Energy Resources Technical Interconnection Requirements, available at the ATCO Electric website.

[24] Distributed Energy Resource Technical Interconnection Requirements, available at the ENMAX website.

[25] Technical Guideline for The Interconnection of Distributed Energy Resources to EPCOR Distribution and Transmission Inc.'s Distribution System, available at the EPCOR Distribution and Transmission Inc. website.

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