Ohio Valley Electric Corporation – Indiana-Kentucky Electric Corporation
Interconnection Requirements

Since its inception in the 1950's, Ohio Valley Electric Corporation (OVEC) and its wholly-owned subsidiary, Indiana-Kentucky Electric Corporation (IKEC, both companies together referred to collectively as OVEC), has contracted with American Electric Power Service Corporation (AEP) to perform certain engineering services, including transmission planning, on OVEC's behalf. Because of this close relationship, OVEC follows the AEP Interconnection Requirements.

On December 1, 2018, OVEC was integrated into the PJM RTO as a Transmission Owning member. As such, OVEC also complies with all PJM Interconnection requirements.

For additional information on OVEC's Interconnection Requirements, contact:

Scott R. Cunningham scunning@ovec.com (740) 289-7217

Mary S. Berkley msberkley@aep.com (614) 933-2209

The remainder of this document contains the AEP Interconnection Requirements.

Requirements for Connection of New Facilities or Changes to Existing Facilities Connected to the AEP Transmission System

Effective: June 30, 2021

Document Control

Revision History

Version	Effective Date	Remarks
Rev. 0	12/08/2010	Combined AEP East and AEP West Interconnection Requirements
Rev. 1	01/02/2014	Periodic Review
Rev. 2	01/01/2019	New FAC-001-3 Requirements, Appendix B Rework, & Periodic Review
Rev. 3	06/30/2021	Complete document reorganization to better align with standard processes, adjustment of requirements needing updates, and addition of 4th customer category for Distributed Energy Resources

Preparation

Prepared By
AEP Transmission Subject Matter Experts

Review Cycle

Quarterly	Semi-annual	Annual	As Needed
			X

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1.0 Document Overview

This document describes the processes and technical requirements for new or materially modified facility connections to the American Electric Power (AEP) system's electrical transmission network.

AEP[1] is responsible for evaluating its transmission network capabilities and formulating plans that maximize functionality and operation in a safe, reliable, cost effective, and environmentally responsible manner. AEP Transmission created the requirements in this document to ensure the transmission system's integrity when providing new or materially modified facility connections. All future Requester facilities, loads, major equipment or setting changes must be submitted to AEP for review before they are placed in service. The Requester is responsible for obtaining the requirements from the regional transmission entity (RTE)[2] within which their operation exists.

This document contains the minimum requirements acceptable for affiliated and non-affiliated connections to the AEP transmission system. The requirements and processes described in this document will guide the planning for new facility installations and upgrading existing facilities. In some specific cases, AEP may request additional details.

For purposes of this requirements document, AEP transmission interconnections are organized into four categories: Distributed Energy Resource (DER), End-User Connection (EUC), Generator Connection (GC), and Transmission Interconnection (TI). Each subsection contains the general requirements that apply to all interconnection categories and indicates any requirements that may be specific to a single category. See *Section 2.0 Initial Engagement* for more information.

AEP has seven electric utilities referred to as Affiliate Operating Companies, and seven electric utilities referred to as Transmission Companies that are geographically dispersed across 11 states. RTEs support and assist with the operation and usage of the larger integrated or interconnected regional transmission system and are generally responsible for ensuring the regional transmission system's safe and reliable operation. Nothing within this document is intended to conflict with applicable RTE requirements.

Entities requesting a Transmission Interconnection are required to register within a Balancing Authority (BA) with their respective RTE. The interconnecting facilities will not be energized until AEP verifies that this registration is complete.

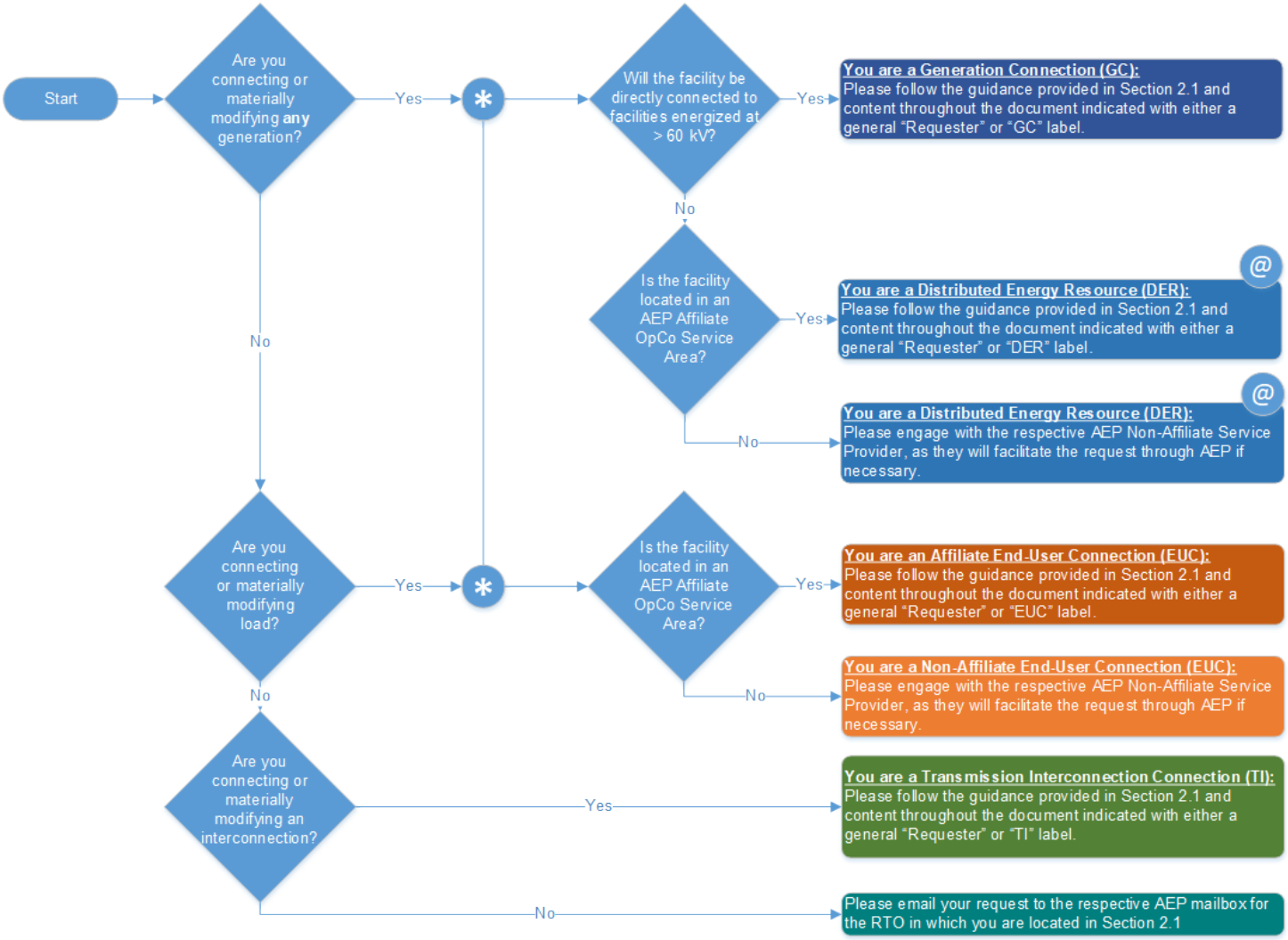
[1] AEP Service Corporation is an agent for Electric Transmission Texas (ETT), Electric Transmission America (ETA), PATH West Virginia, and the Transource entities located in Maryland, Missouri, Pennsylvania, and West Virginia.
[2] Regional transmission entity or RTE – For the purpose of this document, any regional body having jurisdiction over a party, including the applicable RTO, ISO, or regional electric reliability organization under NERC authority.

1.1 Table of Contents & Compliance Alignment

2.0 Initial Engagement

This section explains the first steps the Requester should take when initiating a modification or new connection to the transmission infrastructure. To assist in the understanding of this section and the references to each respective connection type throughout this document, refer to the flowchart in *Figure 1* below.

Figure 1. Requester Connection Decision Type Tree



* If the facility has both generation and load, it may be considered multiple customer types and thus have to follow multiple workflows to satisfy all requirements. This includes primary generation facilities with auxiliary load, where following both processes will enable the facility to secure an associated retail load contract.

@ While considered a DER, if the facility is also anticipated to participate in the wholesale market, you should also engage with your respective RTO as indicated in Section 2.1.

2.1 Procedures

2.1.1 Procedures for Requesting New or Materially Modified Interconnections

This section outlines the first point of contact for requesting new or material modifications to existing connections. Refer to the flowchart in *Figure 1* to determine connection type and requirements. The definitions of each region and connection type are in *Appendix A Definitions*. In addition, the processes, data requirements, and procedures for sharing results for these particular requests are located in *Sections 2.1.2*, *2.2.1*, and *2.2.2*.

Table 1. First Point of Contact for Requesting New or Materially Modified Interconnections

Region	State	Connection Type			
		DER	GC	EUC	TI
ERCOT[3]	Mid/South Texas	AEP Texas[4]	≤10 MW: SIS[5] ERCOT Mailbox[6] >10 MW: ERCOT Website[7]	SIS ERCOT Mailbox[6]	SIS ERCOT Mailbox[6]
SPP[8]	North Texas	AEP SWEPCO[9]	SPP Website[10]	SIS SPP Mailbox and SPP AQ Mailbox[11]	SIS SPP Mailbox[12]
	Arkansas				
	Louisiana				
	Oklahoma	AEP PSO[13]			
PJM [14]	Indiana	AEP I&M[15]	PJM Website[16]	SIS PJM Mailbox[17]	SIS PJM Mailbox[17]
	Michigan				
	Ohio	AEP Ohio[18]			
	West Virginia	AEP APCo[19]			
	Tennessee				
	Virginia				
	Kentucky	AEP KPCo[20]			

[3] Electric Reliability Council of Texas
[4] https://www.aeptexas.com/builders/GeneratingEquipment.aspx
[5] System Interconnection Services
[6] ERCOTrequest@aep.com
[7] http://www.ercot.com/services/rq/re/
[8] Southwest Power Pool
[9] https://www.swepco.com/builders/GeneratingEquipment.aspx
[10] http://opsportal.spp.org/Studies/Gen
[11] SPPrequest@aep.com and AQ-deliverypoints@spp.org
[12] SPPrequest@aep.com
[13] https://www.psoklahoma.com/builders/GeneratingEquipment.aspx
[14] PJM Interconnection
[15] https://www.indianamichiganpower.com/builders/GeneratingEquipment.aspx
[16] http://pjm.com/planning/generation-interconnection.aspx
[17] PJMrequest@aep.com
[18] https://www.aepohio.com/builders/GeneratingEquipment.aspx
[19] https://www.appalachianpower.com/builders/GeneratingEquipment.aspx
[20] https://www.kentuckypower.com/builders/GeneratingEquipment.aspx

2.1.2 Procedures for Coordinated Studies of New or Materially Modified Interconnections

This section outlines the procedures for coordinated studies of new or materially modified interconnections that are summarized in the table below.

Table 2. Procedures for Coordinated Studies of New or Material Modified Interconnections

Region	DER	GC	EUC	TI
ERCOT	The procedures for initiating DER studies are located in *Section 2.1.1*. The respective state and/or OpCo manage a screening process to determine the required level of study.	The procedures for coordinated interconnections within the ERCOT region can be found on the ERCOT website[21]. Small generator interconnections (10 MW or less) within the ERCOT region generally follow the DER process within that region. Please follow the procedures as indicated in the DER column.	Affiliate EUC studies are managed by the respective AEP OpCo. New Requesters should contact AEP Economic & Business Development (EBD)[22], while existing Requesters should contact their respective OpCo representative. Non-affiliate EUC studies are outlined in each Requester's agreement with AEP on file at the FERC's eTariff website[23]. Communicate using the mailbox region in *Section 2.1.1* for details.	Given the unique nature of TI, procedures for coordinated TI studies are managed on a case-by-case basis. The details are outlined in the respective Interconnection Agreements (IA) with AEP.
SPP		The procedures for studies within the SPP region can be found in Attachment V of the SPP Open Access Transmission Tariff (OATT), which is located on the SPP Governance website[24].		
PJM		The procedures for studies within the PJM region can be found in the PJM Manual 14 Series on the PJM website[25].		

2.2 Information Requirements

2.2.1 Data Required to Properly Study the Connection

The following subsections outline or direct Requesters to the information required in order for AEP to properly study the request.

[21] http://www.ercot.com/services/rq/re/
[22] https://aeped.com/
[23] https://etariff.ferc.gov/TariffBrowser.aspx?tid=3822
[24] https://www.spp.org/governance/
[25] https://www.pjm.com/library/manuals.aspx

2.2.1.1 Distributed Energy Resources

The Affiliate [i.e., AEP Operating Companies (OpCo)] or the Non-affiliate entities manage their respective data requirements for coordinated Distributed Energy Resource (DER) studies. These requirements are located on their respective websites. Requesters should engage with the respective Non-affiliate entity directly for their requirements. If it is determined that the request may have an impact to bulk transmission, including backfeed for short periods of time, a study for potential impact and additional data may be required.

2.2.1.2 Generation Connections

Generation Connection (GC) study data requirements are outlined in a form in *Appendix B.1* and upon completion should be communicated to the identified party within the form.

Additional or updated data, beyond RTE requirements, is also required once the facility has been declared ready for operation, including:

- Transmission line length, rating, positive and zero-sequence impedances based on final transmission line design.
- Final collector station relay one-line diagram.
- Final collector station relay (excluding inter-connect transmission line relays) settings, such that both parties must agree that coordination has been achieved before energization. Redundant high-speed protection schemes for generation facilities may be required to achieve coordination with Transmission protection schemes.

  Note: If the Requester's line relays differ from relays that AEP approved previously, backfeed will be delayed until the relays that AEP had approved are obtained and made available for the Requester's line terminal. Changes to settings and coordination of new settings will result in schedule delays and additional costs to the Requester.
- The Requester must supply the following materials to AEP before a generation facility is in operation: all final electrical one-line diagrams, equipment data, and schematic diagrams. Subsequent revisions affecting the generation must be documented with copies of the revised electrical one-line and schematic diagrams.
- Changes in ownership from the original Requester to another Requester or entity before energization may result in schedule delays and additional costs to the Requester. Any change in ownership must be communicated promptly to mitigate delays as much as possible.

2.2.1.3 End-User Connections

End-user Connection (EUC) study data requirements are outlined in a form in *Appendix B.2* and upon completion should be communicated to the identified party within the form.

2.2.1.4 Transmission Interconnections

Transmission Interconnection (TI) study data requirements are specific to each request. A form for initiating communication with AEP is provided in *Appendix B.3* and the respective System Interconnection Services (SIS) representative identified in *Section 2.1.1* will communicate any additional data requirements following AEP's detailed review of the request.

2.2.2 Procedures for Sharing Results of Studies and Data to be Included

At the completion of the respective study, AEP will share the results with the requesting party via the group or representative indicated and including the data illustrated in the following table.

Table 3. Sharing Methodology and Information to be Included in Studies

			GC[26]			EUC		
		DER	Feasibility	Impact	Facilities	Affiliate	Non-Affiliate	TI
Sharing Methodology	OpCo DER Representative	✓						
	RTO		✓	✓	✓			
	Affiliate OpCo CSAM[27] or E&BD[28]					✓		
	Interconnection Services Representative	✓[29]					✓	✓
Data Included in Study	Scope of Study	✓	✓	✓	✓	✓	✓	✓
	Assumptions	✓	✓	✓	✓	✓	✓	✓
	Local & Network Impacts	✓	✓	✓	✓	✓	✓	✓
	Stability Analysis				✓			
	Conceptual Scope of Work	✓	✓	✓		✓	✓	✓
	Functional Scope of Work				✓			
	Anticipated Costs	✓	✓	✓	✓	✓	✓	✓
	Anticipated Schedule	✓	✓	✓	✓	✓	✓	✓
	Appendices with Applicable Drawings, Diagrams, and Maps	✓	✓	✓	✓	✓	✓	✓

[26] For requests in the SPP region, SPP communicates Feasibility and Impact Study information, but requests Facilities Study information from AEP, which SPP communicates to the Requester.
[27] Customer Service Account Manager
[28] Economic and Business Development
[29] Interconnection Services representatives will be involved primarily when DER is connected to Non-affiliate Wholesale distribution facilities, while the AEP Affiliate OpCo DER Representative will manage connections to AEP Affiliate distribution facilities.

2.3 Coordination with Other Codes, Standards, and Agencies

The information contained in this document is supplemental to and does not intentionally conflict with or supersede the National Electric Code (NEC), National Electric Safety Code (NESC), *IEEE*[30] *1547*, *IEEE 1547.1*, *IEEE P2800*, *IEEE P2800.1*, or such federal, state and municipal laws, ordinances, rules, regulations or tariffs as may be in force within cities, towns or communities.

It is the Requester's responsibility to conform to all applicable and current requirements. The Requester's responsibility begins at the point of interconnection (POI) described in the established agreement.

2.4 Indemnification

The Requester, for itself, its successors, assigns and subcontractors will be required to pay, indemnify and save AEP, its successors and assigns, harmless from and against any and all court costs and litigation expenses, including legal fees, incurred or related to the defense of any action asserted by any person or persons for bodily injuries, death or property damage arising or in any manner growing out of the use and reliance upon the information provided by AEP. Reliance upon the information in this document shall not relieve the Requester from responsibility for the protection and safety of the general public within the Requester's facilities as defined in the executed agreement.

[30] Institute of Electrical and Electronics Engineers

3.0 Planning

The following subsections outline the requirements associated with the planning phase of a typical project, including standard connection types, in-line switching, design information, configurations of connected generation, siting and environmental requirements.

3.1 Connection Types and Diagrams

The following subsections illustrate standard connections to the AEP system for EUC and GC connection types. In addition, the diagrams reference detailed design requirements where applicable.

Figure 2. Legend

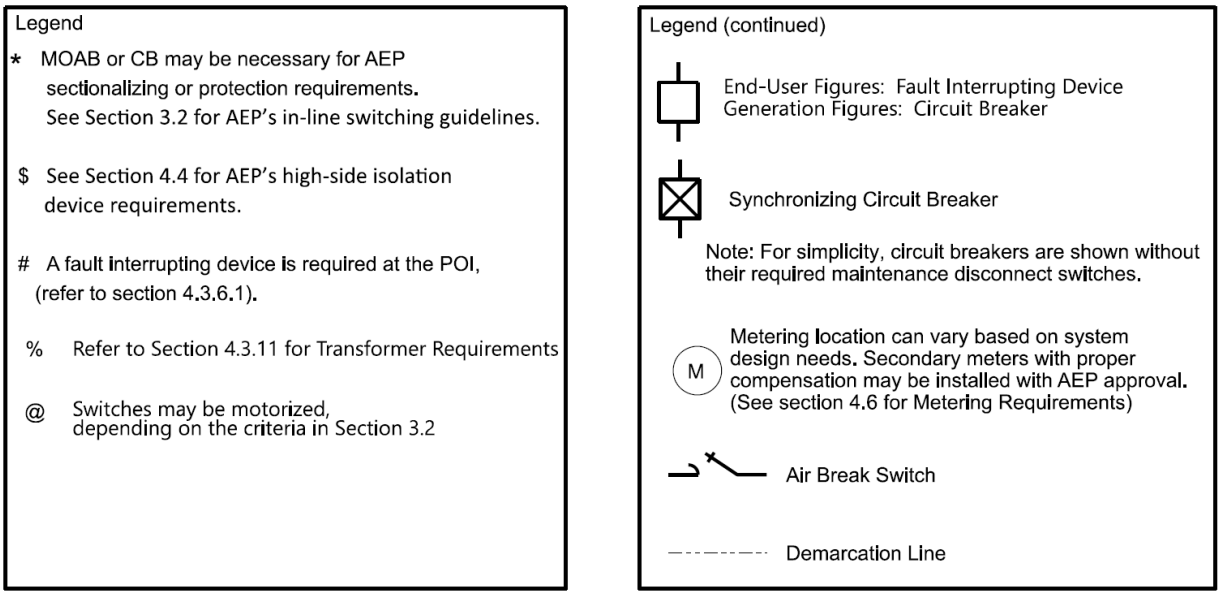


Figure 3. End-user Connection Types

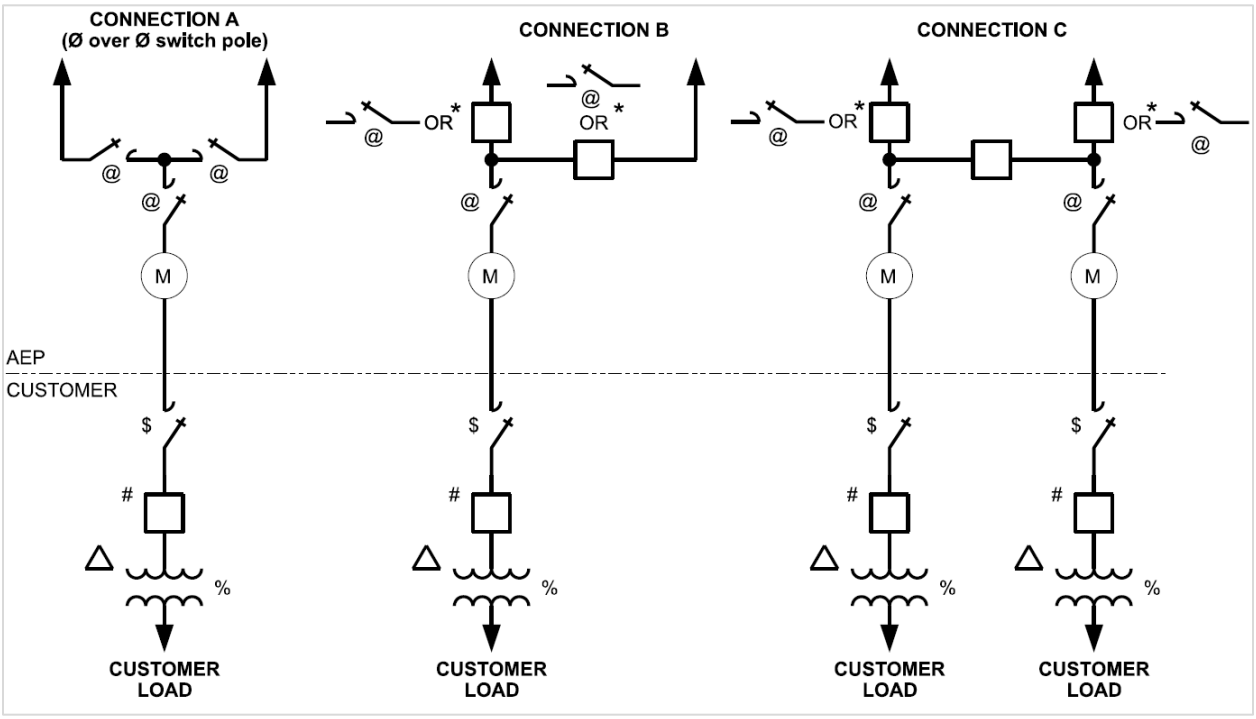


Figure 4. End-user Connection Types

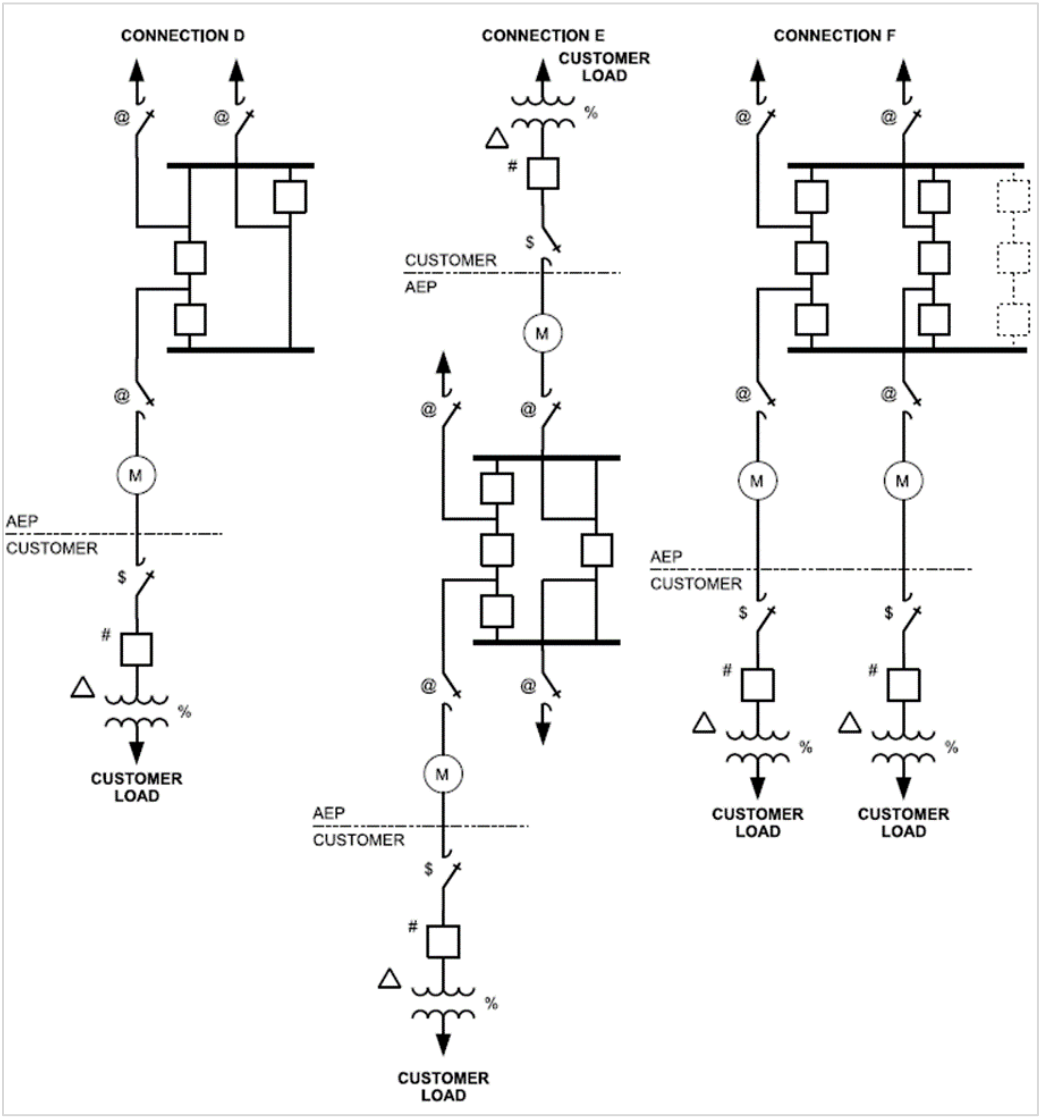


Figure 5. End User Connection Types

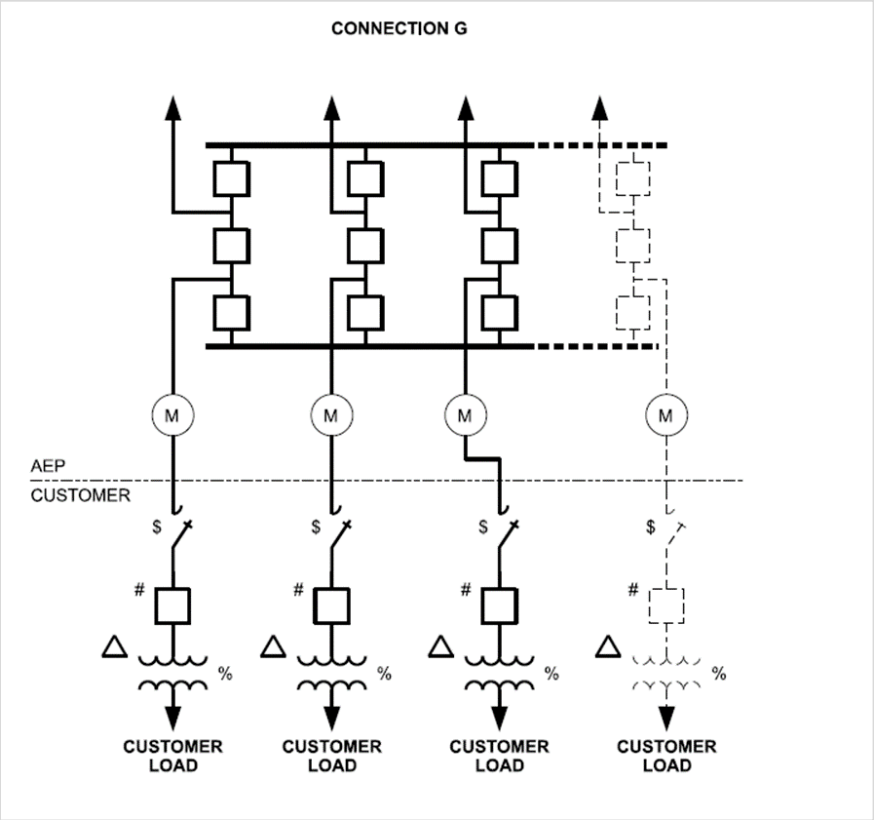


Figure 6. Generation Connection to an Existing Station Bus

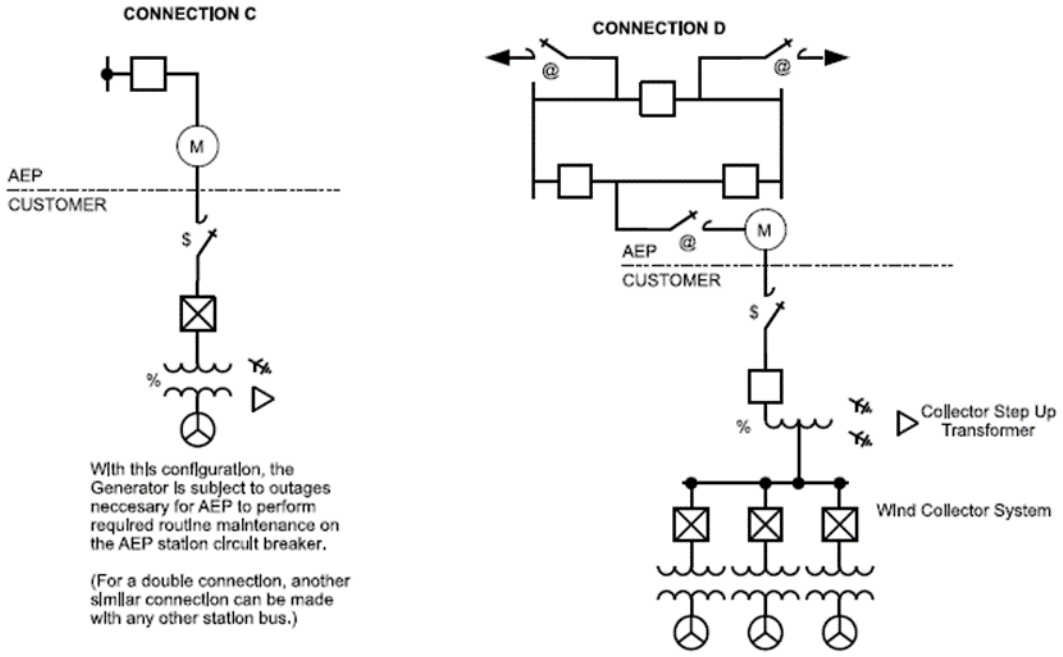


Figure 7. Generation Connection to an Existing Transmission Line

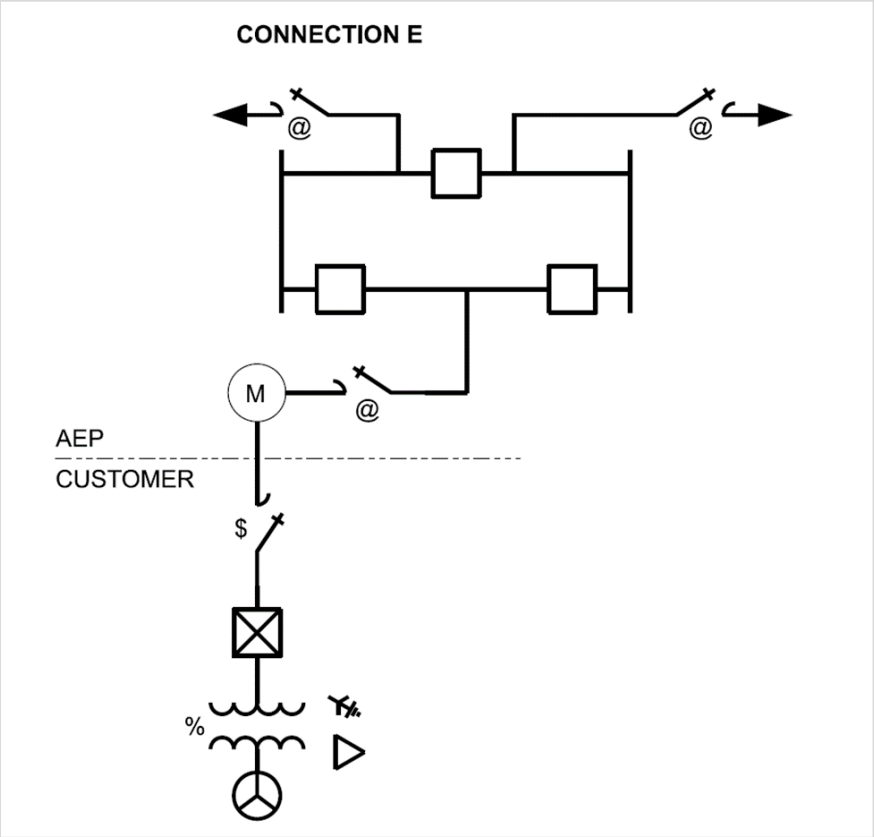
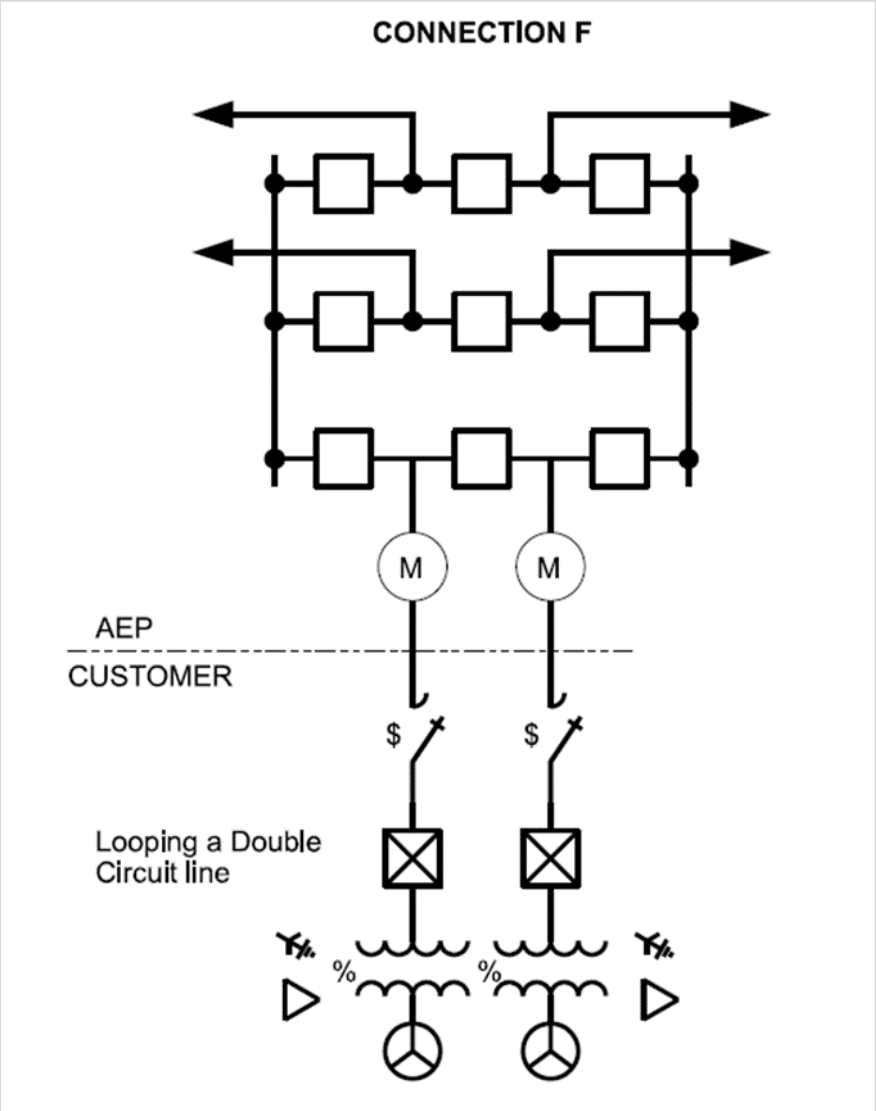


Figure 8. Generation Double Connection to an Existing Line(s)



3.2 Transmission Switching Guidelines

Any connection to AEP will require, at a minimum, motor operated, Supervisory Control and Data Acquisition (SCADA) controlled line disconnect switches, commonly referred to as motor operated air break (MOAB) switches. The only exceptions to this minimum requirement where switches are not required are the following situations:

- The connection established to serve load is temporary and is required for a period less than a year.
- The topography of the tap location is such that the tap is not accessible by road, in which case the in-line switches could be placed elsewhere in a more accessible location.
- The tapped in-line connection is required temporarily under emergency system conditions.

SCADA control and monitoring is required for all in-line sectionalizing unless acceptable justification for manual control exists. Automatic motor operated controls can be added to in-line switches, when justified, to minimize the time required for restoration following a failure of the AEP supply line.

The factors considered when determining whether a load connection is radial or looped MOAB or CB application for in-line switching include, but are not limited to:

Safety & Health	SAIDI performance
Total load magnitude	Criticality of load and customer/community impact
Restoration time	Operational flexibility
MVA-mile calculations	Existing system configurations
FOI calculations for MOABs	Consideration regarding feasibility of maintenance
MPOI calculations for CBs	Area outage statistics

The FOI and MPOI calculations are structured as follows:

Equation 1

$$FOI = L_f \times Miles\ of\ Exposure \times P_f$$

Equation 2

$$MPOI = L_f \times Miles\ of\ Exposure \times (P_f + M_f)$$

where L_f is the peak load (MW) directly jeopardized by the forced outage of the line, Miles of Exposure is the number of line miles between two existing automatic sectionalizing devices (including taps). P_f is the Permanent Forced Outage Rate (Outages per Year, per Mile), and M_f is the Momentary Forced Outage Rate (Outages per Year, per Mile).

AEP manages the specific minimum thresholds of which FOI or MPOI calculations support the installation of auto-sectionalizing MOAB switches or circuit breakers, respectively. AEP also manages the specific minimum thresholds for determining the requirements on when to loop a radially-fed load.

The figures in *Section 3.1* illustrate some basic connection configurations and requirements for facilities below 200kV.

Circuit Breakers are required to connect to the AEP system at or above 200kV.

For more information on isolation and fault interrupting devices, please reference *Sections 4.3.1* and *4.3.2*.

3.3 General Design Information

Nominal voltages on the AEP system are 765kV, 500kV, 345kV, 230kV, 161kV, 138kV, 115kV, 69kV, 46kV, and 34.5kV. The Requester must contact the appropriate entity as shown in *Section 2.1.1* for information on the specific circuit(s) presently serving or available to serve their facility.

For AEP's Planning Criteria, including voltage criteria, please see AEP's *FERC 715* filings on AEP.com[31]. The filings are separated by regional transmission entity (RTE) and are named as follows:

[31] https://aep.com/requiredpostings/AEPTransmissionStudies

- Transmission Planning Reliability Criteria-AEP PJM
- Transmission Planning Reliability Criteria-AEP MISO
- Transmission Planning Reliability Criteria-AEP SPP
- Transmission Planning Reliability Criteria-AEP ERCOT

Transmission Planning will design solutions based on results of power flow analysis in accordance with AEP's planning criteria. Solutions will identify minimum required current carrying capability and establish facility ratings based on AEP's procedure for determining facility ratings.

The Requester will own the breaker(s), protection and control for all equipment at its facility. The Requester is responsible for protection of its facilities from all abnormal conditions occurring on the transmission system. When the Requester's facilities are connected to AEP, the Requester must install, operate, and maintain all facilities AEP requires for safe operation and without cost to AEP. The Requester must install, operate, and maintain its facilities at all times in conformance with generally accepted utility practice and must comply with applicable National Electrical Code, National Electrical Safety Code, local codes, regional transmission entity (RTE), North American Electric Reliability Corporation (NERC) Reliability Standards, and AEP service standards.

Under certain conditions, AEP may operate for a period outside the defined voltage ranges documented in AEP's *FERC 715* filings. The Requester must provide voltage-sensing equipment required to protect its equipment during abnormal voltage operation.

If the Requester's supply voltage requirements are more restrictive than specified above, the Requester should consider adding appropriate voltage regulation equipment in its facility. The Requester is responsible for voltage regulation at the point of power consumption.

The Requester will change their facility or equipment as AEP or an RTE requires to comply with future changes in the transmission system. AEP will provide reasonable notice to the Requester, before the due date, when changes to their facilities are required. The Requester is responsible for the costs of any additions, modifications, or replacements to their facilities that are necessary to maintain or upgrade such facilities consistent with applicable laws and regulations, applicable reliability standards, and good utility practice.

The Requester will design the generating facility to maintain a composite power delivery at continuous rated power output at the POI of the generator substation, at a power factor within the range of 0.95 leading to 0.95 lagging, unless AEP has established a different power factor range that applies to all generators in the control area on a comparable basis. This power factor range standard must be dynamic and can be met using, for example, power electronics designed to supply this level of reactive capability (taking into account any limitations due to voltage level, real power output, etc.) or fixed and switched capacitors, or a combination of the two.

The NERC Reliability Standards state that distribution entities and customers connected directly to the transmission system should plan and design their systems to operate at close to unity power factor to minimize the reactive power burden on the transmission system. AEP interprets close to unity power factor to mean that the connected load should not fall below a 0.95 lagging power factor. Power factor penalties are applied based on local jurisdictional terms and conditions.

Switched shunt capacitors generally provide an effective means of controlling the power factor of a Requester's facility. However, several considerations should be addressed in applying capacitors. They include:

- Transient voltages due to capacitor switching
- Voltage amplification due to resonance conditions

Requesters should work with a qualified consultant to review the specific application and provide recommendations for controlling these occurrences.

Requester's equipment should, at a minimum, comply with the ITIC (Information Technology Industry Council)/CBEMA (Computer & Business Equipment Manufacturer's Association) curve for voltage sag ride-through performance.

See *Section 6.12* for power quality requirements.

3.4 Generation Configurations

GSU Configurations

AEP has established generator step-up (GSU) transformer requirements as shown in *Section 4.3.6* . The final decision as to the requirements for each installation will be made depending on:

- Requester's electrical location of the generator
- Existing electrical facilities
- Rating of existing electrical equipment and generators connected to the system, available short circuit contributions, and other important factors

Induction Generators

Depending on the generator size, reactive power demands of induction generators can pose transmission system problems. The interconnection study process may identify the need for additional equipment that can keep negative impacts to the transmission system from occurring.

Inverter Systems

The reactive power requirements of inverter systems are similar to induction generators. Therefore, the general requirements discussed in the previous section apply. Refer to *Section 6.12* for additional considerations.

3.5 Siting & Environmental Requirements

3.5.1 Transmission Facilities Siting Requirements

The Requester will consult with AEP while evaluating a siting location for the interconnection facilities that the Requester will transfer to AEP during the interconnection process.

This activity must occur during the planning process and before real estate acquisition. This requirement applies to the option to build (OTB) process for facilities that the Requester will transfer to AEP and for acquiring real estate and right-of-way (ROW) that the Requester will turn over to AEP as part of an interconnection project. This siting requirement section is applicable to all Generation Connections (GC), End-User Connections (EUC), Transmission Interconnections (TI), and Distributed Energy Resources (DER).

Typical siting specifications include adherence to state regulatory filing and application requirements in coordination with a line route or substation siting study for a proposed interconnection facility. This documentation supports the environmental permitting process, landowner negotiation, and requests from local officials as well. A conventional line route or substation siting study describes the alternatives considered, provides a comparative analysis of potential environmental and land use impacts, and a rationale for the selection of the proposed site and/or transmission line route. The siting study should describe the input collected from local officials, state and federal permitting agencies, and the local community relative to the site's suitability for the proposed facility.

Refer to the *Standards and Expectations for Siting, Real Estate, Right-of-Way, and Environmental Permitting for Transmission Interconnection Projects* for more information. The Requester is expected to read and understand the expectations described in this document in the project's early stages.

3.5.2 Environmental Requirements

The Requester must work with AEP during the interconnection process to ensure that any facilities, land, or interests that the Requester will transfer to AEP comply with all applicable environmental requirements, law, and regulations. Planning and coordination will occur before any real estate acquisitions take place.

3.5.2.1 Option to Build

AEP must review any permits and mitigation agreements with regulatory agencies before submittal to ensure consistency with AEP's processes and long-term facility management requirements. Compliance requirements apply to real estate acquisition and ROW that the Requester will transfer to AEP as part of an interconnection project. Compliance with these requirements can affect site location, design, and feasibility. Environmental specifications may vary by location and governing authority.

3.5.2.2 Required Documentation and Permits

The Requester is responsible for maintaining documentation related to the laws and regulations compliance. The environmental requirements section of the *Standards and Expectation for Siting, Real Estate, Right-of-Way and Environmental Permitting for Transmission Interconnection Projects*[32], and compliance to all applicable laws and regulations apply to all GC, EUC, IC, and DER.

Typical environmental permits include, but are not limited to, Army Corps of Engineers Section 10/404 (or state authorized program), *State Section 401 Water Quality Certification*, storm water general permits, and floodplain permits. Environmental requirements include adherence to the government authority's laws as well as the environmental requirements resulting from coordination of a line route or substation siting study for a proposed interconnection facility. Associated environmental studies that support the environmental permitting effort and siting study should

32 https://aep.com/assets/docs/requiredpostings/TransmissionStudies/docs/2020/StandardsforsitingREROWandEnvironmental.pdf

include documentation collected from local officials as well as information gathered from state and federal permitting agencies relative to the site's suitability for the proposed facility.

The Requester must provide engineering and compliance documentation for environmental permits and all applicable laws and regulations before real estate is transferred to AEP, including support that the real estate is sufficient to comply with all laws and regulations for post-construction water management. For example, station pad design must accommodate post-construction storm water features in compliance with government authority's laws and regulations.

Refer to the *Standards and Expectations for Siting, Real Estate, Right-of-Way, and Environmental Permitting for Transmission Interconnection Projects*[33] for more details. The Requester is expected to read and understand the expectations in this document during the project's early stages and inform their engineering team of the requirements, laws, and regulations.

33 https://aep.com/assets/docs/requiredpostings/TransmissionStudies/docs/2020/StandardsforsitingREROWandEnvironmental.pdf

4.0 Design

The following subsections outline the requirements associated with the design phase of a typical project, including station, equipment, protection, SCADA, metering, telecommunications, station service, and line design.

4.1 Station Design Requirements

4.1.1 Access Plan Requirements

For AEP interconnection facilities to be located on Requester's property, Requester shall provide an access plan to AEP for review and approval. Such access plan is to document AEP access privileges to interconnection facilities on Requester's property, including, but not limited to, metering equipment, RTU equipment, telecommunications network equipment, and fiber optic facilities. The access plan described above shall be approved by AEP and implemented by Requester prior to AEP placing the interconnection facility in service.

4.1.2 Grounding and Safety Issues

This section provides guidance on design and analysis of ground grids in substations that AEP will own and operate, and a Requester's ground grid that will be connected to or in close proximity to AEP's ground grid. Where the Requester's grid is connected to or in close proximity to AEP's ground grid the Requester shall coordinate with AEP and comply with AEP ground grid design requirements as detailed in the latest revision of AEP standards SS-313000 Station Ground Grid Design Guide, SS-311000 Grounding Application Guide, and IEEE 80. For any conflict among documents, contact the Substation Engineering Design Standards subject matter expert.

Contact the AEP project manager to obtain ground fault values and clearing times for AEP facilities. When Requester's grid is connected to or in close proximity to AEP's facilities the Requester must provide AEP with design drawings, analysis files that are compatible with AEP standards, and material lists for the proposed substation ground grid. Ground grid connections between AEP facilities and the Requester's facilities must be designed and installed in compliance with AEP standards.

4.1.3 Substation Fence

Where Requester's fence will tie to an AEP fence the Requester shall notify AEP of the design intent and coordinate the tie point and the Requester shall also comply with the grounding requirements as detailed in section 4.1.2.

Fencing that encircles AEP owned equipment must comply with the latest revision of AEP standard *SS-250100 Station Fence Guideline*, *SS-250500 Substation Fence Specification,* and National Electrical Safety Code (NESC) requirements.

4.1.4 Substation Bus Design Requirements

Where Requester is interfacing with AEP station bus, the Requester shall match heights and phase spacing of AEP facilities at the point of demarcation. AEP shall provide location for connection to Requester. The preferred method of making connections to AEP equipment is through flexible stranded conductor.

Measures should be taken to ensure the interface between Requester and AEP does not result in a limiting series element.

4.1.5 Station Shielding

Where AEP equipment is located in the same fence as Requester's facilities the lightning protection system must be designed at a minimum inaccordance with the latest version of *SS-499 Lightning Protection Application Guideline*. The Requester will perform a shielding study and the Requester will submit design drawings and analysis files to AEP for comment. The Requester must provide locations and attachments for required static wires that will be terminated on the AEP or or Requester's facilities. AEP will determine loading requirements on a case-by-case basis.

4.2 Substation Structures

Structure Loading

In situations where one or more of the Requester's structures is supporting strain bus, rigid bus, conductor, or shield wires that are connected to AEP structures, those structures must be designed for strength and deflection to meet AEP's structural loading criteria found in AEP *SS-720000 Specification for Substation & Switching Station Structural Steel Design & Fabrication Standard*. The Requester shall coordinate with AEP on tensions & fault loads for these structures.

4.3 Equipment

4.3.1 Fault Interrupting Devices

A fault-interrupting device must be the initial connection point (immediately after the isolation device) inside the Requester's substation. It is the Requester's responsibility to protect all of their equipment and prevent faults on their system from affecting AEP's facilities and other customers. The Requester may need to install and pay for additional station facilities to establish their desired service, or to establish a looped transmission line extension. From an electrical service point of view, it is most desirable for a Requester to locate their substation facilities near an AEP transmission line or substation. If a radial line (longer than 1 mile) is required from the tap point on a transmission line to the Requester's facility, a breaker may be required at the tap location in addition to the breaker at the requester's facility. This specification will be determined on a case-by-case basis. It is solely AEP's discretion to allow variances to this practice.

If a Requester proposes to use a fuse as the interrupting device, see Section 4.3.6.2.

AEP does not allow the installation of a MOAB ground switch combination on the high side of transmission/step-down transformers unless a special need or situation warrants review. All new connections or material modifications to existing connections must comply with the diagrams and requirements shown in *Section 3.1*.

Requester-owned load serving transformers located within the same fenced station as AEP Transmission circuit breakers, do not require Requester-owned fault interrupting devices when connected between two AEP Transmission circuit breakers (i.e., breaker and a half or ring bus designs). Requester-owned load serving transformers within the same fenced station connected

directly to an AEP bus will require a Requester-owned interrupt device. In the rare occasion where non-AEP Requester-owned equipment is located within the same fenced station as AEP Transmission equipment, an agreement is required to define maintenance, operations, and NERC Standard compliance responsibilities.

4.3.2 Isolation Devices

The Requester must provide a readily accessible, lockable, visible-break isolation device as the first device connection inside the Requester's station.

The Requester's isolation device may be included in AEP's *Switching Order System Procedur*e as necessary. Access to the Requester's isolation device must be provided if clearance is necessary on Requester facilities.

4.3.3 Equipment Ratings

AEP establishes facility and equipment ratings requirements during a project's planning phase. In accordance with *Section 4.1.5 Station Shielding*, the Requester must complete insulation coordination studies and requirements.

4.3.4 Circuit Breakers and Switches

Before construction, the Requester must provide AEP with the characteristics of the units to be installed for evaluation as identified in *Section 3.1* for load connection types/diagrams and *Section 3.2* for transmission switching guidelines. The manufacturer must provide the maximum capability values of the circuit breaker/switcher as tested and not IEEE preferred rating values.

AEP will work with the Requester to determine high-speed reclosing (HSR) coordination times. Typical HSR coordination times are listed in the table below.

Table 4. HSR Coordination Times

System Voltage (kV)	Trip Close Time (Cycles)
765	30
345	24
230	21
161	18
138	18
69	9

4.3.5 Line Traps

Load Connection Requirements

Line traps may be required with load connections. Carrier signals can be degraded by transformers and/or tapped loads that are electrically located at multiples of the quarter wavelength of the carrier frequency on the line. It is not practical to predict with accuracy whether newly tapped load will create this condition. The Requester will be responsible for costs necessary to ensure that the new delivery point (DP) does not degrade the power line carrier signal(s) or protection scheme.

This cost may require installing a line trap tuned to the carrier frequency on the appropriate phase at the point of connection. The Requester can install this line trap in advance, or wait to determine whether a line trap is necessary at the time of energizing the newly tapped station. However, if the Requester waits to install the line trap, and it is later determined that the new installation has

degraded the carrier signal(s), then the DP will be de-energized until a line trap is installed to eliminate the source of carrier signal degradation.

4.3.6 Transformers

4.3.6.1 Voltage and Impedance Matching

The Requester is responsible to ensure all de-energized tap changer settings available will not be detrimental to AEP system or their own system. De-energized tap changer (DETC) ratings must match that of AEP transformers in connecting substations. Additionally, transformer impedance must match that of AEP's transformer fleet when paralleling. These requirements are in place to prevent circulating currents and the consequential overloading of AEP facilities.

4.3.6.2 Requester High Voltage Transformer Fusing Rerquirements

If a Requester proposes to use a fuse as the interrupting device for a high voltage transformer, the fuse must have a total clearing time for a fault immediately downstream of the fuse less than the minimum clearing time of AEP upstream protection and interrupting devices. The AEP minimum clearing time for this scenario is typically 5.0 cycles. The requester's fuse must fully clear the fault so that the following AEP reclose attempt can be successful to restore the circuit and other AEP customers. **AEP's Protection and Control Engineering (PCE) Department must pre-approve the Requester's proposed fuse size.** Note that fuses will not be acceptable if the Requester has generation sources as part of their facilities. In addition, if generation sources are added to Requester facilities later, the fuses must be replaced with an interrupt device that can be operated from transfer trip equipment as necessary.

4.3.6.3 Transformer Winding Design

All EUCs must provide a delta connected winding on the AEP line terminal side of the transformer. All GCs must provide an effectively grounded connection on the AEP line terminal side of the transformer. The GC's transformer must remain effectively grounded on the AEP line terminal side of the transformer even when the transformer is unloaded.

4.4 Protection Systems

4.4.1 System Protection and Coordination

4.4.1.1 Basic Protection System Design for Interconnect Projects

There are two basic protection systems that could be implemented on Requester interconnections: bus protection and line protection. This section describes both systems. The system that is chosen depends on the distance between the Requester and AEP, whether ground grids are tied together, and whether the Requester has a generation source. Generation sources can come from primary generation sources, emergency generation sources, or ties to alternate sources of power.

- **Bus Protection System**
  - This system is generally used when the interconnection stations are adjacent to each other and the ground grids are tied together. AEP requires redundant three-phase current circuits from each Requester interface (overlapping the Requester protection zone) to complete the bus protection zone(s). Interface cabling for trip, control, and status signals will depend on the Requester's facility configuration and whether the Requester has generation sources.

- The interface connection must be within the AEP protection zone and isolated by AEP protection devices (Interrupt devices from both AEP and the customer may need to be operated depending on customer generation sources). The Requester is not required to have protection devices for the interface connection when this system is used. All equipment downstream of the Requester interrupt device will be in the Requester protection zone and isolated by Requester protection devices.

- **Line Protection System**
  - **Step Distance Protection System**
    - This system is used when the interconnection stations are not adjacent to each other and the Requester has no generation sources.
    - The interface line connection must be in the AEP protection zone and isolated by AEP protection devices. The Requester is not required to have protection devices for the interface line connection when this system is used. All equipment downstream of the Requester's interrupt device will be in the Requester protection zone and isolated by Requester protection devices.
    - The Requester should understand that when this protection system is used, the AEP protection devices will have high-speed operation for all faults up to and including a portion of the Requester transformer. The AEP total clearing time must allow time for the Requester protection devices to operate and trip the Requester interrupt device for proper isolation and targeting, even though the AEP interrupt device can still trip and isolate the customer for this event.

      Following the initial isolation from AEP, AEP interrupt devices will be allowed to reclose automatically and re-establish power up to the Requester's interrupt device. Note that the AEP protection devices and interrupt devices could clear the fault in five (5) cycles. Therefore, the Requester relay device or fuse must operate faster than the AEP clearing time for the interface line connection to successfully re-energize the Requester's connection and possibly re-energize other AEP customers. Therefore, if the Requester applies a fuse, it must have a total clear time faster than five (5) cycles for a fault immediately downstream of the fuse.

      AEP's Protection and Control Engineering (PCE) Department must pre-approve the Requester's proposed fuse size.

  - **Pilot Protection System**

    Pilot protection systems are required on Bulk Electric System (BES) facilities. AEP reserves the right to apply pilot protection systems on non-BES facilities.

    AEP reserves the right to apply dual pilot protection systems (two pilot protection systems with independent communication paths) to either BES or non-BES facilities as necessary for either coordination or stability.

    - **Current Differential Line Protection System**

      The current differential line protection system is the preferred pilot protection system when the interconnection stations are not adjacent to each other and the Requester has generation sources.

The interface line connection must be in a shared protection zone between AEP and the Requester. The Requester will purchase and install interface line protection devices according to AEP requirements (see below). All equipment on the Requester side of the Requester interrupt device must be in the Requester protection zone and isolated by Requester protection devices.

- **Directional Comparison Blocking Protection System**

  The directional comparison blocking (DCB) protection system is the alternate pilot protection system when the interconnection stations are not adjacent to each other and the customer has generation sources. The DCB protection system may be required when the Requester connects into AEP facilities that have existing DCB protection systems or power line carrier (PLC) protection communications are required for new facilities. The interface line connection must be in a shared protection zone between AEP and the Requester. The Requester will purchase and install interface line protection devices according to AEP requirements (see below). All equipment on the Requester side of the Requester's interrupt device must be in the Requester's protection zone and isolated by Requester protection devices.

- **Breaker Failure Protection System**

  Breaker failure protection systems are required on Bulk Electric System (BES) facilities. For non-BES facilities, AEP reserves the right to require installation of breaker failure protection systems at the Requester's facility and/or at the AEP facility.

- **Anti-Islanding Protection**

  If the Requester's facility contains generation sources, then the Requester must have an anti-islanding protection system. If an anti-islanding system is not viable, then AEP reserves the right to require installation of a direct transfer trip (DTT) system between the AEP facility and the Requester facility.

4.4.1.2 Coordination of Protective Systems

NERC standards require that protective systems be coordinated among operating entities. These standards require transmission and generator operators to notify appropriate entities of relay or equipment failures that could affect system reliability. In addition, transmission and generator operators must coordinate with appropriate entities when new protective systems are installed, or when existing protective systems are modified. It is expected that any data exchange necessary to meet the obligations of the NERC Standards will be accomplished before any protection systems can be placed in service. Refer to *Section 2.1.1* for details.

4.4.1.3 System Protection Equipment Requirements

It is AEP policy to apply fully redundant protection systems at 200kV and above. This includes batteries, DC panel-boards, trip coils, high-speed protection systems, communication paths, and instrument transformers (dual secondary windings on one set of potential devices is acceptable). Prior to the design phase, the Requester and AEP must reach a mutual agreement as to the redundancy requirements, type, model numbers, and firmware version of equipment related to the proposed pilot relaying scheme to ensure proper operation and equipment compatibility.

The Requester must install protective devices (relays and circuit breakers for example) and synchronizing equipment that AEP requires. The protective devices may differ between installations.

The Requester must submit relay one-line drawings of its interconnection equipment to AEP for review. AEP will assess the protection and remote monitoring/control functions illustrated in the drawings. The Requester must make changes that AEP requires prior to final issue. The Requester must provide final copies of the revised drawings to AEP. AEP will review only the portions of the drawings that apply to protection and remote monitoring/control that affect the AEP system. To aid the Requester, AEP may make suggestions on other areas, but AEP will not assume responsibility for the correctness pertaining to the Requester's system.

The Requester is responsible for their system's stability and providing adequate facilities so that critical fault clearing times are met.

The Requester must not connect to AEP's system until AEP gives consent. AEP reserves the right to inspect the Requester's facility and witness equipment or devices testing associated with the interconnection. Additional operating procedures may be included in the Interconnection Agreement (IA). Refer to *SS-451001 AEP Protection Requirements for Connecting to the AEP Transmission Grid* for more information.

4.4.2 Control Cable

AEP uses shielded control cable with both ends grounded. The color codes of control cable for AC or DC circuits must be constructed to match table E-2 of ICEA S-73-532, NEMA WC-57 (black, red, blue, orange, yellow, and brown, for example). The color codes of AC power cables must be constructed to match table E-1 of ICEA S-73-532, NEMA WC-57: black, white, red, and green. If the Requester's interconnect cables do not match these codes, the Requester must wrap each interconnect control wire with the appropriate color code tape. Refer to *SS-480001 Design and Wiring Guide* for more details.

The AEP preferred control cable demarcation point is at the AEP substation fence between AEP's substation yard and Requester's substation yard. It is the Requester's responsibility to supply material and labor for cables installed from their equipment to the demarcation cabinet. AEP is responsible for supplying material and labor for cables installed between AEP's equipment and the demarcation cabinet. Before project construction, AEP must approve any deviations from its preferred control cable demarcation point.

4.4.3 Disturbance Monitoring Requirements

AEP requires disturbance monitoring on all generation resources connected to AEP and all distribution connected generation (single unit or aggregated) that is 5 MW and above connected to a single distribution transformer bank. Disturbance monitoring includes fault recording, sequence of events recording, and phasor measurement unit recordings. AEP is solely responsible for determining exclusions to this requirement on a case-by-case basis.

The disturbance monitoring equipment (DME) location will depend on the generation resource's configuration. The Requester must submit their facilities' relay one-line diagrams to AEP. If sufficient disturbance recording data cannot be collected at the AEP interface station, the Requester must supply monitoring equipment that will support the necessary disturbance

monitoring data. AEP must approve the Requester's data format. AEP will identify the required monitoring locations based on the Requester's relay one-line diagram. Locations could include monitoring each unit in a conventional generation resource and each feeder in a renewable generation resource. In addition:

- The Requester must replace legacy equipment if they cannot provide data in the requested format.
- All DME must be equipped for time synchronization.
- If AEP requires DME installation in the Requester's facilities, the Requester must provide communication facilities so that AEP can collect disturbance monitoring data remotely.
- AEP's monitoring requirements do not reduce the Requester's obligation to meet all NERC disturbance monitoring requirements.

4.5 SCADA Requirements

4.5.1 Data Requirements

Telemetry and status information is required from interconnected facilities rated at 5 MVA or higher in order for AEP to fulfill its real-time monitoring and assessment obligations. The primary means AEP will use to obtain this data will be Inter-control Center Communications Protocol (ICCP) communication links already in place with the RTE. AEP will request the specific data points from the RTE in which the Requester's facility is located.

If a GC Requester is connecting to AEP-owned Transmission facilities and is not able to provide all necessary data to the RTE, AEP will work with the Requester to establish an alternate means of obtaining the necessary real-time operational data until the RTE ICCP link can be established. In cases where fiber-optic facilities described in *Section 4.7* are put in place for reasons other than operational data exchange, AEP may choose to establish a serial connection over those facilities based on the *SS-500000 AEP SCADA RTU Requirements for Transmission Interconnection Facilities*. The term and method for all data exchanges will be outlined in the Interconnection Agreement.

Requesters that represent or serve DER connections may have additional real-time operational data obligations to meet. These obligations are currently evolving — AEP will work with these Requesters to ensure AEP and RTE requirements are met.

Sections 4.5.2 and *4.5.3* below detail the specific telemetry and status points required from interconnecting facilities. Note that not all of the points listed below are universally required. Certain points only apply to Requester facilities of a certain type as designated. The final points list will be engineered for each interconnecting facility based on the design and capabilities of that facility.

AEP Transmission will not install an RTU on the premises of interconnecting facilities (substations) it does not own and will not operate Requester's equipment at such locations except in unique cases where a specific detailed agreement to do so is in place. Requesters are responsible for providing facilities for acquiring real-time operational data from equipment they own and will be responsible for providing that data to AEP Transmission and the appropriate RTE.

4.5.2 Telemetry

Analog telemetry from interconnecting facilities includes power flow and voltage measurements needed by AEP Transmission to perform accurate state estimation and contingency analysis required for situational awareness for reliable operation of the transmission grid.

Table 5. Transmission Line Measurements

Voltage per phase for Requester-owned end of each transmission line	kV
MW for Requester-owned end of each transmission line	MW
MVAR for Requester-owned end of each transmission line	MVAR
MVA for each Requester-owned end of each transmission line	MVA

Table 6. Generator Collector Transformer Measurements

Voltage per phase for each winding of each transformer [wind/solar]	kV
MW for each side of each transformer [wind/solar]	MW
MVAR for each side of each transformer [wind/solar]	MVAR

Table 7. Generation Measurements

Generation gross bidirectional MW [each thermal-powered unit]	MW
Generation gross bidirectional MVAR [each thermal-powered unit]	MVAR
Generation station use MW auxiliary (per aux transformer) [thermal-powered units]	MW
Generation station use MVAR auxiliary (per aux transformer) [thermal-powered units]	MVAR
MW for each collection feeder [wind/solar]	MW
MVAR for each collection feeder [wind/solar]	MVAR

Table 8. Generator Shunt Devices / Reactive Quantities

MVAR for each shunt device (capacitors and reactors)	MVAR
Dynamic MVAR capability at the current MW generation amount (each dynamic reactive controller)	MVAR
Voltage set point (each dynamic reactive controller)	kV
Power factor set point (each dynamic reactive controller)	pf

Table 9. Resource Availability for Injection for Real or Reactive Power

Number of wind turbines or solar inverters connected to transmission system (entire generating facility)	# of units
Number of wind turbines or solar inverters connected to transmission system (per collection feeder)	# of units
Number of wind turbines or solar inverters out of service and unavailable (per collection feeder)	# of units
Number of wind turbines or solar inverters with communications failure and unknown availability (per collection feeder)	# of units
Amount of energy remaining [storage]	MWh

4.5.3 Status

In addition to real-time telemetry values, the operational status of key interconnected facilities must be available to AEP Transmission in real time.

Table 10. Transmission Line Status

Breaker Status for requester end of each transmission line	OPEN/CLOSED
Circuit Switcher / Line Switch Status for requester end of each transmission line	OPEN/CLOSED

Table 11. Generation Facility Status

Generation Breaker Status [Thermal-Powered Units]	OPEN/CLOSED
Auxiliary Breaker Status [Thermal-Powered Units]	OPEN/CLOSED
Transformer High Side Breaker and/or MOAB Status [Wind / Solar]	OPEN/CLOSED
Collection Breaker Feeder Status, Each Feeder [Wind / Solar]	OPEN/CLOSED
Bus Tie Breaker Status	OPEN/CLOSED
Automatic Voltage Control	DISABLED/ENABLED
Black Start Availability	OFF-LINE/AVAILABLE

Table 12. Generator Reactive Device Status

Shunt Device (Capacitor, Reactor) Breaker Status	OPEN/CLOSED
Dynamic Reactive Controller Status	DISABLED/ENABLED
Dynamic Reactive Controller Operation Type	MANUAL/AUTO
Dynamic Reactive Controller Mode	VOLTAGE/POWER FACTOR

4.5.4 Supervisory Control of Requester Facilities

AEP will not operate equipment for which it is not responsible. Therefore, these general real-time operational data requirements exclude supervisory control points for Requester facilities. In some cases, AEP may enter into a specific agreement to operate a Requester's equipment, and AEP could require supervisory control points in order to perform contractually defined duties. In addition, certain status and analog points not covered in this document may be needed. Real-time operational data requirements for such agreements are out of scope for this document and will be addressed individually according to their respective agreements.

4.5.5 SCADA Requirements for AEP Facilities

Before AEP approves an interconnection request, facilities must be equipped with full Supervisory Control and Data Acquisition (SCADA) capability. Existing AEP-owned facilities that provide a connection to the Requester, or facilities the Requester will build and AEP will own under an option to build (OTB) arrangement must meet the following specifications:

- Have a combination of an RTU and intelligent electronic devices (IEDs) at an AEP-owned substation or switching structure. The SCADA equipment must be engineered and installed according to AEP's internal standards. AEP will operate and maintain the equipment exclusively.
- Provide full visibility and supervisory control of AEP's interconnection facility by using a full complement of real-time operational data needed for situational awareness. This data will include (but not be limited to) all voltage, current, power measurements, as well as status and alarm indications for all primary facility components.
- Supervisory control is required for all equipment, primarily circuit breakers and MOAB switches used to interconnect the Requester to AEP. Point selection for the AEP-owned facility must be made in conformance with *SS-502000 Substation SCADA*.
- Connections to AEP are not permitted at locations or facilities that do not provide adequate situational awareness and supervisory control to AEP Energy Delivery Operations personnel and RTEs.

4.5.6 Requester Real-Time Operational Data Requirements

Requesters may require real-time operational data from AEP facilities in order to maintain their facilities' safe and reliable operation. AEP supplies all required real-time operational data to the RTEs in which it is registered. AEP's strong recommendation is that Requesters obtain such data by using Inter-Control Center Communications Protocol (ICCP) interactions with those RTE entities. If ICCP use is not feasible, the Requester can request direct access to real-time operational data for AEP facilities related to its transmission system connection.

AEP will provide limited access to revenue meters and/or remote terminal units (RTUs) capable of providing that data per the *SS-500000 AEP SCADA RTU Requirements for Transmission Interconnection Facilities*. Fulfillment of such requests will be documented in the interconnection agreement and fall within the bounds of AEP transmission standards and common utility practice. Data connectivity for Requester data acquisition connections will be established in accordance with fiber optic or other communications facility requirements covered in *Section 4.7 Telecommunications* in this document.

4.6 Metering Requirements

This section specifies AEP's metering requirements for connecting to its transmission system. These requirements apply to all facilities requesting connection to AEP. References to metering package includes the revenue meter and metering instrument transformers (ITs). Otherwise, separate references will be made to the meter or ITs only.

4.6.1 Industry Standards Exceptions

To the extent that these requirements conflict with the standards and guidelines of any applicable RTE regarding transmission interconnection metering requirements, the standards and guidelines of such RTE take precedence.

4.6.2 Introduction

The metering package design must be sensitive to a wide range of applications for accurate metering of any bidirectional or radial Transmission Interconnection (TI) over the full range of possible scenarios. As an example, the metering package will accurately meter interconnections with injected generation (100's MW in one direction) and backfeed power (less than 1 MW) in the reverse direction. If the metering package cannot be specified to meet the manufacturer's guaranteed accuracy to capture the Requester backfeed load properly, additional metering will need to be evaluated for the Requester's auxiliary load centers.

In addition, if the Requester auxiliary load centers can have different owners, then separate metering is required. Also, telemetry requirements may vary slightly. Therefore, the design of the metering package devices must be flexible. Metering device redundancy is supported (primary and backup energy meters) because transmission revenue metering data is critical. If a project requirement is not covered in this document, or if there are any questions regarding revenue metering application design, consult with AEP's Protection & Control Engineering (PCE) Standards group for clarification. Also, refer to the following AEP transmission standards for more guidance: *SS-497001 Transmission Intercompany & IPP Metering Guide, SS-490050 ERCOT-EPS*[34] *Metering Design Guide, and SS-494001 Transmission Customer Metering Design Guide*.

4.6.3 Requesters and Metering Criteria

- **Affiliate EUC Requester**
  AEP will provide functional specifications for the revenue metering at the Requester's facility for the affiliate EUC. The criteria for these functional specifications will be based on existing AEP measurements practices and standards. AEP reserves the right to specify and approve the type and manufacturer of all associated revenue metering equipment, including the instrument transformers. If requested, subtle changes to the standard AEP metering package are acceptable with mutual agreement between AEP and the Requester. AEP will own the metering package and have testing responsibility.
- **Non-affiliate EUC Requester**
  This Requester can own the metering accuracy ITs. AEP will provide functional specifications for the revenue metering package. The criteria for these functional specifications must be based on existing AEP measurements practices and standards. AEP reserves the right to specify and approve the type and manufacturer of all associated revenue metering equipment including the instrument transformers. Specific agreements will describe exceptions and IT ownership details. AEP will own the meter and have meter testing responsibility.
- **TI Requester**
  This Requester can have metering package ownership when the transmission line ownership boundary occurs at the Requester's facility. It eliminates the need for compensation calculations

[34] For *Section 4.6 Metering Requirements*, EPS refers to ERCOT Polled Settlements.

related to line loss. If it is determined that the TI Requester will own/maintain the metering package, the Requester will provide AEP with accuracy documentation of the meter package components.

- **GC Requester**
  This Requester's meter location can vary, but the preference is to install the GC metering package at the AEP station, which AEP owns/maintains, and may result in the need for loss compensation calculation. Separate GC auxiliary load metering will be required if the specified metering on the generation connection does not provide adequate meter accuracy for its backfeed load, or if GC facility auxiliary loads can have different owners.

4.6.4 Metering Equipment Maintenance & Testing

- Unless otherwise specified, the energy meters must be inspected and tested in accordance with latest applicable ANSI Standards upon installation. The test cycle will vary, depending on region. Refer to *SS-491301 Field Service Testing* for AEP-owned meters. If the Requester needs additional testing other than the normal test cycle, and the meter is found to be within the established tolerances, this additional testing will be performed at the GC, TI or EUC Requester's expense.
- The accuracy of each device in the metering package must be maintained according to the RTE criteria where the meter is installed. The meter test requires the use of a meter standard with accuracy traceable to the National Institute of Standards and Technology (NIST).
- If the metering equipment fails to operate, the energy registration will be determined from the best data available, including backup metering, check metering, or historical metering data.
- The RTE error disclosure criteria must be followed if, at any test of the metering equipment, meets that error criteria. The account between the parties for service before delivered must be adjusted to correct for the inaccuracy. The adjustments will be made according to the applicable regional market guidelines.
- ITs must be inspected and maintained in accordance with good utility practice. AEP-owned ITs must be inspected and maintained based on existing AEP station practices and standards.
- The party that owns the metering equipment must maintain records that demonstrate compliance with all meter tests and maintenance conducted in accordance with good utility practice for the life of the interconnection point. The other party must have reasonable access to the records.

4.6.5 Instrument Transformers

4.6.5.1 230kV and Below

- Separate, free-standing, oil-filled, wire-wound current transformer (CT) units with high accuracy (0.15SB1.8) and extended range are the standard instrument transformer.
- Separate, free-standing, oil-filled, wire-wound voltage transformer (VT) units with high accuracy (0.15%) are the standard instrument transformers.
- High accuracy (0.15%) Combination CT/VT units (combo) can be applied where space constraints or ease of application require their use.

- An exception is made for voltages 34.5kV and below where solid insulated instrument transformers with high accuracy (0.15%) can be applied.

4.6.5.2 IPP Applications 345kV and Above

PJM

- Separate, free-standing, oil-filled, wire-wound CT units with high accuracy (0.15SB1.8) and extended range have been selected as the standard instrument transformer.

  Reason: Independent Power Producers (IPPs) have a high power output, but when not generating, IPPs have a very low load and extended range CTs have supported higher accuracy down to 0.05% of rating (or better). High accuracy bushing current transformers (BCTs) are only guaranteed down to 5% of rating.

- High accuracy (0.15%) Capacitive Voltage Transformer (CVTs) can be used.

ERCOT EPS & SPP

- Separate, free-standing, oil-filled, wire-wound CT units with high accuracy (0.15SB1.8) and extended range have been selected as the standard instrument transformers.
- Separate, free-standing, oil-filled, wire-wound VT units with high accuracy (0.15%) have been selected as the standard instrument transformers (see reason below).

  Reason: CVTs are not recommended on ERCOT EPS applications or SPP region due to a requirement to accuracy test the CVTs every five years. In order to avoid unnecessary outages, AEP will not use CVTs for this application. Meter points in ERCOT that are non-EPS can use high accuracy (0.15%) CVTs.

4.6.5.3 Non-IPP Applications 345kV and Above

PJM

- High accuracy (0.15S-B1.8) BCTs
- High-accuracy (0.15%) CVTs

SPP

- High accuracy (0.15S-B1.8) BCTs
- Separate, free-standing, oil-filled, wire-wound VT units with high accuracy (0.15%) are the standard instrument transformers. See reason in ERCOT EPS below.

ERCOT EPS

- Separate, free-standing, oil-filled, wire-wound high accuracy (0.15S-B1.8) CT units are the standard instrument transformers.
- Separate, free-standing, oil-filled, wire-wound VT units with high accuracy (0.15%) are the standard instrument transformers.

  Reason: CVTs are not recommended on ERCOT EPS applications or SPP region due to a requirement to accuracy test the CVTs every five years. In order to avoid unnecessary outages, AEP will not use CVTs for this application. Meter points in ERCOT that are non-EPS can use 0.15% high accuracy CVTs.

4.6.6 Voltage Transformer Ratio

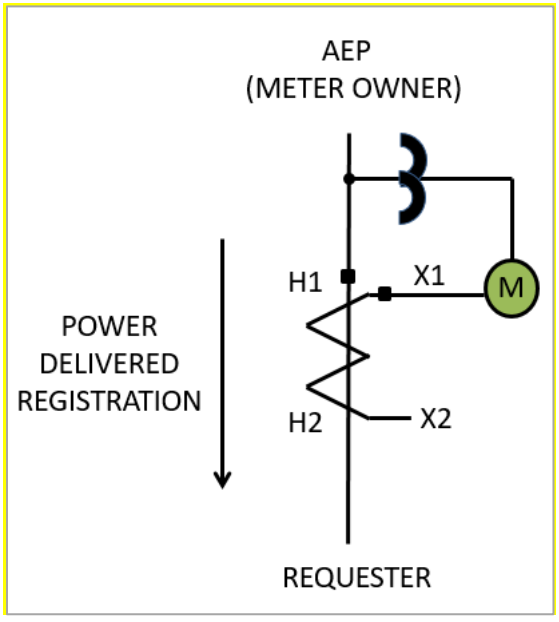
The voltage transformer ratio must be specified with a ratio to provide a nominal of 120 volts at the meter.

4.6.7 Polarity

If AEP owns the meter and is responsible for settlement, then the polarity marking (designated as H1) on the primary side of the instrument transformer must be oriented toward AEP. See *Figure 9* below. The CT secondary terminal designated as X1 is to be connected to the positive current terminals of the energy meter (assuming VTs are connected properly), current flow in H1 (from AEP) and out H2 (to Requester), will register positive MWh (delivered) by the energy meter.

Conversely, for reverse power flow from the interconnecting Requester to AEP (in H2), negative MWh (received) will be registered on an independent register of the energy meter if AEP owns the meter and is responsible for settlement. Note the orientation of the VT primary connection, which is shown between the meter owner, AEP, and the CT. The VT orientation is AEP's practice where it can be done physically so that the meter does not register VT losses.

Figure 9. CT Polarity and VT Connection



4.6.8 Meter Requirements

4.6.8.1 Revenue Meter

The revenue meter accuracy must follow the applicable RTE criteria for where it is installed and must be cabable of MV90 remote readings.

4.6.8.2 Requester Access to AEP Metering Circuits

- The revenue meter must be the only device connected to the metering accuracy instrument transformers.

  Note: There are exceptions where unused secondary windings of the voltage source for applications at 345kV and above can be used in AEP protection relay devices. However, there must be no RTE restrictions for such a case.

- Requesters may specify a check meter in the revenue metering circuit on the same panel or adjacent panel to the revenue meter. The Requester will be responsible for additional costs needed for AEP to provide data connection/communication access to the revenue meter. AEP Transmission PCE Standards must approve this arrangement.

4.6.9 Data Acquisition

4.6.9.1 AEP Access to Real-time Meter Data

If an AEP RTU is present, it will poll the meters. If an AEP RTU is not present, the AEP SCADA system can poll the meters directly when AEP Settlements needs real-time data.

The SCADA RTU design dictates which options (Ethernet or RS-485 serial) are chosen for the meters. An AEP-owned local area network (LAN) connection is preferred for AEP-owned meters. Refer to *SS-500000 Interconnected Facilities SCADA Guide,* and *SS-490100*, *Station Revenue Energy Meter Communication Options* for directions on the data communications interface.

4.6.9.2 Requester Access to Real-time Meter Data

If the Requester needs real-time data from the meter, the connection provided will depend on the SCADA system design. If an AEP RTU polls the meters, AEP may grant the Requester serial access to the AEP RTU. If an AEP RTU is not present, AEP may grant the Requester serial access to the meter(s). Refer to *SS-500000 Interconnected Facilities SCADA Guide*, and to *SS-490100, Station Revenue Energy Meter Communication Options* for directions on the data communications interface.

4.6.10 MV90 Interval Data Retrieval

The AEP Transmission Settlements or Load Research group will use the AEP MV90 data translation system to interrogate AEP-owned revenue energy meters (primary and backup). If the Ethernet is connected to the SCADA wide area network (WAN), MV90 can interrogate the meter's Ethernet port. If the meter's Ethernet port is not connected to the transmission system network, it will be polled using a cellular Internet Protocol-based connection.

If the Requester needs meter interval data retrieval, then a meter serial port can be used, or AEP can be provide an internet proxy.

4.7 Telecommunications Facilities Requirements

4.7.1 Fiber-optic Cable Requirements

The Requester's Interconnection Agreement with AEP will identify requirements for fiber-optic cable installation between Requester and AEP facilities. The agreement could include a requirement for the Requester to install redundant and diversely routed fiber-optic cables. AEP Protection & Control (P&C) Engineering prefers direct fiber relaying rather than fiber optic multiplexers. In addition to using the fiber-optic cable for relaying, supplemental AEP network and serial data connections can be used in the system interconnection design.

The Requester must not terminate or route fiber-optic cable with metallic members at or through the Requester's substation (Substation) control building or the telephone company demarc. Fiber-optic cable with metallic members includes, but is not limited to, optical ground wire (OPGW), fiber-optic cable with an integral trace wire, and metallic-armored fiber optic cable.

Fiber-optic cable with metallic members must be transitioned to all-dielectric fiber-optic cable. AEP must approve fiber-optic cable before it enters the Requester's control shelter or the telephone company interface.

4.7.2 Demarc Requirements

AEP and the local exchange carrier (LEC) must approve all demarcation equipment (demarc or telephone company interface box) for all telephone company circuits that are leased to a Requester-owned Substation. The Requester will install, own, and maintain this equipment.

The demarc must house all telephone company circuit termination equipment at the Substation, including, but not limited to, the network interface and high-voltage (HVP) equipment (See 4.7.3 below). The demarc must provide the interface between the telephone company's service cable and the Substation. The Requester must provide 120 VAC power to the demarc sourced from an appropriately sized DC/AC inverter in the Substation control building. The DC/AC inverter must be powered from a dedicated Substation DC breaker sourced from a minimum 8-hour Substation battery.

If the demarc is located in a position that makes it impractical to power from the station battery, the Requester must have another way to provide 120VAC service to the demarc. AEP must approve this arrangement. The demarc design will include provisions to extend the leased circuit into the Substation control house or other enclosure where AEP equipment will be placed. The demarc must be located on the Substation ground grid, unless HVP requirements cause it to be placed elsewhere. The demarc must be accessible outside the Substation fence or through a secured personnel gate or door.

Telephone company personnel will not have access to the control building housing an AEP RTU. Demarc design must include 24/7 access for AEP personnel without escort from the Requester, telephone company personnel, facility operator, or landowners. Before demarc construction begins, the Requester must submit its design to AEP for review and approval. The design must include physical locations of the telephone company's service cable, Substation ground grid, demarc mounting structure, Substation fence, and Substation control building. Demarc design covered in this section must be operational, and AEP must commission the design before the interconnection facility is placed in service.

4.7.3 High Voltage Isolation Requirements

The demarc must meet all high-voltage protection (HVP) requirements according to the LEC as follows:

- LEC Service – All-dielectric fiber-optic service cable
  - AEP must approve cable design and implementation.
  - The Requester will work with the telephone company to install, own, and maintain all-dielectric fiber service cable to the demarc location of the Requester-owned substation (Substation) ground grid.
  - Armored fiber-optic cable must not be installed within the ground potential rise (GPR) high voltage zone of influence.
  - The telephone company must transition armored fiber-optic cable to all-dielectric fiber-optic cable outside the GPR high voltage zone of influence. This all-dielectric, fiber-optic service

cable must extend from a location at or beyond the 300 volt point, through the GPR high voltage zone of influence, to the demarc.

  - Telephone company personnel must have 24/7 access to the all-dielectric fiber-optic service design without escort from AEP personnel, Requester personnel, facility operator or landowners.

- LEC Service – HVP equipment with copper service cable
  - AEP and the telephone company must approve the equipment.
  - The Requester or local telephone provider must install and maintain equipment.
  - AEP will have no responsibility for maintaining any part of the telephone company demarc or equipment.
  - Copper isolation equipment must be located on the Substation ground grid, unless the LEC has different requirements.
  - Equipment design must include adequate protection against GPR.
  - Equipment installation is required on all telephone company circuits delivered over copper cable to the Substation demarc in compliance with LEC requirements.
  - Access to equipment is required outside the Substation fence or through a secured personnel gate or door.

4.7.4 Circuit Requirements

In some cases, AEP may assign the Requester responsibility for communication circuits that AEP will use. The Requester will be responsible for confirming project-specific circuit requirements and obtaining specific AEP addresses and AEP contact names in preparation for issuing communication circuit orders with AEP. Circuit(s) will be multi-protocol label switching (MPLS) with AT&T, Verizon, or an alternative satisfactory to AEP. The AEP account team will order the circuits from their telecommunication service provider of choice.

The Requester must provide AEP and the telecommunication service provider advance authorization for communication circuit maintenance. AEP and any of its affiliates or subsidiaries can monitor the circuit, report trouble, and take corrective action with the telecommunication service provider, at the Requester's expense, to maintain circuit reliability. This requirement applies to all leased Requester circuits.

The Requester must install and maintain voice communications that meet requirements identified by AEP, OpCo, transmission company, RTE, or applicable agreements. Backup communication circuits may be required according to the agreement. Communication circuits must be operational and AEP must commission the circuits before the interconnection facility is placed in service.

Typical facility circuit requirements include:

- AEP Network Communications Circuit – A leased circuit from the demarc associated with the Requester-owned Substation to an AEP dispatch office.
- Voice Dispatch Circuit – A leased circuit from the Requester facility plant operators to an AEP dispatch office. If the Requester facility plant operators are not located on the plant site, then the circuit must be terminated at the plant operators' actual location. The Requester must provide a dedicated circuit where the total plant generation capacity is equal to or greater than 50 MVA.

This circuit must use dedicated, private line automatic ring down (PLAR) technology and must not rely on the public switched telephone network. AEP must approve this service configuration.

4.8 Station Service

4.8.1 Substation Lighting

Service Lighting is not required on new AEP station installations. Stations containing AEP owned equipment shall comply with AEP lighting standard SS-410000 latest revision. Security Lighting (0.5FC minimum) must be provided at all AEP equipment locations. With security lighting, personnel must be able to observe equipment locations from outside the station fence, and such lighting will serve as a deterrent to keep people from trespassing and/or tampering with equipment.

4.8.2 AC Station Service System

AC station service power systems in AEP and Requester stations must be independent and derived separately. AEP must approve the AC station service system's construction that serves AEP equipment when AEP facilities are located in the Requester's substation. The standard station service voltage is center-tapped 120/240VAC for single-phase or three-phase system. A three-phase system must use open-delta or closed-delta secondary only. For service power serving AEP facilities AC station service systems must comply with the *AEP Standard SS-010000 Service Power for Electrical Stations Design Guide* and *SS-010090 AC/DC Panelboard and AC Station Service Switchboard Specification for Substations*

4.8.3 DC Station Service System

The standard AEP battery voltages for new installations is 125 VDC. Each substation must have a properly sized battery and charger to carry the DC station loads during an AC power failure. Where the DC station service system is supplying AEP owned equipment the DC station service system will not be smaller than the requirements described in *AEP Standard SS-181000 DC Station Service Application Guide*. Requirements outlined in *SS181000* are based on IEEE-485 calculations.

For equipment combined within a single fenced station, AEP Transmission and AEP-affiliate owned DC station service power systems shall only serve AEP Transmission and AEP-affiliate owned and maintained equipment. DC station service power systems serving equipment not owned and maintained by AEP Transmission or AEP-affiliates shall be independent and separately derived. AEP and Requester-owned equipment located in separate fenced stations must have independent and separately derived station service power systems.

4.9 Transmission Line Design

Transmission line design and construction begins after the point of connection is determined. When this work is required for new transmission line facilities on the AEP system to connect the requester's facilities, it must be completed in compliance with:

- *ANSI-C2*, National Electrical Safety Code (NESC), latest edition
- Governmental agencies as needed to obtain permits to construct the line (e.g., the U.S. Army Corps of Engineers or the Federal Aviation Administration)
- Additional applicable state and local code or criteria

- The requirements in *Table 13* below

In addition, all transmission line facilities on the AEP system that involve carrying AEP services to more than one customer, or that AEP will own or maintain, must comply with the design requirements in Table 13 below.

Table 13. Requirements for All Lines Connected to the AEP Transmission System

Parameters	Requirements						
	≤69kV	**138kV**	**161kV**	**230kV**	**345kV**	**500kV**	**765kV**
Extreme Wind Loading	Use ASCE MOP 74-2020 for the 100 year Mean Return Interval (MRI) load as appropriate for the line's location						
Heavy Ice Load (No Wind)	Use ASCE MOP 74-2020 for the 100 year Mean Return Interval (MRI) load as appropriate for the line's location						
Ice with Concurrent Wind	Use ASCE MOP 74-2020 for the 100 year Mean Return Interval (MRI) load as appropriate for the line's location						
Unbalanced Loads [1,2]	Tangent and Running Angle Structures will be designed for the following loads: Broken Phase (single conductor) - 12.25 psf wind with 0" ice at 0°F Broken Phase (two or more bundled conductors) - 0 psf wind with 0" ice at 60°F Broken Ground Wire - 12.25 psf wind with 0' ice at 0°F Unbalanced Ice (Iced span) - 6.25 psf wind with 0.5" ice at 0°F Unbalanced Ice (Bare span) - 6.25 psf wind with 0" ice at 0°F						
NESC Load Requirements	All NESC Load requirements, 250B, 250C, and 250C for Grade B construction will be met.						
OPGW (Optical Ground Wire) Standards	OPGW will comply with AEP Standard OPGW Requirements in *Table 16* or equivalent.						
Static Ground Wire Standards	Static wire needs will be determined by available fault current on the line. All static wire shall be aluminum-clad steel or ACSR conductor. 7-#8 is the minimum size that shall be used.						
Damper Requirements	Aeolian vibration dampers are required unless an engineering study indicates otherwise or twisted-pair conductor is being used.						
Galloping Assumptions	Galloping will be considered for all lines in Indiana, Michigan, western Ohio, Oklahoma, and West Texas north of Abilene. In areas not mentioned above, galloping need not be considered unless local knowledge indicates otherwise.						
Galloping	For all spans, apply the Cigre Ellipse[4] with a 0.5 amplitude factor. The ellipses must have the separation shown in the table below plus the bundle spacing if the line uses bundled conductor. The use of twisted-pair conductor or other mitigation devices is allowed to mitigate galloping.						

Voltage	**69kV**	**138kV**	**161kV**	**230kV**	**345kV**	**500kV**	**765kV**
Phase-Phase (ft)	1.5	2.0	2.5	3.0	4.0	6.5	8.5
Phase-Ground (ft)	1.0	1.5	2.0	2.5	3.0	4.5	6.5

Parameters	Requirements						
	≤69kV	138kV	161kV	230kV	345kV	500kV	765kV
Spacers	The use of spacers in 2-conductor horizontal bundles or bundles of more than 2 conductors is required. Spacer-dampers are allowed.						
Min. Design Clearance	All as built facilities will comply with NESC Clearance Requirements.						
Min. Insulation Leakage Distance [3]	49" 68" 84"	98" 136" 168"	110" 159" 197"	163" 227" 281"	245" 340" 421"	355"	543"
Min. Critical Impulse Flashover Voltage	495kV	760kV	930kV	1105kV	1585kV	2065kV	-2685kV middle phase -2530kV outside phase
Max. Structure Ground Resistance	20 Ω	20 Ω	20 Ω	20 Ω	20 Ω	20 Ω	20 Ω
Max. Shielding Angle	30°	30°	30°	15°	15°	15°	5°
EMF Limits	Must comply with all applicable local, state, and federal regulations.						
Footnotes:							
[1] For all longitudinal load cases, the design load shall be calculated by determining the greatest mechanical load resulting from breaking, removing, or unbalanced ice in the fore span, back span, or tap span. For 138kV lines and below, dead-end structures may be installed at least every 5 miles in lieu of designing for the broken phase, broken ground wire, and unbalance ice loads.							
[2] For vertically bundled conductors without spacers, use the single conductor load case for one sub-conductor for the broken phase loading.							
[3] The three values shown are for Normal, Heavy, and Very Heavy Contamination according to the latest International Electrotechnical Commission (IEC) recommendations. For 500kV and 765kV lines in heavy or very heavy contamination areas, consult AEP Transmission Line Standards.							
[4] For information on the Cigre Ellipse calculation, see *Cigre Technical Brochure Reference 322; State of the Art of Conductor Galloping.*							

Table 14. Additional Requirements for Lines Connecting to the AEP Transmission System

Parameters	Requirements						
	≤69kV	138kV	161kV	230kV	345kV	500kV	765kV
Conductor Sizes for New Construction	For AEP-owned or maintained line, the conductor will be chosen from the *AEP Standard Conductor Table 15*. The conductor for non-AEP owned or maintained lines shall be in the Interconnect Agreement.						

Min. Right-of-Way (ROW) Width	Minimum ROW widths on AEP-owned or maintained lines must be calculated based on NESC clearance requirements to buildings with the conductor displaced by a 6 psf wind at 60°F and at rest.
Provisions for Live Line Maintenance	For AEP-owned or maintained lines, the Minimum Approach Distance according to Occupational Safety and Health Administration (OSHA) regulations for live line work and climbing inspections will be provided.

Table 15. AEP Standard Conductor Table

Size (CM) & Code Name	Stranding	Type	Type
69kV Lines			
1-477,000 - Hawk	26/7	ACSR	ACSS
1-556,500 - Dove [1]	26/7	ACSR	ACSS
1-795,000 - Drake [2]	26/7	ACSR	ACSS
1-954,000 - Cardinal	54/7	ACSR	ACSS
1-1,033,500 - Curlew	54/7	ACSR	ACSS
138kV and 161kV			
1-556,500 - Dove	26/7	ACSR	ACSS
1-795,000 - Drake [1]	26/7	ACSR	ACSS
1-1,033,500 - Curlew [2]	54/7	ACSR	ACSS
1-1,272,000 - Pheasant	54/19	ACSR	ACSS
1-1,590,000 - Falcon	54/19	ACSR	ACSS
230kV [3]			
1-1,033,500 - Curlew	54/7	ACSR	ACSS
1-1,272,000 - Pheasant	54/19	ACSR	ACSS
1-1,590,000 - Falcon	54/19	ACSR	ACSS
2-795,000 - Drake	26/7	ACSR	ACSS
345kV [3]			
2-954,000 - Cardinal	54/7	ACSR	ACSS
2-1,272,000 - Pheasant	54/19	ACSR	ACSS
2-1,590,000 - Falcon	54/19	ACSR	ACSS
Footnotes			
[1] Preferred conductor for rural construction			
[2] Preferred conductor for urban construction			
[3] There is no preferred conductor for 230kV and 345kV.			

Table 16. OPGW Design and Fiber Requirements

	Minimum	Maximum
OPGW "Mechanical" Design Parameters [1]		
Overall Diameter [2]	0.646 inch (16.4 mm)[2]	
Rated Breaking Strength [3, 4]	17,000 lbs. (75.6 kN) or 25,500 lbs. (113.4 kN)[3]	
Diameter or Smallest Dimension of Metal Strands:		
Outside Layer[5]:		
Aluminum-Clad Steel Wires (per ASTM B415)	0.1285 inch (3.25 mm)	
Inner Layers:		
Aluminum-Clad Steel Wires (per ASTM B415)	0.100 inch (2.5 mm)	
Aluminum 6201-T81 Alloy Wires (per ASTM B398)	0.100 inch (2.5 mm)	
Aluminum Wire 1350-H19 (per ASTM B230)	0.100 inch (2.5 mm)	
Fault Current Capability, I squared × T[6]	140 [kiloamps] squared × seconds or as specified in RFQ	
Continuous (RMS) Current	Zero (0) or as specified in RFQ	
Single Mode Fiber Requirements [7]		
Optical Attenuation [8]		
@ Wave length = 1310 nanometers (nm)		0.36 dB/km
@ Wave length = 1550 nanometers (nm)		0.25 dB/km
Total Chromatic Dispersion [8]		
@ 1285 - 1330 nm, (ps/nm - km)		3.5
@ 1530 - 1570 nm, (ps/nm - km)		17.0
Core to Cladding Concentricity Error		1.0 µm
Core Diameter		9.0 µm
Cut-Off Wavelength @ 1310 nm	1130 nm	1270 nm
Typical unspliced OPGW Reel Length	4 miles (21,100 ft.; 6.4 km)	
Footnotes		
[1]As used herein, OPGW is an abbreviation for "Composite, Single-Mode, Optical Fiber Ground Wires for Overhead Use."		

	Minimum	Maximum
[2]The OPGW overall diameter shown is the preferred value so that the associated hardware may be interchangeable. If the specific OPGW being designed, with varying numbers of optical fibers and fault current requirements, requires overall diameters larger than shown, the vendor may quote the larger diameter. In general, within the context of the other OPGW requirements, it is preferred to try to minimize overall diameters.		
[3]The OPGW shall be designed such that, for tensile loads up to 95% of its rated breaking strength (RBS), the optical fibers shall not be damaged and their optical transmission characteristics shall not be affected. If the OPGW is designed such that at a tension equal to 95% of the RBS the optical fibers are subjected to strain, the tension in the OPGW from a 1.25" Radial Ice Load at 0ºF with No Wind shall not exceed 60% RBS (i.e., 60% of 25,500 lbs.). If the OPGW is designed such that at a tension equal to 95% of the RBS the optical fibers are subjected to no strain, the tension in the OPGW from a 1.25" Radial Ice Load at 0ºF with No Wind shall not exceed 90% RBS (i.e.; 90% of 17,000 lbs.).		
[4]The Rated Breaking Strength (RBS) of the OPGW shall not exceed the rated strength of the component strands times a strength reduction factor of 0.90. The minimum RBS requirements are for the preferred OPGW diameter. Actual minimum RBS requirements may need to be higher depending on the specific overall diameters and bare weights of each type of OPGW having varying numbers of optical fibers included.		
[5]The outer layer of strands on the OPGW is to consist only of aluminum-clad steel wires with the minimum diameter specified and is to be Left-hand Lay.		
[6]The required Fault Current Capability, I squared × T, is based upon an OPGW ambient reference temperature of 40ºC (104°F) and a fault duration of 0.25 seconds.		
[7]Single Mode Fibers are to be Corning Specification SMF-28 (latest revision) or the comparable Lucent specification. The use of fibers from other suppliers must be approved in advance by AEP. All optical fibers supplied as part of any one Purchase Order for OPGW shall be supplied from a single source.		
[8]Maximum attenuation and total chromatic dispersion values apply to each fiber within the OPGW for each reel.		

5.0 Construction

The following subsections outline the requirements associated with the construction phase of a typical project, including option to build oversight and inspections.

5.1 Option to Build Oversight Requirements

AEP has guidelines specific to the option to build (OTB) process. They identify AEP's recommendations, expectations, and requirements for Requesters electing to use the OTB transmission facilities as part of their generation facilities interconnection. The *Independent Power Producers Option to Build Guidelines* are located on AEP.com[35] in the AEP Transmission Studies and Requirements section on the Required Postings page. Interconnection Agreements or applicable tariffs supersede these guidelines.

5.2 Inspection Requirements

5.2.1 General Inspections

An interconnection facility must pass AEP inspections before it can be energized to maintain the integrity of the grid. The quantity and frequency of inspections will depend on the type of connection, proximity of connection to existing AEP facilities, any safety concerns due to existing or new facilities or accessibility by the public, and the Requester's project.

5.2.1.1 Protection & Control Inspection

For cut-in outages, an AEP Energy Delivery Representative will retain a construction clearance on the site until the Requester fulfills all of its construction requirements. An AEP Protection & Control (P&C) staff member can retain clearances until all desired/necessary checkouts are completed. AEP reserves the right to inspect all equipment from the point of interconnection to the first protective fault interrupting device and the ground system. This inspection may include circuit breakers, circuit switchers, power fuses, instrument transformers, switches, surge arresters, bushings, and relays and associated equipment including battery, battery chargers or other customer equipment. The inspection may include a visual check of all major equipment and an examination of required test results.

5.2.1.2 Pre-Energization Inspection

At least five business days before energization, an Energy Delivery Representative will attest to all series equipment as required by AEP compliance documentation. The Requester and AEP SCADA personnel must commission and validate the facility before it is declared ready for operation. Validation points are defined in *Sections 4.5.3, 4.5.4, 4.5.6*, and other applicable agreement(s) between AEP and Requesters.

[35] https://www.aep.com/requiredpostings/AEPTransmissionStudies

6.0 Operations

The following subsections outline the requirements associated with facility operations, including general requirements, in-service coordination, NERC requirements, meter agent and settlements requirements, and many more.

6.1 General Operating Requirements

This section outlines the operational requirements for the Requester's connected facilities. Energy Delivery Operations must manage and operate transmission and interconnection facilities based on NERC, regional, and applicable RTE reliability standards. The Requester is responsible for meeting AEP operational requirements in a timely manner, whether or not their connected facilities are in operation. This requirement applies to any transmission operating condition.

A connected facility **must not**:

- Impact safe electric grid operation.
- Increase the risk of in system reliability constraints that stem from facility failures.
- Increase frequency and duration of outage interruptions.
- Prevent effective resource usage to provide efficient and cost-effective service to customers.
- Impact service reliability and capacity to customers.
- Decrease system flexibility associated with day-to-day operations.

The Requester is solely responsible for proper coordination of its equipment with the transmission system and must provide the most current specifications for interconnection equipment, including drawings and one-line diagrams to AEP for review. AEP's review does not confirm or endorse the design, or as a warranty of safety, durability, or reliability of the facility. The Requester must submit any future changes to the specifications that could affect AEP Energy Delivery Operations to AEP for review and approval.

All interconnecting facilities must be operationally tested and/or inspected in order to meet current requirements as specified in *Section 5.2*.

Before the facility is declared ready for operation, the Requester must provide AEP with the name, title, address, telephone number, and email address of individual(s) who will operate the facility. The Requester must keep AEP informed regarding contacts and maintain proper communication channels between AEP and the Requester.

6.2 Advanced In-Service Coordination

The Requester must provide the AEP project manager an advanced written notice of their GC, TI or EUC facility in-service date. The greater of 45 days or any RTE in-service date notification requirements will be used as the advanced written notice time constraint. AEP Energy Delivery Operations will use this time period to ensure that telemetry, system models(s), communication and procedures of all stakeholders are verified.

6.3 Transmission Service and NERC Registration

All entities required to register, under *NERC's Rules of Procedure, Appendix 5A, Section 1*, must provide AEP with this NERC registration information at least 30 days before the in-service date. AEP assumes no additional compliance obligations beyond its NERC registrations, unless specifically defined in a signed interconnect agreement.

6.4 Meter Agent and Transmission Settlements Requirements

Transmission Settlements is responsible for maintaining the system of record for all AEP transmission system loads. Transmission loads represent the amount of load on the AEP transmission system. Load is modeled by metering all generation flowing onto the system, plus interconnection receipts from other transmission systems less deliveries to other transmission systems. AEP loads are calculated by taking the transmission system load and removing non-AEP load (also called top-down load calculation).

Transmission Settlements acts as the meter agent for all AEP entities and some non-AEP entities for AEP zones in the PJM and SPP markets. The main responsibility is to provide meter data to the market for financial billing. Because the calculation of the AEP top-down loads includes all points on the system, Transmission Settlements prefers to be the meter agent in order to minimize errors or mismatched data in the markets.

Transmission Settlements requires the following:

- To be included in and updated on projects during the planning and set-up phase in order to provide feedback and prepare for system changes.
- Revenue quality metering and backup metering (when applicable) installed and compensated to the point of interconnection of AEP's transmission system.
- Access to read meters or other methods to receive meter data.
- To be provided with the following information:
  - Clear location of the point of interconnection.
  - Any losses or losses factors that should be applied in the meter or translation.
  - Designation of meter ownership.
  - Maintenance agreements for all metering equipment including metering transformers.
  - Contact information for meter data reconciliation.
- Any connected Generation must have:
  - Metering to capture generation and auxiliaries accurately.
  - Agreements in place to provide retail auxiliary service.
  - Clear guidance on the treatment of non-generated auxiliary load (NGA) and generation for market submission and retail contracts.
- A clause in all new or updated agreements for Transmission Settlements to be the meter agent in the PJM and SPP markets for all generation and load data on the AEP system; and to be the meter agent when AEP owns the metering on all transmission system to transmission system interconnections in those markets.

6.5 Station Load and Ancillary Service Provider

The Requester is responsible for making all appropriate arrangements for station load and ancillary service requirements, including the delivery component of transmission service, if applicable. The Requester must cause such station load and ancillary service provider arrangements or agreements to be in effect before the in-service date. If the Requester supplies their station service, the station service loads must be netted against the Requester's output. At AEP's request, the Requester must provide their current station service arrangements or agreements.

6.6 Synchronizing Facilities

The Requester is solely responsible for synchronizing its facilities with AEP in the appropriate frequency and voltage ranges, and protecting its facilities from all abnormal conditions occurring on the transmission system during synchronization. The Requester must install a relay with synchronizing function to ensure that their facility is not connected to the energized power system that is out of synchronization. The Requester must own, test, and maintain equipment that synchronizes their facilities to the transmission system to meet AEP's requirements.

Upon AEP supply loss, the Requester's facilities must be separated immediately from AEP. The Requester must ensure that their generator is disconnected from AEP before automatic reclosing by AEP. Otherwise, automatic reclosing out-of-phase with the Requester's generator may cause damage to the Requester's equipment. The Requester is solely responsible for their equipment protection during automatic reclosing by AEP. The Requester may also be responsible for installing additional equipment to operate in island mode and resynchronizing their islanding system to AEP.

At AEP's discretion, the Requester may be required to synchronize their facilities to the transmission system under the direction of AEP Energy Delivery Operations.

If the Requester's facility is a part of black start requirement, there may be additional provisions.

Any future changes to the design, logic, and settings that affect the Requester's synchronization and separation functions must be submitted to AEP for review and approval.

6.7 Asynchronous Network Interconnections

Asynchronous Network Interconnections, including high-voltage direct current (HVDC) connections, are treated on a case-by-case basis and the requirements for the Requester will be outlined as part of the RTE study process. If you need more detailed information on the requirements and process for these connection types, please contact the email outlined in *Section 2.1 Procedures*. The power quality requirements are covered in *Section 6.12 Power Quality Impacts*.

6.8 Voltage, Reactive Power, and Power Factor Correction

The Requester's generating equipment must not cause excessive voltage excursions. AEP will work with the Requester and the RTE to establish the normal operating voltage schedule, power factor schedule and operating limits. During emergency system conditions, the Requester's generation facilities must comply with all special instructions provided by AEP Energy Delivery Operations. Reference *Section 6.12* and *Section 3.3. General Design Information* for further details regarding voltage requirements.

Coordination of Scheduled Outages

The Requester must provide a schedule of all planned equipment outages to AEP and the RTE, and follow the applicable outage coordination procedures. At least 30 days advance notice is required. This period may be extended depending on the RTE

Voltage Control

The Requester's generating equipment must not cause excessive voltage excursions. The Requester must operate generating equipment in such a manner that there are no harmful impacts to system voltage levels. The Requester must provide an automatic method of disconnecting its generating equipment from the AEP facilities to protect against excessive voltage excursions. AEP will provide a reactive schedule letter that specifies generator voltage or power factor schedules and operation bandwidth. The Requester will install, operate, and service an automatic voltage regulator to maintain the assigned voltage schedule to the extent possible. The reactive schedule letter will include notification requirements for steady-state deviation from the voltage or power factor schedule and changes in automatic voltage regulator status as well.

The generation facility must be capable of continuous non-interrupted operation during normal system conditions and during abnormal conditions. All reasonable measures should be taken to avoid tripping the generation facility due to high or low voltage.

During plant start-up conditions, the Requester's auxiliary equipment must not cause excessive voltage flicker on AEP's electric facilities.

All three-phase generation must produce balanced 60 Hertz voltages.

Power Factor Control

The Requester must not place any undue burden on the AEP transmission system with respect to reactive power and must operate their equipment in accordance with any applicable power factor requirements specified in the Requester's agreements with AEP.

6.9 Dynamic MVAR Requirements

For generators, the dynamic MVAR capability at the current MW generation amount must be available in real time. If this dynamic MVAR capability is not available in real time, a dynamic capability curve plotted as a function of MW output is required.

The shunt static reactive available, but not in service, must be provided in sufficient detail to determine the amount of dynamic and static reactive reserve available. Applicability of this requirement based on generator size or size of combined generation, including DER aggregation, may be established in the near future.

6.10 Frequency Requirements

The AEP transmission system frequency operates at a nominal 60.0 Hz with a typical daily variation of ±0.05 Hz. The operating frequency of the Requester's equipment must not deviate from this AEP system frequency. Under emergency conditions, the transmission system could operate outside of this range for a limited period of time.

Generator underfrequency protection must be set to coordinate with the NERC-mandated automatic load shedding protection settings. The AEP underfrequency load shedding (UFLS) schemes begin

dropping load between 59.50 HZ and 58.50 Hz in steps, based on the local Planning Coordinator/RTE requirements. Thus, the generator underfrequency protection must not operate before the system UFLS has a chance to respond. The Requester is responsible for setting their generator underfrequency protection to comply with the local Area Planning Coordinator/RTE requirements for generator underfrequency protection.

6.11 Abnormal Frequency Operation

The Requester will provide the frequency-sensing equipment required to protect their facility during abnormal frequency operation. The generator's manufacturing specifications or the range specified in *Section 6.10 Frequency Requirements* must be followed during abnormal frequency episodes.

The Requester's generator will not separate from the AEP system during under frequency conditions until all UFLS equipment on the AEP system has operated.

The Planning Coordinator may require an automatic load-shedding scheme on connected load to comply with North American Electric Reliability Corporation (NERC) standards or other system stability considerations. AEP is obligated to have an automatic UFLS plan in effect that meets these NERC standards. Connecting parties without an automatic UFLS plan for meeting these NERC requirements may need to install underfrequency relaying and have a load-shedding program in place, as the Planning Coordinator/RTE requires. The AEP Energy Delivery Operations Engineering team will specify the amount of load to be shed and frequency set points as set forth in the UFLS compliance requirements of NERC and the applicable Planning Coordinator/RTE.

6.12 Power Quality Impacts

AEP Power Quality Requirements

This section summarizes the AEP policy on power quality requirements including voltage flicker, harmonic distortion, and other factors for Requesters connected to the AEP transmission system.

Point of Compliance

The point of compliance (POC) is where the power quality (PQ) requirements will be met. Voltage flicker and harmonic distortion requirements are evaluated from the POC between the Requester and AEP's system.

Voltage Flicker Criteria

The random voltage fluctuations (flicker) measured at the POC directly attributable to the Requester, must remain within the limits specified in IEEE Standard 1453-2015 *IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems*.

Harmonic Distortion Criteria

AEP requires that the Requester's operation comply with IEEE Standard 519-2014, *IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems*.

Electrical Interactions

If field measurements, analytical studies or customer complaints indicate likely adverse electrical interactions (e.g., resonance) between the connected facility and the AEP system, AEP and the Requester will collaborate to determine the nature and extent of the electrical interaction.

Compliance and Monitoring

AEP reserves the right to monitor the Requester for the electric distortions referenced in this section, or any other electrical distortions that would be relevant or complementary, at the determined POC. AEP will determine the Requester's compliance with these criteria.

AEP may permit the Requester to operate above some of the criteria stated in applicable IEEE standards until AEP receives complaints from other customers or other operating problems arise for AEP. By so agreeing, AEP does not waive any rights it may have to strictly enforce its established criteria as measured or calculated in the future.

The Requester agrees that if the operation of its facility and equipment result in voltage flicker or harmonic distortions in excess of AEP's criteria, it is the Requester's responsibility to take action to comply with such criteria. Corrective measures could include, but are not limited to, modifying production methods, materials, or installing mitigation equipment necessary to bring the Requester's operations into compliance.

6.13 Operational Issues

Emergency Operation

The Requester must have AEP-approved procedures in place when connecting to AEP. If the Requester's facility is part of any AEP emergency procedures (e.g., Conservative Operations), then the Requester must follow applicable procedures during a system emergency.

Black Start Capability

AEP may use the Requester's generation black start capability. If deemed appropriate for a particular installation, this option will be addressed in the applicable Interconnection Agreement. Factors include the Requester's generation location and other considerations applicable to system restoration in the event of a local or widespread blackout.

If a blackout occurs, the *AEP Black Start Plan* must be followed to aid in system restoration. The Requester must comply with the black start requirements in applicable NERC Reliability Standards. If the Requester's generation becomes completely de-energized or retired, the Requester must advise AEP and the applicable RTE of this status.

In addition to the potential black start capability requirements, the Requester's generation may need the capability to operate at low output levels, and participate in system frequency and/or voltage control as required.

Sub-Synchronous Torsional Interactions or Resonance

Depending on the generation facility's location in the transmission network, close electrical proximity to series compensated transmission lines or Flexible AC Transmission Systems (FACTS) devices may result in undesirable or damaging sub-synchronous currents. Also, the provision of high speed reclosing following transmission line faults may result in excessive torsional duties. The Requester shall provide AEP with immunity from damaging torsional oscillations resulting from all transmission system operations, and ensure the turbine-generator is not excited into resonance by normal system operations.

Frequency and Voltage Ride-Through Capability

The Requester's generation must have frequency and voltage ride-through capability and adhere to applicable NERC and RTE standards or criteria. Requesters must set their applicable generator protective relays such that generating units remain connected during frequency and/or voltage excursion defined in *NERC PRC-024-2*[36]. AEP will also determine the clearing time requirement at the point of interconnection using AEP relaying standards, and document the requirement, as necessary, in the initial or amended Interconnection Agreement.

6.14 Communications & Procedures During Normal and Emergency Operating Conditions

The Requester will direct all switching, outage requests, and maintenance activities affecting the Requester-AEP interface to the appropriate AEP Energy Delivery Operations Center, which is responsible for reviewing, scheduling, and coordinating transmission facility outages and switching. The Requester must provide AEP and the RTE (if applicable) advanced written notice of a planned outage that may affect AEP's operational reliability. The Requester must follow all applicable outage coordination procedures[37].

In accordance with AEP's *Transmission Outage Management System (TOMSS) Business Rules*[38], the Requester will provide at least 30 days advance notice for an outage request except for momentary outages or low-risk, planned maintenance less than 30 minutes in duration. However, the applicable 30-day period may be extended, depending on the RTE. AEP must review and approve outage plan changes that occur less than 30 days before the outage date, which could affect the overall outage risk, on a case-by-case basis. On the switching date, the Requester's operator must contact AEP Energy Delivery Operations before the switching or planned maintenance activity begins.

If the requested outage creates an abnormal condition that could affect AEP system reliability and/or customer reliability, the Requester shall mitigate all identified risks and share its restoration plan with AEP.

If a planned outage affects the protection system(s) resulting in a reduced or inadequate protection scenario on an inter-tie line, the Requester must follow the *AEP Failure or Disabling of Protection Systems Procedure*[39] for proper outage notification. In addition, the Requester must coordinate all switching of its load and backup generation with the local AEP Energy Delivery Operations Center.

For an unplanned outage or maintenance that may affect AEP transmission operation reliability, the Requester must submit the forced outage to AEP and the RTE (if applicable) as soon as practical, and provide updates whenever new information is received. Appropriate communication protocols must be followed according to *AEP Transmission Operations Reliability Communication Protocol*[40],

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[36] NERC, PRC-024-2 — Generator Frequency and Voltage Protective Relay Settings, 7/1/2016
[37] AEP Energy Delivery Operations, Outage Coordination Procedure, TOPS.01.013.00 PRO, Rev. 12, 7/31/2020
[38] AEP Energy Delivery Operations, Transmission Outage Management Strategy System (TOMSS) Business Rules and Process, Rev 3.0.0, 7/1/2020
[39]AEP Transmission, Failure or Disabling of Protection Systems Procedure, Rev. 3, 4/1/2018
[40] AEP Energy Delivery Operations, Reliability Communication Protocol Guideline, TOPS.01.053.00_GUI, 8/28/2020

AEP Transmission Operations Real-time Data Integrity Guideline[41], and the SCADA *Station Quality Procedure*[42].

This communications protocol does not replace any existing agreements between AEP and the Requester. If any conflicts exist between documents, the binding agreements take precedence.

6.15 Underfrequency Load Shedding

The Requester must install under frequency relays and shed load as outlined in the applicable RTE Load Shedding Guides.

[41] AEP Energy Delivery Operations, Real-time Data Integrity Guideline, TOPS.01.015.00_GUI, Rev. 2.0, 7/2/2020
[42] AEP Energy Delivery Operations, SCADA Station Quality Procedure, Rev. 0, 4/1/2018

7.0 Maintenance

The following subsections outline the requirements associated with facility maintenance, including ownership, cost, maintenance, compliance, and maintenance coordination.

7.1 Ownership, Cost, Maintenance, and Compliance

The Requester will install, operate and maintain in good order and repair, and without cost to AEP, all facilities that AEP requires for the safe operation of the Requester's facilities connected to AEP. At all times, the Requester's facilities must conform to good utility practice, National Electrical Safety Code (NESC), RTE requirements, NERC Reliability Standards, National Electric Code, and applicable laws and regulations. Any electrical facility operated as a part of the transmission grid must have the ownership, cost, maintenance, NERC, and RTE compliance responsibilities outlined in the IA or Interconnection and Local Delivery Service Agreement (ILDSA).

7.2 Maintenance Coordination

Maintenance Coordination requirements can be determined on an as needed basis with communication between AEP and the interconnecting parties.

Appendix A – Definitions

Interconnection Requirements Acronyms and Terms	
Acronym/Term	**Definition**
AEP	In this document, AEP refers to the AEP Transmission business unit and associated assets.
	American Electric Power – A major investor-owned electric utility in the United States, delivering electricity to more than five million customers in 11 states. AEP ranks among the nation's largest generators of electricity, and owns the nation's largest electricity transmission system.
AEP Station Service Power	The power consumed within the AEP-owned station to supply substation equipment.
ANSI	American National Standards Institute
Area Electric Power System	Electrical network of the transmission utility provider delivering/transporting electric power to load (Local EPS). See the *IEEE Standard 1547™ 2003 Glossary* for reference.
auxiliary load	A generator's auxiliary power consumption – also referred to as Auxiliary Load, and is provided through the Local Electric Power System owner, otherwise called the load serving entity (LSE).
BCT	bushing current transformer
BES	Bulk Electric System
CT	current transformer – A transformer used to monitor the current going through a piece of equipment. This device steps down the current to a lower level current suitable for a relay or meter input.
CVT	capacitive voltage transformer
DER	Distributed Energy Resources – A generating facility, not directly connected to the AEP transmission system, and may or may not participate in a wholesale market.
Effectively Grounded	X0/X1 less than or equal to 3 and R0/X1 less than or equal to 1 (IEEE definition)
EHV	extra-high voltage – Transmission lines rated 765kV, 500kV, and 345kV, and transformers with secondary voltages at or above 345kV, are considered extra-high voltage (EHV) facilities, and are referred to as *EHV facilities* in this document. These facilities are part of the BES. In some cases, from a design perspective, AEP may treat some facilities as *EHV* while they might not meet that voltage threshold.

EPS	1. Electric Power System – A network of electrical components that supply, transfer, and use electric power.
	2. ERCOT Polled Settlement – The ERCOT-required metering facilities owned by AEP typically installed to meter the interconnection between AEP and the GC Requester.
ERCOT	Electric Reliability Council of Texas – An ISO managing the flow of electric power to about 90% of the state's electric load. ERCOT performs financial settlements for the competitive wholesale bulk-power market. See RTE.
EUC	End-User Connection – New or materially modified connection that consumes all of the energy delivered or ultimately delivers the power to individual users. A delivery point (DP) or point of delivery (POD) is associated with this type of connection and power is expected to flow in one direction, from the AEP transmission system to the EUC Requester. Examples of this connection type are industrial facilities and other load-serving entities, such as electric cooperatives and municipals. Nothing herein should be construed to imply the provision of electric service directly to any retail consumer.
facility	A set of electrical equipment that operates as a single electric system element (e.g., a line, a generator, a shunt compensator, transformer).
FERC	Federal Energy Regulatory Commission
GC	Generator Connection – New or materially modified (affiliated or non-affiliated) connection for a generating facility, typically connected directly to the AEP transmission system, with the intention of participating in a wholesale market.
Generator Station Service Power	A generator's auxiliary power consumption – Also referred to as Auxiliary Load, and is provided through the Local Electric Power System owner, otherwise called the load serving entity (LSE).
GPR	ground potential rise
HV	high voltage – Transmission lines typically rated 230kV, 161kV, and 138kV, and transformers with secondary voltages above 100kV but below 345kV are considered High Voltage (HV) facilities, and are referred to as **HV facilities** in this document. These facilities are part of the BES.
HVP	high-voltage protection
IA	Interconnection Agreement – A legal document specifying terms and conditions for connecting AEP and Requester facilities.
ICCP	Inter-control Center Communications Protocol
IEEE	Institute of Electrical and Electronics Engineers

ILDSA	Interconnection and Local Delivery Service Agreement – A FERC jurisdictional agreement that defines a non-affiliate wholesale customer's physical delivery point interconnections to the AEP system that also contains rates/charges for AEP-provided wholesale distribution services not included in an RTO's Open Access Transmission Tariff (OATT).
IPP	Independent Power Producer
ISO	Independent System Operator – Regional organizations responsible for administering the electric transmission grid. See RTE.
kVA	Kilovoltampere
kVAR	Kilo Volt Ampere Reactive
kWh	Kilowatt-hour
Local Electric Power System	Local Electric Power System (EPS): 1. Affiliate wholesale electric distribution network/system/premises 2. Non-affiliate wholesale electric distribution network/system/ premises 3. Local electric power system is contained entirely with a single premises or group of premises. See the I*EEE Standard 1547™-2003 Glossary* for reference.
looped connection	A connection that is capable of receiving power from two (or more) directions.
LSE	load serving entity – The LSE is also the owner of the Local EPS system.
material modification	Any modification to facilities connected to, or in the process to be connected to AEP, that requires work to be executed on the AEP system or the contract in place for the connecting facility. This includes generation connections requested within an RTO generation interconnection queue and the potential impact of a modification on other requests with a later queue position.
MISO	Midcontinent Independent System Operator – A regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 15 U.S. states and the Canadian province of Manitoba. See RTE.
MLSE	Most Limiting Series Element. All series elements that together make up a line section, or substation transformer circuit, are reviewed to determine which element has the most limiting rating. The most limiting element will determine the normal and emergency ratings of the facility.
MOAB	motor operated air break
MW	Megawatt – One million watts

NEC	National Electric Code as approved by the American National Standards Institute (ANSI).
NERC	North American Electric Reliability Corporation
NESC	National Electric Safety Code
OATT	Open Access Transmission Tariff
OpCo	Operating Company – AEP's regional operating companies that directly serve distribution customers.
OPGW	optical ground wire – A type of shield wire that contains a set of optical fibers for communication.
OTB	option to build – A process whereby a Requester may have the option to assume responsibility for the design, procurement, and construction of certain facilities, which upon completion are typically transferred to AEP per terms of an applicable agreement.
P&C	protection and control
pilot protection systems	A system that uses communication channels to send information from the local relay terminal to the remote relay terminal thereby allowing high-speed tripping for faults occurring within 100% of the protected line.
PJM	PJM Interconnection – A regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia. See RTE.
POC	point of compliance
POI	point of interconnection
PQ	power quality
PT	potential transformer – A transformer used to monitor the voltage on a piece of equipment. This device reduces voltages to a lower level that is compatible for input into a relay or meter. The IEEE industry standard terminology for this is voltage transformer (VT).
radial	A substation or load being served by a single transmission source and can include substations with downstream DER or with batteries used as a transmission asset to support the substation during emergency scenarios.
RBS	rated breaking strength
Requester	In this document, Requester is defined as the entity requesting a new or materially modified interconnection and applies to the following: • Distributed Energy Resource Connection (DER) • End-User Connection (EUC) • Generator Connection (GC)

	• Transmission Interconnection (TI)
RTE	regional transmission entity – For the purpose of this document, any regional body having jurisdiction over a party, including the applicable RTO, ISO, or regional electric reliability organization under NERC authority.
RTO	Regional Transmission Organization – An organization that is responsible for moving electricity over large interstate areas. They coordinate, control, and monitor an electricity transmission grid. See RTE.
RTU	remote terminal unit – A device used for remote monitoring and control by sending telemetry data to SCADA or other industrial control systems.
SCADA	Supervisory Control and Data Acquisition – A system that collects, processes, and communicates real-time information back to a dispatch center, and provides remote control capability.
SIS	System Interconnections Services
SPP	Southwest Power Pool – A regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 17 states. See RTE.
SS Guides	Station Standards Guides – A set of AEP transmission standards that is available upon request with AEP approval.
SWPPP	Storm Water Pollution Prevention Plan
TCR	Transmission Construction Representative
TI	Transmission Interconnection – New or materially modified connection to the AEP transmission system from a non-affiliate power system, where power is expected to flow in either direction. These connections are often referred to as wires-to-wires interconnections, network interconnections, transmission-to-transmission interconnections, or interconnections. An example of a TI is connecting the AEP transmission grid to the transmission system of a neighboring utility.
TLES	Transmission Line Engineering Standards – A set of AEP transmission standards that is available upon request with AEP approval.
VAC	volts alternating current
VT	voltage transformer

Appendix B – Requester Information Requirements

B.1 GC and DER Information Requirements Form

Distributed Energy Resources (DER) Generation Connections (GC)

Generator Request Form Checklist

If the requirement is marked with:

- DER OH – The data is needed for DER facilities located within Ohio.
- DER Non-OH – The data is needed for DER facilities not located within Ohio.
- GC – The data is needed for all GC connections.

If the information was already provided during an earlier stage of study and has not changed, it does not need to be provided for later stages.

		Feasibility Study	Impact Study	Facilities Study	Combined Study
A	**Contact Information**				
A.1	Requester Name	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
A.2	Requester Title	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
A.3	Requester Address	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
A.4	Requester Phone	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
A.5	Requester Email	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
A.6	Technical Lead Name	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
A.7	Technical Lead Title	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
A.8	Technical Lead Phone	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
A.9	Technical Lead Email	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
B	**Project Schedule**				
B.1	Requested Generation Connection In-Service Date	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
C	**Project Scope**				
C.1	Detailed Request Description	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
C.2	AEP Asset that Customer's Facility Will Be Connected to	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
C.3	Electric Distribution Company	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
C.4	GPS Coordinates for the Point of Interconnection (POI)	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
C.5	Requested Voltage Class	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
C.6	RTO Queue Number (if applicable)	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
D	**Modeling Information**				
D.1	Characteristics of the Generator	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
D.2	Unit Capability Data	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
D.3	Unit Transformer Data	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
E	**Detailed Data**				
E.1	Unit Generator Dynamics Data		DER OH & GC	DER OH & GC	DER Non-OH
F	**Drawings, Diagrams, and Maps**				
F.1	Site Plan	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
F.2	One-Line Drawing of Facility	DER OH & GC	DER OH & GC	DER OH & GC	DER Non-OH
F.3	Three-Line Drawing of Generation System			DER OH & GC	DER Non-OH
F.4	Elementary Drawings			DER OH & GC	DER Non-OH

Distributed Energy Resources (DER) / Generation Connections (GC)

Go through the Checklist above to determine what information is required to be submitted to the respective RTO/Affiliate OpCo and/or respective AEP mailbox.

Generator Request Form

Clear Form Add Attachments

Contact Information (Requester)

Date	
Customer Name	
Customer Address	
Name	
Job Title	
Phone	
Email	

Contact Information (Technical Lead)

Name	
Job Title	
Phone	
Email	

Questions Based on Request

Is customer's facilities currently connected to AEP system?[i]

Type of Energy Source[ii]

Type of Generator (Synchronous, Induction, Inverter, etc…)[iii]

Is this a modification of an existing Generation facility?

If so, which facility?

Attachments	Included	Future	N/A
Site Plan[iv]			
One-Line Drawing of Facility[v]			
Three-Line Drawing of Gen. System[vi]			
Elementary Drawings[vii]			
System Modeling Data[viii]			
Project Schedule			

Request Information

Requested Generation Connection In-Service Date

Electric Distribution Company[ix]

County Name

Proposed Location (with GPS Coordinates) for POI

Request Description

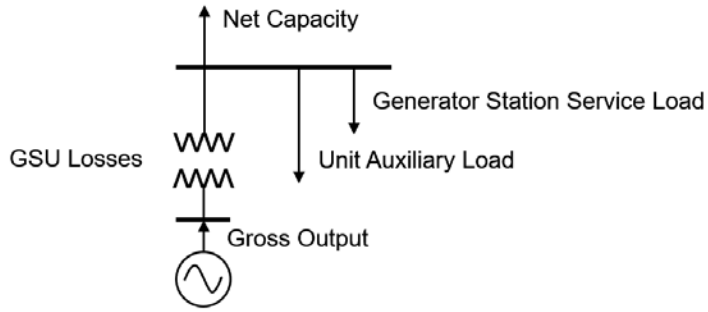
Voltage Class (kV)

Connected to Which AEP Asset?

RTO Queue Number (if applicable)

The Generating Equipment is intended to be used for:
(Emergency/Standby, Peak Shaving, Wholesale Market Participation, etc.)

Unit Capability Data[x]



Net Capacity = (Gross Output – GSU Losses – Unit Auxiliary Load – Generator Station Service Load

Season	**Max/Min**	**Data Point**	**Data**
Summer 92°F ambient air temperature	**Max**	Net Capacity (MW)	
		Unit Auxiliary Load (MW/MVAR)	
		GSU Losses (MW)	
		Gross Output (MW)	
	Min	Net Capacity (MW)	
		Unit Auxiliary Load (MW/MVAR)	
		GSU Losses (MW)	
		Gross Output (MW)	
Winter 30°F ambient air temperature	**Max**	Net Capacity (MW)	
		Unit Auxiliary Load (MW/MVAR)	
		GSU Losses (MW)	
		Gross Output (MW)	
	Min	Net Capacity (MW)	
		Unit Auxiliary Load (MW/MVAR)	
		GSU Losses (MW)	
		Gross Output (MW)	
		Generator Station Service Load (MW/MVAR)	
		Estimated Annual Energy Production (MWh)	
		Gross Reactive Power Capability at Max Gross Output (Leading & Lagging)	

Unit Generator Dynamics Data[xi]

MVA Base	
Nominal Power Factor	
Terminal Voltage (kV)	

Unsaturated Reactances (on MVA Base)

Direct Axis Synchronous Reactance	
Direct Axis Transient Reactance	
Direct Axis Sub-transient Reactance	
Quadrature Axis Synchronous Reactance	
Quadrature Axis Transient Reactance	
Quadrature Axis Sub-transient Reactance	
Stator Leakage Reactance	
Negative Sequence Reactance	
Zero Sequence Reactance	
Saturated Sub-transient Reactance	
Armature Resistance	

Time Constraints (seconds)

Direct Axis Transient Open Circuit	
Direct Axis Sub-transient Open Circuit	
Quadrature Axis Transient Open Circuit	
Quadrature Axis Sub-transient Open Circuit	
Inertia, H (kW-sec/kVA, on KVA Base)	
Speed Damping, D	
Saturation Values at Per-Unit Voltage [S(1.0), S(1.2)]	

IEEE Dynamic Model Parameters

Governor Model	
Exciter Model	
Power System Stabilizer Model	

Unit Transformer Data[xii]

Data Points	Data
# of Transformers	
Transformer MVA Base	
# of Transformer Windings	
Transformer Winding Impedance (R+jX, on transformer MVA Base) – High to Low	
Transformer Winding Impedance – High to Tertiary	
Transformer Winding Impedance – Low to Tertiary	
Transformer Rating (MVA)	
Transformer Low-side Voltage (kV)	
Transformer High-side Voltage (kV)	
Transformer Tertiary Voltage (kV)	
Transformer Winding Types (High-Low-Tertiary)	
Transformer Off-nominal Turns Ratio	
Transformer Number of Taps and Step Size	

Endnotes

[i] If yes, provide one-line diagram of existing connection arrangement with existing meter locations identified. Identify meter type (e.g., kWH revenue).
[ii] List what type of energy source/primary fuel type the generator is for this request: Solar, Wind, Hydro, Diesel, Natural Gas, Fuel Oil, Nuclear, Other (please specify).
[iii] Specify the type of technology used for the type of generator (steam turbine, combustion turbine, combined/simple cycle, etc.)
[iv] Plot plan or description showing the exact location and orientation of proposed facilities and point of electric service delivery. Note: AEP has specific guidelines for site selection and must approve the interconnection substation location and design – refer to Section 3.5.
[v] One-line diagrams shall include:

1. Equipment names and/or numerical designations for all circuit breakers, switches, transformers, generators, etc., associated with the generation.
2. Power Transformers – name or designation, nominal kVA, nominal primary, secondary, tertiary voltages, vector diagram showing winding connections, tap settings, and transformer impedance. A copy of the transformer nameplate and test report that includes both positive and zero sequence impedance information will ultimately be required.
3. Station Service Transformers – Designate phase(s) connected and estimated kVA load.
4. Instrument Transformers – Voltage and current, phase connections.
5. Surge Arresters/Gas Tubes/Metal Oxide Varistors/Avalanche Diode/Spill Gaps/ Surge Capacitors, etc. – Type and Ratings.
6. Capacitor Banks – kVAR rating.

7. Disconnect Switches – Indicate status normally open with a (N.O.) and whether manual or motor operated. Include switch voltage, continuous and interrupting ratings.
8. Circuit Breakers – Interrupting rating, continuous rating, operating times.
9. Generator(s) – Include nameplate, test report, type, connection, kVA, voltage, current, rpm, PF, impedances, time constraints, etc.
10. Point of Interconnection to power delivery system and phase identification.
11. Fuses – Manufacturer, type, size, speed, and location.

[vi] Three-line diagrams shall include, same as ii.

[vii] Provide potential and current drawings associated with the protection and control schemes for the generator and interconnection equipment. The drawings should include:

1. Terminal designation of all devices – relay coils and contacts, switches, transducers, etc.
2. Relay functional designation – per latest ANSI standard. The same functional designation shall be used.
3. Complete relay type (such as CV-2, SEL321-1, REL-301, IJS51A, etc.).
4. Switch contact shall be referenced to the switch development if development is shown on separate drawing.
5. Switch developments and escutcheons shall be shown on the drawing where the majority of contacts are used. Where contacts of a switch are used on a separate drawing, that drawing should be referenced adjacent to the contacts in the switch development. Any contacts not used should be referenced as spare.
6. All switch contacts are to be shown open with each labeled to indicate the positions in which the contract will be closed. Explanatory notes defining switch coordination and adjustment where mid-adjustment could result in equipment failure or safety hazard.
7. Auxiliary relay contacts shall be referenced to the coil location drawing if coil is shown on a separate drawing. All contacts of auxiliary relays should be shown and the appropriate drawing referenced adjacent to the respective contacts.
8. Device auxiliary switches (circuit breakers, contactor, etc.) should be referenced to the drawing where they are used.
9. Any interlocks (electromechanical, key, etc.) associated with the generation or interconnection substation.
10. Ranges of all timers and setting if dictated by control logic.
11. All target ratings; on dual ratings note the appropriate target tap setting.
12. Complete internal for electromechanical protective relays. Microprocessor type relays may be shown as a “black box,” but manufacturer’s instruction book number shall be referenced and terminal connections shown.
13. Isolation points (state links, PK-2 and FT-1 blocks, etc.) including terminal identification.
14. All circuit elements and components, with device designation, rating and setting where applicable. Coil voltage is shown only if different from nominal control voltage.
15. Size, type, rating and designation of all fuses.
16. Phase sequence designation as ABC or CBA.
17. Potential transformers – nameplate ratio, polarity marks, rating, primary and secondary connections (see Requirements for minimum ratings). Current transformers (including aux. CT’s) – polarity marks, rating, tap ratio and connection.

[viii] Modeling data must be supplied to AEP and/or the RTO/ISO to allow necessary interconnection studies to be performed. It is recognized that some of this data may initially be preliminary in nature. Interconnection studies will be based on data submitted. Changes or modifications to this data after the interconnection study has been completed may render the analysis invalid and require re-opening of the interconnection study. It is the Requester’s responsibility to make AEP and/or the RTO/ISO aware of changes to this data, and to provide final certified test reports and modeling data as soon as it is available.

[ix] Locate your EDC on your respective Public Utilities Commission (PUC) website for electric service area based on location.

[x] Provide all information regarding the expected unit capability. Make sure you submit the Reactive Capability Curve.

[xi] Provide all generator dynamics data about the unit. Make sure you submit the generator certified test report information.

[xii] Provide all transformer data about the unit. Make sure you submit the transformer test report information. Note: GSU/Collector step up transformer manufacturer’s certified test report must include positive- and zero-sequence impedances between all windings (including tertiary). Also, indicate whether the transformer is shared with other units.

B.2 EUC Information Requirements Form

End-User Connection (EUC)

New or Material Modification Request Form

Upon completion of the form and inclusion of all required details, please email to the inbox for the RTO in which you are located, as outlined in Section 2.1.1.

Clear Form

Add Attachments

Contact Information

Date (MM/DD/YYYY)	
Customer Name	
Customer Address	
Requester Name	
Requester Job Title	
Requester Phone	
Requester Email	

Attachments	Included	Future	N/A
Site Plan[i]			
One-Line Drawing of Facility[ii]			
System Modeling Data[iii]			

Questions

Do you have an existing contract with AEP?

If yes, who is your AEP Customer Account Manager?

What is your Service Contract # (if applicable)?

What type of load are you connecting?

Is this a new or materially modified delivery point?

If load is being transferred from another location, from where?

If load is being transferred, is the existing delivery point being materially modified? (If so, provide details)

Request Information

What is the target In-Service Date (ISD)?

Which AEP Operating Company (OpCo) is this delivery point located within?

What are the GPS coordinates of the delivery point?

What is the voltage class (kV) of the asset in which you are requesting to connect?

To which AEP asset are you requesting connection?

Please describe your request in further detail:

Load Ramp Schedule

Load Ramp Schedule Step [iv]	Description of Step	Normal Demand (MW)	Anticipated Peak Demand (MW)	Anticipated Power Factor (%)	Anticipated Load Factor (%)
Ultimate					

Is Load Seasonal or Flat?

Motor Information[v]

Motor Description[vi]	Size (hp)	Motor Code/Locked Rotor Current	Efficiency	Voltage on the Motor Side (kV)	Starting Power Factor	Running Power Factor	VFD?

Flicker Requirements

Delivery Point Descriptions[vii]

a) Please explain the planned high-side protection device(s) and relaying scheme, including manufacturer, type, voltage rating, and current rating of each device:

b) If utilizing fuse protection on the transformer(s), please provide the details of that device[viii]:

c) Please explain the power transformer(s) connection type[ix] and details of the unit(s):

d) Please explain the planned low-side protection device(s) and scheme, including all data on fuses, breakers, relays, and relay settings:

e) Please explain, if applicable, the size and the amount of fixed or switched capacitors or other power factor correction equipment and methods that will be utilized for operation:

f) Please explain the maximum magnitudes (MW & MVAR) of sudden load swings at the point of common coupling and the number of fluctuations per second, minute, or hour:

g) Please explain the maximum expected demand (MW & MVAR) at the point of interconnection (if different than indicated in the load ramp schedule):

h) Please provide data on the harmonic and sub-harmonic current/voltage spectra of the equipment to be installed under three-phase balanced and unbalanced conditions:

i) Please provide, if applicable, data on SVC (other FACTS or similar devices) and harmonic filters:

j) Please explain if this request is for the connection of a distribution system with high fault currents:

k) Please explain any special needs or requests:

Endnotes

[i] Plot plan or description showing the exact location and orientation of proposed facilities and point of electric service delivery.
[ii] Including high-side protection device(s), transformer, low-side protection device(s), and electrical configuration of the connection to the facility
[iii] Modeling data must be supplied to AEP and/or the RTO/ISO to allow necessary interconnection studies to be performed. It is recognized that some of this data may initially be preliminary in nature. Interconnection studies will be based on data submitted. Changes or modifications to this data after the interconnection study has been completed may render the analysis invalid and require re-opening of the interconnection study. It is the EUC Requester's responsibility to make AEP and/or the RTO/ISO aware of changes to this data, and to provide final certified test reports and modeling data as soon as it is available.
[iv] Include all steps of the anticipated load ramp, as necessary. Include, at a minimum, the first 5 years following in-service. Please include normal and peak demand in each perspective year.
[v] An additional survey may be required for detailed motor information. This relates to specific data related to motor loads and their protection settings as well as uninterrupted power supply back up information. This information will be collected in the form of an Electric Power Research Institute load survey spreadsheet to be filled out by the Requester. A copy of this survey can be provided by the Advanced Transmission Studies and Technology (ATST) department at AEP, if deemed necessary.
[vi] Include all motors and all the corresponding details regarding the motor.
[vii] Provide detailed descriptions of connection to AEP Transmission system.
[viii] AEP has specific requirements on when fuse style protection can be utilized, please refer to Section 3.1.1 of the Connection Requirements for details
[ix] AEP has specific requirements for the type of transformer connections allowed, please refer to Sections 3.1.1 and 4.4.1 of the Connection Requirements for details. Details needed of the unit(s) include: manufacturer's nameplate, serial number, available voltage taps, MVA ratings, high and low winding connections, low-side grounding (if used), and impedance test report data that includes percent impedance for both positive and zero sequence (primary-secondary1, primary-secondary2, secondary1-secondary2).

B.3 TI Information Requirements Form

Transmission Interconnection (TI)

New or Material Modification Request Form

Upon completion of the form and inclusion of all required details, please email to the inbox depending on the RTO in which you are located, as outlined in Section 2.1.1.

Clear Form Add Attachments

Contact Information

Date (MM/DD/YYYY)	
Customer Name	
Customer Address	
Requester Name	
Requester Job Title	
Requester Phone	
Requester Email	

Attachments	Included	Future	N/A
Site Plan[1]	☐	☐	☐
One-Line Drawing of Facility[2]	☐	☐	☐

Comment(s)/Description

Request Description

Additional Comment(s)

Request Information

Requested In-Service Date

GPS Coordinates of Requested Interconnection

Voltage Class (kV)

To which AEP asset will the interconnection be connected?

What is your Service Contract # (if applicable)?

[1] Plot plan or description showing the exact location and orientation of proposed facilities and point of interconnection.

[2] Including protection device(s) and electrical configuration of the connection.