Self-Build Requirements

Duke Energy Midwest
Transmission Interconnections

Revision 5
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Transmission Engineering
Midwest Production Standards

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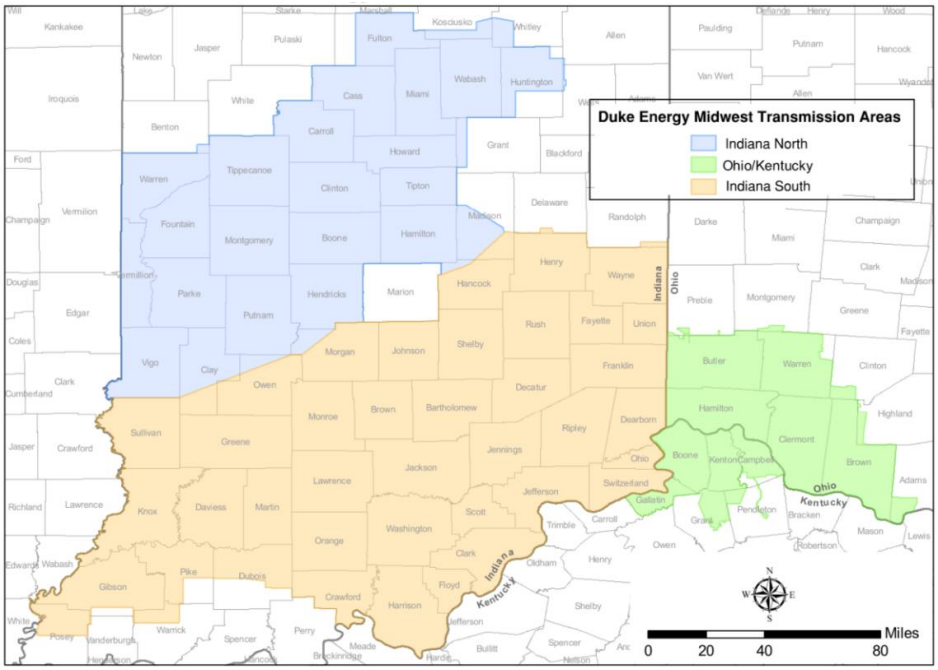
1.0 SUMMARY OF WORK

On April 19, 2018, the Federal Energy Regulatory Commission (FERC) issued its final rule of Order 845, addressing reform of generator interconnection procedures and agreements for generators of more than 20 megawatts (MW). To interconnect generation projects to the grid, developers and transmission providers must coordinate the construction and ownership of new transmission line facilities, a substation at the point where the generation will interconnect with the grid, and, if necessary, any additional upgrades to the transmission providers transmission system required to handle the increased generation capacity.

The purpose of this document is to identify and define necessary standards, specifications, processes, and procedures required to install transmission facilities that meet Duke Energy Midwest Transmission specifications, should the developer elect to self-build these facilities, that will ultimately be owned and operated by Duke Energy (Project). The standards set forth within this document pertain to facilities that Duke Energy will own and operate in the future. These specifications are not required for facilities that will remain owned, operated, and constructed by the developer. Specifications may vary by geographical operating location, so care should be taken to ensure the developer is applying the correct area specifications. Below is an illustration of Duke Energy Midwest's transmission system:

Figure 1: Duke Energy Midwest Electric Service Territories



The information and specifications noted within this document is to be utilized for engineering, procurement, and construction of the scope of work for the individual project, which may include the following transmission facilities:

1.1 Transmission Interconnection Switching Station

The substation portion of the Project shall consist of a three-breaker ring bus configuration, two of which terminals will bifurcate an existing transmission line circuit, and the third will connect to the developer's collector substation. To support the construction of a new substation, all construction activities must satisfy the following specifications:

- All required site preparation, fencing, foundations, grounding, support structures, termination structures, cabling, bus work, station service, DC supplies, Control Enclosure, yard lighting, signage, protection, controls, SCADA and Telecommunications equipment, in accordance with state and local codes as well as Duke Energy Midwest standards and specifications.
- All bus work shall be constructed with the appropriate structural and electrical properties to accommodate the ultimate fault levels provided by Duke Energy Midwest.
- Contractor shall be required to coordinate with Duke Energy Midwest for device number assignments as required. This will be further addressed during project kick-off meeting.
- Clearing and grading will be required to facilitate construction of the proposed substation.
- The following permits have been identified as required for expansion, but not limited to:
    - General Permit
    - Driveway Access Permit
    - Local building permits
    - Construction SWPPP
    - County Zoning (unless exempt by state code)
    - Flood zone use or wetlands modification (as required)

Refer to appendix 3.1 of this document for conceptual drawings for each station voltage rating.

1.2 Transmission Loop-in/out

All interconnection scopes will also require buildout of new transmission line facilities. An existing transmission line circuit will be split into two new segments and loop in and out of the new substation. Duke Energy Midwest will be responsible for making final connections; Contractor may be responsible for

new construction, excluding the final span to connect to existing infrastructure. Contact Duke Energy Midwest for reference information as it pertains to existing system information.

To support the construction of a new transmission line loop, all engineering, procurement, and construction activities will be required per the following specifications:

- All design, procurement, construction, and commissioning required for the project based on the scope of work, including required drawings, permits, project book(s), and information for submission to Duke Energy Midwest Transmission.
- All required site preparation, temporary construction permits, regulatory and local permits, fencing, sediment and erosion control, foundations, structures, and grounding for the project in accordance with the standards and specifications noted in Section 5.
- For an overview of the project on a map, please contact Duke Energy.
    - This is typically in the form of Google Earth Files, KMZ files, and screen captures from Duke Energy's internal network mapping system called MyWorld or Argus.
- Plan and profile drawings are considered record documents within the Duke Energy document management system. Existing or provided PLS CADD files are viewed as conceptual design support information to be vetted by Contractor for use in Contractor's design.

1.3 General Project Requirements and Deliverables

The Contractor will be responsible for the entire design, required studies, procurement, and construction of all the civil, structural, electrical, protection, control, isolation, and grounding systems; required drawings and information for submission to Duke Energy Midwest Transmission; as well as final construction project documentation and "as built drawings" associated with all components of the Project. Specific requirements of each discipline (Substation, P&C, Transmission Line) are noted throughout Section 3.

1.3.1 Site Selection

The site selection shall follow the recommended practices detailed in the Substation Site Elevation Selection Guide (Refer to Appendix Folder 5).

1.3.2 Submittals

The following are the minimum required submittals to be provided by Contractor for review and approval by Duke Energy Midwest Transmission:

A. Calculations, studies, reports, and analyses
B. Engineering Design Drawings
C. Material, shop/manufacture drawings, and equipment cut sheets

D. Construction submittals
E. Submittals shall include native files and PDF copies

1.3.3 General Requirements

A. All deliverables shall be prepared in accordance with Duke Energy Midwest Transmission and industry standards. Developer must request a copy of all pertinent standards and specifications prior to each project as standards may change from time to time.
B. Acceptable electronic formats will be Microsoft Word, Microsoft Excel, Microsoft Power Point, Primavera, Adobe/Bluebeam Revu PDF, Mathcad Prime, LPile, RAM Elements, FAD Tools, WinIGS, Inventor, Civil3D, and AutoCAD. AutoCAD drawings shall be prepared in accordance with Duke Energy Design and Drawing standards.
C. All designs, drawings and documents produced for this project are to be considered confidential and the property of Duke Energy Midwest Transmission and shall be provided in electronic format. Any other use is strictly prohibited without written permission from Duke Energy Midwest Transmission.
D. All design drawings produced for the Project and submitted as "Issued for Bid", "Issued for Permitting", or "Issued for Construction" and as part of the licensing submittal package shall be signed and sealed by a professional engineer licensed in the appropriate state.
E. Asset entry is to occur within the Duke Energy asset management system. Duke Energy Midwest Transmission will work with the contractor to gather the data and information needed to be entered to trigger the Duke Energy Midwest Transmission's maintenance tracking. Duke Energy Midwest Transmission will be responsible for submitting the data and information to the Duke Energy Transmission Data Management group for entry into the asset management system.

1.3.4 Engineering Milestones and Design Review Meetings

The following deliverables shall be provided to Duke Energy Midwest Transmission during the design process and shall be provided for each facility identified in Section 1.0, Overview and Description of Project. All deliverables shall be submitted for review, comments, and **APPROVAL**. Work on any task that depends on a submittal that is pending review by Duke Energy Midwest Transmission shall not be performed until Duke Energy Midwest Transmission comments are returned. Time for reviewing the drawings shall be included in the work schedule (Contractor shall assume a minimum of 4-week review period by Duke Energy Midwest Transmission for each compliance submittal prior to any scheduled design review meeting). The Contractor shall provide Duke Energy Midwest Transmission electronic versions, for each design deliverable in accordance

with the project schedule. Design documents and drawings shall be submitted in both PDF and native formats (to verify adherence to Duke Energy Midwest Transmission drafting or design standards). In addition, the Contractor shall follow the guidelines as described on the Duke Energy Midwest Transmittal Letter when submitting Preliminary and Final design packages.

The Contractor will be required to participate, at a minimum, in the following review meetings to discuss Project deliverables (project manager and designated leads). In addition, discipline-specific bi-weekly meetings will be held during the design phase as the design develops. It shall be assumed the following meetings will take place at a mutually agreed upon location:

- Project Kick-off/Scope Review Meeting
- LiDAR and Boundary Surveys (including Topographic survey)
- Preliminary Design Review Meeting
- Geotechnical Investigations
- Intermediate Design Review Meeting
- Final Design Review Meeting
- Pre-Construction & Post-Construction Walkdowns
- Permit Acquisition/Package Review Meeting

2.0 TRANSMISSION PLANNING REQUIREMENTS

(Refer to Appendix Folder 2)

This section of the document defines the facility connection requirements as defined by Duke Energy Midwest Transmission Planning and detailed in Duke Energy Midwest Transmission Systems Facility Connection Requirements. As the transmission assets will be transferred to Duke Energy Midwest Transmission and operated and maintained by Duke Energy Midwest Transmission in the future, all equipment must meet the design criteria put forth by Duke Energy Midwest Transmission Planning.

2.1 Facility Ratings Requirements

(Refer to Appendix 2.1)

The information below describes the operating requirements of the transmission interconnection facilities:

2.1.1 Operating Voltage and Basic Impulse Level (BIL) Voltage

Refer to Surge Protection/Insulation Coordination for BIL ratings for various equipment based on the nominal system voltage.

2.1.2 Minimum Component Ratings in the Substation

The table below indicates continuous and fault current ratings for various equipment based on nominal system voltage.

Category/Component	**69kV**	**138kV**	**230kV**	**345kV**
Main Bus	2000A	2000A	2000A	3000A
Transmission Terminal (motor-operated isolating switches, jumpers, connectors)	2000A	2000A	2000A	3000A
Circuit Breakers (Operating)	2000A	3000A	3000A	3000A
Circuit Breakers (Interrupting)	40kA	40kA	40kA	50kA

2.1.3 Short Circuit Levels Before Construction

Contact Duke Energy Midwest Transmission to obtain this information prior to start of design:

Base Voltage (kV)	**Pre-Fault Voltage (p.u.)**	**3-Ø Fault (A)**	**Positive Sequence Impedance**	**1- Ø Fault (A)**	**Zero Sequence Impedance**	**3Ø X/R**	**1Ø X/R**
kV	1		__ @ __° Ω		__@ __° Ω		

2.2 Interconnection Metering Requirements

(Refer to Appendix 2.2)

All metering, remote terminal unit (RTU), and communication requirements are provided in Interconnecting Facilities – Metering and Data Exchange Requirements document.

3.0 ENGINEERING DESIGN REQUIREMENTS

(Refer to Appendix Folder 3)

This section of the document defines the facility design requirements as defined by Duke Energy Transmission Engineering. As the Project transmission assets will be transferred to Duke Energy Midwest Transmission and operated and maintained by Duke Energy Midwest Transmission in the future, all designs must comply with Duke Energy Midwest Transmission system standards.

3.1 Substation Engineering Requirements

(Refer to Appendix 3.1)

Design for a switching station implementing a ring-bus configuration with equipment layout composed of rigid tubular conductors supported on post insulators. The design will be based upon the applicable industry and Duke Energy Midwest Transmission standards below. Refer to *IEEE 1127 IEEE Guide for the Design, Construction, and Operation of Electric Power Substations for Community Acceptance and Environmental Compatibility* for a more detailed look into this section.

This portion of the document addresses all requirements of the substation physical design elements of the interconnection. All designs must be approved by Duke Energy Substation Engineering prior to construction.

3.1.1 Applicable Industry Standards

Use the most current industry standards and codes applicable to the Project. The standards applicable to this Project include but are not limited to:

- ANSI C93.1 - Requirements for Power-Line Carrier Coupling Capacitors and Coupling Capacitor Voltage Transformers (CCVT)
- IEEE Std. C93.3 - Requirements for Power-Line Carrier Line Traps
- IEEE Std. C93.4 - Standard for Power-Line Carrier Line-Tuning Equipment (30 kHz to 500 kHz) Associated with Power Transmission Lines
- ANSI C93.5 - Requirements for Single Function Power-Line Carrier Xmit/Rcv Equipment
- ASCE Manuals and Reports on Engineering Practice No. 113 - Substation Structure Design Guide

- ASTM B241 - Standard Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
- IEEE Std. 80 - Guide for Safety in AC Substation Grounding
- IEEE Std. 81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System
- IEEE Std. 367 - Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault
- IEEE Std. 525 - Guide for the Design and Installation of Cable Systems in Substations
- IEEE Std. 605 - Guide for Bus Design in Air Insulated Substations
- IEEE Std. 693 - Recommended Practice for Seismic Design of Substations
- IEEE Std. 837 – Standard for Qualifying Permanent Connections Used in Substation Grounding
- IEEE Std. 980 - Guide for Containment and Control of Oil Spills in Substations
- IEEE Std. 998 - Guide for Direct Lightning Stroke Shielding of Substations
- IEEE Std. 1313.2 - Guide for the Application of Insulation Coordination
- IEEE Std. 1402 - Guide for Physical Security of Electrical Power
- IEEE Std. 1427 - Guide for Recommended Electrical Clearances and Insulation Levels in Air-Insulated Electrical Power Substations
- IEEE Std. C37.30 - American National Standard Definitions and Requirements for High-Voltage Air Switches, Insulators, And Bus Supports
- IEEE Std. C62.82.1 - Standard for Insulation Coordination – Definitions, Principles, and Rules
- National Electrical Safety Code (NESC) C2-2023

3.1.2 Duke Energy Substation Standards, Guides, and Equipment

Substation engineering design shall be in accordance with the list of referenced standards identified in “Index – Self-Build Specifications and Drawings” document. Any deviations from Duke Energy Midwest Transmission standards, or use of subsequently released standards, require written authorization by Duke Energy Midwest Transmission. In the event of a discrepancy in any of the referenced standards, the Contractor shall contact Duke Energy Midwest Transmission for clarification. The results shall be documented accordingly. All files are included as appendices to this document.

3.1.3 Site-Specific Studies

The substation site location shall follow recommended practices outlined in the Substation Site Elevation Selection Guide. Additionally, the studies identified in the table below will help to ensure the substation is safe, reliable, and will meet its intended service life. All studies (including but not limited to those listed in the table below) shall be provided to Duke Energy:

Study	**Purpose**
Site Survey	Develop a Site Plan and Stormwater Management Plan
Geotechnical Investigation	Determine size and depth of foundations
Audible Noise Study	Determine if noise screening measures will be needed
AC Load Study	Size station service transformer needs based on major equipment and control house AC needs
Soil Resistivity	Use in a grounding study to create a grounding grid
Lightning Study	Determine the number of lightning masts and overhead shield wires

3.1.4 Site Grading

Site grading design will differ at various sites based on the region's topology and results from the site survey. The site elevation shall follow the following recommended practices outlined in the Substation Site Elevation Selection Guide. The substation pad (substation perimeter fence plus five feet outside the fence) shall have a maximum slope of one percent. The site outside the substation pad shall have a maximum slope of three-to-one. The substation pad shall be designed to shed stormwater outside the substation pad. The substation pad shall be designed to avoid any stormwater features (catch basin, retention pond, stormwater piping, etc.) inside the substation fence. A Stormwater Management Plan will be developed per state requirements for each site. This plan will specify detention pond requirements (if needed) for stormwater runoff. Stormwater runoff calculations to be submitted to Duke Energy for review. Final stormwater runoff calculations to be signed and sealed by PE and submitted to Duke Energy.

3.1.5 Spill Prevention Control and Countermeasure (SPCC) Plan

The contractor is responsible to complete Section III of the Spill Prevention Control and Countermeasure (SPCC) Plan (Appendix 3.1) including drawings and supporting documents. Section III of the Plan shall be signed and sealed by a Professional Engineer. The contractor shall submit all native files to Duke Energy after completion.

3.1.6 Foundations

The foundation layout will follow a standardized station layout. Detailed engineering for foundations will be site specific based on the geotechnical investigation. Foundation design calculations shall be submitted to Duke Energy for review. Final foundation design calculations shall be signed and sealed by Professional Engineer and submitted to Duke Energy. Depending on a site's size and grade, foundations may be required to be at different top-of-concrete elevations, while maintaining continuity of the bus and structure heights. Typically, the top-of-concrete is between two to six inches above the stone blanket inside the substation. Refer to Appendix 5 for concrete installation requirements.

3.1.7 Fences and Screening

NESC regulations and guidelines stipulate that all power substations be protected by a chain-link fence with warning signs. If the site is located near a public area, then contact Duke Energy Midwest Transmission to discuss options. The permitting process may trigger any additional requirements, as dictated by the local municipality. All local municipal requirements must be met and incorporated into the design. The fence shall be located away from energized equipment and conductors in accordance with NESC requirements. Refer to Appendix 5 for permanent fencing and Appendix 5 for temporary fencing requirements.

3.1.8 Access Roads

The substation standard design will allow for vehicular access to the substation and around the interior perimeter of the substation fence. To facilitate maintenance, additional access drives will be built to allow vehicle access to each structure. Access roads will connect to existing roadways and have a maximum slope of five percent outside the substation pad. Refer to Appendix 5 for access road and drive aggregate requirements.

3.1.9 Grounding Design

The Grounding Design section covers the design aspects as well as materials, parameters, and considerations. Without a properly designed grounding system, large potential differences can exist between different points within the substation itself. Under normal circumstances, it is the current flow through the grounding grid from line-to-ground faults that constitutes the main threat to personnel. An effective substation grounding system consists of the following components:

- Driven ground rods,
- Buried interconnecting grounding cables or grid,

- Equipment ground mats,
- Cables from the buried grounding grid to metallic parts of structures and equipment,
- Connections to grounded system neutrals, and
- The ground surface insulating cover material.

Soil resistivity is site specific and will be measured before commencing grounding design. Resistivity values shall be obtained in accordance with IEEE Std. 81. The ground grid design will be based heavily upon the site's soil resistivity tests and short circuit currents. WinIGS Integrated Grounding System Analysis & Design software shall be used to model soil layers, step potential, and touch potential for ground grid design. The WinIGS file and Ground Grid Design report must be submitted to Duke Energy for review. Final ground grid design report must be signed and sealed by Professional Engineer and submitted to Duke Energy. Final WinIGS file shall be submitted to Duke Energy. Refer to appendix 3.1 for specific information related to ground grid analysis and design, including soil resistivity minimum specification requirements.

Soil testing shall be conducted a minimum of three days since the last rainfall at the site. All adjacent property owners shall be notified testing will take place. "Traverse lines" shall be defined as two perpendicular lines as it pertains to the specification.

3.1.10 Lightning Protection

The designer shall verify adequate shielding with the actual station layout. The lighting protection system will be designed using the "Rolling Sphere Method" as established in IEEE Std. 998. The design shall result in zero equipment area exposure. It is recommended to use WinIGS for this design. The lightning protection design report and any native files (Ex. WinIGS) shall be submitted to Duke Energy for review. Final lightning protection design report and native design files shall be signed and sealed by a Professional Engineer and submitted to Duke Energy. Protection is provided with a combination of shield masts and high transmission line shield wires. The high transmission line shield wires shall not cross directly over the substation high voltage bus and equipment.

3.1.11 Substation Cable Trench

In ground cable trench shall be one-piece sized for the immediate cable requirements with 100 percent additional capacity for future cables. Trench lids shall be fiberglass lightweight composite material; lifting tools shall be provided and kept at the station. All trenches provided shall be rated for H20 Heavy Traffic (32,000#/axle). All lids shall also be lightweight composite material and suitable for H20 Heavy Traffic.

3.1.12 Substation Outdoor Cabinets and Boxes

Outdoor cabinets and boxes shall be aluminum or stainless steel NEMA 3R or 4X. Painted steel cabinets and boxes are not allowed. Outdoor safety switches shall have stainless steel enclosures. Outdoor AC power cabinets shall be standard indoor panels mounted inside separate aluminum or stainless-steel cabinets.

3.1.13 Substation Bus Design

The current edition of the Institute of Electric and Electronic Engineers (IEEE) Std 605 and Std 693 shall be used along with ASCE/SEI Substation Design Guide 113 methodology shall be used for analysis and design of the rigid bus. The rigid bus design shall be designed to the Circuit Breaker short circuit ratings (Ex. 40kA, 63kA). Insulators shall also be verified to have enough capacity to support the rigid or flexible bus. Bus design and insulator checks to be completed by design firm and calculations submitted to Duke Energy for review. Final bus design calculations shall be signed and sealed by Professional Engineer and submitted to Duke Energy.

3.1.14 Substation Structures

All structures shall be Duke Energy standard designs. Calculations for Duke Energy standard structures will not be provided. Contractor to complete calculations on all Duke Energy Standard structures. If a Duke Energy standard design does not exist, then new structure shall be designed to meet applicable industry standards and Duke Energy standards. Structural Design in Ram Elements model and design calculation report shall be submitted to Duke Energy for review. Final Ram Elements Model and signed and sealed structural calculations report shall be submitted to Duke Energy.

3.1.15 Substation Preliminary Design Deliverables

The following section details all requirements of a preliminary substation design, to be submitted to Duke Energy Midwest Transmission when engineering design is approximately 30 percent complete:

- Major Materials List with associated cut sheets
- Conceptual Single Line and Three Line Diagrams (three-line to be physically arranged)
- Drawing List (of drawings included in this package)
- Geotechnical Testing Requirements and Soil Boring Locations
- Standard and Non-Standard Structures Identified
- Scope Document Revisions

- Substation Plan View with Section Cut Callouts
- Misc. Section Cuts (if concerns with clearances or tight spaces exist)
- Trench Plan Sketch
- Polysided Tubular Steel Design Drawing (with loading diagram)
- Foundation Plan
- Site Development Plan (with existing contours shown)
- Stormwater Drainage Requirements (memo with county-specific requirements)
- Flood Mapping
- Equipment Rating Notification Forms
- Permitting Requirements

3.1.16 Substation Intermediate Design Deliverables

The Contractor shall provide Intermediate Design Submittal Packages that will include all drawings and submittals listed in the preliminary design submittal, which have incorporated all Duke Energy Midwest Transmission preliminary design review comments, and advanced in design to approximately 60 percent complete. Contractor shall also include the following additional submittals for intermediate review:

- Conduit and Raceway
- Circuit Schedule (Coordinate with P&C)
- Foundation Plan and Details with Calculations
- Oil Containment Plan with Calculations
- Steel Details / Loading Diagrams with Calculations
- Steel Ram Elements model and structural calculations reports
- Bus Design Calculations
- Material List
- Shop/Manufacturer Drawings
- Control Enclosure Construction Drawings
- Soil Resistivity Data
- WinIGS Ground Grid Design files and PDF copy of the ground grid design report
- Grounding Plan
- Lightning Protection Design Report with Calculations / Design Files
- Landscaping Plan (as required)
- Site Development Plan

- Site Development Calculations
- Lighting Plan (designed to minimum 2 foot-candles across yard surface)
- Permit Package
- Drawing Index

3.1.17 Substation Final Design Deliverables

The Contractor shall provide Final Design Submittal Packages and shall include all drawings and submittals listed in the preliminary and intermediate design submittal, which have incorporated all Duke Energy Midwest Transmission preliminary and intermediate design review comments, and advanced in design to 100 percent complete. Contractor shall also include the following additional submittals for final review:

- Site Development Plan & Details
- Stormwater Management Plan
- Permitting Package
- Landscaping Plan & Details
- Geotechnical Reports
- Foundation Plan & Details (with final calculations)
- Grounding Plan & Details (with ground grid design report)
- Oil Containment/SPCC (as required)
- Substation Plan View and Elevations
- Lightning Protection Design Report
- Construction Sequence Drawings (as required)
- Commissioning Plan
- Conduit and Raceway Plan & Details
- Circuit Schedule (Coordinate with Protection and Control [P&C])
- Steel Details / Loading Diagrams (with final calculations)
- Final Bus Design Calculations
- Material List
- Shop/Manufacture Drawings
- Control Enclosure Construction Drawings
- Single Line and Three Line Diagrams (three-line to be physically arranged)
- Drawing Index

3.1.18 Substation Issued for Construction Submittal Packages

The Contractor shall provide Final Issued for Construction Packages which have incorporated all Duke Energy Midwest Transmission final design review comments. Final drawings shall be signed and sealed by Professional Engineer. All final calculations shall be signed and sealed by Professional Engineer.

3.1.19 Substation As-built Deliverables

The Contractor shall provide a Final As-built Packages for the completed Project. All as-built drawings shall be signed and sealed by Professional Engineer. For Substation As-Built packages, the Contractor shall set up a meeting with Duke Energy two weeks before the energization day to review the field marks. The Contractor shall also provide all equipment documentation, including drawings, instruction books, test manuals, etc. as part of this submittal. As part of the As-Built process, the Contractor is responsible for reviewing the integrity of the final product and rectifying in the field any non-conformities to Engineer-of-Record's intent. As-built deliverables include the following:

- Drawing Index (Substation)
- Complete set of As-Built drawings set to Rev 0 (Auto-CAD and PDF)
- Final Bill of Material
- Equipment Manufacturer Drawings
- Final As-Built site development plan including as-built survey data
- Ground Grid Verification (As-built Fall of Potential Test)
- All the final Study Reports (if any changes from the Final Submittal)
- Revised Calculations (if applicable)
- Four (4) sets of signed & sealed SPCC Plan hard copies as well as signed and sealed electronic PDF copy, including all final supporting files (if applicable)
- Construction photos from start to finish with a maximum of two weeks between groups of photos

3.1.20 Document Control

Duke Energy Midwest Transmission will be responsible for all document control in their Engineering Document Management System. Additional procedures for drawing and document control are to be established upon the project kick-off meeting as necessary.

3.2 Protection & Controls Engineering Requirements

(Refer to Appendix 3.2)

This portion of the document addresses all requirements of the P&C design elements of the interconnection. All designs must be approved by Duke Energy Midwest Transmission P&C Engineering prior to construction. Designs shall adhere to the P&C Design Standards as listed below:

3.2.1 P&C Engineering Standards, Guides, and Equipment

P&C engineering design shall be in accordance with the list of referenced standards identified in the "Index-Self-Build Specifications and Drawings" document. Any deviations from Duke Energy Midwest Transmission standards, or use of subsequently released standards, require written authorization by Duke Energy. In the event of a discrepancy in any of the referenced standards, the Contractor shall contact Duke Energy Midwest Transmission for clarification. The results shall be documented accordingly. All files are included as appendices to this document.

3.2.2 Protection Settings

Duke Energy Midwest Transmission will provide a relay writeup and all the protective relay settings for this project, as well as a SCADA Point Assignment List. Duke Energy Midwest Transmission will schedule regular meetings as needed between the Contractor and Duke Energy settings engineers. The Contractor shall submit the Preliminary Design Package to Duke Energy Midwest Transmission's settings engineers at least two weeks before the Preliminary Design Review Meeting.

3.2.3 P&C Preliminary Design Deliverables

The following section details all requirements of a preliminary P&C design, to be submitted to Duke Energy Midwest Transmission when engineering design is approximately 30 percent complete:

- Drawing Index (P&C drawings for this package only)
- Composite Panel Arrangement/Individual Panel Layouts w/BOMs
- Control Enclosure Layout
- Relay One-Line Diagram
- DC System Arrangement/layout (Fuse Panels, safety switches, batteries, charger, etc.)
- Preliminary Cable Tabulation
- Battery Calculation Results (spreadsheet)

- P&C Scope Revisions
- Relay diagrams

3.2.4 P&C Intermediate Design Deliverables

The Contractor shall provide Intermediate Design Submittal Packages that will include all drawings and submittals listed in the preliminary design submittal, which have incorporated all Duke Energy Midwest Transmission preliminary design review comments, and advanced in design to approximately 60 percent complete. Contractor shall also include the following additional submittals for intermediate review:

- Latest version of ALL drawings submitted in the Preliminary Submittal Package
- AC Schematics
- DC Schematics
- Partial Relay Panel and Equipment Wiring Diagrams
- Point Assignment Chart Drawings

3.2.5 P&C Final Design Deliverables

The Contractor shall provide Final Design Submittal Packages that will include all drawings and submittals listed above, which have incorporated all Duke Energy Midwest Transmission design review comments and completed all design. P&C Design Package will be considered 90 percent complete at this time. This submittal package shall include:

- Latest version of ALL drawings submitted in the Intermediate Submittal Package
- Drawing Index (P&C)
- Cable Tabulation
- Relay Panel and Equipment Wiring Diagrams

3.2.6 P&C Issued for Construction Submittal Packages

The Contractor shall provide Final Issued for Construction Packages which have incorporated all Duke Energy Midwest Transmission final design review comments. P&C construction packages will be distributed as outlined on the transmittal document.

3.2.7 P&C As-Built Deliverables

The Contractor shall provide Final As-built Packages for the completed Project. The Contractor shall also provide all equipment documentation, including drawings, instruction books, test manuals, etc. as part of this submittal. As part of the As-Built process, the Contractor is responsible

for reviewing the integrity of the final product and rectifying in the field any non-conformities to Engineer-of-Record's intent. P&C As-built deliverables shall include the following:

- Drawing Index (P&C drawings only)
- BOM/Panel Arrangement
- Relay Settings Files
- Control Enclosure Layout
- DC System Arrangement/layout (Fuse Panels, safety switches, batteries, charger, etc.)
- Cable Tabulations
- AC & DC Schematics
- Relay Panel and Equipment Wiring Diagrams
- Relay One-Line

3.3 Transmission Line Engineering Requirements

(Refer to Appendix 3.3)

This portion of the document addresses all requirements of the transmission line design elements of the interconnection. All designs must be approved by Duke Energy Midwest Transmission Line Engineering prior to construction. Designs shall adhere to the Line Design Standards as listed below:

3.3.1 Transmission Line Industry Standards, Guides, and Equipment

Use the most current industry standards and codes applicable to the project. The standards applicable to this project include but are not limited to:

- ASCE 10 – Design of Latticed Steel Transmission Structures
- ASCE 48 – Design of Steel Transmission Pole Structures
- ASCE MOP 74 – Guidelines for Electrical Transmission Line Structural Loading
- IEEE Std. 516 – Guide for Maintenance Methods on Energized Power Lines
- IEEE Std. 524 – Guide for the Installation of Overhead Transmission Line Conductors
- IEEE Std. 691 – Guide for Transmission Structure Foundation Design and Testing
- IEEE Std. 1048 – Guide for Protective Grounding of Power Lines
- IEEE Std. 1313.2 – Guide for the Application of Insulation Coordination
- IEEE Std. C62.82.1 – Standard for Insulation Coordination – Definitions, Principles and Rules
- National Electrical Safety Code (NESC) C2-2023

3.3.2 Duke Energy Transmission Line Standards, Guides, and Equipment

Transmission line engineering design shall be in accordance with the list of referenced standards identified in the "Index – Self-Build Specifications and Drawings" document. Any deviations from Duke Energy Midwest Transmission standards, or use of subsequently released standards, require written authorization by Duke Energy Midwest Transmission. In the event of a discrepancy in any of the referenced standards, the Contractor shall contact Duke Energy Midwest Transmission for clarification. The results shall be documented accordingly. All files are included as appendices to this document.

3.3.3 Surveys and Geotechnical Investigation

The studies and reports identified below are required to verify an accurate and safe design:

- Topographic and Boundary Surveys
- LiDAR Surveys
- Geotechnical Reports
- Electric and Magnetic Field (EMF) Analysis [if applicable]

3.3.4 Transmission Line Preliminary Design Deliverables

The following section details all requirements of a preliminary transmission line design, to be submitted to Duke Energy Midwest Transmission when engineering design is approximately 30 percent complete:

- Project Drawing List
- Routing Plan Drawing
- One-Line Drawing
- Design Criteria
- Permitting Matrix [Coordinate with Duke Energy as required]
- Equipment Rating Notification Form, If Applicable
- Conceptual Plan and Profile Drawings
- Conceptual Structure Framing Drawings
- Conceptual Construction Sequence Drawings as required
- Conceptual Commissioning Plan
- Geotechnical Scope of Work and Boring Plan
- Survey Package (LiDAR, Boundary Survey, Utility Survey, Environmental and Cultural) [Coordinate with Duke Energy as required]

3.3.5 Transmission Line Intermediate Design Deliverables

The Contractor shall provide Intermediate Design Submittal Packages that will include all drawings and submittals listed in the preliminary design submittal, which have incorporated all Duke Energy Midwest Transmission preliminary design review comments, and advanced in design to approximately 60 percent complete. Contractor shall also include the following additional submittals for intermediate review:

- Project Drawing List
- Routing Plan Drawing
- One-Line Drawing
- Design Criteria
- Equipment Rating Notification Form, If Applicable
- EMF Calculations, If Applicable
- EMF Package, If Applicable
- FAA Notice Submission
- Environmental Permits and Drawings [Coordinate with Duke Energy as required)
- Clearing Plan
- PLS CADD Backup file (uncompressed)
- Plan and Profile Drawings
- Structure Framing Drawings
- Construction Sequence Drawings
- Commissioning Plan

3.3.6 Transmission Line Final Design Deliverables

The Contractor shall provide Final Design Submittal Packages and shall include all drawings and submittals listed in the preliminary and intermediate design submittal, which have incorporated all Duke Energy Midwest Transmission preliminary and intermediate design review comments, and advanced in design to 100 percent complete. Contractor shall also include the following additional submittals for final design review:

- Auto-CAD Plan & Profiles (version 2009)
- PLS-CADD Backup files (uncompressed)
- PLS-Pole Backup files (uncompressed)
- Design Criteria

- Phasing Diagrams Eng Field Reports
- Clearing Project Book:
    - State Location Map
    - Detailed Location Map
    - Material List (if applicable)
    - Work Instructions
    - Easement List
    - Notification & Permits (including approved drawings)
    - Plan & Profile Drawings (in indicated clearing info)
    - Standards & Assemblies (if applicable)
    - Field Reports
- Foundation Project Book:
    - State Location Map
    - Detailed Location Map
    - Material
    - Work Details
        - List of Structures – Construction
        - Foundation Instructions
        - Foundation Construction Schedule
        - Soil Borings
        - Excavation/Subsurface Engineering Reports
        - Easement List
        - Notification & Permits (including approved drawings)
        - Structure Delivery Notification
        - Plan & Profile Drawings
        - Foundation Installation Drawings
        - Steel Pole Manufacturer Drawings
        - Structure Orientation Drawings
        - Standards & Assemblies (if applicable)
        - Field Reports
- Electrical Project Book:
    - State Location Map
    - Detailed Location Map
    - Preliminary (Construction) One-Line

- Existing One-Line
- Switch Location Map
- Switch Number Information Drawing
- Phasing Details
- Bill of Material – Construction
- Site Bill of Material – Construction
- Work Details:
  - List of Structures – Construction
  - Foundation Construction Schedule
  - Soil Borings
  - Excavation/Subsurface Engineering Reports
  - Wire Installation Instructions
  - Table of Wire Installation Charts
  - Wire Installation Charts
  - List of Structures – Removal
  - Wire Removal Instructions
  - Table of Wire Removal Charts
  - Wire Removal Charts
  - Orientation Drawings (Auto-CAD)
  - Survey Reports

- Easement List
- Pole Delivery Notification & Permit Drawings
  - Pole Delivery Notification
  - Permit Drawing Index
  - Permits (with Approved Drawings)
- Drawings
  - Plan & Profile Drawings (Proposed and Referenced)
  - Concrete Manufacturer Drawings
  - Foundation Installation Drawings
  - Steel Pole Manufacturer Drawings
  - Structure Orientation Drawings
- Standards and Assemblies
- Field Reports
  - Transmission Design/Construction Project Summary

- Sag Reports
- Line Data Forms (filled out)
- Steel Pole Jacking Report
- Capital Project Close-out Checklist - Line Construction Projects

3.3.7 Transmission Line Issued for Construction Submittal Packages

The Contractor shall provide Final Issued for Construction Packages which have incorporated all Duke Energy Midwest Transmission final design review comments. Transmission Line construction packages will be distributed as outlined on the transmittal document.

3.3.8 Transmission Line As-Built Submittals

The Contractor shall provide a Final As-built Packages for the completed Project. As part of the As-Built process, the Contractor is responsible for reviewing the integrity of the final product and rectifying in the field any non-conformities to Engineer-of-Record's intent. As-built deliverables include the following:

- As-Built Plan & Profiles (Auto-CAD)
- Other Reference Plan & Profile Drawings (Auto-CAD)
- PLS-CADD Backup files with As-Built LiDAR incorporated (uncompressed)
- PLS-Pole Backup files with As-Built information incorporated (uncompressed)
- Grounding Resistance Report
- Pole Installation Report
- Rock and Screw Anchor Reports
- Wire Sag Report
- Project Books (Clearing, Foundation, & Electrical) including field revisions as PDF
- Construction photos from start to finish
- Post-Construction Lidar (as required)

3.4 Owner's Engineer

Duke Energy Midwest Transmission will, at the Contractor's expense, employ an Owner's Engineering team to verify all engineering deliverables are in accordance with Duke Energy Midwest Transmission standards and specifications.

4.0 MATERIAL & EQUIPMENT REQUIREMENTS

(Refer to Appendix Folder 4)

This section of the document defines the facility equipment requirements as defined by Duke Energy Midwest Transmission Engineering. As the transmission assets will be transferred to Duke Energy Midwest Transmission and operated and maintained by Duke Energy Midwest Transmission in the future, all material and equipment must comply with Duke Energy Midwest Transmission specifications. The Contractor must procure all equipment for this project. The Contractor shall acquire required equipment for the project based on the standard equipment list provided. The project schedule shall identify all the equipment and the lead times to acquire. All major equipment drawings must be approved by Duke Energy Midwest Transmission prior to construction. Refer to Section 3 regarding submittals to Duke Energy Midwest Transmission engineering departments.

4.1 Substation Equipment Specifications

(Refer to Appendix 4.1)

The following sections contain detailed material specifications for various substation major equipment. Refer to documents listed within the "Index – Self-Build Specifications and Drawings" document when purchasing major equipment for transmission substation projects.

4.1.1 Control Enclosure

All enclosures will be prefabricated off site with panels pre-wired in the factory. The enclosure shall be delivered to the site assembled as completely as possible

4.1.2 High-Voltage Circuit Breakers

The circuit breakers shall be as listed in the Major Equipment List. Reference Duke Energy Midwest Transmission Item Number when ordering.

4.1.3 Transmission Disconnect Switches

High voltage switches shall be as listed in the Major Equipment List.

4.1.4 Station Service Voltage Transformers (SSVTs)

SSVTs shall be as listed in the Major Equipment List.

4.1.5 Coupling Capacitor Voltage Transformers (CCVTs)

Relay and meter accuracy CCVTs shall be as listed in the Major Equipment List. All CCVTs should include carrier accessories (except 69kV).

4.1.6 Current Transformers

Interconnection Metering Current Transformers shall be as listed in the Major Equipment List, 0.15 B1.8 accuracy with Rating Factor of 2.0.

4.1.7 Surge Arresters

Surge arresters shall be as listed in the Major Equipment List. Note: The customer collector substation should be utilizing wye-grounding high side transformers. If not, consult with Duke Energy to determine appropriate Surge Arrester sizes needed.

4.1.8 Wave Traps

Wave traps and line tuners shall be as listed in theMajor Equipment List. Contact Duke Energy Midwest Transmission system protection for final tuning frequencies.

4.1.9 Polysided Tubular Steel (Substation Dead-End) Structures

The detailed steel specification is included. Contact substation engineering for a current list of preferred steel manufacturers.

4.1.10 Standard Shape Steel (Substation General) Structures

The detailed steel specification is included. Contact substation engineering for a current list of preferred steel fabricators.

4.1.11 Control and Instrumentation Cables

The detailed control cable specification and the detailed instrumentation cable specification is included. Contact substation engineering for a current list of preferred control cable manufacturers.

4.1.12 Substation Yard Lighting

Substation lighting shall be designed to provide 2 horizontal foot-candles across the surface of the substation. Yard lighting shall be provided by LED luminaires and include reflector shields, Eaton UFLD-X40-D-U-66-T-BZ-4N7-10K-U0037 or approved equal.

4.1.13 Cable Trench

The detailed cable trench specification is included. Contact substation engineering for a current list of preferred manufacturers.

4.2 Control Enclosure Requirements

(Refer to Appendix 4.2)

The Contractor will supply a pre-manufactured control enclosure for the Project. All enclosures will be prefabricated off site with panels pre-wired in the factory. The control enclosure shall be delivered to the site assembled as completely as possible. Subject to the specification, the control enclosure shall include:

- Transmission Line Relay Panels
- Circuit Breaker Control Panels
- RTU and Telecommunications Panels
- Interconnection Metering Equipment
- Station Battery & Charger
- AC & DC Distribution Panels and Station Service Transfer Equipment
- HVAC Equipment

The Duke Energy Midwest Transmission P&C equipment is listed in the Control Enclosure specification. All relay firmware shall meet SEL Special Specs Duke Midwest 783 document. The Contractor shall design schematic and wiring drawings using the example drawings provided. The Contractor shall be responsible for confirming that they have the latest standard drawings available. Duke Energy reserves the right to require the Contractor to use an alternative standard up until the Preliminary Design Review. The only exception to this shall be if the Owner believes there is a safety concern or if the project scope changes. Note that these are typical drawings. Contractor drawings shall be formatted and presented like the standard drawings with the correct options included. Telecom equipment shall not be shown on any P&C drawings. Rather, room will be reserved for telecom equipment in the panels. In addition, (1) 30A DC breaker will be provided for powering telecom equipment, with cable run to the appropriate panel for installation. The Contractor shall be responsible for following Duke Energy Midwest Transmission's CAD standards and plot styles. The Contractor shall use Duke Energy Midwest Transmission's standard drawings as well as the P&C Blocks for creating and/or modifying all drawings the Contractor is responsible for. All files are included as appendices to this document and are listed in the "Index – Self-Build Specifications and Drawings" document.

4.2.1 AC and DC Auxiliary Requirements

The battery system shall be single-cell jar and sized appropriately for the application. Refer to specification for battery sizing requirements. AC and DC load centers shall be site specific and sized appropriately.

4.2.2 Communication Requirements

Communication hardware requirements are listed in the Control Enclosure specification. Additional requirements will depend on the type of primary communications specified by Duke Energy Midwest Transmission. The following is the order of preference:

A. Direct fiber-optic connection to Duke Energy private network:
- Install (1) 2" conduit from inside the Control Enclosure to the outside fence (extend 10' beyond fence and cap conduit).

B. Cambium pole/radio installation:
- Install a cambium dish on top of a steel pole inside the substation (to be determined by site information).
- Install (1) 2" conduit between the pole and the Control Enclosure. Verify pole height, embedment, and location with Telecom group prior to design.

C. Leased line copper T1 service from Local Telco w/Positron copper type isolation (the copper T1 from the telco is terminated in the Positron box and converted to fiber which then connects to the control enclosure):
- Install fence bump out 10'x10' area for positron equipment (accessible by telecom company)
- Install 10' x 10' standalone fence for telecom equipment ("Dog Pen")
- Install 36" x 60" Outdoor NEMA 4X Hoffman box (aka Positron Cabinet) for demarcation point of entry
- Install (1) 3" conduit between control enclosure and Positron Cabinet
- Install (1) 4" conduit from the Positron Cabinet to 10' beyond the fence toward the street and cap
- Install fiber distribution panel in control enclosure and Positron Cabinet
- Install 12/12 single mode/multimode 50-micron hybrid fiber optic cable from control enclosure to Positron Cabinet
- Install outdoor rated CAT5 cable from control enclosure to Positron Cabinet
- Install DC power cable from control enclosure to Positron Cabinet
- Terminate DC in flip out dual fuse holder with properly sized fuses

D. Leased line copper T1 service from local telco w/RLH copper type isolation (the copper T1 from the telco is terminated in the RLH box then converted to fiber which then connects to the control enclosure):

- Install 2" conduit from an agreed upon pole outside of Substation to the Control Enclosure. Install fiber from RLH cabinet to communications panel. RLH copper type isolation will need to be installed inside and outside the Substation.

4.2.3 Protection Communication Hardware

Two (2) separate single-mode fiber paths shall be provided for communication between Owner relays and Contractor relays. These paths shall be physically separated. Either overhead optical ground wire (OPGW) or an underground path utilizing 2" conduit shall be used.

4.2.4 Revenue/Interconnect Metering

The Owner has identified the required interconnection metering in the Control Enclosure Specification. Upon delivery to the site, revenue meters are to be sent to Duke Energy Metering Department for acceptance testing and configuration prior to installation. The meters shall be installed per the schematics and key protection diagram provided. The primary meter shall be connected to metering class CT's and CCVT's.

4.2.5 Electrical Studies and Calculations

- AC and DC Station Load Calculations
- Control Enclosure HVAC Calculations
- Battery Ventilation Calculations
- Voltage Drop Calculations to substation equipment operating coils greater than 500 feet from Control Enclosure.
- Battery Sizing Calculations (refer to Sizing Lead-acid Batteries and Battery Chargers**)**

4.3 Transmission Line Equipment Specifications

(Refer to Appendix 4.3)

The following sections contain detailed material specifications for transmission line major equipment. Documents pertinaing to this section are listed in the "Index – Self-Build Specifications and Drawings" document.

4.3.1 Standard Series Steel Pole Structures

The detailed specification is included. Typical fabrication drawings are included. Contact Duke Energy Midwest Transmission line engineering for a current list of preferred suppliers.

4.3.2 Engineered Steel Pole Structures

The detailed specification and sample drawings are included. Contact Duke Energy Midwest Transmission line engineering for a current list of preferred suppliers.

5.0 CONSTRUCTION REQUIREMENTS

(Refer to Appendix Folder 5)

This section of the document defines the facility construction requirements as defined by Duke Energy Midwest Transmission Construction. As the transmission assets will be transferred to Duke Energy Midwest Transmission and operated and maintained by Duke Energy Midwest Transmission in the future, all construction must meet the requirements put forth by Duke Energy Midwest Transmission. Documents pertaining to this section are listed in the "Index – Self-Build Specifications and Drawings" document.

5.1 Siting, Permits, Land or Land-Use Acquisition, Regulatory and Outreach

Contractor to perform all siting under supervision of Duke Energy Midwest Transmission. Contractor will perform environmental studies to prepare the required application, permit and license for authorization of the work. The Contractor will be required to support this work by providing surveys, preliminary engineering, estimates of alternatives, information, drawings, schedules, etc. Contractor will develop a strategic Communication Plan with coordination and input from the Duke Energy Midwest Transmission for engaging local authorities, stakeholders, and agencies. The Communication Plan will detail who will be contacted and when and how to respond to stakeholder's questions and concerns, agency questions and/or hearing proceedings.

The Contractor will obtain all work permits, development permits, FAA permits, and other local approvals specific to the construction.

The Contractor will consult with Duke Energy Midwest Transmission's Land Agent to discuss project needs for temporary, revised, or supplemental easements as well as any greenfield easements necessary for the project. In addition, a review of potential encroachments along the proposed transmission line will be completed and an action plan developed with Duke Energy Midwest Transmission's Asset Protection Specialist. Contractor will provide the necessary plats, drawings, and property descriptions for inclusion into the final easement document.

5.2 Commissioning, Acceptance and Energization

Duke Energy Midwest Transmission, or a Duke Energy-provided contractor, shall be responsible for all the testing, commissioning, acceptance, and energization of all new facilities. The Contractor shall coordinate with Duke Energy Midwest Transmission to plan all required outages to integrate the new facilities to the existing system. The Contractor shall also be responsible for the planning and consideration of any outages required. The Contractor must coordinate with Duke Energy Midwest Transmission to meet the necessary

requirements for the design, communication, and protection. The Contractor shall be required to submit to Duke Energy Midwest Transmission the following deliverables:

5.2.1 Model Data Information (Impedance & Ratings)

- Model / System Configuration Changes
    - Nomenclature – new lines/breaker/switch – comes from Owner
    - Preliminary system configuration information needed (4) months prior to completion of outage
    - Major system changes / new substations / lines need to be incorporated into ECC/FRCC Seasonal Assessment, approximately six (6) months out submittal

5.3 Outage Constraints

Contractor shall design and construct in a manner that limits reliability risks to Duke Energy Midwest Transmission.

5.4 Construction Oversight

Duke Energy Midwest Transmission will, at the contractor's expense, provide a construction oversight individual to monitor construction activity.

5.5 Construction Testing

Duke Energy Midwest Transmission will require, at the contractor's expense, testing and inspections including but not limited to concrete testing, reinforcing steel inspection, steel inspections, welding inspections, compaction testing on fill, foundation observations, and drilled pier observations. Refer to minimum construction testing requirements.

APPENDIX

Supplementary specifications and drawings that were referenced throughout this document can be located on the following Duke Energy SharePoint (for internal users) and will be provided to customers (external users) following contractual agreement and project kickoff.

https://dukeenergy.sharepoint.com/sites/PSDEM/SitePages/Self-Build-Specs-&-Drawings.aspx

Folder 1 includes this document, and a document titled "Index – JTS Specifications and Drawings". "Index – JTS Specifications and Drawings", provides a list with descriptions of documents relating to JTS Requirements. Folders 2 thru 6 are supplementary documents to support this specification. Folders 2 thru 5

align with the sections of this document (i.e. Folder 3 within the SharePoint has Engineering Requirement Documents that support section 3 of this document).