Transmission Cost Estimation Guide

MTEP19

MISO

Purpose statement

The MISO transmission planning process focuses on making the benefits of an economically efficient electricity market available to customers by identifying transmission projects that provide access to electricity at the lowest total electric system cost. As a part of this process, MISO identifies essential transmission projects that will improve the reliability and efficiency of energy delivery in the region. Those projects are included in the MISO Transmission Expansion Plan (MTEP), an annual publication that is collaboration between MISO planning staff and stakeholders.

Certain types of projects as identified in MTEP require cost estimates to justify the business case for recommendation to MISO's Board of Directors. MISO provides cost estimates for these certain types of projects in order to evaluate alternatives. MISO's transmission cost estimation guide for MTEP 19 describes the approach and cost data that MISO uses in developing its cost estimates. This document's assumptions and cost data are reviewed yearly with stakeholders.

All cost estimate data in this document are in 2019 US Dollars and are inclusive of all applicable taxes. In general, costs were escalated 2.5% from values shown in MISO's cost estimation guide for MTEP 2018.

Disclaimer: This document is prepared for informational purposes only to support MISO planning staff in developing cost estimates and deriving benefit-to-cost ratios for solutions proposed for inclusion in the MISO Transmission Expansion Plan (MTEP). MISO's cost estimation approach is based on staff experience, vendor consultation, industry practice, and stakeholder feedback. MISO makes every effort to develop its cost estimates from the most accurate and appropriate assumptions and information available at that time. However, MISO cannot and does not guarantee the accuracy of information, assumptions, judgments, or opinions contained herein or derived therefrom. MISO may revise or terminate this document at any time at its discretion without notice. MISO's cost estimation assumptions are not an indication or a direction for how any particular project shall be designed or built.

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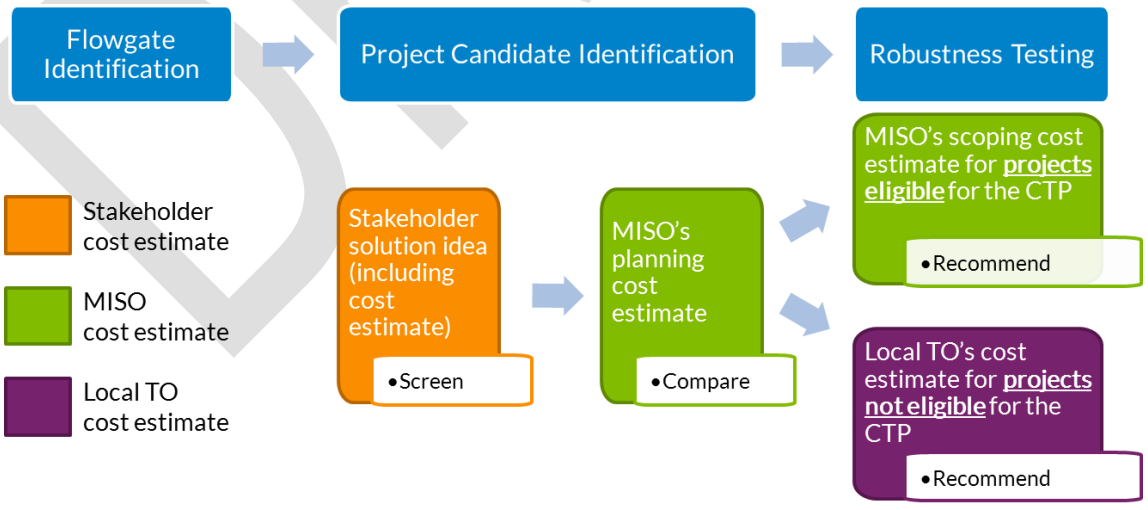
1. Cost estimates in the planning process

In MISO's planning process, estimated project costs are necessary to evaluate alternatives and recommend projects in the Market Congestion Planning Study (MCPS). The MISO Transmission Expansion Plan (MTEP) may result in a project(s) to be eligible as a Market Efficiency Project (MEP) or in a portfolio of Multi-value Projects (MVP). Eligibility for MEPs and MVPs include a benefit-to-cost ratio requirement - MISO determines the benefits through its planning process, and costs are estimated. A calculation template spreadsheet for calculating the benefit-to-cost ratio is on MISO's website.[1]

Estimating project costs requires review and coordination throughout the planning process. At the onset of the MCPS, stakeholders submit solution ideas that contain their cost estimate for a potential project. MISO utilizes stakeholders' cost estimate for initial screening of potential projects.

If a potential project passes the initial screening phase, MISO evaluates the costs of a potential project, and provides its planning cost estimate. MISO's planning cost estimates allow all potential projects' costs to be compared to each other using the same cost data and indicative assumptions.

If a potential project continues to show benefits in excess of cost, a more comprehensive scoping cost estimate is created. If the project is not eligible for the Competitive Transmission Process (CTP), the local Transmission Owner will provide the cost estimate and will discuss and review the project scope of work with MISO. If the project is eligible for the Competitive Transmission Process, MISO will provide the scoping cost estimate. MISO's scoping cost estimate is specific for that individual potential project and MISO may adjust any of its cost estimate assumptions and/or any of its unit costs as necessary for that specific potential project. For any facility upgrades included in the project, MISO will discuss its estimate assumptions with the facility owner. With either MISO's scoping cost estimate, or the local Transmission Owner's cost estimate, if the project continues to show a benefit-to-cost ratio of 1.25 or greater and is eligible, it will be recommended to MISO Board for approval.



[1] https://www.misoenergy.org > Planning > Transmission Studies and Reports > Economic Planning > MCPS

1.1 Power industry practices for project cost estimation

MISO researched industry practices for project cost estimating approaches, and has included an instructive reference from the AACE (formerly the Association for the Advancement of Cost Engineering) International©. The cost estimates that MISO provides generally align with the classes in the table below as described:

Class 5 – MISO's exploratory cost estimate

Class 4 – MISO's planning cost estimate

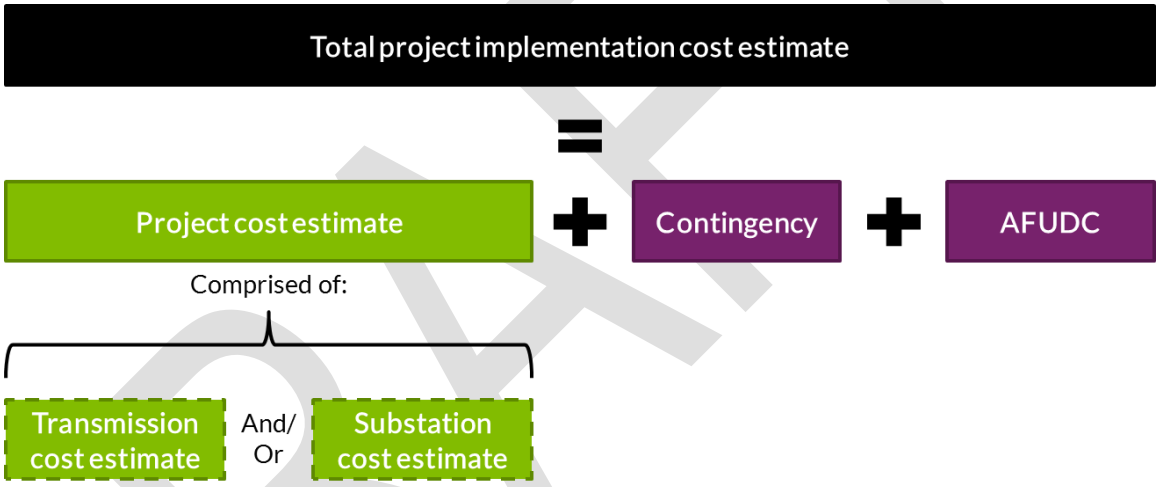
Class 3 – MISO's scoping cost estimate

	Primary Characteristic	*Secondary Characteristic*		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

Notes: [a] The state of process technology, availability of applicable reference cost data, and many other risks affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

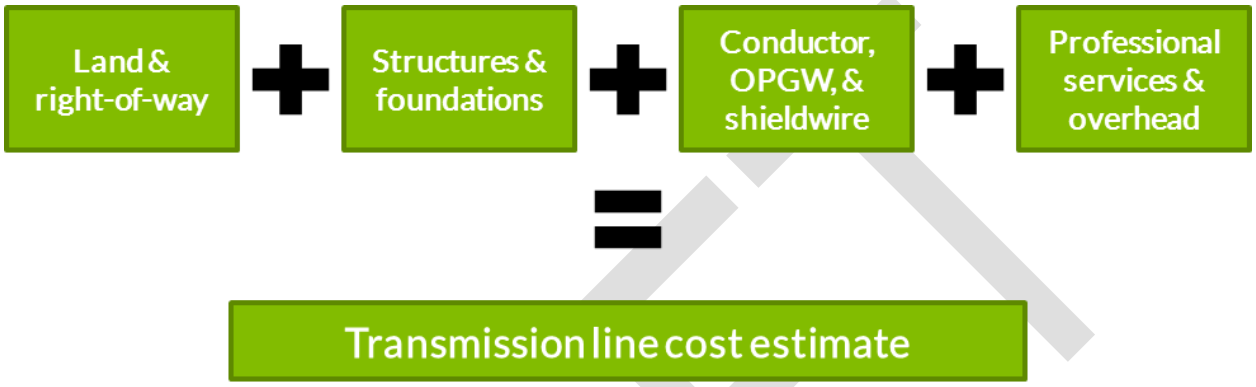
1.2 Total Project Implementation Cost

Cost estimates that MISO provides are intended to be inclusive of all costs required to implement the project. This is the total project implementation cost for a potential project. Included in the total project implementation cost estimate is the project cost (including professional services and overhead), contingency, and Allowance for Funds Used During Construction (AFUDC). Contingency is a cost adder to account for all the uncertainties/unpredictability and level of scope definition at the time of estimation. AFUDC is a cost adder to account for the cost of debt and/or the cost of equity required to develop and place the project in service. As shown in the diagram below, project cost plus contingency plus AFUDC equates to the total project implementation cost estimate that MISO uses for its cost estimates.



2. Transmission lines

MISO's transmission line cost estimates are sub-divided into four categories: land and right-of-way; structures & foundations; conductor, OPGW, & shieldwire; professional services and overhead. MISO's cost data and assumptions for transmission lines are described further in this section. The diagram below shows the four categories of a transmission line cost estimate:



2.1 Line length

The line length for a transmission line is a consideration for determining its cost estimate for a potential project. For planning cost estimates, the line length is determined by the straight line distance between the two substations plus a 30% line length adder. This 30% line length adder is intended to account for routing constraints that will be determined upon further development of the potential transmission line project. For scoping cost estimates, the line length is determined by a MISO-created proxy route based upon a desktop study. For new potential projects, MISO considers new right-of-way. For retrofit/re-conductor projects, MISO assumes that the existing right-of-way is adequate. MISO does not share its assumed proxy route information with stakeholders, as the route could be perceived as a MISO endorsed/preferred route. MISO's proxy route is merely an instrument to support the MISO's transmission line cost estimate. MISO utilizes Google Earth to determine route length, land types, and terrain types encountered.

2.2 Land and Right-of-Way

Land and right-of-way costs are all the costs required to acquire and prepare the land area for new potential transmission line projects. Land costs are based upon the acreage of land that the new transmission line would traverse. The total land affected is the length of the transmission line multiplied by the right-of-way width of the line. The right-of-way widths that MISO considers are intended to be indicative of right-of-way widths for transmission lines in each voltage class. Different project conditions in different locations may have a wider or narrower right-of-way width than the indicative value MISO assumes. MISO selects a right-of-way width for the purposes of creating its cost estimate. MISO's assumptions for right-of-way width are in the table below:

Single circuit and double circuit right-of-way width

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Right-of-way width indicative assumption (feet)	80	90	95	100	125	175	200

Land

MISO assumes that new land is required for all projects except transmission line rebuild projects. MISO has three categories of land costs: pasture, crop, and urban/suburban. Pasture land values are based on USDA published values. MISO utilizes the USDA pasture price as its initial cost for land value as it is a public resource that is updated yearly. MISO assumes that crop land is 3 times more expensive per acre than pasture land and that suburban/urban land is 5 times more expensive than pasture land. Based on its desktop analysis, MISO will determine the land type encountered for potential transmission line projects and estimate accordingly.

In addition to the cost of the land, MISO also includes indicative acquisition cost per acre and regulatory and permitting cost per acre. Real property rights for transmission projects include good faith negotiations with the land owners to acquire rights through easements, options, leases, fee purchases or eminent domain/condemnation. The costs includes routing analysis, public outreach, regulatory approval and permitting process, property tracts and mapping, land owner negotiations, land acquisition and condemnation fees.

Pasture land unit cost				
State – land	Land cost per acre	Acquisition cost per acre	Regulatory & permitting cost per acre	**Total cost per acre**
Arkansas	$2,648	$12,000	$2,500	**$17,148**
Illinois	$3,673	$12,000	$2,500	**$18,173**
Indiana	$2,721	$12,000	$2,500	**$17,221**
Iowa	$3,257	$12,000	$2,500	**$17,757**
Kentucky	$2,900	$12,000	$2,500	**$17,400**
Louisiana	$2,837	$12,000	$2,500	**$17,337**
Michigan	$2,679	$12,000	$2,500	**$17,179**
Minnesota	$1,787	$12,000	$2,500	**$16,287**
Mississippi	$2,322	$12,000	$2,500	**$16,822**
Missouri	$2,069	$12,000	$2,500	**$16,569**
Montana	$694	$12,000	$2,500	**$15,194**
North Dakota	$893	$12,000	$2,500	**$15,393**
South Dakota	$1,114	$12,000	$2,500	**$15,614**
Texas	$1,733	$12,000	$2,500	**$16,233**
Wisconsin	$2,469	$12,000	$2,500	**$16,969**

Crop land unit cost				
State – land	Land cost per acre	Acquisition cost per acre	Regulatory & permitting cost per acre	**Total cost per acre**
Arkansas	$7,943	$12,000	$2,500	**$22,443**
Illinois	$11,018	$12,000	$2,500	**$25,518**
Indiana	$8,164	$12,000	$2,500	**$22,664**
Iowa	$9,772	$12,000	$2,500	**$24,272**
Kentucky	$8,699	$12,000	$2,500	**$23,199**
Louisiana	$8,512	$12,000	$2,500	**$23,012**
Michigan	$8,038	$12,000	$2,500	**$22,538**
Minnesota	$5,360	$12,000	$2,500	**$19,860**
Mississippi	$6,965	$12,000	$2,500	**$21,465**
Missouri	$6,208	$12,000	$2,500	**$20,708**
Montana	$2,082	$12,000	$2,500	**$16,582**
North Dakota	$2,678	$12,000	$2,500	**$17,178**
South Dakota	$3,343	$12,000	$2,500	**$17,843**
Texas	$5,200	$12,000	$2,500	**$19,700**
Wisconsin	$7,408	$12,000	$2,500	**$21,908**

Suburban/Urban land unit cost				
State – land	Land cost per acre	Acquisition cost per acre	Regulatory & permitting cost per acre	**Total cost per acre**
Arkansas	$13,238	$12,000	$2,500	**$27,738**
Illinois	$18,363	$12,000	$2,500	**$32,863**
Indiana	$13,607	$12,000	$2,500	**$28,107**
Iowa	$16,287	$12,000	$2,500	**$30,787**
Kentucky	$14,499	$12,000	$2,500	**$28,999**
Louisiana	$14,186	$12,000	$2,500	**$28,686**
Michigan	$13,397	$12,000	$2,500	**$27,897**
Minnesota	$8,933	$12,000	$2,500	**$23,433**
Mississippi	$11,608	$12,000	$2,500	**$26,108**
Missouri	$10,347	$12,000	$2,500	**$24,847**
Montana	$3,470	$12,000	$2,500	**$17,970**
North Dakota	$4,464	$12,000	$2,500	**$18,964**
South Dakota	$5,571	$12,000	$2,500	**$20,071**
Texas	$8,666	$12,000	$2,500	**$23,166**
Wisconsin	$12,346	$12,000	$2,500	**$26,846**

Terrain and grading

Terrain and grading unit costs include all the costs associated with clearing and navigating the terrain along the route for the transmission line construction. These costs are the same for all voltage classes, and vary by the total amount of acreage encountered. The unit costs below are applied where portions of the potential transmission project encounter the different terrain types and grading conditions listed below. MISO will assume certain project specific mitigation costs when necessary.

Terrain and grading unit costs	
Voltage class	69kV – 500kV line
Level ground with light vegetation (per acre)	$265
Forested land (per acre)	$5,050
Wetland (per acre)	$106,215
Mountainous terrain (per acre)	$6,565

2.3 Structures and foundations

Structure costs are all the costs required to procure and install structures (inclusive of its required foundation) for new potential transmission line projects. MISO's transmission line cost estimates are comprised of five different structure types.

Structures per mile

In order to create a cost estimate for transmission lines, MISO makes indicative assumptions about the quantity of structures per mile required. The indicative assumptions are not connected to any specific project. The quantity of structures per mile that MISO assumes for its cost estimates are shown in the tables below:

Structures per mile – single circuit
Steel tower & steel pole

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Tangent structures	9.0	8.5	8.0	7.0	5.0	4.5	3.0
Small angle structures	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Large angle structures	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Strain structures	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Deadend structures	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total structures per mile	**10.5**	**10.0**	**9.5**	**8.5**	**6.5**	**6.0**	**4.5**

Structures per mile – double circuit
Steel tower & steel pole

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Tangent structures	9.5	9.0	8.5	7.5	7.0	6.0	5.0
Small angle structures	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Large angle structures	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Strain structures	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Deadend structures	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total structures per mile	**11.0**	**10.5**	**10.0**	**9.0**	**8.5**	**7.5**	**6.5**

Structures per mile – single circuit Wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Tangent structures	15.5	13.5	13.5	10.5	7.5	N/A	N/A
Small angle structures	0.5	0.5	0.5	0.5	0.5	N/A	N/A
Large angle structures	0.5	0.5	0.5	0.5	0.5	N/A	N/A
Strain structures	0.0	0.0	0.0	0.0	0.0	N/A	N/A
Deadend structures	0.5	0.5	0.5	0.5	0.5	N/A	N/A
Total structures per mile	**17.0**	**15.0**	**15.0**	**12.0**	**9.0**	N/A	N/A

Structures per mile – double circuit Wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Tangent structures	18.5	16.5	N/A	N/A	N/A	N/A	N/A
Small angle structures	0.5	0.5	N/A	N/A	N/A	N/A	N/A
Large angle structures	0.5	0.5	N/A	N/A	N/A	N/A	N/A
Strain structures	0.0	0.0	N/A	N/A	N/A	N/A	N/A
Deadend structures	0.5	0.5	N/A	N/A	N/A	N/A	N/A
Total structures per mile	**20.0**	**18.0**	N/A	N/A	N/A	N/A	N/A

Structure types

Tangent structures are the most commonly used structures where the transmission line alignment is relatively straight. Tangent structures support the conductor using a suspension insulator assembly. The suspension insulator assembly consists of insulator and hardware to provide necessary electrical insulation and strength for load transfer. The shieldwire (OPGW) is attached to the shieldwire suspension assembly near the top of the structure. The tangent structures are designed for 0° to 2° line angle with the highest applicable NESC loading in the MISO region.

Small angle structures are used where the line alignment changes direction and the line angle is between 2° and 15°. The structures are designed for the highest applicable NESC loading in the MISO region. Small angle structures support the conductor with suspension insulator assembly similar to tangent structures. The shieldwire (OPGW) is attached to the shieldwire suspension assembly near top of structure.

Large angle structures are used where the line alignment changes direction and the line angle is between 15° and 45°. The structures are designed for the highest applicable NESC loading in the MISO region. Large angle structures support the conductor with a suspension insulator assembly similar to tangent and small angle structures. The shieldwire (OPGW) is attached to a shieldwire suspension assembly near top of structure.

Strain structures are partial deadend structures and not designed for full terminal loads. They are designed to withstand some unbalanced wire tensions in one direction of one or all wires on one face of the structure. The strain structures are designed for line angle between 5° to 45°. The structures are designed for the highest applicable NESC loading in the MISO region.

Deadend structures are designed for full terminal loads for all wires and line angles between 0° and 90°. The structures are designed for the highest applicable NESC loading in the MISO region.

The steel weights and foundation sizes MISO considers for its steel pole and steel tower structure unit costs are intended to be an indicative value for structures at different voltage classes, and are not tied directly to any one structure design for that structure type. The steel pole structures are default structures for MISO project cost estimation process unless otherwise noted in the project scope definition.

The single and double circuit wood pole structures are included in the guide to address some of the project specific need involving wood pole construction. The wood pole structure costs that MISO considers for its unit costs are intended to be an indicative value for the structures at different voltage classes, and are not tied directly to any one structure design for that structure type. The single circuit wood pole structure costs up to 230 kV and double circuit wood pole structure costs up to 115 kV are included in this guide.

All structures have the following unit costs as shown in the tables below:

- Material cost includes the cost of design, manufacture (material, labor, equipment) and delivery of the structure including anchor bolts to site (laydown yard).
- Installation cost is the cost to haul, assemble, and install the structure, insulator, line hardware and grounding assemblies. Inclusive of the installation costs is access to the structure location, and restoration.
- Hardware cost includes material cost for insulator, line hardware and grounding assemblies.
- Foundation cost is the combination of the material cost and the installation cost for the foundation. Steel structures are assumed to be supported on a concrete drilled pier foundation. Wood pole structures are assumed to be embedded directly in the ground and embedment cost is included in the Installation cost. Drilled pier foundation size for a structure is indicated as concrete volume required per structure in cubic yards.

Tangent structure – single circuit – steel pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	7,000	7,900	8,400	9,300	11,100	22,300	35,100
Foundation size (Cu. Yd)	5.5	6.0	8.0	9.0	13.0	21.0	41.0
Material cost	$15,330	$17,301	$18,396	$20,367	$24,309	$48,837	$76,869
Installation cost	$22,995	$25,952	$27,594	$30,551	$36,464	$73,256	$115,304
Hardware cost	$4,028	$4,699	$5,036	$5,707	$6,713	$8,983	$9,834
Foundation cost	$7,205	$7,860	$10,480	$11,790	$17,030	$27,510	$53,710
Total cost per structure	**$49,558**	**$55,812**	**$61,506**	**$68,414**	**$84,516**	**$158,585**	**$255,716**

Tangent structure – single circuit – steel tower							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	6,100	6,900	7,300	8,100	10,100	20,300	27,000
Foundation size (Cu. Yd)	8.5	11.5	13.5	14.5	15.5	19.5	33.5
Material cost	$11,102	$12,558	$13,286	$14,742	$18,382	$36,946	$49,140
Installation cost	$16,653	$18,837	$19,929	$22,113	$27,573	$55,419	$73,710
Hardware cost	$4,028	$4,699	$5,036	$5,707	$6,713	$8,983	$9,834
Foundation cost	$11,135	$15,065	$17,685	$18,995	$20,305	$25,545	$43,885
Total cost per structure	**$42,918**	**$51,159**	**$55,936**	**$61,557**	**$72,973**	**$126,893**	**$176,569**

Tangent structure – single circuit – wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$4,300	$8,050	$8,150	$10,850	$11,750	N/A	N/A
Installation cost	$12,000	$12,500	$14,000	$20,000	$30,000	N/A	N/A
Hardware cost	$4,200	$4,750	$5,200	$5,750	$7,500	N/A	N/A
Total cost per structure	**$20,500**	**$25,300**	**$27,350**	**$36,600**	**$49,250**	N/A	N/A

Tangent structure – double circuit – steel pole

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	11,300	12,700	13,500	14,900	18,600	36,000	50,300
Foundation size (Cu. Yd)	8.0	10.0	14.5	17.5	23.0	46.5	78.5
Material cost	$24,747	$27,813	$29,565	$32,631	$40,734	$78,840	$110,157
Installation cost	$37,121	$41,720	$44,348	$48,947	$61,101	$118,260	$165,236
Hardware cost	$7,842	$9,149	$9,802	$11,109	$13,070	$17,587	$19,268
Foundation cost	$10,480	$13,100	$18,995	$22,925	$30,130	$60,915	$102,835
Total cost per structure	**$80,189**	**$91,781**	**$102,710**	**$115,612**	**$145,035**	**$275,602**	**$397,496**

Tangent structure – double circuit – steel tower

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	9,200	10,400	11,000	12,200	15,200	36,000	41,900
Foundation size (Cu. Yd)	13.0	17.0	19.5	21.0	22.0	31.5	48.5
Material cost	$16,744	$18,928	$20,020	$22,204	$27,664	$65,520	$76,258
Installation cost	$25,116	$28,392	$30,030	$33,306	$41,496	$98,280	$114,387
Hardware cost	$7,842	$9,149	$9,802	$11,109	$13,070	$17,587	$19,268
Foundation cost	$17,030	$22,270	$25,545	$27,510	$28,820	$41,265	$63,535
Total cost per structure	**$66,732**	**$78,739**	**$85,397**	**$94,129**	**$111,050**	**$222,652**	**$273,448**

Tangent structure – double circuit – wood pole

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$7,100	$13,300	N/A	N/A	N/A	N/A	N/A
Installation cost	$19,800	$20,650	N/A	N/A	N/A	N/A	N/A
Hardware cost	$6,950	$7,850	N/A	N/A	N/A	N/A	N/A
Total cost per structure	**$33,850**	**$41,800**	N/A	N/A	N/A	N/A	N/A

Small angle structure – single circuit – steel pole

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	8,400	9,500	10,100	11,200	13,300	31,800	45,600
Foundation size (Cu. Yd)	6.5	7.5	9.5	10.5	15.0	24.0	45.5
Material cost	$18,396	$20,805	$22,119	$24,528	$29,127	$69,642	$99,864
Installation cost	$27,594	$31,208	$33,179	$36,792	$43,691	$104,463	$149,796
Hardware cost	$4,028	$4,699	$5,036	$5,707	$6,713	$8,983	$9,834
Foundation cost	$8,515	$9,825	$12,445	$13,755	$19,650	$31,440	$59,605
Total cost per structure	**$58,533**	**$66,537**	**$72,778**	**$80,782**	**$99,181**	**$214,528**	**$319,099**

Small angle structure – single circuit – steel tower

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	6,800	7,700	8,100	9,000	11,300	22,600	30,100
Foundation size (Cu. Yd)	12.5	14.5	17.0	18.5	19.5	24.0	47.0
Material cost	$12,376	$14,014	$14,742	$16,380	$20,566	$41,132	$54,782
Installation cost	$18,564	$21,021	$22,113	$24,570	$30,849	$61,698	$82,173
Hardware cost	$4,028	$4,699	$5,036	$5,707	$6,713	$8,983	$9,834
Foundation cost	$16,375	$18,995	$22,270	$24,235	$25,545	$31,440	$61,570
Total cost per structure	**$51,343**	**$58,729**	**$64,161**	**$70,892**	**$83,673**	**$143,253**	**$208,359**

Small angle structure – single circuit – wood pole

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$5,600	$10,500	$10,600	$14,100	$15,300	N/A	N/A
Installation cost	$15,600	$16,250	$18,200	$26,000	$39,000	N/A	N/A
Hardware cost	$5,450	$6,200	$6,750	$7,500	$9,750	N/A	N/A
Total cost per structure	**$26,650**	**$32,950**	**$35,550**	**$47,600**	**$64,050**	N/A	N/A

Small angle structure – double circuit – steel pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	12,400	14,000	14,900	16,400	20,500	39,600	55,300
Foundation size (Cu. Yd)	9.5	12.0	17.0	20.0	26.0	51.5	85.5
Material cost	$27,156	$30,660	$32,631	$35,916	$44,895	$86,724	$121,107
Installation cost	$40,734	$45,990	$48,947	$53,874	$67,343	$130,086	$181,661
Hardware cost	$7,842	$9,149	$9,802	$11,109	$13,070	$17,587	$19,268
Foundation cost	$12,445	$15,720	$22,270	$26,200	$34,060	$67,465	$112,005
Total cost per structure	**$88,177**	**$101,519**	**$113,650**	**$127,099**	**$159,367**	**$301,862**	**$434,041**

Small angle structure – double circuit – steel tower							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	10,600	12,000	12,700	14,000	17,500	40,500	47,100
Foundation size (Cu. Yd)	18.0	22.0	27.0	28.5	30.0	39.5	59.0
Material cost	$19,292	$21,840	$23,114	$25,480	$31,850	$73,710	$85,722
Installation cost	$28,938	$32,760	$34,671	$38,220	$47,775	$110,565	$128,583
Hardware cost	$7,842	$9,149	$9,802	$11,109	$13,070	$17,587	$19,268
Foundation cost	$23,580	$28,820	$35,370	$37,335	$39,300	$51,745	$77,290
Total cost per structure	**$79,652**	**$92,569**	**$102,957**	**$112,144**	**$131,995**	**$253,607**	**$310,863**

Small angle structure – double circuit – wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$9,250	$17,350	N/A	N/A	N/A	N/A	N/A
Installation cost	$25,750	$26,800	N/A	N/A	N/A	N/A	N/A
Hardware cost	$9,000	$10,250	N/A	N/A	N/A	N/A	N/A
Total cost per structure	**$44,000**	**$54,400**	N/A	N/A	N/A	N/A	N/A

Large angle structure – single circuit – steel pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	11,600	13,000	13,900	15,300	18,300	37,900	59,700
Foundation size (Cu. Yd)	9.0	10.5	13.0	14.0	19.5	30.0	54.5
Material cost	$25,404	$28,470	$30,441	$33,507	$40,077	$83,001	$130,743
Installation cost	$38,106	$42,705	$45,662	$50,261	$60,116	$124,502	$196,115
Hardware cost	$4,028	$4,699	$5,036	$5,707	$6,713	$8,983	$9,834
Foundation cost	$11,790	$13,755	$17,030	$18,340	$25,545	$39,300	$71,395
Total cost per structure	**$79,328**	**$89,629**	**$98,168**	**$107,814**	**$132,451**	**$255,785**	**$408,086**

Large angle structure – single circuit – steel tower							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	9,200	10,400	11,000	12,200	15,200	30,500	39,800
Foundation size (Cu. Yd)	16.0	19.0	19.5	22.0	24.5	39.0	72.5
Material cost	$16,744	$18,928	$20,020	$22,204	$27,664	$55,510	$72,436
Installation cost	$25,116	$28,392	$30,030	$33,306	$41,496	$83,265	$108,654
Hardware cost	$4,028	$4,699	$5,036	$5,707	$6,713	$8,983	$9,834
Foundation cost	$20,960	$24,890	$25,545	$28,820	$32,095	$51,090	$94,975
Total cost per structure	**$66,848**	**$76,909**	**$80,631**	**$90,037**	**$107,968**	**$198,848**	**$285,899**

Large angle structure – single circuit – wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$7,550	$14,100	$14,250	$19,000	$20,550	N/A	N/A
Installation cost	$21,000	$21,900	$24,500	$35,000	$52,500	N/A	N/A
Hardware cost	$7,350	$8,300	$9,100	$10,050	$13,150	N/A	N/A
Total cost per structure	**$35,900**	**$44,300**	**$47,850**	**$64,050**	**$86,200**	N/A	N/A

Large angle structure – double circuit – steel pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	15,000	16,800	17,900	19,700	24,600	47,700	70,400
Foundation size (Cu. Yd)	13.0	15.5	21.5	25.5	32.5	61.0	99.0
Material cost	$32,850	$36,792	$39,201	$43,143	$53,874	$104,463	$154,176
Installation cost	$49,275	$55,188	$58,802	$64,715	$80,811	$156,695	$231,264
Hardware cost	$7,842	$9,149	$9,802	$11,109	$13,070	$17,587	$19,268
Foundation cost	$17,030	$20,305	$28,165	$33,405	$42,575	$79,910	$129,690
Total cost per structure	**$106,997**	**$121,434**	**$135,970**	**$152,372**	**$190,330**	**$358,655**	**$534,398**

Large angle structure – double circuit – steel tower							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	13,800	15,600	16,500	18,300	22,800	53,100	62,900
Foundation size (Cu. Yd)	22.5	28.0	34.5	37.5	46.5	59.0	87.5
Material cost	$25,116	$28,392	$30,030	$33,306	$41,496	$96,642	$114,478
Installation cost	$37,674	$42,588	$45,045	$49,959	$62,244	$144,963	$171,717
Hardware cost	$7,842	$9,149	$9,802	$11,109	$13,070	$17,587	$19,268
Foundation cost	$29,475	$36,680	$45,195	$49,125	$60,915	$77,290	$114,625
Total cost per structure	**$100,107**	**$116,809**	**$130,072**	**$143,499**	**$177,725**	**$336,482**	**$420,088**

Large angle structure – double circuit – wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$12,450	$23,250	N/A	N/A	N/A	N/A	N/A
Installation cost	$34,650	$36,150	N/A	N/A	N/A	N/A	N/A
Hardware cost	$12,150	$13,700	N/A	N/A	N/A	N/A	N/A
Total cost per structure	**$59,250**	**$73,100**	N/A	N/A	N/A	N/A	N/A

Strain structure – single circuit – steel pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	14,000	15,800	16,800	18,600	22,200	42,400	66,700
Foundation size (Cu. Yd)	11.0	12.0	15.0	16.5	22.5	33.5	60.0
Material cost	$30,660	$34,602	$36,792	$40,734	$48,618	$92,856	$146,073
Installation cost	$45,990	$51,903	$55,188	$61,101	$72,927	$139,284	$219,110
Hardware cost	$7,943	$9,267	$9,928	$11,252	$13,238	$32,286	$50,787
Foundation cost	$14,410	$15,720	$19,650	$21,615	$29,475	$43,885	$78,600
Total cost per structure	**$99,003**	**$111,492**	**$121,558**	**$134,702**	**$164,258**	**$308,311**	**$494,570**

Strain structure – single circuit – steel tower							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	10,400	11,700	12,400	13,800	17,200	34,500	45,900
Foundation size (Cu. Yd)	21.5	25.0	25.5	28.5	34.0	48.5	96.0
Material cost	$18,928	$21,294	$22,568	$25,116	$31,304	$62,790	$83,538
Installation cost	$28,392	$31,941	$33,852	$37,674	$46,956	$94,185	$125,307
Hardware cost	$7,943	$9,267	$9,928	$11,252	$13,238	$32,286	$50,787
Foundation cost	$28,165	$32,750	$33,405	$37,335	$44,540	$63,535	$125,760
Total cost per structure	**$83,428**	**$95,252**	**$99,753**	**$111,377**	**$136,038**	**$252,796**	**$385,392**

Strain structure – double circuit – steel pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	16,700	18,700	19,900	22,000	27,400	54,000	75,500
Foundation size (Cu. Yd)	15.5	18.5	25.0	29.5	37.0	68.5	109.0
Material cost	$36,573	$40,953	$43,581	$48,180	$60,006	$118,260	$165,345
Installation cost	$54,860	$61,430	$65,372	$72,270	$90,009	$177,390	$248,018
Hardware cost	$15,665	$18,276	$19,582	$22,192	$26,108	$64,214	$101,207
Foundation cost	$20,305	$24,235	$32,750	$38,645	$48,470	$89,735	$142,790
Total cost per structure	**$127,402**	**$144,893**	**$161,284**	**$181,287**	**$224,593**	**$449,599**	**$657,359**

Strain structure – double circuit – steel tower							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	16,100	18,200	19,300	21,400	26,600	61,200	71,200
Foundation size (Cu. Yd)	28.5	34.5	43.0	48.5	70.5	86.5	126.5
Material cost	$29,302	$33,124	$35,126	$38,948	$48,412	$111,384	$129,584
Installation cost	$43,953	$49,686	$52,689	$58,422	$72,618	$167,076	$194,376
Hardware cost	$15,665	$18,276	$19,582	$22,192	$26,108	$64,214	$101,207
Foundation cost	$37,335	$45,195	$56,330	$63,535	$92,355	$113,315	$165,715
Total cost per structure	**$126,255**	**$146,281**	**$163,727**	**$183,097**	**$239,493**	**$455,989**	**$590,882**

Deadend structure – single circuit – steel pole

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	20,400	23,000	24,500	27,100	32,400	48,100	80,700
Foundation size (Cu. Yd)	15.0	16.5	20.0	21.5	29.0	41.5	72.0
Material cost	$44,676	$50,370	$53,655	$59,349	$70,956	$105,339	$176,733
Installation cost	$67,014	$75,555	$80,483	$89,024	$106,434	$158,009	$265,100
Hardware cost	$7,943	$9,267	$9,928	$11,252	$13,238	$32,286	$50,787
Foundation cost	$19,650	$21,615	$26,200	$28,165	$37,990	$54,365	$94,320
Total cost per structure	**$139,283**	**$156,807**	**$170,266**	**$187,790**	**$228,618**	**$349,998**	**$586,940**

Deadend structure – single circuit – steel tower

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	13,400	15,200	16,100	17,800	22,200	44,700	59,400
Foundation size (Cu. Yd)	33.5	38.0	39.0	43.0	52.0	90.0	176.0
Material cost	$24,388	$27,664	$29,302	$32,396	$40,404	$81,354	$108,108
Installation cost	$36,582	$41,496	$43,953	$48,594	$60,606	$122,031	$162,162
Hardware cost	$7,943	$9,267	$9,928	$11,252	$13,238	$32,286	$50,787
Foundation cost	$43,885	$49,780	$51,090	$56,330	$68,120	$117,900	$230,560
Total cost per structure	**$112,798**	**$128,207**	**$134,273**	**$148,572**	**$182,368**	**$353,571**	**$551,617**

Deadend structure – single circuit – wood pole

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$8,600	$16,150	$16,300	$21,700	$23,500	N/A	N/A
Installation cost	$24,000	$25,000	$28,000	$40,000	$60,000	N/A	N/A
Hardware cost	$8,400	$9,500	$10,400	$11,500	$15,000	N/A	N/A
Total cost per structure	**$41,000**	**$50,650**	**$54,700**	**$73,200**	**$98,500**	N/A	N/A

Deadend structure – double circuit – steel pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	26,000	29,200	31,100	34,300	42,800	84,600	118,200
Foundation size (Cu. Yd)	20.0	24.0	32.0	37.0	46.0	81.5	127.0
Material cost	$56,940	$63,948	$68,109	$75,117	$93,732	$185,274	$258,858
Installation cost	$85,410	$95,922	$102,164	$112,676	$140,598	$277,911	$388,287
Hardware cost	$15,665	$18,276	$19,582	$22,192	$26,108	$64,214	$101,207
Foundation cost	$26,200	$31,440	$41,920	$48,470	$60,260	$106,765	$166,370
Total cost per structure	**$184,215**	**$209,586**	**$231,774**	**$258,455**	**$320,698**	**$634,164**	**$914,722**

Deadend structure – double circuit – steel tower							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Steel weight (pounds)	21,200	23,900	25,300	28,100	35,000	79,200	92,200
Foundation size (Cu. Yd)	43.0	50.5	61.5	68.5	99.0	125.0	236.0
Material cost	$38,584	$43,498	$46,046	$51,142	$63,700	$144,144	$167,804
Installation cost	$57,876	$65,247	$69,069	$76,713	$95,550	$216,216	$251,706
Hardware cost	$15,665	$18,276	$19,582	$22,192	$26,108	$64,214	$101,207
Foundation cost	$56,330	$66,155	$80,565	$89,735	$129,690	$163,750	$309,160
Total cost per structure	**$168,455**	**$193,176**	**$215,262**	**$239,782**	**$315,048**	**$588,324**	**$829,877**

Deadend structure – double circuit – wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$14,200	$26,650	N/A	N/A	N/A	N/A	N/A
Installation cost	$39,600	$41,250	N/A	N/A	N/A	N/A	N/A
Hardware cost	$13,850	$15,700	N/A	N/A	N/A	N/A	N/A
Total cost per structure	**$67,650**	**$83,600**	N/A	N/A	N/A	N/A	N/A

2.4 Conductor, OPGW, and shieldwire

Conductor, OPGW, and shieldwire costs are all the costs required to procure and install the conductor, OPGW, and shieldwire required for potential transmission line projects. Conductor costs are based upon the conductor selected and the length of the transmission line. Conductor type and size are based on the information contained in solution idea submission form and are based on economic planning model considerations for the required ampacity. MISO uses its Business Practice Manual 029 to assign appropriate conductor type and size for a project in lieu of necessary conductor information in the solution idea form.

Solution ideas may involve re-conductoring or upgrading existing conductor size to allow more power transfer by increasing ampacity of the existing circuit. In providing cost estimates for re-conductoring project scope, MISO assumes that the existing structures including foundations, insulators and hardware are adequate to support the new conductor size and configuration and discusses this assumption with the Transmission Owner. The costs of new conductor and installation are considered for the estimate of the retrofit projects.

Unless otherwise specified by the solution idea, MISO assumes one OPGW and one steel shieldwire per transmission circuit. MISO assumes conductor and shieldwire length adder of 4% for sag and wastage per conductor, OPGW, and shieldwire.

MISO primarily considers ACSR (Aluminum Conductor Steel Reinforce) and ACSS (Aluminum Conductor Steel Supported) conductor types in its cost estimates. Where required, MISO would consider the cost for T2 to be equivalent to two conductors of that size to the same cost when creating its cost estimate.

Conductors have the following unit costs as shown in the tables below:

- Material cost is the cost of manufacturing and deliver conductor to site (laydown yard).
- Installation cost is the cost to haul conductor reels, install, and sag and clip conductor on transmission structures.
- Accessories are the sleeves, spacers, and dampers material and installation cost required for a transmission line.

ACSR conductor (<1000 kcmil)				
Conductor	Installation cost per 1000 feet	Material cost per 1000 feet	Accessories cost per 1000 feet	**Total cost per 1000 feet**
266.8 kcmil "Waxwing"	$662	$539	$233	**$1,434**
266.8 kcmil "Partridge"	$841	$650	$233	**$1,724**
336.4 kcmil "Merlin"	$809	$575	$233	**$1,617**
336.4 kcmil "Linnet"	$988	$662	$233	**$1,882**
336.4 kcmil "Oriole"	$1,061	$826	$233	**$2,120**
397.5 kcmil "Chickadee"	$925	$709	$233	**$1,867**
397.5 kcmil "Ibis"	$1,124	$852	$233	**$2,209**
397.5 kcmil "Lark"	$1,261	$841	$233	**$2,334**
477 kcmil "Pelican"	$1,135	$831	$233	**$2,199**
477 kcmil "Flicker"	$1,187	$798	$233	**$2,219**
477 kcmil "Hawk"	$1,313	$993	$233	**$2,539**
477 kcmil "Hen"	$1,429	$1,106	$233	**$2,768**
556.5 kcmil "Osprey"	$1,271	$998	$233	**$2,502**
556.5 kcmil "Parakeet"	$1,460	$1,171	$233	**$2,865**
556.5 kcmil "Dove"	$1,523	$1,107	$233	**$2,864**
636 kcmil "Kingbird"	$1,429	$964	$233	**$2,626**
636 kcmil "Rook"	$1,649	$1,093	$233	**$2,975**
636 kcmil "Grosbeak"	$1,713	$1,252	$233	**$3,198**
666.6 kcmil "Flamingo"	$1,891	$1,261	$233	**$3,385**
795 kcmil "Coot"	$1,765	$1,278	$233	**$3,276**
795 kcmil "Tern"	$1,797	$1,208	$233	**$3,238**
795 kcmil "Cuckoo"	$2,028	$1,345	$233	**$3,605**
795 kcmil "Condor"	$2,112	$1,397	$233	**$3,742**
795 kcmil "Drake"	$2,091	$1,513	$233	**$3,837**
900 kcmil "Canary"	$2,564	$1,713	$233	**$4,509**
954 kcmil "Rail"	$2,112	$1,596	$233	**$3,941**
954 kcmil "Cardinal"	$2,690	$1,748	$233	**$4,671**

ACSR conductor (> 1000 kcmil)				
Conductor	Installation cost per 1000 feet	Material cost per 1000 feet	Accessories cost per 1000 feet	**Total cost per 1000 feet**
1033.5 kcmil "Ortolan"	$2,280	$1,750	$233	**$4,263**
1033.5 kcmil "Curlew"	$2,889	$1,930	$233	**$5,052**
1113 kcmil "Bluejay"	$2,437	$1,860	$233	**$4,530**
1192.5 kcmil "Bunting"	$2,606	$1,734	$233	**$4,572**
1272 kcmil "Bittern"	$2,774	$2,009	$233	**$5,015**
1272 kcmil "Pheasant"	$3,299	$2,196	$233	**$5,728**
1351.5 kcmil "Dipper"	$2,921	$2,173	$233	**$5,326**
1351.5 kcmil "Martin"	$3,425	$2,693	$233	**$6,351**
1431 kcmil "Bobolink"	$3,362	$2,463	$233	**$6,058**
1590 kcmil "Lapwing"	$3,751	$2,540	$233	**$6,524**
1590 kcmil "Falcon"	$4,371	$2,998	$233	**$7,602**
1780 kcmil "Chukar"	$5,348	$3,267	$233	**$8,848**
2156 kcmil "Bluebird"	$6,377	$3,848	$233	**$10,459**
2167 kcmil "Kiwi"	$5,705	$3,485	$233	**$9,423**
2312 kcmil "Thrasher"	$6,010	$3,992	$233	**$10,235**
2515 kcmil "Joree"	$6,356	$4,243	$233	**$10,833**

ACSS conductor (< 1000 kcmil)				
Conductor	Installation cost per 1000 feet	Material cost per 1000 feet	Accessories cost per 1000 feet	**Total cost per 1000 feet**
266.8 kcmil "Waxwing"	$662	$525	$233	**$1,420**
266.8 kcmil "Partridge"	$841	$672	$233	**$1,746**
336.4 kcmil "Merlin"	$809	$641	$233	**$1,683**
336.4 kcmil "Linnet"	$988	$767	$233	**$1,987**
336.4 kcmil "Oriole"	$1,061	$851	$233	**$2,145**
397.5 kcmil "Chickadee"	$925	$746	$233	**$1,903**
397.5 kcmil "Ibis"	$1,124	$909	$233	**$2,266**
397.5 kcmil "Lark"	$1,261	$1,009	$233	**$2,502**
477 kcmil "Pelican"	$1,135	$914	$233	**$2,282**
477 kcmil "Flicker"	$1,187	$956	$233	**$2,376**
477 kcmil "Hawk"	$1,313	$1,061	$233	**$2,607**
477 kcmil "Hen"	$1,429	$1,135	$233	**$2,796**
556.5 kcmil "Osprey"	$1,271	$1,009	$233	**$2,513**
556.5 kcmil "Parakeet"	$1,460	$1,166	$233	**$2,860**
556.5 kcmil "Dove"	$1,523	$1,219	$233	**$2,975**
636 kcmil "Kingbird"	$1,429	$1,135	$233	**$2,796**
636 kcmil "Rook"	$1,649	$1,313	$233	**$3,196**
636 kcmil "Grosbeak"	$1,713	$1,366	$233	**$3,311**
666.6 kcmil "Flamingo"	$1,891	$1,513	$233	**$3,637**
795 kcmil "Coot"	$1,765	$1,418	$233	**$3,416**
795 kcmil "Tern"	$1,797	$1,439	$233	**$3,469**
795 kcmil "Cuckoo"	$2,028	$1,618	$233	**$3,879**
795 kcmil "Condor"	$2,028	$1,618	$233	**$3,879**
795 kcmil "Drake"	$2,091	$1,522	$233	**$3,846**
900 kcmil "Canary"	$2,564	$1,670	$233	**$4,467**
954 kcmil "Rail"	$2,112	$1,624	$233	**$3,969**
954 kcmil "Cardinal"	$2,690	$1,801	$233	**$4,723**

ACSS conductor (> 1000 kcmil)				
Conductor	Installation cost per 1000 feet	Material cost per 1000 feet	Accessories cost per 1000 feet	**Total cost per 1000 feet**
1033.5 kcmil "Ortolan"	$2,280	$2,164	$233	**$4,677**
1033.5 kcmil "Curlew"	$2,889	$1,828	$233	**$4,950**
1113 kcmil "Bluejay"	$2,437	$2,322	$233	**$4,992**
1192.5 kcmil "Bunting"	$2,606	$1,944	$233	**$4,782**
1272 kcmil "Bittern"	$2,774	$2,080	$233	**$5,087**
1272 kcmil "Pheasant"	$3,299	$2,405	$233	**$5,937**
1351.5 kcmil "Dipper"	$2,921	$2,637	$233	**$5,791**
1351.5 kcmil "Martin"	$3,425	$2,343	$233	**$6,001**
1431 kcmil "Bobolink"	$3,362	$2,742	$233	**$6,337**
1590 kcmil "Lapwing"	$3,751	$2,690	$233	**$6,673**
1590 kcmil "Falcon"	$4,371	$3,001	$233	**$7,604**
1780 kcmil "Chukar"	$5,348	$3,499	$233	**$9,079**
2156 kcmil "Bluebird"	$6,377	$4,276	$233	**$10,886**
2167 kcmil "Kiwi"	$5,705	$5,096	$233	**$11,033**
2312 kcmil "Thrasher"	$6,010	$4,570	$233	**$10,813**
2515 kcmil "Joree"	$6,356	$4,791	$233	**$11,380**

OPGW and shieldwire

Optical Groundwire (OPGW) and shieldwire are installed at the top of structures to protect the conductors below from direct lightning strikes, and includes fiber optic cable.

OPGW and shield wires have the following unit costs as shown in the tables below:

- Material cost is the cost of manufacturing and delivery of the OPGW or shieldwire to site (laydown yard).
- Installation cost is the cost to haul the OPGW and shieldwire reels, install, and sag and clip conductor on transmission structures.

OPGW and shieldwire

Wire	Installation cost per 1000 feet	Material cost per 1000 feet	**Total cost per 1000 feet**
Shieldwire	$788	$525	**$1,313**
OPGW	$3,562	$2,374	**$5,936**

2.5 Professional services and overhead

Professional services and overhead cost adders are intended to include the costs to develop a project that are spread out over the entire project and are not easily quantifiable by individual items. MISO aggregates these costs into three subcategories in order to facilitate discussion on the larger cost adder value that MISO considers for these costs.

MISO has estimated the professional services and overhead required for potential projects as:

- 5.5% of project cost estimate: Project management (including mobilization and demobilization)
- 3.0% of project cost estimate: Engineering, environmental studies, testing and commissioning
- 1.5% of project cost estimate: Administrative and General Overhead (A&G)

2.6 Transmission Line Removal/Retirement

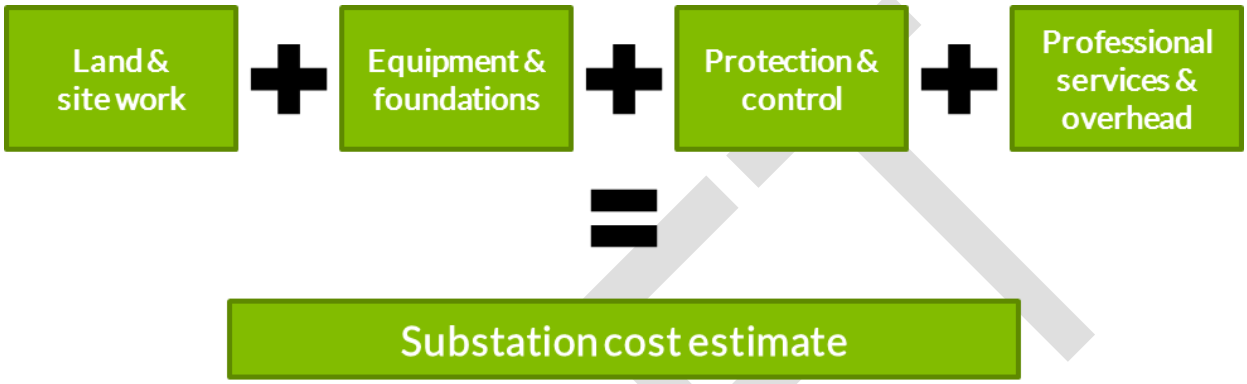
Removal cost of existing transmission line and/or substation involves complete removal or retirement of existing transmission line or substation equipment. The removal costs include all plant, tools, equipment, machinery, skill, supervision and labor.

Transmission line removal/retirement $/mile

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Wood pole – single circuit	$185,000	$215,000	$225,000	$237,500	$265,000	N/A	N/A
Wood pole – double circuit	$300,000	$345,000	N/A	N/A	N/A	N/A	N/A

3. Substations

Substation cost estimates are sub-divided in to four cost categories: land and site work; equipment and foundations; protection and control; professional services and overhead. MISO's cost data and assumptions are described further in this section. The diagram below shows the four categories of a substation cost estimate:



MISO provides cost estimates for both substation upgrades and for new substation sites. For planning cost estimates, MISO assumes size (acreage) requirements and equipment quantities based on general assumptions for the project area. Both the size of the substation facilities and the equipment quantities are dependent upon the voltage class of the facility and the number of new line/transformer positions being considered. For scoping cost estimates that are upgrades of existing substations, MISO discusses its scope of work assumptions with the existing substation owner. If the substation is a new facility, MISO follows requirements in its Business Practice Manual 029 (BPM-029).

3.1 Land and site work

Land and site work costs are all the costs required to acquire the land for the substation site and to procure and install all the substation general facilities. Land and site work unit costs are based on the acreage required to complete the substation work. MISO will adjust its land requirements as required by specific potential project ideas. For the access road into a substation, MISO uses Google Earth to estimate the length of the access road required.

Land

MISO assumes that new land is required for new substation sites, and as required for substation upgrades. Similar to with transmission line cost estimates; MISO has three categories of land costs: pasture, crop, and suburban/urban. Pasture land values are based on USDA published values. It is assumed that the crop land is 3 times the unit cost of pasture land and the suburban/urban land is 5 times the unit cost of pasture land. Based on its desktop analysis, MISO will determine the land type encountered for new potential substation projects.

In addition to the cost of the land, MISO also includes indicative acquisition cost per acre and regulatory and permitting cost per acre. Real property rights for transmission projects include good faith negotiations with the land owners to acquire rights through easements, options, leases, fee purchases or eminent domain/condemnation. The costs includes routing analysis, public outreach, regulatory approval and permitting process, property tracts and mapping, land owner negotiations, land acquisition and condemnation fees.

Pasture land unit cost

State – land	Land cost per acre	Acquisition cost per acre	Regulatory & permitting cost per acre	**Total cost per acre**
Arkansas	$2,648	$12,000	$2,500	**$17,148**
Illinois	$3,673	$12,000	$2,500	**$18,173**
Indiana	$2,721	$12,000	$2,500	**$17,221**
Iowa	$3,257	$12,000	$2,500	**$17,757**
Kentucky	$2,900	$12,000	$2,500	**$17,400**
Louisiana	$2,837	$12,000	$2,500	**$17,337**
Michigan	$2,679	$12,000	$2,500	**$17,179**
Minnesota	$1,787	$12,000	$2,500	**$16,287**
Mississippi	$2,322	$12,000	$2,500	**$16,822**
Missouri	$2,069	$12,000	$2,500	**$16,569**
Montana	$694	$12,000	$2,500	**$15,194**
North Dakota	$893	$12,000	$2,500	**$15,393**
South Dakota	$1,114	$12,000	$2,500	**$15,614**
Texas	$1,733	$12,000	$2,500	**$16,233**
Wisconsin	$2,469	$12,000	$2,500	**$16,969**

Crop land unit cost				
State – land	Land cost per acre	Acquisition cost per acre	Regulatory & permitting cost per acre	**Total cost per acre**
Arkansas	$7,943	$12,000	$2,500	**$22,443**
Illinois	$11,018	$12,000	$2,500	**$25,518**
Indiana	$8,164	$12,000	$2,500	**$22,664**
Iowa	$9,772	$12,000	$2,500	**$24,272**
Kentucky	$8,699	$12,000	$2,500	**$23,199**
Louisiana	$8,512	$12,000	$2,500	**$23,012**
Michigan	$8,038	$12,000	$2,500	**$22,538**
Minnesota	$5,360	$12,000	$2,500	**$19,860**
Mississippi	$6,965	$12,000	$2,500	**$21,465**
Missouri	$6,208	$12,000	$2,500	**$20,708**
Montana	$2,082	$12,000	$2,500	**$16,582**
North Dakota	$2,678	$12,000	$2,500	**$17,178**
South Dakota	$3,343	$12,000	$2,500	**$17,843**
Texas	$5,200	$12,000	$2,500	**$19,700**
Wisconsin	$7,408	$12,000	$2,500	**$21,908**

Suburban/Urban land unit cost				
State – land	Land cost per acre	Acquisition cost per acre	Regulatory & permitting cost per acre	**Total cost per acre**
Arkansas	$13,238	$12,000	$2,500	**$27,738**
Illinois	$18,363	$12,000	$2,500	**$32,863**
Indiana	$13,607	$12,000	$2,500	**$28,107**
Iowa	$16,287	$12,000	$2,500	**$30,787**
Kentucky	$14,499	$12,000	$2,500	**$28,999**
Louisiana	$14,186	$12,000	$2,500	**$28,686**
Michigan	$13,397	$12,000	$2,500	**$27,897**
Minnesota	$8,933	$12,000	$2,500	**$23,433**
Mississippi	$11,608	$12,000	$2,500	**$26,108**
Missouri	$10,347	$12,000	$2,500	**$24,847**
Montana	$3,470	$12,000	$2,500	**$17,970**
North Dakota	$4,464	$12,000	$2,500	**$18,964**
South Dakota	$5,571	$12,000	$2,500	**$20,071**
Texas	$8,666	$12,000	$2,500	**$23,166**
Wisconsin	$12,346	$12,000	$2,500	**$26,846**

Site work

Site work unit cost is differentiated by three different terrain types that could be encountered on a substation site – level ground with light vegetation, forested land, or wetland. Site work is inclusive of clearing and grubbing, grading, lightning protection, physical security, and grounding. Where specialized site components are required (e.g. specialized gates, access protection, import/export of soil) MISO will add those costs to its cost estimate and will call them out separately. Access roads are estimated based on the length of the road. Access roads allow entry to the substation site from the nearest drivable public road.

Site work unit costs

Voltage class	69kV – 500kV
Level ground with light vegetation (per acre)	$340,153
Forested land (per acre)	$344,938
Wetland (per acre)	$446,103
Access road (per mile)	$525,000

3.2 Equipment and foundations

Equipment and foundation costs are all the costs required to procure and install all the required equipment needed for substation upgrades or new substation facilities, and to procure and install their foundation in the substation site. In Section 4, MISO provided indicative equipment assumptions for its exploratory estimates that in general show equipment quantity assumptions MISO considers for its cost estimates. As cost estimates are more refined to specific projects, MISO may adjust its equipment quantities as required by specific potential project ideas.

Circuit Breakers

This unit cost is for the cost associated with one complete circuit breaker. Material cost is the cost to procure and deliver one circuit breaker to site (laydown yard). Installation cost includes: assembly; placement on the foundation; connection to the main ground grid; above ground conduit to connect the below grade conduit to the equipment control box; wiring to land the control cables on the terminal blocks in the equipment control box; jumpers and fittings to connect to substation bus. Foundation size is the amount of cubic yards of concrete required for the foundation. Foundation cost is the combination of the material and installation cost for the foundation.

Circuit breaker unit costs

Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Foundation size (Cu. Yd)	3.6	4.5	5.3	6.7	8.0	8.8	19.8
Material cost	$52,000	$65,000	$74,500	$84,000	$103,500	$314,500	$414,000
Installation cost	$10,400	$13,000	$14,900	$16,800	$20,700	$62,900	$82,800
Foundation cost	$4,716	$5,895	$6,943	$8,777	$10,480	$11,528	$25,938
Total cost per circuit breaker	**$67,116**	**$83,895**	**$96,343**	**$109,577**	**$134,680**	**$388,928**	**$522,738**

Disconnect Switches

This unit cost is the cost associated with one disconnect switch. Material cost is the cost to procure and deliver one disconnect switch to site (laydown yard). Installation cost includes: assembly; placement on the steel stand; connection to main ground grid; jumpers and fittings to connect to substation bus. Steel stand weight is an estimated pounds of steel required to manufacture the steel stand. Steel stand material cost is the cost to procure and deliver one steel stand for a disconnect switch to site (laydown yard). Steel stand installation cost is the cost to place the steel stand on the foundation. Foundation size is the amount of cubic yards of concrete required for the foundation. Foundation cost is the combination of the material and installation cost for the foundation.

Disconnect switch (3-phase) unit costs							
Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Foundation size (Cu. Yd)	3.4	4.2	5.2	6.5	7.8	8.0	18.0
Steel stand weight (pounds)	1500	1750	2000	2500	3500	4000	5000
Disconnect switch material cost	$19,625	$24,500	$29,000	$33,100	$37,250	$53,000	$69,500
Disconnect switch installation cost	$8,831	$11,025	$13,050	$14,895	$16,763	$23,850	$31,275
Steel stand material cost	$3,285	$3,833	$4,380	$5,475	$7,665	$8,760	$10,950
Steel stand installation cost	$3,778	$4,407	$5,037	$6,296	$8,815	$10,074	$12,593
Foundation cost	$4,454	$5,502	$6,812	$8,515	$10,218	$10,480	$23,580
Total cost per disconnect switch	**$39,973**	**$49,267**	**$58,279**	**$68,281**	**$80,710**	**$106,164**	**$147,898**

Voltage Transformers

This unit cost is the cost associated with one set of three voltage transformers. Material cost is the cost to procure and deliver one set of three voltage transformers to site (laydown yard). Installation cost includes: assembly; placement on the steel stand; connection to the main ground grid; above ground conduit to connect the below grade conduit to the equipment control box; wiring to land the control cables on the terminal blocks in the equipment control box; jumpers and fittings to connect to substation bus. Steel stand weight is an estimated pounds of steel required to manufacture the steel stand. Steel stand material cost is the cost to procure and deliver one steel stand for a voltage transformer to site (laydown yard). Steel stand installation cost is the cost to place each steel stand on the foundation. Foundation size is the amount of cubic yards of concrete required for the foundation. Foundation cost is the combination of the material and installation cost for the foundation.

Voltage Transformer (set of 3) unit costs

Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Foundation size (Cu. Yd)	1.8	2.3	2.7	3.4	4.0	8.0	12.1
Steel stand weight (pounds)	1250	1350	1425	1500	1750	2000	2500
Voltage transformer material cost	$39,250	$49,100	$57,800	$64,100	$68,300	$84,125	$131,400
Voltage transformer installation cost	$17,663	$22,095	$26,010	$28,845	$30,735	$37,856	$59,130
Steel stand material cost	$2,675	$2,889	$3,050	$3,210	$3,745	$4,280	$5,350
Steel stand installation cost	$3,076	$3,322	$3,507	$3,692	$4,307	$4,922	$6,153
Foundation cost	$2,358	$3,013	$3,537	$4,454	$5,240	$10,480	$15,851
Total cost per voltage transformer	**$65,022**	**$80,419**	**$93,903**	**$104,301**	**$112,327**	**$141,663**	**$217,884**

Current Transformers

This unit cost is the cost associated with one set of three current transformers. Material cost is the cost to procure and deliver one set of three current transformers to site (laydown yard). Installation cost includes: assembly; placement on the steel stand; connect to main ground grid; above ground conduit to connect the below grade conduit to the equipment control box; wiring to land the control cables on the terminal blocks in the equipment control box; jumpers and fittings to connect to substation bus. Steel stand weight is an estimated pounds of steel required to manufacture the steel stand. Steel stand material cost is the cost to procure and deliver one steel stand to site (laydown yard). Steel stand installation cost is the cost to place each steel stand on the foundation. Foundation size is the amount of cubic yards of concrete required for the foundation. Foundation cost is the combination of the material and installation cost for the foundation.

Current Transformer (set of 3) unit costs

Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Foundation size (Cu. Yd)	1.8	2.3	2.7	3.4	4.0	8.0	12.1
Steel stand weight (pounds)	1250	1350	1425	1500	1750	2000	2500
Material cost	$61,725	$77,150	$105,100	$115,600	$126,150	$210,225	$367,900
Installation cost	$15,431	$19,288	$26,275	$28,900	$31,538	$52,556	$91,975
Steel stand material cost	$2,675	$2,889	$3,050	$3,210	$3,745	$4,280	$5,350
Steel stand installation cost	$3,076	$3,322	$3,507	$3,692	$4,307	$4,922	$6,153
Foundation cost	$2,358	$3,013	$3,537	$4,454	$5,240	$10,480	$15,851
Total cost per current transformer	**$85,266**	**$105,662**	**$141,468**	**$155,856**	**$170,979**	**$282,463**	**$487,229**

Bus support, bus, and fittings

This unit cost is the cost associated with one three-phase bus support, and its associated bus and fittings. Material cost is the cost to procure and deliver to site (laydown yard) a set of three: insulators; electrical aluminum bus; all required bus fittings. Installation cost includes: assembly; electrically connect bus (as supported by this bus stand) to adjacent electrical equipment. Steel stand weight is an estimated pounds of steel required to manufacture the steel stand. Steel stand material cost is the cost to procure and deliver one steel stand to site (laydown yard). Steel stand installation cost is the cost to place each steel stand on the foundation. Foundation size is the amount of cubic yards of concrete required for the foundation. Foundation cost is the combination of the material and installation cost for the foundation.

Bus support, bus, and fittings (3-phase) unit costs

Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Foundation size (Cu. Yd)	3.1	3.9	4.8	6.0	7.2	9.6	14.4
Steel stand weight (pounds)	1000	1250	1500	1750	2000	3000	4500
Material cost	$5,750	$7,200	$8,300	$8,725	$9,150	$10,825	$12,475
Installation cost	$6,900	$8,640	$9,960	$10,470	$10,980	$12,990	$14,970
Steel stand material cost	$2,140	$2,675	$3,210	$3,745	$4,280	$6,420	$9,630
Steel stand installation cost	$2,461	$3,076	$3,692	$4,307	$4,922	$7,383	$11,075
Foundation cost	$4,061	$5,109	$6,288	$7,860	$9,432	$12,576	$18,864
Total cost per bus support, bus, and fittings	**$21,312**	**$26,700**	**$31,450**	**$35,107**	**$38,764**	**$50,194**	**$67,014**

Deadend structure

This unit cost is the cost associated with one full-tension deadend structure. The unit cost utilized for a deadend structure installed in a substation is shown in the transmission line section 2. The same unit cost is used for substation estimates as is used for transmission line estimates.

Power transformer

This unit cost is the cost associated with one power transformer. Power transformer cost varies based on the low side voltage winding and high side voltage winding. Unit cost includes all material, shipping, foundation, and installation costs with that transformer.

Power transformer ($/MVA)

Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
69kV	$4,720	$3,840	$4,260	$4,480	$4,970	$6,100	$7,860
115kV	$3,840	$5,230	$4,260	$4,480	$4,970	$5,790	$7,110
138kV	$4,260	$4,260	$5,790	$4,720	$4,970	$5,790	$7,110
161kV	$4,480	$4,480	$4,720	$6,420	$5,230	$6,100	$7,490
230kV	$4,970	$4,970	$4,970	$5,230	$7,110	$6,100	$7,490
345kV	$6,100	$5,790	$5,790	$6,100	$6,100	$8,670	$7,860
500kV	$7,860	$7,110	$7,110	$7,490	$7,490	$7,860	$11,610

Major equipment

These unit costs are the costs associated with major equipment than can be installed in substation sites. Major equipment is a reactor, a capacitor bank, or a Static VAr compensator. Unit costs include all material, shipping, foundation, and installation costs with each major equipment item.

Major equipment unit costs

Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Reactor ($/MVAr)	$13,575	$13,575	$13,575	$13,575	$13,575	$13,575	$13,575
Capacitor bank ($/MVAr)	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
Static VAr Compensator ($/MVAr)	$96,175	$96,175	$96,175	$96,175	$96,175	$96,175	$96,175

3.3 Protection and control

Protection and control costs are all the costs required to procure and install the protection and control equipment for substation upgrades or new substation facilities. MISO will adjust its protection and control quantities as required by specific potential project ideas.

Control enclosure

This unit cost is the cost associated with one control enclosure. Material and installation cost is the cost to procure and deliver one control enclosure to site (laydown yard), offload and placement of the control enclosure on the foundation; wiring of the AC/DC systems to field equipment; and wiring of control enclosure to communication systems. Control enclosure includes all components (e.g. AC panels, DC panels, cable tray, etc.) except for relay panels which are considered separately. Station service power is the cost to provide station service power to the control enclosure. Foundation size is the amount of cubic yards of concrete required for the foundation. Foundation cost is the combination of the material and installation cost for the foundation.

Control enclosure unit costs

Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Foundation size (Cu. Yd)	18.0	18.0	18.0	18.0	18.0	18.0	18.0
Material and installation cost	$580,000	$580,000	$580,000	$580,000	$580,000	$580,000	$580,000
Station service power	$50,000	$60,000	$70,000	$80,000	$90,000	$100,000	$100,000
Foundation cost	$23,580	$23,580	$23,580	$23,580	$23,580	$23,580	$23,580
Total cost control enclosure	**$653,580**	**$663,580**	**$673,580**	**$683,580**	**$693,580**	**$703,580**	**$703,580**

Relay panels

This unit cost is the cost associated with one relay panel. Material cost is the cost to procure and deliver one relay panel to site (laydown yard). Procurement of the relay panel includes all the relays and devices in the panel, and all the internal wiring for the devices in each individual relay panel. Installation cost includes: placement of relay panel in control enclosure; wiring from field equipment; inter-panel wiring to other relay panels inside control enclosure.

Relay panel unit costs

Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Material cost	$18,750	$23,375	$29,250	$33,000	$36,500	$48,750	$61,000
Installation cost	$37,500	$46,750	$58,500	$66,000	$73,000	$97,500	$122,000
Total Relay Panel cost	$56,250	$70,125	$87,750	$99,000	$109,500	$146,250	$183,000

Conduit

This unit cost is the cost associated with 1000 feet of conduit. Material cost is the cost to procure and deliver 1000 feet of conduit to site (laydown yard). Included in the material cost is the conduit along with applicable fittings and connectors. Installation cost includes excavation, placement of conduit, and utilizing all applicable fittings and connectors.

Conduit unit costs

Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Material cost per 1000 feet	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600	$3,600
Installation cost per 1000 feet	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800	$1,800
Conduit total cost per 1000 feet	**$5,400**	**$5,400**	**$5,400**	**$5,400**	**$5,400**	**$5,400**	**$5,400**

Control cable

This unit cost is the cost associated with 1000 feet of control cable. Material cost is the cost to procure and deliver 1000 feet of control cable to site (laydown yard). Installation cost includes placing, and pulling control cable in conduit and/or cable trench, and bringing the control cable to its end point where it will be landed. Final wiring of landing on terminal blocks is included in other unit costs.

Control cable unit costs							
Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Material cost per 1000 feet	$3,075	$3,075	$3,075	$3,075	$3,075	$4,075	$4,075
Installation cost per 1000 feet	$1,550	$1,550	$1,550	$1,550	$1,550	$1,550	$1,550
Control cable total cost per 1000 feet	**$4,625**	**$4,625**	**$4,625**	**$4,625**	**$4,625**	**$5,625**	**$5,625**

Cable trench

This unit cost is the cost associated with 1 foot of cable trench inclusive of lid/cover. Material cost is the cost to procure and deliver 1 foot of cable trench to site (laydown yard). Installation cost includes excavation, and placement of cable trench. Placement of control cables in cable trench is included in the control cable installation cost.

Cable trench unit costs							
Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Material cost per 1 foot	$205	$205	$205	$205	$205	$205	$205
Installation cost per 1 foot	$51	$51	$51	$51	$51	$51	$51
Cable trench total cost per 1 foot	**$256**	**$256**	**$256**	**$256**	**$256**	**$256**	**$256**

3.4 Professional services and overhead

Professional services and overhead cost adders are intended to include the costs to develop a potential project that are spread out over the entire project and are not easily quantifiable by individual items. MISO aggregates these costs into three subcategories in order to facilitate discussion on the larger cost adder value that MISO considers for these costs.

MISO has estimated the professional services and overhead required for potential projects as:

- 5.5% of project cost estimate: Project management (including mobilization and demobilization)
- 3.0% of project cost estimate: Engineering, environmental studies, testing and commissioning
- 1.5% of project cost estimate: Administrative and General Overhead (A&G)

3.5 Substation equipment removal

Removal cost of existing substation equipment includes all plant, tools, equipment, machinery, skill, supervision and labor. For any substation equipment that is required to be removed, MISO will utilize its installation cost for that item and consider it equivalent as the cost of removal.

4. Exploratory cost estimates

In the planning process it can be helpful to explore many different project ideas quickly to assess broadly if they would be viable. MISO provides exploratory cost estimates which are intended for projects with low levels of scope definition. Exploratory cost estimates are high-level cost estimates which MISO does not recommend using for any particular solution idea in the regular planning cycle due to the breadth of the assumptions used to derive the unit costs and lower level of granularity regarding specific project components. The exploratory cost estimates provided below are based on the assumptions as shown in sections 2, 3 and the cost data contained in this guide. Before a potential project is recommended for approval to MISO's Board of Directors, MISO completes a thorough scoping cost estimate, all of the details of which are shared with stakeholders for their review and comment.

4.1 Transmission line exploratory cost estimate

In the tables below, MISO is providing its exploratory cost estimate in a $/mile cost as defined by its voltage class and by the State where the potential project would be developed.

Single circuit transmission line $/mile
Exploratory cost estimate

Location – State	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Arkansas	$1.3M	$1.4M	$1.5M	$1.6M	$1.7M	$2.7M	$2.9M
Illinois	$1.4M	$1.5M	$1.5M	$1.6M	$1.7M	$2.8M	$2.9M
Indiana	$1.3M	$1.4M	$1.5M	$1.6M	$1.7M	$2.7M	$2.8M
Iowa	$1.4M	$1.5M	$1.5M	$1.6M	$1.7M	$2.7M	$2.9M
Kentucky	$1.4M	$1.5M	$1.6M	$1.7M	$1.8M	$2.9M	$3.0M
Louisiana	$1.6M	$1.7M	$1.7M	$1.9M	$2.0M	$3.2M	$3.4M
Michigan	$1.4M	$1.5M	$1.6M	$1.7M	$1.8M	$2.9M	$3.0M
Minnesota	$1.3M	$1.4M	$1.5M	$1.5M	$1.6M	$2.6M	$2.7M
Mississippi	$1.6M	$1.6M	$1.7M	$1.8M	$2.0M	$3.2M	$3.4M
Missouri	$1.3M	$1.4M	$1.5M	$1.6M	$1.7M	$2.7M	$2.8M
Montana	$1.2M	$1.3M	$1.4M	$1.5M	$1.5M	$2.5M	$2.6M
North Dakota	$1.2M	$1.3M	$1.4M	$1.5M	$1.5M	$2.5M	$2.6M
South Dakota	$1.3M	$1.3M	$1.4M	$1.5M	$1.5M	$2.5M	$2.6M
Texas	$1.5M	$1.6M	$1.7M	$1.8M	$1.9M	$3.1M	$3.3M
Wisconsin	$1.3M	$1.4M	$1.5M	$1.6M	$1.7M	$2.7M	$2.8M

Includes contingency and AFUDC

Double circuit transmission line $/mile Exploratory cost estimate							
Location – State	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Arkansas	$1.9M	$2.1M	$2.2M	$2.3M	$2.8M	$4.5M	$4.9M
Illinois	$2.0M	$2.1M	$2.3M	$2.4M	$2.8M	$4.6M	$5.0M
Indiana	$1.9M	$2.1M	$2.2M	$2.3M	$2.7M	$4.5M	$4.9M
Iowa	$1.9M	$2.1M	$2.2M	$2.4M	$2.8M	$4.6M	$5.0M
Kentucky	$2.0M	$2.2M	$2.3M	$2.4M	$2.9M	$4.7M	$5.1M
Louisiana	$2.2M	$2.3M	$2.5M	$2.6M	$3.1M	$5.0M	$5.5M
Michigan	$2.0M	$2.2M	$2.3M	$2.4M	$2.9M	$4.7M	$5.1M
Minnesota	$1.9M	$2.1M	$2.2M	$2.3M	$2.7M	$4.4M	$4.8M
Mississippi	$2.1M	$2.3M	$2.5M	$2.6M	$3.1M	$5.0M	$5.5M
Missouri	$1.9M	$2.1M	$2.2M	$2.3M	$2.7M	$4.5M	$4.9M
Montana	$1.8M	$2.0M	$2.1M	$2.2M	$2.6M	$4.3M	$4.6M
North Dakota	$1.8M	$2.0M	$2.1M	$2.2M	$2.6M	$4.3M	$4.6M
South Dakota	$1.8M	$2.0M	$2.1M	$2.2M	$2.6M	$4.3M	$4.7M
Texas	$2.1M	$2.3M	$2.4M	$2.6M	$3.0M	$4.9M	$5.4M
Wisconsin	$1.9M	$2.1M	$2.2M	$2.3M	$2.7M	$4.5M	$4.9M

Includes contingency and AFUDC

4.2 Transmission line exploratory cost estimate assumptions

In order to create exploratory cost estimates, MISO must make indicative assumptions about the scope of work for a potential project. The assumptions shown below in Section 4 are not tied to any one specific project are intended for the sole purpose of creating an exploratory cost estimate.

Conductor selection

Conductor selection for MISO's exploratory cost estimates are shown in the table below. The conductor selected is intended to be typical for a circuit in the voltage class. Specific solution ideas may necessitate different conductors than as shown below.

Conductor selection per circuit Exploratory cost estimate assumption							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Conductor size	477kcmil	795kcmil	795kcmil	795kcmil	795kcmil	795kcmil	954kcmil
Conductor type	ACSS	ACSS	ACSS	ACSS	ACSS	ACSS	ACSR
Conductor quantity	1	1	1	1	1	2	3

Land type

A significant cost driver for transmission line projects is the land and terrain types encountered. MISO recognizes that different States present different environments to be accounted for in its cost estimates. In order to provide exploratory cost estimates on a State-by-State basis, MISO makes different assumptions on the land and terrain encountered unique to each State in the MISO footprint. The indicative assumptions in the tables below are not tied to any specific project and are intended for the sole purpose of providing MISO's exploratory cost estimate.

Land type per State
Exploratory cost estimate assumption

State – land	Pasture land	Crop land	Suburban/Urban
Arkansas	25%	65%	10%
Illinois	25%	65%	10%
Indiana	25%	65%	10%
Iowa	10%	80%	10%
Kentucky	25%	65%	10%
Louisiana	25%	65%	10%
Michigan	25%	65%	10%
Minnesota	10%	80%	10%
Mississippi	25%	65%	10%
Missouri	25%	65%	10%
Montana	70%	20%	10%
North Dakota	70%	20%	10%
South Dakota	50%	40%	10%
Texas	65%	25%	10%
Wisconsin	25%	65%	10%

Terrain type per State Exploratory cost estimate assumption			
State – land	Level ground with light vegetation	Forested	Wetland
Arkansas	40%	55%	5%
Illinois	55%	40%	5%
Indiana	80%	15%	5%
Iowa	80%	15%	5%
Kentucky	65%	25%	10%
Louisiana	55%	25%	20%
Michigan	50%	40%	10%
Minnesota	70%	25%	5%
Mississippi	55%	25%	20%
Missouri	40%	55%	5%
Montana	85%	10%	5%
North Dakota	90%	5%	5%
South Dakota	90%	5%	5%
Texas	50%	30%	20%
Wisconsin	70%	25%	5%

4.3 Substation exploratory cost estimates

Substations have a variety of layouts and arrangements. MISO's exploratory cost estimates for substations are intended to capture the most common substation arrangements that are estimated in the MCPS. The arrangements selected for the exploratory indicative cost estimates in this section are not an all-inclusive list for substation arrangements. Exploratory cost estimates are provided for both substation upgrades and new substations.

Substation upgrade - Exploratory cost estimate							
Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Add 1 position (ring bus)	$0.7M	$0.9M	$1.1M	$1.2M	$1.4M	$2.3M	$3.5M
Add 1 position (breaker-and-a-half bus)	$1.1M	$1.3M	$1.6M	$1.8M	$2.2M	$3.6M	$5.3M
Add 1 position (double-breaker bus)	$1.2M	$1.5M	$1.8M	$2.1M	$2.4M	$3.9M	$5.7M
Add 2 positions (ring bus)	$1.5M	$1.8M	$2.2M	$2.5M	$2.9M	$4.7M	$7.1M
Add 2 positions (breaker-and-a-half bus)	$1.8M	$2.3M	$2.8M	$3.2M	$3.8M	$6.0M	$9.1M
Add 2 positions (double-breaker bus)	$2.4M	$3.0M	$3.7M	$4.2M	$4.8M	$7.8M	$11.4M

Includes contingency and AFUDC

New substation - Exploratory cost estimate							
Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
4 positions (ring bus)	$4.6M	$5.4M	$6.2M	$6.8M	$7.6M	$10.7M	$15.4M
4 positions (breaker-and-a-half bus)	$5.7M	$6.8M	$7.8M	$8.6M	$9.7M	$14.3M	$20.3M
4 positions (double-breaker bus)	$6.6M	$7.9M	$9.1M	$10.1M	$11.5M	$17.3M	$25.0M
6 positions (ring bus)	$5.8M	$6.8M	$7.9M	$8.7M	$9.8M	$14.4M	$20.6M
6 positions (breaker-and-a-half bus)	$7.3M	$8.7M	$10.1M	$11.2M	$12.8M	$19.2M	$27.6M
6 positions (double-breaker bus)	$8.6M	$10.3M	$12.1M	$13.5M	$15.4M	$23.6M	$34.1M

Includes contingency and AFUDC

4.4 Substation exploratory cost estimate assumptions

In order to provide exploratory cost estimates for substations, MISO makes indicative assumptions for the quantity of equipment required for substation upgrades and for new substations. The indicative assumptions for substation equipment tables below are not tied to any specific project, and are intended for the sole purpose of providing MISO's exploratory cost estimate.

Substation upgrade – add 1 position (ring / breaker-and-a-half / double-breaker bus) Exploratory cost estimate assumptions

Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Land required (acre)	0.25/0.30/ 0.40	0.35/0.40/ 0.50	0.45/0.50/ 0.70	0.50/0.60/ 0.80	0.60/0.80/ 0.90	0.75/0.90/ 1.10	1.25/1.60/ 1.90
Access road (mile)	0/0/0	0/0/0	0/0/0	0/0/0	0/0/0	0/0/0	0/0/0
Circuit breaker(s) (each)	1/2/2	1/2/2	1/2/2	1/2/2	1/2/2	1/2/2	1/2/2
Disconnect switches (each)	2/4/4	2/4/4	2/4/4	2/4/4	2/4/4	2/4/4	2/4/4
Voltage transformer(s) (set of 3)	1/1/2	1/1/2	1/1/2	1/1/2	1/1/2	1/1/2	1/1/2
Bus support, bus, and fittings (3-phase)	4/4/6	4/4/6	4/4/6	4/4/6	4/4/6	6/6/8	8/8/10
Deadend structure	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1
Control enclosure	0/0/0	0/0/0	0/0/0	0/0/0	0/0/0	0/0/0	0/0/0
Relay panel(s)	1/2/2	1/2/2	1/2/2	1/2/2	1/2/2	1/2/2	1/2/2
Conduit (feet)	300/450/ 600	350/525/ 700	400/600/ 800	450/675/ 900	500/750/ 1000	600/900/ 1200	800/1200/ 1600
Control cable (1000 feet)	3/4.5/6	3.5/5.3/7	4/6/8	4.5/6.8/9	5/7.5/10	6/9/12	8/12/16
Cable trench (feet)	30/45/60	35/53/70	40/60/80	45/68/90	50/75/100	60/90/120	80/120/ 160

Substation upgrade – add 2 positions (ring / breaker-and-a-half / double-breaker bus) Exploratory cost estimate assumptions

Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Land required (acre)	0.50/0.60/ 0.80	0.70/0.80/ 1.00	0.90/1.00/ 1.40	1.00/1.20/ 1.60	1.20/1.60/ 1.80	1.50/1.80/ 2.20	2.50/3.20/ 3.80
Access road (mile)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Circuit breakers (each)	2/3/4	2/3/4	2/3/4	2/3/4	2/3/4	2/3/4	2/3/4
Disconnect switches (each)	4/6/8	4/6/8	4/6/8	4/6/8	4/6/8	4/6/8	4/6/8
Voltage transformers (set of 3)	2/2/2	2/2/2	2/2/2	2/2/2	2/2/2	2/2/2	2/2/2
Bus support, bus, and fittings (3-phase)	8/8/12	8/8/12	8/8/12	8/8/12	8/8/12	12/12/16	16/16/20
Deadend structure	2/2/2	2/2/2	2/2/2	2/2/2	2/2/2	2/2/2	2/2/2
Control enclosure	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relay panel(s)	2/3/4	2/3/4	2/3/4	2/3/4	2/3/4	2/3/4	2/3/4
Conduit (feet)	600/900/ 1200	700/1050/ 1400	800/1200/ 1600	900/1350/ 1800	1000/ 1500/ 2000	1200/ 1800/ 2400	1600/ 2400/ 3200
Control cable (1000 feet)	6/9/12	7/11/14	8/12/16	9/13.5/18	10/15/20	12/18/24	16/24/32
Cable trench (feet)	60/90/120	70/105/ 140	80/120/ 160	90/135/ 180	100/150/ 200	120/180/ 240	160/240/ 320

New substation – 4 positions (ring / breaker-and-a-half / double-breaker bus) Exploratory cost estimate assumptions

Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Land required (acre)	1.00/1.25/ 1.50	1.40/1.75/ 2.10	1.80/2.25/ 2.70	2.00/2.50/ 3.00	2.40/3.00/ 3.60	3.00/3.75/ 4.50	5.00/6.25/ 7.50
Access road (mile)	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1
Circuit breakers (each)	4/6/8	4/6/8	4/6/8	4/6/8	4/6/8	4/6/8	4/6/8
Disconnect switches (each)	8/12/16	8/12/16	8/12/16	8/12/16	8/12/16	8/12/16	8/12/16
Voltage transformers (set of 3)	4/6/6	4/6/6	4/6/6	4/6/6	4/6/6	4/6/6	4/6/6
Bus support, bus, and fittings (3-phase)	10/12/14	10/12/14	10/12/14	10/12/14	10/12/14	12/16/20	20/24/32
Deadend structure	4/4/4	4/4/4	4/4/4	4/4/4	4/4/4	4/4/4	4/4/4
Control enclosure	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1
Relay panel(s)	6/8/10	6/8/10	6/8/10	6/8/10	6/8/10	6/8/10	6/8/10
Conduit (feet)	1200/ 1800/ 2400	1400/ 2100/ 2800	1600/ 2400/ 3200	1800/ 2700/ 3600	2000/ 3000/ 4000	2400/ 3600/ 4800	3200/ 4800/ 6400
Control cable (1000 feet)	12/18/24	14/21/28	16/24/32	18/27/36	20/30/40	24/36/48	32/48/64
Cable trench (feet)	120/180/ 240	140/210/ 280	160/240/ 320	180/270/ 360	200/300/ 400	240/360/ 480	320/480/ 640

New substation – 6 positions (ring / breaker-and-a-half / double-breaker bus) Exploratory cost estimate assumptions

Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Land required (acre)	1.25/1.60/ 1.90	1.75/2.20/ 2.60	2.25/2.80/ 3.40	2.50/3.10/ 3.80	3.00/3.80/ 4.50	3.75/4.70/ 5.60	6.25/7.80/ 9.40
Access road (mile)	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Circuit breakers (each)	6/9/12	6/9/12	6/9/12	6/9/12	6/9/12	6/9/12	6/9/12
Disconnect switches (each)	12/18/24	12/18/24	12/18/24	12/18/24	12/18/24	12/18/24	12/18/24
Voltage transformers (set of 3)	6/8/8	6/8/8	6/8/8	6/8/8	6/8/8	6/8/8	6/8/8
Bus support, bus, and fittings (3-phase)	12/16/20	12/16/20	12/16/20	12/16/20	12/16/20	16/20/24	24/32/40
Deadend structure	6/6/6	6/6/6	6/6/6	6/6/6	6/6/6	6/6/6	6/6/6
Control enclosure	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1	1/1/1
Relay panel(s)	8/11/14	8/11/14	8/11/14	8/11/14	8/11/14	8/11/14	8/11/14
Conduit (feet)	1800/ 2700/ 3600	2100/ 3150/ 4200	2400/ 3600/ 4800	2700/ 4050/ 5400	3000/ 4500/ 6000	3600/ 5400/ 7200	4800/ 7200/ 9600
Control cable (1000 feet)	18/27/36	21/32/42	24/36/48	27/41/54	30/45/60	36/54/72	48/72/96
Cable trench (feet)	180/270/ 360	210/315/ 420	240/360/ 480	270/405/ 540	300/450/ 600	360/540/ 720	480/720/ 960