Transmission Cost Estimation Guide

MTEP20

April 14, 2020

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 MTEP20 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 2020 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 MTEP19.

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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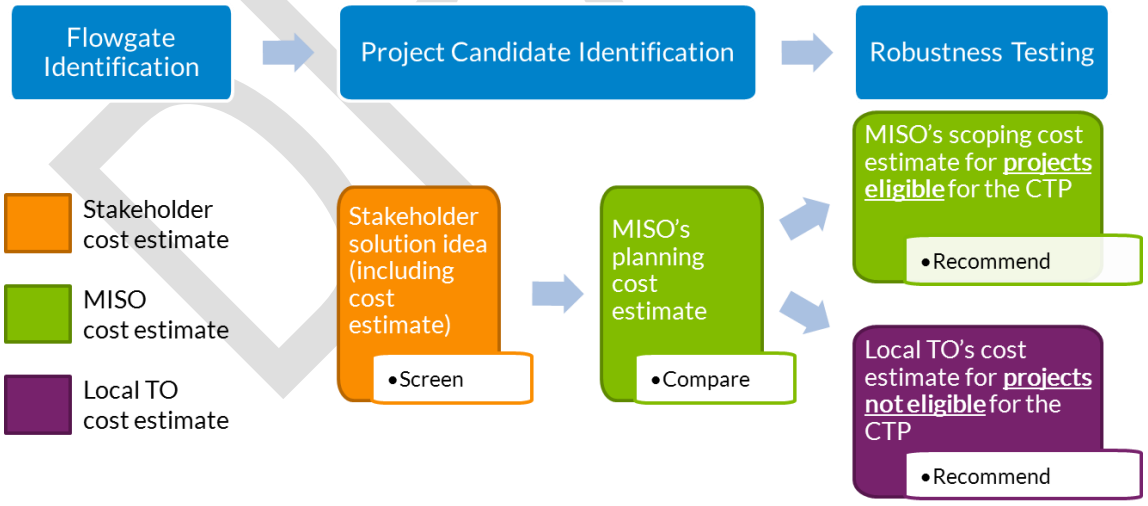
1. Cost Estimates in the planning process

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.

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 refined 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.



Power industry practices

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

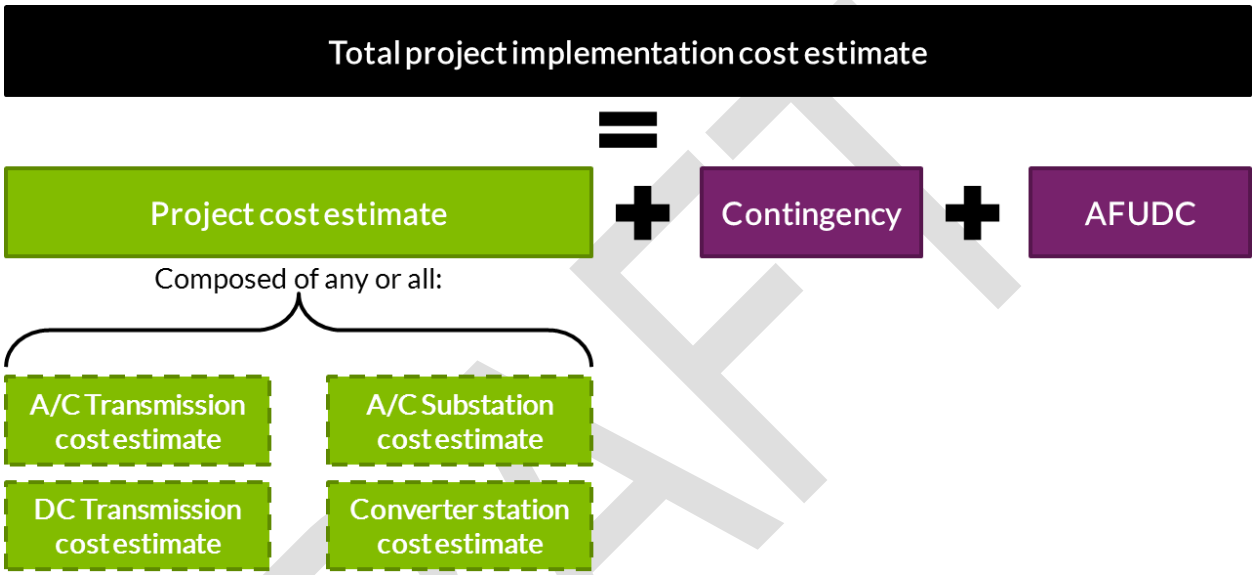
Class 3 – MISO's scoping cost estimate

	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.

2. Total Project Implementation Cost

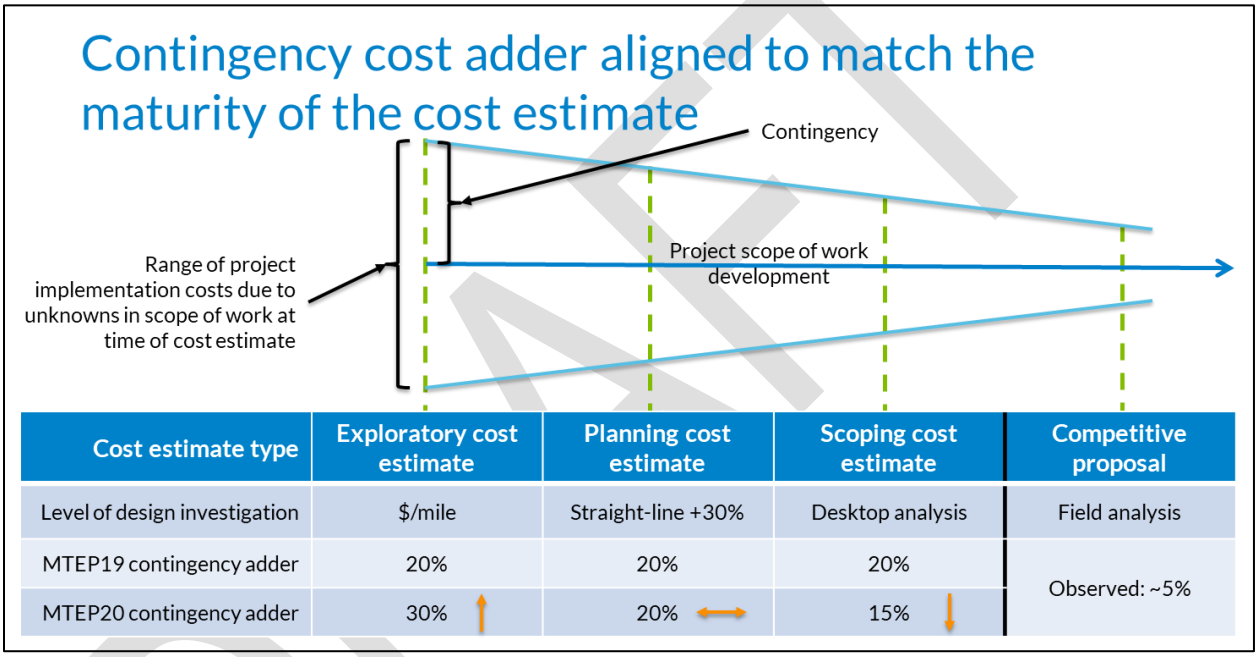
Cost estimates that MISO provides are intended to be inclusive of all costs required to implement the project. This is the total project implementation cost for a potential project. Included in the total project implementation cost estimate is the project cost (including professional services and overhead), contingency, and Allowance for Funds Used During Construction (AFUDC). 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.



Contingency

Contingency is a cost adder to account for all the uncertainties/unpredictability and level of scope definition at the time of estimation. As more investigation is completed for a cost estimate (and a project), less contingency is carried as a cost in the cost estimate. MISO has three cost estimates it provides, with different levels of contingency for each one:

- Exploratory cost estimate: 30% contingency
- Planning cost estimate: 20% contingency
- Scoping cost estimate: 15% contingency



Cost estimate type	Exploratory cost estimate	Planning cost estimate	Scoping cost estimate	Competitive proposal
Level of design investigation	$/mile	Straight-line +30%	Desktop analysis	Field analysis
MTEP19 contingency adder	20%	20%	20%	Observed: ~5%
MTEP20 contingency adder	30% ↑	20% ↔	15% ↓	

AFUDC

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. AFUDC is assumed to be the same value for all the cost estimates MISO provides and is assumed to be 7.5% of the sum of the project cost and contingency.

3. Project costs

3.1 A/C & HVDC Transmission Lines

MISO's cost estimation guide contains costs both for alternating current (A/C) transmission lines and for high voltage direct current (HVDC) transmission lines. Both types of transmission lines rely on some similar project costs (i.e., land costs, conductor costs), and some unique costs dependent on the scope of work (i.e., structure costs).

MISO's A/C 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. MISO's cost estimation guide includes estimated for costs for A/C transmission in voltage classes ranging from 69kV – 500kV.

HVDC transmission has two major components – Transmission Line and Converter station. With the advancement of technology, both components of HVDC transmission have many options and customization for a specific need. For the purposes of creating a cost estimate, MISO will assume a bipole HVDC transmission line with a ground electrode return. Ground electrodes are assumed to be located at each end of the transmission line and connected by a ground electrode line. MISO's cost estimation guide includes estimated costs for HVDC transmission in voltage classes ranging from ±250kV to ±600kV.

Line length

The line length for a transmission line is a consideration for determining its cost estimate for a potential project. For exploratory and 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.

Land & 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, and those costs are shown in Section 3.4. 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's assumptions for right-of-way width are in the tables below:

A/C transmission
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 (feet)	80	90	95	100	125	175	200

HVDC transmission
Single circuit right-of-way width

Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Right-of-way width (feet)	130	180	200	215

Certain states have unique circumstances to be accounted for in their cost estimates. Wisconsin projects involving transmission lines with nominal voltage of 345kV and above have a one-time environmental impact fee in the amount of 5% of the total implementation cost of the transmission line – MISO will include this additional cost in its cost estimate for projects in Wisconsin. Minnesota has a "buy the farm" statue where additional land may be required to be purchased in addition to the right-of-way required for the transmission line – MISO may consider additional land requirements for projects in Minnesota.

Terrain and grading unit costs include all the costs associated with clearing and navigating the terrain for the transmission line. 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)	$272
Forested land (per acre)	$5,176
Wetland (per acre)	Matting & construction difficulties: $60,411
	Wetland mitigation credits: $48,460
Mountainous terrain (per acre)	$6,729

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 four different 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.

Running angle structures are used where the line alignment changes direction and the line angle is between 2° and 45°. The structures are designed for the highest applicable NESC loading in the MISO region. Running 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.

Non-Angled deadend 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 non-angled deadend structures are designed for line angle between 5° to 45°. The structures are designed for the highest applicable NESC loading in the MISO region.

Angled 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 needs 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.

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.

A/C Transmission
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	$15,680	$17,696	$18,816	$20,832	$24,864	$49,952	$78,624
Installation cost	$23,520	$26,544	$28,224	$31,248	$37,296	$74,928	$117,936
Hardware cost	$4,129	$4,817	$5,162	$5,850	$6,881	$9,207	$10,080
Foundation cost	$7,387	$8,058	$10,744	$12,087	$17,459	$28,203	$55,063
Total cost per structure	**$50,715**	**$57,115**	**$62,946**	**$70,017**	**$86,500**	**$162,290**	**$261,703**
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	$11,407	$12,903	$13,651	$15,147	$18,887	$37,961	$50,490
Installation cost	$17,111	$19,355	$20,477	$22,721	$28,331	$56,942	$75,735
Hardware cost	$4,129	$4,817	$5,162	$5,850	$6,881	$9,207	$10,080
Foundation cost	$11,416	$15,445	$18,131	$19,474	$20,817	$26,189	$44,991
Total cost per structure	**$44,062**	**$52,519**	**$57,420**	**$63,191**	**$74,915**	**$130,298**	**$181,295**
Wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$4,408	$8,251	$8,354	$11,121	$12,044	N/A	N/A
Installation cost	$12,300	$12,813	$14,350	$20,500	$30,750	N/A	N/A
Hardware cost	$4,305	$4,869	$5,330	$5,894	$7,688	N/A	N/A
Total cost per structure	**$21,013**	**$25,933**	**$28,034**	**$37,515**	**$50,481**	N/A	N/A

HVDC Transmission Tangent structures – bipole				
Steel Pole				
Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Steel weight (pounds)	14,773	19,943	21,938	26,325
Foundation size (Cu. Yd)	17	23	26	31
Material cost	$33,161	$44,767	$49,244	$59,093
Installation cost	$49,742	$67,151	$73,866	$88,640
Hardware cost	$4,475	$5,700	$6,200	$6,500
Foundation cost	$22,876	$30,883	$34,408	$41,290
Total cost per structure	**$110,254**	**$148,502**	**$163,718**	**$195,522**
Steel Tower				
Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Steel weight (pounds)	10,227	15,341	16,875	20,250
Foundation size (Cu. Yd)	13	19	21	25
Material cost	$19,079	$28,618	$31,480	$37,776
Installation cost	$28,618	$42,928	$47,220	$56,665
Hardware cost	$4,475	$5,700	$6,200	$6,500
Foundation cost	$17,039	$25,558	$28,114	$33,737
Total cost per structure	**$69,211**	**$102,804**	**$113,015**	**$134,678**
Guyed Steel Tower				
Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Total cost per structure	**$41,527**	**$61,683**	**$67,809**	**$80,807**

A/C Transmission
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	$25,312	$28,448	$30,240	$33,376	$41,664	$80,640	$112,672
Installation cost	$37,968	$42,672	$45,360	$50,064	$62,496	$120,960	$169,008
Hardware cost	$8,038	$9,378	$10,047	$11,387	$13,397	$18,027	$19,750
Foundation cost	$10,744	$13,430	$19,474	$23,503	$30,889	$62,450	$105,426
Total cost per structure	**$82,062**	**$93,928**	**$105,121**	**$118,330**	**$148,446**	**$282,077**	**$406,856**
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	$17,204	$19,448	$20,570	$22,814	$28,424	$67,320	$78,353
Installation cost	$25,806	$29,172	$30,855	$34,221	$42,636	$100,980	$117,530
Hardware cost	$8,038	$9,378	$10,047	$11,387	$13,397	$18,027	$19,750
Foundation cost	$17,459	$22,831	$26,189	$28,203	$29,546	$42,305	$65,136
Total cost per structure	**$68,507**	**$80,829**	**$87,661**	**$96,625**	**$114,003**	**$228,632**	**$280,768**
Wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$7,278	$13,633	N/A	N/A	N/A	N/A	N/A
Installation cost	$20,295	$21,166	N/A	N/A	N/A	N/A	N/A
Hardware cost	$7,124	$8,046	N/A	N/A	N/A	N/A	N/A
Total cost per structure	**$34,696**	**$42,845**	N/A	N/A	N/A	N/A	N/A

A/C Transmission
Running 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	$25,984	$29,120	$31,136	$34,272	$40,992	$84,896	$133,728
Installation cost	$38,976	$43,680	$46,704	$51,408	$61,488	$127,344	$200,592
Hardware cost	$4,129	$4,817	$5,162	$5,850	$6,881	$9,207	$10,080
Foundation cost	$12,087	$14,102	$17,459	$18,802	$26,189	$40,290	$73,194
Total cost per structure	**$81,176**	**$91,718**	**$100,461**	**$110,332**	**$135,550**	**$261,737**	**$417,593**
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	$17,204	$19,448	$20,570	$22,814	$28,424	$57,035	$74,426
Installation cost	$25,806	$29,172	$30,855	$34,221	$42,636	$85,553	$111,639
Hardware cost	$4,129	$4,817	$5,162	$5,850	$6,881	$9,207	$10,080
Foundation cost	$21,488	$25,517	$26,189	$29,546	$32,904	$52,377	$97,368
Total cost per structure	**$68,627**	**$78,954**	**$82,775**	**$92,431**	**$110,845**	**$204,172**	**$293,512**
Wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$7,739	$14,453	$14,606	$19,475	$21,064	N/A	N/A
Installation cost	$21,525	$22,448	$25,113	$35,875	$53,813	N/A	N/A
Hardware cost	$7,534	$8,508	$9,328	$10,301	$13,479	N/A	N/A
Total cost per structure	**$36,798**	**$45,408**	**$49,046**	**$65,651**	**$88,355**	N/A	N/A

HVDC Transmission Running angle structures – bipole				
Steel Pole				
Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Steel weight (pounds)	25,126	33,920	37,313	44,775
Foundation size (Cu. Yd)	23	31	34	41
Material cost	$56,402	$76,143	$83,757	$100,509
Installation cost	$84,603	$114,214	$125,636	$150,763
Hardware cost	$5,594	$7,125	$7,750	$8,125
Foundation cost	$30,800	$41,579	$45,737	$54,885
Total cost per structure	**$177,399**	**$239,062**	**$262,881**	**$314,282**
Steel Tower				
Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Steel weight (pounds)	16,751	22,614	24,875	29,850
Foundation size (Cu. Yd)	31	41	45	54
Material cost	$31,249	$42,186	$46,404	$55,685
Installation cost	$46,873	$63,279	$69,606	$83,528
Hardware cost	$5,594	$7,125	$7,750	$8,125
Foundation cost	$40,972	$55,312	$60,843	$73,012
Total cost per structure	**$124,687**	**$167,901**	**$184,604**	**$220,350**

A/C Transmission
Running 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	$33,600	$37,632	$40,096	$44,128	$55,104	$106,848	$157,696
Installation cost	$50,400	$56,448	$60,144	$66,192	$82,656	$160,272	$236,544
Hardware cost	$8,038	$9,378	$10,047	$11,387	$13,397	$18,027	$19,750
Foundation cost	$17,459	$20,817	$28,875	$34,247	$43,648	$81,923	$132,957
Total cost per structure	**$109,497**	**$124,274**	**$139,162**	**$155,954**	**$194,804**	**$367,070**	**$546,947**
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	$25,806	$29,172	$30,855	$34,221	$42,636	$99,297	$117,623
Installation cost	$38,709	$43,758	$46,283	$51,332	$63,954	$148,946	$176,435
Hardware cost	$8,038	$9,378	$10,047	$11,387	$13,397	$18,027	$19,750
Foundation cost	$30,218	$37,604	$46,334	$50,363	$62,450	$79,237	$117,513
Total cost per structure	**$102,770**	**$119,912**	**$133,518**	**$147,302**	**$182,436**	**$345,507**	**$431,320**
Wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$12,761	$23,831	N/A	N/A	N/A	N/A	N/A
Installation cost	$35,516	$37,054	N/A	N/A	N/A	N/A	N/A
Hardware cost	$12,454	$14,043	N/A	N/A	N/A	N/A	N/A
Total cost per structure	**$60,731**	**$74,928**	N/A	N/A	N/A	N/A	N/A

A/C Transmission
Non-Angled 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)	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	$31,360	$35,392	$37,632	$41,664	$49,728	$94,976	$149,408
Installation cost	$47,040	$53,088	$56,448	$62,496	$74,592	$142,464	$224,112
Hardware cost	$8,141	$9,498	$10,177	$11,533	$13,569	$33,093	$52,057
Foundation cost	$14,773	$16,116	$20,145	$22,160	$30,218	$44,991	$80,580
Total cost per structure	**$101,314**	**$114,094**	**$124,402**	**$137,853**	**$168,106**	**$315,523**	**$506,157**
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	$19,448	$21,879	$23,188	$25,806	$32,164	$64,515	$85,833
Installation cost	$29,172	$32,819	$34,782	$38,709	$48,246	$96,773	$128,750
Hardware cost	$8,141	$9,498	$10,177	$11,533	$13,569	$33,093	$52,057
Foundation cost	$28,875	$33,575	$34,247	$38,276	$45,662	$65,136	$128,928
Total cost per structure	**$85,636**	**$97,771**	**$102,393**	**$114,324**	**$139,641**	**$259,516**	**$395,567**

HVDC Transmission Non-Angled deadend structures – bipole				
Steel Pole				
Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Steel weight (pounds)	28,072	37,898	41,688	50,025
Foundation size (Cu. Yd)	25	34	38	45
Material cost	$63,015	$85,071	$93,578	$112,294
Installation cost	$94,523	$127,606	$140,367	$168,440
Hardware cost	$8,825	$21,375	$23,250	$24,375
Foundation cost	$33,908	$45,776	$50,353	$60,424
Total cost per structure	**$200,272**	**$279,828**	**$307,548**	**$365,533**
Steel Tower				
Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Steel weight (pounds)	19,318	26,080	28,688	34,425
Foundation size (Cu. Yd)	40	55	60	72
Material cost	$36,038	$48,651	$53,517	$64,220
Installation cost	$54,057	$72,977	$80,275	$96,330
Hardware cost	$8,825	$21,375	$23,250	$24,375
Foundation cost	$54,253	$73,241	$80,565	$96,678
Total cost per structure	**$153,173**	**$216,244**	**$237,606**	**$281,603**

A/C Transmission
Non-Angled 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)	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	$37,408	$41,888	$44,576	$49,280	$61,376	$120,960	$169,120
Installation cost	$56,112	$62,832	$66,864	$73,920	$92,064	$181,440	$253,680
Hardware cost	$16,056	$18,733	$20,071	$22,747	$26,761	$65,820	$103,737
Foundation cost	$20,817	$24,846	$33,575	$39,619	$49,691	$91,996	$146,387
Total cost per structure	**$130,393**	**$148,298**	**$165,086**	**$185,566**	**$229,892**	**$460,215**	**$672,924**
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	$30,107	$34,034	$36,091	$40,018	$49,742	$114,444	$133,144
Installation cost	$45,161	$51,051	$54,137	$60,027	$74,613	$171,666	$199,716
Hardware cost	$16,056	$18,733	$20,071	$22,747	$26,761	$65,820	$103,737
Foundation cost	$38,276	$46,334	$57,749	$65,136	$94,682	$116,170	$169,890
Total cost per structure	**$129,599**	**$150,151**	**$168,048**	**$187,928**	**$245,797**	**$468,099**	**$606,486**

A/C Transmission
Angled 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	$45,696	$51,520	$54,880	$60,704	$72,576	$107,744	$180,768
Installation cost	$68,544	$77,280	$82,320	$91,056	$108,864	$161,616	$271,152
Hardware cost	$8,141	$9,498	$10,177	$11,533	$13,569	$33,093	$52,057
Foundation cost	$20,145	$22,160	$26,860	$28,875	$38,947	$55,735	$96,696
Total cost per structure	**$142,526**	**$160,458**	**$174,237**	**$192,168**	**$233,956**	**$358,187**	**$600,673**
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	$25,058	$28,424	$30,107	$33,286	$41,514	$83,589	$111,078
Installation cost	$37,587	$42,636	$45,161	$49,929	$62,271	$125,384	$166,617
Hardware cost	$8,141	$9,498	$10,177	$11,533	$13,569	$33,093	$52,057
Foundation cost	$44,991	$51,034	$52,377	$57,749	$69,836	$120,870	$236,368
Total cost per structure	**$115,777**	**$131,592**	**$137,821**	**$152,497**	**$187,190**	**$362,935**	**$566,120**
Wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$8,815	$16,554	$16,708	$22,243	$24,088	N/A	N/A
Installation cost	$24,600	$25,625	$28,700	$41,000	$61,500	N/A	N/A
Hardware cost	$8,610	$9,738	$10,660	$11,788	$15,375	N/A	N/A
Total cost per structure	**$42,025**	**$51,916**	**$56,068**	**$75,030**	**$100,963**	N/A	N/A

HVDC Transmission Angled deadend structures – bipole				
Steel Pole				
Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Steel weight (pounds)	33,965	45,852	50,438	60,525
Foundation size (Cu. Yd)	30	41	45	54
Material cost	$76,242	$102,927	$113,220	$135,863
Installation cost	$114,363	$154,390	$169,829	$203,795
Hardware cost	$8,825	$21,375	$23,250	$24,375
Foundation cost	$40,689	$54,931	$60,424	$72,509
Total cost per structure	**$240,120**	**$333,623**	**$366,723**	**$436,542**
Steel Tower				
Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Steel weight (pounds)	25,000	33,750	37,125	44,550
Foundation size (Cu. Yd)	74	100	110	132
Material cost	$46,638	$62,961	$69,257	$83,108
Installation cost	$69,956	$94,441	$103,885	$124,662
Hardware cost	$8,825	$21,375	$23,250	$24,375
Foundation cost	$99,463	$134,275	$147,703	$177,243
Total cost per structure	**$224,882**	**$313,052**	**$344,094**	**$409,388**

A/C Transmission
Angled 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	$58,240	$65,408	$69,664	$76,832	$95,872	$189,504	$264,768
Installation cost	$87,360	$98,112	$104,496	$115,248	$143,808	$284,256	$397,152
Hardware cost	$16,056	$18,733	$20,071	$22,747	$26,761	$65,820	$103,737
Foundation cost	$26,860	$32,232	$42,976	$49,691	$61,778	$109,455	$170,561
Total cost per structure	**$188,516**	**$214,485**	**$237,207**	**$264,518**	**$328,219**	**$649,034**	**$936,218**
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	$39,644	$44,693	$47,311	$52,547	$65,450	$148,104	$172,414
Installation cost	$59,466	$67,040	$70,967	$78,821	$98,175	$222,156	$258,621
Hardware cost	$16,056	$18,733	$20,071	$22,747	$26,761	$65,820	$103,737
Foundation cost	$57,749	$67,822	$82,595	$91,996	$132,957	$167,875	$316,948
Total cost per structure	**$172,915**	**$198,287**	**$220,943**	**$246,110**	**$323,343**	**$603,955**	**$851,720**
Wood pole							
Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Material cost	$14,555	$27,316	N/A	N/A	N/A	N/A	N/A
Installation cost	$40,590	$42,281	N/A	N/A	N/A	N/A	N/A
Hardware cost	$14,196	$16,093	N/A	N/A	N/A	N/A	N/A
Total cost per structure	**$69,341**	**$85,690**	N/A	N/A	N/A	N/A	N/A

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"	$678	$552	$239	**$1,470**
266.8 kcmil "Partridge"	$862	$667	$239	**$1,767**
336.4 kcmil "Merlin"	$829	$589	$239	**$1,657**
336.4 kcmil "Linnet"	$1,012	$678	$239	**$1,929**
336.4 kcmil "Oriole"	$1,088	$846	$239	**$2,173**
397.5 kcmil "Chickadee"	$948	$727	$239	**$1,913**
397.5 kcmil "Ibis"	$1,152	$873	$239	**$2,264**
397.5 kcmil "Lark"	$1,292	$862	$239	**$2,393**
477 kcmil "Pelican"	$1,163	$852	$239	**$2,254**
477 kcmil "Flicker"	$1,217	$818	$239	**$2,274**
477 kcmil "Hawk"	$1,346	$1,018	$239	**$2,603**
477 kcmil "Hen"	$1,465	$1,134	$239	**$2,837**
556.5 kcmil "Osprey"	$1,303	$1,023	$239	**$2,565**
556.5 kcmil "Parakeet"	$1,497	$1,201	$239	**$2,936**
556.5 kcmil "Dove"	$1,561	$1,135	$239	**$2,935**
636 kcmil "Kingbird"	$1,465	$989	$239	**$2,692**
636 kcmil "Rook"	$1,691	$1,120	$239	**$3,049**
636 kcmil "Grosbeak"	$1,755	$1,284	$239	**$3,278**
666.6 kcmil "Flamingo"	$1,938	$1,292	$239	**$3,469**
795 kcmil "Coot"	$1,809	$1,309	$239	**$3,357**
795 kcmil "Tern"	$1,841	$1,238	$239	**$3,319**
795 kcmil "Cuckoo"	$2,078	$1,378	$239	**$3,696**
795 kcmil "Condor"	$2,165	$1,432	$239	**$3,836**
795 kcmil "Drake"	$2,143	$1,551	$239	**$3,933**
900 kcmil "Canary"	$2,628	$1,755	$239	**$4,622**
954 kcmil "Rail"	$2,165	$1,636	$239	**$4,039**
954 kcmil "Cardinal"	$2,757	$1,792	$239	**$4,788**

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"	$2,337	$1,794	$239	**$4,370**
1033.5 kcmil "Curlew"	$2,961	$1,978	$239	**$5,178**
1113 kcmil "Bluejay"	$2,498	$1,906	$239	**$4,643**
1192.5 kcmil "Bunting"	$2,671	$1,777	$239	**$4,686**
1272 kcmil "Bittern"	$2,843	$2,059	$239	**$5,141**
1272 kcmil "Pheasant"	$3,381	$2,251	$239	**$5,871**
1351.5 kcmil "Dipper"	$2,994	$2,227	$239	**$5,460**
1351.5 kcmil "Martin"	$3,511	$2,760	$239	**$6,510**
1431 kcmil "Bobolink"	$3,446	$2,524	$239	**$6,209**
1590 kcmil "Lapwing"	$3,844	$2,604	$239	**$6,687**
1590 kcmil "Falcon"	$4,480	$3,073	$239	**$7,792**
1780 kcmil "Chukar"	$5,481	$3,349	$239	**$9,069**
2156 kcmil "Bluebird"	$6,537	$3,945	$239	**$10,720**
2167 kcmil "Kiwi"	$5,848	$3,572	$239	**$9,658**
2312 kcmil "Thrasher"	$6,160	$4,092	$239	**$10,491**
2515 kcmil "Joree"	$6,515	$4,350	$239	**$11,104**

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"	$678	$538	$239	**$1,456**
266.8 kcmil "Partridge"	$862	$689	$239	**$1,790**
336.4 kcmil "Merlin"	$829	$657	$239	**$1,725**
336.4 kcmil "Linnet"	$1,012	$786	$239	**$2,037**
336.4 kcmil "Oriole"	$1,088	$872	$239	**$2,199**
397.5 kcmil "Chickadee"	$948	$765	$239	**$1,951**
397.5 kcmil "Ibis"	$1,152	$932	$239	**$2,323**
397.5 kcmil "Lark"	$1,292	$1,034	$239	**$2,565**
477 kcmil "Pelican"	$1,163	$937	$239	**$2,339**
477 kcmil "Flicker"	$1,217	$980	$239	**$2,436**
477 kcmil "Hawk"	$1,346	$1,088	$239	**$2,673**
477 kcmil "Hen"	$1,465	$1,163	$239	**$2,866**
556.5 kcmil "Osprey"	$1,303	$1,034	$239	**$2,576**
556.5 kcmil "Parakeet"	$1,497	$1,195	$239	**$2,931**
556.5 kcmil "Dove"	$1,561	$1,249	$239	**$3,049**
636 kcmil "Kingbird"	$1,465	$1,163	$239	**$2,866**
636 kcmil "Rook"	$1,691	$1,346	$239	**$3,276**
636 kcmil "Grosbeak"	$1,755	$1,400	$239	**$3,394**
666.6 kcmil "Flamingo"	$1,938	$1,551	$239	**$3,728**
795 kcmil "Coot"	$1,809	$1,454	$239	**$3,502**
795 kcmil "Tern"	$1,841	$1,475	$239	**$3,556**
795 kcmil "Cuckoo"	$2,078	$1,658	$239	**$3,976**
795 kcmil "Condor"	$2,078	$1,658	$239	**$3,976**
795 kcmil "Drake"	$2,143	$1,560	$239	**$3,942**
900 kcmil "Canary"	$2,628	$1,712	$239	**$4,579**
954 kcmil "Rail"	$2,165	$1,665	$239	**$4,068**
954 kcmil "Cardinal"	$2,757	$1,846	$239	**$4,841**

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"	$2,337	$2,218	$239	**$4,794**
1033.5 kcmil "Curlew"	$2,961	$1,874	$239	**$5,074**
1113 kcmil "Bluejay"	$2,498	$2,380	$239	**$5,117**
1192.5 kcmil "Bunting"	$2,671	$1,992	$239	**$4,902**
1272 kcmil "Bittern"	$2,843	$2,132	$239	**$5,214**
1272 kcmil "Pheasant"	$3,381	$2,465	$239	**$6,085**
1351.5 kcmil "Dipper"	$2,994	$2,703	$239	**$5,936**
1351.5 kcmil "Martin"	$3,511	$2,401	$239	**$6,151**
1431 kcmil "Bobolink"	$3,446	$2,811	$239	**$6,496**
1590 kcmil "Lapwing"	$3,844	$2,757	$239	**$6,840**
1590 kcmil "Falcon"	$4,480	$3,076	$239	**$7,794**
1780 kcmil "Chukar"	$5,481	$3,586	$239	**$9,306**
2156 kcmil "Bluebird"	$6,537	$4,383	$239	**$11,158**
2167 kcmil "Kiwi"	$5,848	$5,223	$239	**$11,309**
2312 kcmil "Thrasher"	$6,160	$4,684	$239	**$11,083**
2515 kcmil "Joree"	$6,515	$4,911	$239	**$11,665**

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	$808	$538	**$1,346**
OPGW	$3,651	$2,434	**$6,084**

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 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)

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	$189,625	$220,375	$230,625	$243,438	$271,625	N/A	N/A
Wood pole – double circuit	$307,500	$353,625	N/A	N/A	N/A	N/A	N/A

Exploratory costs

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 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 and cost data as shown 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 the details of which are shared with stakeholders for their review and comment. 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.

A/C Transmission
New 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	$1.4M	$1.5M	$1.6M	$1.7M	$1.8M	$2.8M	$3.0M
Illinois	$1.4M	$1.5M	$1.6M	$1.7M	$1.8M	$2.9M	$3.1M
Indiana	$1.4M	$1.5M	$1.5M	$1.6M	$1.7M	$2.8M	$2.9M
Iowa	$1.4M	$1.5M	$1.6M	$1.7M	$1.8M	$2.8M	$3.0M
Kentucky	$1.5M	$1.6M	$1.6M	$1.7M	$1.9M	$3.0M	$3.2M
Louisiana	$1.6M	$1.7M	$1.8M	$1.9M	$2.1M	$3.3M	$3.5M
Michigan	$1.5M	$1.6M	$1.6M	$1.7M	$1.9M	$3.0M	$3.2M
Minnesota	$1.4M	$1.5M	$1.6M	$1.7M	$1.8M	$2.9M	$3.1M
Mississippi	$1.6M	$1.7M	$1.8M	$1.9M	$2.1M	$3.3M	$3.5M
Missouri	$1.4M	$1.5M	$1.5M	$1.6M	$1.7M	$2.8M	$2.9M
Montana	$1.3M	$1.4M	$1.4M	$1.5M	$1.6M	$2.6M	$2.7M
North Dakota	$1.3M	$1.4M	$1.5M	$1.5M	$1.6M	$2.6M	$2.8M
South Dakota	$1.3M	$1.4M	$1.5M	$1.5M	$1.6M	$2.6M	$2.8M
Texas	$1.6M	$1.7M	$1.7M	$1.9M	$2.0M	$3.2M	$3.4M
Wisconsin	$1.5M	$1.5M	$1.6M	$1.7M	$1.8M	$2.9M	$3.1M

Includes contingency (20%) and AFUDC (7.5%)

A/C Transmission
New 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	$2.0M	$2.2M	$2.3M	$2.4M	$2.9M	$4.7M	$4.9M
Illinois	$2.0M	$2.2M	$2.3M	$2.5M	$2.9M	$4.7M	$5.0M
Indiana	$2.0M	$2.2M	$2.3M	$2.4M	$2.8M	$4.6M	$4.9M
Iowa	$2.0M	$2.2M	$2.3M	$2.4M	$2.9M	$4.7M	$5.0M
Kentucky	$2.1M	$2.2M	$2.4M	$2.5M	$3.0M	$4.8M	$5.1M
Louisiana	$2.2M	$2.4M	$2.6M	$2.7M	$3.2M	$5.2M	$5.5M
Michigan	$2.1M	$2.3M	$2.4M	$2.5M	$3.0M	$4.8M	$5.1M
Minnesota	$2.0M	$2.2M	$2.3M	$2.5M	$2.9M	$4.8M	$5.0M
Mississippi	$2.2M	$2.4M	$2.5M	$2.7M	$3.2M	$5.2M	$5.5M
Missouri	$2.0M	$2.2M	$2.3M	$2.4M	$2.8M	$4.6M	$4.9M
Montana	$1.9M	$2.1M	$2.2M	$2.3M	$2.7M	$4.4M	$4.6M
North Dakota	$1.9M	$2.1M	$2.2M	$2.3M	$2.7M	$4.5M	$4.7M
South Dakota	$1.9M	$2.1M	$2.2M	$2.3M	$2.7M	$4.5M	$4.7M
Texas	$2.2M	$2.4M	$2.5M	$2.6M	$3.1M	$5.1M	$5.4M
Wisconsin	$2.0M	$2.2M	$2.4M	$2.5M	$2.9M	$4.8M	$5.1M

Includes contingency (20%) and AFUDC (7.5%)

HVDC Transmission New bipole transmission line $/mile Exploratory cost estimate				
Location – State	250kV line	400kV line	500kV line	600kV line
Arkansas	$1.9M	$2.0M	$2.1M	$2.3M
Illinois	$1.9M	$2.1M	$2.2M	$2.4M
Indiana	$1.8M	$2.0M	$2.1M	$2.2M
Iowa	$1.9M	$2.0M	$2.2M	$2.3M
Kentucky	$2.0M	$2.2M	$2.3M	$2.5M
Louisiana	$2.2M	$2.5M	$2.7M	$2.9M
Michigan	$2.0M	$2.2M	$2.3M	$2.5M
Minnesota	$1.9M	$2.1M	$2.2M	$2.4M
Mississippi	$2.2M	$2.5M	$2.6M	$2.8M
Missouri	$1.8M	$2.0M	$2.1M	$2.2M
Montana	$1.7M	$1.8M	$1.9M	$2.0M
North Dakota	$1.7M	$1.8M	$1.9M	$2.1M
South Dakota	$1.7M	$1.8M	$1.9M	$2.1M
Texas	$2.1M	$2.4M	$2.5M	$2.7M
Wisconsin	$1.9M	$2.1M	$2.3M	$2.4M

Includes contingency (20%) and AFUDC (7.5%)

A/C Transmission
Rebuild Single circuit transmission line $/mile
Exploratory cost estimate

Location – State	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
All States	$1.3M	$1.4M	$1.5M	$1.5M	$1.5M	N/A	N/A

Includes contingency (20%) and AFUDC (7.5%)

A/C Transmission
Rebuild Double circuit transmission line $/mile
Exploratory cost estimate

Location – State	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
All States	$2.0M	$2.3M	N/A	N/A	N/A	N/A	N/A

Includes contingency (20%) and AFUDC (7.5%)

A/C Transmission
Reconductor transmission line $/mile per circuit
Exploratory cost estimate

Location – State	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
All States	$.26M	$.31M	$.31M	$.31M	$.31M	$.49M	$.60M

Includes contingency (20%) and AFUDC (7.5%)

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. For A/C Transmission, MISO assumes steel pole structure type for 69kV – 345kV, and steel tower structure type for 500kV. For HVDC, MISO assumes steel pole structure type for 250kV, and steel tower structure for 400kV – 600kV. The quantity of structures per mile that MISO assumes for its cost estimates are shown in the tables below:

A/C Transmission
Structures per mile – Steel tower & steel pole
(single circuit / double circuit)

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Tangent structures	9 / 9.5	8.5 / 9	8 / 8.5	7 / 7.5	5 / 7	4.5 / 6	3.0 / 5
Running angle structures	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1
Non-angled deadend structures	0.25 / 0.25	0.25 / 0.25	0.25 / 0.25	0.25 / 0.25	0.25 / 0.25	0.25 / 0.25	0.25 / 0.25
Angled deadend structures	0.25 / 0.25	0.25 / 0.25	0.25 / 0.25	0.25 / 0.25	0.25 / 0.25	0.25 / 0.25	0.25 / 0.25
Total structures per mile	**10.5 / 11**	**10 / 10.5**	**9.5 / 10**	**8.5 / 9**	**6.5 / 8.5**	**6 / 7**	**4.5 / 6.5**

A/C Transmission
Structures per mile – wood pole
(single circuit / double circuit)

Voltage class	69kV line	115kV line	138kV line	161kV line	230kV line	345kV line	500kV line
Tangent structures	15.5 / 18.5	13.5 / 16.5	13.5 / N/A	10.5 / N/A	7.5 / N/A	N/A / N/A	N/A / N/A
Running angle structures	1 / 1	1 / 1	1 / N/A	1 / N/A	1 / N/A	N/A / N/A	N/A / N/A
Angled deadend structures	0.5 / 0.5	0.5 / 0.5	0.5 / N/A	0.5 / N/A	0.5 / N/A	N/A / N/A	N/A / N/A
Total structures per mile	**17 / 20**	**15 / 18**	**15 / N/A**	**12 / N/A**	**9 / N/A**	N/A / N/A	N/A / N/A

HVDC Transmission
Structures per mile – steel tower & steel pole
Single circuit

Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Tangent structures	4.5	4.0	3.5	3.0
Running angle structures	0.5	0.5	0.5	0.5
Non-angled structures	0.25	0.25	0.25	0.25
Angled structures	0.25	0.25	0.25	0.25
Total structures per mile	**5.5**	**5.0**	**4.5**	**4.0**

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.

A/C Transmission
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
Amp rating	1175	1650	1650	1650	1650	3300	3000
Power rating (MVA)	140	329	394	460	657	1972	2598

HVDC Transmission
Conductor Selection per circuit
Exploratory cost estimate assumption

Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Conductor size	1590kcmil	1590kcmil	1590kcmil	1590kcmil
Conductor type	ACSR	ACSR	ACSR	ACSR
Conductor quantity per pole	1	2	2	2
Power transfer	500MW	1500MW	2000MW	2400MW

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%

3.2 A/C 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. 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).

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. Land costs are shown in Section 3.4. 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.

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. Variations in Substation site work costs based upon land type include the costs shown in the Terrain and Grading Costs table in section 3.1. 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)	$348,385
Forested land (per acre)	+$5,176
Wetland (per acre)	+$60,411 for matting and construction difficulties
	+$48,460 for wetland mitigation credits
Access road (per mile)	$538,125

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 provides 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 Breaker 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 and placement on the foundation. Jumpers, conduit, wiring, and grounding cost includes material and installation of the electrical jumpers and fittings to connect to adjacent electrical equipment, above grade conduit, landing control cables on terminal block in equipment, and the above grade ground grid connection. 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	$41,000	$51,250	$53,813	$56,375	$97,375	$322,363	$424,350
Installation cost	$7,688	$8,200	$8,713	$9,225	$10,250	$15,375	$20,500
Jumpers, conduit, wiring, grounding	$8,200	$9,225	$10,250	$12,300	$15,375	$20,500	$25,625
Foundation cost	$4,835	$6,044	$7,118	$8,998	$10,744	$11,818	$26,591
Total cost per circuit breaker	**$61,722**	**$74,719**	**$79,893**	**$86,898**	**$133,744**	**$370,056**	**$497,066**

Disconnect Switches unit cost is the cost associated with one (3-phase) disconnect switch. Material cost is the cost to procure and deliver one disconnect switch to site (laydown yard). Installation cost includes assembly and placement on the steel stand. Jumpers and grounding cost include material and installation of the electrical jumpers and fittings to connect to adjacent electrical equipment and the above grade ground grid connection. If it is determined that the switch requires a motor operator, MISO will add in costs for above grade conduit and wiring. 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
Material cost	$10,250	$12,813	$15,375	$17,938	$20,500	$35,875	$51,250
Installation cost	$6,150	$7,175	$8,200	$9,225	$10,250	$15,375	$20,500
Jumpers, and grounding	$4,100	$4,613	$5,125	$6,150	$7,688	$10,250	$12,813
Steel stand material cost	$3,360	$3,920	$4,480	$5,600	$7,840	$8,960	$11,200
Steel stand installation cost	$3,864	$4,508	$5,152	$6,440	$9,016	$10,304	$12,880
Foundation cost	$4,566	$5,641	$6,984	$8,730	$10,475	$10,744	$24,174
Total cost per disconnect switch	**$32,290**	**$38,669**	**$45,316**	**$54,082**	**$65,769**	**$91,508**	**$132,817**

Voltage Transformer 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 and placement on the steel stand. Jumpers, conduit, wiring, and grounding cost includes material and installation of the electrical jumpers and fittings to connect to adjacent electrical equipment, above grade conduit, landing control cables on terminal block in equipment, and the above grade ground grid connection. 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
Material cost	$20,500	$23,063	$25,625	$28,188	$35,875	$43,050	$82,000
Installation cost	$2,050	$2,306	$2,563	$2,819	$3,075	$4,100	$5,125
Jumpers, conduit, wiring, grounding	$6,150	$6,919	$7,688	$9,225	$11,531	$15,375	$19,219
Steel stand material cost	$2,800	$3,024	$3,192	$3,360	$3,920	$4,480	$5,600
Steel stand installation cost	$3,220	$3,478	$3,671	$3,864	$4,508	$5,152	$6,440
Foundation cost	$2,417	$3,089	$3,626	$4,566	$5,372	$10,744	$16,250
Total cost per voltage transformer	**$37,137**	**$41,878**	**$46,364**	**$52,021**	**$64,281**	**$82,901**	**$134,634**

Current Transformers 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 and placement on the steel stand. Jumpers, conduit, wiring, and grounding cost includes material and installation of the electrical jumpers and fittings to connect to adjacent electrical equipment, above grade conduit, landing control cables on terminal block in equipment, and the above grade ground grid connection. 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	$63,268	$79,079	$107,728	$118,490	$129,304	$215,481	$377,098
Installation cost	$2,050	$2,306	$2,563	$2,819	$3,075	$4,100	$5,125
Jumpers, conduit, wiring, grounding	$6,150	$6,919	$7,688	$9,225	$11,531	$15,375	$19,219
Steel stand material cost	$2,800	$3,024	$3,192	$3,360	$3,920	$4,480	$5,600
Steel stand installation cost	$3,220	$3,478	$3,671	$3,864	$4,508	$5,152	$6,440
Foundation cost	$2,417	$3,089	$3,626	$4,566	$5,372	$10,744	$16,250
Total cost per current transformer	**$79,906**	**$97,894**	**$128,466**	**$142,324**	**$157,710**	**$255,332**	**$429,732**

Bus support, bus, and fittings 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 and 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	$5,894	$7,380	$8,508	$8,943	$9,379	$11,096	$12,787
Installation cost	$7,073	$8,856	$10,209	$10,732	$11,255	$13,315	$15,344
Steel stand material cost	$2,240	$2,800	$3,360	$3,920	$4,480	$6,720	$10,080
Steel stand installation cost	$2,576	$3,220	$3,864	$4,508	$5,152	$7,728	$11,592
Foundation cost	$4,163	$5,238	$6,446	$8,058	$9,670	$12,893	$19,339
Total cost per bus support, bus, and fittings	**$21,946**	**$27,494**	**$32,387**	**$36,161**	**$39,935**	**$51,751**	**$69,142**

Deadend structure 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 3.1. The same unit cost is used for substation estimates as is used for transmission line estimates.

Power transformer 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. For a scoping cost estimate, MISO will discuss power transformer pricing with vendors.

Power transformer ($/MVA)

Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
69kV	$4,840	$3,940	$4,360	$4,590	$5,090	$6,250	$8,060
115kV	$3,940	$5,360	$4,360	$4,590	$5,090	$5,940	$7,290
138kV	$4,360	$4,360	$5,940	$4,840	$5,090	$5,940	$7,290
161kV	$4,590	$4,590	$4,840	$6,580	$5,360	$6,250	$7,670
230kV	$5,090	$5,090	$5,090	$5,360	$7,290	$6,250	$7,670
345kV	$6,250	$5,940	$5,940	$6,250	$6,250	$8,880	$8,060
500kV	$8,060	$7,290	$7,290	$7,670	$7,670	$8,060	$11,900

Major equipment 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. For a scoping cost estimate, MISO will discuss major equipment pricing with vendors.

Major equipment unit costs

Voltage class	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Reactor ($/MVAr)	$13,914	$13,914	$13,914	$13,914	$13,914	$13,914	$13,914
Capacitor bank ($/MVAr)	$10,250	$10,250	$10,250	$10,250	$10,250	$10,250	$10,250
Static VAr Compensator ($/MVAr)	$98,579	$98,579	$98,579	$98,579	$98,579	$98,579	$98,579

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 unit cost is the cost associated with one control enclosure of approximately 500 square feet. Material and installation cost are the cost to procure and deliver one control enclosure to site (laydown yard), offload and placement of the control enclosure on the foundation and wiring of the AC/DC systems to field equipment. Control enclosure includes AC panels, DC panels, cable tray, and all other typical components. Relay panels are considered separately. Battery and battery charger costs is the material and installation cost for the batteries in the control enclosure and their associated battery charger. Communication equipment costs are the cost to account for communication equipment placed inside the substation (e.g. fiber patch panel, remote terminal unit, human machine interface). 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	$307,500	$307,500	$307,500	$307,500	$307,500	$307,500	$307,500
Battery and battery charger	$102,500	$102,500	$102,500	$102,500	$102,500	$102,500	$102,500
Communication equipment	$102,500	$102,500	$102,500	$102,500	$102,500	$153,750	$153,750
Station service power	$112,750	$112,750	$112,750	$112,750	$112,750	$133,250	$133,250
Foundation cost	$24,174	$24,174	$24,174	$24,174	$24,174	$24,174	$24,174
Total cost control enclosure	**$649,424**	**$649,424**	**$649,424**	**$649,424**	**$649,424**	**$721,174**	**$721,174**

Relay panels 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	$19,219	$23,959	$29,981	$33,825	$37,413	$49,969	$62,525
Installation cost	$38,438	$47,919	$59,963	$67,650	$74,825	$99,938	$125,050
Total Relay Panel cost	**$57,656**	**$71,878**	**$89,944**	**$101,475**	**$112,238**	**$149,906**	**$187,575**

Conduit 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	$3,075	$3,075	$3,075	$3,075	$3,075	$3,075	$3,075
Installation cost per 1000 feet	$41,000	$41,000	$41,000	$41,000	$41,000	$41,000	$41,000
Conduit total cost per 1000 feet	**$44,075**	**$44,075**	**$44,075**	**$44,075**	**$44,075**	**$44,075**	**$44,075**

Control cable 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	$4,100	$4,100
Installation cost per 1000 feet	$5,125	$5,125	$5,125	$5,125	$5,125	$5,125	$5,125
Control cable total cost per 1000 feet	**$8,200**	**$8,200**	**$8,200**	**$8,200**	**$8,200**	**$9,225**	**$9,225**

Cable trench 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	$51	$51	$51	$51	$51	$51	$51
Installation cost per 1 foot	$205	$205	$205	$205	$205	$205	$205
Cable trench total cost per 1 foot	**$256**	**$256**	**$256**	**$256**	**$256**	**$256**	**$256**

Professional Services & 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 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)

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.

Exploratory Costs

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 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 and cost data as shown 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 the details of which are shared with stakeholders for their review and comment.

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 MISO's planning process. 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. Bus ratings per voltage class are included in the indicative assumptions and are aligned line ratings assumed by MISO for its transmission line project cost estimates.

Substation upgrade - Exploratory cost estimate							
Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Add 1 position (ring bus)	$1.0M	$1.2M	$1.3M	$1.5M	$1.7M	$2.8M	$4.2M
Add 1 position (breaker-and-a-half bus)	$1.4M	$1.6M	$1.8M	$2.1M	$2.4M	$3.9M	$5.9M
Add 1 position (double-breaker bus)	$1.6M	$1.8M	$2.1M	$2.3M	$2.7M	$4.3M	$6.4M
Add 2 positions (ring bus)	$2.0M	$2.4M	$2.7M	$3.0M	$3.5M	$5.5M	$8.5M
Add 2 positions (breaker-and-a-half bus)	$2.5M	$2.9M	$3.3M	$3.7M	$4.3M	$6.9M	$10.4M
Add 2 positions (double-breaker bus)	$3.2M	$3.7M	$4.2M	$4.6M	$5.4M	$8.6M	$12.8M

Includes contingency (20%) and AFUDC (7.5%)

New substation - Exploratory cost estimate							
Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
4 positions (ring bus)	$5.8M	$6.5M	$7.1M	$7.7M	$8.7M	$12.5M	$18.1M
4 positions (breaker-and-a-half bus)	$7.0M	$7.8M	$8.6M	$9.4M	$10.7M	$15.7M	$22.8M
4 positions (double-breaker bus)	$8.0M	$9.1M	$10.0M	$10.9M	$12.6M	$18.8M	$27.5M
6 positions (ring bus)	$7.4M	$8.3M	$9.1M	$9.9M	$11.4M	$16.7M	$24.6M
6 positions (breaker-and-a-half bus)	$9.0M	$10.1M	$11.2M	$12.3M	$14.2M	$21.3M	$31.4M
6 positions (double-breaker bus)	$10.5M	$12.0M	$13.3M	$14.6M	$16.9M	$25.7M	$37.8M

Includes contingency (20%) and AFUDC (7.5%)

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
Exploratory cost estimate assumptions
(ring / breaker-and-a-half / double-breaker bus)

Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Land required (acre)	0.40/0.50/ 0.60	0.45/0.56/ 0.68	0.50/0.63/ 0.75	0.55/0.69/ 0.83	0.60/0.75/ 0.90	0.75/0.94/ 1.13	1.25/1.56/ 1.88
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)	450/ 675/ 900	475/ 713/ 950	500/ 750/ 1,000	525/ 788/ 1,050	550/ 825/ 1,100	600/ 900/ 1,200	700/ 1,050/ 1,400
Control cable (feet)	4,500/ 6,750/ 9,000	4,750/ 7,130/ 9,500	5,000/ 7,500/ 10,000	5,250/ 7,880/ 10,500	5,500/ 8,250/ 11,000	6,000/ 9,000/ 12,000	7,000/ 10,500/ 14,000
Cable trench (feet)	45/ 68/ 90	48/ 71/ 95	50/ 75/ 100	53/ 79/ 105	55/ 83/ 110	60/ 90/ 120	70/ 105/ 140
Bus rating (Amps)	1200	2000	2000	2000	2000	3000	3000

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

Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Land required (acre)	0.80/1.00/ 1.20	0.90/1.13/ 1.35	1.00/1.25/ 1.50	1.10/1.38/ 1.65	1.20/1.50/ 1.80	1.50/1.88/ 2.25	2.50/3.13/ 3.75
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)	900/ 1,350/ 1,800	950/ 1,425/ 1,900	1,000/ 1,500/ 2,000	1,050/ 1,575/ 2,100	1,100/ 1,650/ 2,200	1,200/ 1,800/ 2,400	1,400/ 2,100/ 2,800
Control cable (feet)	9,000/ 13,500/ 18,000	9,500/ 14,250/ 19,000	10,000/ 15,000/ 20,000	11,000/ 15,750/ 21,000	11,000/ 16,500/ 22,000	12,000/ 18,000/ 24,000	14,000/ 21,000/ 28,000
Cable trench (feet)	90/ 135/ 180	95/ 143/ 190	100/ 150/ 200	105/ 158/ 210	110/ 165/ 220	120/ 180/ 240	140/ 210/ 280
Bus rating (Amps)	1200	2000	2000	2000	2000	3000	3000

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

Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Land required (acre)	1.60/2.00/ 2.40	1.80/2.25/ 2.70	2.00/2.50/ 3.00	2.20/2.75/ 3.30	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)	12/14/16	12/14/16	12/14/16	12/14/16	12/14/16	14/16/20	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)	1,800/ 2,700/ 3,600	1,900/ 2,850/ 3,800	2,000/ 3,000/ 4,000	2,100/ 3,150/ 4,200	2,200/ 3,300/ 4,400	2,400/ 3,600/ 4,800	2,800/ 4,200/ 5,600
Control cable (feet)	18,000/ 27,000/ 36,000	19,000/ 28,500/ 38,000	20,000/ 30,000/ 40,000	21,000/ 31,500/ 42,000	22,000/ 33,000/ 44,000	24,000/ 36,000/ 48,000	28,000/ 42,000/ 56,000
Cable trench (feet)	180/ 270/ 360	190/ 285/ 380	200/ 300/ 400	210/ 315/ 420	220/ 330/ 440	240/ 360/ 480	280/ 420/ 560
Bus rating (Amps)	1200	2000	2000	2000	2000	3000	3000

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

Scope of work	69kV	115kV	138kV	161kV	230kV	345kV	500kV
Land required (acre)	2.00/2.50/ 3.00	2.25/2.80/ 3.40	2.50/3.10/ 3.80	2.75/3.40/ 4.10	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)	14/16/20	14/16/20	14/16/20	14/16/20	14/16/20	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)	2,700/ 4,050/ 5,400	2,850/ 4,275/ 5,700	3,000/ 4,500/ 6,000	3,150/ 4,725/ 6,300	3,300/ 4,950/ 6,600	3,600/ 5,400/ 7,200	4,200/ 6,300/ 8,400
Control cable (feet)	27,000/ 40,500/ 54,000	28,500/ 42,750/ 57,000	30,000/ 45,000/ 60,000	31,500/ 47,250/ 63,000	33,000/ 49,500/ 66,000	36,000/ 54,000/ 72,000	42,000/ 63,000/ 84,000
Cable trench (feet)	270/ 405/ 540	285/ 428/ 570	300/ 450/ 600	315/ 473/ 630	330/ 495/ 660	360/ 540/ 720	420/ 630/ 840
Bus rating (Amps)	1200	2000	2000	2000	2000	3000	3000

3.3 HVDC Converter Stations

Converter stations are required at each endpoint of an HVDC transmission line in order to interconnection with the A/C transmission system. MISO includes in its guide two converter station design types - line-commutated thyristor valve technology (LCC) and Voltage-Source transistor technology (VSC).

In addition to only a converter station, there would also be A/C substation equipment needed to interconnect. Typical interconnection voltages would be 230kV A/C for a ±250kV HVDC transmission line, 345kV A/C for a ±400kV HVDC transmission line, and 500kV A/C for a ±500kV and ±600kV HVDC transmission line. For the purposes of creating a cost estimate, in the tables below, MISO assumes its exploratory costs for a new 4-position, breaker-and-a-half substation for the A/C substation costs connected with a new converter station.

At each converter station, MISO assumes a ground electrode is installed. Historically, HVDC electrodes have been installed to provide a low resistance path during both monopolar and bipolar operations, using earth as a conductive medium. Although this option of return path in HVDC is less expensive, there are environmental and regulatory implications. For the purpose of the cost estimate, MISO assumes that those concerns are permitted by respective authorities and addressed by the developer.

The ground electrode is a structure with a conductor, or a group of conductors embedded in the soil directly or surrounded by conductive medium providing an electric path to ground. The electrodes are generally located relatively close to the converter stations. MISO's unit cost of a ground electrode includes engineering study, permitting, material, labor and land. In addition to the ground electrode, there is also the ground electrode line which is an electrical connection between conversions and ground electrode. The cost of overhead ground electrode line includes supporting structures, foundations, conductor material and labor. MISO assumes 20 miles of ground electrode line at each of the HVDC transmission line.

Line Commutated Converter (LCC) Stations are composed of thyristor valves and are located indoors to provide safe, clean and controlled operating environment. The cost of bipolar converter station valve hall includes land and land acquisition, building, DC switching station equipment including DC filters, converter transformer, insulation, control devices and services. LCC stations require A/C filters which are included in the converter station costs. Reactive power compensation is assumed to be a Static Var Compensator, which the costs are shown in section 3.2.

Converter Station Line Commutated Converter (LCC) – one end				
Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Power Transfer	500MW	1500MW	2000MW	2400MW
Assumed Reactive Power Need	167MVAR	500MVAR	667MVAR	800MVAR
Ground electrode line length	20 miles	20 miles	20 miles	20 miles
Valve hall	$30.0M	$110.0M	$150.0M	$185.0M
A/C filters	$3.0M	$11.0M	$15.0M	$18.5M
Reactive power	$16.5M	$49.3M	$65.8M	$78.9M
A/C Substation	$10.7M	$15.7M	$22.8M	$22.8M
Ground electrode	$2.7M	$3.6M	$3.7M	$3.9M
Ground electrode line	$4.0M	$10.0M	$12.0M	$15.0M
Total Converter Station cost:	**$66.9M**	**$199.6M**	**$269.3M**	**$324.1M**

Voltage Source Converter (VSC) Stations are composed of IGBT valves and are located indoors to provide safe, clean and controlled operating environment. The cost of bipolar converter station valve hall includes land and land acquisition, building, DC switching station equipment including DC filters, converter transformer, insulation, control devices and services. It is assumed that VSC converter stations do not require any additional reactive power support and they can inherently provide power with a 0.95 leading to a 0.95 lagging power factor.

Converter Station Voltage Source Converter (VSC) – one end				
Voltage class	± 250kV line	± 400kV line	± 500kV line	± 600kV line
Power Transfer	500MW	1500MW	2000MW	2400MW
Ground electrode line length	20 miles	20 miles	20 miles	20 miles
Valve hall	$72.0M	$230.0M	$310.0M	$380.0M
A/C Substation	$10.7M	$15.7M	$22.8M	$22.8M
Ground electrode	$2.7M	$3.6M	$3.7M	$3.9M
Ground electrode line	$4.0M	$10.0M	$12.0M	$15.0M
Total Converter Station cost:	**$89.4M**	**$259.3M**	**$348.5M**	**$421.7M**

Professional Services & 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 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)

3.4 Shared Project costs among all project types

Certain types of costs of shared among all project types and are discussed here.

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 each potential project and estimate accordingly.

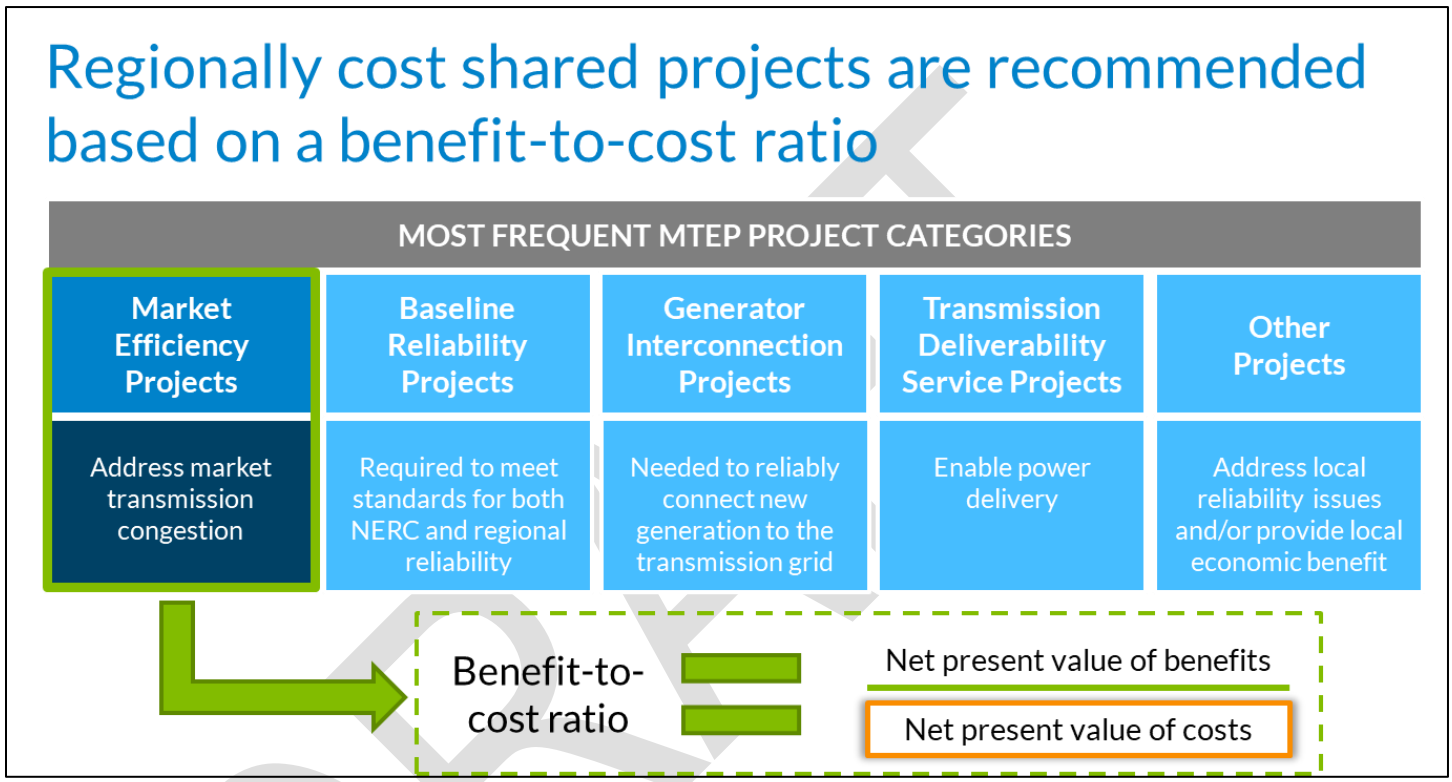
In addition to the cost of the land, MISO also includes indicative acquisition cost per acre and regulatory and permitting cost per acre. Real property rights for transmission projects include good faith negotiations with the land owners to acquire rights through easements, options, leases, fee purchases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

Land Cost

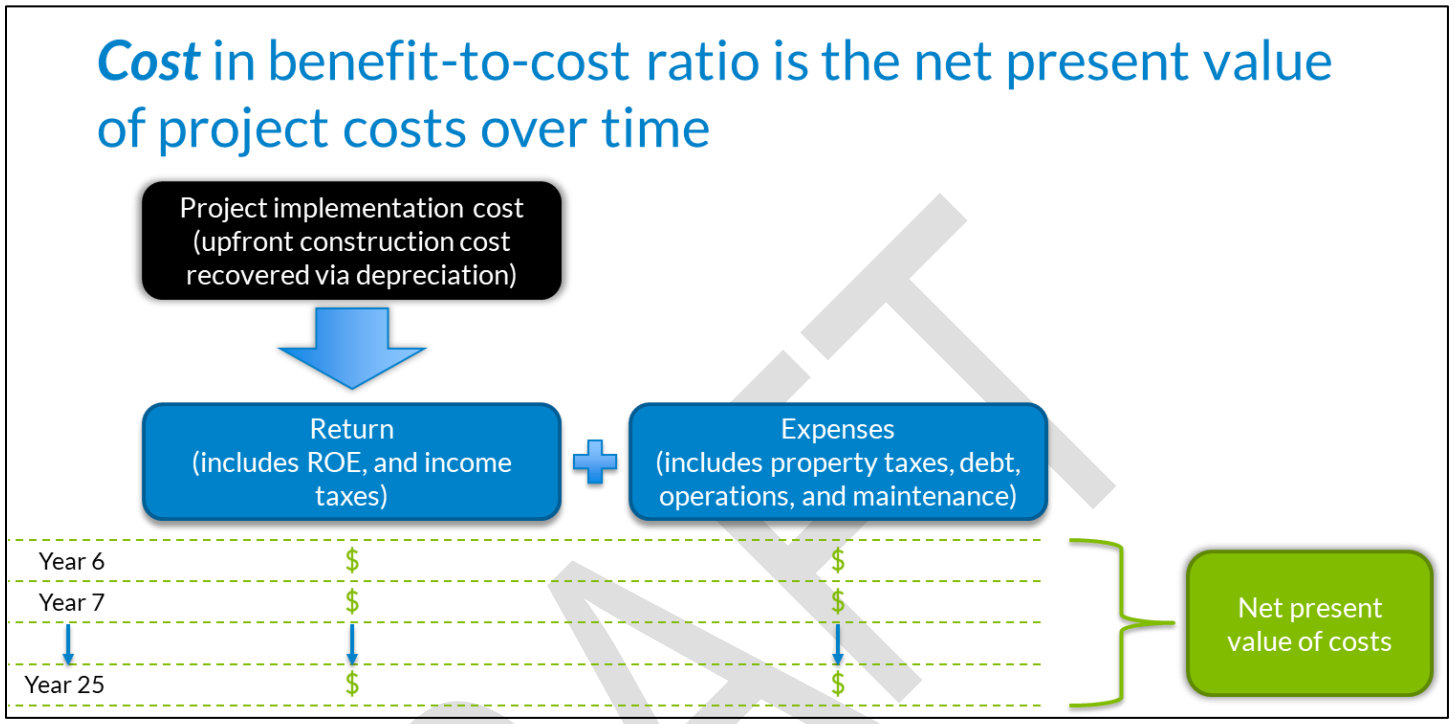
State – land	Land cost per acre			Acquisition cost per acre	Regulatory & permitting cost per acre
	Pasture	Crop	Suburban & Urban		
Arkansas	$2,714	$8,141	$13,569	$12,300	$2,563
Illinois	$3,764	$11,293	$18,822	$12,300	$2,563
Indiana	$2,789	$8,368	$13,947	$12,300	$2,563
Iowa	$3,339	$10,017	$16,694	$12,300	$2,563
Kentucky	$2,972	$8,917	$14,861	$12,300	$2,563
Louisiana	$2,908	$8,724	$14,541	$12,300	$2,563
Michigan	$2,746	$8,239	$13,732	$12,300	$2,563
Minnesota	$1,831	$5,494	$9,156	$12,300	$8,559
Mississippi	$2,380	$7,139	$11,898	$12,300	$2,563
Missouri	$2,121	$6,364	$10,606	$12,300	$2,563
Montana	$711	$2,134	$3,556	$12,300	$2,563
North Dakota	$915	$2,745	$4,575	$12,300	$4,279
South Dakota	$1,142	$3,426	$5,710	$12,300	$3,434
Texas	$1,777	$5,330	$8,883	$12,300	$2,563
Wisconsin	$2,531	$7,593	$12,655	$12,300	$8,559

4. Costs over time

In MISO's yearly MTEP, certain types of projects may be identified to be recommended to our Board that are justified on a benefit-to-cost ratio requirement. In order to evaluate alternatives in the planning process, MISO estimates the net present value of costs over time of differing solution ideas that may also be differing technology types (e.g., energy storage project vs. transmission line project).



In order to estimate costs over time, MISO estimates depreciation costs, expense factors, and return factors for transmission projects. Expense factors and return factors vary by State to account for state-level differences in taxes (e.g., income taxes and property taxes).



In its estimate of costs over time, MISO makes assumptions about the following cost inputs:

Year #	Present Value Discount Rate	Gross Plant Project Cost ISD Yr.$ (PI)	Net Plant Project Cost ISD Yr.$ (PI)	Annual Depreciation Factor	Return Factor subject to decrease in net plant	Expense Factor	Annual Cost to be Recovered	Net Present Value Cost

Year(s)

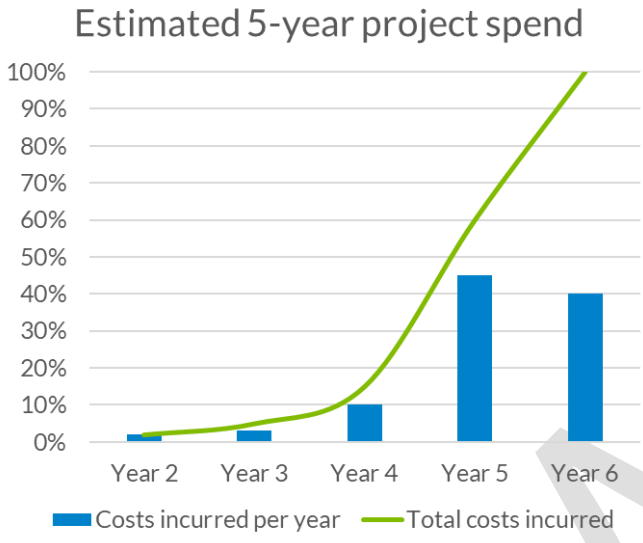
MISO defines the Project Costs to be used in the benefit-to-cost ratio as the present value of the annual revenue requirements projected for the first 20 years of the project's life (Attachment FF Section II.C.7). An example of the years used in the calculation for a project that will take 5 years to construct is that years 6 through 25 will be the first 20 annual revenue requirement years. The present value cost calculation is over the same period for which the project benefits are determined.

Present Value Discount Rate

Calculated by MISO annually as the after-tax weighted average cost of capital of the Transmission owners that make up the Transmission Provider Transmission System. For MTEP20, the discount rate is 7.10%.

Gross Plant (nominal cost estimate)

The nominal cost to construct the project is also the amount used for the annual revenue requirements calculation. The present year project cost estimate is converted to nominal cost by factoring a construction spend per year and an annual inflation rate of 2.5%. The graph and table below show how an example $100M project is expressed as a nominal cost estimate at an assumed 5-year project development time span.



Example: Project cost = $100M, Contingency = $20M, AFUDC = $9M
Present year project implementation cost = $129M
Nominal project implementation cost = $146.6M

Estimated 5-year project spend

Year	2*	3	4	5	6	Subtotal
Costs incurred per year	2%	3%	10%	45%	40%	100%
Present year project implementation cost	$2.6M	$3.9M	$12.9M	$58.0M	$51.6M	$129.0M
Convert to nominal dollars at 2.5% inflation rate. Nominal cost = present year cost * (1 + inflation rate) ^ (project year)						
Nominal project implementation cost	$2.7M	$4.2M	$14.2M	$65.7M	$59.8M	$146.6M

Net Plant and Annual Depreciation Factor

The Gross plant less depreciation based on a 40-Year asset life, which is 2.5% depreciation per year.

Return Factor and Expense Factor (by State)

The Return Factor accounts for the cost of equity and income taxes. The return factor changes annually as it is a factor of net gross plant which is reduced annually as a result of depreciation. The Expense Factor accounts for property taxes, the cost of debt, and operations and maintenance. Both factors vary by State and are shown in the table below:

Expense Factor and Return Factor (by State)		
State	Expense Factor	Return Factor (adjusted for the first year of depreciation)
Arkansas	2.89%	8.28%
Illinois	3.54%	8.47%
Indiana	3.06%	8.41%
Iowa	3.30%	8.63%
Kentucky	2.99%	8.25%
Louisiana	3.58%	8.37%
Michigan	3.48%	8.25%
Minnesota	3.17%	8.49%
Mississippi	2.89%	8.18%
Missouri	3.10%	8.26%
Montana	3.05%	8.29%
North Dakota	3.37%	8.20%
South Dakota	3.30%	7.86%
Texas	3.58%	7.86%
Wisconsin	3.56%	8.37%

Annual cost to be recovered

Calculation of the estimated annual revenue requirement which is the sum of the depreciation factor, the expense factor, and the return factor multiplied by the Gross Transmission Plant value.

Net Present Value Cost

Appling the discount rate to the first 20 years of the annual revenue requirement results in the NPV cost to be used in the benefit-to-cost ratio. Net Present Value Cost is calculated per year by multiplying the annual cost to be recovered by the Present Value Discount Rate for their respective years.

Example

For example, if we were estimating the costs over time for a project in Arkansas, that had a nominal cost estimate of $146.6M, and we use a discount rate of 7.10%, based on the approach we described above, the net present value of cost over the first 20 years of in-service life would be $130.7M as shown in the table below:

Year #	Present Value Discount Rate	Gross Plant Project Cost ISD Yr.$ (PI)	Net Plant Project Cost ISD Yr.$ (PI)	Annual Depreciation Factor	Return Factor subject to decrease in net plant	Expense Factor	Annual Cost to be Recovered	Net Present Value Cost
MTEP Year	1.000							
1	0.934							
2	0.872							
3	0.814							
4	0.760							
5	0.710				8.28%			
6	0.663	$146,635,793	$142,969,898	2.50%	8.07%	2.89%	$19,733,990	$13,076,095
7	0.619	$146,635,793	$139,304,003	2.50%	7.86%	2.89%	$19,430,499	$12,021,472
8	0.578	$146,635,793	$135,638,108	2.50%	7.66%	2.89%	$19,127,007	$11,049,211
9	0.539	$146,635,793	$131,972,213	2.50%	7.45%	2.89%	$18,823,516	$10,153,026
10	0.504	$146,635,793	$128,306,319	2.50%	7.24%	2.89%	$18,520,024	$9,327,105
11	0.470	$146,635,793	$124,640,424	2.50%	7.04%	2.89%	$18,216,533	$8,566,068
12	0.439	$146,635,793	$120,974,529	2.50%	6.83%	2.89%	$17,913,041	$7,864,945
13	0.410	$146,635,793	$117,308,634	2.50%	6.62%	2.89%	$17,609,550	$7,219,135
14	0.383	$146,635,793	$113,642,739	2.50%	6.42%	2.89%	$17,306,059	$6,624,385
15	0.357	$146,635,793	$109,976,844	2.50%	6.21%	2.89%	$17,002,567	$6,076,765
16	0.334	$146,635,793	$106,310,950	2.50%	6.00%	2.89%	$16,699,076	$5,572,639
17	0.312	$146,635,793	$102,645,055	2.50%	5.80%	2.89%	$16,395,584	$5,108,647
18	0.291	$146,635,793	$98,979,160	2.50%	5.59%	2.89%	$16,092,093	$4,681,684
19	0.272	$146,635,793	$95,313,265	2.50%	5.38%	2.89%	$15,788,601	$4,288,878
20	0.254	$146,635,793	$91,647,370	2.50%	5.17%	2.89%	$15,485,110	$3,927,579
21	0.237	$146,635,793	$87,981,476	2.50%	4.97%	2.89%	$15,181,619	$3,595,334
22	0.221	$146,635,793	$84,315,581	2.50%	4.76%	2.89%	$14,878,127	$3,289,879
23	0.206	$146,635,793	$80,649,686	2.50%	4.55%	2.89%	$14,574,636	$3,009,123
24	0.193	$146,635,793	$76,983,791	2.50%	4.35%	2.89%	$14,271,144	$2,751,132
25	0.180	$146,635,793	$73,317,896	2.50%	4.14%	2.89%	$13,967,653	$2,514,124
								$130,717,224