Underground vs. Overhead Transmission

Based on white paper provided by HDR, Inc.

*** ***Information only – no action required*** ***

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Report contains conceptual estimates

- Chelan PUD does not have experience with underground transmission.
- Cost estimates are based on the conceptual design of one consultant using experience nationwide.
- Specific construction methods and materials along with other assumptions are stated in the report provided to Chelan PUD. These specific methods may not be the methods chosen for a specific project.
- Cost estimates could be significantly different for a site specific feasibility.
- Substation taps require double circuit construction for redundancy to eliminate prolonged outages

Construction (per mile cost)

Underground

- Based on level terrain, urban setting
- If on hilly/mountainous terrain, cost increases two-fold or more
- Substation tap requires redundant supply
- Life Expectancy **40+ years**
- Not included:
  - Environmental studies
  - Local, state, federal permits
  - Easements, land acquisition

Conceptual Estimate DESCRIPTION	Double Circuit 1000 A 2,500-kcmil CU
UNDERGROUND	$ 4,218,000
SURVEY, GEOTECH, ENGINEERING AND OTHER	$ 463,000
CONTINGENCY (30%)	$ 1,404,000
DOUBLE CIRCUIT COST PER MILE	$ 6,085,000

NOTE: A single transition structure is required for a project. Is not part of per-mile costs but is added to the project total --- $222,000

RESULT: Total Project Cost for 1 Mile Double Circuit = $ 6,307,000

Overhead

- Based on level terrain, urban setting
- If on hilly/mountainous terrain, costs could increase two-fold
- Life Expectancy **80+ years**
- Not included:
  - Environmental studies
  - Local, state, federal permits
  - Easements, land acquisition

Conceptual Estimate DESCRIPTION	Double Circuit 1000A 954-kcmil AAC
OVERHEAD	$ 573,000
SURVEY, GEOTECH, ENGINEERING AND OTHER	$ 42,000
CONTINGENCY (30%)	$ 185,000
DOUBLE CIRCUIT COST PER MILE	$ 800,000

NOTE: A termination support structure inside the substation is required for a project. Is not part of per-mile costs but is added to the project total --- $200,000

RESULT: Total Project Cost for 1 Mile Double Circuit = $ 1,000,000

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Right of Way (ROW)

Underground

Figure 18-12 ROW Requirements for a Double Circuit Installation

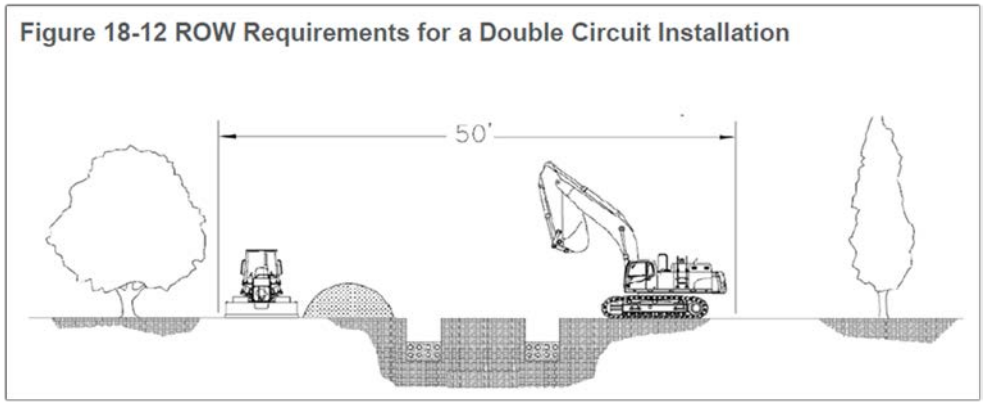
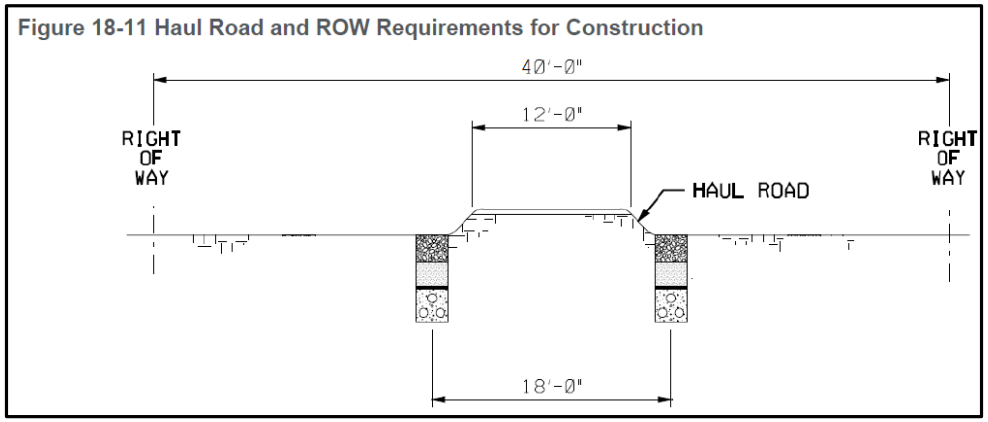


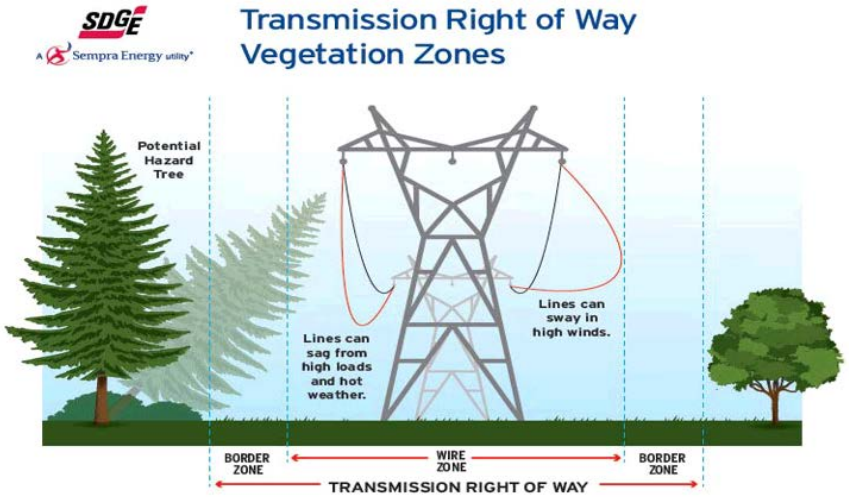
Figure 18-11 Haul Road and ROW Requirements for Construction



Concern: Very limited land use within the ROW

- Trees
- Driveways
- Buildings

Overhead



- Generally 100 ft. ROW
- Land use mostly impacted at structure locations
- Can still have trees and buildings in ROW under many circumstances

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Construction Methods - Underground

Conduit and Trenches

- Required for entire length
- Backfill for thermal characteristics

Figure 18-13 Conduit Placement

Figure 18-14 Conduit Backfilling

Construction Methods - Underground

Vaults

- Required at least every 2500 ft (limitations in the length of cable run)
- 8ft x 20ft x 10ft (or larger)
- For cable splicing and anchoring on hilly/mountainous terrain

Figure 18-15 Vault Placement

Figure 18-16 Vault Placement - Top

Construction Methods - Underground

Splices

- Requires specialized equipment and highly trained personnel
- Relatively short cable runs (2500ft maximum)

NOTE: Hilly terrain requires more vaults and elaborate restraint systems to keep cables from creeping downhill. Costs may double or more.

Figure 16-1 Rigid Straight-Through Single Circuit Arrangement in Vault

Restraints to keep from moving (thermal cycling)

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Construction Methods - Underground

Transitions

- Steel structure required at overhead transmission line
- Substation termination is inside the fence

Underground into substation

Transition structure at transmission line

Construction Methods - Overhead

Direct buried steel poles

- Most poles directly embedded (no foundations)
- Installation using conventional excavation equipment and line trucks

Construction Methods - Overhead

Foundations and guy-wires

- Angles and dead-end structures may have foundations and/or guy wires

Repair Considerations

Underground

- Must stock materials or accept 4 to 6 month lead time for parts
- Repairs require skilled specialists to perform
  - Chelan PUD not likely to perform repairs in-house

26.3.2 Repair Time for 115 kV Cable Fault

For 115 kV systems, we estimate a minimum of 10 days to repair a cable failure provided that:

- All spare parts such as cable and splices are available from on hand stock.
- Fault finding equipment and trained personnel are available in-house to locate the fault.
- Trained personnel, equipment and special tools are available in-house to:
  - Undo two splices
  - Remove the faulted cable
  - Redo two splices
  - Conduct proof tests before re-energizing the line.

If other entities need to be contracted for fault finding and to make the repairs then the repair time may be longer depending on time requirements to have contracts in place and the time requirements for contracted companies to mobilize to locate and make the repairs. Under this scenario, repair times could easily approach 20 days or longer.

** Substations must have a means for redundant supply lines, otherwise a fault could result in power outage for 20 days or longer

Overhead

- Typically hours to repair, maybe 2 days
- We already stock standardized parts
- Crews currently perform this work daily

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SUMMARY - Substation Tap Installation

Cost for 1 mile tap to substation:

*** Conceptual Estimates ***

All calculations assume 7% discount rate and 2.5% general inflation

SCENARIO 1: Double Circuit Underground, varied terrain installation

$6,307,000 to $12,614,000 Installation Cost
$20,700 annual inspection for 79 years (50% higher than single circuit inspection costs)
$2,000,000 re-cable project at year 40
NPV = ($7,122,000) to ($13,429,000)

SCENARIO 2: Double Circuit Overhead, varied terrain installation

$1,000,000 to $2,000,000 Installation Cost
$1,300 annual maintenance for 79 years
NPV = ($1,028,000) to ($2,029,000)

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SUMMARY - Substation Tap Installation

Favors Underground

Favors Overhead

Summary of Advantages and Disadvantages - substation tap installation		
Description	**Under Ground Line**	**Overhead Line**
Aesthetics	Minimal since cables are buried	Visual impact from lines and poles
Atmospheric Phenomena	Practically immune to weather conditions and events	Very susceptible to weather events
Public safety (just for comparison, Overhead Lines are also considered very safe)	Cables are buried and have limited electrocution hazard	Higher potential for electrocution hazard due to bare overhead wires
Human activities (Theft, Vandalism, Terrorism etc.)	More protected	Full exposure
Flexibility	Difficult to reroute, reconfigure or upgrade	Relatively easy to reroute, reconfigure and upgrade
Fault Location	Difficult and requires specialized equipment and trained personnel	Faults can be easily located
Repair Time	10-20 days if all materials and personnel are available	Typically less than a day to 2 days
Repair Complexity	Difficult to repair and requires skilled personnel	Relatively easy and District staff is very efficient and experienced
Installation Costs	6.3 - 12.6 times more costly than overhead	Much less costly
Life Cycle Costs	6.9 - 13.1 times more costly	Much less costly
Life Expectancy	40+ years	80+ years
Reliability	Faults rarely occur however take a long time to repair	Faults are more frequent but are typically smaller and can be repaired much more rapidly
Practical Uses	Relatively flat urban areas or crossing under waterbodies and short distances	All geographies, topographies and distances

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