230-kV UG Transmission Line Segment RTRP Project Opinion of Probable Cost

For

Lennar Corporation

May 22, 2015

(Updated October 22, 2015)

Background

Southern California Edison is proceeding with the planning and design of an overhead 230-kV double circuit transmission line. This line is part of the Riverside Transmission Reliability Project (Project). (Riverside, 2014) A large portion of the Project traverses property under a planned development by Lennar homes in the Jurupa Valley area.

There are 230-kV underground transmission lines currently operated by Southern California Edison, Pacific Gas & Electric, Silicon Valley Power in California and elsewhere across the country. It is notable that 230 KV transmission lines have been typically constructed as an overhead facility. However, the alternative of underground construction has gained a higher degree of occurrence as the availability of rights-of-way have become more scarce, more costly, and harder to obtain. It is also of note that over the past few decades, the design of 230-kV cable systems has progressed to become a reliable solution.

The increases in cost for land rights for overhead lines is converging with the decrease in cost associated with the utilization of underground technology for the construction of 230-kV transmission lines. Accordingly as these costs converge is no longer a simple matter to say that underground transmission is too expensive to install. Even when considering the fact that underground systems costs still remain from 5 to 10 times the cost of overhead facilities. The California Public Utility Commission (CPUC) has previously issued a certificates of public convenience and necessity (CPCN's) for projects that include large segments of 230-kV underground.

This report provides an opinion of probable cost based on a specific alignment. No attempt is made to evaluate the cost of land in this report which addresses the cost of construction and the acquisition of materials only.

ROUTE ALIGNMENT MAP USED FOR ESTIMATE

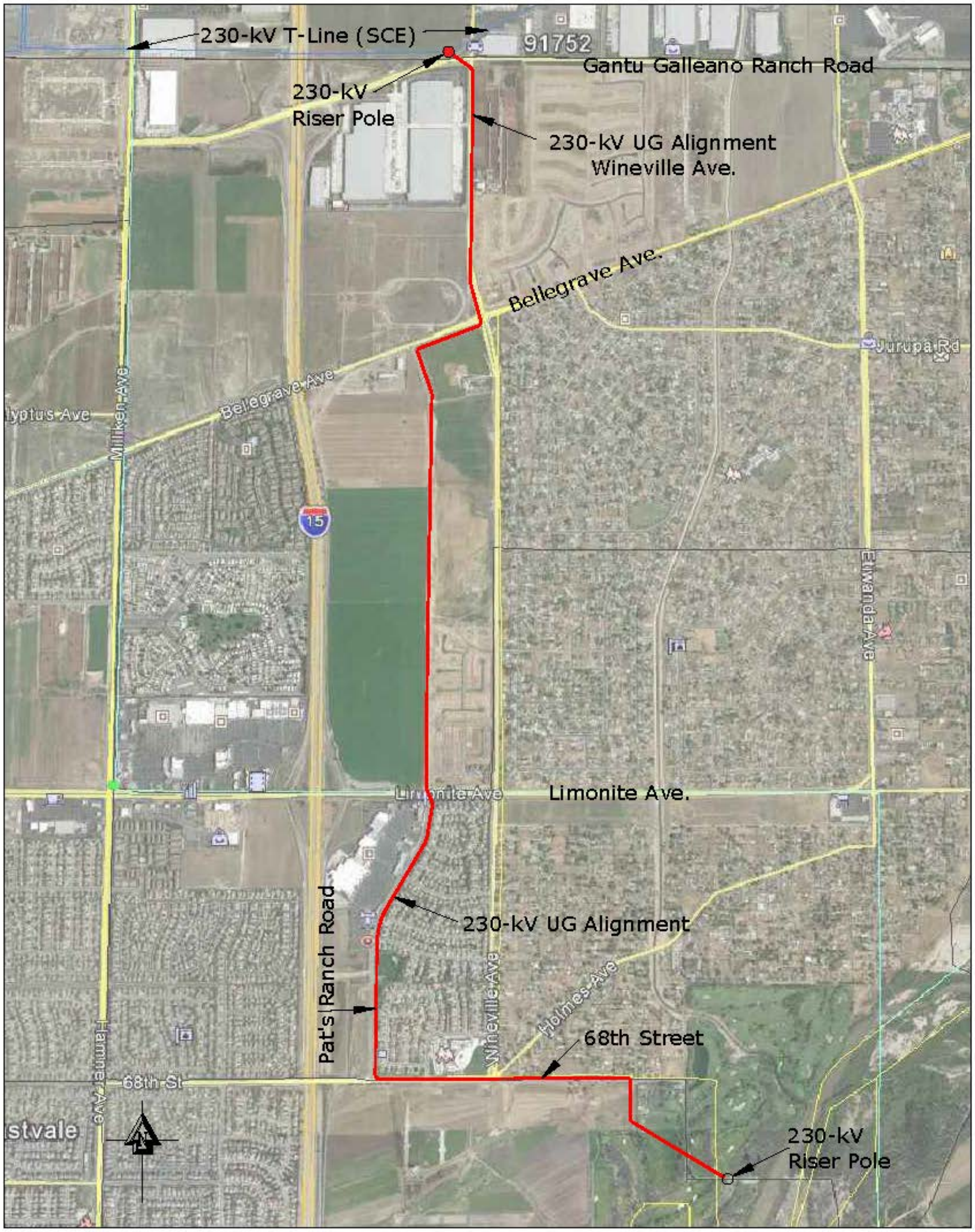


Figure 1 – Study Alignment Map

TYPICAL 230-KV UNDERGROUND TRANSMISSION LINE CONSTRUCTION

Underground construction begins by surveying the alignment and establishing the extent of the construction area. Underground system installations typically encounter many conflicts, such as other electric, gas, and water utilities; fiber optics installations, storm drain and sewer lines and others during construction, which will mandate special trench routing and design depths to resolve. Identification of these inevitable conflicts must be made prior to constriction to update designs and to prevent impacts to other underground systems.

Underground facilities require the installation of a trench system to place conduits and cable along a carefully selected alignment. The design also demands close coordination with other utilities and services that could cause a co-location conflict. Underground transmission construction is most often used in urban areas that have been developed or are otherwise congested where limited space is available for overhead construction. Underground transmission construction may be disruptive to street traffic and individuals because of the extensive excavation necessary. During construction, vehicular and pedestrian traffic would typically be impacted.

While it true that the trenching for the construction of underground lines causes greater surface disturbance than overhead lines, restoration of road surfaces, grassy and unpaved areas recover quickly.

The following sections describe the typical components of an underground 230-kV transmission circuit.

TRENCHES

Extensive excavation is required to dig the needed trenches for the placement of conduits. For 230-kV systems, typical trenches are approximately 3 to 4 feet wide and 6 to 8 feet deep. The Project is a double circuit system, so two trenches will be required, which are typically separated by 3 to 6 feet. Figure 2 below is a typical cross section of a trench installation for a 230-kV underground design. Figures 3 is a photograph of a typical underground construction during installation.

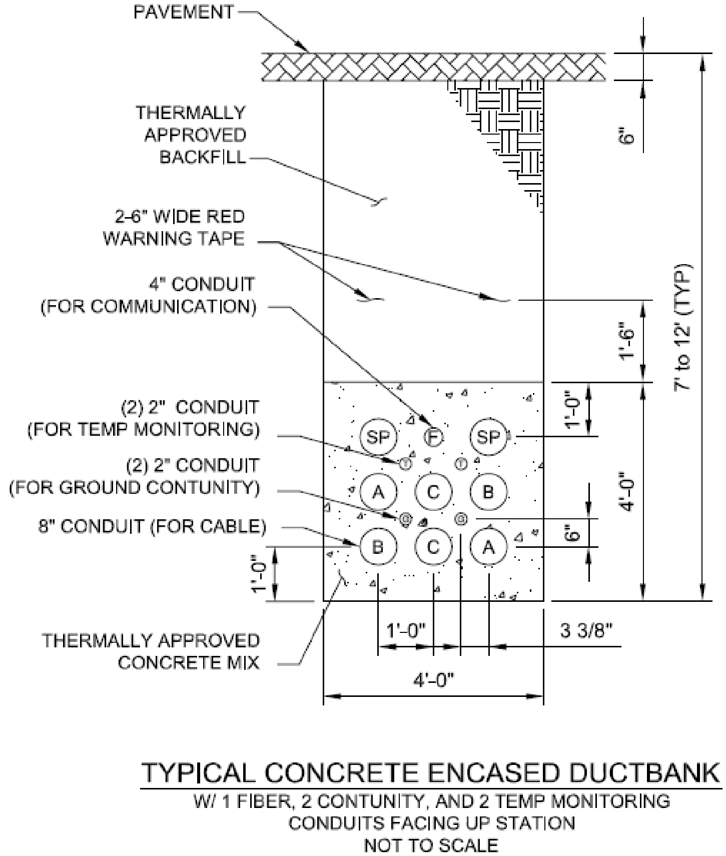


Figure 2 – Typical Cross Section of 230-kV UG

Figure 3 – Trench Installation

JACK AND BORE

Jack and bore construction is used in areas where open trench construction is not feasible or where trench construction is impractical. It is anticipated that jack and bore construction will be used to cross under busy roadways where traffic interruptions would be a high impact.

The amount of disturbed construction area excavations for jack and bore operations include excavation of a boring pit at each end of the bore to accommodate drilling and jacking equipment. The cables will be encased in a large pipe that is jacked in and is backfilled with a grout for temperature control. Bore pits can be as long as 125 feet to allow adequate movement of the equipment.

Figure 4 – Typical Jack and Bore Installation

VAULTS

Large underground vaults are spaced at regular intervals to facilitate the pulling of the large XLPE cable through the conduits, the installation of cable splices, and the installation of cables on the transition structures where the cables are connected to the overhead conductors. Vaults for 230-kV systems are typically 20- 24 feet long, 8 to 12 feet wide and 8 to 10 feet deep to provide sufficient space for workers to splice or pull cables. Figure 5 below is an illustration of a typical vault used by Southern California Edison.

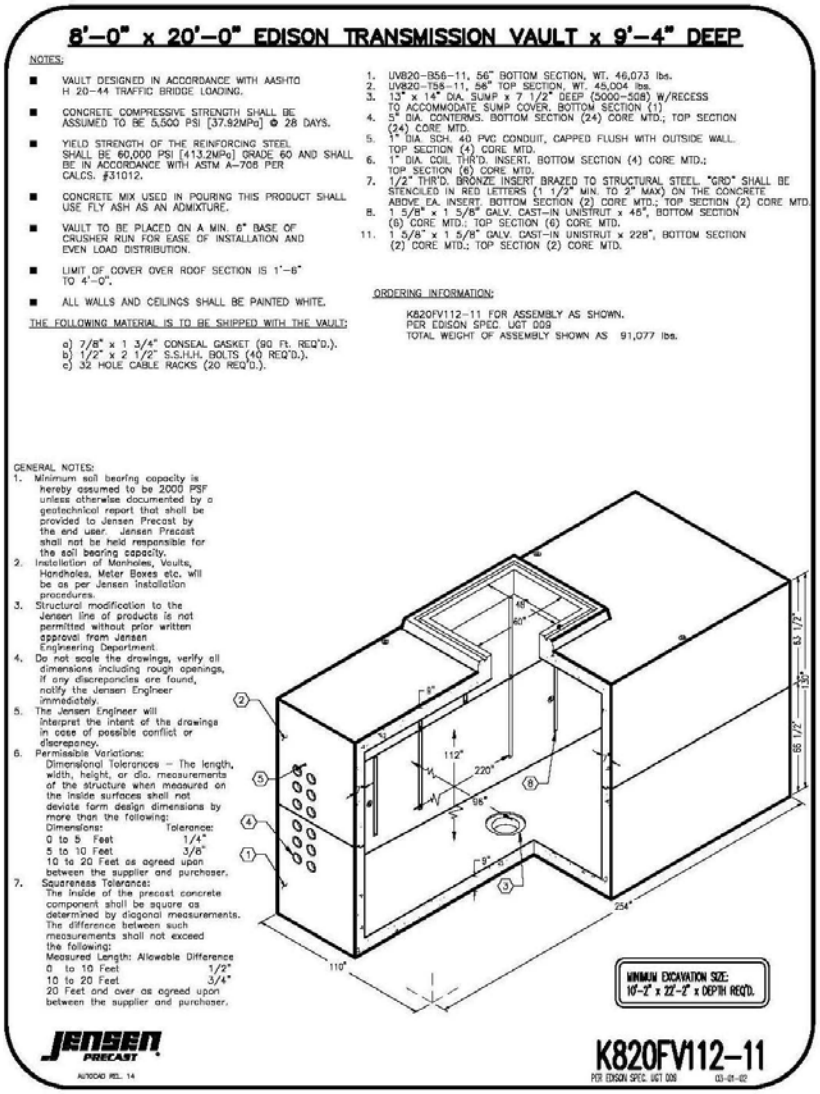


Figure 5 – SCE Vault (Curtesy Jensen Precast)

XLPE 230-kV Cable

Cross-linked polyethylene (XLPE) cable, illustrated in figure 6 below, cable is being used for 230-kV underground transmission line systems. Figure 7 is a photo of a typical cable pulling arrangement. There is less maintenance associated with underground XLPE cable systems simply because the system is contained in dedicated duct banks and underground vaults.

However, insulation failures, when they occur, result in prolonged outages and are much more difficult to monitor and detect. Twin sets of three cables (six cables) are used for each circuit, primarily so that the underground segment matches the capacity of the overhead section. This practice also mitigates the extent of the consequences of a cable failure by shortening the time to restore service.

The overhead design of the Project specifies the use of twin (2) 1590 kcmil "Lapwing" ACSR conductors, 1.492" in diameter per phase. A total of twelve (12) are required to accommodate both circuits. The rated ampacity taken from manufacturer's data (Cable, 2014) for Lapwing is 1500 amperes, which equates to 3000 amperes per phase. It is believed that the Lapwing conductor selected was sized for a maximum temperature operation under emergency conditions of 212ºF. According to published reports (Southwire, 2015) XLPE cable can also operate at these temperatures under emergency conditions. Based on cable capacity and average loading, twin 4000 kcmil copper XPLE cable was selected, which matches the ampacity rating of the overhead Lapwing conductor.

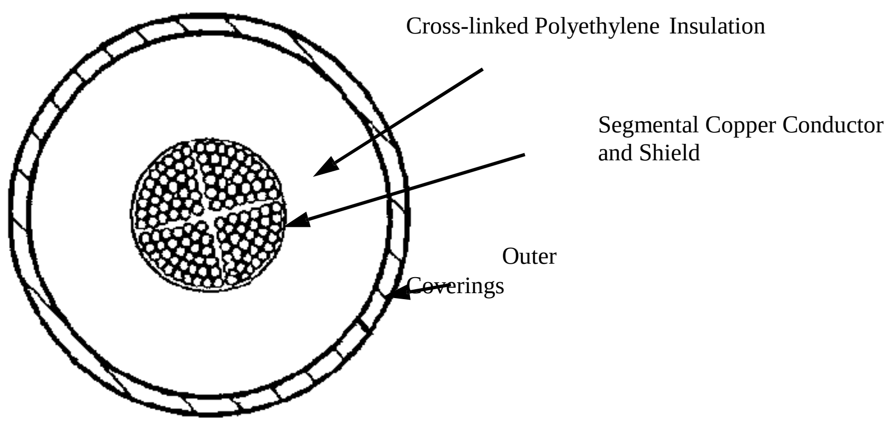


Figure 6 – Typical Cross Section of XPLE Cable

Figure 7 – Typical XLPE Cable

Riser Pole Structures

The transition from overhead to underground and vice versa requires the use of a specialty designed steel pole structure for that purpose. These structures are known as risers. They can be 100 or more feet in height. They are designed so that the three twin conductors are effectively separated and meet GO95 electric code requirements.

The twin 4000 kcmil XPLE copper cable is terminated with a specially designed termination that includes a compatible connector for the twin Lapwing conductor of the overhead line. The structure also supports the needed surge arresters to protect the cable insulation and jacket. A sketch of a typical riser is shown in figure 8 below. A photograph of a 230-kV riser pole currently is service on the 230-kV Silicon Valley Power system in Santa Clara is shown in figure 9.

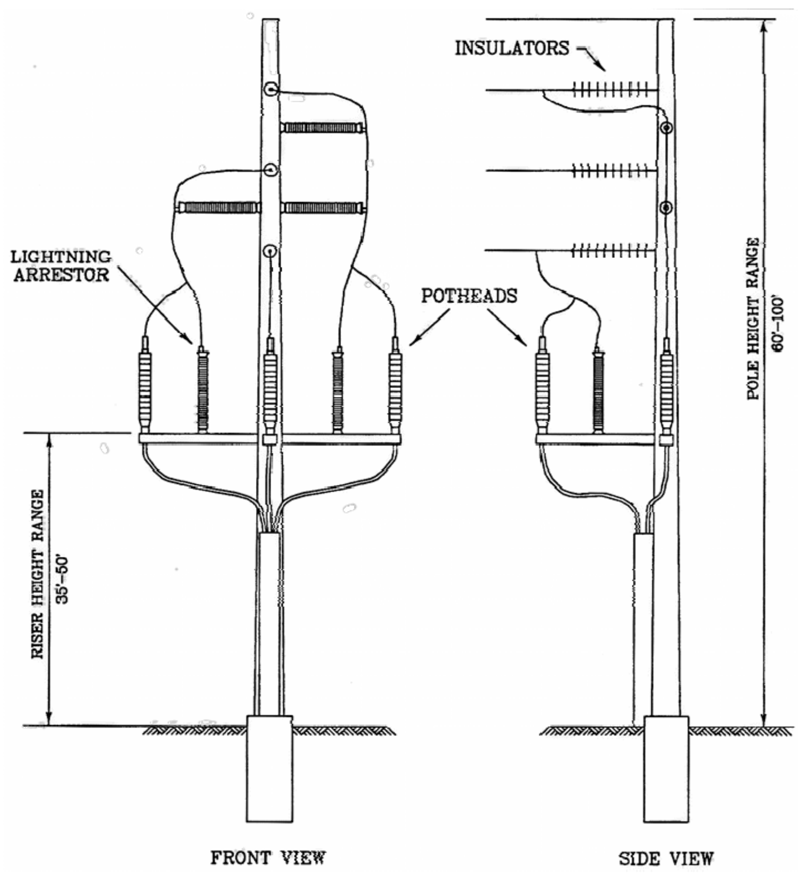


Figure 8 – Typical Riser Poles

Figure 9– Silicon Valley Power 230-kV Riser

CONDUIT INSTALLATION FOR XLPE CONSTRUCTION

The assembly of conduits for the installation of XLPE cable are illustrated in Figures 10 and 11 below. Six to eight inch PVC conduits will be needed to accommodate the 4 to 5 inch diameter cable. Eight conduits would be required in a typical design providing two spares. The conduits are joined using PVC cement and placed in the trench using spacer assemblies specifically design for that purpose. The use of spacers assures that conduits are properly spaced and separated from each other.

Figure 10 – Conduit Placement

Figure 11 – Conduit Installation at a Corner

Backfilling

Heat must be carried away from the conductors for them to operate efficiently. The air performs this function for overhead lines. The soils in and around the trench do this for underground lines.

All of the heat generated from direct buried cables must be dissipated through the soil. The selection of backfill type can make a strong difference on the capacity rating. Different soils have different abilities to transfer heat. Saturated soils conduct heat more easily than for instance, sandy soils. For this reason, the design needs to determine the type of soil nearest the line. A soil thermal survey may be necessary before construction to help determine the soil's ability to move heat away from the line. In many cases, a special backfill material is used instead of soil in the trench around the cables to ensure sufficient heat transfer to the surrounding soils and groundwater.

CABLE INSTALLATION

Cable pulling and splicing is done after the conduit and vaults are completed. The conduit is tested and cleaned by the contractor before pulling for each conduit. A typical pulling arrangement is shown in figure 12 below. The cables is then pulled from one vault to the next vault. Cables splices are contained within a vault.

Figure 12 – Cable Pulling Arrangement

Figure 13 - Typical Cable Splice Vault

Site Restoration

Site restoration for underground construction is similar to overhead transmission line construction restoration. When construction is completed, roadways, landscaped areas, and undeveloped areas are restored to their original condition. Roads (Figure 14) and sidewalks are resurfaced to meet traffic standards for access and loading. Landscaped areas on private and public properties are restored. Driveways, curbs, and private utilities are restored to their previous use.

Figure 14 – Typical Restored Roadway

LABOR AND MATERIAL COST ESTIMATE FOR 230-KV UNDERGROUND

Many engineering factors significantly increase the cost of underground transmission facilities. As the voltage increases, engineering constraints and costs dramatically increase. The cost estimate below presumes construction within roadways. This will require lane closures and traffic control in accordance with CalTRAN requirements for public safety. Typically, several hundred feet of lanes or roadways are closed during a phase of construction. Construction areas must accommodate the safe operation of construction equipment and the hauling of materials. Adjacent features along portions of the road ROW will require excavation and/or replacement of side walk and driveway features. All shrubs and trees are cleared and grubbed in areas to be trenched that are not located along or under roadways.

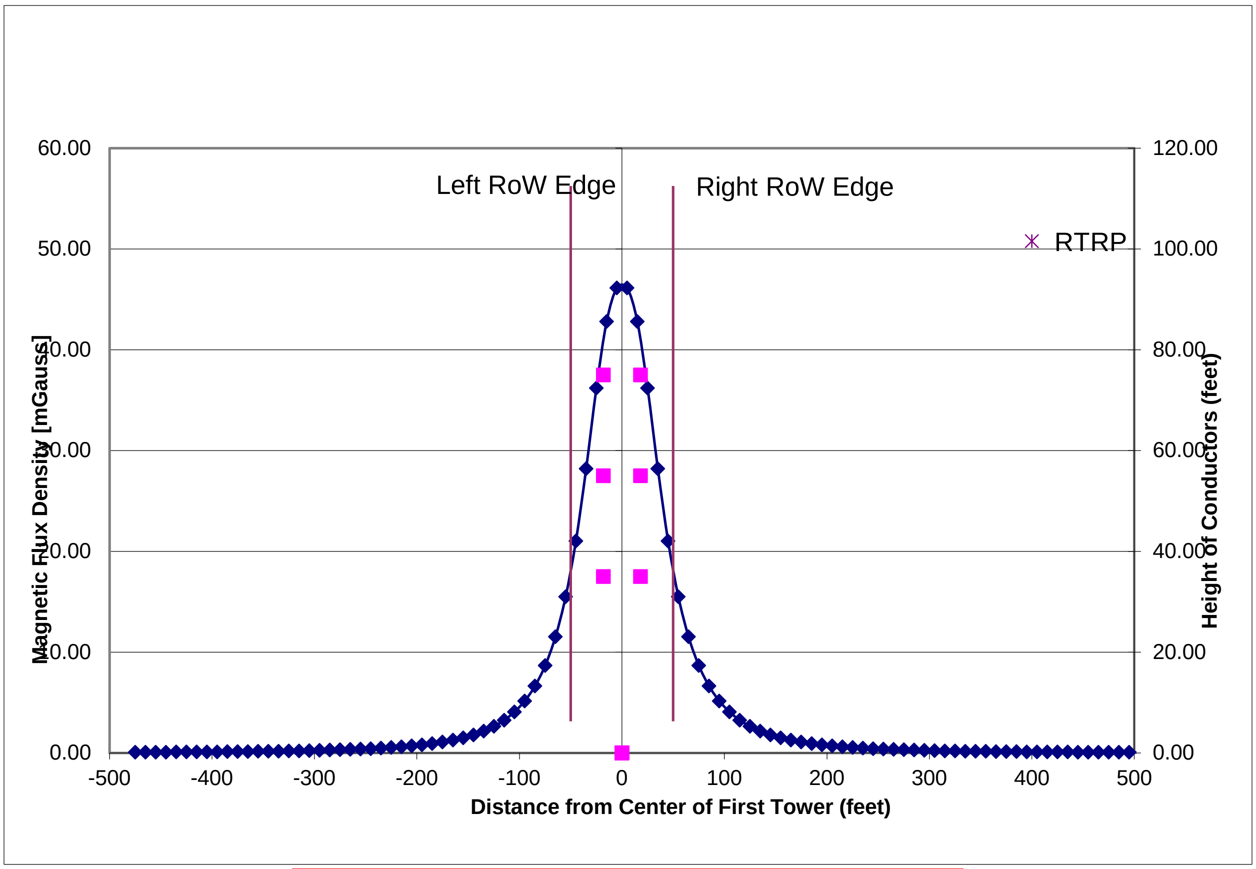
Costs

Costs are presented for both overhead and underground configurations. The estimates are for labor and materials only and do not include adders and other adjustments associated with corporate overhead, financing, land acquisition, land rights, maintenance, construction oversight, environmental mitigation, engineering, permits, etal.

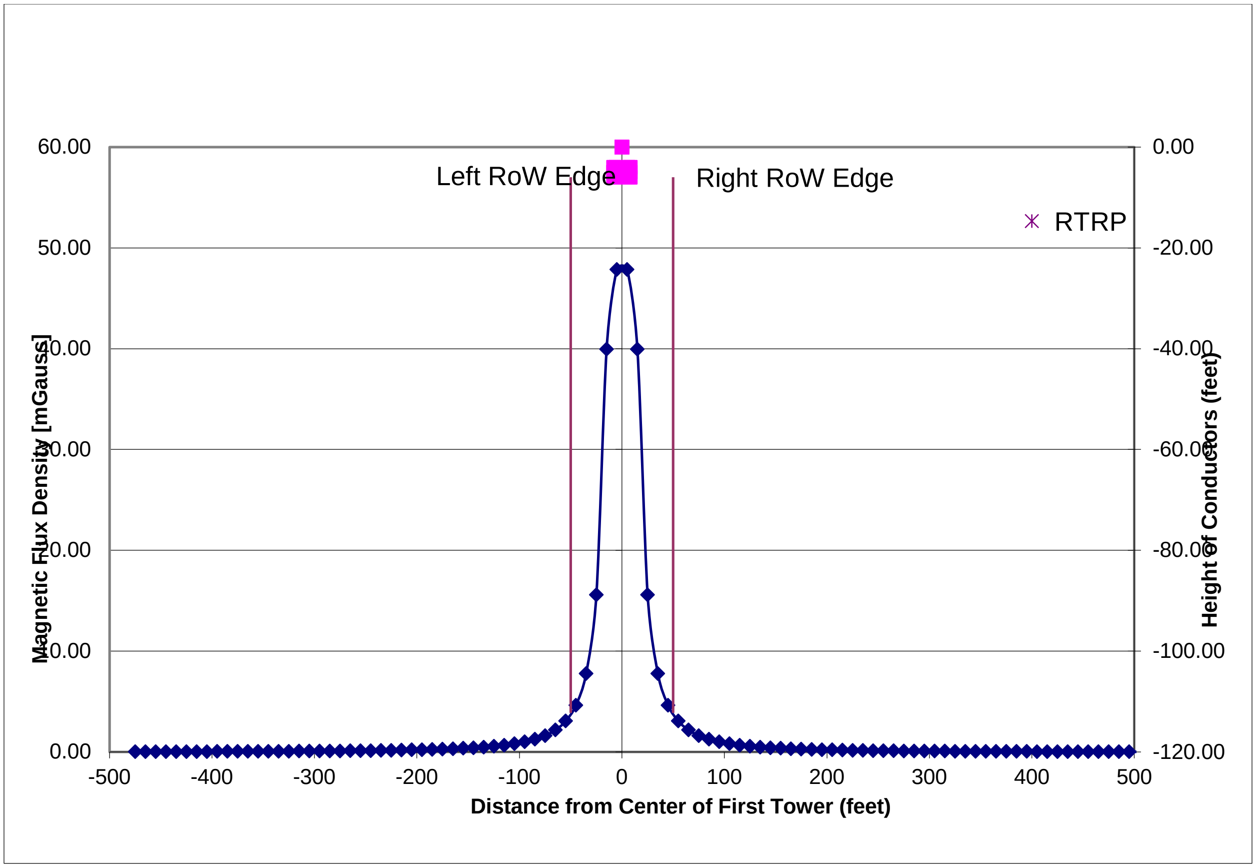
The costs presented were determined using estimated quantities and current material pricing. Distances were estimated from RTRP maps and the route alignment map shown in figure are determined by the local environment, the distances between splices and termination points, and the number of ancillary facilities required. Other issues that make underground transmission lines more costly are right-of-way access, start-up complications, construction limitations in urban areas, conflicts with other utilities, trenching construction issues, crossing natural or manmade barriers, and the potential need for forced cooling facilities. Other transmission facilities in or near the line may also require new or upgraded facilities to balance power issues such fault currents and voltage transients, all adding to the cost.

While it may be useful to sometimes compare the general cost differences between overhead and underground construction, the actual costs for underground may be quite different. Underground transmission construction can be very site-specific, especially for higher voltage lines. Components of underground transmission are often not interchangeable as they are for overhead. A complete in-depth study and characterization of the subsurface and electrical environment is necessary in order to get an accurate cost estimate for undergrounding a specific section of transmission. This can make the cost of underground transmission extremely variable when calculated on a per-mile basis.

EMF



Magnetic Flux Density [mGauss]	
at Left RoW Edge	18.049
at Right RoW Edge	18.049
Max MFD Value	46.1



Magnetic Flux Density [mGauss]	
at Left RoW Edge	3.740
at Right RoW Edge	3.740
Max MFD Value	47.9

LABOR AND MATERIAL COST ESTIMATE FOR 230-KV OVERHEAD FOR COMPARISON

The estimated costs for overhead is based the use of tubular steel structures in a double circuit configuration as described by the RTRP project. Costs were developed using current material and labor price estimates. The line length used is 23,000 feet to agree with the alignment shown in figure 1 above.

The estimates are shown below

230-kV Double Circuit Underground Transmission Line   length   23000   feet

Cost Estimate for Lennar Homes

Item	material	labor	L&M	quantity	unit	total material	total labor	total	Description
XLPE Cable	85600	96000	181600	276	Mft	23,625,600	26,496,000	50,121,600	4000 kcmil copper
Surface Cuts	0	4000	4000	46	Mft	0	184,000	184,000	Saw cuts concrete and asphalt
Trench	0	150000	150000	46	Mft	0	6,900,000	6,900,000	2-3.5' by 6 ft. trenches
Vaults	25000	42000	67000	40	each	1,000,000	1,680,000	2,680,000	24 X 10 X 8 Concrete
8" PVC Conduit	1750	9500	11250	276	Mft	483,000	2,622,000	3,105,000	Schedule 40
4" PVC Conduit	750	5500	6250	46	Mft	34,500	253,000	287,500	Schedule 40
2" PVC Conduit	750	3375	4125	46	Mft	34,500	155,250	189,750	Schedule 40
Spacers	2.5	2.5	5	4600	each	11,500	11,500	23,000	Conduit positioning
Horizontal Bore	25	25	50	100	ft	2,500	2,500	5,000	Pipe and spacers and grout
Splices	1500	3500	5000	18	each	27,000	63,000	90,000	connection end to end
Splice Racks	350	1000	1350	80	each	28,000	80,000	108,000	on walls in vaults
Risers	35000	150000	185000	4	each	140,000	600,000	740,000	Tubular Steel Poles
Riser Foundations	15000	30000	45000	4	each	60,000	120,000	180,000	Support for risers
Terminations	750	3500	4250	24	each	18,000	84,000	102,000	at cable ends on risers
Surge Arresters	550	350	900	12	each	6,600	4,200	10,800	At connection on riser
Grounding Systems	3500	7500	11000	4	each	14,000	30,000	44,000	Between vaults to cable wire mesh
Concrete Backfill	120	95	215	6814.815	CY	817,778	647,407	1,465,185	controlled heat transfer
Concrete Encasement	120	135	255	20444.44	CY	2,453,333	2,760,000	5,213,333	controlled heat transfer
Resurfacing	15	8.75	23.75	60375	SF	905,625	528,281	1,433,906	curb and gutter and roadways

Total L&M	72,883,075
Engineering (2%-3%)	2,186,492
Project Management (1%)	728,831
Construction Management (3% - 5%)	3,644,154
Total	$79,442,551 ^

SEE PRICING SUPPORT IN APPENDIX

* Excludes environmental mitigation, monitoring, SCE charges, and reactive compensation if required.

230-kV Double Circuit TSP Base Case Estimate
750 Megawatt Case

line length	4.3 miles	Conductor size	
		2- 1590 "Lapwing" per phase	
		weight per ft.	1.79
Average Span	600 ft	diameter	1.504
No. Structures	37.84	price per lb.	$1.75

item	type		unit	material cost	unit price	labor cost	L&M Unit	Quantity	extended
Steel Poles	tangent	22,000	lb	1.75	38,500	77,000	115,500	32	3,714,942
	small angle	25,000	lb	1.75	43,750	87,500	131,250	3	347,655
	large angle	28,000	lb	1.75	49,000	98,000	147,000	1	166,874
	strain	35,000	lb	1.75	61,250	122,500	183,750	1	208,593
	terminal	57,000	lb	1.75	99,750	199,500	299,250	1	226,472
conductor	2- 1590 "Lapwing" per phase	1,000	ft	3.13	3,133	6,265	9,398	281	2,637,140
shield wire	7#8	1,000	ft	0.50	500	1,000	1,500	23	35,078
OPGW	48	1,000	ft	2.25	2,250	4,500	6,750	23	157,850
insulators	ceramic tangent	42	bells	15.00	630	1,260	1,890	108	203,825
	Deadend	90	bells	20.00	1,800	3,600	5,400	11.352	61,301
hardware	tangent V-string	1	set	200.00	200	400	600	108	64,706
	Deadend	1	set	300.00	300	600	900	11	10,217
foundations	tangent	18	yds		750.00		13,500	32	434,214
	small angle	20	yds		750.00		15,000	3	39,732
	large angle	24	yds		750.00		18,000	1	20,434
	strain	35	yds		750.00		26,250	1	29,799
	Deadend	60	yds		750.00		45,000	1	34,056
accessories	splices	1	ea	68.00	68	136	204	900	183,600
	spacers dampers	1	ea	75.00	80	160	240	7,800	1,872,000
grounding	ground rods	2	twr	70.00	140	280	420	38	15,893

Total Estimate	10,464,381
Estimate per mile	2,433,577
Engineering (1%)	104,644
Project Management (1%)	104,644
Construction Management (2%)	209,288
Total	$10,882,956

CONCLUSIONS

This report compares the cost of underground construction to overhead construction for equivalent 230-kV double circuit designs. The estimates exclude project adders and/or cost multipliers that are associated with any specific utility business model or specific corporate philosophy.

Comparing the costs yields an underground to overhead ratio of 7.3 to 1, which is consistent with utility experience.

APPENDIX
PRICING QUOTES

Pricing resource for trenching, placing conduit, surface cuts and backfill

A.D. Wilson,
Inc.
951-737-3822

11-Aug-15

Jeff Hamen
Utility
Specialist

RE: Pats Ranch Rd. - Budget #'s

Per 100 lf

1	Trench	200 lf	$6,000.00
2	8" Sch 40 Conduit	1800 lf	$17,100.00
3	2" Sch 40 Conduit	800 lf	$2,700.00
4	4" Sch 40 Conduit	600 lf	$3,300.00
5	Spacers	300 ea	$375.00
6	2 Sack Backfill	90 yds	$8,800.00
7	5 Sack Encasement	50 yds	$6,720.00
8	6" Warning Tape	400 lf	$600.00
9	Grind or Sawcut	800 sf	$3,150.00
10	Repave - inc AC Cap	800 sf	$7,000.00
11	Pave	800 sf	$4,830.00
12	Plate Rental	1 ls	$500.00
13	Rope-Misc	1 ls	$400.00
14	Restripe	1 ls	$150.00
			$61,625.00

= $616.25 per foot

Additional Items:

1	10x20x9.6 Vault	35,000 ea
2	Bore on 68th St.	600.00 per foot

HV Solutions

Quote#: Budgetary 230kV Cable Proctor Engineering **7/6/2015**

Main

Description	Quantity	Spare Quantity	Unit	Comments/Product number	Unit Price	Total price	Unit
230 kV Cable, 4.4 mile Double Circuit	320,000	0	ft.	3000 kcmil Copper 850 mil XLPE	66.00	21,120,000.00	USD/ft
					Total	**21,120,000.00**	

NOTE: CABLE DELIVERED ON RETURNABLE STEEL REELS

The people behind the power.™ Southwire®

HV Solutions

Quote#: Proctor Engineering Cable Budget 8/14/2015

MAIN

Description	Quantity	Spare Quantity	Unit	Comments/Product number	Unit Price	Total price	Unit
230kv cable option 1	280,000	0	ft.	3500kcmil Copper Cable Cu CN Al LAM Tape PE Jacket	78.80	22,064,000.00	USD/ft
230kv cable option 2	280,000	0	ft.	4000kcmil Copper Cable Cu CN Al LAM Tape PE Jacket	85.60	23,968,000.00	USD/ft
					Total	**46,032,000.00**	

NOTE: Prices are in $USD
Freight FCA Destination Included in Above Pricing

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