BEFORE THE NEW MEXICO PUBLIC REGULATION COMMISSION

IN THE MATTER OF THE APPLICATION OF PACIFIC WIND DEVELOPMENT LLC FOR APPROVAL OF THE LOCATION OF THE LA JOYA WIND PROJECT AND 345 KV GEN-TIE LINE IN TORRANCE COUNTY, NEW MEXICO PURSUANT TO NMSA § 62-9-3; AND RIGHT OF WAY WIDTH DETERMINATION PURSUANT TO NMSA § 62-9-3.2	)	**Case No. 18-00353-UT**

DIRECT TESTIMONY OF

AARON WHITE

ON BEHALF OF PACIFIC WIND DEVELOPMENT LLC

November 19, 2018

I. WITNESS INTRODUCTION AND QUALIFICATIONS

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Aaron White. My business address is 3521 Gabel Road, Billings, Montana 59102.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am employed by Electrical Consultants, Inc. ("ECI") as a project engineer.

Q. PLEASE DESCRIBE YOUR EDUCATIONAL BACKGROUND AND EXPERIENCE.

A. I received my B.S. degree in civil engineering from University of Utah in 2012. I have two years of experience as an engineering/survey technician, two years of experience in design engineering, and four years of experience in project engineering and project management. I have extensive experience and strengths in all aspects of overhead transmission and distribution system design, analysis, and construction.

Q. ON WHOSE BEHALF ARE YOU APPEARING IN THIS PROCEEDING?

A. I am testifying on behalf of the applicant, Pacific Wind Development LLC ("Pacific Wind").

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. My testimony supports Pacific Wind's application to the New Mexico Public Regulation Commission ("Commission") for right-of-way ("ROW") width determination for the generation tie transmission line ("Gen-Tie Line") associated with the La Joya wind energy generation project ("La Joya Project").

Q. HAVE YOU TESTIFIED BEFORE ANY REGULATORY AUTHORITIES?

A. I have provided testimony before the New Mexico Public Regulation Commission regarding ROW width on behalf of Sagamore Wind Energy LLC regarding its proposed Sagamore Wind Project in Case No. 07-00275-UT.

Q. WHAT EXHIBITS DO YOU SPONSOR AS PART OF YOUR TESTIMONY?

A. I sponsor Exhibit AW-1, which is my resume; and Exhibit AW-2, which is my report regarding Gen-Tie Line ROW width for the La Joya Gen-Tie Line.

Q. WERE EXHIBITS AW-1 AND AW-2 PREPARED BY YOU OR UNDER YOUR SUPERVISION?

A. Yes.

Q. ARE EXHIBITS AW-1 AND AW-2 TRUE AND CORRECT COPIES OF THE DOCUMENTS YOU DESCRIBE IN YOUR TESTIMONY?

A. Yes.

II. ROW WIDTH EVALUATION.

Q. PLEASE EXPLAIN THE PURPOSE OF YOUR ROW WIDTH EVALUATION.

A. The purpose of my evaluation was to determine the range of ROW widths that would ensure safety, minimize landowner impact, provide adequate space in which to work, and allow flexibility during detailed design of the 345 kV Gen-Tie Line proposed by Pacific Wind. National Electrical Safety Code ("NESC") and industry best practice ("ASCE 7-10") were used as the basis for determining the necessary ROW widths.

Q. PLEASE EXPLAIN THE BASIC DESIGN CONDITIONS YOU EVALUATED.

A. We evaluated two primary design conditions to determine the required ROW width. The first condition was 6 pounds per square foot ("psf") wind acting perpendicular to the conductor at a 60 degree ambient temperature, as provided in NESC § 234.C.1.b. The second condition was 90 miles per hour ("mph") wind speed (the 50 year mean recurrence interval) at a 60 degree ambient temperature, reflecting the extreme wind condition as provided in ASCE 7-10. Under these conditions, we evaluated structure configuration and conductor offset from centerline of Gen-Tie Line, structure deflection, conductor displacement and horizontal clearance requirements to obtain design calculation results for different span lengths.

Q. HOW DO SPAN LENGTH AND STRUCTURE CONFIGURATION AFFECT ROW WIDTH?

A. Structure configuration and spacing determine span length. As the span length increases, the minimum ROW width also increases due to greater conductor displacement. We understand Pacific Wind wishes to retain flexibility to site the structures to take landowner preferences and avoidance of resources into account. We performed the ROW width calculations shown in Exhibit AW-2 for a range of span lengths.

Q. DID YOU TAKE OTHER CONSIDERATIONS INTO ACCOUNT?

A. Yes. Other considerations such as power line noise, electric and magnetic fields, line constructability, and maintenance and operations also affect ROW width. These factors were considered by adhering to industry best practice approach. For example, power line noise can be reduced by selecting structure configurations and conductor types that will limit the line gradient to be below industry best practice.

Q. HOW DO CONSTRUCTION, OPERATIONS AND MAINTENANCE AFFECT THE NECESSARY ROW WIDTH?

A. The ROW width must be large enough to move equipment along the Gen-Tie Corridor. Large cranes used to erect the Gen-Tie Line structures are typically the controlling factor.

In this case, the recommended 150 to 170 foot ROW will be adequate for access and operations purposes. Considering the terrain of the Gen-Tie Corridor, we did not identify any extraordinary issues for construction, maintenance or operations.

Q. WERE THERE ANY OTHER IMPORTANT CONSIDERATIONS?

A. Yes. The proposed La Joya Gen-Tie Line will parallel the existing 345 kV El Cabo gen-tie line for some of its route. As shown in Exhibit AW-2, we determined a maximum ROW width for the La Joya Gen-Tie Line of about 150 to 170 feet is necessary.

Q. WHAT WERE THE RESULTS OF YOUR CALCULATIONS FOR DIFFERENT SPAN LENGTH AND STRUCTURE CONFIGURATIONS?

A. Our calculations and results are shown in Exhibit AW-2. Tables 1.1, 2.1, and 2.2 of Exhibit AW-2 provide a summary of the results, and detailed calculations are attached to the report. We analyzed an H-frame structure configuration and six different span lengths (800 to 1300 feet), as shown in our report, Exhibit AW-2. Our calculations demonstrate that a ROW width between 150 feet and 170 feet is necessary depending on the span length.

III. <u>CONCLUSION</u>.

Q. BASED ON YOUR ANALYSIS, WHAT IS THE NECESSARY ROW WIDTH?

A. I recommend a ROW width of 150 to 170 feet as shown in our report in Exhibit AW-2. This range will provide sufficient ROW width for variation in design while addressing electrical safety code requirements and construction and operational considerations according to industry best practice.

Q. DOES THIS CONCLUDE YOUR TESTIMONY AT THIS TIME?

A. Yes, it does.

AARON WHITE, P.E. (NEW MEXICO – 24489) ECI

PROJECT TITLE: TRANSMISSION LINE ENGINEER

EXPERIENCE SUMMARY

Professional engineer possessing extensive experience in overhead, estimating, construction, and maintenance for power delivery facilities ranging from distribution to EHV levels. Core competencies encompass:

- Comprehensive T&D Design & Analysis through 500 kV
- Right-of-Way Analysis, including Routing Width Optimization
- Transmission Planning Feasibility Studies
- Solar & Wind Energy Interconnection
- Engineering Contract Management
- Quality Assurance / Quality Management

Accomplished in the use of various industry leading design software platforms including:

- PLS-CADD™ by Powerline Systems, Inc.
- PLS-Pole™ by Powerline Systems, Inc.
- PLS-Tower™ by Powerline Systems, Inc.
- Caisson™ by Powerline Systems, Inc.
- L-Pile™ by Ensoft, Inc.
- Shaft™ by Ensoft, Inc.
- MFAD™ by EPRI Solutions
- SAG 10™ by Southwire
- SWRATE™ by Southwire

Strengths extend to all aspects of overhead transmission and distribution system design, analysis, and construction through 500 kV.

APPLICABLE EXPERIENCE

Invenergy – Sagamore Wind 345 kV (2016)

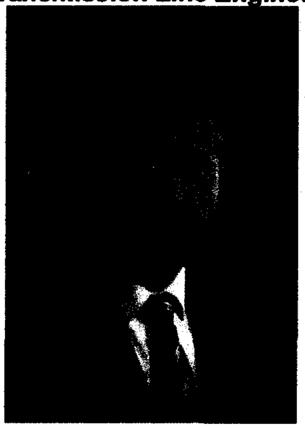
Project Engineer responsible for providing Right-of-Way Width Calculations, transmission line corridor evaluation of potential construction and maintenance constraints, and supporting testimony of the necessary Right-of-Way width for the proposed 345 kV generation tie for the Sagamore Wind development project.

Invenergy – Santa Rita 345 kV (2017-2018)

Project Engineer overseeing and coordinating the detailed conceptual to final design of approximately 14 miles of 345 kV transmission line located in Reagan County, Texas. The transmission line was designed to interconnect 400 Megawatts of wind energy to the LCRA system grid. ECI was responsible for preparing all design specifications and construction drawings and documents necessary for the complete construction of the transmission line.

PROFESSIONAL EXPERIENCE

Transmission Line Engineer



Oversees the team direction and is responsible for design, construction coordination and project management. Project oversight ranges from small scale projects to larger system expansions with line lengths up to 172 miles. Specializes in green field design and optimization of all design aspects. Performs 3rd party reviews of as-built projects to resolve operation and maintenance issues.

EDUCATION

B.S. Civil Engineering, University of Utah, 2012

EXPERIENCE TENURE

2 Years Engineering/Survey Technician
2 Years Design Engineering
4 Years Project Engineering & Project Mgmt.

Adept in the routing and design of 12.4 kV – 500 kV power line systems. Experienced in right-of-way proceedings, preparation of costs opinions, surveying techniques and procedures, permitting and licensing requirements for agencies such as DOT, USFS, BLM, BIA, as well as regulations associated with NEPA, FAA and APLIC. Proficient in transmission line design utilizing PLS CADD software with a strong understanding of the NESC, RUS Bulletin, GO 95 code requirements as well as transmission line construction operations.

AFFILIATIONS

- Structural Engineers Association of Montana (SEAMT) Member
- American Society of Civil Engineers (ASCE) Member
- Structural Engineering Institute (SEI) Member
- IEEE Member

AARON WHITE, P.E. (NEW MEXICO – 24489) ECI

Invenergy – El Salvador Ahuachapán-Acajutla 230 kV (2016)

Project Manager overseeing and coordinating the preparation of the RFP package for all components of the 230/115 kV El Salvador project. Project work included (1) one 230 kV substation, (1) one 115 kV substation, (1) one 115/230 kV switchyard, 0.4 miles of double circuit underground 115 kV, and 28 miles of double circuit 230 kV lattice towers. ECI was responsible for preparing all contract exhibits, material specifications, design specifications, preliminary design drawings and construction specifications. ECI will continue working on this project in 2017 as the Owner's Engineer.

McKenzie Electric Cooperative – System Expansion (2013-2016)

Project Engineer performing detailed design work for 23 miles of 345 kV transmission line developing routing, PLS CADD modeling, structure configuration, structure point load calculations, swing calculations, EMF calculations, flashover calculations, insulation calculations, structure detail drawings, stringing charts, plan and profile drawings, staking sheets, phasing diagram, foundation calculations. Prepared specifications for OPGW, insulators and hardware, steel poles, and construction operations. Worked closely with client, contractor, and material suppliers regarding schedules and critical project items. Successfully maintained document control as well as complete and accurate engineering record keeping.

Invenergy, LLC – 345 kV Wake Wind (2015-2016)

Project Engineer performing detailed design work for 23 miles of 345 kV transmission line developing routing, PLS CADD modeling, structure configuration, structure point load calculations, swing calculations, EMF calculations, flashover calculations, insulation calculations, structure detail drawings, stringing charts, plan and profile drawings, staking sheets, phasing diagram, foundation calculations. Prepared specifications for OPGW, insulators and hardware, steel poles, and construction operations. Worked closely with client, contractor, and material suppliers regarding schedules and critical project items. Successfully maintained document control as well as complete and accurate engineering record keeping.

EPC Services – 345 kV Sigurd to Red Butte (2013-2015)

Project Engineer for this EPC project that included approximately 170 miles of single circuit 345 kV line on steel H-frame structures. Responsibilities included line modeling, engineering calculations such as insulator swing, wind study and structure usage, EMF, embedment and foundation design. Many challenges were met throughout the design and construction that required engineering judgment and team collaboration.

Invenergy – 345 kV Miami Wind (2013-2014)

Project Lead in direct communication with client for this 23-mile, single circuit, 345 kV on steel pole structures project. Responsibilities included preparing design criteria, line routing, line modeling, structure development, embedment and foundation design, material specifications, and other detailed engineering calculations.

Umatilla Electric Cooperative – 115 kV Port of Umatilla (2013-2014)

Project Engineer for this project which was approximately three (3) miles of steel structures and included both double and single circuit 115 kV transmission as well as double circuit distribution. Responsibilities included line modeling, structure design, foundation design and material lists development. The greatest learning opportunity with this project was designing through an extremely dense utility corridor and working with other utilities to develop the best possible solution.

PacifiCorp – Mona-Oquirrh 345/500 kV T-Line Project

Project Engineer responsible for quality control, development of structural drawings, hydraulic calculations and working with project leads to prepare reports for the client. The project included approximately 30 miles of double circuit 345 kV on steel structures and 60 miles of 500 kV on lattice towers.

Gen-Tie Line Right-of-Way Width
Engineering Report
For

AVANGRID RENEWABLES

La Joya 345 kV Single Circuit Gen-Tie Line

Revision B

Prepared by: Electrical Consultants, Inc.
3521 Gabel Road
Billings, MT 59102

QA/QC Review and Sign-Off:

Task	*Responsible Individual*		*Date*
Prepared	*Transmission Engineer*	*A. White*	*11/8/2018*
Reviewed	*Transmission QA/QC*	*N. Gilman*	*11/9/2018*
Issued	*Project Manager*	*A. White*	*11/14/2018*

Contents

References:

The following references were used in the comprehensive evaluation of the required project Right-of-Way width:

1. NESC C2-2017, National Electric Safety Code, 2017 Edition IEEE, New York, NY, 2016, 234.A.2, Application of horizontal clearances (with wind displacement)
2. NESC C2-2017, National Electric Safety Code, 2017 Edition IEEE, New York, NY, 2016, 234.C.1.b, Clearance of wires, conductors, cables, and rigid live parts from buildings, sings, billboards, chimneys, radio and television antennas, tanks, flagpoles and flags, banners, and other installations except bridges
3. Applied Technology Council (ATC) Wind Speed by Location. [Online]. Available: http://windspeed.atcouncil.org/index.php?option=com_locationfinder&view=location&Itemid=10
4. ASCE 7-10, Minimum Design Loads for Buildings and Other Structures, 2010 Edition ASCE, Reston, VA, 2010
5. IEEE 738-2012, IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors, 2012 Edition IEEE, New York, NY, 2012
6. RUS Bulletin 1724E-200, Design Manual for High Voltage Transmission Lines, U.S. Department of Agriculture Rural Utilities Service Electric Staff Division. [Online]. Available: https://www.rd.usda.gov/files/UEP_Bulletin_1724E-102.pdf
7. Overhead Conductor Manual, 2nd Edition Southwire Company, Carrollton, GA, 2007
8. La Joya Collector Sub and T-Line.kmz (google earth file for 1000-foot Gen-Tie line corridor)

Objective:

The intent of this engineering report is to evaluate the 1000-foot Gen-Tie line corridor and to determine through reliability and safety assessment, the necessary Right-of-Way (ROW) width for the La Joya 345 kV Gen-Tie line. The evaluation and assessment of the ROW width will include determining the required current load and conductor size of the Gen-Tie line sized for 700 MW capacity, evaluating the conductor displacement under wind events, calculating the required horizontal clearances according to the National Electric Safety Code and industry best practice, evaluating site specific constraints and their impact to the Gen-Tie line corridor.

Input:

This section of the engineering report will summarize the input and assumptions made for the calculations used in determining the necessary ROW width for the La Joya 345 kV Gen-Tie line.

Conductor Sizing and Current Load:

Both the wind area and weight of a conductor are critical inputs in determining the overall displacement of the Gen-Tie line within a given corridor; the larger the wind area of the conductor, the greater the wind load applied as a component of horizontal displacement. The conductor weight acts as an opposing force to the wind by pulling the conductor down and to some degree holding it in place.

The following input was utilized for determining the current load of the proposed wind farm.

1. Load Capacity: 700 MW
2. Nominal Voltage: 345 kV
3. Power Factor: 0.95
4. Current Load for 700 MW at 345 kV: 1233 Amps

Several conductor types were considered adequate for meeting the required current load.

1. (2x) 795 kcmil 26/7 ACSR, Ampacity at 75°C (non-geographic): 1,814 Amps
2. (2x) 954 kcmil 54/7 ACSR, Ampacity at 75°C (non-geographic): 1,992 Amps
3. (2x) 1272 kcmil 45/7 ACSR, Ampacity at 75°C (non-geographic): 2,368 Amps

Conductors were evaluated for performance ampacity based on geographic location and site specific conditions per IEEE [5]. A performance criteria of 1233 Amps at a conductor temperature of 75°C was used. The geographic and site specific conditions used for determining performance ampacity can be found in Appendix A.

Design Basis for Conductor Displacement:

There were two primary design conditions evaluated to determine the required ROW width for the La Joya 345 kV Gen-Tie line. All wind conditions were considered acting perpendicular to the conductor. The conditions, together with a variation of span lengths, conductor tension and structure configuration were used to evaluate conductor movement, structure deflection and horizontal clearance.

1. NESC 234.A.2 [1], [2]
   a. 6 psf. wind
   b. 60°F Ambient Temperature
2. Extreme Wind (ACSE 7-10) [3], [4]
   a. 90 mph wind speed for 50-year mean recurrence interval (MRI)
   b. 60°F Ambient Temperature
3. Gen-tie Line Elevation, [8]
   a. 7,300 feet
4. Location of Gen-Tie Line for 50-year MRI wind, [8] (Appendix B)
   a. Latitude: 34.9652°
   b. Longitude: -105.7147°
5. Structure Geometry (see Appendix C)
6. Insulator Assembly Properties
   a. Assembly Length: 13 ft. (includes all attachment and conductor hardware)
   b. Assembly Weight: 46 lbs. (polymer insulator assembly)
7. Conductor Type and Tension Data
   a. (2x) 795 kcmil 26/7 ACSR (other larger conductors were not considered for displacement due to the (2x) 795 kcmil 26/7 ACSR conductor type meeting all ampacity requirements)
   b. Diameter: (2x) 1.107 inches
   c. Weight: (2x) 1.093 lbs. /ft.
   d. Conductor Tension for all span lengths limited to 20% of the Rated Breaking Strength (RBS) of the conductor at 20°F for vibration control (See Appendix D for detailed

span lengths and conductor tension)

8. Structure Height for Deflection, Max Conductor Sag and Required Vertical Clearance:
   a. 45 feet of conductor sag at the final elongation condition of the conductor operating at 100°C for a 1200-foot span.
   b. 32 feet of ground clearance (value can be refined with further review of site conditions, NESC 232.D.3.c, and variation in elevation along Gen-Tie line corridor).
   c. 90 feet above ground to the insulator attachment location on the cross arm.
   d. Structure deflection (δ) was assumed to be 1% of the structure height or equal to 0.9 feet

Output and Results:

Detailed calculations of the output for Conductor Current Load and Conductor Displacement can be found in Appendices A and D, respectively. A summary of the output has been provided below:

Conductor Current Load:

The (2x) 795 kcmil 26/7 ACSR was calculated to have the following Normal and Emergency Ratings for summer and winter conditions:

Table 1.1

Voltage (kV)	Design Temp.	Conductor		40°C - Ambient Temp.	0°C - Ambient Temp.
345	167°F (75°C)	(2x) 795 kcmil 26/7 ACSR "Drake"		1320	2104
345	212°F (100°C)	(2x) 795 kcmil 26/7 ACSR "Drake"		1840	2424
		Normal	MAX Capacity (MVA)	789	1257
		Emergency	MAX Capacity (MVA)	1100	1448

Conductor Displacement and ROW Width:

Conductor displacement is dependent on the weather conditions, variation of span lengths, conductor type and associated tension or sag, insulator swing angle and structure configuration. The conductor displacement results of various span lengths and tensions along with other associated variables are summarized in Table 2.1. Results are based on a structure geometry and configuration as shown in Appendix C. Detailed calculations are shown in Appendix D.

Table 2.1

Span Length (ft.)	Conductor Offset from Center (ft.)	6 psf. Wind Condition			90 mph. Wind Condition		
		Conductor Sag (ft.)	Insulator Swing Angle (deg.)	Conductor Displace- (ft.)	Conductor Sag (ft.)	Insulator Swing Angle (deg.)	Conductor Displace- (ft.)
800 ft.	30 ft.	17.97 ft.	26.6°	13.85 ft.	20.58 ft.	59.9°	29.06 ft.
900 ft.	30 ft.	22.05 ft.	26.6°	15.69 ft.	24.94 ft.	60.0°	32.84 ft.
1000 ft.	30 ft.	26.51 ft.	26.6°	17.70 ft.	29.65 ft.	60.0°	36.94 ft.
1100 ft.	30 ft.	31.37 ft.	26.6°	19.89 ft.	34.75 ft.	60.0°	41.36 ft.
1200 ft.	30 ft.	36.61 ft.	26.7°	22.26 ft.	40.22 ft.	60.0°	46.11 ft.
1300 ft.	30 ft.	42.27 ft.	26.7°	24.81 ft.	46.08 ft.	60.1°	51.19 ft.

ROW width is recommended as a summation of the following in both the right and left directions: conductor offset from the center line of the Gen-Tie line, structure deflection (δ) assumed to be 1% of the structure height or equal to 0.9 feet, conductor displacement and required horizontal clearances.

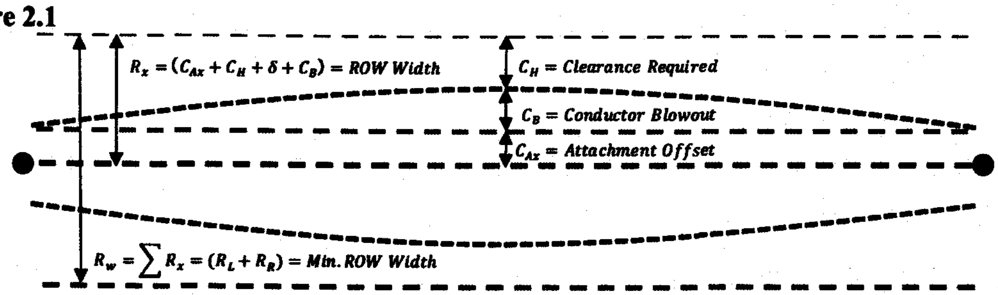
The horizontal clearance to buildings for a 345 kV Gen-Tie line was calculated to be 14.4 feet based off of an elevation of 7,300 feet and utilizing the calculations prescribed in the National Electric Safety Code [2]. A lesser horizontal clearance requirement was used for extreme events such as a 90 mph. wind. The required horizontal clearance for extreme events used in the ROW width calculations was 2.875 feet and is approximately equal to the Critical Flashover Phase to Ground Air Gap. The ROW width for various span lengths was calculated and the results shown in Table 2.2. Detailed calculations of the below results are shown in Appendix D.

Table 2.2

Span Length (ft.)	6 psf. Wind Condition	90 mph. Wind Condition
	Total ROW Width (ft.)	Total ROW Width (ft.)
800 ft.	119 ft.	126 ft.
900 ft.	122 ft.	134 ft.
1000 ft.	127 ft.	142 ft.
1100 ft.	131 ft.	151 ft.
1200 ft.	136 ft.	160 ft.
1300 ft.	141 ft.	170 ft.

Equation 2.9: $R_x = (C_{Ax} + C_H + \delta + C_B)$ $R_W = \sum R_x = (R_L + R_R)$

Figure 2.1



Additional Considerations:

Other considerations should be made when determining the necessary ROW width for any given project. These considerations include power line noise, effects of electric and magnetic fields (EMF), constructability and maintenance and operations of the Gen-Tie line.

New Mexico does not currently have regulations which pertain to power line noise and, or EMF. Power line noise can be reduced by selecting a structure configuration and conductor type which limits the line gradient to be within industry best practice (< 17 kV/cm). Preliminary calculations have been performed which indicate that the effects of EMF are within industry best practice. Measurements for noise and EMF are typically taken at the edge of the ROW and approximately one (1) meter above the ground. It is industry best practice to limit the electric field and magnetic field to 8-10 kV/m and 200 mG (milligauss), respectively.

Gen-Tie line utilities and developers should consider construction and maintenance operations in acquiring ROW. The amount of ROW width required for construction can be negotiated separately as temporary ROW and is typically reclaimed post construction. Maintenance ROW is typically less than that required by regulations and safety codes. It is recommended as industry best practice that a minimum construction and maintenance ROW of 100 feet be acquired for the 345 kV Gen-Tie line. Existing easements should be considered when acquiring new ROW for a Gen-Tie line.

Consideration of existing easements, whether exclusive or non-exclusive, can be accomplished by working with the owner of the easement to obtain permission for any given crossing or encroachment. This collaboration ensures that both parties will be able to occupy said easement without unexpected difficulties. The proposed 1000-foot Gen-Tie corridor overlaps with the existing Avangrid Renewables El Cabo 345 kV Gen-Tie line. In the case where the Gen-Tie line may encroach on the existing easement owned by Avangrid Renewables, it is obligation of the owner to evaluate the encroachment for operational and reliability impacts.

Conclusion:

It is recommended that the acquired ROW width be 150 to 170 feet for the La Joya 345 kV Gen-Tie line. The recommended ROW width will allow for spans ranging between 800 and 1300 feet with the typical span lengths of 1000 to 1100 feet. The recommended ROW width will allow the optimization of structure spotting, provide flexibility such that the Gen-Tie line may span any environmentally or culturally sensitive areas and is prescribed to appropriately consider reliability and safety according to the NESC and industry best practice.

Appendix A: Conductor Sizing and Line Rating

ECI "Engineering with Distinction" ELECTRICAL CONSULTANTS, INC.	Office:	Billings	Client:	Avangrid Renewables
			Project No.	AVR-003

Subject:	Conductor Sizing and Losses for Single Circuit								
Project Name:	La Joya 345 kV Gen-Tie Line								
By:	A.White	Date:	11/5/2018	Chk. By:	N.Gilman	Date:	11/8/2018	Rev.	B

Objective: To calculate preliminary sizing of conductor and structure configuration considering anticipated loading, line losses, and conductor gradient.

Input:

General Input

MVA	700 MW	*User Input*
V_N	345 kV	*User Input*
TOV	1.05	*User Input*
L	30 miles	*User Input*
S	18 in.	*User Input*
PF	95%	*User Input*
V_M	362 kV	*V_M = (TOV) (V_N)*
I	1233 Amps	*I = MVA / [(√3) (PF) (VN)] x 1000*

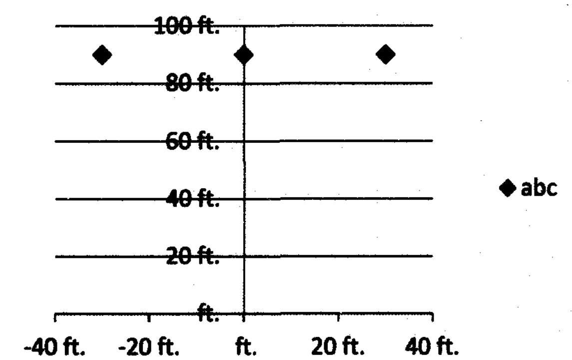
MVA @Unity PF (MVA)	700 MW	*MVA/1*
MVA @ 95% PF (MVA)	737 MW	*MVA/0.95*

Conductor Options

Option	Conductor		No. of Subconductors
1	ACSR	795 Drake	1
2	ACSR	954 Cardinal	1
3	ACSR	1272 Bittern	1
4	ACSR	795 Drake	2
5	ACSR	954 Cardinal	2
6	ACSR	1272 Bittern	2

Structure Geometry

Phase	X (COP)	Y (TOP)
A, 1	-30 ft.	90 ft.
B, 2	ft.	90 ft.
C, 3	30 ft.	90 ft.



D_{12}	D_{13}	D_{23}
30 ft.	60 ft.	30 ft.
Geometric Mean Distance (ft) $GMD = (D_{12} \times D_{13} \times D_{23})^{(1/3)}$		37.8 ft.

ACSS and ACCC conductor ratings based on maximum operating temperature of 200°C; all other conductor ratings based on 75°C Conductor Temp. and 25°C Ambient Temp.

Conductor Consideration Factors

Conductor	Ampacity	Rating (MVA @345 kV)	% Loading	Resistance - Conductor (Ω/1000ft)	Resistance - Conductor (Ω/Mile)	T-Line Total Losses (MW)	% Loss	Diameter (in)	Gradient (kV/cm)
795 Drake (1x)	907	542	136.0	0.0263	0.1389	18.687	2.67	1.11	22.187
954 Cardinal (1x)	996	595	123.8	0.0228	0.1204	16.200	2.31	1.20	20.776
1272 Bittern (1x)	1,184	707	104.1	0.0171	0.0903	12.150	1.74	1.35	18.807
795 Drake (2x)	1,814	1,084	68.0	0.0132	0.0694	9.344	1.33	1.11	15.903
954 Cardinal (2x)	1,992	1,190	61.9	0.0114	0.0602	8.100	1.16	1.20	14.904
1272 Bittern (2x)	2,368	1,415	52.1	0.0086	0.0451	6.075	0.87	1.35	13.517

**See detailed calculations on sheet 2/2 for selected conductor.*

***Resistance assumes the existence of alternating current with a line temperature of 75°C*

****A gradient of no more than 16 kV/cm is recommended to minimize radio noise.*

ELECTRICAL CONSULTANTS, INC. "Engineering with Distinction"	Office:	Billings	Client:	Avangrid Renewables
			Project No.	AVR-003

Subject:	Conductor Sizing and Losses for Single Circuit						
Project Name:	La Joya 345 kV Gen-Tie Line						
By:	A.White	Date:	11/5/2018	Chk. By:	N.Gilman	Date:	11/8/2018	Rev.	B

Detailed Calculations:

Defined Values:	795 Drake (1x)	954 Cardinal (1x)	1272 Bittern (1x)	795 Drake (2x)	954 Cardinal (2x)	1272 Bittern (2x)
$k' = 4.093/f$	0.06822	0.06822	0.06822	0.06822	0.06822	0.06822
$f = 60\ Hz$	60	60	60	60	60	60
$GMD = (D_{12} \times D_{13} \times D_{23})^{\wedge}(1/3)$	37.8 ft.	37.8 ft.	37.8 ft.	37.8 ft.	37.8 ft.	37.8 ft.
$GMR = (e^{-\mu r/4})r$	0.0359 ft.	0.0388 ft.	0.0436 ft.	0.0359 ft.	0.0388 ft.	0.0436 ft.
$GMR_B = [N(GMR)A^{(N-1)}]^{1/N}$	0.0359 ft.	0.0388 ft.	0.0436 ft.	0.2321 ft.	0.2413 ft.	0.2559 ft.
$\mu_r \approx 1$ for Aluminum and Copper	1	1	1	1	1	1
N	1	1	1	2	2	2
S (ft.)	1.5 ft.	1.5 ft.	1.5 ft.	1.5 ft.	1.5 ft.	1.5 ft.
$A = S / [2\sin(\pi/N)],\ N > 1$	1.000 ft.	1.000 ft.	1.000 ft.	0.750 ft.	0.750 ft.	0.750 ft.
$r = d/2$	0.0461 ft.	0.0498 ft.	0.0560 ft.	0.0461 ft.	0.0498 ft.	0.0560 ft.
$X'_d = k' \log(GMD)$	0.108 MΩ-mile	0.108 MΩ-mile	0.108 MΩ-mile	0.108 MΩ-mile	0.108 MΩ-mile	0.108 MΩ-mile
$X'_a = k' \log(1/r_B)$	0.091 MΩ-mile	0.089 MΩ-mile	0.085 MΩ-mile	0.040 MΩ-mile	0.038 MΩ-mile	0.037 MΩ-mile
$X_c = X'_d + X'_a$	0.199 MΩ-mile	0.196 MΩ-mile	0.193 MΩ-mile	0.147 MΩ-mile	0.146 MΩ-mile	0.144 MΩ-mile
$r_B = (NrA^{N-1})^{1/N}$	0.0461 ft.	0.0498 ft.	0.0560 ft.	0.2630 ft.	0.2734 ft.	0.2899 ft.
d (cm)	2.812 cm	3.038 cm	3.416 cm	2.812 cm	3.038 cm	3.416 cm
$\varepsilon_0 = (1/36\pi) \times 10^{-9}$ (farads/meter)	8.84E-12	8.84E-12	8.84E-12	8.84E-12	8.84E-12	8.84E-12
$D_B = 2A$	60.96 cm	60.96 cm	60.96 cm	45.72 cm	45.72 cm	45.72 cm
$C = 10^{-6}/[(377.4)(Xc)(1609)]$	8.286E-12 f/m	8.382E-12 f/m	8.533E-12 f/m	11.189E-12 f/m	11.277E-12 f/m	11.413E-12 f/m
$V_{LG} = (V_M) / (\sqrt{3})$	209.1 kV	209.1 kV	209.1 kV	209.1 kV	209.1 kV	209.1 kV
$Q = CV_{LG}/N$	1.7E-09 kC/m	1.8E-09 kC/m	1.8E-09 kC/m	1.2E-09 kC/m	1.2E-09 kC/m	1.2E-09 kC/m
$E_{AV} = Q/(2\pi \varepsilon_0 r)$	22.19 kV/cm	20.78 kV/cm	18.81 kV/cm	14.98 kV/cm	13.98 kV/cm	12.58 kV/cm
$E_{MAX} = E_{AV} [1 + (d/D)(N-1)]$	22.19 kV/cm	20.78 kV/cm	18.81 kV/cm	15.90 kV/cm	14.90 kV/cm	13.52 kV/cm
Length = L (miles)	30 miles	30 miles	30 miles	30 miles	30 miles	30 miles
TOV = Minimum of 1.05	1.05	1.05	1.05	1.05	1.05	1.05
$V_N = MVA / [(1/1000)(\sqrt{3})]$	345 kV	345 kV	345 kV	345 kV	345 kV	345 kV
$V_M = (TOV)(V_N)$	362 kV	362 kV	362 kV	362 kV	362 kV	362 kV
$I = MVA / [(\sqrt{3})(VN)] \times 1000$	1233 Amps	1233 Amps	1233 Amps	1233 Amps	1233 Amps	1233 Amps
$MVA = [(I/1000)(\sqrt{3})(VN)]$	700 MW	700 MW	700 MW	700 MW	700 MW	700 MW
R (Ω/mile)	0.139 Ω/mile	0.120 Ω/mile	0.090 Ω/mile	0.069 Ω/mile	0.060 Ω/mile	0.045 Ω/mile
$L_L = 3 \times [(10^{-6})(L)(R)(I)^{\wedge}2]$	18.687 MW	16.200 MW	12.150 MW	9.344 MW	8.100 MW	6.075 MW

ELECTRICAL CONSULTANTS, INC. "Engineering with Distinction"	Office:	Billings	Client:	Avangrid Renewables
			Project No.	AVR-003

Subject:	Conductor Sizing and Losses for Single Circuit							
Project Name:	La Joya 345 kV Gen-Tie Line							
By:	A.White	Date:	11/5/2018	Chk. By:	N.Gilman	Date:	11/8/2018	Rev. B

References:

EPRI, Transmission Line Reference Book, 345 kV and Above/Second Edition

Chapter 3, Electrical Characteristics of EHV-UHV Conductor Configurations and Circuits

Reference Variables:			Defined Values:
k'	-	Frequency Factor	k' = 4.093/f
f	-	Frequency (Hz.) (60 Hz for Transmission)	f = 60 Hz
GMD	-	Geometric Mean Distance (ft.)	$GMD = (D_{12} \times D_{13} \times D_{23})^{\wedge}(1/3)$
COP	-	Distance from Center of Pole (ft.)	*User Defined*
TOP	-	Distance from Top of Pole (ft.)	*User Defined*
$D_{1,2,3}$	-	Phase to Phase Distance (ft.)	$\sqrt{[(X_1-X_2)^2+(Y_1-Y_2)^2]}$
GMR	-	Geometric Mean Radius (ft.)	$GMR = (e^{-\mu r/4})r$
GMR_B	-	Geometric Mean Radius Symmetrically Bundled (ft.)	$GMR_B = [N(GMR)A^{(N-1)}]^{1/N}$
μr	-	Relative Permeability of Conductor	$\mu_r \approx 1$ for Aluminum and Copper
N	-	Number of SubConductors Symetrically Bundled	*User Defined*
S	-	Bundle Spacing (ft.)	*User Defined*
A	-	Bundle Radius (ft.)	$A = S / [2\sin(\pi/N)]$, N > 1
r	-	Radius of Subconductor (ft.)	r = d/2
X'_d	-	Capacitive Reatance Spacing Factor (Megaohm-Mile)	$X'_d = k' \log(GMD)$
X'_a	-	Capacitive Reactance at one-foot Spacing (Megaohm-Mile)	$X'_a = k' \log(1/r_B)$
X_c	-	Total Shunt Capacitive Reactance (Megaohm-Mile)	$X_c = X'_d + X'_a$
r_B	-	Effective Radius of Phase Conductor (ft.)	$r_B = (NrA^{N-1})^{1/N}$
d	-	Subconductor diameter (cm)	*User Defined*
ε_0	-	Charge to Voltage Conv. Factor (farads/meter)	$\varepsilon_0 = (1/36\pi) \times 10^{-9}$
D_B	-	Bundle Diameter (cm)	$D_B = 2A$
C	-	Positive Sequence Capacitance (farads/meter)	$C = 10^{-6}/[(377.4)(Xc)(1609)]$
V_{LG}	-	Line to Ground Voltage (kV)	$V_L = (V_M) / (\sqrt{3})$
Q	-	Average Charge on (1) one Conductor (kC(rms)/meter)	Q = CV/N
E_{AV}	-	Average Conductor Gradient (kV(rms)/cm)	$E_{AV} = Q/(2\pi \varepsilon_0 r)$
E_{MAX}	-	Maximum Gradient for Conductor Periphery (kV/cm)	$E_{MAX} = E_{AV} [1+ (d/D) (N-1)]$
L	-	Line Length (mile(s))	*User Defined*
TOV	-	Trasient Overvoltage Factor	Minimum of 1.05
V_N	-	Nominal Line Voltage (kV)	$V_N = MVA / [I/1000) (\sqrt{3})]$
V_M	-	Maximum Line Voltage (kV)	$V_M = (TOV) (V_N)$
I	-	Current/Ampacity (Amps)	$I = MVA / [(\sqrt{3}) (VN)] \times 1000$
MVA	-	Generation/Load (MW)	$MVA = [(I/1000) (\sqrt{3}) (VN)]$
R	-	Resistance (Ω/mile)	*User Defined*
L_L	-	Line Losses (MW)	$L_L = 3 \times [(10^{-6}) (L) (R) (I)^{\wedge}2]$

"Engineering with Distinction"
ECI ELECTRICAL CONSULTANTS, INC.
3521 GABEL ROAD BILLINGS, MT 59102 • PHONE: 406-259-9933 • FAX: 406-259-3441

PROJECT: LA JOYA 345 KV GEN-TIE LINE	NM/IEEE 738-2012	DATE:11/09/2018

Voltage (kV)	Design Temp.	Wind Speed	Conductor	Wind Angle	40°C - Ambient Temp	0°C - Ambient Temp
345	167°F (75°C)	2 ft/sec	(2x) 795 kcmil 26/7 ACSR "Drake'	90°	1320	2104
	212°F (100°C)				1840	2424
			Normal	MAX Capacity (MVA)	789	1257
			Emergency	MAX Capacity (MVA)	1100	1448

Notes:

Calculation determined per IEEE STD 738-2012 with the following parameters: emissivity 0.5 and solar absorptivity 0.5, clear atmosphere, line azimuth 90° (east-west), wind angle 90°, solar day of June 21 at 1300 hours, north latitude of 34.6°, and elevation of 7300 ft.
Emergency rating determined using 100°C conductor temperature.

			Engineering Record	
Project Number:	AVG-000			
Client Name:	AvanGrid Renewables		Engineer	Date
Project Name:	La Joya 345 kV	Prepared By:	A.White	November 6, 2018
Issue Date:	November 6, 2018	Reviewed By:	N. Gilman	November 7, 2018
Status:	Issued for Permitting	Approved By:		

Appendix B: ASCE 50-Year MRI Extreme Wind

Applied Technology Council

WINDSPEED BY LOCATION

This site will be taken offline soon. Please start using the new site at https://hazards.atcouncil.org.

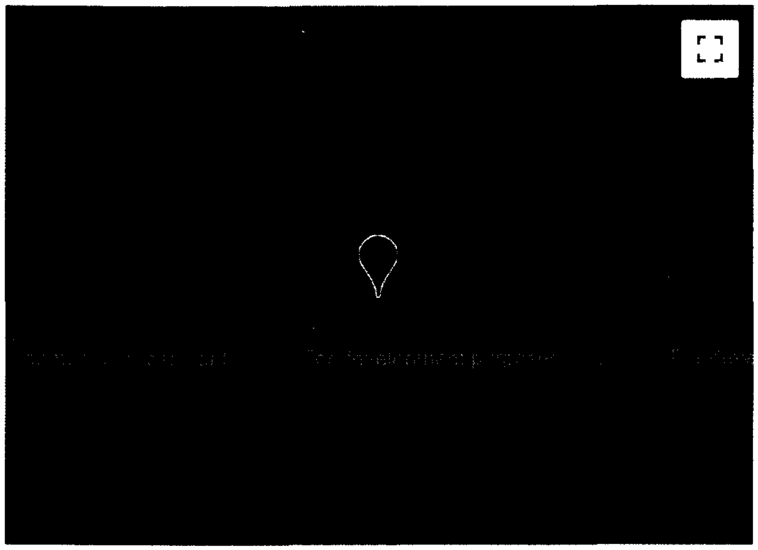
Search Results

Query Date: Fri Nov 09 2018
Latitude: 34.9652
Longitude: -105.7147

ASCE 7-10 Windspeeds (3-sec peak gust in mph*):

Risk Category I: 105
Risk Category II: 115
Risk Category III-IV: 120
MRI 10-Year:** 76
MRI 25-Year:** 84
MRI 50-Year:** 90
MRI 100-Year:** 96

ASCE 7-05 Windspeed:
90 (3-sec peak gust in mph)
ASCE 7-93 Windspeed:
76 (fastest mile in mph)



Google

Map data ©2018 Google, INEGI

*Miles per hour
**Mean Recurrence Interval

Users should consult with local building officials to determine if there are community-specific wind speed requirements that govern.

Print your results

WINDSPEED WEBSITE DISCLAIMER

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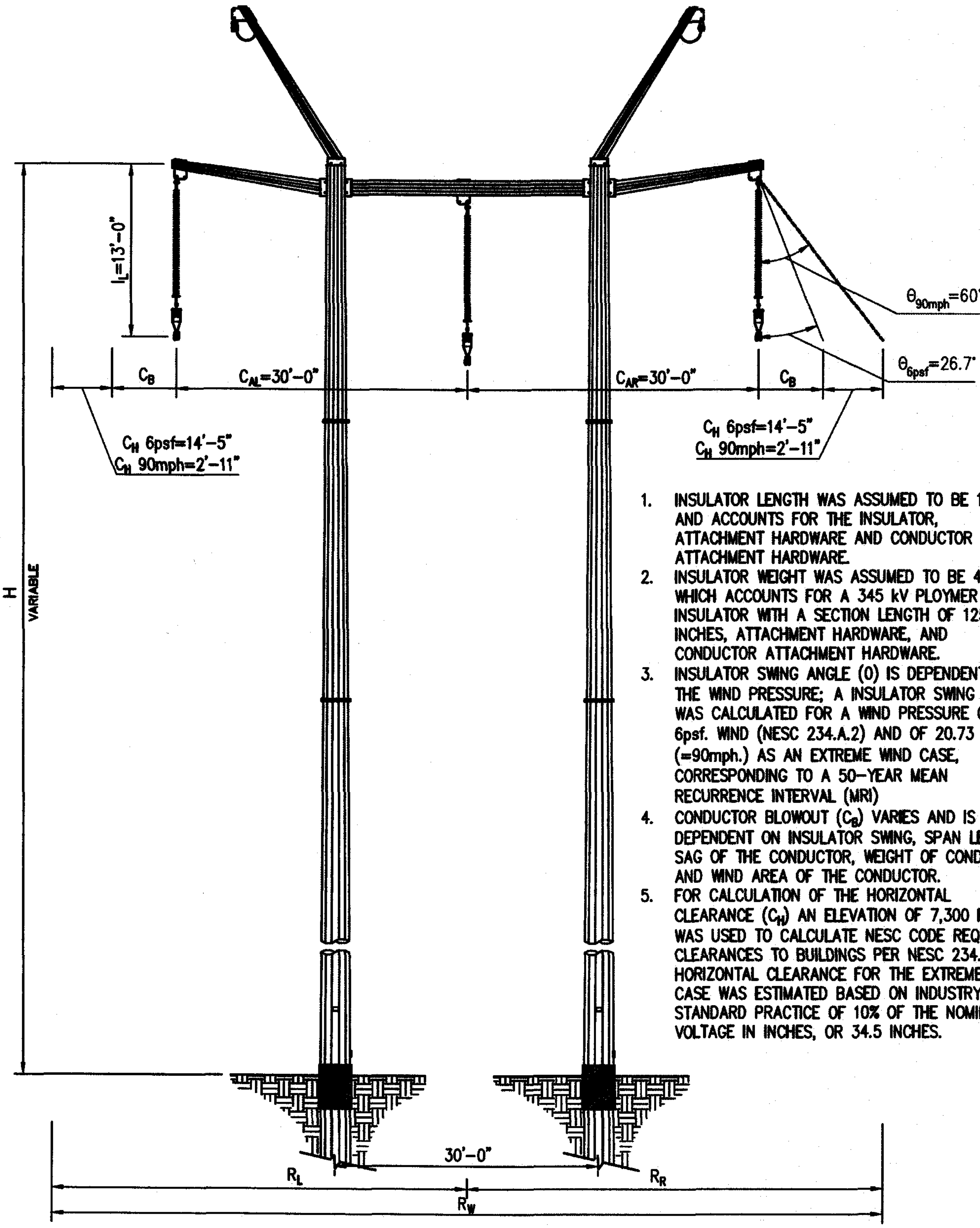
Appendix C: Structure Geometry



1. INSULATOR LENGTH WAS ASSUMED TO BE 13 FEET AND ACCOUNTS FOR THE INSULATOR, ATTACHMENT HARDWARE AND CONDUCTOR ATTACHMENT HARDWARE.
2. INSULATOR WEIGHT WAS ASSUMED TO BE 46 lbs. WHICH ACCOUNTS FOR A 345 kV PLOYMER INSULATOR WITH A SECTION LENGTH OF 125 INCHES, ATTACHMENT HARDWARE, AND CONDUCTOR ATTACHMENT HARDWARE.
3. INSULATOR SWING ANGLE (0) IS DEPENDENT ON THE WIND PRESSURE; A INSULATOR SWING ANGLE WAS CALCULATED FOR A WIND PRESSURE OF 6psf. WIND (NESC 234.A.2) AND OF 20.73 (=90mph.) AS AN EXTREME WIND CASE, CORRESPONDING TO A 50-YEAR MEAN RECURRENCE INTERVAL (MRI)
4. CONDUCTOR BLOWOUT (C_B) VARIES AND IS DEPENDENT ON INSULATOR SWING, SPAN LENGTH, SAG OF THE CONDUCTOR, WEIGHT OF CONDUCTOR, AND WIND AREA OF THE CONDUCTOR.
5. FOR CALCULATION OF THE HORIZONTAL CLEARANCE (C_H) AN ELEVATION OF 7,300 FEET WAS USED TO CALCULATE NESC CODE REQUIRED CLEARANCES TO BUILDINGS PER NESC 234.C.1.B HORIZONTAL CLEARANCE FOR THE EXTREME WIND CASE WAS ESTIMATED BASED ON INDUSTRY STANDARD PRACTICE OF 10% OF THE NOMINAL VOLTAGE IN INCHES, OR 34.5 INCHES.

ECI ELECTRICAL CONSULTANTS, INC

AVANGRID RENEWABLES

ENGINEERING RECORD		DATE
DRAWN	M. COTTET	11/09/18
DESIGNED	A. WHITE	11/09/18
CHECKED		
APPROVED		
DWG SCALE: AS NOTED	PLT SCALE: 1:1	

LA JOYA 345 kV GEN-TIE LINE
SINGLE CIRCUIT STEEL H-FRAME STRUCTURE
TH-345S

DWG NAME: AGR-A-7009-1 REVISION NO.: A

LOCATION: F:\ECI\TRANSMISSION\AVANGRID RENEWABLES\TRANSMISSION\CADD\7009 EXHIBIT\ASSEMBLY DRAWINGS\AGR-A-7009-1.DWG LAST SAVED BY: mcottet 11/14/2018 11:35 AM PLOTTED BY: Michael D. Cottet

Appendix D: Right-of-Way Calculations

ELECTRICAL CONSULTANTS, INC. "Engineering with Distinction"

Office:	Billings	Client:	Avangrid Renewables
		Project No.	AVR-003

Subject: ROW Width Calculations

Project Name: La Joya 345 kV Gen-Tie Line

By: A.White | Date: 11/7/2018 | Chk. By: N. Gilman | Date: 11/9/2018 | Rev. B

Objective: Provide preliminary ROW calculations.

Input:

Symbol		Description	Input
V	-	Voltage Class	345 kV
TOV	-	Transient Overvoltage	1.05
Elev.	-	Elevation	7300 ft.
θ	-	Line Angle	0.0 °
I_L	-	Insulator Length	13.0 ft.
W_i	-	Insulator Weight	46 lbs
C_{AL}	-	Conductor Att. Left Most Offset to Centerline	-30 ft.
C_{AR}	-	Conductor Att. Right Most Offset to Centerline	30 ft.
H	-	Max. Att. Height Above Groundline	90 ft.
$d_{\%}$	-	Structure Deflection (% of attach. height)	1 %
F_1	-	Wind Pressure (1)	6.00 psf.
F_2	-	Wind Pressure (2)	20.73 psf.
C	-	Conductor Data	Type: ACSR; Size: 795 Drake; SC - *No. of SubCond.*: x 2
w_c	-	Conductor Weight	*see Span Data Table below*
d_c	-	Conductor Diameter	*see Span Data Table below*
HS/WS	-	Horizontal Span/Weight Span	*see Span Data Table below*
T	-	Conductor Tension	*see Span Data Table below*

CL, − 0 ft. +

Option	Horizontal Span (HS) (ft.)	Weight Span (WS) (ft.)	Dia. (d_c) (in.)	Weight (w_c) (plf.)	Tension at 6 psf. (T) (lbs.)	Tension at 20.73 psf. (T) (lbs.)
1	800 ft.	800 ft.	1.107 in.	1.093 plf.	5453 lbs.	8561 lbs.
2	900 ft.	900 ft.			5626 lbs.	8944 lbs.
3	1000 ft.	1000 ft.			5777 lbs.	9285 lbs.
4	1100 ft.	1100 ft.			5908 lbs.	9587 lbs.
5	1200 ft.	1200 ft.			6023 lbs.	9857 lbs.
6	1300 ft.	1300 ft.			6123 lbs.	10099 lbs.

Output:

2.1	V_M	-	*Maximum Operating Voltage*	$V_M = TOV \times V$
2.2	C_H	-	*Required Horizontal Clearance*	$C_H = 7.5' + [(50\,kV - 22\,kV)] \times \frac{0.4}{12} + \left(\frac{V_M}{\sqrt{3}} - 50\,kV\right) \times \frac{0.4}{12} \times 1.03^{Elev.-3300/1000}$
2.3	δ	-	*Deflection @ Max. Att. Height (H)*	$\delta = H \times d_{\%}$
2.4	S	-	*Sag*	$w_T = \sqrt{w_c^2 + p_c^2}$ $S = \frac{w_T \times HS^2}{8 \times T_i}$ *Assumes conductor attachment point at equal elevtions.*
2.5	p_c	-	*Wind Load/Linear ft. Cond.*	$p_c = \frac{(d_c)(F)}{12}$
2.6	p_T	-	*Total Wind Load/Linear ft. Cond.*	$p_T = p_c \times (SC)$ SC = *(No.Sub Conductors)*
2.7	$\emptyset$	-	*Swing Angle*	$\emptyset = \tan^{-1}\left(\frac{(2)(T_i \times SC)\sin(\theta/2) + (HS)(p_T)}{(WS)(w_c \times SC) + (1/2)(W_i)}\right)$
2.8	C_B	-	*Conductor Blowout*	$C_B = (I_L + S) \times \sin(\emptyset)$
2.9	R_w	-	*Total ROW Width*	$R_x = (C_{Ax} + C_H + \delta + C_B)$ $R_W = \sum R_x = (R_L + R_R)$

ELECTRICAL CONSULTANTS, INC. "Engineering with Distinction"

Office:	Billings	Client:	Avangrid Renewables
		Project No.	AVR-003

Subject:	ROW Width Calculations
Project Name:	La Joya 345 kV Gen-Tie Line

By: A.White | Date: 11/7/2018 | Chk. By: N. Gilman | Date: 11/9/2018 | Rev. B

Results:

Clearance Check Selection: Required Clearance @ 6 psf. blowout (NESC 234.C.1.b)

Option	V_M 2.1	C_H 2.2	δ 2.3	S 2.4	p_c 2.5	p_T 2.6	ø 2.7	C_B 2.8	R_L 2.9	R_R 2.9	R_W 2.9
1a	362 kV	14.4 ft.	0.90 ft.	17.97 ft.	0.55 plf.	1.11 plf.	26.6°	13.85 ft.	59.2 ft.	59.2 ft.	119 ft.
2a				22.05 ft.			26.6°	15.69 ft.	61.0 ft.	61.0 ft.	122 ft.
3a				26.51 ft.			26.6°	17.70 ft.	63.0 ft.	63.0 ft.	127 ft.
4a				31.37 ft.			26.6°	19.89 ft.	65.2 ft.	65.2 ft.	131 ft.
5a				36.61 ft.			26.7°	22.26 ft.	67.6 ft.	67.6 ft.	136 ft.
6a				42.27 ft.			26.7°	24.81 ft.	70.1 ft.	70.1 ft.	141 ft.

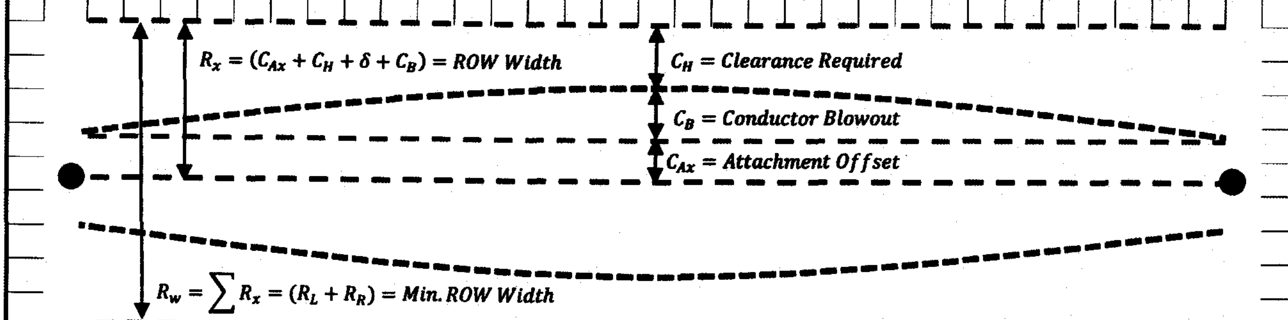
Clearance Check Selection: Extreme Wind Clearance Check. (10% nominal voltage)

Option	V_M 2.1	C_H 2.2	δ 2.3	S 2.4	p_c 2.5	p_T 2.6	ø 2.7	C_B 2.8	R_L 2.9	R_R 2.9	R_W 2.9
1b	362 kV	2.9 ft.	0.90 ft.	20.58 ft.	1.91 plf.	3.82 plf.	59.9°	29.06 ft.	62.8 ft.	62.8 ft.	126 ft.
2b				24.94 ft.			60.0°	32.84 ft.	66.6 ft.	66.6 ft.	134 ft.
3b				29.65 ft.			60.0°	36.94 ft.	70.7 ft.	70.7 ft.	142 ft.
4b				34.75 ft.			60.0°	41.36 ft.	75.1 ft.	75.1 ft.	151 ft.
5b				40.22 ft.			60.0°	46.11 ft.	79.9 ft.	79.9 ft.	160 ft.
6b				46.08 ft.			60.1°	51.19 ft.	85.0 ft.	85.0 ft.	170 ft.

Detailed Calculations:

Option	6a	*Select option for which to perform detailed calculations.*

2.1	-	V_M =	*345 x 1.05 = 362.25 kV*
2.2	-	C_H =	*7.5+(50-22) x (0.4/12)+((362.25/√3 - 50) x (0.4/12) x (1.03)^((7300-3300)/1000)) = 14.4 ft.*
2.3	-	δ =	*90 x 1% = 0.9 ft.*
2.4	-	S =	*(√(1.093²+ 0.554²) x 1300²)/(8 x 6123) = 42.27 ft.*
2.5	-	p_c =	*(1.107 x 6)/12 = 0.554 plf.*
2.6	-	p_T =	*0.55 x 2 = 1.107 plf.*
2.7	-	ø =	*TAN^-1[((2 x 6123 x 2 x SIN(0/2))+(1300 x 0.554))/((1300 x 1.093 x 2)+(0.5 x 46))] = 26.7°*
2.8	-	C_B =	*(13 + 42.27) x SIN(26.7) = 24.81 ft.*
2.9	-	R_L =	*(ABS(-30) + 14.4 + 0.9 + 24.8) = 70.11 ft.*
		R_R =	(30 + 14.4 + 0.9 + 24.8) = 70.11 ft.
		R_W =	(70.11 + 70.11) = 141 ft.



VERIFICATION

STATE OF Utah)
) ss.
COUNTY OF Washington)

Aaron White, first being sworn on his oath, states:

I am the witness identified in the foregoing Direct Testimony of Aaron White. I hereby verify that I have read the foregoing Direct Testimony of Aaron White and the statements contained therein are true and correct to the best of my knowledge and belief.

Aaron White

Subscribed, sworn to, and acknowledged before me on this 13 day of November, 2018.

Notary Public

My commission expires May 15, 2021

DANIEL SHUPE
Notary Public • State of Utah
Commission # 694887
My Commission Expires
May 15, 2021