Norconsult

Noise from a 400 kV transmission line

Summary/Conclusion

Two parallel 400 kV transmission lines connect Fraugde to Landerupgård. The older line has exceeded its lifetime and Energinet is working on renewing it. The project is so-called 1:1 reinvestment, which means that the line's technical characteristics and route will not change. Towers and all conductors will be replaced, and foundations renovated where necessary.

Energinet has asked Norconsult to perform a noise calculation for the line since it goes through populated areas. The calculations are performed in the simulation software EFC400.

The audible noise is calculated for only one 400 kV line and for two parallel 400 kV lines for the following cases:

1. 20°C ambient temperature
    a. No rain
    b. Light rain (2.5 mm/h)
    c. Heavy rain (7.7 mm/h)
2. 0°C ambient temperature
    a. No rain
    b. Light rain (2.5 mm/h)
    c. Heavy rain (7.7 mm/h)

For all cases, the calculations are made at the lowest point of the span at 1, 2 and 3 m above ground level. The noise level was calculated from the centre of the lines up to 100 m in both directions.

Statnett, in collaboration with the Norwegian Environmental Agency has prepared a guide for how the noise from power lines should be handled and processed. Statnett has self-imposed a limit value for audible noise from Power lines of 50 dB(A). This value is calculated on the right-of-way (ROW), at 1 m above ground level [1]. For this study, it is assumed that ROW is 20 m in both directions from the centre of the 400 kV line.

The results show that for one 400 kV line, the audible noise does not exceed 50 dB(A) outside the right of way for any weather condition.

For two parallel 400 kV lines, the audible noise for the heavy rain cases (7.7 mm/h) is just above 50 dB(A) at the border of the right of way. For other cases, the audible noise does not exceed 50 dB(A) outside the right of way.

Version	Date	Description	Prepared by	Checked by	Approved by
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1 Introduction

There are two 400 kV lines in parallel between Fraugde and Landerupgård, Energinet is working on renewing one of the line which was built in 1971-1973 and has therefore exceeded its lifetime.
The project is so-called 1:1 reinvestment, which means that the line's technical characteristics and route will not change. Towers and all conductors will be replaced, and foundations renovated where necessary. [2]

Energinet has asked Norconsult to perform a noise calculation for the line since it goes through populated areas. The calculations are performed in the simulation software EFC-400.

2 System description

The two 400 kV lines use identical tower types and conductors, information about the lines can be found in Table 1.

Table 1 – Transmission line information

Length		52 km
Distance between lines		30 m
Phase conductors	**Type**	AAAC 769
	Cross section area	768.92 mm^2
	Diameter	32.8 mm
	No. of subconductors	2
	Subconductor distance	0.4 m
Earth wires	**Type**	OPGW
	Cross section area	143.7 mm^2
	Diameter	16.0 mm
Tower types		Y-tower
Phase conductor formation		Delta formation
Average span length		280 m
Average sag		11 m

Detailed information about the conductors can be found in Appendix A.

The towers used in 400 kV Fraugde - Landerupgård are in a Y-shape, hence the name Y-tower. Figure 1 shows the dimensions of the towers.

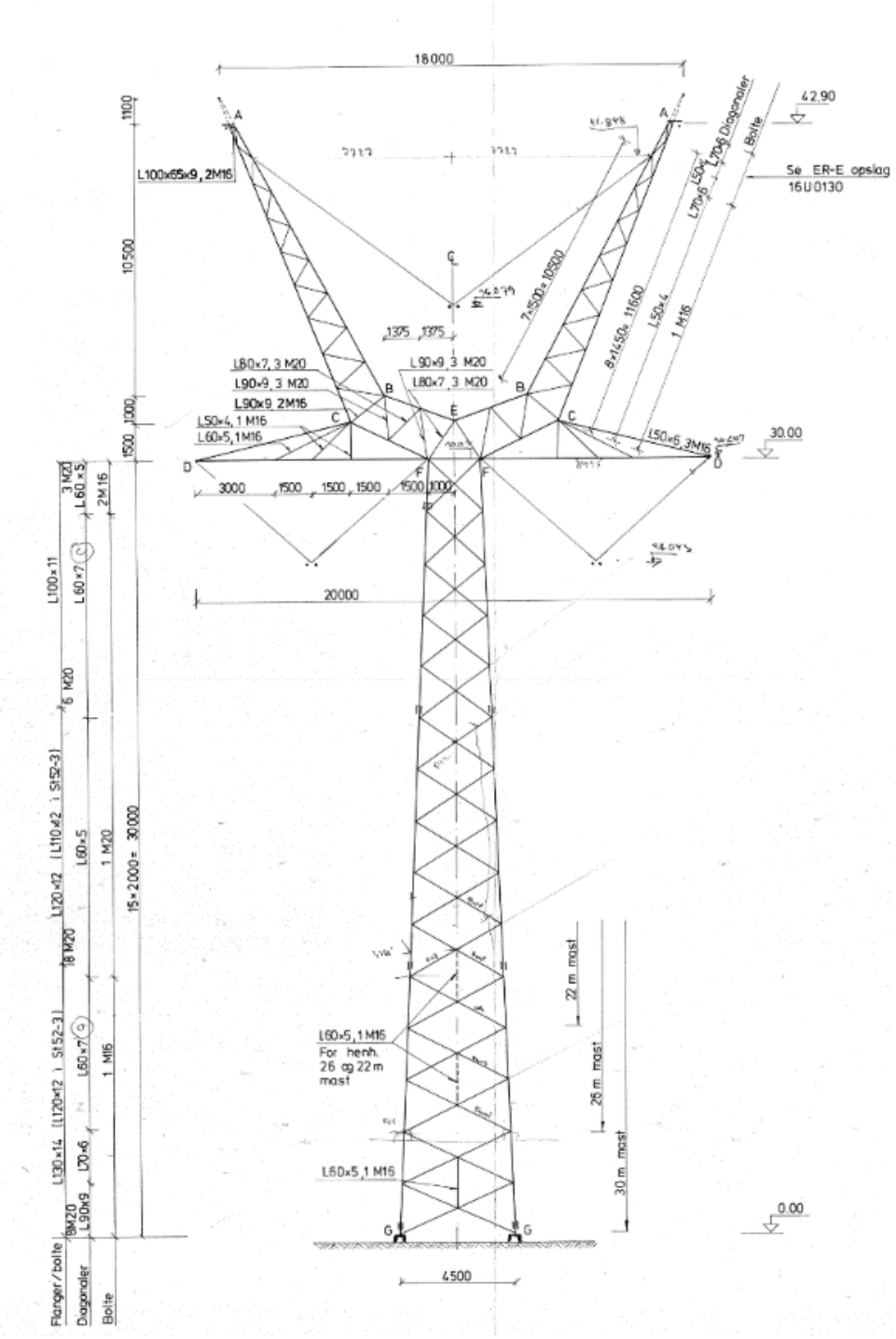

Figure 1 - Tower in 400 kV Fraugde-Landerupgård

3 Model description

The model was set up in EFC-400. For simplification, the lines are modelled with a constant 280 m span length, 11 m sag and 30 m distance between the lines. The audible noise is calculated at the lowest point of the span, at 1, 2 and 3 m above ground level. The ground clearance at the point of measurement is 15 m for the two lower wires and 25 m for the top wire. The audible noise is calculated for different ambient temperature (0°C and 20°C) and different rain conditions (0 mm/h, 2.5 mm/h and 7.7 mm/h).

4 Results

4.1 One 400 kV line

The results can be seen in Figures 2 - 7. The right of way is marked in red, 20 m from the centre of the line. For all cases, the noise level does not exceed the limit of 50 dB(A) outside the right of way.

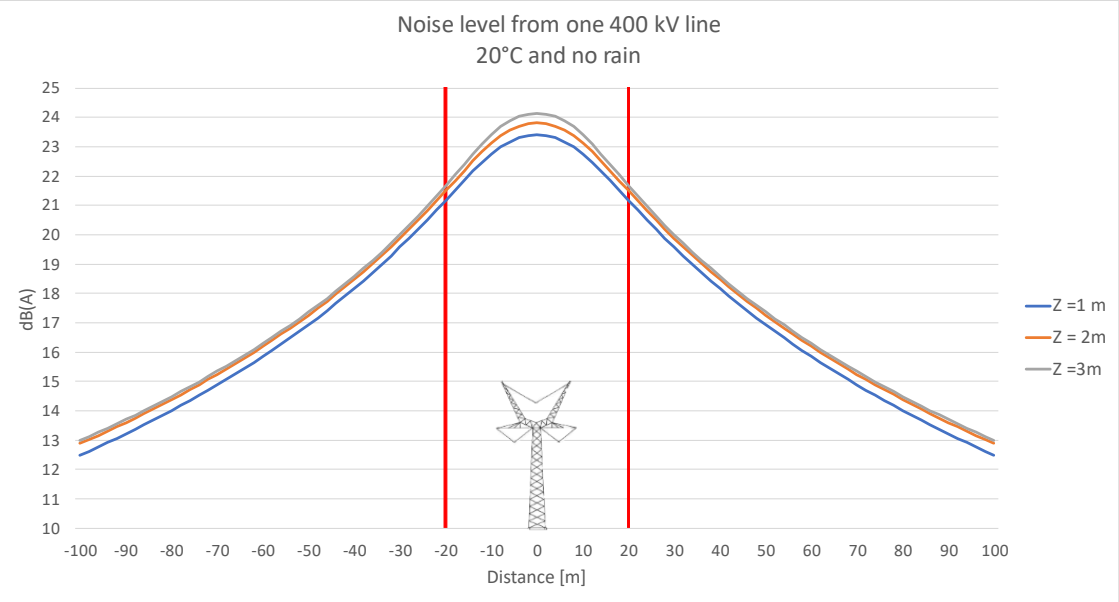

Figure 2 - Noise level from one 400 kV line, 20°C and no rain

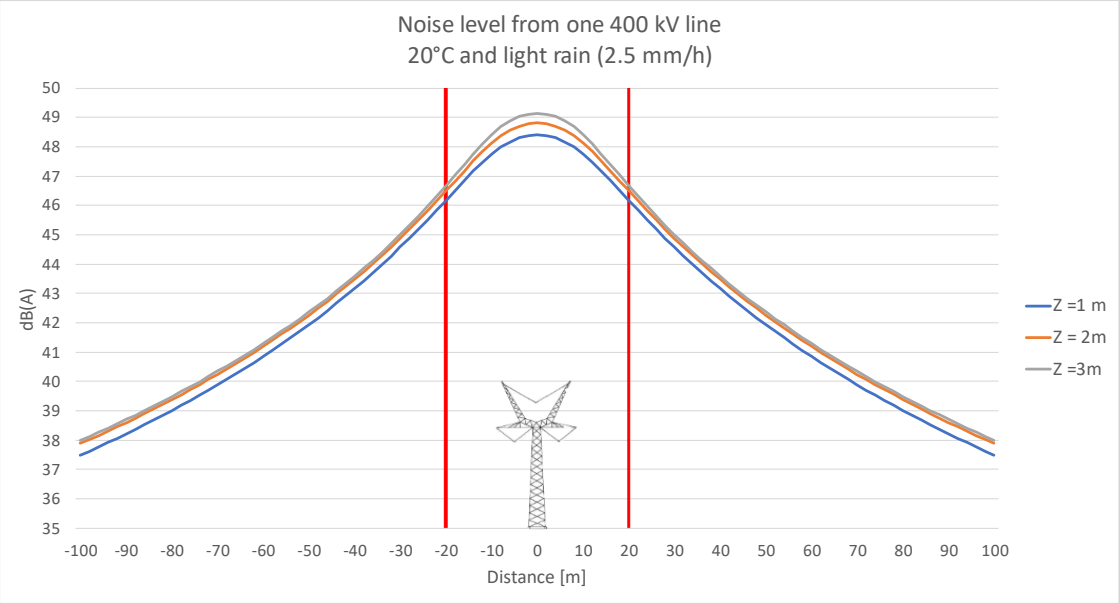

Figure 3 - Noise level from one 400 kV line, 20°C and 2.5 mm/h

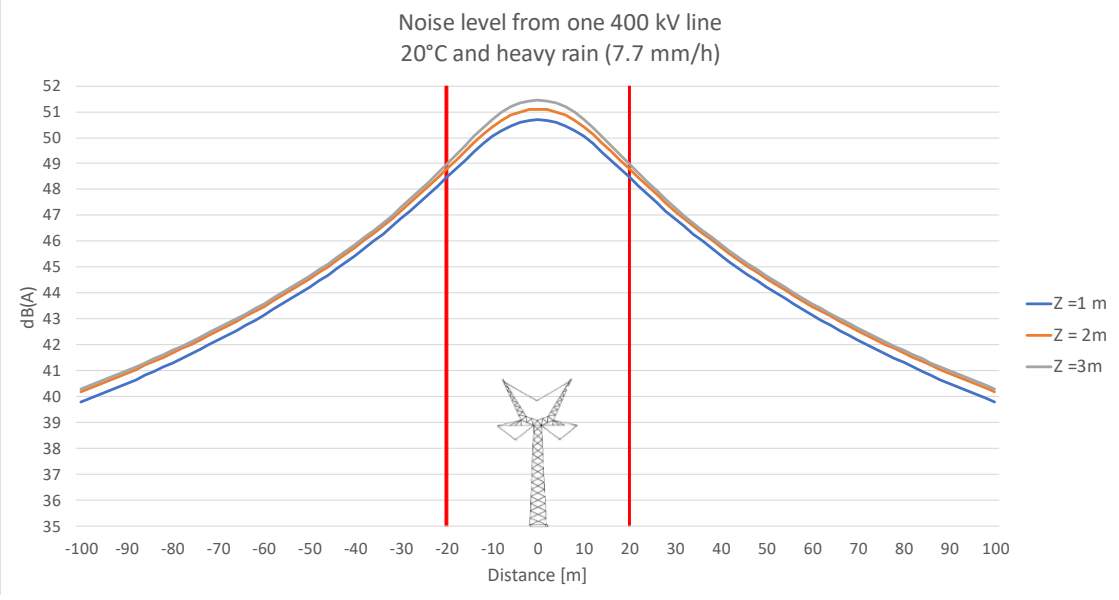

Figure 4 - Noise level from one 400 kV line, 20°C and 7.7 mm/h

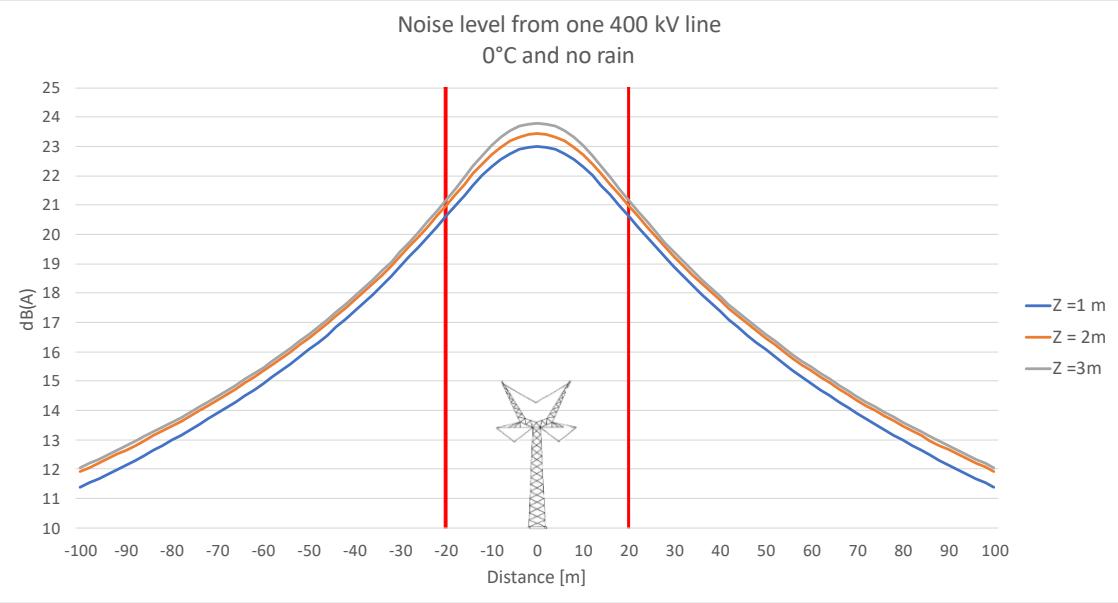

Figure 5 - Noise level from one 400 kV line, 0°C and no rain

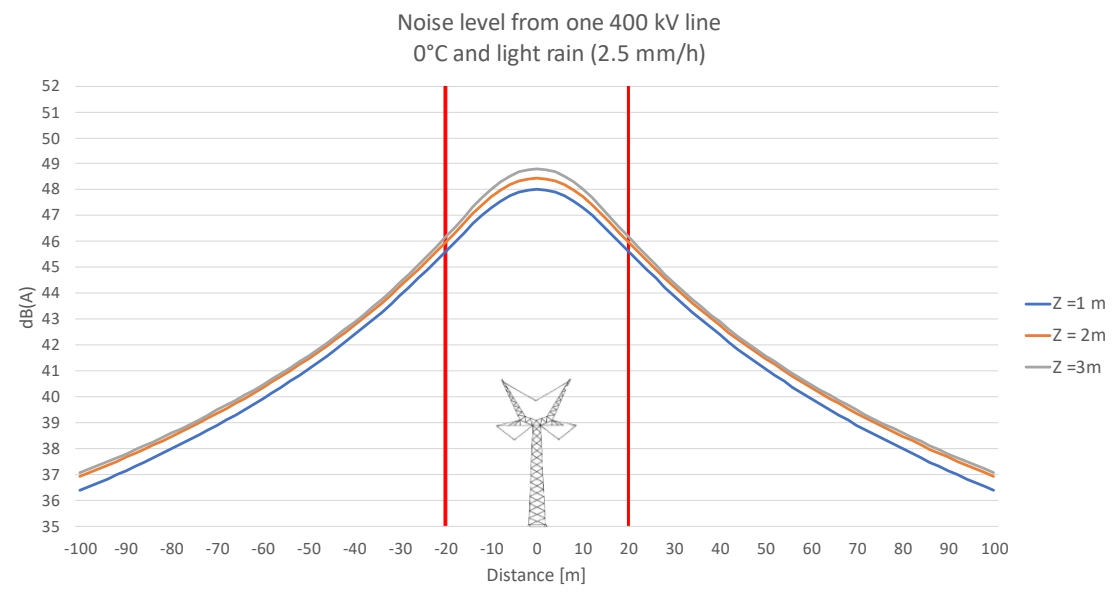

Figure 6 - Noise level from one 400 kV line, 0°C and 2.5 mm/h

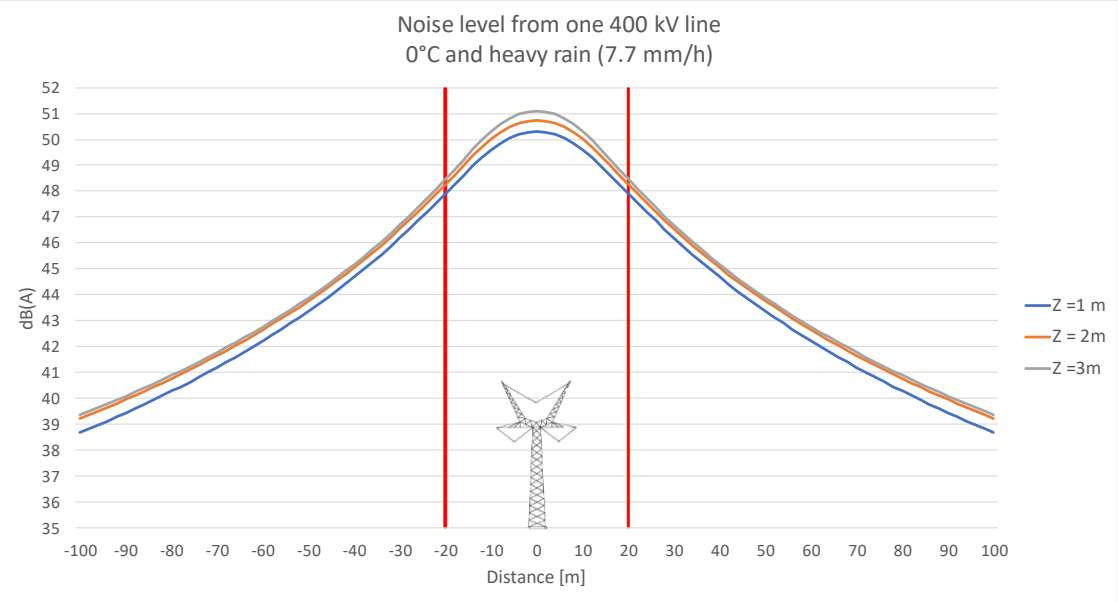

Figure 7 - Noise level from one 400 kV line, 0°C and 7.7 mm/h

4.2 Two parallel 400 kV lines

The results can be seen in Figures 8 - 13. The right of way (ROW) is marked in red, 20 m from the centre of each line.
For 20°C and heavy rain (7.7 mm/h), the noise level at the border of the right of way is 50.3, 50.6 and 50.8 dB(A) for 1, 2 and 3 m above ground respectively.
For 0°C and heavy rain (7.7 mm/h), the noise level at the border of the right of way is 49.6, 50.0 and 50.2 dB(A) for 1, 2 and 3 m above ground respectively.
For other cases, the noise level does not exceed the limit of 50 dB(A) outside the right of way.

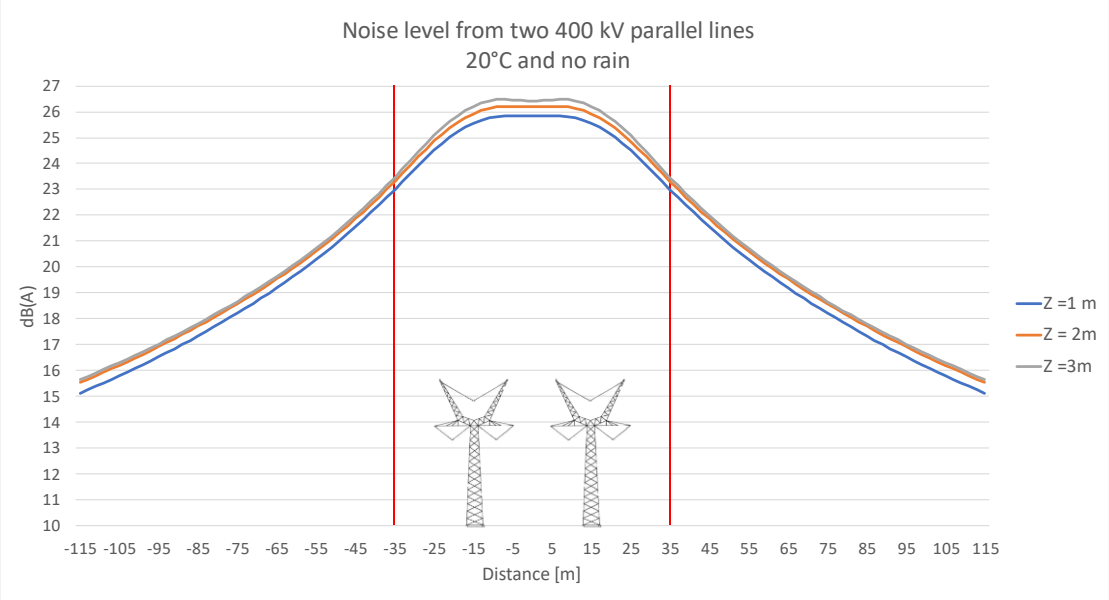

Figure 8 - Noise level for two parallel 400 kV lines, 20°C and no rain

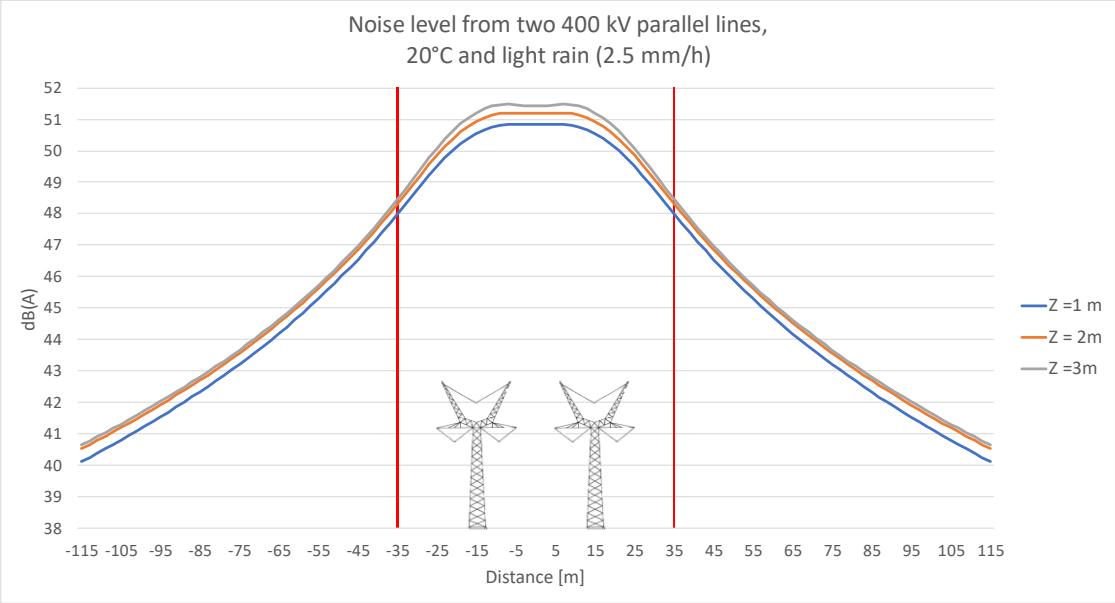

Figure 9 - Noise level for two parallel 400 kV lines, 20°C and 2.5 mm/h

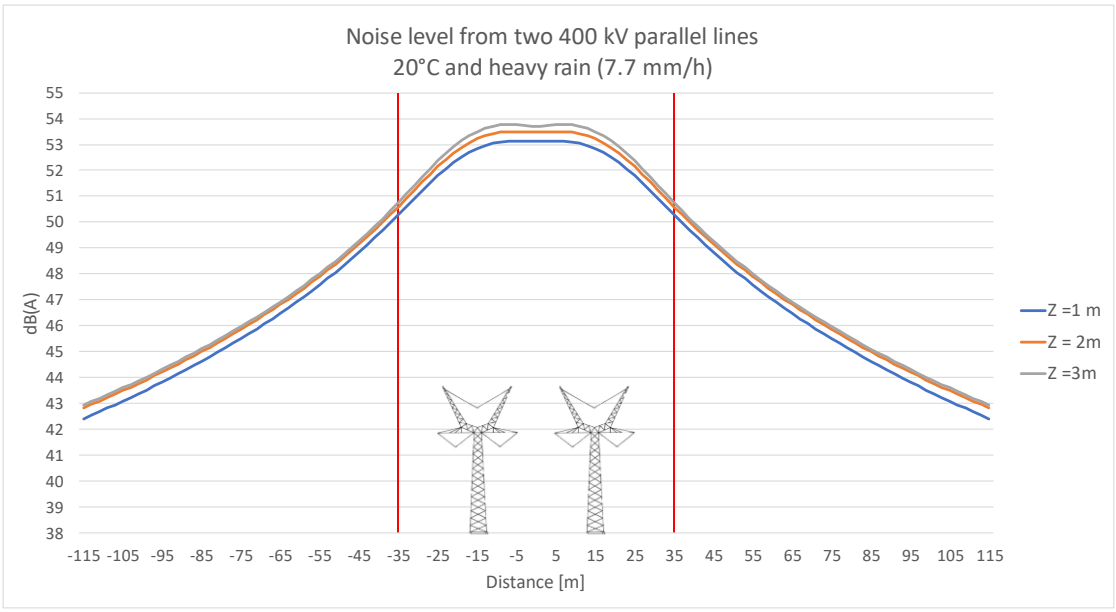

Figure 10 - Noise level for two parallel 400 kV lines, 20°C and 7.7 mm/h

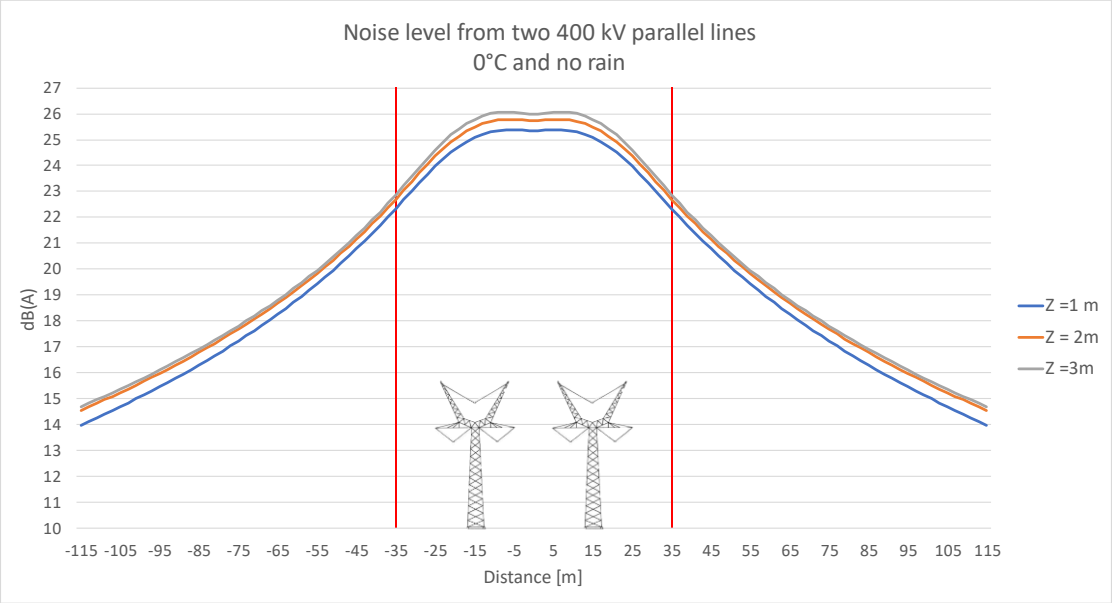

Figure 11 - Noise level for two parallel 400 kV lines, 0°C and no rain

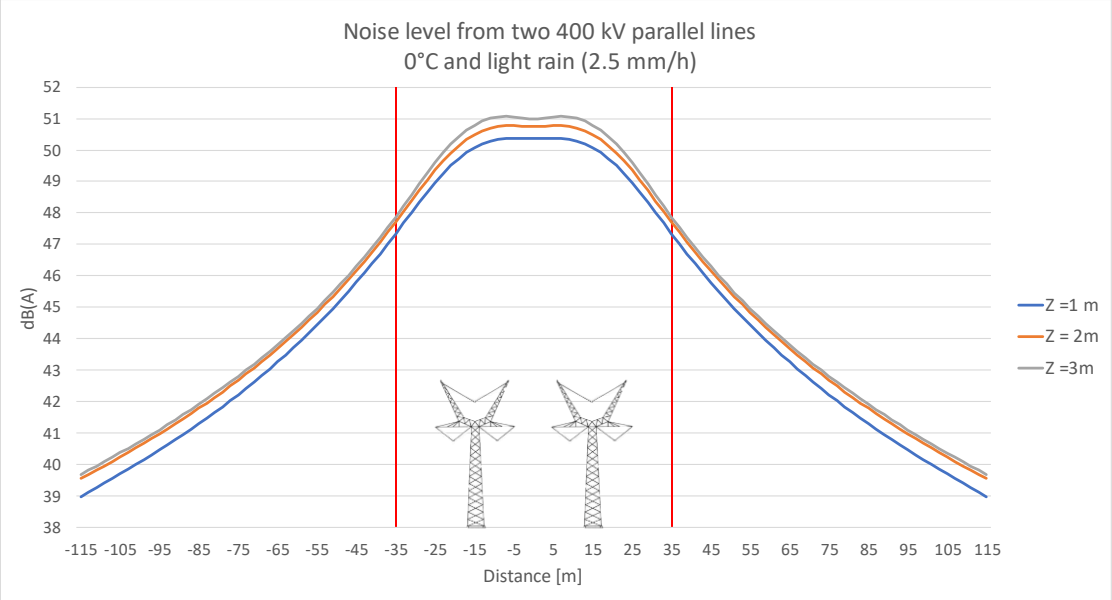

Figure 12 - Noise level for two parallel 400 kV lines, 0°C and 2.5 mm/h

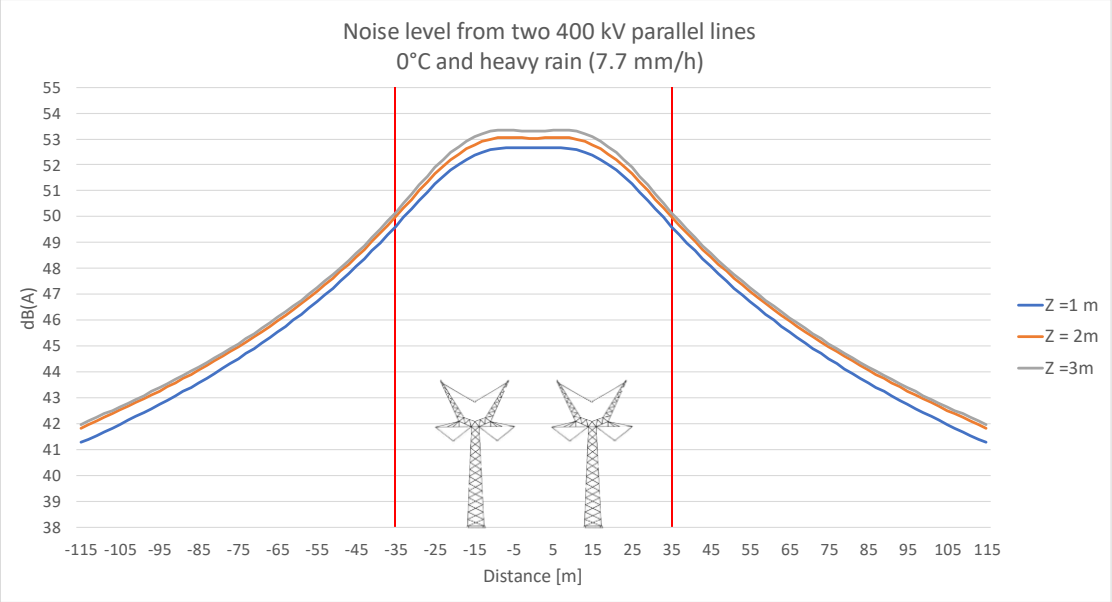

Figure 13 - Noise level for two parallel 400 kV lines, 0°C and 7.7 mm/h

5 References

[1] Statnett, “Teknisk standard SDOK-39-50,” Statnett, 2021.

[2] Energinet, “Projektbeskrivelse - Vedligeholdelse af 400 kV-luftledningen mellem Kauslunde og Fraugde,” Energinet, 2020.

Appendix A. Conductors datasheet

A.1. Phase conductors

Mechanical Characteristics					
Overall Diameter	mm	32.8			
Cross sectional area	mm^2	768.92			
Core diameter	mm	11.25			
No # size of the wires in the core	No#mm	19	2.25	R	A7
No.# Size of shaped wires - First layet	No#mm^2	8	19.47	Z	A9
No. & size of shaped wires-Second layer	No#mm^2	12	19.26	Z	A9
No. & size of shaped wires-third layer	No#mm^2	16	19.16	Z	A9
Lay ratio, inner layers	-	10-16			
Lay ratio outer layer	-	10-14			
Lay direction of outer layer	-	Right hand			
Nominal mass aluminum	kg/km	2135			
Nominal mass of grease	kg/km	25			
Nominal mass of the conductor	kg/km	2160			
Grease (Type 20A150)		OCG 5000 (Metalube)			
Rated Tensile Strength (RTS) of conductor	kN	182			
Modulus of Elasticity - Conductor	kg/mm^2	5598			
Linear thermal expansion coefficient - Conductor	/°C x 10^{-6}	22.72			
Estimated creep for 10 years	µ/m	531.24			
Electrical Characteristics					
DC Resistance at 20°C	Ω/km	0.03841			
AC Resistance at 20°C	Ω/km	0.04046			
Max operating temperaure	°C	90			
AC resistance at the max operating temperature	Ω/km	0.04975			
Inductive reactance @50Hz	Ω/km	0.1993			
Capacitive reactance @50Hz	MΩ.km	0.1674			
Geometric mean radius	mm	12.77			
Continuous current carrying capacity max.at 90°C	A	1583			
Project related data					
Wind perpendicular to conductor	m/s	0.6			
Emissivity		0.6			
Absorptivity		0.6			
Solar radiation	W/m^2	900			
Ambient temperature	°C	20			
Comparison with equivalent ACSR					
Equivalent ACSR Conductor		ACSR Finch			
Current rating of ACSR at 80°C	A	1271			
Temperature of AAAC at 1271 A	°C	65.6			
Estimated Sag at 1271 A (ACSR current rating) in 360m span					
ACSR Finch	m	11.53			
AAAC 769	m	11.23			

A.2. Ground wires

Configuration			*Substitute for ACSR Dorking*
Center		1 A20SA - Wire	3,40 mm
Layer 1		4 A20SA - Wires	3,30 mm
		1 AL3 - Wire	3,30 mm
	+	1 Stainless Steel Tube with 48 SMF	2,85 / 3,25 mm
Layer 2		13 AL3 - Wires	3,00 mm

Mechanical Data		
Cable Diameter		16,0 mm
Cable Weight		612 kg/km
Weight of ACS Wires		290 kg/km
Weight of AL3 Wires		279 kg/km
Weight of Steel Tube		22 kg/km
Weight of Grease		21 kg/km
Supporting Cross Section		143,7 mm²
Rated Tensile Strength (RTS)		80,7 kN
Modulus of Elasticity		88,6 kN/mm²
Thermal Elongation Coefficient		17,5 10^{-6}/K
Permissible Maximum Working Stress (42% RTS)		235,7 N/mm² (33,9kN)
Recommended Everyday Stress (16% RTS)		89,8 N/mm² (12,9kN)
Ultimate Exceptional Stress (72% RTS)		404,1 N/mm² (58,1kN)

Electrical Data		
DC Resistance (20°C)		0,284 Ω/km
Conductivity		42,3% IACS
Short Time Current	(1,0s,20-200°C)	13,5 kA
Short Time Current Capacity I²t	(20-200°C)	181,0 kA²s