Wind speed:	Average		Power Generation:	42.000	kW		Operation duration	2.763	Hrs

MV + HV Cable data

XLPE Cables		ARE4H1R 18/30 kV - Parameters		Alumium Conductors					Trefoil in ground							
Single core	Cross	$R_{90°C}$	X_c	Capacit.	Z_c	External	Weigth	Drum	Bending	Refer.	Current	R.c.c.*	R.c.c.*	R.c.c.*	R.c.c.*	R.c.c.*
Al cables	Section	Ohm/	Ohm/	microF/	Ohm/	Dia		length	Radius	Price		for 1 circ.	for 2 circ.	for 3 circ.	for 4 circ.	for 5 circ.
Cu wires	sqmm	km	km	km	km	mm	kg/mt	mt	mm	€/m	A	A	A	A	A	A
screen																
1 x	50	0,82	0,15	0,130	0,83	30	0,89	500	450	4,94	**173**	**166**	**141**	**125**	**116**	**106**
1 x	70	0,57	0,14	0,150	0,58	31	0,97	500	465	5,29	**208**	**200**	**170**	**150**	**140**	**128**
1 x	95	0,41	0,13	0,170	0,43	33	1,11	500	495	6,11	**247**	**237**	**202**	**178**	**166**	**152**
1 x	120	0,33	0,13	0,190	0,35	34	1,16	500	510	6,73	**281**	**270**	**229**	**202**	**189**	**173**
1 x	150	0,26	0,12	0,200	0,29	36	1,38	500	540	7,50	**319**	**306**	**260**	**230**	**214**	**196**
1 x	185	0,21	0,12	0,210	0,24	38	1,56	500	570	8,46	**361**	**347**	**295**	**260**	**243**	**222**
1 x	240	0,16	0,12	0,230	0,20	40	1,72	500	600	9,85	**417**	**400**	**340**	**300**	**280**	**256**
1 x	300	0,13	0,11	0,260	0,18	43	2,05	500	645	11,20	**474**	**455**	**387**	**341**	**319**	**291**
1 x	400	0,11	0,108	0,270	0,15	46	2,34	500	690	13,67	**540**	**518**	**441**	**389**	**363**	**332**
1 x	500	0,09	0,100	0,300	0,13	49	2,82	500	735	15,94	**618**	**593**	**504**	**445**	**415**	**380**
1 x	630	0,07	0,098	0,340	0,12	52	2,92	500	780	18,98	**704**	**676**	**574**	**507**	**473**	**433**

XLPE Cables		ARE4H1R 64/110 kV - Parameters		Alumium Conductors					Trefoil in ground		
Single core	Cross	$R_{90°C}$	X_c	Capacit.	Z_c	External	Weigth	Drum	Bending	Refer.	Current	R.c.c.*
Al cables	Section	Ohm/	Ohm/	microF/	Ohm/	Dia		length	Radius	Price		for 1 circ.
Cu wires	sqmm	km	km	km	km	mm	kg/mt	mt	mm	€/m	A	A
screen												
1 x	*400*	*0,10*	*0,43*	*0,157*	*0,44*	*84*	*6,50*	*1.000*	*1.700*	*35,00*	*530*	*509*

Basic Design Data

											2 x	
Operation Hypotesis								**Trafos:**		**2.500**	**50.000**	**[kVA]**
Cos fi:	**0,95**				sin fi	**0,31**			V_{1n} =	690	30.000	[V]
Rated Voltage(kV)				**30**					V_{2n} =	30	150	[kV]
Generation Power (kW)				**2.100**					I_N	48	192	[A]
Generation hours:				**2.763**	Hrs/year				I	42,54	85,08	[A]
WTG nos.				**20**					V_{cc} =	7,00	12,00	%
Losses coorrection factor: Equivalent operation versus effective one						**0,76**			P_{fe} =	5,50	19,50	kW
Cp = Net Present value of losses: ax'((1+i)^n-1)/((1+i)^n)xi									Pcu	14,1	27,6	kW
									P_{cu} =	18,00	141,00	kW
where	a =	selling price				**0,126**			P_{tot} =	23,50	160,50	
	i =	Net present value interest rate				**0,06**			Zn	360,00	450,00	Ohm
	n =	number of years for return of investment:				**20**			Z_{t20} =	25,20	54,00	Ohm
	Cp =	**1,4452101**		**€/kWh**					R_{t20} =	2,59	1,27	Ohm
									X_{t20} =	25,07	53,99	Ohm
Generation factor					**1**				$Q_{cosfi=1}$	136.094	1.172.419	VAR
									Q_{tot}		**5.066.722**	**VAR**

Speed	Unit power	Rev. Op. Hours		Unit Gen. Energy	Total Gen. Energy
m/s	kW/unit	hours		MWh	MWh
≤3	-	2988,00		-	-
4	55,90	669,77		37,44	748,80
5	191,50	670,08		128,32	2.566,40
6	381,90	677,25		258,64	5.172,80
7	631,60	659,28		416,40	8.328,00
8	956,00	611,46		584,56	11.691,20
9	1.350,20	541,85		731,60	14.632,00
10	1.750,80	460,09		805,52	16.110,40
11	2.004,30	380,74		763,12	15.262,40
12	2.083,40	303,93		633,20	12.664,00
13	2.098,30	230,89		484,48	9.689,60
14	2.101,20	167,45		351,84	7.036,80
15	2.100,40	116,40		244,48	4.889,60
16	2.098,70	77,61		162,88	3.257,60
17	2.097,70	49,69		104,24	2.084,80
18	2.095,50	30,66		64,24	1.284,80
19	2.093,90	18,26		38,24	764,80
20	2.090,90	6,73		14,08	281,60
				5.823	**116.466**

					Wind speed:		Average			Power Generation:			42.000	kW		Operation duration			2.763	Hrs		
					M.V. branches parameters calculation																	
	Circuit Line 1 and 2																				
Node	Param.	Lenght	Cable Al	R.c.c.	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	Losses	$Q_{Ind.i\ lost}$	$Q_{capac.i\ lost}$	$Q_{tot.i}$	DV_i	Dvi%	En. Lost	Losses Cost	Cable Cost	Total Cost
No.	$L_{(i-1)-i}$	mts	mm^2	A	ohm	ohm	microF	ohm	kW	kW	A	W	%	VAR	VAR	VAR	V		kWh/year	€	€	
	Circuit Line 1.1																					
1	L_{7-1}	530	1 x 70	200	0,299	0,074	0,080	0,309	2.100	2.100	42,54	1.626	**0,077**	403	22.467	-22.064	22,63	**0,113**	3.414	4.933	8.407	13.341
2	L_{1-18}	500	1 x 150	306	0,132	0,060	0,100	0,145	2.100	4.200	85,08	2.867	**0,068**	1.303	28.260	-26.957	21,20	**0,106**	6.019	8.699	11.253	19.952
3	L_{18-2}	400	1 x 300	455	0,054	0,045	0,104	0,070	2.100	6.300	127,62	2.619	**0,042**	2.209	29.390	-27.182	14,34	**0,072**	5.499	7.948	13.446	21.393
4	$L_{2-Cab.1}$	1.700	1 x 300	455	0,228	0,192	0,442	0,298	2.100	8.400	170,17	19.789	**0,236**	16.688	124.909	-108.222	81,25	**0,406**	41.550	60.048	57.143	117.192
	Circuit Line 1.2																					
5	L_{19-3}	490	1 x 70	200	0,277	0,069	0,074	0,285	2.100	2.100	42,54	1.503	**0,072**	372	20.771	-20.399	20,92	**0,105**	3.156	4.561	7.773	12.334
6	L_{3-20}	550	1 x 150	306	0,145	0,066	0,110	0,159	2.100	4.200	85,08	3.153	**0,075**	1.433	31.086	-29.653	23,32	**0,117**	6.621	9.569	12.378	21.947
7	L_{20-17}	820	1 x 300	455	0,110	0,093	0,213	0,144	2.100	6.300	127,62	5.369	**0,085**	4.528	60.250	-55.723	29,39	**0,147**	11.273	16.293	27.563	43.856
8	$L_{17-Cab.1}$	390	1 x 300	455	0,052	0,044	0,101	0,068	2.100	8.400	170,17	4.540	**0,054**	3.828	28.656	-24.827	18,64	**0,093**	9.532	13.776	13.109	26.885
	Circuit Line 1.3																					
9	L_{10-12}	1.150	1 x 70	200	0,650	0,161	0,173	0,669	2.100	2.100	42,54	3.528	**0,168**	874	48.749	-47.874	49,10	**0,246**	7.407	10.705	18.243	28.947
10	L_{13-12}	490	1 x 70	200	0,277	0,069	0,074	0,285	2.100	2.100	42,54	1.503	**0,072**	372	20.771	-20.399	20,92	**0,105**	3.156	4.561	7.773	12.334
11	$L_{12-Cab.1}$	2.050	1 x 300	455	0,275	0,232	0,533	0,359	2.100	6.300	127,62	13.423	**0,213**	11.319	150.626	-139.306	73,48	**0,367**	28.184	40.731	68.908	109.640
										23.100												
	Line from Cab. 1 to Cab .2																					
	$L_{cab1-Cab.2}$	3.800	2//3x1x500	593	0,334	0,380	1,140	0,506	2.100	**23.100**	233,98	109.718	**0,475**	124.821	644.328	-519.507	176,19	**0,881**	460.738	665.863	363.334	1.029.197
Node	Param.	Lenght	Cable Al	R.c.c.	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	Losses	$Q_{Ind.i\ lost}$	$Q_{capac.i\ lost}$	$Q_{tot.i}$	DV_i	Dvi%	En. Lost	Losses Cost	Cable Cost	
No.	$L_{(i-1)-i}$	mts	mm^2	A	ohm	ohm	microF	ohm	kW	kW	A	W	%	VAR	VAR	VAR	V		kWh/year	€	€	
	Circuit Line 2.1																					
12	L_{4-16}	1.200	1 x 70	200	0,678	0,168	0,180	0,699	2.100	2.100	42,54	3.681	**0,175**	912	50.868	-49.956	51,24	**0,256**	7.729	11.170	19.036	30.206
13	$L_{16-Cab.2}$	5.800	1 x 150	306	1,531	0,696	1,160	1,682	2.100	4.200	85,08	33.254	**0,792**	15.115	327.816	-312.701	245,88	**1,229**	69.821	100.906	130.535	231.441
	Circuit Line 2.2																					
14	L_{11-8}	700	1 x 70	200	0,396	0,098	0,105	0,407	2.100	2.100	42,54	2.147	**0,102**	532	29.673	-29.141	29,89	**0,149**	4.509	6.516	11.104	17.620
15	L_{8-5}	2.360	1 x 150	306	0,623	0,283	0,472	0,684	2.100	4.200	85,08	13.531	**0,322**	6.150	133.387	-127.237	100,05	**0,500**	28.410	41.059	53.114	94.173
16	L_{5-9}	640	1 x 300	455	0,086	0,072	0,166	0,112	2.100	6.300	127,62	4.191	**0,067**	3.534	47.025	-43.491	22,94	**0,115**	8.799	12.716	21.513	34.229
17	$L_{9-Cab.2}$	240	1 x 300	455	0,032	0,027	0,062	0,042	2.100	8.400	170,17	2.794	**0,033**	4.712	35.268	-30.557	11,47	**0,057**	5.866	8.477	8.067	16.545
	Circuit Line 2.3																					
18	L_{14-6}	650	1 x 70	200	0,367	0,091	0,098	0,378	2.100	2.100	42,54	1.994	**0,095**	494	27.554	-27.059	27,75	**0,139**	4.187	6.050	10.311	16.361
19	L_{6-21}	4.700	1 x 150	306	1,241	0,564	0,940	1,363	2.100	4.200	85,08	26.947	**0,642**	12.249	265.644	-253.395	199,24	**0,996**	56.579	81.769	105.778	187.547
20	$L_{21-Cab.2}$	3.550	1 x 150	306	0,937	0,426	0,710	1,029	2.100	6.300	127,62	45.796	**0,727**	20.816	200.646	-179.830	225,74	**1,129**	96.155	138.964	79.896	218.860
										18.900												
									Circuit line from S/S Utenza to S/S Terna													
Node	Param.	Lenght	Cable Al	R.c.c.	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	Losses	$Q_{Ind.i\ lost}$	$Q_{capac.i\ lost}$	$Q_{tot.i}$	DV_i	Dvi%	En. Lost	Losses Cost	Cable Cost	Total Cost
No.	$L_{(i-1)-i}$	mts	mm^2	A	ohm	ohm	microF	ohm	kW	kW	A	W	%	VAR	VAR	VAR	V		kWh/year	€	€	
	Alt 1		**30 kV cable connection to Terna Substation**																			
MV Line	$L_{SS-Terna}$	18.900	3//3x1x500	593	1,661	1,890	5,670	2,516		**42.000**	283,61	1.202.647	**2,863**	1.368.199	4.807.026	-3.438.827	1.064,03	**5,320**	7.575.423	10.948.077	2.710.663	13.658.739
	Alt 2		**150 kV cable connection to Terna Substation**																			
HV Line	$L_{SS-Terna}$	18.900	1 x 400	509	1,890	8,127	2,967	8,344		**42.000**	170,17	164.183,93	**0,391**	1.411.982	20.963.975	-19.551.993	1.275,16	**0,850**	344.729,12	498.206,00	1.984.500	**2.482.706**

Wind speed: **Average** | Power Generation: **42.000 kW** | Operation duration **2.763 Hrs**

Optimisation summary tables

Cable ARE4H1RX - 18/30 kV

Cables & Cable Accessories Summary

	Line	Lenght	Cable size	Drum Nos	Joints	Terminations	Losses - W	VAR	kWh/year	Losses €	Cable cost €
60	$L_{7\text{-}1}$	530	3x1x70	1		6	1.626	-22.064	3.414	4.933	8.407
66	$L_{19\text{-}3}$	490	3x1x70	1		6	1.503	-20.399	3.156	4.561	7.773
72	$L_{10\text{-}12}$	1150	3x1x70	3	6	6	3.528	-47.874	7.407	10.705	18.243
73	$L_{13\text{-}12}$	490	3x1x70	1		6	1.503	-20.399	3.156	4.561	7.773
83	$L_{4\text{-}16}$	1200	3x1x70	3	6	6	3.681	-49.956	7.729	11.170	19.036
87	$L_{11\text{-}8}$	700	3x1x70	2	3	6	2.147	-29.141	4.509	6.516	11.104
93	$L_{14\text{-}6}$	650	3x1x70	2	3	6	1.994	-27.059	4.187	6.050	10.311
	Total	**5.210**	**3x1x70**	**13**	**18**	**42**	***15.982***	***-216.892***	***33.557***	***48.497***	***82.647***
61	$L_{1\text{-}18}$	500	3x1x150	2	3	6	2.867	-26.957	6.019	8.699	11.253
67	$L_{3\text{-}20}$	550	3x1x150	2	3	6	3.153	-29.653	6.621	9.569	12.378
84	$L_{16\text{-}Cab.2}$	5.800	3x1x150	15	42	6	33.254	-312.701	69.821	100.906	130.535
88	$L_{8\text{-}5}$	2.360	3x1x150	3	6	6	13.531	-127.237	28.410	41.059	53.114
94	$L_{6\text{-}21}$	4.700	3x1x150	1		6	26.947	-253.395	56.579	81.769	105.778
95	$L_{21\text{-}Cab.2}$	3.550	3x1x150	13	36	6	45.796	-179.830	96.155	138.964	79.896
	Total	**17.460**	**3x1x150**	**36**	**90**	**36**	***125.547***	***-929.772***	***263.606***	***380.965***	***392.955***
62	$L_{18\text{-}2}$	1.200	1x300	3		6	2.619	-27.182	5.499	7.948	13.446
63	$L_{2\text{-}Cab.1}$	5.100	1x300	6	3	6	19.789	-108.222	41.550	60.048	57.143
68	$L_{20\text{-}17}$	2.460	1x300	3		6	5.369	-55.723	11.273	16.293	27.563
69	$L_{17\text{-}Cab.1}$	1.170	1x300	1		6	4.540	-24.827	9.532	13.776	13.109
74	$L_{12\text{-}Cab.1}$	6.150	1x300	6	6	6	13.423	-139.306	28.184	40.731	68.908
89	$L_{5\text{-}9}$	1.920	1x300				4.191	-43.491	8.799	12.716	21.513
90	$L_{9\text{-}cab.2}$	720	1x300				2.794	-30.557	5.866	8.477	8.067
	Total	**16.080**	**3x1x300**	**19**	**9**	**30**	***52.724***	***-429.307***	***110.703***	***159.989***	***209.750***
77	$L_{cab.1\text{-}Cab.2}$	22.800	1x500	24	18	12	***109.718***	***-519.507***	***460.738***	***665.863***	***363.334***
	Total	**22.800**	**1x300**	**24**	**18**	**12**	**Sub-Total**	***303.972***	***-2.095.478***	***868.604***	***1.255.315***	***1.048.686***
Alt.2-150	$L_{SS\text{-}Terna}$	**56.700**	**1x400 HV**	**72**	**69**	**6**	***164.184***	***-19.551.993***	***344.729***	***498.206***	***1.984.500***
							Grand Total Alt.2	**468.156**	**-21.647.471**	**1.213.333**	**1.753.521**	**3.033.186**

Specific Losses	kVAR	Perdite kW	% Perdite	Max. % DV
MV Cables	- 2.095	304,0	**0,72**	**1,23**
bt/MV TR P_{fe}	2.722	110,0	**0,26**	
bt/MV TR P_{cu}		281,5	**0,67**	
MV/AT TR P_{fe}	2.345	39,0	**0,09**	
MV/AT TR P_{cu}		55,1	**0,13**	
Alt 2 - 150 kV	- 19.552	164,2	**0,39**	**0,85**
Tot. Alt 150 kV	- 16.581	954	**2,27**	**1,23**
		805		

					Wind speed:			≤3		Power Generation:			20			2.988	Hrs			
					Basic Design Data									Unit power	Rev. Op. Hours	Unit Gen. Energy	Total Gen. Energy			
														kW/unit	hours	MWh	MWh			
												2 x		1,00	2987,87	2,99	59,76			
Operation Hypotesis									**Trafos:**		**2.500**	**50.000**	**[kVA]**	55,90	669,77	37,44	748,80			
														191,50	670,08	128,32	2.566,40			
Cos fi:	**0,95**				sin fi	**0,31**			V_{1n} =	690	30.000	[V]		381,90	677,25	258,64	5.172,84			
Rated Voltage(kV)				**30**					V_{2n} =	30	150	[kV]		631,60	659,28	416,40	8.328,00			
Generation Power (kW)				**1,0**					I_N	48	192	[A]		956,00	611,46	584,56	11.691,20			
Generation hours:				**2.987,9**	Hrs/year				I	0,02	0,04	[A]		1.350,20	541,85	731,60	14.632,00			
WTG nos.				**20**					V_{cc} =	7,00	12,00	%		1.750,80	460,09	805,52	16.110,40			
Losses coorrection factor: Equivalent operation versus effective one						**1,00**			P_{fe} =	5,50	19,50	kW		2.004,30	380,74	763,12	15.262,40			
Cp = Net Present value of losses: ax'((1+i)^n-1)/((1+i)^n)xi									Pcu	0,0	0,0	kW		2.083,40	303,93	633,20	12.664,00			633.200,00
									P_{cu} =	18,00	141,00	kW		2.098,30	230,89	484,48	9.689,60			484.480,00
where	a =	selling price				**0,126**			P_{tot} =	23,50	160,50			2.101,20	167,45	351,84	7.036,80			351.840,00
	i =	Net present value interest rate				**0,06**			Zn	360,00	450,00	Ohm		2.100,40	116,40	244,48	4.889,60			244.480,00
	n =	number of years for return of investment:				**20**			Z_{t20} =	25,20	54,00	Ohm		2.098,70	77,61	162,88	3.257,60			162.880,00
														2.097,70	49,69	104,24	2.084,80			104.240,00
	Cp =	**1,4452101**		**€/kWh**					R_{t20} =	2,59	1,27	Ohm		2.095,50	30,66	64,24	1.284,80			64.240,00
									X_{t20} =	25,07	53,99	Ohm		2.093,90	18,26	38,24	764,80			38.240,00
Generation factor					**1**				$Q_{cosfi=1}$	0	0	VAR		2.090,90	6,73	14,08	281,60			14.080,00
									Q_{tot}		**1**	**VAR**			8660,00	**5.826**	**116.525**			**2.097.680**

					Wind speed:		≤3		Power Generation:	20			2.988	Hrs			
					M.V. branches parameters calculation												
	Circuit Line 1 and 2																
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	**Losses**	$Q_{tot.i}$	DV_i	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	$L_{(i-1)-i}$	**mts**	**mm²**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 1.1																			
1	L_{7-1}	530	1 x 70	200	0,299	0,074	0,080	0,309	1	1	0,02	0	**0,000**	-22.467	0,01	**0,000**	0	0	8.407	8.407
2	L_{1-18}	500	1 x 150	306	0,132	0,060	0,100	0,145	1	2	0,04	0	**0,000**	-28.260	0,01	**0,000**	0	0	11.253	11.253
3	L_{18-2}	400	1 x 300	455	0,054	0,045	0,104	0,070	1	3	0,06	0	**0,000**	-29.390	0,01	**0,000**	0	0	13.446	13.446
4	$L_{2-Cab.1}$	1.700	1 x 300	455	0,228	0,192	0,442	0,298	1	4	0,08	0	**0,000**	-124.909	0,04	**0,000**	0	0	57.143	57.143
	Circuit Line 1.2																			
5	L_{19-3}	490	1 x 70	200	0,277	0,069	0,074	0,285	1	1	0,02	0	**0,000**	-20.771	0,01	**0,000**	0	0	7.773	7.773
6	L_{3-20}	550	1 x 150	306	0,145	0,066	0,110	0,159	1	2	0,04	0	**0,000**	-31.086	0,01	**0,000**	0	0	12.378	12.378
7	L_{20-17}	820	1 x 300	455	0,110	0,093	0,213	0,144	1	3	0,06	0	**0,000**	-60.250	0,01	**0,000**	0	0	27.563	27.563
8	$L_{17-Cab.1}$	390	1 x 300	455	0,052	0,044	0,101	0,068	1	4	0,08	0	**0,000**	-28.656	0,01	**0,000**	0	0	13.109	13.109
	Circuit Line 1.3																			
9	L_{10-12}	1.150	1 x 70	200	0,650	0,161	0,173	0,669	1	1	0,02	0	**0,000**	-48.748	0,02	**0,000**	0	0	18.243	18.243
10	L_{13-12}	490	1 x 70	200	0,277	0,069	0,074	0,285	1	1	0,02	0	**0,000**	-20.771	0,01	**0,000**	0	0	7.773	7.773
11	$L_{12-Cab.1}$	2.050	1 x 300	455	0,275	0,232	0,533	0,359	1	3	0,06	0	**0,000**	-150.626	0,03	**0,000**	0	0	68.908	68.908
										11										
	Line from Cab. 1 to Cab .2																			
	$L_{cab1-Cab.2}$	3.800	2//3x1x500	593	0,334	0,380	1,140	0,506	1	**11**	0,11	0	**0,000**	-644.328	0,08	**0,000**	0	0	363.334	363.334
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	**Losses**	$Q_{tot.i}$	DV_i	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	
No.	$L_{(i-1)-i}$	**mts**	**mm²**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 2.1																			
12	L_{4-16}	1.200	1 x 70	200	0,678	0,168	0,180	0,699	1	1	0,02	0	**0,000**	-50.868	0,02	**0,000**	0	0	19.036	19.036
13	$L_{16-Cab.2}$	5.800	1 x 150	306	1,531	0,696	1,160	1,682	1	2	0,04	0	**0,000**	-327.816	0,12	**0,001**	0	0	130.535	130.535
	Circuit Line 2.2																			
14	L_{11-8}	700	1 x 70	200	0,396	0,098	0,105	0,407	1	1	0,02	0	**0,000**	-29.673	0,01	**0,000**	0	0	11.104	11.104
15	L_{8-5}	2.360	1 x 150	306	0,623	0,283	0,472	0,684	1	2	0,04	0	**0,000**	-133.387	0,05	**0,000**	0	0	53.114	53.114
16	L_{5-9}	640	1 x 300	455	0,086	0,072	0,166	0,112	1	3	0,06	0	**0,000**	-47.025	0,01	**0,000**	0	0	21.513	21.513
17	$L_{9-Cab.2}$	240	1 x 300	455	0,032	0,027	0,062	0,042	1	4	0,08	0	**0,000**	-35.268	0,01	**0,000**	0	0	8.067	8.067
	Circuit Line 2.3																			
18	L_{14-6}	650	1 x 70	200	0,367	0,091	0,098	0,378	1	1	0,02	0	**0,000**	-27.553	0,01	**0,000**	0	0	10.311	10.311
19	L_{6-21}	4.700	1 x 150	306	1,241	0,564	0,940	1,363	1	2	0,04	0	**0,000**	-265.644	0,09	**0,000**	0	0	105.778	105.778
20	$L_{21-Cab.2}$	3.550	1 x 150	306	0,937	0,426	0,710	1,029	1	3	0,06	0	**0,000**	-200.646	0,11	**0,001**	0	0	79.896	79.896
										9										
									Circuit line from S/S Utenza to S/S Terna											
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	**Losses**	$Q_{tot.i}$	DV_i	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	$L_{(i-1)-i}$	**mts**	**mm²**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Alt 1		**30 kV cable connection to Terna Substation**																	
MV Line	$L_{SS-Terna}$	18.900	3//3x1x500	593	1,661	1,890	5,670	2,516		**20**	0,14	0	**0,001**	-4.807.026	0,51	**0,003**	2	4	2.710.663	2.710.666
	Alt 2		**150 kV cable connection to Terna Substation**																	
HV Line	$L_{SS-Terna}$	18.900	1 x 400	509	1,890	8,127	2,967	8,344		**20**	0,08	0,04	**0,000**	-20.963.974	0,60	**0,000**	0,11	0,16	1.984.500	**1.984.500**

Wind speed: ≤3 Power Generation: 20 2.988 **Hrs**

Optimisation summary tables

Cable ARE4H1RX - 18/30 kV

Cables & Cable Accessories Summary

	Line	Lenght	Cable size	Drum Nos	Joints	Terminations	Losses - W	VAR	kWh/year	Losses €	Cable cost €	kVAR	Perdite kW	% Perdite	Max. % DV
60	L_{7-1}	530	3x1x70	1		6	0	-22.467	0	0	8.407	- 2.328	0,0	**0,00**	**0,00**
66	L_{19-3}	490	3x1x70	1		6	0	-20.771	0	0	7.773				
72	L_{10-12}	1150	3x1x70	3	6	6	0	-48.748	0	0	18.243	0	110,0	**550,00**	
73	L_{13-12}	490	3x1x70	1		6	0	-20.771	0	0	7.773		0,0	**0,00**	
83	L_{4-16}	1200	3x1x70	3	6	6	0	-50.868	0	0	19.036				
87	L_{11-8}	700	3x1x70	2	3	6	0	-29.673	0	0	11.104	0	39,0	**195,00**	
93	L_{14-6}	650	3x1x70	2	3	6	0	-27.553	0	0	10.311		0,0	**0,00**	
	Total	**5.210**	**3x1x70**	**13**	**18**	**42**	***0***	***-220.852***	***0***	***0***	***82.647***				
61	L_{1-18}	500	3x1x150	2	3	6	0	-28.260	0	0	11.253	- 20.964	0,0	**0,00**	**0,00**
67	L_{3-20}	550	3x1x150	2	3	6	0	-31.086	0	0	12.378				
84	$L_{16-Cab.2}$	5.800	3x1x150	20	57	6	0	-327.816	0	0	130.535				
88	L_{8-5}	2.360	3x1x150	8	21	6	0	-133.387	0	0	53.114	- 23.292	149	**745,00**	**0,00**
94	L_{6-21}	4.700	3x1x150	16	45	6	0	-265.644	0	0	105.778				
95	$L_{21-Cab.2}$	3.550	3x1x150	12	33	6	0	-200.646	0	0	79.896				
	Total	**17.460**	**3x1x150**	**60**	**162**	**36**	***0***	***-986.839***	***0***	***0***	***392.955***				
62	L_{18-2}	1.200	1x300	3		6	0	-29.390	0	0	13.446				
63	$L_{2-Cab.1}$	5.100	1x300	9	6	6	0	-124.909	0	0	57.143				
68	L_{20-17}	2.460	1x300	6	3	6	0	-60.250	0	0	27.563				
69	$L_{17-Cab.1}$	1.170	1x300	1		6	0	-28.656	0	0	13.109				
74	$L_{12-Cab.1}$	6.150	1x300	12	9	6	0	-150.626	0	0	68.908				
89	L_{5-9}	1.920	1x300	3		6	0	-47.025	0	0	21.513				
90	$L_{9-cab.2}$	720	1x300	1		6	0	-35.268	0	0	8.067				
	Total	**16.080**	**3x1x300**	**35**	**18**	**42**	***0***	***-476.124***	***0***	***0***	***209.750***				
77	$L_{cab.1-Cab.2}$	22.800	1x500	36	30	12	***0***	***-644.328***	***0***	***0***	***363.334***				
	Total	**22.800**	**1x500**	**36**	**30**	**12**	**Sub-Total**	***0***	***-2.328.144***	***0***	***0***	***1.048.686***			
Alt.2-150	$L_{SS-Terna}$	**56.700**	**1x400 HV**	**72**	**69**	**6**	***0***	***-20.963.974***	***0***	***0***	***1.984.500***				
							Grand Total Alt.2	**0**	**-23.292.118**	**0**	**1**	**3.033.186**			

					Wind speed:		**4**		Power Generation:			**1.118**			**670**	**Hrs**			
					Basic Design Data								**Unit power**	**Rev. Op. Hours**	**Unit Gen. Energy**	**Total Gen. Energy**			
													kW/unit	**hours**	**MWh**	**MWh**			
											2 x		1,00	2987,87	2,99	59,76			
Operation Hypotesis								**Trafos:**		**2.500**	**50.000**	**[kVA]**	55,90	669,77	37,44	748,80			
													191,50	670,08	128,32	2.566,40			
Cos fi:	**0,95**				sin fi	**0,31**			V_{1n} =	690	30.000	[V]	381,90	677,25	258,64	5.172,84			
Rated Voltage(kV)				**30**					V_{2n} =	30	150	[kV]	631,60	659,28	416,40	8.328,00			
Generation Power (kW)				**55,9**					I_N	48	192	[A]	956,00	611,46	584,56	11.691,20			
Generation hours:				**669,8**	Hrs/year				I	1,13	2,26	[A]	1.350,20	541,85	731,60	14.632,00			
WTG nos.				**20**					V_{cc} =	7,00	12,00	%	1.750,80	460,09	805,52	16.110,40			
Losses coorrection factor: Equivalent operation versus effective one						**1,00**			P_{fe} =	5,50	19,50	kW	2.004,30	380,74	763,12	15.262,40			
Cp = Net Present value of losses: ax'((1+i)^n-1)/((1+i)^n)xi									Pcu	0,0	0,0	kW	2.083,40	303,93	633,20	12.664,00			633.200,00
									P_{cu} =	18,00	141,00	kW	2.098,30	230,89	484,48	9.689,60			484.480,00
where	a =	selling price				**0,126**			P_{tot} =	23,50	160,50		2.101,20	167,45	351,84	7.036,80			351.840,00
	i =	Net present value interest rate				**0,06**			Zn	360,00	450,00	Ohm	2.100,40	116,40	244,48	4.889,60			244.480,00
	n =	number of years for return of investment:				**20**			Z_{t20} =	25,20	54,00	Ohm	2.098,70	77,61	162,88	3.257,60			162.880,00
													2.097,70	49,69	104,24	2.084,80			104.240,00
	Cp =	**1,4452101**		**€/kWh**					R_{t20} =	2,59	1,27	Ohm	2.095,50	30,66	64,24	1.284,80			64.240,00
									X_{t20} =	25,07	53,99	Ohm	2.093,90	18,26	38,24	764,80			38.240,00
Generation factor					**1**				$Q_{cosfi=1}$	96	831	VAR	2.090,90	6,73	14,08	281,60			14.080,00
									Q_{tot}		**3.590**	**VAR**		8660,00	**5.826**	**116.525**			**2.097.680**

					Wind speed:		**4**		Power Generation:			**1.118**			**670**	**Hrs**			
					M.V. branches parameters calculation														
	Circuit Line 1 and 2																		
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	**Losses**	$Q_{tot.i}$	DV_i	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	$L_{(i-1)-i}$	**mts**	**mm²**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 1.1																			
1	L_{7-1}	530	1 x 70	200	0,299	0,074	0,080	0,309	56	56	1,13	1	**0,002**	-22.466	0,60	**0,003**	1	1	8.407	8.409
2	L_{1-18}	500	1 x 150	306	0,132	0,060	0,100	0,145	56	112	2,26	2	**0,002**	-28.259	0,56	**0,003**	1	2	11.253	11.255
3	L_{18-2}	400	1 x 300	455	0,054	0,045	0,104	0,070	56	168	3,40	2	**0,001**	-29.389	0,38	**0,002**	1	2	13.446	13.447
4	$L_{2-Cab.1}$	1.700	1 x 300	455	0,228	0,192	0,442	0,298	56	224	4,53	14	**0,006**	-124.897	2,16	**0,011**	9	14	57.143	57.157
	Circuit Line 1.2																			
5	L_{19-3}	490	1 x 70	200	0,277	0,069	0,074	0,285	56	56	1,13	1	**0,002**	-20.771	0,56	**0,003**	1	1	7.773	7.774
6	L_{3-20}	550	1 x 150	306	0,145	0,066	0,110	0,159	56	112	2,26	2	**0,002**	-31.085	0,62	**0,003**	1	2	12.378	12.380
7	L_{20-17}	820	1 x 300	455	0,110	0,093	0,213	0,144	56	168	3,40	4	**0,002**	-60.247	0,78	**0,004**	3	4	27.563	27.567
8	$L_{17-Cab.1}$	390	1 x 300	455	0,052	0,044	0,101	0,068	56	224	4,53	3	**0,001**	-28.653	0,50	**0,002**	2	3	13.109	13.112
	Circuit Line 1.3																			
9	L_{10-12}	1.150	1 x 70	200	0,650	0,161	0,173	0,669	56	56	1,13	2	**0,004**	-48.748	1,31	**0,007**	2	2	18.243	18.245
10	L_{13-12}	490	1 x 70	200	0,277	0,069	0,074	0,285	56	56	1,13	1	**0,002**	-20.771	0,56	**0,003**	1	1	7.773	7.774
11	$L_{12-Cab.1}$	2.050	1 x 300	455	0,275	0,232	0,533	0,359	56	168	3,40	10	**0,006**	-150.618	1,96	**0,010**	6	9	68.908	68.917
										615										
	Line from Cab. 1 to Cab .2																			
	$L_{cab1-Cab.2}$	3.800	2//3x1x500	593	0,334	0,380	1,140	0,506	56	**615**	6,23	78	**0,013**	-644.240	4,69	**0,023**	104	151	363.334	363.484
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	**Losses**	$Q_{tot.i}$	DV_i	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	
No.	$L_{(i-1)-i}$	**mts**	**mm²**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 2.1																			
12	L_{4-16}	1.200	1 x 70	200	0,678	0,168	0,180	0,699	56	56	1,13	3	**0,005**	-50.867	1,36	**0,007**	2	3	19.036	19.038
13	$L_{16-Cab.2}$	5.800	1 x 150	306	1,531	0,696	1,160	1,682	56	112	2,26	24	**0,021**	-327.805	6,54	**0,033**	16	23	130.535	130.558
	Circuit Line 2.2																			
14	L_{11-8}	700	1 x 70	200	0,396	0,098	0,105	0,407	56	56	1,13	2	**0,003**	-29.673	0,80	**0,004**	1	1	11.104	11.106
15	L_{8-5}	2.360	1 x 150	306	0,623	0,283	0,472	0,684	56	112	2,26	10	**0,009**	-133.383	2,66	**0,013**	6	9	53.114	53.123
16	L_{5-9}	640	1 x 300	455	0,086	0,072	0,166	0,112	56	168	3,40	3	**0,002**	-47.022	0,61	**0,003**	2	3	21.513	21.516
17	$L_{9-Cab.2}$	240	1 x 300	455	0,032	0,027	0,062	0,042	56	224	4,53	2	**0,001**	-35.265	0,31	**0,002**	1	2	8.067	8.069
	Circuit Line 2.3																			
18	L_{14-6}	650	1 x 70	200	0,367	0,091	0,098	0,378	56	56	1,13	1	**0,003**	-27.553	0,74	**0,004**	1	1	10.311	10.312
19	L_{6-21}	4.700	1 x 150	306	1,241	0,564	0,940	1,363	56	112	2,26	19	**0,017**	-265.635	5,30	**0,027**	13	18	105.778	105.797
20	$L_{21-Cab.2}$	3.550	1 x 150	306	0,937	0,426	0,710	1,029	56	168	3,40	32	**0,019**	-200.631	6,01	**0,030**	22	31	79.896	79.928
										503										
									Circuit line from S/S Utenza to S/S Terna										
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	**Losses**	$Q_{tot.i}$	DV_i	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	$L_{(i-1)-i}$	**mts**	**mm²**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Alt 1		**30 kV cable connection to Terna Substation**																	
MV Line	$L_{SS-Terna}$	18.900	3//3x1x500	593	1,661	1,890	5,670	2,516		**1.118**	7,55	852	**0,076**	-4.806.057	28,27	**0,141**	1.712	2.475	2.710.663	2.713.137
	Alt 2		**150 kV cable connection to Terna Substation**																	

					Wind speed:			4		Power Generation:			1.118			670	Hrs			
HV Line	$L_{SS\text{-}Terna}$	18.900	1 x 400	509	1,890	8,127	2,967	8,344		**1.118**	4,53	116,34	**0,010**	-20.962.974	33,82	**0,023**	77,92	112,61	1.984.500	**1.984.613**
										Optimisation summary tables										
	Cable ARE4H1RX - 18/30 kV																			
	Cables & Cable Accessories Summary								**Losses - W**	**VAR**	**kWh/year**	**Losses €**	**Cable cost €**	**kVAR**	**Perdite kW**	**% Perdite**	**Max. % DV**			
	Line	**Lenght**	**Cable size**	**Drum Nos**	**Joints**	**Terminations**														
60	$L_{7\text{-}1}$	530	3x1x70	1		6			1	-22.466	1	1	8.407	- 2.328	0,2	**0,02**	**0,03**			
66	$L_{19\text{-}3}$	490	3x1x70	1		6			1	-20.771	1	1	7.773							
72	$L_{10\text{-}12}$	1150	3x1x70	3	6	6			2	-48.748	2	2	18.243	2	110,0	**9,84**				
73	$L_{13\text{-}12}$	490	3x1x70	1		6			1	-20.771	1	1	7.773		0,2	**0,02**				
83	$L_{4\text{-}16}$	1200	3x1x70	3	6	6			3	-50.867	2	3	19.036							
87	$L_{11\text{-}8}$	700	3x1x70	2	3	6			2	-29.673	1	1	11.104	2	39,0	**3,49**				
93	$L_{14\text{-}6}$	650	3x1x70	2	3	6			1	-27.553	1	1	10.311		0,0	**0,00**				
	Total	**5.210**	**3x1x70**	**13**	**18**	**42**			***11***	***-220.849***	***8***	***11***	***82.647***							
61	$L_{1\text{-}18}$	500	3x1x150	2	3	6			2	-28.259	1	2	11.253	- 20.963	0,1	**0,01**	**0,02**			
67	$L_{3\text{-}20}$	550	3x1x150	2	3	6			2	-31.085	1	2	12.378							
84	$L_{16\text{-}Cab.2}$	5.800	3x1x150	20	57	6			24	-327.805	16	23	130.535							
88	$L_{8\text{-}5}$	2.360	3x1x150	8	21	6			10	-133.383	6	9	53.114	- 23.287	150	**13,38**	**0,03**			
94	$L_{6\text{-}21}$	4.700	3x1x150	16	45	6			19	-265.635	13	18	105.778							
95	$L_{21\text{-}Cab.2}$	3.550	3x1x150	12	33	6			32	-200.631	22	31	79.896							
	Total	**17.460**	**3x1x150**	**60**	**162**	**36**			***89***	***-986.799***	***60***	***86***	***392.955***							
62	$L_{18\text{-}2}$	1.200	1x300	3		6			2	-29.389	1	2	13.446							
63	$L_{2\text{-}Cab.1}$	5.100	1x300	9	6	6			14	-124.897	9	14	57.143							
68	$L_{20\text{-}17}$	2.460	1x300	6	3	6			4	-60.247	3	4	27.563							
69	$L_{17\text{-}Cab.1}$	1.170	1x300	1		6			3	-28.653	2	3	13.109							
74	$L_{12\text{-}Cab.1}$	6.150	1x300	12	9	6			10	-150.618	6	9	68.908							
89	$L_{5\text{-}9}$	1.920	1x300	3		6			3	-47.022	2	3	21.513							
90	$L_{9\text{-}cab.2}$	720	1x300	1		6			2	-35.265	1	2	8.067							
	Total	**16.080**	**3x1x300**	**35**	**18**	**42**			***37***	***-476.091***	***25***	***36***	***209.750***							
77	$L_{cab.1\text{-}Cab.2}$	22.800	1x500	36	30	12			***78***	***-644.240***	***104***	***151***	***363.334***							
	Total	**22.800**	**1x500**	**36**	**30**	**12**	**Sub-Total**		***215***	***-2.327.979***	***196***	***284***	***1.048.686***							
Alt.2-150	$L_{SS\text{-}Terna}$	**56.700**	**1x400 HV**	**72**	**69**	**6**			***116***	***-20.962.974***	***78***	***113***	***1.984.500***							
							Grand Total Alt.2		**332**	**-23.290.953**	**274**	**396**	**3.033.186**							

					Wind speed:		**5**		Power Generation:			**3.830**				**670**	**Hrs**				
					Basic Design Data										**Unit power**	**Rev. Op. Hours**	**Unit Gen. Energy**	**Total Gen. Energy**			
															kW/unit	**hours**	**MWh**	**MWh**			
											2 x				1,00	2987,87	2,99	59,76			
Operation Hypotesis								**Trafos:**		**2.500**	**50.000**	**[kVA]**			55,90	669,77	37,44	748,80			
															191,50	670,08	128,32	2.566,40			
Cos fi:	**0,95**				sin fi	**0,31**			V_{1n} =	690	30.000	[V]			381,90	677,25	258,64	5.172,84			
Rated Voltage(kV)				**30**					V_{2n} =	30	150	[kV]			631,60	659,28	416,40	8.328,00			
Generation Power (kW)				**191,5**					I_N	48	192	[A]			956,00	611,46	584,56	11.691,20			
Generation hours:				**670,1**	Hrs/year				I	3,88	7,76	[A]			1.350,20	541,85	731,60	14.632,00			
WTG nos.				**20**					V_{cc} =	7,00	12,00	%			1.750,80	460,09	805,52	16.110,40			
Losses coorrection factor: Equivalent operation versus effective one						**1,00**			P_{fe} =	5,50	19,50	kW			2.004,30	380,74	763,12	15.262,40			
Cp = Net Present value of losses: ax'((1+i)^n-1)/((1+i)^n)xi									Pcu	0,1	0,2	kW			2.083,40	303,93	633,20	12.664,00			633.200,00
									P_{cu} =	18,00	141,00	kW			2.098,30	230,89	484,48	9.689,60			484.480,00
where	a =	selling price				**0,126**			P_{tot} =	23,50	160,50				2.101,20	167,45	351,84	7.036,80			351.840,00
	i =	Net present value interest rate				**0,06**			Zn	360,00	450,00	Ohm			2.100,40	116,40	244,48	4.889,60			244.480,00
	n =	number of years for return of investment:				**20**			Z_{t20} =	25,20	54,00	Ohm			2.098,70	77,61	162,88	3.257,60			162.880,00
															2.097,70	49,69	104,24	2.084,80			104.240,00
	Cp =	**1,4452101**		**€/kWh**					R_{t20} =	2,59	1,27	Ohm			2.095,50	30,66	64,24	1.284,80			64.240,00
									X_{t20} =	25,07	53,99	Ohm			2.093,90	18,26	38,24	764,80			38.240,00
Generation factor					**1**				$Q_{cosfi=1}$	1.132	9.749	VAR			2.090,90	6,73	14,08	281,60			14.080,00
									Q_{tot}		**42.133**	**VAR**				8660,00	**5.826**	**116.525**			**2.097.680**

					Wind speed:		**5**		Power Generation:			**3.830**			**670**	**Hrs**			
					M.V. branches parameters calculation														
	Circuit Line 1 and 2																		
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**Capac.$_{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 1.1																			
1	L_{7-1}	530	1 x 70	200	0,299	0,074	0,080	0,309	192	192	3,88	14	**0,007**	-22.463	2,06	**0,010**	9	13	8.407	8.421
2	L_{1-18}	500	1 x 150	306	0,132	0,060	0,100	0,145	192	383	7,76	24	**0,006**	-28.249	1,93	**0,010**	16	23	11.253	11.276
3	L_{18-2}	400	1 x 300	455	0,054	0,045	0,104	0,070	192	575	11,64	22	**0,004**	-29.372	1,31	**0,007**	15	21	13.446	13.467
4	$L_{2-Cab.1}$	1.700	1 x 300	455	0,228	0,192	0,442	0,298	192	766	15,52	165	**0,021**	-124.770	7,41	**0,037**	110	159	57.143	57.303
	Circuit Line 1.2																			
5	L_{19-3}	490	1 x 70	200	0,277	0,069	0,074	0,285	192	192	3,88	12	**0,007**	-20.768	1,91	**0,010**	8	12	7.773	7.785
6	L_{3-20}	550	1 x 150	306	0,145	0,066	0,110	0,159	192	383	7,76	26	**0,007**	-31.074	2,13	**0,011**	18	25	12.378	12.404
7	L_{20-17}	820	1 x 300	455	0,110	0,093	0,213	0,144	192	575	11,64	45	**0,008**	-60.213	2,68	**0,013**	30	43	27.563	27.607
8	$L_{17-Cab.1}$	390	1 x 300	455	0,052	0,044	0,101	0,068	192	766	15,52	38	**0,005**	-28.624	1,70	**0,008**	25	37	13.109	13.146
	Circuit Line 1.3																			
9	L_{10-12}	1.150	1 x 70	200	0,650	0,161	0,173	0,669	192	192	3,88	29	**0,015**	-48.741	4,48	**0,022**	20	28	18.243	18.271
10	L_{13-12}	490	1 x 70	200	0,277	0,069	0,074	0,285	192	192	3,88	12	**0,007**	-20.768	1,91	**0,010**	8	12	7.773	7.785
11	$L_{12-Cab.1}$	2.050	1 x 300	455	0,275	0,232	0,533	0,359	192	575	11,64	112	**0,019**	-150.532	6,70	**0,034**	75	108	68.908	69.016
										2.107										
	Line from Cab. 1 to Cab .2																			
	$L_{cab1-Cab.2}$	3.800	2//3x1x500	593	0,334	0,380	1,140	0,506	192	**2.107**	21,34	912	**0,043**	-643.290	16,06	**0,080**	1.223	1.767	363.334	365.101
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**Capac.$_{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 2.1																			
12	L_{4-16}	1.200	1 x 70	200	0,678	0,168	0,180	0,699	192	192	3,88	31	**0,016**	-50.860	4,67	**0,023**	21	30	19.036	19.065
13	$L_{16-Cab.2}$	5.800	1 x 150	306	1,531	0,696	1,160	1,682	192	383	7,76	277	**0,072**	-327.690	22,42	**0,112**	185	268	130.535	130.803
	Circuit Line 2.2																			
14	L_{11-8}	700	1 x 70	200	0,396	0,098	0,105	0,407	192	192	3,88	18	**0,009**	-29.669	2,73	**0,014**	12	17	11.104	11.121
15	L_{8-5}	2.360	1 x 150	306	0,623	0,283	0,472	0,684	192	383	7,76	113	**0,029**	-133.336	9,12	**0,046**	75	109	53.114	53.223
16	L_{5-9}	640	1 x 300	455	0,086	0,072	0,166	0,112	192	575	11,64	35	**0,006**	-46.995	2,09	**0,010**	23	34	21.513	21.547
17	$L_{9-Cab.2}$	240	1 x 300	455	0,032	0,027	0,062	0,042	192	766	15,52	23	**0,003**	-35.229	1,05	**0,005**	16	22	8.067	8.090
	Circuit Line 2.3																			
18	L_{14-6}	650	1 x 70	200	0,367	0,091	0,098	0,378	192	192	3,88	17	**0,009**	-27.549	2,53	**0,013**	11	16	10.311	10.327
19	L_{6-21}	4.700	1 x 150	306	1,241	0,564	0,940	1,363	192	383	7,76	224	**0,059**	-265.542	18,17	**0,091**	150	217	105.778	105.995
20	$L_{21-Cab.2}$	3.550	1 x 150	306	0,937	0,426	0,710	1,029	192	575	11,64	381	**0,066**	-200.473	20,59	**0,103**	255	369	79.896	80.265
										1.724										
									Circuit line from S/S Utenza to S/S Terna										
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**Capac.$_{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Alt 1		**30 kV cable connection to Terna Substation**																	
MV Line	$L_{SS-Terna}$	18.900	3//3x1x500	593	1,661	1,890	5,670	2,516		**3.830**	25,86	10.001	**0,261**	-4.795.648	96,85	**0,484**	20.104	29.055	2.710.663	2.739.717
	Alt 2		**150 kV cable connection to Terna Substation**																	

					Wind speed:			**5**		Power Generation:			**3.830**				**670**	**Hrs**			
HV Line	$L_{SS\text{-}Terna}$	18.900	1 x 400	509	1,890	8,127	2,967	8,344		**3.830**	15,52	1.365,30	**0,036**	-20.952.233	115,88	**0,077**	914,86	1.322,17	1.984.500	**1.985.822**
										Optimisation summary tables										
	Cable ARE4H1RX - 18/30 kV																			
	Cables & Cable Accessories Summary								**Losses - W**	**VAR**	**kWh/year**	**Losses €**	**Cable cost €**	**kVAR**	**Perdite kW**	**% Perdite**	**Max. % DV**			
	Line	**Lenght**	**Cable size**	**Drum Nos**	**Joints**	**Terminations**														
60	$L_{7\text{-}1}$	530	3x1x70	1		6			14	-22.463	9	13	8.407	- 2.326	2,5	**0,07**	**0,11**			
66	$L_{19\text{-}3}$	490	3x1x70	1		6			12	-20.768	8	12	7.773							
72	$L_{10\text{-}12}$	1150	3x1x70	3	6	6			29	-48.741	20	28	18.243	23	110,0	**2,87**				
73	$L_{13\text{-}12}$	490	3x1x70	1		6			12	-20.768	8	12	7.773		2,3	**0,06**				
83	$L_{4\text{-}16}$	1200	3x1x70	3	6	6			31	-50.860	21	30	19.036							
87	$L_{11\text{-}8}$	700	3x1x70	2	3	6			18	-29.669	12	17	11.104	19	39,0	**1,02**				
93	$L_{14\text{-}6}$	650	3x1x70	2	3	6			17	-27.549	11	16	10.311		0,5	**0,01**				
	Total	**5.210**	**3x1x70**	**13**	**18**	**42**			***133***	***-220.819***	***89***	***129***	***82.647***							
61	$L_{1\text{-}18}$	500	3x1x150	2	3	6			24	-28.249	16	23	11.253	- 20.952	1,4	**0,04**	**0,08**			
67	$L_{3\text{-}20}$	550	3x1x150	2	3	6			26	-31.074	18	25	12.378							
84	$L_{16\text{-}Cab.2}$	5.800	3x1x150	20	57	6			277	-327.690	185	268	130.535							
88	$L_{8\text{-}5}$	2.360	3x1x150	8	21	6			113	-133.336	75	109	53.114	- 23.236	156	**4,07**	**0,11**			
94	$L_{6\text{-}21}$	4.700	3x1x150	16	45	6			224	-265.542	150	217	105.778							
95	$L_{21\text{-}Cab.2}$	3.550	3x1x150	12	33	6			381	-200.473	255	369	79.896							
	Total	**17.460**	**3x1x150**	**60**	**162**	**36**			***1.044***	***-986.365***	***700***	***1.011***	***392.955***							
62	$L_{18\text{-}2}$	1.200	1x300	3		6			22	-29.372	15	21	13.446							
63	$L_{2\text{-}Cab.1}$	5.100	1x300	9	6	6			165	-124.770	110	159	57.143							
68	$L_{20\text{-}17}$	2.460	1x300	6	3	6			45	-60.213	30	43	27.563							
69	$L_{17\text{-}Cab.1}$	1.170	1x300	1		6			38	-28.624	25	37	13.109							
74	$L_{12\text{-}Cab.1}$	6.150	1x300	12	9	6			112	-150.532	75	108	68.908							
89	$L_{5\text{-}9}$	1.920	1x300	3		6			35	-46.995	23	34	21.513							
90	$L_{9\text{-}cab.2}$	720	1x300	1		6			23	-35.229	16	22	8.067							
	Total	**16.080**	**3x1x300**	**35**	**18**	**42**			***438***	***-475.735***	***294***	***425***	***209.750***							
77	$L_{cab.1\text{-}Cab.2}$	22.800	1x500	36	30	12			***912***	***-643.290***	***1.223***	***1.767***	***363.334***							
	Total	**22.800**	**1x500**	**36**	**30**	**12**	**Sub-Total**		***2.528***	***-2.326.209***	***2.305***	***3.331***	***1.048.686***							
Alt.2-150	$L_{SS\text{-}Terna}$	**56.700**	**1x400 HV**	**72**	**69**	**6**			***1.365***	***-20.952.233***	***915***	***1.322***	***1.984.500***							
							Grand Total Alt.2		**3.893**	**-23.278.442**	**3.220**	**4.654**	**3.033.186**							

					Wind speed:		**6**		Power Generation:			**7.638**				**677**	**Hrs**			
					Basic Design Data															
													Unit power	**Rev. Op. Hours**	**Unit Gen. Energy**	**Total Gen. Energy**				
													kW/unit	**hours**	**MWh**	**MWh**				
											2 x		1,00	2987,87	2,99	59,76				
Operation Hypotesis								**Trafos:**		**2.500**	**50.000**	**[kVA]**	55,90	669,77	37,44	748,80				
													191,50	670,08	128,32	2.566,40				
Cos fi:	**0,95**				sin fi	**0,31**			V_{1n} =	690	30.000	[V]	381,90	677,25	258,64	5.172,84				
Rated Voltage(kV)				**30**					V_{2n} =	30	150	[kV]	631,60	659,28	416,40	8.328,00				
Generation Power (kW)				**381,9**					I_N	48	192	[A]	956,00	611,46	584,56	11.691,20				
Generation hours:				**677,3**	Hrs/year				I	7,74	15,47	[A]	1.350,20	541,85	731,60	14.632,00				
WTG nos.				**20**					V_{cc} =	7,00	12,00	%	1.750,80	460,09	805,52	16.110,40				
Losses coorrection factor: Equivalent operation versus effective one						**1,00**			P_{fe} =	5,50	19,50	kW	2.004,30	380,74	763,12	15.262,40				
Cp = Net Present value of losses: ax'((1+i)^n-1)/((1+i)^n)xi									Pcu	0,5	0,9	kW	2.083,40	303,93	633,20	12.664,00				633.200,00
									P_{cu} =	18,00	141,00	kW	2.098,30	230,89	484,48	9.689,60				484.480,00
where	a =	selling price				**0,126**			P_{tot} =	23,50	160,50		2.101,20	167,45	351,84	7.036,80				351.840,00
	i =	Net present value interest rate				**0,06**			Zn	360,00	450,00	Ohm	2.100,40	116,40	244,48	4.889,60				244.480,00
	n =	number of years for return of investment:				**20**			Z_{t20} =	25,20	54,00	Ohm	2.098,70	77,61	162,88	3.257,60				162.880,00
													2.097,70	49,69	104,24	2.084,80				104.240,00
	Cp =	**1,4452101**		**€/kWh**					R_{t20} =	2,59	1,27	Ohm	2.095,50	30,66	64,24	1.284,80				64.240,00
									X_{t20} =	25,07	53,99	Ohm	2.093,90	18,26	38,24	764,80				38.240,00
Generation factor					**1**				$Q_{cosfi=1}$	4.501	38.774	VAR	2.090,90	6,73	14,08	281,60				14.080,00
									Q_{tot}		**167.567**	**VAR**		8660,00	**5.826**	**116.525**				**2.097.680**

					Wind speed:		**6**		Power Generation:			**7.638**				**677**	**Hrs**			
					M.V. branches parameters calculation															
	Circuit Line 1 and 2																			
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**Capac.$_{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 1.1																			
1	L_{7-1}	530	1 x 70	200	0,299	0,074	0,080	0,309	382	382	7,74	54	**0,014**	-22.453	4,12	**0,021**	36	53	8.407	8.460
2	L_{1-18}	500	1 x 150	306	0,132	0,060	0,100	0,145	382	764	15,47	95	**0,012**	-28.217	3,85	**0,019**	64	93	11.253	11.346
3	L_{18-2}	400	1 x 300	455	0,054	0,045	0,104	0,070	382	1.146	23,21	87	**0,008**	-29.317	2,61	**0,013**	59	85	13.446	13.530
4	$L_{2-Cab.1}$	1.700	1 x 300	455	0,228	0,192	0,442	0,298	382	1.528	30,95	654	**0,043**	-124.357	14,77	**0,074**	443	641	57.143	57.784
	Circuit Line 1.2																			
5	L_{19-3}	490	1 x 70	200	0,277	0,069	0,074	0,285	382	382	7,74	50	**0,013**	-20.759	3,80	**0,019**	34	49	7.773	7.822
6	L_{3-20}	550	1 x 150	306	0,145	0,066	0,110	0,159	382	764	15,47	104	**0,014**	-31.039	4,24	**0,021**	71	102	12.378	12.480
7	L_{20-17}	820	1 x 300	455	0,110	0,093	0,213	0,144	382	1.146	23,21	178	**0,015**	-60.101	5,34	**0,027**	120	174	27.563	27.737
8	$L_{17-Cab.1}$	390	1 x 300	455	0,052	0,044	0,101	0,068	382	1.528	30,95	150	**0,010**	-28.529	3,39	**0,017**	102	147	13.109	13.256
	Circuit Line 1.3																			
9	L_{10-12}	1.150	1 x 70	200	0,650	0,161	0,173	0,669	382	382	7,74	117	**0,031**	-48.720	8,93	**0,045**	79	114	18.243	18.357
10	L_{13-12}	490	1 x 70	200	0,277	0,069	0,074	0,285	382	382	7,74	50	**0,013**	-20.759	3,80	**0,019**	34	49	7.773	7.822
11	$L_{12-Cab.1}$	2.050	1 x 300	455	0,275	0,232	0,533	0,359	382	1.146	23,21	444	**0,039**	-150.251	13,36	**0,067**	301	435	68.908	69.343
										4.201										
	Line from Cab. 1 to Cab .2																			
	$L_{cab1-Cab.2}$	3.800	2//3x1x500	593	0,334	0,380	1,140	0,506	382	**4.201**	42,55	3.629	**0,086**	-640.200	32,03	**0,160**	4.915	7.103	363.334	370.437
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**Capac.$_{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 2.1																			
12	L_{4-16}	1.200	1 x 70	200	0,678	0,168	0,180	0,699	382	382	7,74	122	**0,032**	-50.838	9,32	**0,047**	82	119	19.036	19.155
13	$L_{16-Cab.2}$	5.800	1 x 150	306	1,531	0,696	1,160	1,682	382	764	15,47	1.100	**0,144**	-327.316	44,71	**0,224**	745	1.076	130.535	131.611
	Circuit Line 2.2																			
14	L_{11-8}	700	1 x 70	200	0,396	0,098	0,105	0,407	382	382	7,74	71	**0,019**	-29.655	5,44	**0,027**	48	70	11.104	11.174
15	L_{8-5}	2.360	1 x 150	306	0,623	0,283	0,472	0,684	382	764	15,47	447	**0,059**	-133.184	18,19	**0,091**	303	438	53.114	53.552
16	L_{5-9}	640	1 x 300	455	0,086	0,072	0,166	0,112	382	1.146	23,21	139	**0,012**	-46.908	4,17	**0,021**	94	136	21.513	21.648
17	$L_{9-Cab.2}$	240	1 x 300	455	0,032	0,027	0,062	0,042	382	1.528	30,95	92	**0,006**	-35.113	2,09	**0,010**	63	90	8.067	8.158
	Circuit Line 2.3																			
18	L_{14-6}	650	1 x 70	200	0,367	0,091	0,098	0,378	382	382	7,74	66	**0,017**	-27.537	5,05	**0,025**	45	65	10.311	10.376
19	L_{6-21}	4.700	1 x 150	306	1,241	0,564	0,940	1,363	382	764	15,47	891	**0,117**	-265.239	36,23	**0,181**	604	872	105.778	106.650
20	$L_{21-Cab.2}$	3.550	1 x 150	306	0,937	0,426	0,710	1,029	382	1.146	23,21	1.515	**0,132**	-199.958	41,05	**0,205**	1.026	1.482	79.896	81.379
										3.437										
									Circuit line from S/S Utenza to S/S Terna										
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**Capac.$_{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Alt 1		**30 kV cable connection to Terna Substation**																	
MV Line	$L_{SS-Terna}$	18.900	3//3x1x500	593	1,661	1,890	5,670	2,516		**7.638**	51,58	39.774	**0,521**	-4.761.777	193,17	**0,966**	80.811	116.789	2.710.663	2.827.451
	Alt 2		**150 kV cable connection to Terna Substation**																	

					Wind speed:			**6**		Power Generation:			**7.638**			**677**	**Hrs**			
HV Line	$L_{SS\text{-}Terna}$	18.900	1 x 400	509	1,890	8,127	2,967	8,344		**7.638**	30,95	5.429,89	**0,071**	-20.917.277	231,17	**0,154**	3.677,40	5.314,61	1.984.500	**1.989.815**
										Optimisation summary tables										
	Cable ARE4H1RX - 18/30 kV																			
	Cables & Cable Accessories Summary									**Losses - W**	**VAR**	**kWh/year**	**Losses €**	**Cable cost €**	**kVAR**	**Perdite kW**	**% Perdite**	**Max. % DV**		
	Line	**Lenght**	**Cable size**	**Drum Nos**	**Joints**	**Terminations**														
60	$L_{7\text{-}1}$	530	3x1x70	1		6				54	-22.453	36	53	8.407	- 2.320	10,1	**0,13**	**0,22**		
66	$L_{19\text{-}3}$	490	3x1x70	1		6				50	-20.759	34	49	7.773						
72	$L_{10\text{-}12}$	1150	3x1x70	3	6	6				117	-48.720	79	114	18.243	90	110,0	**1,44**			
73	$L_{13\text{-}12}$	490	3x1x70	1		6				50	-20.759	34	49	7.773		9,3	**0,12**			
83	$L_{4\text{-}16}$	1200	3x1x70	3	6	6				122	-50.838	82	119	19.036						
87	$L_{11\text{-}8}$	700	3x1x70	2	3	6				71	-29.655	48	70	11.104	78	39,0	**0,51**			
93	$L_{14\text{-}6}$	650	3x1x70	2	3	6				66	-27.537	45	65	10.311		1,8	**0,02**			
	Total	**5.210**	**3x1x70**	**13**	**18**	**42**				***529***	***-220.721***	***358***	***517***	***82.647***						
61	$L_{1\text{-}18}$	500	3x1x150	2	3	6				95	-28.217	64	93	11.253	- 20.917	5,4	**0,07**	**0,15**		
67	$L_{3\text{-}20}$	550	3x1x150	2	3	6				104	-31.039	71	102	12.378						
84	$L_{16\text{-}Cab.2}$	5.800	3x1x150	20	57	6				1.100	-327.316	745	1.076	130.535						
88	$L_{8\text{-}5}$	2.360	3x1x150	8	21	6				447	-133.184	303	438	53.114	- 23.070	176	**2,30**	**0,22**		
94	$L_{6\text{-}21}$	4.700	3x1x150	16	45	6				891	-265.239	604	872	105.778						
95	$L_{21\text{-}Cab.2}$	3.550	3x1x150	12	33	6				1.515	-199.958	1.026	1.482	79.896						
	Total	**17.460**	**3x1x150**	**60**	**162**	**36**				***4.152***	***-984.952***	***2.812***	***4.064***	***392.955***						
62	$L_{18\text{-}2}$	1.200	1x300	3		6				87	-29.317	59	85	13.446						
63	$L_{2\text{-}Cab.1}$	5.100	1x300	9	6	6				654	-124.357	443	641	57.143						
68	$L_{20\text{-}17}$	2.460	1x300	6	3	6				178	-60.101	120	174	27.563						
69	$L_{17\text{-}Cab.1}$	1.170	1x300	1		6				150	-28.529	102	147	13.109						
74	$L_{12\text{-}Cab.1}$	6.150	1x300	12	9	6				444	-150.251	301	435	68.908						
89	$L_{5\text{-}9}$	1.920	1x300	3		6				139	-46.908	94	136	21.513						
90	$L_{9\text{-}cab.2}$	720	1x300	1		6				92	-35.113	63	90	8.067						
	Total	**16.080**	**3x1x300**	**35**	**18**	**42**				***1.744***	***-474.576***	***1.181***	***1.707***	***209.750***						
77	$L_{cab.1\text{-}Cab.2}$	22.800	1x500	36	30	12				***3.629***	***-640.200***	***4.915***	***7.103***	***363.334***						
	Total	**22.800**	**1x500**	**36**	**30**	**12**	**Sub-Total**			***10.053***	***-2.320.449***	***9.266***	***13.391***	***1.048.686***						
Alt.2-150	$L_{SS\text{-}Terna}$	**56.700**	**1x400 HV**	**72**	**69**	**6**				***5.430***	***-20.917.277***	***3.677***	***5.315***	***1.984.500***						
							Grand Total Alt.2			**15.483**	**-23.237.726**	**12.943**	**18.706**	**3.033.186**						

					Wind speed:			**7**		Power Generation:			**12.632**			**659**	**Hrs**			
					Basic Design Data									**Unit power**	**Rev. Op. Hours**	**Unit Gen. Energy**	**Total Gen. Energy**			
														kW/unit	**hours**	**MWh**	**MWh**			
											2 x			1,00	2987,87	2,99	59,76			
Operation Hypotesis								**Trafos:**		**2.500**	**50.000**	**[kVA]**		55,90	669,77	37,44	748,80			
														191,50	670,08	128,32	2.566,40			
Cos fi:	**0,95**				sin fi	**0,31**			V_{1n} =	690	30.000	[V]		381,90	677,25	258,64	5.172,84			
Rated Voltage(kV)				**30**					V_{2n} =	30	150	[kV]		631,60	659,28	416,40	8.328,00			
Generation Power (kW)				**631,6**					I_N	48	192	[A]		956,00	611,46	584,56	11.691,20			
Generation hours:				**659,3**	Hrs/year				I	12,79	25,59	[A]		1.350,20	541,85	731,60	14.632,00			
WTG nos.				**20**					V_{cc} =	7,00	12,00	%		1.750,80	460,09	805,52	16.110,40			
Losses coorrection factor: Equivalent operation versus effective one						**1,00**			P_{fe} =	5,50	19,50	kW		2.004,30	380,74	763,12	15.262,40			
Cp = Net Present value of losses: ax'((1+i)^n-1)/((1+i)^n)xi									Pcu	1,3	2,5	kW		2.083,40	303,93	633,20	12.664,00			633.200,00
									P_{cu} =	18,00	141,00	kW		2.098,30	230,89	484,48	9.689,60			484.480,00
where	a =	selling price				**0,126**			P_{tot} =	23,50	160,50			2.101,20	167,45	351,84	7.036,80			351.840,00
	i =	Net present value interest rate				**0,06**			Zn	360,00	450,00	Ohm		2.100,40	116,40	244,48	4.889,60			244.480,00
	n =	number of years for return of investment:				**20**			Z_{t20} =	25,20	54,00	Ohm		2.098,70	77,61	162,88	3.257,60			162.880,00
														2.097,70	49,69	104,24	2.084,80			104.240,00
	Cp =	**1,4452101**		**€/kWh**					R_{t20} =	2,59	1,27	Ohm		2.095,50	30,66	64,24	1.284,80			64.240,00
									X_{t20} =	25,07	53,99	Ohm		2.093,90	18,26	38,24	764,80			38.240,00
Generation factor					**1**				$Q_{cosfi=1}$	12.311	106.054	VAR		2.090,90	6,73	14,08	281,60			14.080,00
									Q_{tot}		**458.324**	**VAR**			8660,00	**5.826**	**116.525**			**2.097.680**

					Wind speed:		7		Power Generation:			12.632			659	Hrs			
					M.V. branches parameters calculation														
	Circuit Line 1 and 2																		
Node	Param.	Lenght	Cable Al	R.c.c.	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	Losses	$Q_{tot.i}$	DV_i	Dvi%	En. Lost	Losses Cost	Cable Cost	Total Cost
No.	$L_{(i-1)-i}$	mts	mm^2	A	ohm	ohm	microF	ohm	kW	kW	A	W	%	VAR	V		kWh/year	€	€	
	Circuit Line 1.1																			
1	L_{7-1}	530	1 x 70	200	0,299	0,074	0,080	0,309	632	632	12,79	147	**0,023**	-22.430	6,81	**0,034**	97	140	8.407	8.548
2	L_{1-18}	500	1 x 150	306	0,132	0,060	0,100	0,145	632	1.263	25,59	259	**0,021**	-28.142	6,37	**0,032**	171	247	11.253	11.500
3	L_{18-2}	400	1 x 300	455	0,054	0,045	0,104	0,070	632	1.895	38,38	237	**0,013**	-29.191	4,31	**0,022**	156	226	13.446	13.671
4	$L_{2-Cab.1}$	1.700	1 x 300	455	0,228	0,192	0,442	0,298	632	2.526	51,18	1.790	**0,071**	-123.400	24,43	**0,122**	1.180	1.706	57.143	58.849
	Circuit Line 1.2																			
5	L_{19-3}	490	1 x 70	200	0,277	0,069	0,074	0,285	632	632	12,79	136	**0,022**	-20.737	6,29	**0,031**	90	130	7.773	7.902
6	L_{3-20}	550	1 x 150	306	0,145	0,066	0,110	0,159	632	1.263	25,59	285	**0,023**	-30.956	7,01	**0,035**	188	272	12.378	12.650
7	L_{20-17}	820	1 x 300	455	0,110	0,093	0,213	0,144	632	1.895	38,38	486	**0,026**	-59.841	8,84	**0,044**	320	463	27.563	28.026
8	$L_{17-Cab.1}$	390	1 x 300	455	0,052	0,044	0,101	0,068	632	2.526	51,18	411	**0,016**	-28.309	5,61	**0,028**	271	391	13.109	13.501
	Circuit Line 1.3																			
9	L_{10-12}	1.150	1 x 70	200	0,650	0,161	0,173	0,669	632	632	12,79	319	**0,051**	-48.669	14,77	**0,074**	210	304	18.243	18.547
10	L_{13-12}	490	1 x 70	200	0,277	0,069	0,074	0,285	632	632	12,79	136	**0,022**	-20.737	6,29	**0,031**	90	130	7.773	7.902
11	$L_{12-Cab.1}$	2.050	1 x 300	455	0,275	0,232	0,533	0,359	632	1.895	38,38	1.214	**0,064**	-149.602	22,10	**0,110**	801	1.157	68.908	70.065
										6.948										
	Line from Cab. 1 to Cab .2																			
	$L_{cab1-Cab.2}$	3.800	2//3x1x500	593	0,334	0,380	1,140	0,506	632	**6.948**	70,37	9.925	**0,143**	-633.037	52,98	**0,265**	13.086	18.913	363.334	382.247
Node	Param.	Lenght	Cable Al	R.c.c.	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	Losses	$Q_{tot.i}$	DV_i	Dvi%	En. Lost	Losses Cost	Cable Cost	
No.	$L_{(i-1)-i}$	mts	mm^2	A	ohm	ohm	microF	ohm	kW	kW	A	W	%	VAR	V		kWh/year	€	€	
	Circuit Line 2.1																			
12	L_{4-16}	1.200	1 x 70	200	0,678	0,168	0,180	0,699	632	632	12,79	333	**0,053**	-50.785	15,41	**0,077**	220	317	19.036	19.353
13	$L_{16-Cab.2}$	5.800	1 x 150	306	1,531	0,696	1,160	1,682	632	1.263	25,59	3.008	**0,238**	-326.449	73,95	**0,370**	1.983	2.866	130.535	133.401
	Circuit Line 2.2																			
14	L_{11-8}	700	1 x 70	200	0,396	0,098	0,105	0,407	632	632	12,79	194	**0,031**	-29.625	8,99	**0,045**	128	185	11.104	11.289
15	L_{8-5}	2.360	1 x 150	306	0,623	0,283	0,472	0,684	632	1.263	25,59	1.224	**0,097**	-132.831	30,09	**0,150**	807	1.166	53.114	54.280
16	L_{5-9}	640	1 x 300	455	0,086	0,072	0,166	0,112	632	1.895	38,38	379	**0,020**	-46.705	6,90	**0,034**	250	361	21.513	21.874
17	$L_{9-Cab.2}$	240	1 x 300	455	0,032	0,027	0,062	0,042	632	2.526	51,18	253	**0,010**	-34.842	3,45	**0,017**	167	241	8.067	8.308
	Circuit Line 2.3																			
18	L_{14-6}	650	1 x 70	200	0,367	0,091	0,098	0,378	632	632	12,79	180	**0,029**	-27.509	8,35	**0,042**	119	172	10.311	10.483
19	L_{6-21}	4.700	1 x 150	306	1,241	0,564	0,940	1,363	632	1.263	25,59	2.438	**0,193**	-264.536	59,92	**0,300**	1.607	2.323	105.778	108.101
20	$L_{21-Cab.2}$	3.550	1 x 150	306	0,937	0,426	0,710	1,029	632	1.895	38,38	4.143	**0,219**	-198.763	67,89	**0,339**	2.731	3.947	79.896	83.843
										5.684										
									Circuit line from S/S Utenza to S/S Terna										
Node	Param.	Lenght	Cable Al	R.c.c.	R_{cable}	X_{cable}	$Capac._{cable}$	Z_{cable}	PG_i	PG_{0-i}	I_{0-i}	P_{Li}	Losses	$Q_{tot.i}$	DV_i	Dvi%	En. Lost	Losses Cost	Cable Cost	Total Cost
No.	$L_{(i-1)-i}$	mts	mm^2	A	ohm	ohm	microF	ohm	kW	kW	A	W	%	VAR	V		kWh/year	€	€	
	Alt 1		**30 kV cable connection to Terna Substation**																	
MV Line	$L_{SS-Terna}$	18.900	3//3x1x500	593	1,661	1,890	5,670	2,516		**12.632**	85,30	108.789	**0,861**	-4.683.262	319,56	**1,598**	215.166	310.960	2.710.663	3.021.623
	Alt 2		**150 kV cable connection to Terna Substation**																	

					Wind speed:			7		Power Generation:			12.632			659	Hrs			
HV Line	$L_{SS\text{-}Terna}$	18.900	1 x 400	509	1,890	8,127	2,967	8,344		**12.632**	51,18	14.851,70	**0,118**	-20.836.250	382,49	**0,255**	9.791,40	14.150,63	1.984.500	**1.998.651**
										Optimisation summary tables										
	Cable ARE4H1RX - 18/30 kV																			
	Cables & Cable Accessories Summary									**Losses - W**	**VAR**	**kWh/year**	**Losses €**	**Cable cost €**	**kVAR**	**Perdite kW**	**% Perdite**	**Max. % DV**		
	Line	**Lenght**	**Cable size**	**Drum Nos**	**Joints**	**Terminations**														
60	$L_{7\text{-}1}$	530	3x1x70	1		6				147	-22.430	97	140	8.407	- 2.307	27,5	**0,22**	**0,37**		
66	$L_{19\text{-}3}$	490	3x1x70	1		6				136	-20.737	90	130	7.773						
72	$L_{10\text{-}12}$	1150	3x1x70	3	6	6				319	-48.669	210	304	18.243	246	110,0	**0,87**			
73	$L_{13\text{-}12}$	490	3x1x70	1		6				136	-20.737	90	130	7.773		25,5	**0,20**			
83	$L_{4\text{-}16}$	1200	3x1x70	3	6	6				333	-50.785	220	317	19.036						
87	$L_{11\text{-}8}$	700	3x1x70	2	3	6				194	-29.625	128	185	11.104	212	39,0	**0,31**			
93	$L_{14\text{-}6}$	650	3x1x70	2	3	6				180	-27.509	119	172	10.311		5,0	**0,04**			
	Total	**5.210**	**3x1x70**	**13**	**18**	**42**				***1.446***	***-220.494***	***953***	***1.377***	***82.647***						
61	$L_{1\text{-}18}$	500	3x1x150	2	3	6				259	-28.142	171	247	11.253	- 20.836	14,9	**0,12**	**0,25**		
67	$L_{3\text{-}20}$	550	3x1x150	2	3	6				285	-30.956	188	272	12.378						
84	$L_{16\text{-}Cab.2}$	5.800	3x1x150	20	57	6				3.008	-326.449	1.983	2.866	130.535						
88	$L_{8\text{-}5}$	2.360	3x1x150	8	21	6				1.224	-132.831	807	1.166	53.114	- 22.685	222	**1,76**	**0,37**		
94	$L_{6\text{-}21}$	4.700	3x1x150	16	45	6				2.438	-264.536	1.607	2.323	105.778						
95	$L_{21\text{-}Cab.2}$	3.550	3x1x150	12	33	6				4.143	-198.763	2.731	3.947	79.896						
	Total	**17.460**	**3x1x150**	**60**	**162**	**36**				***11.357***	***-981.677***	***7.487***	***10.821***	***392.955***						
62	$L_{18\text{-}2}$	1.200	1x300	3		6				237	-29.191	156	226	13.446						
63	$L_{2\text{-}Cab.1}$	5.100	1x300	9	6	6				1.790	-123.400	1.180	1.706	57.143						
68	$L_{20\text{-}17}$	2.460	1x300	6	3	6				486	-59.841	320	463	27.563						
69	$L_{17\text{-}Cab.1}$	1.170	1x300	1		6				411	-28.309	271	391	13.109						
74	$L_{12\text{-}Cab.1}$	6.150	1x300	12	9	6				1.214	-149.602	801	1.157	68.908						
89	$L_{5\text{-}9}$	1.920	1x300	3		6				379	-46.705	250	361	21.513						
90	$L_{9\text{-}cab.2}$	720	1x300	1		6				253	-34.842	167	241	8.067						
	Total	**16.080**	**3x1x300**	**35**	**18**	**42**				***4.769***	***-471.889***	***3.144***	***4.544***	***209.750***						
77	$L_{cab.1\text{-}Cab.2}$	22.800	1x500	36	30	12				***9.925***	***-633.037***	***13.086***	***18.913***	***363.334***						
	Total	**22.800**	**1x500**	**36**	**30**	**12**		**Sub-Total**		***27.497***	***-2.307.097***	***24.671***	***35.655***	***1.048.686***						
Alt.2-150	$L_{SS\text{-}Terna}$	**56.700**	**1x400 HV**	**72**	**69**	**6**				***14.852***	***-20.836.250***	***9.791***	***14.151***	***1.984.500***						
								Grand Total Alt.2		**42.348**	**-23.143.347**	**34.463**	**49.806**	**3.033.186**						

					Wind speed:		**8**		Power Generation:			**19.120**				**611**	**Hrs**			
					Basic Design Data															
													Unit power	**Rev. Op. Hours**	**Unit Gen. Energy**	**Total Gen. Energy**				
													kW/unit	**hours**	**MWh**	**MWh**				
											2 x		1,00	2987,87	2,99	59,76				
Operation Hypotesis								**Trafos:**		**2.500**	**50.000**	**[kVA]**	55,90	669,77	37,44	748,80				
													191,50	670,08	128,32	2.566,40				
Cos fi:	**0,95**				sin fi	**0,31**			V_{1n} =	690	30.000	[V]	381,90	677,25	258,64	5.172,84				
Rated Voltage(kV)				**30**					V_{2n} =	30	150	[kV]	631,60	659,28	416,40	8.328,00				
Generation Power (kW)				**956,0**					I_N	48	192	[A]	956,00	611,46	584,56	11.691,20				
Generation hours:				**611,5**	Hrs/year				I	19,37	38,73	[A]	1.350,20	541,85	731,60	14.632,00				
WTG nos.				**20**					V_{cc} =	7,00	12,00	%	1.750,80	460,09	805,52	16.110,40				
Losses coorrection factor: Equivalent operation versus effective one						**1,00**			P_{fe} =	5,50	19,50	kW	2.004,30	380,74	763,12	15.262,40				
Cp = Net Present value of losses: ax'((1+i)^n-1)/((1+i)^n)xi									Pcu	2,9	5,7	kW	2.083,40	303,93	633,20	12.664,00				633.200,00
									P_{cu} =	18,00	141,00	kW	2.098,30	230,89	484,48	9.689,60				484.480,00
where	a =	selling price				**0,126**			P_{tot} =	23,50	160,50		2.101,20	167,45	351,84	7.036,80				351.840,00
	i =	Net present value interest rate				**0,06**			Zn	360,00	450,00	Ohm	2.100,40	116,40	244,48	4.889,60				244.480,00
	n =	number of years for return of investment:				**20**			Z_{t20} =	25,20	54,00	Ohm	2.098,70	77,61	162,88	3.257,60				162.880,00
													2.097,70	49,69	104,24	2.084,80				104.240,00
	Cp =	**1,4452101**		**€/kWh**					R_{t20} =	2,59	1,27	Ohm	2.095,50	30,66	64,24	1.284,80				64.240,00
									X_{t20} =	25,07	53,99	Ohm	2.093,90	18,26	38,24	764,80				38.240,00
Generation factor					**1**				$Q_{cosfi=1}$	28.204	242.974	VAR	2.090,90	6,73	14,08	281,60				14.080,00
									Q_{tot}		**1.050.036**	**VAR**		8660,00	**5.826**	**116.525**				**2.097.680**

					Wind speed:		**8**		Power Generation:			**19.120**			**611**	**Hrs**			
					M.V. branches parameters calculation														
	Circuit Line 1 and 2																		
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 1.1																			
1	L_{7-1}	530	1 x 70	200	0,299	0,074	0,080	0,309	956	956	19,37	337	**0,035**	-22.383	10,30	**0,052**	206	298	8.407	8.705
2	L_{1-18}	500	1 x 150	306	0,132	0,060	0,100	0,145	956	1.912	38,73	594	**0,031**	-27.990	9,65	**0,048**	363	525	11.253	11.778
3	L_{18-2}	400	1 x 300	455	0,054	0,045	0,104	0,070	956	2.868	58,10	543	**0,019**	-28.933	6,53	**0,033**	332	480	13.446	13.925
4	$L_{2-Cab.1}$	1.700	1 x 300	455	0,228	0,192	0,442	0,298	956	3.824	77,47	4.101	**0,107**	-121.451	36,98	**0,185**	2.508	3.624	57.143	60.768
	Circuit Line 1.2																			
5	L_{19-3}	490	1 x 70	200	0,277	0,069	0,074	0,285	956	956	19,37	312	**0,033**	-20.694	9,52	**0,048**	190	275	7.773	8.048
6	L_{3-20}	550	1 x 150	306	0,145	0,066	0,110	0,159	956	1.912	38,73	654	**0,034**	-30.789	10,61	**0,053**	400	578	12.378	12.956
7	L_{20-17}	820	1 x 300	455	0,110	0,093	0,213	0,144	956	2.868	58,10	1.113	**0,039**	-59.312	13,38	**0,067**	680	983	27.563	28.547
8	$L_{17-Cab.1}$	390	1 x 300	455	0,052	0,044	0,101	0,068	956	3.824	77,47	941	**0,025**	-27.862	8,48	**0,042**	575	831	13.109	13.941
	Circuit Line 1.3																			
9	L_{10-12}	1.150	1 x 70	200	0,650	0,161	0,173	0,669	956	956	19,37	731	**0,076**	-48.567	22,35	**0,112**	447	646	18.243	18.889
10	L_{13-12}	490	1 x 70	200	0,277	0,069	0,074	0,285	956	956	19,37	312	**0,033**	-20.694	9,52	**0,048**	190	275	7.773	8.048
11	$L_{12-Cab.1}$	2.050	1 x 300	455	0,275	0,232	0,533	0,359	956	2.868	58,10	2.782	**0,097**	-148.280	33,45	**0,167**	1.701	2.458	68.908	71.367
										10.516										
	Line from Cab. 1 to Cab .2																			
	$L_{cab1-Cab.2}$	3.800	2//3x1x500	593	0,334	0,380	1,140	0,506	956	**10.516**	106,52	22.738	**0,216**	-618.460	80,19	**0,401**	27.807	40.187	363.334	403.521
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 2.1																			
12	L_{4-16}	1.200	1 x 70	200	0,678	0,168	0,180	0,699	956	956	19,37	763	**0,080**	-50.679	23,32	**0,117**	466	674	19.036	19.710
13	$L_{16-Cab.2}$	5.800	1 x 150	306	1,531	0,696	1,160	1,682	956	1.912	38,73	6.892	**0,360**	-324.683	111,93	**0,560**	4.214	6.090	130.535	136.625
	Circuit Line 2.2																			
14	L_{11-8}	700	1 x 70	200	0,396	0,098	0,105	0,407	956	956	19,37	445	**0,047**	-29.563	13,61	**0,068**	272	393	11.104	11.497
15	L_{8-5}	2.360	1 x 150	306	0,623	0,283	0,472	0,684	956	1.912	38,73	2.804	**0,147**	-132.113	45,54	**0,228**	1.715	2.478	53.114	55.592
16	L_{5-9}	640	1 x 300	455	0,086	0,072	0,166	0,112	956	2.868	58,10	868	**0,030**	-46.292	10,44	**0,052**	531	767	21.513	22.280
17	$L_{9-Cab.2}$	240	1 x 300	455	0,032	0,027	0,062	0,042	956	3.824	77,47	579	**0,015**	-34.292	5,22	**0,026**	354	512	8.067	8.579
	Circuit Line 2.3																			
18	L_{14-6}	650	1 x 70	200	0,367	0,091	0,098	0,378	956	956	19,37	413	**0,043**	-27.451	12,63	**0,063**	253	365	10.311	10.676
19	L_{6-21}	4.700	1 x 150	306	1,241	0,564	0,940	1,363	956	1.912	38,73	5.585	**0,292**	-263.106	90,70	**0,454**	3.415	4.935	105.778	110.713
20	$L_{21-Cab.2}$	3.550	1 x 150	306	0,937	0,426	0,710	1,029	956	2.868	58,10	9.491	**0,331**	-196.332	102,76	**0,514**	5.803	8.387	79.896	88.283
										8.604										
									Circuit line from S/S Utenza to S/S Terna										
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Alt 1		**30 kV cable connection to Terna Substation**																	
MV Line	$L_{SS-Terna}$	18.900	3//3x1x500	593	1,661	1,890	5,670	2,516		**19.120**	129,11	249.239	**1,304**	-4.523.478	483,84	**2,419**	457.202	660.753	2.710.663	3.371.415
	Alt 2		**150 kV cable connection to Terna Substation**																	

					Wind speed:			**8**		Power Generation:			**19.120**			**611**	**Hrs**			
HV Line	$L_{SS\text{-}Terna}$	18.900	1 x 400	509	1,890	8,127	2,967	8,344		**19.120**	77,47	34.025,76	**0,178**	-20.671.353	579,28	**0,386**	20.805,54	30.068,38	1.984.500	**2.014.568**

Optimisation summary tables

Cable ARE4H1RX - 18/30 kV

Cables & Cable Accessories Summary

	Line	Lenght	Cable size	Drum Nos	Joints	Terminations			Losses - W	VAR	kWh/year	Losses €	Cable cost €	kVAR	Perdite kW	% Perdite	Max. % DV
60	$L_{7\text{-}1}$	530	3x1x70	1		6			337	-22.383	206	298	8.407	- 2.280	63,0	**0,33**	**0,56**
66	$L_{19\text{-}3}$	490	3x1x70	1		6			312	-20.694	190	275	7.773				
72	$L_{10\text{-}12}$	1150	3x1x70	3	6	6			731	-48.567	447	646	18.243	564	110,0	**0,58**	
73	$L_{13\text{-}12}$	490	3x1x70	1		6			312	-20.694	190	275	7.773		58,3	**0,31**	
83	$L_{4\text{-}16}$	1200	3x1x70	3	6	6			763	-50.679	466	674	19.036				
87	$L_{11\text{-}8}$	700	3x1x70	2	3	6			445	-29.563	272	393	11.104	486	39,0	**0,20**	
93	$L_{14\text{-}6}$	650	3x1x70	2	3	6			413	-27.451	253	365	10.311		11,4	**0,06**	
	Total	**5.210**	**3x1x70**	**13**	**18**	**42**			***3.312***	***-220.031***	***2.025***	***2.927***	***82.647***				
61	$L_{1\text{-}18}$	500	3x1x150	2	3	6			594	-27.990	363	525	11.253	- 20.671	34,0	**0,18**	**0,39**
67	$L_{3\text{-}20}$	550	3x1x150	2	3	6			654	-30.789	400	578	12.378				
84	$L_{16\text{-}Cab.2}$	5.800	3x1x150	20	57	6			6.892	-324.683	4.214	6.090	130.535				
88	$L_{8\text{-}5}$	2.360	3x1x150	8	21	6			2.804	-132.113	1.715	2.478	53.114	- 21.901	316	**1,65**	**0,56**
94	$L_{6\text{-}21}$	4.700	3x1x150	16	45	6			5.585	-263.106	3.415	4.935	105.778				
95	$L_{21\text{-}Cab.2}$	3.550	3x1x150	12	33	6			9.491	-196.332	5.803	8.387	79.896				
	Total	**17.460**	**3x1x150**	**60**	**162**	**36**			***26.019***	***-975.013***	***15.909***	***22.993***	***392.955***				
62	$L_{18\text{-}2}$	1.200	1x300	3		6			543	-28.933	332	480	13.446				
63	$L_{2\text{-}Cab.1}$	5.100	1x300	9	6	6			4.101	-121.451	2.508	3.624	57.143				
68	$L_{20\text{-}17}$	2.460	1x300	6	3	6			1.113	-59.312	680	983	27.563				
69	$L_{17\text{-}Cab.1}$	1.170	1x300	1		6			941	-27.862	575	831	13.109				
74	$L_{12\text{-}Cab.1}$	6.150	1x300	12	9	6			2.782	-148.280	1.701	2.458	68.908				
89	$L_{5\text{-}9}$	1.920	1x300	3		6			868	-46.292	531	767	21.513				
90	$L_{9\text{-}cab.2}$	720	1x300	1		6			579	-34.292	354	512	8.067				
	Total	**16.080**	**3x1x300**	**35**	**18**	**42**			***10.927***	***-466.422***	***6.681***	***9.656***	***209.750***				
77	$L_{cab.1\text{-}Cab.2}$	22.800	1x500	36	30	12			***22.738***	***-618.460***	***27.807***	***40.187***	***363.334***				
	Total	**22.800**	**1x500**	**36**	**30**	**12**	**Sub-Total**		***62.996***	***-2.279.926***	***52.423***	***75.762***	***1.048.686***				
Alt.2-150	$L_{SS\text{-}Terna}$	**56.700**	**1x400 HV**	**72**	**69**	**6**			***34.026***	***-20.671.353***	***20.806***	***30.068***	***1.984.500***				
							Grand Total Alt.2		**97.021**	**-22.951.278**	**73.229**	**105.831**	**3.033.186**				

					Wind speed:		**10**		Power Generation:			**35.016**				**460**	**Hrs**			
					Basic Design Data								**Unit power**	**Rev. Op. Hours**	**Unit Gen. Energy**	**Total Gen. Energy**			
													kW/unit	**hours**	**MWh**	**MWh**			
											2 x		1,00	2987,87	2,99	59,76			
Operation Hypotesis								**Trafos:**		**2.500**	**50.000**	**[kVA]**	55,90	669,77	37,44	748,80			
													191,50	670,08	128,32	2.566,40			
Cos fi:	**0,95**				sin fi	**0,31**			V_{1n} =	690	30.000	[V]	381,90	677,25	258,64	5.172,84			
Rated Voltage(kV)				**30**					V_{2n} =	30	150	[kV]	631,60	659,28	416,40	8.328,00			
Generation Power (kW)				**1.750,8**					I_N	48	192	[A]	956,00	611,46	584,56	11.691,20			
Generation hours:				**460,1**	Hrs/year				I	35,47	70,94	[A]	1.350,20	541,85	731,60	14.632,00			
WTG nos.				**20**					V_{cc} =	7,00	12,00	%	1.750,80	460,09	805,52	16.110,40			
Losses coorrection factor: Equivalent operation versus effective one						**1,00**			P_{fe} =	5,50	19,50	kW	2.004,30	380,74	763,12	15.262,40			
Cp = Net Present value of losses: ax'((1+i)^n-1)/((1+i)^n)xi									Pcu	9,8	19,2	kW	2.083,40	303,93	633,20	12.664,00			633.200,00
									P_{cu} =	18,00	141,00	kW	2.098,30	230,89	484,48	9.689,60			484.480,00
where	a =	selling price				**0,126**			P_{tot} =	23,50	160,50		2.101,20	167,45	351,84	7.036,80			351.840,00
	i =	Net present value interest rate				**0,06**			Zn	360,00	450,00	Ohm	2.100,40	116,40	244,48	4.889,60			244.480,00
	n =	number of years for return of investment:				**20**			Z_{t20} =	25,20	54,00	Ohm	2.098,70	77,61	162,88	3.257,60			162.880,00
													2.097,70	49,69	104,24	2.084,80			104.240,00
	Cp =	**1,4452101**		**€/kWh**					R_{t20} =	2,59	1,27	Ohm	2.095,50	30,66	64,24	1.284,80			64.240,00
									X_{t20} =	25,07	53,99	Ohm	2.093,90	18,26	38,24	764,80			38.240,00
Generation factor					**1**				$Q_{cosfi=1}$	94.596	814.924	VAR	2.090,90	6,73	14,08	281,60			14.080,00
									Q_{tot}		**3.521.775**	**VAR**		8660,00	**5.826**	**116.525**			**2.097.680**

					Wind speed:		**10**		Power Generation:			**35.016**			**460**	**Hrs**			
					M.V. branches parameters calculation														
	Circuit Line 1 and 2																		
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 1.1																			
1	L_{7-1}	530	1 x 70	200	0,299	0,074	0,080	0,309	1.751	1.751	35,47	1.130	**0,065**	-22.187	18,87	**0,094**	520	751	8.407	9.159
2	L_{1-18}	500	1 x 150	306	0,132	0,060	0,100	0,145	1.751	3.502	70,94	1.993	**0,057**	-27.354	17,67	**0,088**	917	1.325	11.253	12.578
3	L_{18-2}	400	1 x 300	455	0,054	0,045	0,104	0,070	1.751	5.252	106,40	1.820	**0,035**	-27.855	11,95	**0,060**	838	1.210	13.446	14.656
4	$L_{2-Cab.1}$	1.700	1 x 300	455	0,228	0,192	0,442	0,298	1.751	7.003	141,87	13.755	**0,196**	-113.310	67,73	**0,339**	6.328	9.146	57.143	66.289
	Circuit Line 1.2																			
5	L_{19-3}	490	1 x 70	200	0,277	0,069	0,074	0,285	1.751	1.751	35,47	1.045	**0,060**	-20.512	17,44	**0,087**	481	695	7.773	8.468
6	L_{3-20}	550	1 x 150	306	0,145	0,066	0,110	0,159	1.751	3.502	70,94	2.192	**0,063**	-30.090	19,44	**0,097**	1.008	1.457	12.378	13.836
7	L_{20-17}	820	1 x 300	455	0,110	0,093	0,213	0,144	1.751	5.252	106,40	3.732	**0,071**	-57.103	24,50	**0,123**	1.717	2.482	27.563	30.045
8	$L_{17-Cab.1}$	390	1 x 300	455	0,052	0,044	0,101	0,068	1.751	7.003	141,87	3.156	**0,045**	-25.995	15,54	**0,078**	1.452	2.098	13.109	15.208
	Circuit Line 1.3																			
9	L_{10-12}	1.150	1 x 70	200	0,650	0,161	0,173	0,669	1.751	1.751	35,47	2.452	**0,140**	-48.141	40,94	**0,205**	1.128	1.630	18.243	19.873
10	L_{13-12}	490	1 x 70	200	0,277	0,069	0,074	0,285	1.751	1.751	35,47	1.045	**0,060**	-20.512	17,44	**0,087**	481	695	7.773	8.468
11	$L_{12-Cab.1}$	2.050	1 x 300	455	0,275	0,232	0,533	0,359	1.751	5.252	106,40	9.330	**0,178**	-142.758	61,26	**0,306**	4.293	6.204	68.908	75.112
										19.259										
	Line from Cab. 1 to Cab .2																			
	$L_{cab1-Cab.2}$	3.800	2//3x1x500	593	0,334	0,380	1,140	0,506	1.751	**19.259**	195,07	76.263	**0,396**	-557.567	146,88	**0,734**	70.175	101.417	363.334	464.751
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 2.1																			
12	L_{4-16}	1.200	1 x 70	200	0,678	0,168	0,180	0,699	1.751	1.751	35,47	2.559	**0,146**	-50.234	42,72	**0,214**	1.177	1.701	19.036	20.737
13	$L_{16-Cab.2}$	5.800	1 x 150	306	1,531	0,696	1,160	1,682	1.751	3.502	70,94	23.114	**0,660**	-317.310	204,99	**1,025**	10.634	15.369	130.535	145.904
	Circuit Line 2.2																			
14	L_{11-8}	700	1 x 70	200	0,396	0,098	0,105	0,407	1.751	1.751	35,47	1.493	**0,085**	-29.303	24,92	**0,125**	687	992	11.104	12.097
15	L_{8-5}	2.360	1 x 150	306	0,623	0,283	0,472	0,684	1.751	3.502	70,94	9.405	**0,269**	-129.112	83,41	**0,417**	4.327	6.254	53.114	59.368
16	L_{5-9}	640	1 x 300	455	0,086	0,072	0,166	0,112	1.751	5.252	106,40	2.913	**0,055**	-44.568	19,12	**0,096**	1.340	1.937	21.513	23.450
17	$L_{9-Cab.2}$	240	1 x 300	455	0,032	0,027	0,062	0,042	1.751	7.003	141,87	1.942	**0,028**	-31.993	9,56	**0,048**	893	1.291	8.067	9.359
	Circuit Line 2.3																			
18	L_{14-6}	650	1 x 70	200	0,367	0,091	0,098	0,378	1.751	1.751	35,47	1.386	**0,079**	-27.210	23,14	**0,116**	638	922	10.311	11.233
19	L_{6-21}	4.700	1 x 150	306	1,241	0,564	0,940	1,363	1.751	3.502	70,94	18.730	**0,535**	-257.130	166,11	**0,831**	8.618	12.454	105.778	118.232
20	$L_{21-Cab.2}$	3.550	1 x 150	306	0,937	0,426	0,710	1,029	1.751	5.252	106,40	31.832	**0,606**	-186.177	188,20	**0,941**	14.645	21.166	79.896	101.062
										15.757										
									Circuit line from S/S Utenza to S/S Terna										
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Alt 1		**30 kV cable connection to Terna Substation**																	
MV Line	$L_{SS-Terna}$	18.900	3//3x1x500	593	1,661	1,890	5,670	2,516		**35.016**	236,45	835.936	**2,387**	-3.856.019	886,79	**4,434**	1.153.809	1.667.496	2.710.663	4.378.159
	Alt 2		**150 kV cable connection to Terna Substation**																	

					Wind speed:			**10**		Power Generation:			**35.016**			**460**	**Hrs**			
HV Line	$L_{SS-Terna}$	18.900	1 x 400	509	1,890	8,127	2,967	8,344		**35.016**	141,87	114.120,89	**0,326**	-19.982.535	1.062,44	**0,708**	52.505,52	75.881,50	1.984.500	**2.060.382**

Optimisation summary tables

Cable ARE4H1RX - 18/30 kV

Cables & Cable Accessories Summary

	Line	Lenght	Cable size	Drum Nos	Joints	Terminations	Losses - W	VAR	kWh/year	Losses €	Cable cost €	kVAR	Perdite kW	% Perdite	Max. % DV
60	L_{7-1}	530	3x1x70	1		6	1.130	-22.187	520	751	8.407	- 2.166	211,3	**0,60**	**1,02**
66	L_{19-3}	490	3x1x70	1		6	1.045	-20.512	481	695	7.773				
72	L_{10-12}	1150	3x1x70	3	6	6	2.452	-48.141	1.128	1.630	18.243	1.892	110,0	**0,31**	
73	L_{13-12}	490	3x1x70	1		6	1.045	-20.512	481	695	7.773		195,6	**0,56**	
83	L_{4-16}	1200	3x1x70	3	6	6	2.559	-50.234	1.177	1.701	19.036				
87	L_{11-8}	700	3x1x70	2	3	6	1.493	-29.303	687	992	11.104	1.630	39,0	**0,11**	
93	L_{14-6}	650	3x1x70	2	3	6	1.386	-27.210	638	922	10.311		38,3	**0,11**	
	Total	**5.210**	**3x1x70**	**13**	**18**	**42**	***11.109***	***-218.099***	***5.111***	***7.387***	***82.647***				
61	L_{1-18}	500	3x1x150	2	3	6	1.993	-27.354	917	1.325	11.253	- 19.983	114,1	**0,33**	**0,71**
67	L_{3-20}	550	3x1x150	2	3	6	2.192	-30.090	1.008	1.457	12.378				
84	$L_{16-Cab.2}$	5.800	3x1x150	20	57	6	23.114	-317.310	10.634	15.369	130.535				
88	L_{8-5}	2.360	3x1x150	8	21	6	9.405	-129.112	4.327	6.254	53.114	- 18.627	708	**2,02**	**1,02**
94	L_{6-21}	4.700	3x1x150	16	45	6	18.730	-257.130	8.618	12.454	105.778				
95	$L_{21-Cab.2}$	3.550	3x1x150	12	33	6	31.832	-186.177	14.645	21.166	79.896				
	Total	**17.460**	**3x1x150**	**60**	**162**	**36**	***87.265***	***-947.173***	***40.150***	***58.025***	***392.955***				
62	L_{18-2}	1.200	1x300	3		6	1.820	-27.855	838	1.210	13.446				
63	$L_{2-Cab.1}$	5.100	1x300	9	6	6	13.755	-113.310	6.328	9.146	57.143				
68	L_{20-17}	2.460	1x300	6	3	6	3.732	-57.103	1.717	2.482	27.563				
69	$L_{17-Cab.1}$	1.170	1x300	1		6	3.156	-25.995	1.452	2.098	13.109				
74	$L_{12-Cab.1}$	6.150	1x300	12	9	6	9.330	-142.758	4.293	6.204	68.908				
89	L_{5-9}	1.920	1x300	3		6	2.913	-44.568	1.340	1.937	21.513				
90	$L_{9-cab.2}$	720	1x300	1		6	1.942	-31.993	893	1.291	8.067				
	Total	**16.080**	**3x1x300**	**35**	**18**	**42**	***36.648***	***-443.583***	***16.861***	***24.368***	***209.750***				
77	$L_{cab.1-Cab.2}$	22.800	1x500	36	30	12	***76.263***	***-557.567***	***70.175***	***101.417***	***363.334***				
	Total	**22.800**	**1x500**	**36**	**30**	**12**	**Sub-Total**	***211.284***	***-2.166.422***	***132.297***	***191.196***	***1.048.686***				
Alt.2-150	$L_{SS-Terna}$	**56.700**	**1x400 HV**	**72**	**69**	**6**		***114.121***	***-19.982.535***	***52.506***	***75.882***	***1.984.500***				
							Grand Total Alt.2	**325.405**	**-22.148.957**	**184.802**	**267.078**	**3.033.186**				

					Wind speed:		**11**		Power Generation:			**40.086**				**381**	**Hrs**			
					Basic Design Data								**Unit power**	**Rev. Op. Hours**	**Unit Gen. Energy**	**Total Gen. Energy**			
													kW/unit	**hours**	**MWh**	**MWh**			
											2 x		1,00	2987,87	2,99	59,76			
Operation Hypotesis								**Trafos:**		**2.500**	**50.000**	**[kVA]**	55,90	669,77	37,44	748,80			
													191,50	670,08	128,32	2.566,40			
Cos fi:	**0,95**				sin fi	**0,31**			V_{1n} =	690	30.000	[V]	381,90	677,25	258,64	5.172,84			
Rated Voltage(kV)				**30**					V_{2n} =	30	150	[kV]	631,60	659,28	416,40	8.328,00			
Generation Power (kW)				**2.004,3**					I_N	48	192	[A]	956,00	611,46	584,56	11.691,20			
Generation hours:				**380,7**	Hrs/year				I	40,60	81,21	[A]	1.350,20	541,85	731,60	14.632,00			
WTG nos.				**20**					V_{cc} =	7,00	12,00	%	1.750,80	460,09	805,52	16.110,40			
Losses coorrection factor: Equivalent operation versus effective one						**1,00**			P_{fe} =	5,50	19,50	kW	2.004,30	380,74	763,12	15.262,40			
Cp = Net Present value of losses: ax'((1+i)^n-1)/((1+i)^n)xi									Pcu	12,8	25,1	kW	2.083,40	303,93	633,20	12.664,00			633.200,00
									P_{cu} =	18,00	141,00	kW	2.098,30	230,89	484,48	9.689,60			484.480,00
where	a =	selling price				**0,126**			P_{tot} =	23,50	160,50		2.101,20	167,45	351,84	7.036,80			351.840,00
	i =	Net present value interest rate				**0,06**			Zn	360,00	450,00	Ohm	2.100,40	116,40	244,48	4.889,60			244.480,00
	n =	number of years for return of investment:				**20**			Z_{t20} =	25,20	54,00	Ohm	2.098,70	77,61	162,88	3.257,60			162.880,00
													2.097,70	49,69	104,24	2.084,80			104.240,00
	Cp =	**1,4452101**		**€/kWh**					R_{t20} =	2,59	1,27	Ohm	2.095,50	30,66	64,24	1.284,80			64.240,00
									X_{t20} =	25,07	53,99	Ohm	2.093,90	18,26	38,24	764,80			38.240,00
Generation factor					**1**				$Q_{cosfi=1}$	123.973	1.067.996	VAR	2.090,90	6,73	14,08	281,60			14.080,00
									Q_{tot}		**4.615.449**	**VAR**		8660,00	**5.826**	**116.525**			**2.097.680**

					Wind speed:		**11**		Power Generation:			**40.086**			**381**	**Hrs**			
					M.V. branches parameters calculation														
	Circuit Line 1 and 2																		
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 1.1																			
1	L_{7-1}	530	1 x 70	200	0,299	0,074	0,080	0,309	2.004	2.004	40,60	1.481	**0,074**	-22.100	21,60	**0,108**	564	815	8.407	9.222
2	L_{1-18}	500	1 x 150	306	0,132	0,060	0,100	0,145	2.004	4.009	81,21	2.611	**0,065**	-27.073	20,23	**0,101**	994	1.437	11.253	12.690
3	L_{18-2}	400	1 x 300	455	0,054	0,045	0,104	0,070	2.004	6.013	121,81	2.386	**0,040**	-27.378	13,68	**0,068**	908	1.313	13.446	14.758
4	$L_{2-Cab.1}$	1.700	1 x 300	455	0,228	0,192	0,442	0,298	2.004	8.017	162,41	18.026	**0,225**	-109.708	77,54	**0,388**	6.863	9.919	57.143	67.063
	Circuit Line 1.2																			
5	L_{19-3}	490	1 x 70	200	0,277	0,069	0,074	0,285	2.004	2.004	40,60	1.369	**0,068**	-20.432	19,97	**0,100**	521	753	7.773	8.526
6	L_{3-20}	550	1 x 150	306	0,145	0,066	0,110	0,159	2.004	4.009	81,21	2.873	**0,072**	-29.780	22,25	**0,111**	1.094	1.581	12.378	13.959
7	L_{20-17}	820	1 x 300	455	0,110	0,093	0,213	0,144	2.004	6.013	121,81	4.891	**0,081**	-56.126	28,05	**0,140**	1.862	2.691	27.563	30.255
8	$L_{17-Cab.1}$	390	1 x 300	455	0,052	0,044	0,101	0,068	2.004	8.017	162,41	4.135	**0,052**	-25.168	17,79	**0,089**	1.575	2.276	13.109	15.385
	Circuit Line 1.3																			
9	L_{10-12}	1.150	1 x 70	200	0,650	0,161	0,173	0,669	2.004	2.004	40,60	3.214	**0,160**	-47.952	46,86	**0,234**	1.224	1.768	18.243	20.011
10	L_{13-12}	490	1 x 70	200	0,277	0,069	0,074	0,285	2.004	2.004	40,60	1.369	**0,068**	-20.432	19,97	**0,100**	521	753	7.773	8.526
11	$L_{12-Cab.1}$	2.050	1 x 300	455	0,275	0,232	0,533	0,359	2.004	6.013	121,81	12.227	**0,203**	-140.315	70,13	**0,351**	4.656	6.728	68.908	75.636
										22.047										
	Line from Cab. 1 to Cab .2																			
	$L_{cab1-Cab.2}$	3.800	2//3x1x500	593	0,334	0,380	1,140	0,506	2.004	**22.047**	223,32	99.946	**0,453**	-530.624	168,16	**0,841**	76.107	109.990	363.334	473.324
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 2.1																			
12	L_{4-16}	1.200	1 x 70	200	0,678	0,168	0,180	0,699	2.004	2.004	40,60	3.353	**0,167**	-50.037	48,90	**0,245**	1.277	1.845	19.036	20.881
13	$L_{16-Cab.2}$	5.800	1 x 150	306	1,531	0,696	1,160	1,682	2.004	4.009	81,21	30.292	**0,756**	-314.047	234,67	**1,173**	11.533	16.668	130.535	147.203
	Circuit Line 2.2																			
14	L_{11-8}	700	1 x 70	200	0,396	0,098	0,105	0,407	2.004	2.004	40,60	1.956	**0,098**	-29.188	28,53	**0,143**	745	1.076	11.104	12.180
15	L_{8-5}	2.360	1 x 150	306	0,623	0,283	0,472	0,684	2.004	4.009	81,21	12.326	**0,307**	-127.785	95,49	**0,477**	4.693	6.782	53.114	59.896
16	L_{5-9}	640	1 x 300	455	0,086	0,072	0,166	0,112	2.004	6.013	121,81	3.817	**0,063**	-43.806	21,89	**0,109**	1.453	2.101	21.513	23.613
17	$L_{9-Cab.2}$	240	1 x 300	455	0,032	0,027	0,062	0,042	2.004	8.017	162,41	2.545	**0,032**	-30.976	10,95	**0,055**	969	1.400	8.067	9.468
	Circuit Line 2.3																			
18	L_{14-6}	650	1 x 70	200	0,367	0,091	0,098	0,378	2.004	2.004	40,60	1.816	**0,091**	-27.103	26,49	**0,132**	692	999	10.311	11.310
19	L_{6-21}	4.700	1 x 150	306	1,241	0,564	0,940	1,363	2.004	4.009	81,21	24.547	**0,612**	-254.486	190,16	**0,951**	9.346	13.507	105.778	119.285
20	$L_{21-Cab.2}$	3.550	1 x 150	306	0,937	0,426	0,710	1,029	2.004	6.013	121,81	41.717	**0,694**	-181.684	215,45	**1,077**	15.883	22.955	79.896	102.851
										18.039										
									Circuit line from S/S Utenza to S/S Terna										
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Alt 1		**30 kV cable connection to Terna Substation**																	
MV Line	$L_{SS-Terna}$	18.900	3//3x1x500	593	1,661	1,890	5,670	2,516		**40.086**	270,69	1.095.532	**2,733**	-3.560.687	1.015,44	**5,077**	1.251.343	1.808.454	2.710.663	4.519.117
	Alt 2		**150 kV cable connection to Terna Substation**																	

					Wind speed:			**11**		Power Generation:			**40.086**			**381**	**Hrs**			
HV Line	$L_{SS\text{-}Terna}$	18.900	1 x 400	509	1,890	8,127	2,967	8,344		**40.086**	162,41	149.560,71	**0,373**	-19.677.752	1.216,83	**0,811**	56.943,96	82.295,98	1.984.500	**2.066.796**

Optimisation summary tables

Cable ARE4H1RX - 18/30 kV

Cables & Cable Accessories Summary

	Line	Lenght	Cable size	Drum Nos	Joints	Terminations			Losses - W	VAR	kWh/year	Losses €	Cable cost €	kVAR	Perdite kW	% Perdite	Max. % DV
60	$L_{7\text{-}1}$	530	3x1x70	1		6			1.481	-22.100	564	815	8.407	- 2.116	276,9	**0,69**	**1,17**
66	$L_{19\text{-}3}$	490	3x1x70	1		6			1.369	-20.432	521	753	7.773				
72	$L_{10\text{-}12}$	1150	3x1x70	3	6	6			3.214	-47.952	1.224	1.768	18.243	2.479	110,0	**0,27**	
73	$L_{13\text{-}12}$	490	3x1x70	1		6			1.369	-20.432	521	753	7.773		256,4	**0,64**	
83	$L_{4\text{-}16}$	1200	3x1x70	3	6	6			3.353	-50.037	1.277	1.845	19.036				
87	$L_{11\text{-}8}$	700	3x1x70	2	3	6			1.956	-29.188	745	1.076	11.104	2.136	39,0	**0,10**	
93	$L_{14\text{-}6}$	650	3x1x70	2	3	6			1.816	-27.103	692	999	10.311		50,2	**0,13**	
	Total	**5.210**	**3x1x70**	**13**	**18**	**42**			***14.559***	***-217.244***	***5.543***	***8.011***	***82.647***				
61	$L_{1\text{-}18}$	500	3x1x150	2	3	6			2.611	-27.073	994	1.437	11.253	- 19.678	149,6	**0,37**	**0,81**
67	$L_{3\text{-}20}$	550	3x1x150	2	3	6			2.873	-29.780	1.094	1.581	12.378				
84	$L_{16\text{-}Cab.2}$	5.800	3x1x150	20	57	6			30.292	-314.047	11.533	16.668	130.535				
88	$L_{8\text{-}5}$	2.360	3x1x150	8	21	6			12.326	-127.785	4.693	6.782	53.114	- 17.179	882	**2,20**	**1,17**
94	$L_{6\text{-}21}$	4.700	3x1x150	16	45	6			24.547	-254.486	9.346	13.507	105.778				
95	$L_{21\text{-}Cab.2}$	3.550	3x1x150	12	33	6			41.717	-181.684	15.883	22.955	79.896				
	Total	**17.460**	**3x1x150**	**60**	**162**	**36**			***114.365***	***-934.855***	***43.544***	***62.930***	***392.955***				
62	$L_{18\text{-}2}$	1.200	1x300	3		6			2.386	-27.378	908	1.313	13.446				
63	$L_{2\text{-}Cab.1}$	5.100	1x300	9	6	6			18.026	-109.708	6.863	9.919	57.143				
68	$L_{20\text{-}17}$	2.460	1x300	6	3	6			4.891	-56.126	1.862	2.691	27.563				
69	$L_{17\text{-}Cab.1}$	1.170	1x300	1		6			4.135	-25.168	1.575	2.276	13.109				
74	$L_{12\text{-}Cab.1}$	6.150	1x300	12	9	6			12.227	-140.315	4.656	6.728	68.908				
89	$L_{5\text{-}9}$	1.920	1x300	3		6			3.817	-43.806	1.453	2.101	21.513				
90	$L_{9\text{-}cab.2}$	720	1x300	1		6			2.545	-30.976	969	1.400	8.067				
	Total	**16.080**	**3x1x300**	**35**	**18**	**42**			***48.028***	***-433.477***	***18.286***	***26.428***	***209.750***				
77	$L_{cab.1\text{-}Cab.2}$	22.800	1x500	36	30	12			***99.946***	***-530.624***	***76.107***	***109.990***	***363.334***				
	Total	**22.800**	**1x500**	**36**	**30**	**12**	**Sub-Total**		***276.898***	***-2.116.200***	***143.480***	***207.359***	***1.048.686***				
Alt.2-150	$L_{SS\text{-}Terna}$	**56.700**	**1x400 HV**	**72**	**69**	**6**			***149.561***	***-19.677.752***	***56.944***	***82.296***	***1.984.500***				
							Grand Total Alt.2		**426.459**	**-21.793.953**	**200.424**	**289.655**	**3.033.186**				

					Wind speed:		**≥ 12**		Power Generation:			**41.940**				**1.002**	**Hrs**			
					Basic Design Data								**Unit power**	**Rev. Op. Hours**	**Unit Gen. Energy**	**Total Gen. Energy**			
													kW/unit	**hours**	**MWh**	**MWh**			
											2 x		1,00	2987,87	2,99	59,76			
Operation Hypotesis								**Trafos:**		**2.500**	**50.000**	**[kVA]**	55,90	669,77	37,44	748,80			
													191,50	670,08	128,32	2.566,40			
Cos fi:	**0,95**				sin fi	**0,31**			V_{1n} =	690	30.000	[V]	381,90	677,25	258,64	5.172,84			
Rated Voltage(kV)				**30**					V_{2n} =	30	150	[kV]	631,60	659,28	416,40	8.328,00			
Generation Power (kW)				**2.097,0**					I_N	48	192	[A]	956,00	611,46	584,56	11.691,20			
Generation hours:				**1.001,6**	Hrs/year				I	42,48	84,96	[A]	1.350,20	541,85	731,60	14.632,00			
WTG nos.				**20**					V_{cc} =	7,00	12,00	%	1.750,80	460,09	805,52	16.110,40		MWh/Unit	
Losses coorrection factor: Equivalent operation versus effective one						**1,00**			P_{fe} =	5,50	19,50	kW	2.004,30	380,74	763,12	15.262,40			
Cp = Net Present value of losses: ax'((1+i)^n-1)/((1+i)^n)xi									Pcu	14,0	27,5	kW	2.083,40	303,93	633,20	12.664,00		633.200,00	
									P_{cu} =	18,00	141,00	kW	2.098,30	230,89	484,48	9.689,60		484.480,00	
where	a =	selling price				**0,126**			P_{tot} =	23,50	160,50		2.101,20	167,45	351,84	7.036,80		351.840,00	
	i =	Net present value interest rate				**0,06**			Zn	360,00	450,00	Ohm	2.100,40	116,40	244,48	4.889,60		244.480,00	
	n =	number of years for return of investment:				**20**			Z_{t20} =	25,20	54,00	Ohm	2.098,70	77,61	162,88	3.257,60		162.880,00	
													2.097,70	49,69	104,24	2.084,80		104.240,00	
	Cp =	**1,4452101**		**€/kWh**					R_{t20} =	2,59	1,27	Ohm	2.095,50	30,66	64,24	1.284,80		64.240,00	
									X_{t20} =	25,07	53,99	Ohm	2.093,90	18,26	38,24	764,80		38.240,00	
Generation factor					**1**				$Q_{cosfi=1}$	135.706	1.169.071	VAR	2.090,90	6,73	14,08	281,60		14.080,00	
									Q_{tot}		**5.052.256**	**VAR**		8660,00	**5.826**	**116.525**		**2.097.680**	

					Wind speed:		≥ 12		Power Generation:			41.940			1.002	Hrs			
					M.V. branches parameters calculation								2.097,0	1.001,62					
	Circuit Line 1 and 2																		
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 1.1																			
1	L_{7-1}	530	1 x 70	200	0,299	0,074	0,080	0,309	2.097	2.097	42,48	1.621	**0,077**	-22.065	22,60	**0,113**	1.624	2.347	8.407	10.754
2	L_{1-18}	500	1 x 150	306	0,132	0,060	0,100	0,145	2.097	4.194	84,96	2.859	**0,068**	-26.961	21,17	**0,106**	2.863	4.138	11.253	15.391
3	L_{18-2}	400	1 x 300	455	0,054	0,045	0,104	0,070	2.097	6.291	127,44	2.612	**0,042**	-27.188	14,32	**0,072**	2.616	3.780	13.446	17.226
4	$L_{2-Cab.1}$	1.700	1 x 300	455	0,228	0,192	0,442	0,298	2.097	8.388	169,92	19.732	**0,235**	-108.269	81,13	**0,406**	19.764	28.564	57.143	85.707
	Circuit Line 1.2																			
5	L_{19-3}	490	1 x 70	200	0,277	0,069	0,074	0,285	2.097	2.097	42,48	1.499	**0,071**	-20.400	20,89	**0,104**	1.501	2.170	7.773	9.943
6	L_{3-20}	550	1 x 150	306	0,145	0,066	0,110	0,159	2.097	4.194	84,96	3.144	**0,075**	-29.657	23,28	**0,116**	3.149	4.552	12.378	16.930
7	L_{20-17}	820	1 x 300	455	0,110	0,093	0,213	0,144	2.097	6.291	127,44	5.354	**0,085**	-55.735	29,35	**0,147**	5.363	7.750	27.563	35.313
8	$L_{17-Cab.1}$	390	1 x 300	455	0,052	0,044	0,101	0,068	2.097	8.388	169,92	4.527	**0,054**	-24.838	18,61	**0,093**	4.534	6.553	13.109	19.662
	Circuit Line 1.3																			
9	L_{10-12}	1.150	1 x 70	200	0,650	0,161	0,173	0,669	2.097	2.097	42,48	3.518	**0,168**	-47.877	49,03	**0,245**	3.523	5.092	18.243	23.335
10	L_{13-12}	490	1 x 70	200	0,277	0,069	0,074	0,285	2.097	2.097	42,48	1.499	**0,071**	-20.400	20,89	**0,104**	1.501	2.170	7.773	9.943
11	$L_{12-Cab.1}$	2.050	1 x 300	455	0,275	0,232	0,533	0,359	2.097	6.291	127,44	13.385	**0,213**	-139.339	73,37	**0,367**	13.406	19.375	68.908	88.283
										23.067									**245.997**	
	Line from Cab. 1 to Cab .2																			
	$L_{cab1-Cab.2}$	3.800	2//3x1x500	593	0,334	0,380	1,140	0,506	2.097	**23.067**	233,64	109.404	**0,474**	-519.863	175,94	**0,880**	219.163	316.736	**363.334**	680.070
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Circuit Line 2.1																			
12	L_{4-16}	1.200	1 x 70	200	0,678	0,168	0,180	0,699	2.097	2.097	42,48	3.671	**0,175**	-49.958	51,16	**0,256**	3.677	5.313	19.036	24.349
13	$L_{16-Cab.2}$	5.800	1 x 150	306	1,531	0,696	1,160	1,682	2.097	4.194	84,96	33.159	**0,791**	-312.744	245,53	**1,228**	33.212	47.999	130.535	178.534
	Circuit Line 2.2																			
14	L_{11-8}	700	1 x 70	200	0,396	0,098	0,105	0,407	2.097	2.097	42,48	2.141	**0,102**	-29.142	29,85	**0,149**	2.145	3.099	11.104	14.204
15	L_{8-5}	2.360	1 x 150	306	0,623	0,283	0,472	0,684	2.097	4.194	84,96	13.492	**0,322**	-127.254	99,90	**0,500**	13.514	19.531	53.114	72.645
16	L_{5-9}	640	1 x 300	455	0,086	0,072	0,166	0,112	2.097	6.291	127,44	4.179	**0,066**	-43.501	22,91	**0,115**	4.185	6.049	21.513	27.562
17	$L_{9-Cab.2}$	240	1 x 300	455	0,032	0,027	0,062	0,042	2.097	8.388	169,92	2.786	**0,033**	-30.570	11,45	**0,057**	2.790	4.033	8.067	12.100
	Circuit Line 2.3																			
18	L_{14-6}	650	1 x 70	200	0,367	0,091	0,098	0,378	2.097	2.097	42,48	1.988	**0,095**	-27.061	27,71	**0,139**	1.991	2.878	10.311	13.189
19	L_{6-21}	4.700	1 x 150	306	1,241	0,564	0,940	1,363	2.097	4.194	84,96	26.870	**0,641**	-253.430	198,96	**0,995**	26.914	38.896	105.778	144.674
20	$L_{21-Cab.2}$	3.550	1 x 150	306	0,937	0,426	0,710	1,029	2.097	6.291	127,44	45.665	**0,726**	-179.889	225,42	**1,127**	45.739	66.102	79.896	145.998
										18.873									**439.355**	
									Circuit line from S/S Utenza to S/S Terna									**1.048.686**	
Node	**Param.**	**Lenght**	**Cable Al**	**R.c.c.**	**R_{cable}**	**X_{cable}**	**$Capac._{cable}$**	**Z_{cable}**	**PG_i**	**PG_{0-i}**	**I_{0-i}**	**P_{Li}**	**Losses**	**$Q_{tot.i}$**	**DV_i**	**Dvi%**	**En. Lost**	**Losses Cost**	**Cable Cost**	**Total Cost**
No.	**$L_{(i-1)-i}$**	**mts**	**mm^2**	**A**	**ohm**	**ohm**	**microF**	**ohm**	**kW**	**kW**	**A**	**W**	**%**	**VAR**	**V**		**kWh/year**	**€**	**€**	
	Alt 1		**30 kV cable connection to Terna Substation**																	
MV Line	$L_{SS-Terna}$	18.900	3//3x1x500	593	1,661	1,890	5,670	2,516		**41.940**	283,21	1.199.214	**2,859**	-3.442.733	1.062,50	**5,313**	3.603.459	5.207.755	2.710.663	7.918.418
	Alt 2		**150 kV cable connection to Terna Substation**																	

					Wind speed:			≥ 12		Power Generation:			41.940			1.002	Hrs			
HV Line	$L_{SS\text{-}Terna}$	18.900	1 x 400	509	1,890	8,127	2,967	8,344		**41.940**	169,92	163.715,17	**0,390**	-19.556.024	1.273,33	**0,849**	163.979,92	236.985,44	1.984.500	**2.221.485**
										Optimisation summary tables										
	Cable ARE4H1RX - 18/30 kV																			
	Cables & Cable Accessories Summary								**Losses - W**	**VAR**	**kWh/year**	**Losses €**	**Cable cost €**	**kVAR**	**Perdite kW**	**% Perdite**	**Max. % DV**			
	Line	**Lenght**	**Cable size**	**Drum Nos**	**Joints**	**Terminations**														
60	$L_{7\text{-}1}$	530	3x1x70	1		6			1.621	-22.065	1.624	2.347	8.407	- 2.096	303,1	**0,72**	**1,23**			
66	$L_{19\text{-}3}$	490	3x1x70	1		6			1.499	-20.400	1.501	2.170	7.773							
72	$L_{10\text{-}12}$	1150	3x1x70	3	6	6			3.518	-47.877	3.523	5.092	18.243	2.714	110,0	**0,26**				
73	$L_{13\text{-}12}$	490	3x1x70	1		6			1.499	-20.400	1.501	2.170	7.773		280,7	**0,67**				
83	$L_{4\text{-}16}$	1200	3x1x70	3	6	6			3.671	-49.958	3.677	5.313	19.036							
87	$L_{11\text{-}8}$	700	3x1x70	2	3	6			2.141	-29.142	2.145	3.099	11.104	2.338	39,0	**0,09**				
93	$L_{14\text{-}6}$	650	3x1x70	2	3	6			1.988	-27.061	1.991	2.878	10.311		55,0	**0,13**				
	Total	**5.210**	**3x1x70**	**13**	**18**	**42**			***15.937***	***-216.903***	***15.962***	***23.069***	***82.647***							
61	$L_{1\text{-}18}$	500	3x1x150	2	3	6			2.859	-26.961	2.863	4.138	11.253	- 19.556	163,7	**0,39**	**0,85**			
67	$L_{3\text{-}20}$	550	3x1x150	2	3	6			3.144	-29.657	3.149	4.552	12.378							
84	$L_{16\text{-}Cab.2}$	5.800	3x1x150	20	57	6			33.159	-312.744	33.212	47.999	130.535							
88	$L_{8\text{-}5}$	2.360	3x1x150	8	21	6			13.492	-127.254	13.514	19.531	53.114	- 16.600	951	**2,27**	**1,23**			
94	$L_{6\text{-}21}$	4.700	3x1x150	16	45	6			26.870	-253.430	26.914	38.896	105.778							
95	$L_{21\text{-}Cab.2}$	3.550	3x1x150	12	33	6			45.665	-179.889	45.739	66.102	79.896							
	Total	**17.460**	**3x1x150**	**60**	**162**	**36**			***125.189***	***-929.935***	***125.391***	***181.217***	***392.955***							
62	$L_{18\text{-}2}$	1.200	1x300	3		6			2.612	-27.188	2.616	3.780	13.446							
63	$L_{2\text{-}Cab.1}$	5.100	1x300	9	6	6			19.732	-108.269	19.764	28.564	57.143							
68	$L_{20\text{-}17}$	2.460	1x300	6	3	6			5.354	-55.735	5.363	7.750	27.563							
69	$L_{17\text{-}Cab.1}$	1.170	1x300	1		6			4.527	-24.838	4.534	6.553	13.109							
74	$L_{12\text{-}Cab.1}$	6.150	1x300	12	9	6			13.385	-139.339	13.406	19.375	68.908							
89	$L_{5\text{-}9}$	1.920	1x300	3		6			4.179	-43.501	4.185	6.049	21.513							
90	$L_{9\text{-}cab.2}$	720	1x300	1		6			2.786	-30.570	2.790	4.033	8.067							
	Total	**16.080**	**3x1x300**	**35**	**18**	**42**			***52.574***	***-429.441***	***52.659***	***76.103***	***209.750***							
77	$L_{cab.1\text{-}Cab.2}$	22.800	1x500	36	30	12			***109.404***	***-519.863***	***219.163***	***316.736***	***363.334***							
	Total	**22.800**	**1x500**	**36**	**30**	**12**	**Sub-Total**		***303.104***	***-2.096.142***	***413.175***	***597.125***	***1.048.686***							
Alt.2-150	$L_{SS\text{-}Terna}$	**56.700**	**1x400 HV**	**72**	**69**	**6**			***163.715***	***-19.556.024***	***163.980***	***236.985***	***1.984.500***							
							Grand Total Alt.2		**466.819**	**-21.652.166**	**577.155**	**834.110**	**3.033.186**							