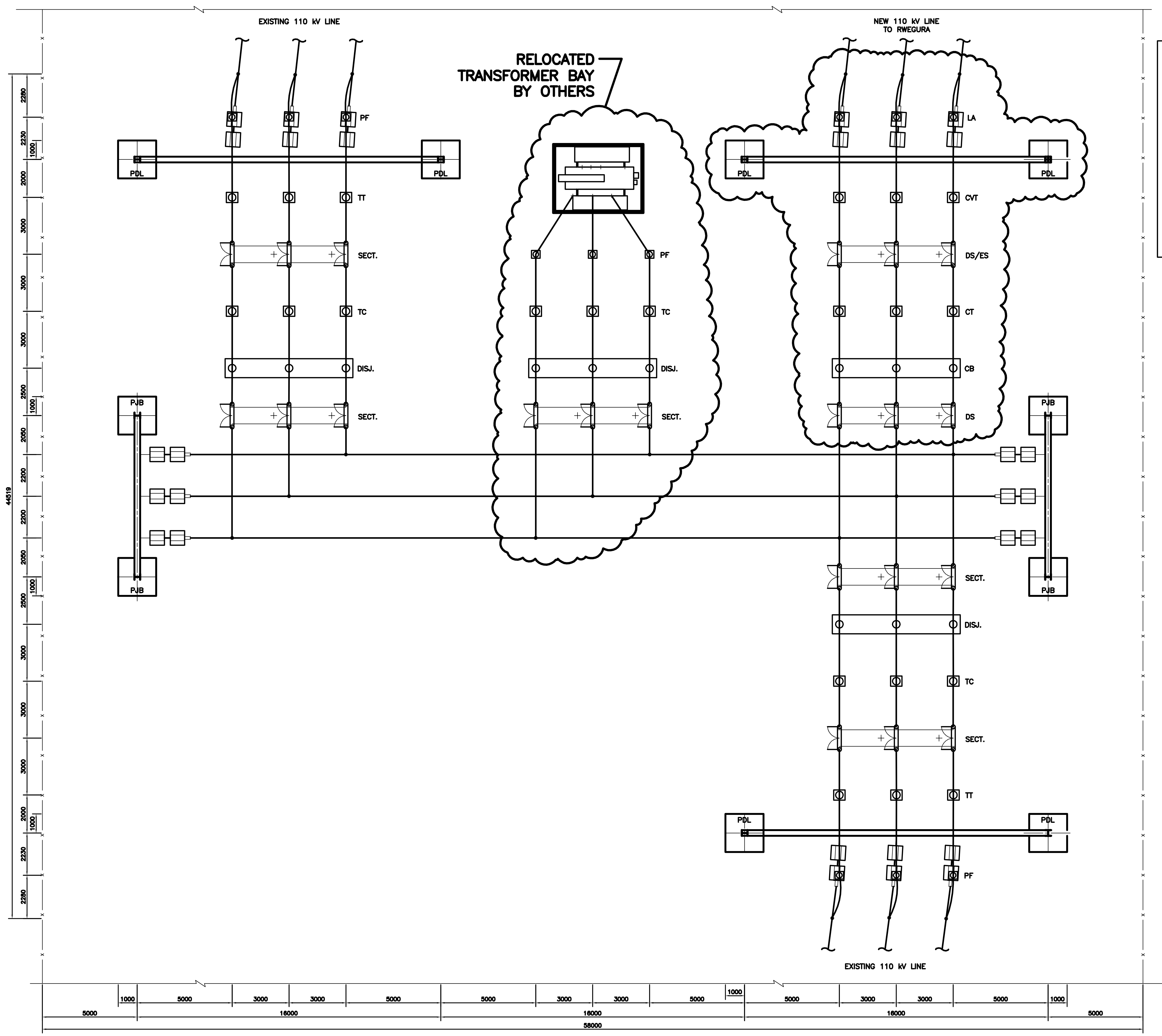


LEGEND		LÉGENDE
CB	CIRCUIT BREAKER	DISJONCTEUR
CT	CURRENT TRANSFORMER	TRANSFORMATEUR DE COURANT
CVT	CAPACITIVE VOLTAGE TRANSFORMER	TRANSFORMATEUR DE TENSION CAPACITIF
DS	DISCONNECTOR	SECTIONNEUR
DS/ES	DISCONNECTOR WITH EARTH SWITCH	SECTIONNEUR AVEC SECTIONNEUR DE MALT
GTR	GROUNDING TRANSFORMER	TRANSFORMATEUR DE MALT
LA	LIGHTNING ARRESTER	PARAFOUDRE
PA	PANTOGRAPH DISCONNECTOR	SECTIONNEUR TYPE PANTOGRAPHE
PI	POST INSULATOR	ISOLATEUR RIGIDE
SHR	SHUNT REACTOR	RÉACTANCE SHUNT
TR	TRANSFORMER	TRANSFORMATEUR

PLAN

1:100

NELSAP	PAALEN
STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES	ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL

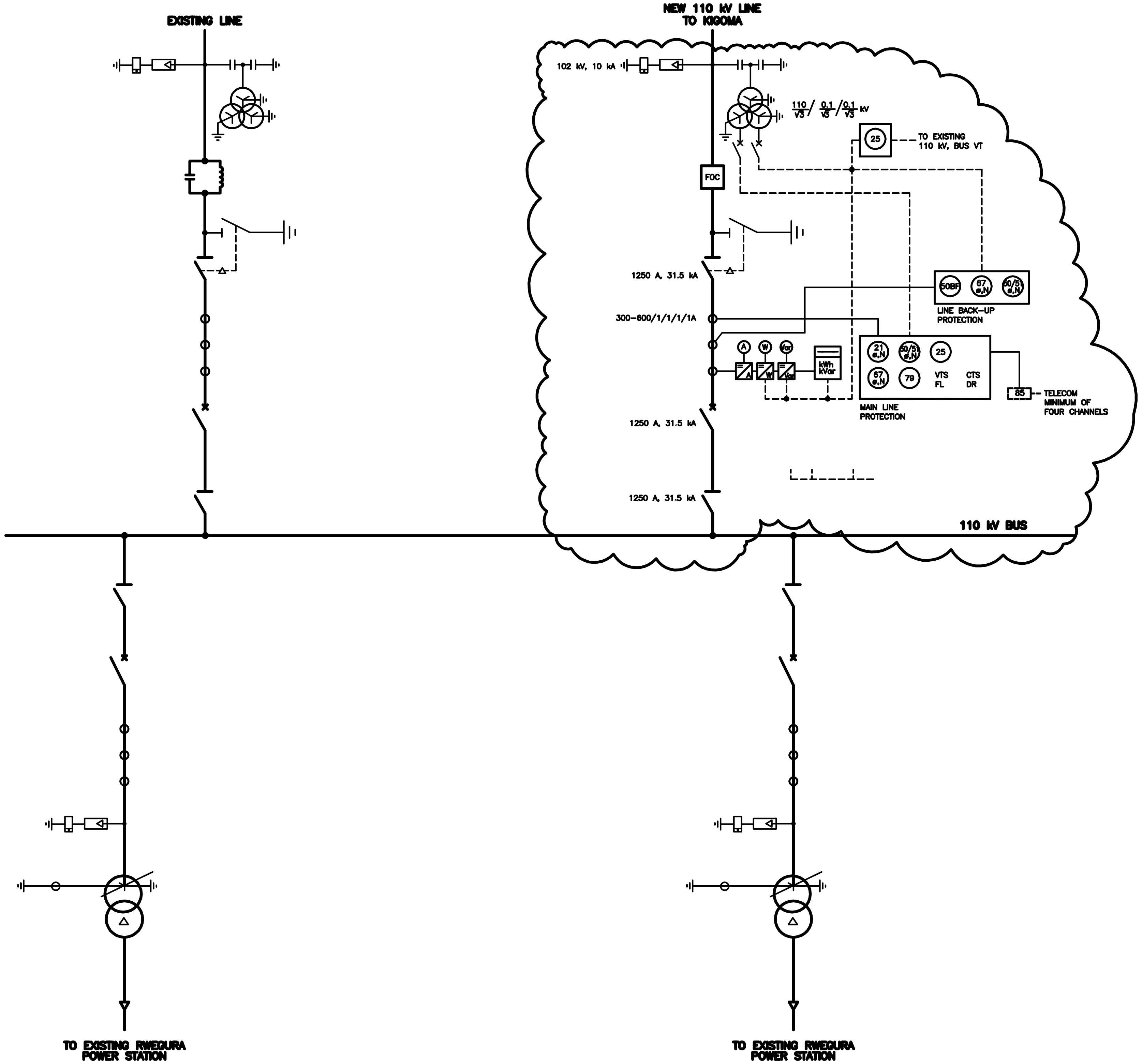
FEASIBILITY REPORT / RAPPORT DE FAISABILITE

INTERCONNEXION BURUNDI-RWANDA
POSTE KIGOMA SUBSTATION
VUE EN PLAN / PLAN VIEW

N° R P KG 002 0

Date : June / Juin 2007

A1 841 x 594



LEGEND		LÉGENDE
	CIRCUIT BREAKER	DISJONCTEUR
	DISCONNECTOR	SECTIONNEUR
	DISCONNECTOR WITH EARTH SWITCH	SECTIONNEUR AVEC SECTIONNEUR DE TERRE
	LIGHTNING ARRESTOR (WITH COUNTER)	PARAFOUDRE AVEC COMPTEUR
	CURRENT TRANSFORMER	TRANSFORMATEUR DE COURANT
	CAPACITIVE VOLTAGE TRANSFORMER	TRANSFORMATEUR DE TENSION CAPACITIF
	SHUNT REACTOR	INDUCTANCE SHUNT
	LINE TRAP	CIRCUIT BOUCHON
FOC	FIBER OPTICAL COMMUNICATION	COMMUNICATION PAR FIBRE OPTIQUE
	CABLE AND CABLE END	CÂBLE ET TERMINAISON DE CÂBLE
	SHUNT CAPACITOR	CONDENSATEUR SHUNT
21 ø,N	PHASE AND GROUND DISTANCE PROTECTION	PROTECTION DE DISTANCE, PHASE ET TERRE
27	UNDERVOLTAGE PROTECTION	PROTECTION DE SOUS TENSION
46	PHASE BALANCE	ÉQUILIBRE DE PHASE
49	THERMAL RELAY	RELAIS THERMIQUE
50BF	BREAKER FAILURE PROTECTION	DÉFAUT DISJONCTEUR
50/51 ø,N	NON DIRECTIONAL PHASE AND GROUND OVERCURRENT PROTECTION	PROTECTION NON DIRECTIONALE DE PHASE ET TERRE
50/51 Q	NEGATIVE SEQUENCE OVERCURRENT PROTECTION	PROTECTION DES SURINTENSITÉS DE SÉQUENCE INVERSE
51N	NEUTRAL TIME OVERCURRENT	RELAIS TEMPORISÉ À MAX. DE COURANT DE TERRE
59	OVERVOLTAGE RELAY	PROTECTION DE SURTENSION DE SÉQUENCE INVERSE
63	GAS PRESSURE, OIL PRESSURE	PRESSION DE GAZ, PRESSION D'HUILE
67G	GROUND DIRECTIONAL OVERCURRENT	RELAIS DIRECTIONEL À MAX. DE COURANT DE TERRE
67 ø,N	DIRECTIONAL PHASE AND GROUND PROTECTION	DIRECTIONNELLE, PHASE ET TERRE
67N	NEUTRAL DIRECTIONAL OVERCURRENT	RELAIS DIRECTIONNEL À MAX. DE COURANT DE NEUTRE
79	AUTORECLUSE	RELAIS DE RÉENCLENCHEMENT
87	CURRENT DIFFERENTIAL PROTECTION	PROTECTION DIFFÉRENTIELLE
87L	PHASE SEGRAGATED LINE DIFFEENTIAL PROTECTION	PROTECTION DIFFÉRENTIELLE DE .... À DISCRIMINATION DE PHASE
87V	VOLTAGE DIFFERENTIAL PROTECTION RELAY	PORTECTION DIFFÉRENTIELLE DE TENSION
CTS	CURRENT TRANSFORMER SUPERVISION	SUPERVISION DE TRANSFORMATEUR DE COURANT
DR	DISTRUBANCE RECORDER	ENREGISTREMENT D'ÉVÈNEMENT
FL	FAULT LOCATOR	LOCALISATION DE DÉFAUT
VTS	VOLTAGE TRANSFORMER SUPERVISION	SUPERVISION DE TRANSFORMATEUR DE TENSION
A	AMMETER	AMPÈREMÈTRE
V	VOLTMETER	VOLTMÈTRE
W	WATTMETER	WATTMÈTRE
Var	VARMETER	VARMÈTRE

NELSAP
STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES

PAALEN
ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL

FEASIBILITY REPORT / RAPPORT DE FAISABILITE

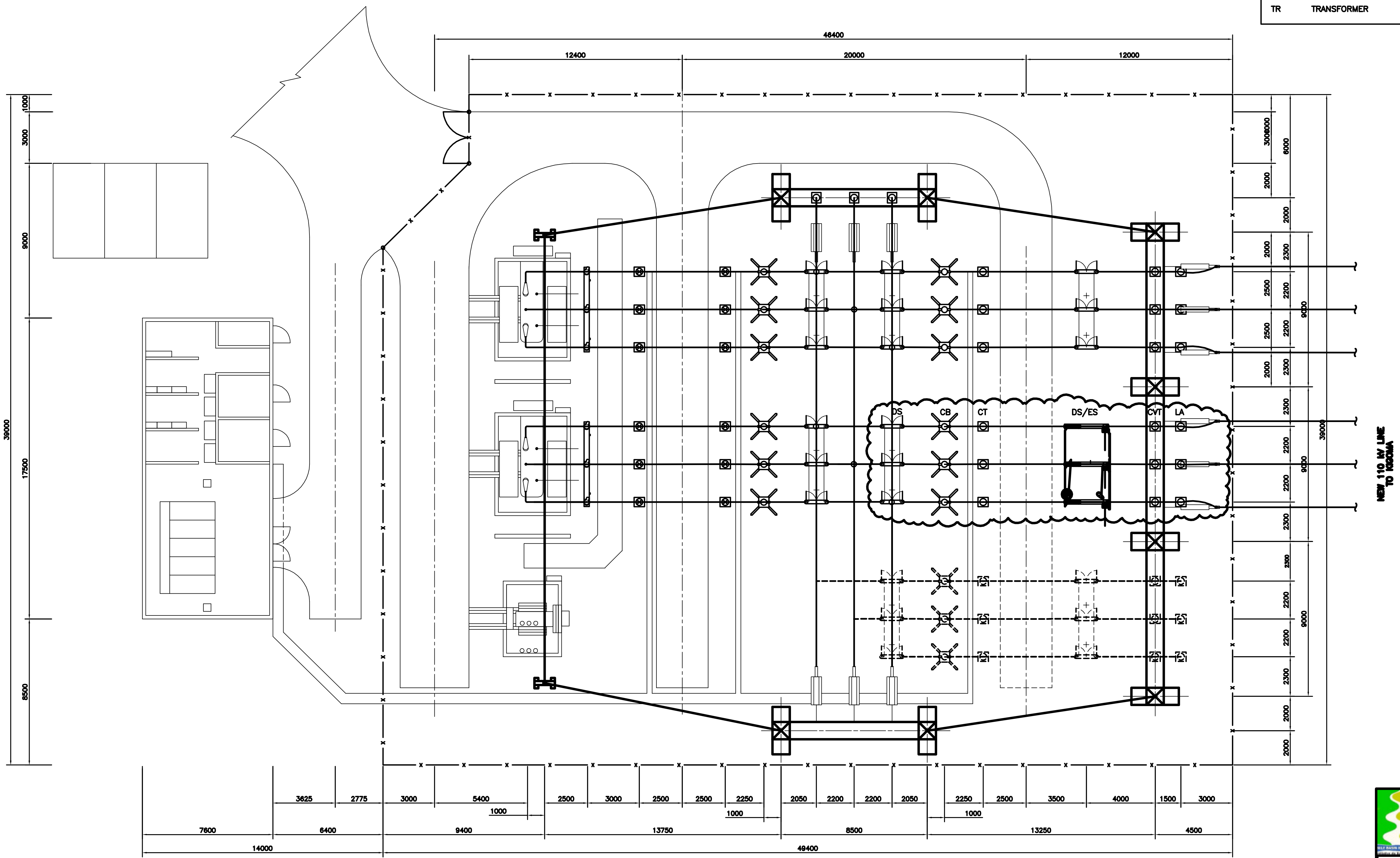
INTERCONNEXION BURUNDI-RWANDA
POSTE RWEGURA SUBSTATION
UNIFILAIRE / SINGLE LINE DIAGRAM

N° R P RW 001 0

Date : June / Juin 2007

A1 841 x 594

LEGEND		LÉGENDE
CB	CIRCUIT BREAKER	DISJONCTEUR
CT	CURRENT TRANSFORMER	TRANSFORMATEUR DE COURANT
CVT	CAPACITIVE VOLTAGE TRANSFORMER	TRANSFORMATEUR DE TENSION CAPACITIF
DS	DISCONNECTOR	SECTIONNEUR
DS/ES	DISCONNECTOR WITH EARTH SWITCH	SECTIONNEUR AVEC SECTIONNEUR DE MALT
GTR	GROUNDING TRANSFORMER	TRANSFORMATEUR DE MALT
LA	LIGHTNING ARRESTER	PARAFOUDRE
PA	PANTOGRAPH DISCONNECTOR	SECTIONNEUR TYPE PANTOGRAPHE
PI	POST INSULATOR	ISOLATEUR RIGIDE
SHR	SHUNT REACTOR	RÉACTANCE SHUNT
TR	TRANSFORMER	TRANSFORMATEUR



PLAN
1:125

A1 841 x 594

NELSAP
STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES

PAALEN
ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL

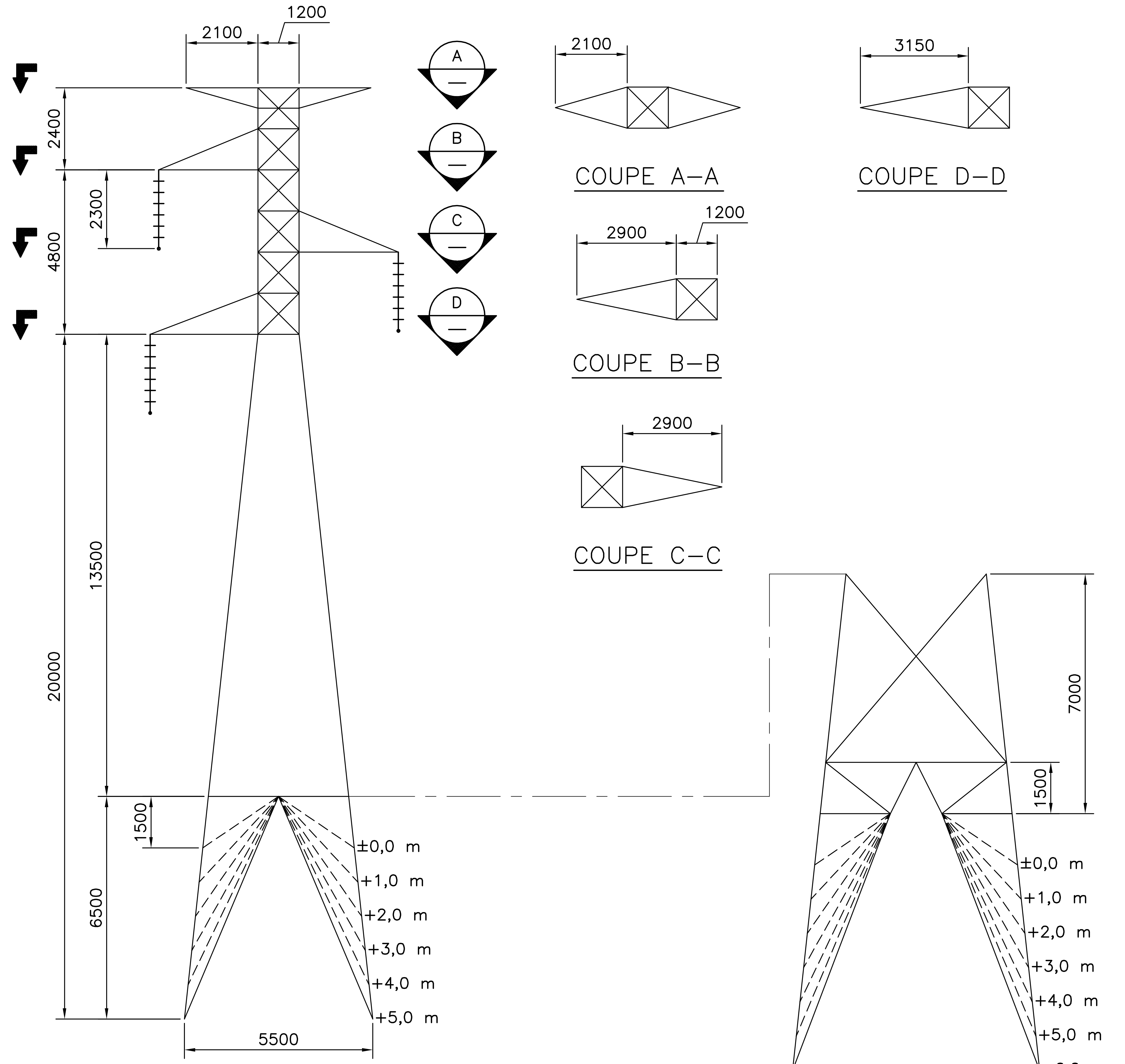
FEASIBILITY REPORT / RAPPORT DE FAISABILITE

INTERCONNEXION BURUNDI-RWANDA
POSTE RWEGURA SUBSTATION
VUE EN PLAN / PLAN VIEW

N° R P RW 002 0

Date : June / Juin 2007

ANNEX E – TOWER MODELS



1:125

SCALE / ÉCHELLE 0 1,25 2,50 4,00 5,50 6,25 m

NELSAP STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES	**PAALEN** ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL

FEASIBILITY REPORT / RAPPORT DE FAISABILITÉ

INTERCONNEXION BURUNDI-RWANDA

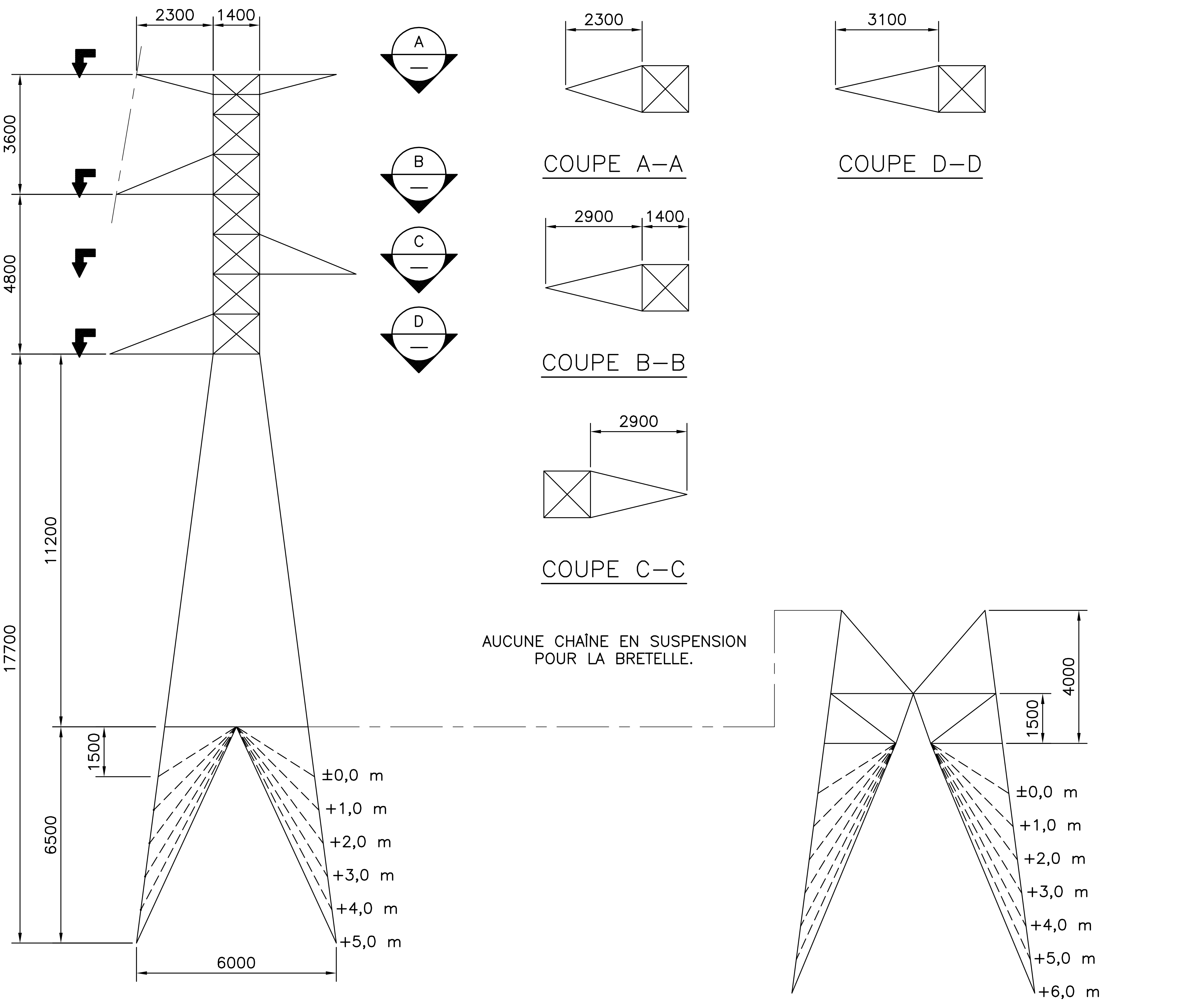
110 kV-ÉPURE PYLÔNE D'ALIGNEMENT DE 0° À 2°

N° R L BR 100 0

Date : June / Juin 2007

Dessiné par: J. Savoie Controlé par: XDS

Référence informatique: P:\Secteur_36\P36_3020\Dao\Dessins pour rapport\Interconnexion Burundi Rwanda\R L BR 100 0.dwg



NELSAP
STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES

PAALEN
ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL

FEASIBILITY REPORT / RAPPORT DE FAISABILITÉ

INTERCONNEXION BURUNDI-RWANDA

110 kV-ÉPURE PYLÔNE D'ANGLE DE 0° À 15°

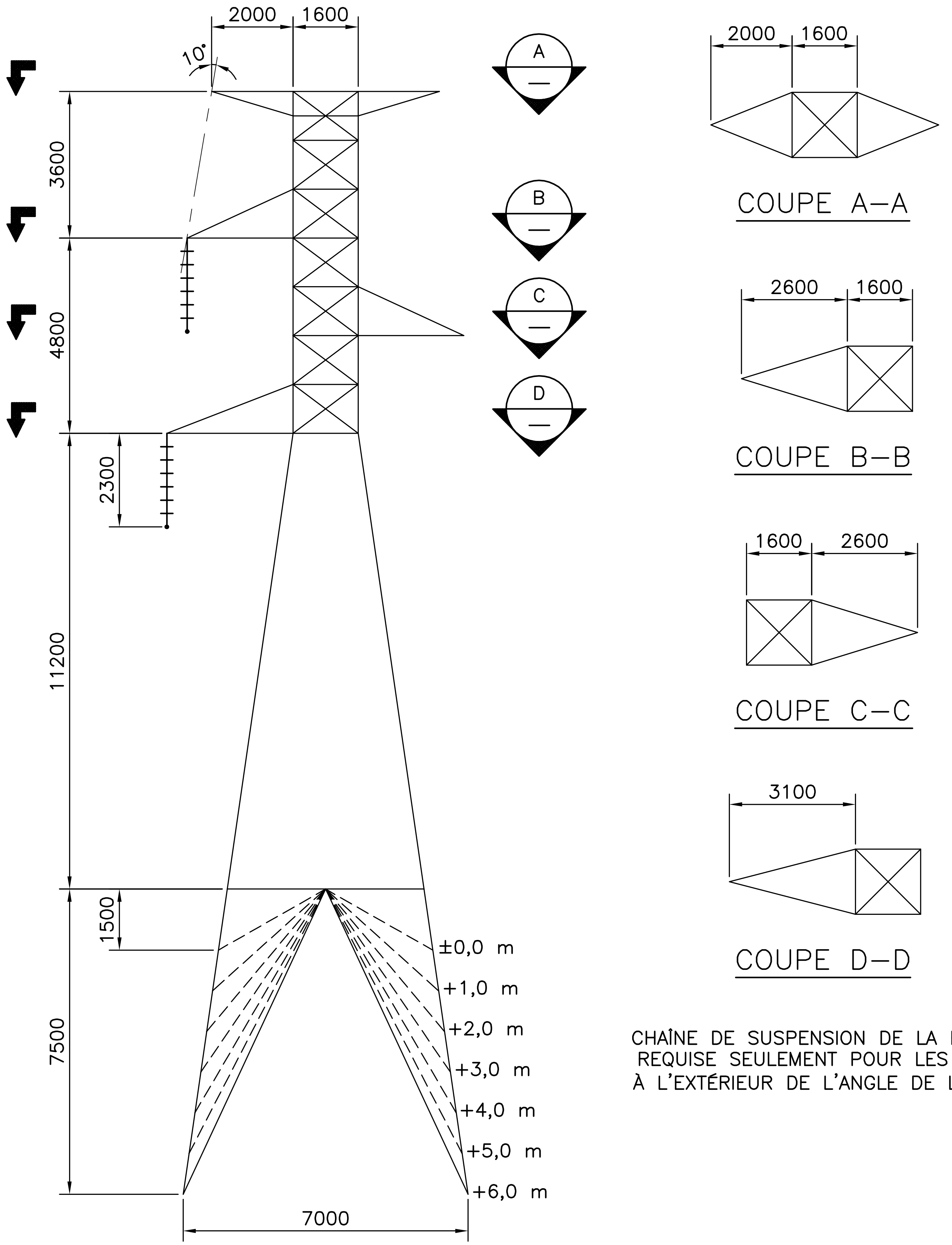
SOGREAH · RSW International · Hifab · Hydro Québec International

N° R L BR 101 0

Date : June / Juin 2007

Dessiné par: J. Savoie   Controlé par: XDS

Référence informatique: P:\Secteur_36\P36_3020\Dao\Dessins pour rapport\Interconnexion Burundi Rwanda\R L BR 101 0.dwg



CHAÎNE DE SUSPENSION DE LA BRETELLE REQUISE SEULEMENT POUR LES PHASES À L'EXTÉRIEUR DE L'ANGLE DE LA LIGNE.

1:125

SCALE / ÉCHELLE 0 1,25 2,50 3,75 5,00 6,25 m

NELSAP	PAALEN
STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES	ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL

FEASIBILITY REPORT / RAPPORT DE FAISABILITÉ

INTERCONNEXION BURUNDI-RWANDA

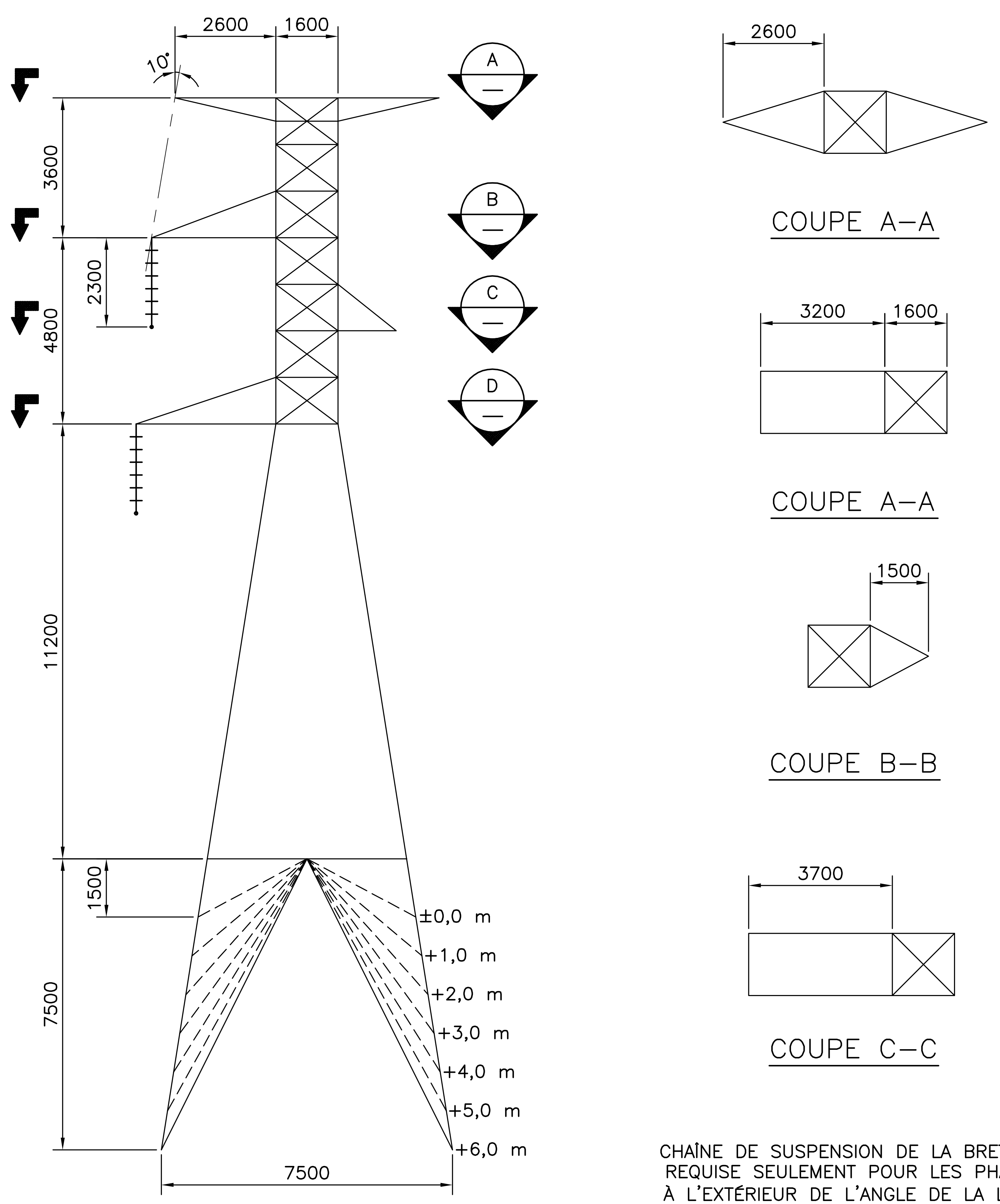
110 kV-ÉPURE PYLÔNE D'ANGLE DE 15° À 60° ET D'ARRÊT À 0°

N° R L BR 102 0

Date : June / Juin 2007

Dessiné par: J. Savoie Controlé par: XDS

Référence informatique: P:\Secteur_36\P36_3020\Dao\Dessins pour rapport\Interconnexion Burundi Rwanda\R L BR 102 0.dwg



CHAÎNE DE SUSPENSION DE LA BRETELLE REQUISE SEULEMENT POUR LES PHASES À L'EXTÉRIEUR DE L'ANGLE DE LA LIGNE

1:125

SCALE / ÉCHELLE 0 1,25 2,50 3,75 5,00 6,25 m

NELSAP	PAALEN
STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES	ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL

FEASIBILITY REPORT / RAPPORT DE FAISABILITÉ

INTERCONNEXION BURUNDI-RWANDA

110 kV-ÉPURE PYLÔNE D'ANGLE DE 60° À 90°

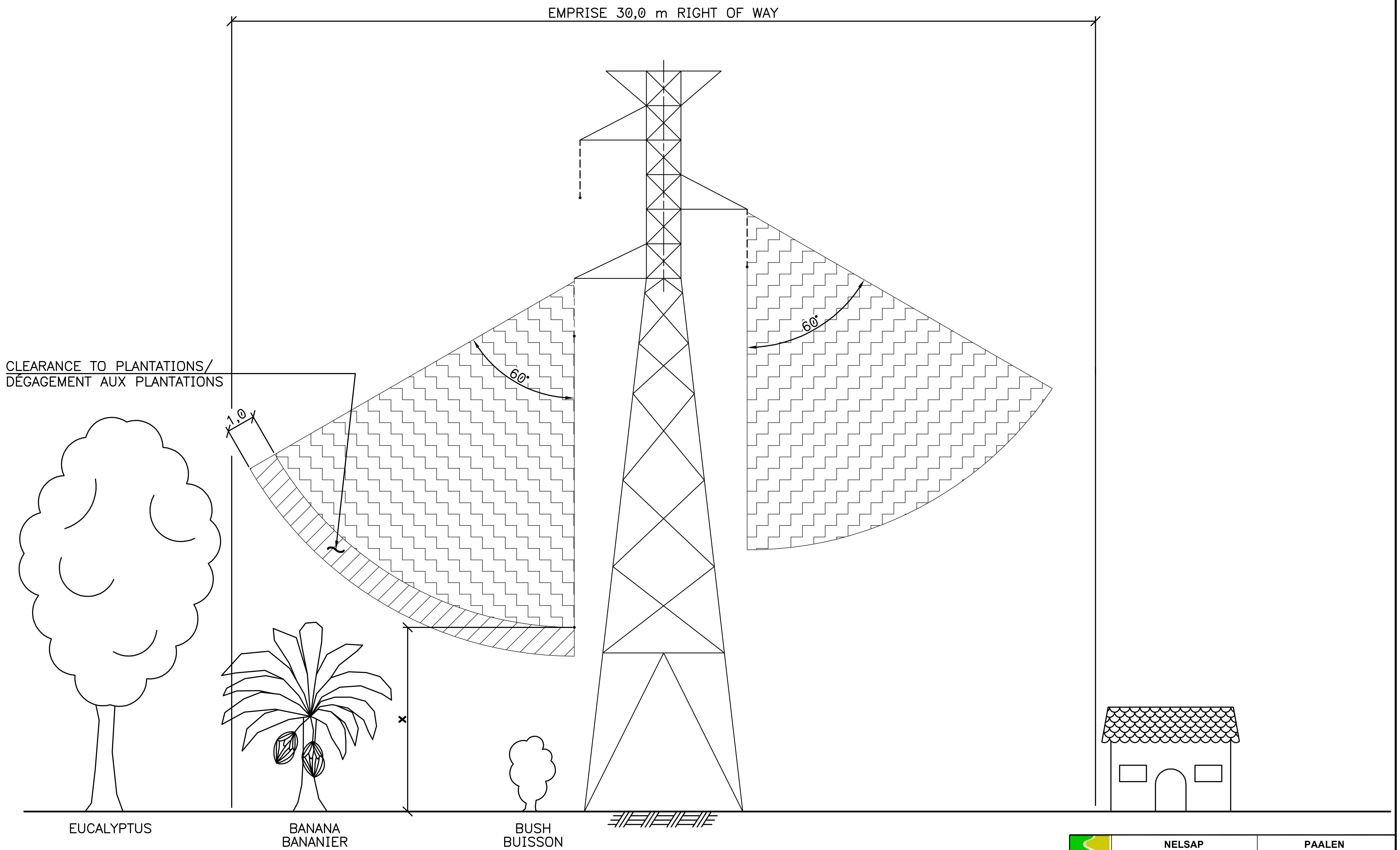
N° R L BR 103 0

Date : June / Juin 2007

Dessiné par: J. Savoie Controlé par: XDS

Référence informatique: P:\Secteur_36\P36_3020\Dao\Dessins pour rapport\Interconnexion Burundi Rwanda\R L BR 103 0.dwg

ANNEX F – CLEARANCE TO GROUND



CLEARANCE TO GROUND/ DÉGAGEMENT AU SOL	x (m)
220 kV	8,0
110 kV	7,0

NOTE : RULLING SPAN
PORTÉE DÉTERMINANTE : 350 m

SCALE / ÉCHELLE 0 1,25 2,50 3,75 5,00 6,25 m

NELSAP
STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES

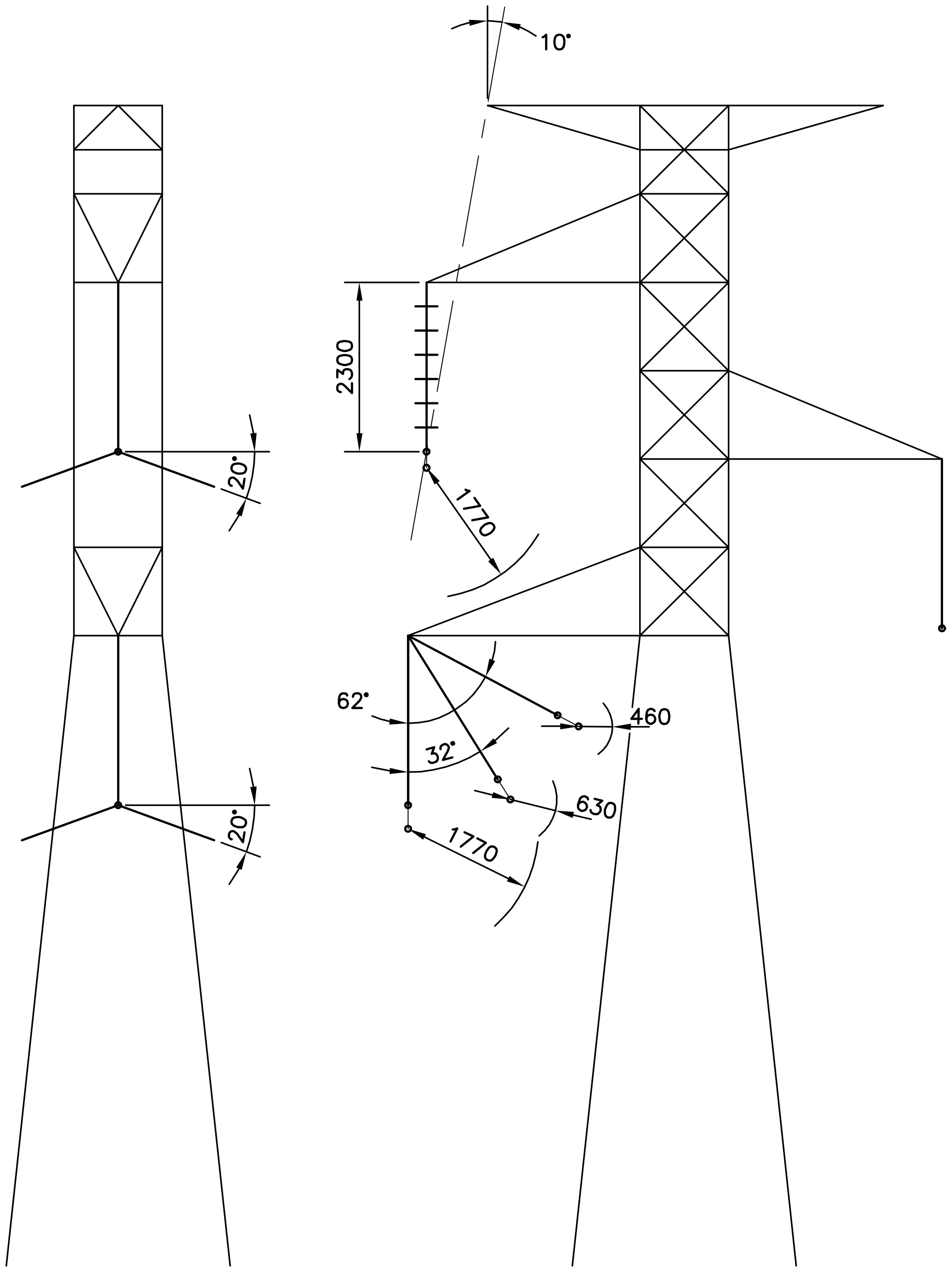
PAALEN
ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL

FEASIBILITY REPORT / RAPPORT DE FAISABILITÉ

INTERCONNEXION BURUNDI-RWANDA-RDC
110 & 220 kV - DÉGAGEMENTS DE L'EMPRISE

N° R L BR 031 0
Date : June / Juin 2007

Dessiné par: J. Fournier Controlé par: XDS
Référence informatique: P:\Secteur_36\P36_3020\Dao\Dessin Rapport\Interconnexion Rwanda OugandaR L BR 031 0.dwg



1:100

SCALE / ÉCHELLE 0 1,00 2,00 3,00 4,00 5,00 m

NELSAP

STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES

PAALEN

ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL

FEASIBILITY REPORT / RAPPORT DE FAISABILITÉ

INTERCONNEXION BURUNDI-RWANDA

DÉGAGEMENT ÉLECTRIQUE

110 kV - PYLÔNE D'ALIGNEMENT 0°À 2°

N° R L BR 104 0

Date : June / Juin 2007

Dessiné par: J. Savoie

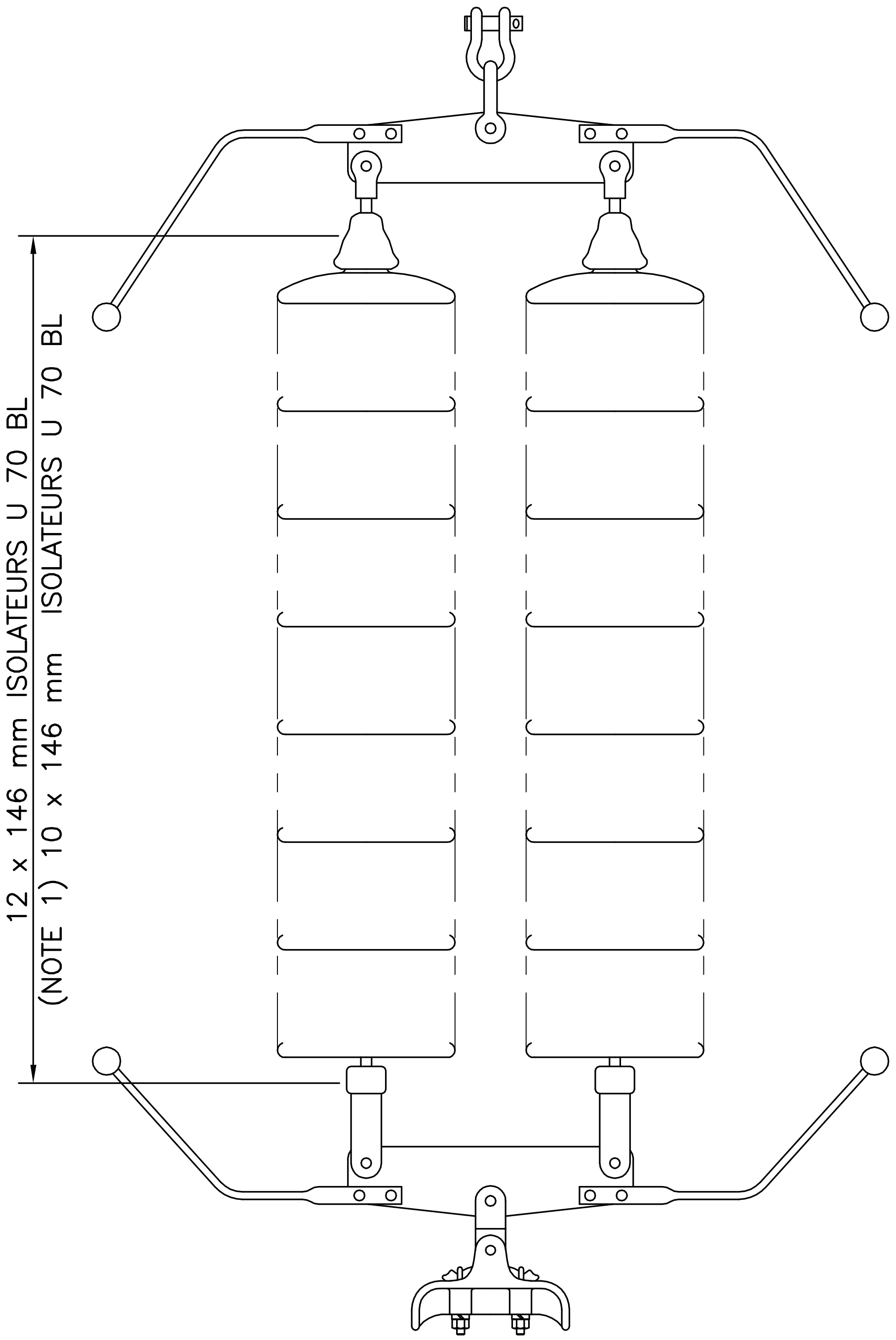
Contrôlé par: XDS

Référence informatique: P:\Secteur_36\P36_3020\Dao\Dessins pour rapport\Interconnexion Burundi Rwanda\R L BR 104 0.dwg

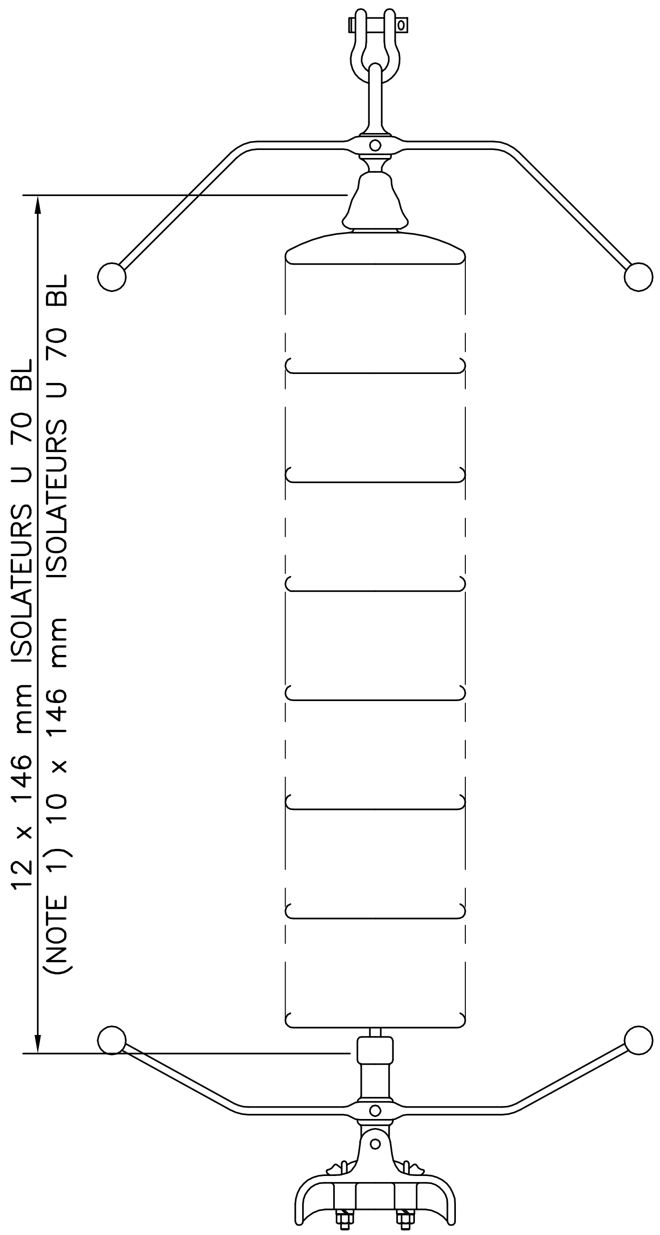
ANNEX G – INSULATORS

NOTES:

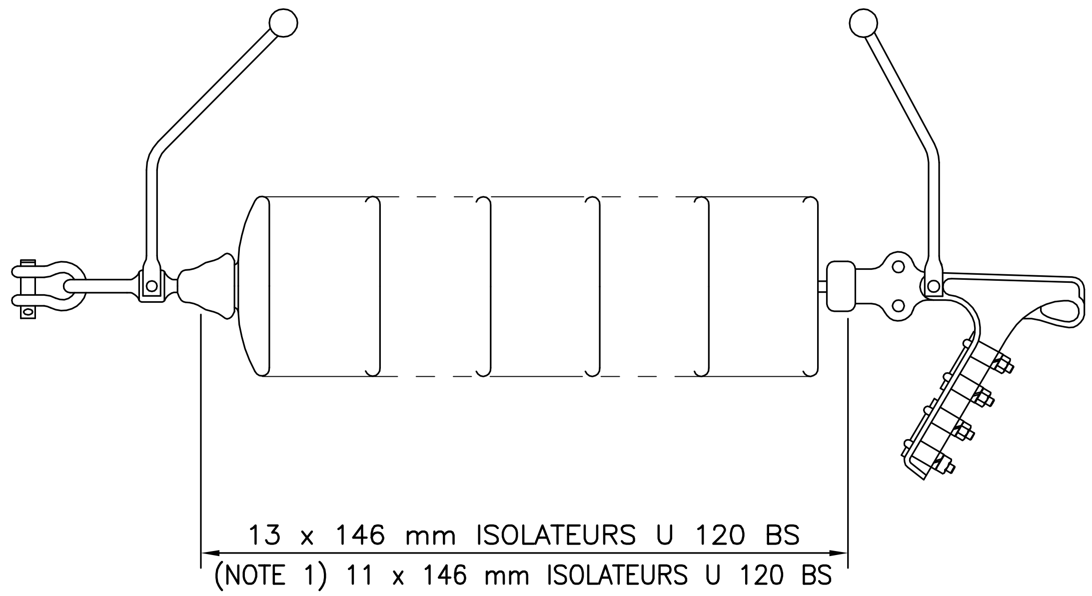
1. CONVERSION DES LIGNES 70 kV À 110 kV.



CHAÎNE DOUBLE EN SUSPENSION



CHAÎNE SIMPLE EN SUSPENSION



CHAÎNE SIMPLE EN ARRÊT

1:10

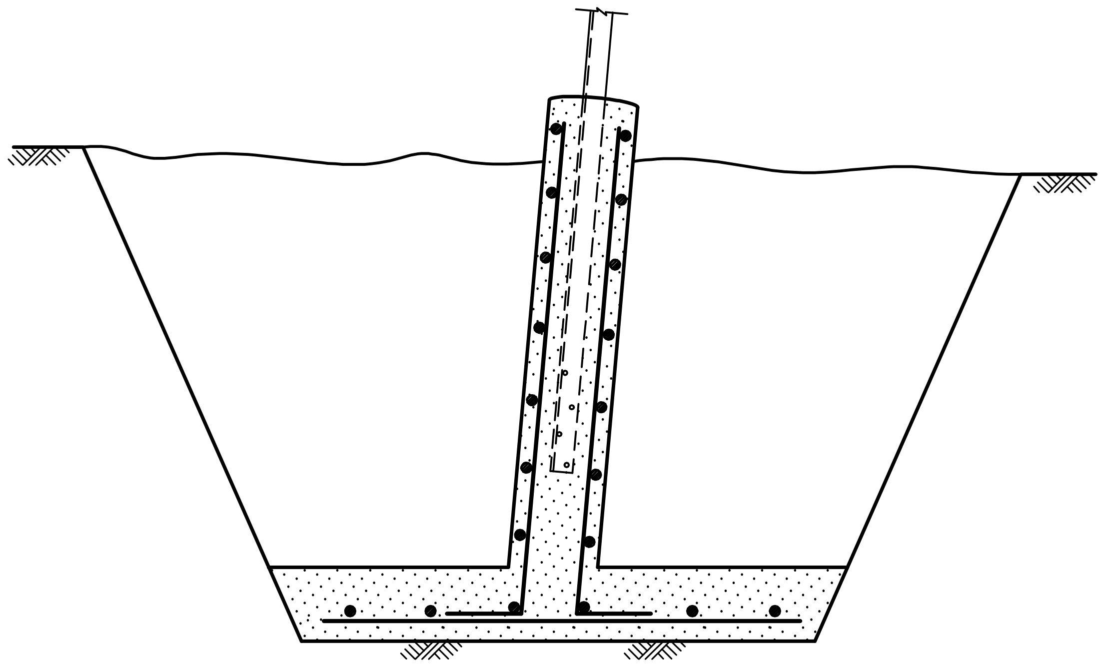
SCALE / ÉCHELLE 0 100 200 300 400 500 mm

NELSAP STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES	PAALEN ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL
FEASIBILITY REPORT / RAPPORT DE FAISABILITÉ	
INTERCONNEXION BURUNDI-RWANDA 110 kV - CHAÎNES D'ISOLATEURS	
SOGREAH, RSW International, Hifab, Hydro Québec International	N° R L BR 105 0 Date : June / Juin 2007

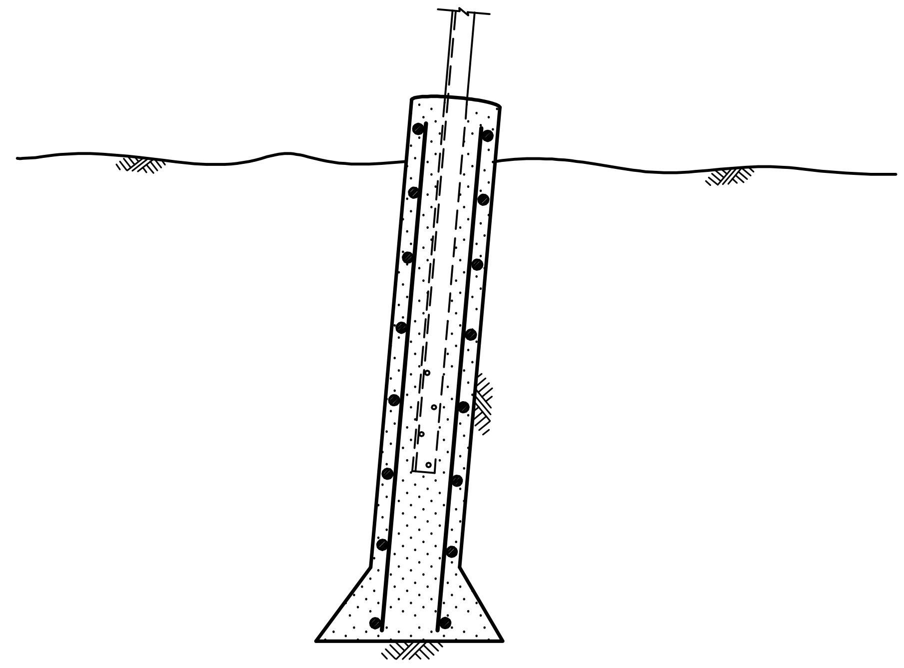
Dessiné par: J. Savoie   Controlé par: XDS

Référence informatique: P:\Secteur_36\P36_3020\Dao\Dessins pour rapport\Interconnexion Burundi Rwanda\R L BR 105 0.dwg

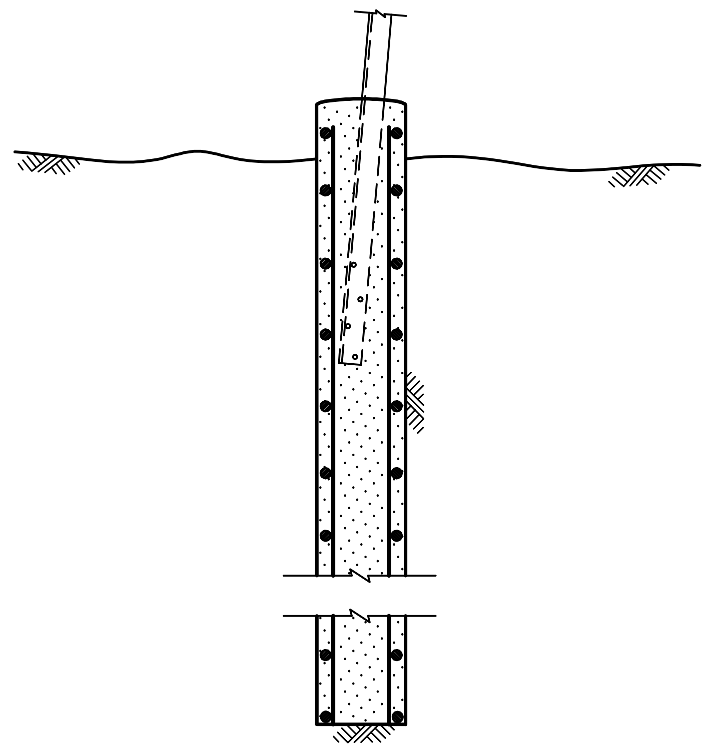
ANNEX H – FOUNDATION MODELS



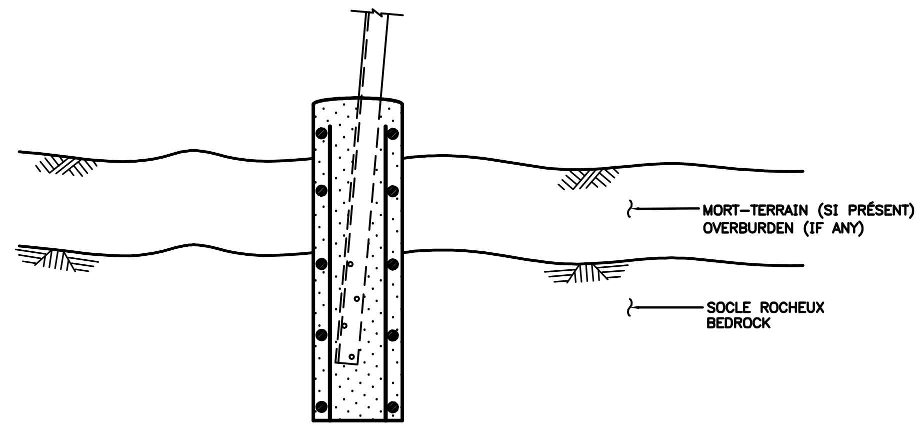
FONDATION SUPERFICIELLE
SPREAD FOUNDATION



PIEU COURT À BASE ÉLARGIE
SHORT BELLED SHAFT



PIEU LONG
LONG PILE



EMBOÎTURE DANS LE ROC
ROCK SOCKET

NELSAP STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES	**PAALEN** ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL

FEASIBILITY REPORT / RAPPORT DE FAISABILITÉ

INTERCONNEXION BURUNDI-RWANDA
FONDATIONS

N° R L BR 200 1

Date : June / Juin 2007

Dessiné par: M.-A. TREMBLAY Controlé par:

Référence informatique: P:\Secteur_36\P36_3020\Dao\Dessins pour rapport\Interconnexion Burundi Rwanda\R L BR 200 0 .dwg

ANNEX I – DETAILLED COSTS

110 kV LINE BURUNDI - RWANDA (BETWEEN KIGOMA AND RWEGURA)

No	ITEM	UNIT	EST Qty	Supply		Sea		Inland		Erection		Total price	
	DESCRIPTION			Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	Including complete design, manufacturing, testing, transport, loading, unloading, intermediate storage, erection installation, testing and commissioning.												
1,0	**GENERAL WORKS**												
	Including all necessary survey activities like tower spotting, survey of crossing objects including pegging of towers, diagonal profiles and all necessary documentation for the OHTL, soil investigations and route clearing & access roads.												
1,1	Check survey, review of tower plotting and preparation of profile drawings and tower schedule.	route km	103		$ -		$ -		$ -	$ 1 922	$ 197 955	$ 1 922	$ 197 955
1,2	Sub-soil investigation at support locations by means of machine boring, including all necessary drilling, sampling, soil penetration test (SPT), establishment of ground water level, laboratory testing and determinationof soil/water aggresiveness	per tower	10		$ -		$ -		$ -	$ 1 279	$ 12 791	$ 1 279	$ 12 791
1,3	Sub-soil investigation at support locations by means of in situ penetrometer, vane test or bearing test.	per tower	271		$ -		$ -		$ -	$ 259	$ 70 116	$ 259	$ 70 116
1,4	Specialist soil investigation		5		$ -		$ -		$ -	$ 2 243	$ 11 213	$ 2 243	$ 11 213
1,5	Clearing the right-of-way & construction of all required access and maintance roads	lump sum	1		$ -		$ -		$ -	$ 75 799	$ 75 799	$ 75 799	$ 75 799
	SUB - TOTAL CARRIED TO SUMMARY OF PRICES				$ -		$ -		$ -		$ 367 873		$ 367 873
2,0	**FOUNDATIONS**												
	All Foundations for Tower Types according to the specification, including all transport, excavation, installation of stubs, all necessary reinforcement, shuttering, concreting, backfilling, compacting, complete tower earthing and their connections to towe												
2,1	Type A Tower, Good rock at low depth (5a)	per tower	5		$ -		$ -		$ -	$ 761	$ 3 805	$ 761	$ 3 805
2,2	Type A Tower, Bad rock at low depth (5b)	per tower	12		$ -		$ -		$ -	$ 2 469	$ 29 628	$ 2 469	$ 29 628
2,3	'Type A Tower, Good Soil (3)	per tower	33		$ -		$ -		$ -	$ 1 945	$ 64 185	$ 1 945	$ 64 185
2,4	Type A Tower, Very good soil (1)	per tower	66		$ -		$ -		$ -	$ 1 231	$ 81 246	$ 1 231	$ 81 246
2,5	'Type A Tower, Good soil submerged (2)	per tower	3		$ -		$ -		$ -	$ 3 890	$ 11 670	$ 3 890	$ 11 670
2,6	Type A Tower, Poor soil (4)	per tower	16		$ -		$ -		$ -	$ 4 619	$ 73 896	$ 4 619	$ 73 896

110 kV LINE BURUNDI - RWANDA (BETWEEN KIGOMA AND RWEGURA)

No	ITEM	UNIT	EST Qty	Supply		Sea		Inland		Erection		Total price	
	DESCRIPTION			Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
2,7	Type B Tower, Good rock at low depth (5a)	per tower	5		$ -		$ -		$ -	$ 857	$ 4 285	$ 857	$ 4 285
2,8	Type B Tower, Bad rock at low depth (5b)	per tower	11		$ -		$ -		$ -	$ 3 185	$ 35 035	$ 3 185	$ 35 035
2,9	'Type B Tower, Good Soil (3)	per tower	29		$ -		$ -		$ -	$ 2 063	$ 59 827	$ 2 063	$ 59 827
2.10	Type B Tower, Very good soil (1)	per tower	58		$ -		$ -		$ -	$ 1 484	$ 86 072	$ 1 484	$ 86 072
2,11	'Type B Tower, Good soil submerged (2)	per tower	2		$ -		$ -		$ -	$ 4 126	$ 8 252	$ 4 126	$ 8 252
2,12	Type B Tower, Poor soil (4)	per tower	14		$ -		$ -		$ -	$ 9 986	$ 139 804	$ 9 986	$ 139 804
2,13	Type C Tower, Good rock at low depth (5a)	per tower	1		$ -		$ -		$ -	$ 1 508	$ 1 508	$ 1 508	$ 1 508
2,14	Type C Tower, Bad rock at low depth (5b)	per tower	1		$ -		$ -		$ -	$ 3 647	$ 3 647	$ 3 647	$ 3 647
2,15	'Type C Tower, Good Soil (3)	per tower	3		$ -		$ -		$ -	$ 3 776	$ 11 328	$ 3 776	$ 11 328
2,16	Type C Tower, Very good soil (1)	per tower	7		$ -		$ -		$ -	$ 2 687	$ 18 809	$ 2 687	$ 18 809
2,17	'Type C Tower, Good soil submerged (2)	per tower	0		$ -		$ -		$ -	$ 7 552	$ -	$ 7 552	$ -
2,18	Type C Tower, Poor soil (4)	per tower	2		$ -		$ -		$ -	$ 14 181	$ 28 362	$ 14 181	$ 28 362
2,19	Type D Tower, Good rock at low depth (5a)	per tower	0		$ -		$ -		$ -	$ 1 783	$ -	$ 1 783	$ -
2.20	Type D Tower, Bad rock at low depth (5b)	per tower	0		$ -		$ -		$ -	$ 4 319	$ -	$ 4 319	$ -
2,21	Type D Tower, Good Soil (3)	per tower	1		$ -		$ -		$ -	$ 4 409	$ 4 409	$ 4 409	$ 4 409
2,22	Type D Tower, Very good soil (1)	per tower	2		$ -		$ -		$ -	$ 2 966	$ 5 932	$ 2 966	$ 5 932
2,23	'Type D Tower, Good soil submerged (2)	per tower	0		$ -		$ -		$ -	$ 8 818	$ -	$ 8 818	$ -
2,24	Type D Tower, Poor soil (4)	per tower	0		$ -		$ -		$ -	$ 17 181	$ -	$ 17 181	$ -
2,25	Tower type A, foundation poor soil . Foundation type test to ultimate loads including mobilisation and all testing equipment in accordance with C3.6.13	per footing	1		$ -		$ -		$ -	$ 10 119	$ 10 119	$ 10 119	$ 10 119
2,26	Tower type A, foundation very good soil. Foundation type test to ultimate loads including mobilisation and all testing equipment in accordance with C3.6.13	per footing	1		$ -		$ -		$ -	$ 6 731	$ 6 731	$ 6 731	$ 6 731
2,27	Tower type A, foundation sgood soil. Foundation type test to ultimate loads including mobilisation and all testing equipment in accordance with C3.6.13	per footing	1		$ -		$ -		$ -	$ 7 445	$ 7 445	$ 7 445	$ 7 445
2,28	Anchor rod type test in accordance with C3.6.13	per anchor	0		$ -		$ -		$ -	$ 4 810	$ -	$ 4 810	$ -
	SUB - TOTAL CARRIED TO SUMMARY OF PRICES				$ -		$ -		$ -		$ 695 995		$ 695 995

110 kV LINE BURUNDI - RWANDA (BETWEEN KIGOMA AND RWEGURA)

No	ITEM	UNIT	EST Qty	Supply		Sea		Inland		Erection		Total price	
	DESCRIPTION			Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
3,0	**TOWER GROUNDING**												
	All tower groundings including excavation, laying of counterpoise, connection to towers including all clamps or other connections, corrosion protection, backfilling, compaction and measuring of ohmic value												
3,1	Basic grounding, consisting of 2 x three (3) ground rods 1m long and 5m counterpoise	per tower	271	$ 92	$ 24 801	$ 3	$ 868	$ 29	$ 7 936	$ 22	$ 6 056	$ 146	$ 39 661
3,2	Grading rings as specified in C4.4.3	per tower	2	$ 90	$ 180	$ 3	$ 6	$ 29	$ 58	$ 48	$ 95	$ 170	$ 339
3,3	Grounding comprising 7/4.0mm galvanised steel wire on all the line (twice)	km	103	$ 1 616	$ 166 448	$ 57	$ 5 826	$ 242	$ 24 967	$ 323	$ 33 290	$ 2 238	$ 230 530
	SUB - TOTAL CARRIED TO SUMMARY OF PRICES				191 429		6 700		32 961		39 441		270 531
4,0	**STEEL TOWERS**												
	Supply and erection of hot dip galvanised lattice steel towers according to the design including stubs, stub extensions, leg extensions, earthing connections and measuring of earth resistance and submittance of record to Employer/ Engineer, warning and da												
4,1	Type A Tower Basic body and crossarms (without legs) - Suspension 0 @ 2°	each	135	$ 3 080	$ 415 818	$ 137	$ 18 481	$ 1 217	$ 164 329	$ 379	$ 51 197	$ 4 814	$ 649 824
4,2	Type A Tower, Extra over for 7.0m Body Extension	each	54	$ 1 415	$ 76 421	$ 63	$ 3 396	$ 559	$ 30 201	$ 174	$ 9 409	$ 2 212	$ 119 427
4,3	Type A Tower, Extra over for each +0.0m Leg Extension	each	136	$ 62	$ 8 491	$ 3	$ 377	$ 25	$ 3 356	$ 8	$ 1 045	$ 98	$ 13 270
4,4	Type A Tower, Extra over for each +1.0m Leg Extension	each	72	$ 104	$ 7 492	$ 5	$ 333	$ 41	$ 2 961	$ 13	$ 922	$ 163	$ 11 709
4,5	Type A Tower, Extra over for each +2.0m Leg Extension	each	72	$ 146	$ 10 489	$ 6	$ 466	$ 58	$ 4 145	$ 18	$ 1 291	$ 228	$ 16 392
4,6	Type A Tower, Extra over for each +3.0m Leg Extension	each	72	$ 187	$ 13 486	$ 8	$ 599	$ 74	$ 5 330	$ 23	$ 1 660	$ 293	$ 21 075
4,7	Type A Tower, Extra over for each +4.0m Leg Extension	each	48	$ 229	$ 10 989	$ 10	$ 488	$ 90	$ 4 343	$ 28	$ 1 353	$ 358	$ 17 173
4,8	Type A Tower, Extra over for each +5.0m Leg Extension	each	84	$ 271	$ 22 726	$ 12	$ 1 010	$ 107	$ 8 981	$ 33	$ 2 798	$ 423	$ 35 516
4,9	Type A Tower, Extra over for each +6.0m Leg Extension	each	56	$ 312	$ 17 482	$ 14	$ 777	$ 123	$ 6 909	$ 38	$ 2 152	$ 488	$ 27 320
4,10	Type B Tower Basic body and crossarms (without legs) - Suspension 2 @ 15°	each	119	$ 4 956	$ 589 767	$ 200	$ 23 776	$ 1 948	$ 231 812	$ 599	$ 71 327	$ 7 703	$ 916 681
4,11	Type B Tower, Extra over for 4.0m Body Extension	each	28	$ 1 473	$ 41 256	$ 59	$ 1 663	$ 579	$ 16 216	$ 178	$ 4 989	$ 2 290	$ 64 124
4,13	Type B Tower, Extra over for each +0.0m Leg Extension	each	180	$ 100	$ 18 083	$ 4	$ 729	$ 39	$ 7 108	$ 12	$ 2 187	$ 156	$ 28 106

110 kV LINE BURUNDI - RWANDA (BETWEEN KIGOMA AND RWEGURA)

No	ITEM	UNIT	EST Qty	Supply		Sea		Inland		Erection		Total price	
	DESCRIPTION			Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
4,14	Type B Tower, Extra over for each +1.0m Leg Extension	each	72	$ 167	$ 12 055	$ 7	$ 486	$ 66	$ 4 738	$ 20	$ 1 458	$ 260	$ 18 738
4,15	Type B Tower, Extra over for each +2.0m Leg Extension	each	60	$ 234	$ 14 064	$ 9	$ 567	$ 92	$ 5 528	$ 28	$ 1 701	$ 364	$ 21 860
4,16	Type B Tower, Extra over for each +3.0m Leg Extension	each	84	$ 301	$ 25 316	$ 12	$ 1 021	$ 118	$ 9 951	$ 36	$ 3 062	$ 468	$ 39 349
4,17	Type B Tower, Extra over for each +4.0m Leg Extension	each	28	$ 368	$ 10 314	$ 15	$ 416	$ 145	$ 4 054	$ 45	$ 1 247	$ 573	$ 16 031
4,18	Type B Tower, Extra over for each +5.0m Leg Extension	each	24	$ 435	$ 10 448	$ 18	$ 421	$ 171	$ 4 107	$ 53	$ 1 264	$ 677	$ 16 239
4,19	Type B Tower, Extra over for each +6.0m Leg Extension	each	28	$ 502	$ 14 064	$ 20	$ 567	$ 197	$ 5 528	$ 61	$ 1 701	$ 781	$ 21 860
4,20	Type C Tower Basic body and crossarms (without legs) - DE 15 @ 60°	each	14	$ 6 613	$ 92 578	$ 270	$ 3 782	$ 2 598	$ 36 368	$ 847	$ 11 864	$ 10 328	$ 144 592
4,21	Type C Tower, Extra over for each +0.0m Leg Extension	each	28	$ 134	$ 3 753	$ 5	$ 153	$ 53	$ 1 474	$ 17	$ 481	$ 209	$ 5 862
4,22	Type C Tower, Extra over for each +1.0m Leg Extension	each	4	$ 223	$ 894	$ 9	$ 37	$ 88	$ 351	$ 29	$ 115	$ 349	$ 1 396
4,23	Type C Tower, Extra over for each +2.0m Leg Extension	each	0	$ 313	$ -	$ 13	$ -	$ 123	$ -	$ 40	$ -	$ 488	$ -
4,24	Type C Tower, Extra over for each +3.0m Leg Extension	each	4	$ 402	$ 1 609	$ 16	$ 66	$ 158	$ 632	$ 52	$ 206	$ 628	$ 2 512
4,25	Type C Tower, Extra over for each +4.0m Leg Extension	each	0	$ 491	$ -	$ 20	$ -	$ 193	$ -	$ 63	$ -	$ 768	$ -
4,26	Type C Tower, Extra over for each +5.0m Leg Extension	each	12	$ 581	$ 6 970	$ 24	$ 285	$ 228	$ 2 738	$ 74	$ 893	$ 907	$ 10 886
4,27	Type C Tower, Extra over for each +6.0m Leg Extension	each	8	$ 670	$ 5 362	$ 27	$ 219	$ 263	$ 2 106	$ 86	$ 687	$ 1 047	$ 8 374
4,28	Type D Tower Basic body and crossarms (without legs) - DE 60 @ 90°	each	3	$ 8 266	$ 24 798	$ 338	$ 1 013	$ 3 247	$ 9 741	$ 1 059	$ 3 178	$ 12 910	$ 38 730
4,29	Type D Tower, Extra over for each +0.0m Leg Extension	each	8	$ 168	$ 1 340	$ 7	$ 55	$ 66	$ 527	$ 21	$ 172	$ 262	$ 2 094
4,30	Type D Tower, Extra over for each +1.0m Leg Extension	each	0	$ 279	$ -	$ 11	$ -	$ 110	$ -	$ 36	$ -	$ 436	$ -
4,31	Type D Tower, Extra over for each +2.0m Leg Extension	each	0	$ 391	$ -	$ 16	$ -	$ 154	$ -	$ 50	$ -	$ 611	$ -
4,32	Type D Tower, Extra over for each +3.0m Leg Extension	each	0	$ 503	$ -	$ 21	$ -	$ 197	$ -	$ 64	$ -	$ 785	$ -
4,33	Type D Tower, Extra over for each +4.0m Leg Extension	each	0	$ 614	$ -	$ 25	$ -	$ 241	$ -	$ 79	$ -	$ 960	$ -
4,34	Type D Tower, Extra over for each +5.0m Leg Extension	each	0	$ 726	$ -	$ 30	$ -	$ 285	$ -	$ 93	$ -	$ 1 134	$ -
4,35	Type D Tower, Extra over for each +6.0m Leg Extension	each	4	$ 838	$ 3 351	$ 34	$ 137	$ 329	$ 1 316	$ 107	$ 429	$ 1 308	$ 5 234
4,36	Aircraft warning spheres 60cm diameter	each	0	$ 103	$ -	$ 5	$ -	$ 62	$ -	$ 12	$ -	$ 181	$ -
4,37	Welding of tower bolts & nuts and painting over with Anti-rust and galvanizing paint including Steel Cradle guards	per tower	271		0		0		0	$ 73	19699	$ 73	$ 19 699

No	ITEM	UNIT	EST Qty	Supply		Sea		Inland		Erection		Total price	
	DESCRIPTION			Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	SUB - TOTAL CARRIED TO SUMMARY OF PRICES				$ 1 459 415		$ 61 320		$ 574 850		$ 198 489		$ 2 294 073
5,0	**TOWER LOAD TESTS**												
	Tower type test to ultimate loading including, supply, erection and dismantling. The test shall include a minimum of 4 (four) Loading cases, (NB. cost of tests are split between Ethiopia and Djibouti)												
5,1	Tower type A	per test	1	$ 42 202	$ 42 202		$ -		$ -		$ -	$ 42 202	$ 42 202
5,2	Tower type B	per test	1	$ 46 341	$ 46 341		$ -		$ -		$ -	$ 46 341	$ 46 341
5,3	Tower type C	per test	1	$ 74 250	$ 74 250		$ -		$ -		$ -	$ 74 250	$ 74 250
	Tower type D	per test	1	$ 77 879	$ 77 879		$ -		$ -		$ -	$ 77 879	$ 77 879
5,4	Tower Type Test witnessing, as per A2.21	per trip	1	$ 18 259	$ 18 259		$ -		$ -		$ -	$ 18 259	$ 18 259
	SUB - TOTAL CARRIED TO SUMMARY OF PRICES				$ 258 931		$ -		$ -		$ -		$ 258 931
6,0	**LINE CONDUCTOR INSULATORS AND FITTINGS**												
	Supply and installation of Complete Insulator Sets including insulators, all types of clamps, armour rods, extension links, pilot insulator sets, counterweights and all connectiones to Tower.												
6,1	Normal Suspension insulator set for single "HAWK" conductor including all clamps and fittings, armour rods and connections to tower, arcing device both ends	each	528	$ 228	$ 120 384	$ 8	$ 4 213	$ 46	$ 24 077	$ 23	$ 12 144	$ 305	$ 160 818
6,2	Double Suspension insulator set for single "HAWK" conductor including all clamps and fittings, armour rods and connections to tower, arcing device both ends	each	0	$ 426	$ -	$ 15	$ -	$ 85	$ -	$ 45	$ -	$ 571	$ -
6,3	Normal Tension Insulator set for single "HAWK" conductor including all connections to towers, clamps and fittings, armor rods arcing device both ends.	each	570	$ 270	$ 153 900	$ 9	$ 5 387	$ 54	$ 30 780	$ 27	$ 15 390	$ 360	$ 205 457
6,4	Mid - span tension joint for "HAWK" conductor.	each	102	$ 13	$ 1 275	$ 0	$ 45	$ 2	$ 230	$ 10	$ 1 020	$ 25	$ 2 569
6,5	Electrical Performance Test witnessing of suspension strings as per A2.21, costs are split between Ethiopia and Djibouti	per test	1	$ 18 259	$ 18 259		$ -		$ -		$ -	$ 18 259	$ 18 259
6,6	Electrical Performance Test witnessing of tension strings as per A2.21, costs are split between Ethiopia and Djibouti	per test	1	$ 18 259	$ 18 259		$ -		$ -		$ -	$ 18 259	$ 18 259

No	ITEM	UNIT	EST Qty	Supply		Sea		Inland		Erection		Total price	
	DESCRIPTION			Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
	SUB - TOTAL CARRIED TO SUMMARY OF PRICES				$ 312 077		$ 9 645		$ 55 086		$ 28 554		$ 405 363
7,0	**OPGW FITTINGS AND ACCESSORIES**												
	Supply and installation of complete Sets of Fittings, including all types of clamps, extension links, armor rods, counterweights, earth bonds and all connectiones to Tower.												
7,1	Suspension set for OPGW	each	159	$ 117	$ 18 575	$ 4	$ 650	$ 20	$ 3 158	$ 25	$ 4 018	$ 166	$ 26 400
7,2	Straight through double Tension set for OPGW	each	75	$ 257	$ 19 287	$ 9	$ 675	$ 44	$ 3 279	$ 51	$ 3 817	$ 361	$ 27 058
7,3	Double dead end tension set, including down the tower connection to joint box on suspension or tension tower for OPGW	each	35	$ 300	$ 10 510	$ 11	$ 368	$ 51	$ 1 787	$ 95	$ 3 339	$ 457	$ 16 003
7,4	Tension terminal dead end down set for OPGW	each	2	$ 200	$ 400	$ 7	$ 14	$ 34	$ 68	$ 65	$ 130	$ 306	$ 612
7,5	Jointing Box for OPGW/OPGW, for use within the transmission line, including fixing, splicing and downlead clamps, with feed through sets, suitable for up to 72 SMF/ NZSDF fibres and OPGW, types as per specification	each	35	$ 1 295	$ 45 325	$ 45	$ 1 586	$ 220	$ 7 705	$ 338	$ 11 829	$ 1 898	$ 66 445
7,6	Terminal Box for OPGW/FOC, for the connection at substation gantry, including fixing, splicing and downlead clamps, for up to 72 SMF/ NZSDF fibres and OPGW/FOC, types as per specification	each	2	$ 1 254	$ 2 509	$ 44	$ 88	$ 213	$ 427	$ 687	$ 1 375	$ 2 199	$ 4 398
7,7	Suspension set for OHGW	per tower	176	$ 117	$ 20 592	$ 4	$ 721	$ 20	$ 3 501	$ 25	$ 4 410	$ 166	$ 29 223
7,8	Straight through double Tension set for OHGW	per tower	95	$ 257	$ 24 415	$ 9	$ 855	$ 44	$ 4 151	$ 51	$ 4 853	$ 361	$ 34 273
	SUB - TOTAL CARRIED TO SUMMARY OF PRICES				$ 141 613		$ 4 956		$ 24 074		$ 33 770		$ 204 413
8,0	**CONDUCTOR AND SHIELD WIRE**												
	Supply, stringing and installation including all joints, sleeves, jumper loops, spacers and necessary dampers, earthing connections and all downleads												
8,1	ACSR Conductor Code Name "HAWK"; 3 phases, simple bundled, stringing of single circuit.	route km	103	$ 14 481	$ 1 491 589	$ 507	$ 52 206	$ 2 172	$ 223 738	$ 3 982	$ 410 187	$ 21 143	$ 2 177 720
8,2	Single Optical Groundwire (OPGW) with 24 fibres, including all splicing and connections to joint boxes.	route km	103	$ 4 000	$ 412 000	$ 289	$ 29 764	$ 1 700	$ 175 100	$ 1 238	$ 127 561	$ 7 227	$ 744 425
8,3	Factory inspection, tests, conductors as per A2.21	per test	1	$ 18 259	$ 18 259		$ -		$ -		$ -	$ 18 259	$ 18 259
8,4	Factory inspection, tests, OPGW as per A2.21	per test	1	$ 18 259	$ 18 259		$ -		$ -		$ -	$ 18 259	$ 18 259

110 kV LINE BURUNDI - RWANDA (BETWEEN KIGOMA AND RWEGURA)

No	ITEM	UNIT	EST Qty	Supply		Sea		Inland		Erection		Total price	
	DESCRIPTION			Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount	Unit Price	Amount
8,5	Galvanized steel wire, OHGW, 9.1mm, nuance 1100	route km	103	$ 506	$ 52 118	$ 18	$ 1 824	$ 139	$ 14 332	$ 76	$ 7 818	$ 739	$ 76 092
	SUB - TOTAL CARRIED TO SUMMARY OF PRICES				$ 1 992 226		$ 83 794		$ 413 171		$ 545 566		$ 3 034 757

GÉNÉRAL WORK	$ 367 872,96
FOUNDATION	$ 695 994,50
3.0 TOWER GROUINDING	$ 270 530,63
4.0 STEEL TOWERS	$ 2 294 073,02
5.0 TOWER LOAD TESTS	$ 258 931,02
6.0 LINE CONDUCTOR INSULATORS AND FITTINGS	$ 405 362,67
7.0 OPGW FITTINGS AND ACCESSORIES	$ 204 413,05
8.0 CONDUCTOR AND SHIELD WIRE	$ 3 034 756,56
9.0 SPARES (1.9% of the total)	$ 143 106,75
SUBTOTAL	$ 7 675 041,16
SITE SUPERVISION (6%)	$ 460 502,47
CONTINGENCE	$ 767 504,12
TOTAL :	$ 8 903 047,74

SCHEDULE OF PRICES

SUPPLY AND ERECTION

KIGOMA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		Total Amount
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
1,0	**LIGHTNING ARRESTORS**													
1,1	108 kV, 10 kA		No.	3	4 000	**12 000**	**840**	**300**	**84**	**-**	**-**	300	**900**	**14 124**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				**-**	**12 000**	**840**	**300**	**84**	**-**	**-**	**-**	**900**	**14 124**
2,0	**CAPACITIVE VOLTAGE TRANSFORMERS**													
2,1	$\frac{110kV}{\sqrt{3}}$ / $\frac{0,1}{\sqrt{3}}$ / $\frac{0,1}{\sqrt{3}}$ kV CVT		No.	3	9 000	**27 000**	**1 890**	**675**	**189**	-	**-**	200	**600**	**30 354**
2,2	Line trap		No.	2	5 000	**10 000**	**700**	**250**	**70**	-	**-**	150	**300**	**11 320**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				**-**	**37 000**	**2 590**	**925**	**259**	**-**	**-**	**-**	**900**	**41 674**
3,0	**DISCONNECTOR**													
3,1	110 kV Disconnector, center break, with earthing switch		No.	1	20 000	**20 000**	**1 400**	**500**	**140**	-	**-**	1 600	**1 600**	**23 640**
3,2	110 kV Disconnector , 3-Pole		No.	0	18 000	**-**	**-**	**-**	**-**	-	**-**	1 500	**-**	**-**
3,3	110 kV Busbar Disconnector, pantographic type		No.	0	15 000	**-**	**-**	**-**	**-**	-	**-**	1 800	**-**	**-**
3,4	110 KV Disconnector, center break type		No.	1	18 000	**18 000**	**1 260**	**450**	**126**	-	**-**	1 801	**1 801**	**21 637**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				**-**	**38 000**	**2 660**	**950**	**266**	**-**	**-**	**6 701**	**3 401**	**45 277**

SCHEDULE OF PRICES

SUPPLY AND ERECTION

KIGOMA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
4,0	**CURRENT TRANSFORMERS**													
4,1	110 kV, 300-600/1/1/1A, 3 cores		No.	3	13 000	**39 000**	**2 730**	**975**	**273**	-	**-**	200	**600**	**43 578**
4,2			No.			**-**	**-**	**-**	**-**		**-**		**-**	**-**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				**-**	**39 000**	**2 730**	**975**	**273**	**-**	**-**	**-**	**600**	**43 578**
5,0	**CIRCUIT BREAKER**													
5,1	110 kV circuit breakers, live tank, 3 single pole		No.	1	80 000	**80 000**	**5 600**	**2 000**	**560**	-	**-**	2 500	**2 500**	**90 660**
5,2			No.		-	**-**	**-**	**-**	**-**	-	**-**	2 500	**-**	**-**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				**-**	**80 000**	**5 600**	**2 000**	**560**	**-**	**-**	**-**	**2 500**	**90 660**
6,0	**POWER TRANSFORMER**													
6,1	Power transformer, 110/33KV, 25/31,5 MVA, complete with rails and accessories		No	0	450 000	**-**	**-**	**-**	**-**	-	**-**	10 000	**-**	**-**
6,2	33 kV Grounding transformer		No	0	35 000	**-**	**-**	**-**	**-**	-	**-**	8 750	**-**	**-**
6,3	110 kV 10 MVAR 3 phase Shunt Reactor / Neutral reactor		No.	0	-	**-**	**-**	**-**	**-**	-	**-**	-	**-**	**-**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

SCHEDULE OF PRICES

SUPPLY AND ERECTION

KIGOMA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
7,0	**RIGID BUS SYSTEM AND INTER CONNECTION OF ELECTRICAL EQUIPMENT**													
7,1	Aluminium Alloy tube for 110 kV busbar		lot	0	8 000	-	-	-	-	-	-	2 500	-	-
7,2	Post insulators for 110 kV busbar		lot	0	8 000	-	-	-	-	-	-	1 500	-	-
7,3	110 kV Post insulators for line and transformer bay.		lot	0	6 000	-	-	-	-	-	-	1 000	-	-
7,4	Conductor, Insulator strings, Clamps and Hardware, aluminium conductor for equipment interconnections		lot	1	10 000	**10 000**	**700**	**250**	**70**	-	-	2 000	**2 000**	**13 020**
7,5	110 kV post insulator for shunt reactor bay		lot	0	-	-	-	-	-	-	-	-	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**10 000**	**700**	**250**	**70**	-	-	-	**2 000**	**13 020**
8,0	**FIBER OPTIC COMMUNICATION**													
8,1	PDH / SDH optical multiplexer equipment complete with all required functions		lot	1	26 700	**26 700**	**1 869**	**668**	**187**	-	-	350	**350**	**29 773**
8,2	Optical amplfier / booster		No	1	20 000	**20 000**	**1 400**	**500**	**140**	-	-	250	**250**	**22 290**
8,3	Telephone and data interfacing equipment (PCM, Digital distribution frame)		lot	1	21 500	**21 500**	**1 505**	**538**	**151**	-	-	250	**250**	**23 943**
8,4	Fiber optic cable		lot	1	1 700	**1 700**	**119**	**43**	**12**	-	-	1 300	**1 300**	**3 173**

SCHEDULE OF PRICES

SUPPLY AND ERECTION

KIGOMA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
8,5	PC based Network Management System		lot	1	11 000	**11 000**	**770**	**275**	**77**	-	-	1 400	**1 400**	**13 522**
8,6	Digital electronic exchange		No.	1	52 000	**52 000**	**3 640**	**1 300**	**364**	-	-	500	**500**	**57 804**
8,7	Normal subscriber set, desk type, indoor		No.	1	100	**100**	**7**	**3**	**1**	-	-	100	**100**	**210**
8,8	Outdoor subscriber set, wall type,weather proof		No.	1	1 200	**1 200**	**84**	**30**	**8**	-	-	150	**150**	**1 472**
8,9	Telephone cable		lot	1	1 100	**1 100**	**77**	**28**	**8**	-	-	1 500	**1 500**	**2 712**
8,10	Low voltage cables and all required installation material		lot	1	7 800	**7 800**	**546**	**195**	**55**	-	-	2 200	**2 200**	**10 796**
8,11	Connecting hardware, clamps and accessories		lot	1	1 100	**1 100**	**77**	**28**	**8**	-	-	600	**600**	**1 812**
8,12	Installation tools, mechanical fittings and cross connection cabinets		lot	1	4 200	**4 200**	**294**	**105**	**29**	-	-	250	**250**	**4 878**
8,13	Equipment not included in above but considered essential for complete installation and all interfacings. Give details in a separate sheet		lot	1	8 600	**8 600**	**602**	**215**	**60**	-	-	1 200	**1 200**	**10 677**
SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES					-	**157 000**	**10 990**	**3 925**	**1 099**	-	-	-	**10 050**	**183 064**

SCHEDULE OF PRICES

SUPPLY AND ERECTION

KIGOMA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
9,0						-	-	-	-		-		-	-
9,1	Cabinets complete with auxiliary devices and terminal blocks		No.	1	7 000	**7 000**	**490**	**175**	**49**	-	-	500	**500**	**8 214**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**7 000**	**490**	**175**	**49**	-	-	-	**500**	**8 214**
10,0	**33 KV METAL CLAD SWITCHGEAR**			0										
10,1	Transformer feeder with 33 kV + VT		No.	0	42 200	-	-	-	-	-	-	800	-	-
10,2	33 kV Line feeder cubicle		No.	0	40 000	-	-	-	-	-	-	800	-	-
10,3	33 kV auxiliary cubicle with all accessories.		No.	0	36 200	-	-	-	-	-	-	800	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-
11,0	**33 KV OUTDOOR EQUIPMENT**													
11,1	33 kV Disconnector with earthing switch, 3-pole, 630A, vertical break		No.	0	7 000	-	-	-	-	-	-	600	-	-
11,2	33 kV Disconnector with earthing switch, 3-pole, 1250A, vertical break		No.	0	13 000	-	-	-	-	-	-	500	-	-

SCHEDULE OF PRICES

SUPPLY AND ERECTION

KIGOMA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
11,3	27 kV, 10kA lightning arresror		No.	0	800	-	-	-	-	-	-	100	-	-
11,4	Support steel		lot	0	2 700	-	-	-	-	-	-	2 000	-	-
11,5	Bus, cable, conductor and hardware		No.	0	30 200	-	-	-	-	-	-	800	-	-
11,6	33/0.4 kV 315 KVA auxiliary transformer indoor type complete with all accessories		No.	0	26 600	-	-	-	-	-	-	800	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-
12.0	**CONTROL AND RELAY PANELS**													
12.1	Control and signalling panel for incoming & out going 110 kV line bays		No.	1	15 000	**15 000**	**1 050**	**375**	**105**	-	-	1 000	**1 000**	**17 530**
12.2	Control and signalling panel for 110/33 kV transformer		No.	0	15 000	-	-	-	-	-	-	1 000	-	-
12.3	Mosaic type Control, Metering and Signaling board		No.	0	45 000	-	-	-	-	-	-	1 000	-	-
12.4	Protection panel for 110 kV incoming & out going line bays		No.	1	60 000	**60 000**	**4 200**	**1 500**	**420**	-	-	1 000	**1 000**	**67 120**
12.5	Protection panel for 110/33 kV transformer bay		No.	0	30 000	-	-	-	-	-	-	1 000	-	-
12.6	Protection panel for grounding transformer		No.	0	5 000	-	-	-	-	-	-	1 000	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**75 000**	**5 250**	**1 875**	**525**	-	-	-	**2 000**	**84 650**

SCHEDULE OF PRICES

SUPPLY AND ERECTION

KIGOMA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
13,0	**Digital Control and Monitoring System**													
13,1	Common Equipment		lot	0	93 000	-	-	-	-	-	-	2 500	-	-
13,2	Furniture		lot	0	4 000	-	-	-	-	-	-	300	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-
14,0	**AC AUXILIARY SERVICES**													
14,1	AC auxiliary service board complete with all equipment		lot	0	14 000	-	-	-	-	-	-	600	-	-
14,2	Emergency lighting system DC 125 VDS lamps and emergency hand lamps system lighting		lot	0	22 500	-	-	-	-	-	-	4 500	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-
15,0	**DC AUXILIARY SERVICES**													
15,1	Battery 125 V complete with with all accessories (60 cells), 220 Ah		Sets	0	13 000	-	-	-	-	-	-	1 500	-	-
15,2	Battery charger, 125 V DC,50A, DC		Sets	0	9 000	-	-	-	-	-	-	400	-	-
15,3	125 V DC Distribution board		Sets	0	6 000	-	-	-	-	-	-	600	-	-
15,4	Battery 48 VDC battery complete with all accessories 26 cells, 220 Ah		No.	0	4 500	-	-	-	-	-	-	1 300	-	-

SCHEDULE OF PRICES

SUPPLY AND ERECTION

KIGOMA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
15,5	Battery charger, 48 V DC		No.	0	8 000	-	-	-	-	-	-	300	-	-
15,6	48VDC Distribution board		No	0	5 000	-	-	-	-	-	-	500	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-
16,0	**GALVANIZED STEEL STRUCTURES**													
16,1	Steel fabricated structure for 110 and 33 kV line termination intermediate gantries and switch yard bus support		lot	1	-	-	-	-	-	17 850	**17 850**	-	-	**17 850**
16,2	Steel fabricated structure for shield wire tower and switchyard lighting support		lot	1	-	-	-	-	-	12 000	**12 000**	-	-	**12 000**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	**29 850**	-	-	**29 850**
17,0	**RTU / SCADA INTERFACE PANEL**													
17,1	RTU Panel with all cabling and connecting		No.		10 200	-	-	-	-	-	-	300	-	-
17,2	SCADA Interface panels complete with all BCU, cables and connectors, PC, workstation, hardware and soft ware		No.		7 800	-	-	-	-	-	-	300	-	-
17,3	Cross connection panels		set		8 500	-	-	-	-	-	-	400	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-

SCHEDULE OF PRICES

SUPPLY AND ERECTION

KIGOMA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
18,0	**SUBSTATION GROUNDING**													
18,1	Cable, rods, conductor, connectors and hard ware		lot	1	5 000	**5 000**	**350**	**125**	**35**	-	-	2 000	**2 000**	**7 510**
18,2	Portable maintenance earthing cables, 3 phase set.		set	0	-	-	-	-	-	-	-	-	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**5 000**	**350**	**125**	**35**	-	-	-	**2 000**	**7 510**
19,0	**SHIELD WIRE SYSTEM**													
19,1	Conductor, Clamps and Hardware,etc		lot	1	1 000	**1 000**	**70**	**25**	**7**	-	-	500	**500**	**1 602**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**1 000**	**70**	**25**	**7**	-	-	-	**500**	**1 602**
20,0	**MISCELLANEOUS**													
20,1	Control and signalling cable		lot	1	5 000	**5 000**	**350**	**125**	**35**	-	-	5 000	**5 000**	**10 510**
20,2	Low voltage cable		lot	1	5 000	**5 000**	**350**	**125**	**35**	-	-	5 000	**5 000**	**10 510**
20,3	33 kV power cable		lot		30 000	-	-	-	-	-	-	4 100	-	-
20,4	Steel or plastic conduit and cable tray		lot	1	2 000	**2 000**	**140**	**50**	**14**	-	-	500	**500**	**2 704**
20,5	Switch yard lighting and power out lets		lot		35 000	-	-	-	-	-	-	10 200	-	-
20,6	Supply of Embedded steel parts		lot		6 000	-	-	-	-	-	-	900	-	-
20,7	Boxes for padlocks and keys		lot		500	-	-	-	-	-	-	100	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**12 000**	**840**	**300**	**84**	-	-	-	**10 500**	**23 724**

SCHEDULE OF PRICES

SUPPLY AND ERECTION

KIGOMA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
21,0	**CIVIL WORKS**													
21,1	General site preparation & earth work including internal access road, drainage system, gravelling substation area, gate and fences		lot	1	-	-	-	-	-	10 000	**10 000**	-	-	**10 000**
21,2	Equipment fundations and embedded parts		lot	1	-	-	-	-	-	68 800	**68 800**	-	-	**68 800**
21,3	Control building		lot	0	-	-	-	-	-	-	-	-	-	-
21,4	Water supply System, Septic tank and spetic system		lot	0	-	-	-	-	-	-	-	-	-	-
21,5	Cable tranches, ducts and covers		lot	1	-	-	-	-	-	5 571	**5 571**	-	-	**5 571**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	**84 371**	-	-	**84 371**

NB:- The column designated as 'civil works' shall include the costs of civil design, supply of design drawings, materials and civil construction!!

SCHEDULE OF PRICES

SUPPLY AND ERECTION

RWEGURA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
1,0	**LIGHTNING ARRESTORS**													
1,1	108 kV, 10 kA		No.	3	4 000	**12 000**	**840**	**300**	**84**	-	-	300	**900**	**14 124**
1,2	27 kV 10 kA outdoor type		No.	0	700	-	-	-	-	-	-	100	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**12 000**	**840**	**300**	**84**	-	-	-	**900**	**14 124**
2,0	**CAPACITIVE VOLTAGE TRANSFORMERS**													
2,1	110kV/√3 / 0,1/√3 / 0,1/√3 kV CVT		No.	3	9 000	**27 000**	**1 890**	**675**	**189**	-	-	200	**600**	**30 354**
2,2	Line trap		No.	0	5 000	-	-	-	-	-	-	150	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**27 000**	**1 890**	**675**	**189**	-	-	-	**600**	**30 354**
3,0	**DISCONNECTOR**													
3,1	110 kV Line Disconnector with earthing switch , 3-Pole		No.	1	20 000	**20 000**	**1 400**	**500**	**140**	-	-	1 600	**1 600**	**23 640**
3,2	110 kV Disconnector , 3-Pole		No.	0	18 000	-	-	-	-	-	-	1 500	-	-
3,3	110 kV Busbar Disconnector, pantographic type		No.	0	15 000	-	-	-	-	-	-	1 800	-	-
3,4	110 KV Disconnector, center break type		No.	1	18 000	**18 000**	**1 260**	**450**	**126**	-	-	1 801	**1 801**	**21 637**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**38 000**	**2 660**	**950**	**266**	-	-	**6 701**	**3 401**	**45 277**

RWEGURA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
4,0	**CURRENT TRANSFORMERS**													
4,1	110 kV, 300-600/1/1/1A, 3 cores		No.	3	13 000	**39 000**	**2 730**	**975**	**273**	-	-	200	**600**	**43 578**
4,2			No.			-	-	-	-		-		-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**39 000**	**2 730**	**975**	**273**	-	-	-	**600**	**43 578**
5,0	**CIRCUIT BREAKER**													
5,1	110 kV circuit breakers, live tank, 3 single pole		No.	1	80 000	**80 000**	**5 600**	**2 000**	**560**	-	-	2 500	**2 500**	**90 660**
5,2			No.		-	-	-	-	-	-	-	2 500	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**80 000**	**5 600**	**2 000**	**560**	-	-	-	**2 500**	**90 660**
6,0	**POWER TRANSFORMER**													
6,1	Power transformer, 110/33KV, 30/37,5 MVA, complete with rails and accessories		No	0	450 000	-	-	-	-	-	-	10 000	-	-
6,2	33 kV Grounding transformer		No	0	35 000	-	-	-	-	-	-	8 750	-	-
6,3	110 kV 10 MVAR 3 phase Shunt Reactor / Neutral reactor		No.	0	-	-	-	-	-	-	-	-	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-

SCHEDULE OF PRICES

SUPPLY AND ERECTION

RWEGURA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
7,0	**RIGID BUS SYSTEM AND INTER CONNECTION OF ELECTRICAL EQUIPMENT**													
7,1	Aluminium Alloy tube for 110 kV busbar		lot	0	8 000	-	-	-	-	-	-	2 500	-	-
7,2	Post insulators for 110 kV busbar		lot	0	8 000	-	-	-	-	-	-	1 500	-	-
7,3	110 kV Post insulators for line and transformer bay.		lot	0	6 000	-	-	-	-	-	-	1 000	-	-
7,4	Conductor, Insulator strings, Clamps and Hardware, aluminium conductor for equipment interconnections		lot	1	10 000	**10 000**	**700**	**250**	**70**	-	-	2 000	**2 000**	**13 020**
7,5	110 kV post insulator for shunt reactor bay		lot	0	-	-	-	-	-	-	-	-	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**10 000**	**700**	**250**	**70**	-	-	-	**2 000**	**13 020**
8,0	**FIBER OPTIC COMMUNICATION**													
8,1	PDH / SDH optical multiplexer equipment complete with all required functions		lot	1	26 700	**26 700**	**1 869**	**668**	**187**	-	-	350	**350**	**29 773**
8,2	Optical amplfier / booster		No	1	20 000	**20 000**	**1 400**	**500**	**140**	-	-	250	**250**	**22 290**
8,3	Telephone and data interfacing equipment (PCM, Digital distribution frame)		lot	1	21 500	**21 500**	**1 505**	**538**	**151**	-	-	250	**250**	**23 943**
8,4	Fiber optic cable		lot	1	1 700	**1 700**	**119**	**43**	**12**	-	-	1 300	**1 300**	**3 173**

SCHEDULE OF PRICES

SUPPLY AND ERECTION

RWEGURA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
8,5	PC based Network Management System		lot	1	11 000	**11 000**	**770**	**275**	**77**	-	-	1 400	**1 400**	**13 522**
8,6	Digital electronic exchange		No.	1	52 000	**52 000**	**3 640**	**1 300**	**364**	-	-	500	**500**	**57 804**
8,7	Normal subscriber set, desk type, indoor		No.	1	100	**100**	**7**	**3**	**1**	-	-	100	**100**	**210**
8,8	Outdoor subscriber set, wall type,weather proof		No.	1	1 200	**1 200**	**84**	**30**	**8**	-	-	150	**150**	**1 472**
8,9	Telephone cable		lot	1	1 100	**1 100**	**77**	**28**	**8**	-	-	1 500	**1 500**	**2 712**
8,10	Low voltage cables and all required installation material		lot	1	7 800	**7 800**	**546**	**195**	**55**	-	-	2 200	**2 200**	**10 796**
8,11	Connecting hardware, clamps and accessories		lot	1	1 100	**1 100**	**77**	**28**	**8**	-	-	600	**600**	**1 812**
8,12	Installation tools, mechanical fittings and cross connection cabinets		lot	1	4 200	**4 200**	**294**	**105**	**29**	-	-	250	**250**	**4 878**
8,13	Equipment not included in above but considered essential for complete installation and all interfacings. Give details in a separate sheet		lot	1	8 600	**8 600**	**602**	**215**	**60**	-	-	1 200	**1 200**	**10 677**
SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES					-	**157 000**	**10 990**	**3 925**	**1 099**	-	-	-	**10 050**	**183 064**

SCHEDULE OF PRICES

SUPPLY AND ERECTION

RWEGURA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
9,0						-	-	-	-		-		-	-
9,1	Cabinets complete with auxiliary devices and terminal blocks		No.	1	7 000	**7 000**	**490**	**175**	**49**	-	-	500	**500**	**8 214**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**7 000**	**490**	**175**	**49**	-	-	-	**500**	**8 214**
10,0	**33 KV METAL CLAD SWITCHGEAR**			0										
10,1	Transformer feeder with 33 kV + VT		No.	0	42 200	-	-	-	-	-	-	800	-	-
10,2	33 kV Line feeder cubicle		No.	0	40 000	-	-	-	-	-	-	800	-	-
10,3	33 kV auxiliary cubicle with all accessories.		No.	0	36 200	-	-	-	-	-	-	800	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-
11,0	**33 KV OUTDOOR EQUIPMENT**													
11,1	33 kV Disconnector with earthing switch, 3-pole, 630A, vertical break		No.	0	7 000	-	-	-	-	-	-	600	-	-
11,2	33 kV Disconnector with earthing switch, 3-pole, 1250A, vertical break		No.	0	13 000	-	-	-	-	-	-	500	-	-

SCHEDULE OF PRICES

SUPPLY AND ERECTION

RWEGURA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
11,3	27 kV, 10kA lightning arresror		No.	0	800	-	-	-	-	-	-	100	-	-
11,4	Support steel		lot	0	2 700	-	-	-	-	-	-	2 000	-	-
11,5	Bus, cable, conductor and hardware		No.	0	30 200	-	-	-	-	-	-	800	-	-
11,6	33/0.4 kV 315 KVA auxiliary transformer indoor type complete with all accessories		No.	0	26 600	-	-	-	-	-	-	800	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-
12.0	**CONTROL AND RELAY PANELS**													
12.1	Control and signalling panel for incoming & out going 110 kV line bays		No.	1	15 000	**15 000**	**1 050**	**375**	**105**	-	-	1 000	**1 000**	**17 530**
12.2	Control and signalling panel for 110/33 kV transformer		No.	0	15 000	-	-	-	-	-	-	1 000	-	-
12.3	Mosaic type Control, Metering and Signaling board		No.	0	45 000	-	-	-	-	-	-	1 000	-	-
12.4	Protection panel for 110 kV incoming & out going line bays		No.	1	60 000	**60 000**	**4 200**	**1 500**	**420**	-	-	1 000	**1 000**	**67 120**
12.5	Protection panel for 110/33 kV transformer bay		No.	0	30 000	-	-	-	-	-	-	1 000	-	-
12.6	Protection panel for grounding transformer		No.	0	5 000	-	-	-	-	-	-	1 000	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**75 000**	**5 250**	**1 875**	**525**	-	-	-	**2 000**	**84 650**

RWEGURA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
13,0	**Digital Control and Monitoring System**													
13,1	Common Equipment		lot	0	93 000	-	-	-	-	-	-	2 500	-	-
13,2	Furniture		lot	0	4 000	-	-	-	-	-	-	300	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-
14,0	**AC AUXILIARY SERVICES**													
14,1	AC auxiliary service board complete with all equipment		lot	0	14 000	-	-	-	-	-	-	600	-	-
14,2	Emergency lighting system DC 125 VDS lamps and emergency hand lamps system lighting		lot	0	22 500	-	-	-	-	-	-	4 500	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-
15,0	**DC AUXILIARY SERVICES**													
15,1	Battery 125 V complete with with all accessories (60 cells), 220 Ah		Sets	0	13 000	-	-	-	-	-	-	1 500	-	-
15,2	Battery charger, 125 V DC,50A, DC		Sets	0	9 000	-	-	-	-	-	-	400	-	-
15,3	125 V DC Distribution board		Sets	0	6 000	-	-	-	-	-	-	600	-	-
15,4	Battery 48 VDC battery complete with all accessories 26 cells, 220 Ah		No.	0	4 500	-	-	-	-	-	-	1 300	-	-

SCHEDULE OF PRICES

SUPPLY AND ERECTION

RWEGURA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
15,5	Battery charger, 48 V DC		No.	0	8 000	-	-	-	-	-	-	300	-	-
15,6	48VDC Distribution board		No	0	5 000	-	-	-	-	-	-	500	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-
16,0	**GALVANIZED STEEL STRUCTURES**													
16,1	Steel fabricated structure for 110 and 33 kV line termination intermediate gantries and switch yard bus support		lot	1	-	-	-	-	-	14 100	**14 100**	-	-	**14 100**
16,2	Steel fabricated structure for shield wire tower and switchyard lighting support		lot		-	-	-	-	-	-	-	-	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	**14 100**	-	-	**14 100**
17,0	**RTU / SCADA INTERFACE PANEL**													
17,1	RTU Panel with all cabling and connecting		No.	0	10 200	-	-	-	-	-	-	300	-	-
17,2	SCADA Interface panels complete with all BCU, cables and connectors, PC, workstation, hardware and soft ware		No.	0	7 800	-	-	-	-	-	-	300	-	-
17,3	Cross connection panels		set	0	8 500	-	-	-	-	-	-	400	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	-	-	-	-	-	-	-	-	-

SCHEDULE OF PRICES

SUPPLY AND ERECTION

RWEGURA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
18,0	**SUBSTATION GROUNDING**													
18,1	Cable, rods, conductor, connectors and hard ware		lot	1	5 000	**5 000**	**350**	**125**	**35**	-	-	2 000	**2 000**	**7 510**
18,2	Portable maintenance earthing cables, 3 phase set.		set	1	6 000	**6 000**	**420**	**150**	**42**	-	-	300	**300**	**6 912**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**11 000**	**770**	**275**	**77**	-	-	-	**2 300**	**14 422**
19,0	**SHIELD WIRE SYSTEM**													
19,1	Conductor, Clamps and Hardware,etc		lot	1	1 000	**1 000**	**70**	**25**	**7**	-	-	500	**500**	**1 602**
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**1 000**	**70**	**25**	**7**	-	-	-	**500**	**1 602**
20,0	**MISCELLANEOUS**													
20,1	Control and signalling cable		lot	1	5 000	**5 000**	**350**	**125**	**35**	-	-	5 000	**5 000**	**10 510**
20,2	Low voltage cable		lot	1	5 000	**5 000**	**350**	**125**	**35**	-	-	5 000	**5 000**	**10 510**
20,3	33 kV power cable		lot	0	30 000	-	-	-	-	-	-	4 100	-	-
20,4	Steel or plastic conduit and cable tray		lot	1	2 000	**2 000**	**140**	**50**	**14**	-	-	500	**500**	**2 704**
20,5	Switch yard lighting and power out lets		lot	0	35 000	-	-	-	-	-	-	10 200	-	-
20,6	Supply of Embedded steel parts		lot	0	6 000	-	-	-	-	-	-	900	-	-
20,7	Boxes for padlocks and keys		lot	0	500	-	-	-	-	-	-	100	-	-
	SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES				-	**12 000**	**840**	**300**	**84**	-	-	-	**10 500**	**23 724**

SCHEDULE OF PRICES

SUPPLY AND ERECTION

RWEGURA 110/33 kV SUBSTATION

ALL RATES AND AMOUNTS IN : **USD**

Item	Description	Reference	Unit	Est. Qty.	Supply (FOB)		Inland transport.	Sea transport	Insurance	Civil Works		Erection, Testing & commissioning		
					Unit Price	Amount	Amount	Amount	Amount	Unit Price	Amount	Unit Price	Amount	Total Amount
21,0	**CIVIL WORKS**													
21,1	General site preparation & earth work including internal access road, drainage system, gravelling substation area, gate and fences		lot	1	-	-	-	-	-	10 000	**10 000**	-	-	**10 000**
21,2	Equipment fundations and embedded parts		lot	1	-	-	-	-	-	16 000	**16 000**	-	-	**16 000**
21,3	Control building		lot	0	-	-	-	-	-	-	-	-	-	-
21,4	Water supply System, Septic tank and spetic system		lot	0	-	-	-	-	-	-	-	-	-	-
21,5	Cable tranches, ducts and covers		lot	1	-	-	-	-	-	5 527	**5 527**	-	-	**5 527**
SUB-TOTAL CARRIED OUT TO SUMMARY OF PRICES					-	-	-	-	-	-	**31 527**	-	-	**31 527**

NB:- The column designated as 'civil works' shall include the costs of civil design, supply of design drawings, materials and civil construction!!

ANNEX J – REFERENCES

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ANNEX K – CONSULTED PARTIES

List of consulted Parties during site and line route investigation

Liste des Personnes et organismes rencontrés au Burundi

Nom et prénom	Position	Institution
Monsieur Herménégilde RUPEREZA	Coordonnateur des programmes	Geste humanitaire
Madame Solange HABONIMANA	Directrice Adjointe	Office national du Tourisme (ONT), Ministère de l'Environnement et de l'Aménagement du Territoire
Madame Emmanuella NGENZEBUHORO	Directrice de l'Environnement	Direction générale de l'Environnement, Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement
Monsieur Astère BARAGWANDIKA	Directeur des Forêts	Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement
Monsieur Damien NINDORERA	Conseiller juridique	Institut National pour l'Environnement et la Conservation de la Nature (INECN), Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement
Monsieur Alphonse FOFO	Conseiller principal du Directeur Général	Institut National pour l'Environnement et la Conservation de la Nature (INECN), Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement
Monsieur Gabriel HAKIZIMANA	Directeur de l'Environnement	Institut National pour l'Environnement et la Conservation de la Nature (INECN), Ministère de l'Environnement et de l'Aménagement du Territoire
Monsieur Édouard NIYONZIMA	Trésorier	Association de protection de l'environnement Biraturaba
Madame Odette KAYITESI	Ministre	Ministère de l'Aménagement du Territoire, du Tourisme et de l'environnement
Monsieur Anaclet NZIRIKWA'	Conseiller Juridique	Ministère de l'Aménagement du Territoire, du tourisme et de l'Environnement
Monsieur Ruzima SALVATOR	Coordonnateur National	Projet Action environnementale du Bassin du Nil
Col. Joseph NZEYIMANA	Directeur	Régie des Services aéronautiques
Ir. Didace YAMUREMYE	Chargé des infrastructures	Régie des Services aéronautiques
Monsieur Damien NINDORERA	Conseiller Juridique	Institut National pour l'Environnement et la Conservation de la Nature (INECN), Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement
Monsieur Oscar NDAYIZIGA	Directeur Général	Institut National pour l'Environnement et la Conservation de la Nature (INECN), Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement

Nom et prénom	Position	Institution
Monsieur Alphonse FOFO	Conseiller principal à l'INECN, chargé de la gestion de la Réserve de la Rusizi	Institut National pour l'Environnement et la Conservation de la Nature (INECN), Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement
Monsieur Léonidas BAMBARA	Conseiller a la Direction Technique de l'INECN et ancien Chef de Parc National de la Kibira	Institut National pour l'Environnement et la Conservation de la Nature (INECN), Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement
Monsieur Louis NDUWIMANA	Chef de programme	Programme Lutte contre la pauvreté au PNUD Bujumbura
Monsieur Dieudonné NDAGIJEMANA	Directeur Technique à l'INECN charge de la gestion des aires protégées	Institut National pour l'Environnement et la Conservation de la Nature (INECN), Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement
Monsieur Pierre BARAMPANZE	Directeur de l'énergie au Burundi	Ministère de l'Énergie et des Mines
Madame Aline IRIMBERE	Conseillère	Département de l'Environnement, de la Recherche et de l'Éducation Environnementales de l'Institut National pour l'Environnement et la Conservation de la Nature (INECN), Ministère de l'Aménagement du Territoire, du Tourisme et de l'Environnement
Monsieur NOLASQUE	Conseiller principal	Département de l'Énergie, Direction Générale de l'Eau et de l'Énergie, Ministère de l'Énergie et des Mines
Monsieur Térence MBONABUCA	Directeur Général	Administration du Territoire
Monsieur Gabriel KANYAMUGAMBWE	Chef	Réserve naturelle de la Rusizi
Monsieur Freddy NIYONGERE	Technicien Principal	Société Nationale d'Électricité

Liste des Personnes et organismes rencontrés au Rwanda

Nom et prénom	Position	Institution
M Augustin HATEGEKA	Chargé d'étude et Planification	Projet UPEGAZ[1] , MININFRA[2]
M Aloys Makuza Kanamugire	Directeur Technique/Electricité	ELECTROGAZ
M Charles Kanyamihigo	Directeur d'exploitation/électricité	ELECTROGAZ
M Gaspard Niyiragira	Assistant technique/Aménagement des marais	Projet d'Appui au Secteur Rural/MINAGRI
M Stany Nizeyimana	Chef de la Centrale Electrique de Gisenyi	ELECTROGAZ
M Paul Mbonimpa	Chef de la Station de Gisenyi	ELECTROGAZ
M Méthode Ntagungira	Chef de Poste de Ngoma/Butare	ELECTROGAZ
M Josaphate Mugemanyi	Chef de la Station Butare	ELECTROGAZ
M Jacinthe Sana	Chef de Poste de Kigoma	ELECTROGAZ
M Gaspard Niyiragira	Assistant technique/Aménagement des marais	Projet d'Appui au Secteur Rural/MINAGRI[3]
M Désiré Florent Nzayanga	Chargé de Programme Enérgetique	Initiative du Bassin du Nil
M Albert Yaramba	Coordinateur du projet	Projet National d'Alimentation en eau potable et Assainissement en Milieu Rural
M Frank Rutabingwa	Coordinateur du Projet	Projet d'Appui à la foresterie (PAFOR)
M Robert Kashemeza	Maire	District de Nyagatare/Province de l'Est
M Daniel	Chargé de la Carte pédologique	MINAGRI
M Syldio Gakwisi	Chargé du service d'analyse des données météorologiques	Service National de Météorologie/MININFRA
M Vital Nzabanita	Chargé de la Cartographie	Service National des Statistiques/MINECOFIN[4]
M Innocent Gashugi	Chargé d'Etude d'Impact Environnemental	Rwanda Environment Management Authority/MINITERE
M Eugène Kayijamahe	Chargé de Recherche au Centre GIS de Butare	Université National de Butare
M Kayitaba Gallican	Coordinateur du Groupe de travail chargé de préparer le Schéma Directeur d'Utilisation des Terres au Rwanda	MINITERE[5]
Mme Prisca Mujawayezu	Secrétaire Exécutive	Conseil de Concertation des Organisations d'appui aux Initiatives de Base/CCOAIB

[1] UPEGAZ : Unité de production et d'extraction du gaz
[2] MINIFRA : Ministère des Infrastructures
[3] MINAGRI : Ministère de l'Agriculture et de l'énergie
[4] MINECOFIN : Ministère des Finances et de la Planification économique
[5] MINITERE : Ministère des Terres, de l'Environnement, des Forêts, de l'Eau et des Mines.

Nom et prénom	Position	Institution
Mme Agnès Mujawayezu	Secrétaire Exécutive	Collectif des Organisations Rwandaises de Promotion de la Femme, de la Paix et du Développement (PROFEMME TWESE HAMWE).
M Fidèle Ruzigandekwe	Directeur Exécutif	Agence Rwandaise de Conservation de la Faune et la Flore Sauvage/Rwanda Wildlife Agency
M Donatien	Chargé de l'expropriation	MINITERE
M Adrien Ruberanziza	Chargé des juridictions Gacaca/Habitant du Village de Birembo	Cellule Runyinya/Village de Birembo
M Roger MUGISHA	Agent	Institut National de Statistique/Kigali
M Denis	Chargé de la Cartographie	Electrogaz, Kigali
M Népomuscène RUGEMINTWAZA	Chargé du suivi évaluation	Projet d' appui à la décentralisation /PNUD/MINALOC, Kigali
M Didace KAYIRANGA	Chercheur	Institut Agronomique du Rwanda(ISAR/Rubona)
M Ignace RWAKAYIRU	Consultant, Expert en Politique de population	Centre CIEDEP/Kigali
M Antoine KAPITENI	Coordinateur	Projet de Gestion intégré des écosystèmes critiques, MINITERE, Kigali
M Viateur NGIRUWONSANGA	Coordinateur	Projet SIG/HIMO(Système intégré de Gestion de Haute intensité de Main d' oeuvre)/Halpage Rwanda, Ruhengeri
Mme Rita RWIRANGIRA	Chargée du Rapatriement et Réintégration d es réfugiés	Conseil National pour les Réfugiés, Kigali
M Hycinthe SANA	Chef de poste de Transformation électrique	Kigoma
Mme Yvonne MUREBWAYIRE	Chargée des Relations Publiques	Association PRO Femmes Twese Hamwe, Kigali
Mme Claudine ZANINKA	Chef de Division	Direction de la planification Stratégique et de Suivi de Réduction de la Pauvreté, MINECOFIN, Kigali
		ORTPN, Kigali
		Université National du Rwanda, Butare
		Musée National du Rwanda, Butare

ANNEX L – PHOTOS ALONG THE CORRIDOR

Départ Ligne 110 kV – Poste Rwegura

Au Nord de Rwegura

Départ des Lignes – Poste Kigoma

Ligne 30 kV – Butare

ANNEX M – RURAL ELECTRIFICATION

CONTENTS

1. RURAL ELECTRIFICATION

1.1. INTRODUCTION

In developing countries numerous cases can be found of small towns, villages and farms located alongside HV transmission lines but which are not electrified because these HV lines serve only to supply electricity to the main towns or to evacuate the power produced by distant electricity generating plants. These villages are sometimes more than 100 km from the nearest HV/MV transformer substation. In view of the small quantities of power to be supplied (a few tens or hundreds of kW) and the considerable distances to cover, the use of conventional three-phase MV lines and/or additional HV/MV substations is not economically justifiable in spite of the social aspects, and also leads to additional impacts on the environment.

It is more logical to consider the use of the HV lines passing in the vicinity of villages to supply them with electricity. Several techniques exist and are discussed below. An additional advantage is also worth considering insofar as the villagers would appreciate the benefits of an HV line providing them with electricity whereas, if this were not the case, there would only be drawbacks from having the power line near them.

The purpose of this section is to determine whether rural electrification from new HV transmission lines can be justified and, if so, define the most appropriate technique to achieve this objective. The various rural electrification techniques from HV power lines are therefore presented in the first part. This is followed by a specific analysis for each of the lines involved in the interconnection project.

1.2. SCOPE OF THE STUDY

The comparison of the various rural electrification solutions is limited to the supply of "rural electrification source substations", in other words MV or LV substations spread out along the HV lines and which will supply villages or other small load centres.

The actual MV or LV rural networks (i.e., power lines from the source substations to the villages, or lines between villages, for example) are not described or compared in this part since their technology is conventional and is independent of the supply scheme to the rural electrification source substations.

The recommended solutions must also be appreciated taking into account solutions that have already been developed or tested in the countries, in order to minimise the use of different technologies along any one interconnection line. For example, having a single parts list for the same technology leads to appreciable savings. The same argument can be used for training of operators.

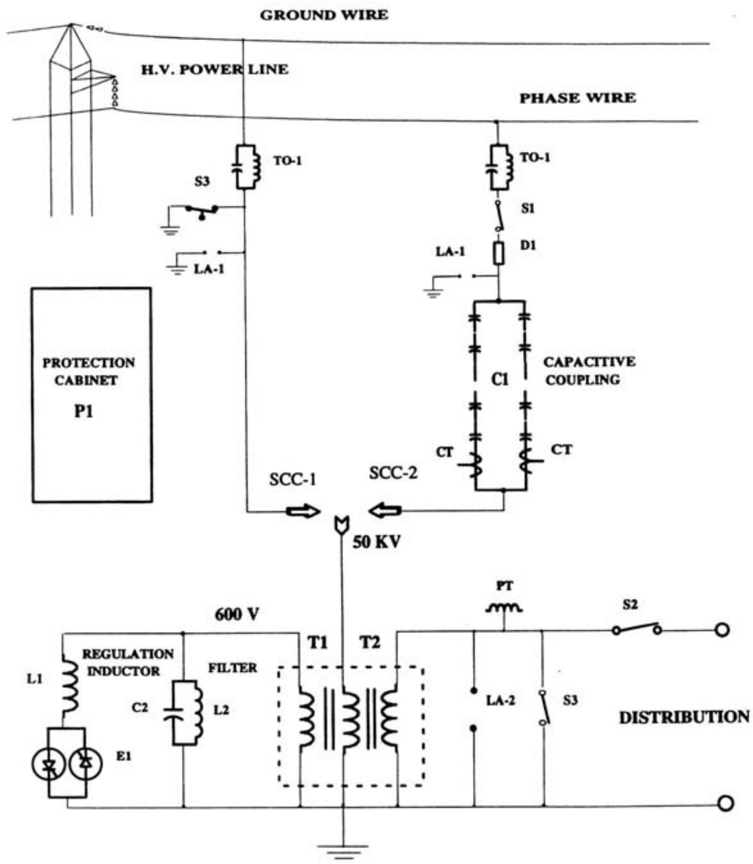
1.3. POSSIBLE SOLUTIONS

Apart from the basic solution consisting in creating a simplified HV/MV substation and constructing MV lines parallel to the HV line, four possible solutions can be considered and are described below:

- capacitive coupling
- capacitive transformer substations,
- SF6 single-phase voltage transformers,
- insulated overhead earth wires.

1.3.1. CAPACITIVE COUPLING

Capacitive coupling distribution diagrams have been proposed by IREQ (Canada) and are described in the publication "Capacitive Coupling Substations" by CEGELEC/BC CHECO-IREQ. A simplified diagram is given below.



In this diagram, called SCC (Capacitive Coupling System), small load centres are supplied with induced voltage by capacitive coupling from an insulated overhead earth wire or phase conductor of an HV line section, by means of a MV/LV transformer connected between the floating potential cable and earth. This method can be used only for supplying very small single-phase loads (of the order of 0.5 kW per km of insulated cable in a 161 kV single circuit line). This method is thus particularly well suited for supplying radio relays or other information repeaters although it also competes with solar-panel supply systems over which it nonetheless has the advantage of not requiring bulky chargers and batteries.

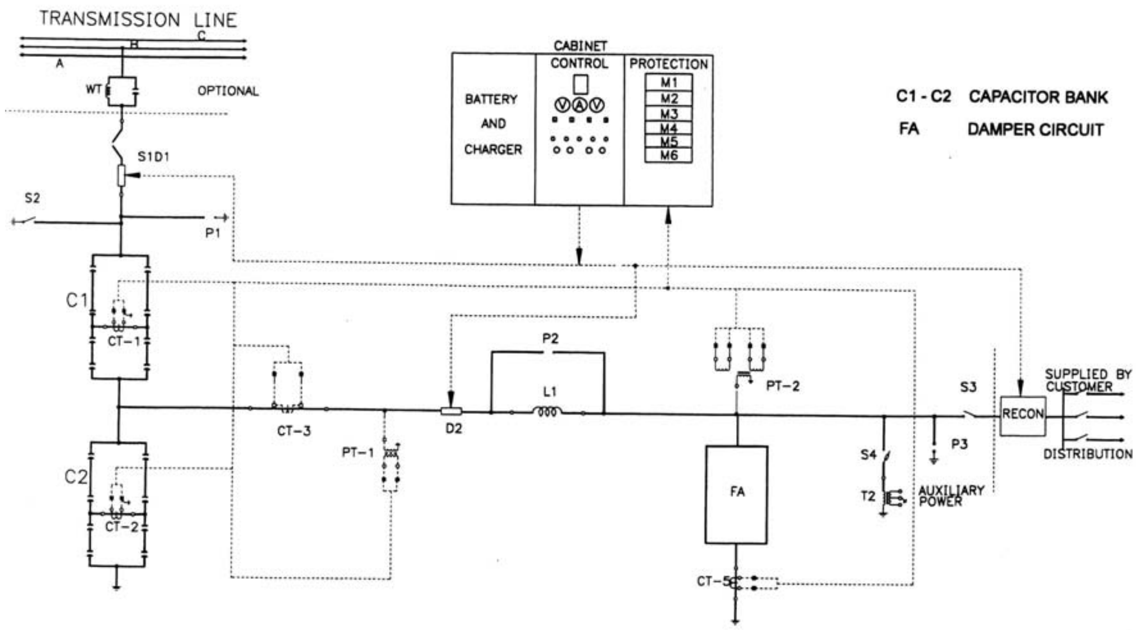
IREQ gives details of a single-phase supply of up to 70 kVA in a 220 kV line. Special equipment (thyristor-controlled inductance and filter circuit) is required in each village in order to obtain a relatively constant voltage in spite of load variations. The SCC in fact operates as a voltage distributor in which one branch is the constant equivalent capacity between the floating cable and the HV circuit conductors, and the other branch is the variable impedance of the load transferred to the MV/LV transformer primary, thus explaining the need for voltage adjustment.

The SCC scheme with floating cable(s) is not applicable to the rural electrification aspect of the Nile equatorial lakes subsidiary action programme, for the following reasons:

- The power levels that it is possible to supply are very low, two orders of magnitude lower than the power of an insulated overhead earth wire scheme (10 000-12 000 kW),
- The scheme does not allow normal three-phase distribution, which is preferable or even necessary in certain villages.

1.3.2. CAPACITIVE TRANSFORMER SUBSTATIONS

For the three-phase supply of relatively high loads (up to 2000 kVA) IREQ has proposed a scheme with three-phase capacitive divider bridge consisting of three high-power capacitor banks as illustrated by the following diagram.



To prevent voltage fluctuations due to load variations, and to minimise voltage surges during short-circuits on the distribution network, IREQ uses an inductance protected by a metal oxide variator connected in parallel. To prevent ferroresonance, a complex damper circuit is also required. The three-phase capacitor bank (with a power of about 15 MVAR) is protected by a load interrupter or by a circuit-breaker on the HV power supply side and by conventional protection systems of the HV capacitor banks.

Three-phase HV capacitor bank substations are proposed as a replacement for the conventional small substations with HV/MV transformers. The cost is of the order of 2 MEUR for a 115 kV substation, which can supply up to 2 MVA in MV. This cost is approximately the same as that of a small conventional substation with 115 kV/MV step-down transformer, which can also supply a much higher MV power (10 MVA or more). This is because the substation requires an HV bay similar to that needed for an HV/MV transformer (disconnecting link, load interrupter or normal circuit-breaker, lightning arresters, carrier-current line traps, current transformers, voltage transformers). For a 225 kV bay, the cost will be considerably greater.

It should also be noted that, in Canada, the cost of a capacitor bridge substation may be more advantageous compared to the cost of a conventional substation with HV/MV transformer, but this is not necessarily the case in other continents for the following reasons:

- The cost of capacitors produced in North America is low, very often lower than the cost of an equivalent capacitor in other continents;
- The cost of power transformers produced in North America is generally higher than the cost of an equivalent transformer in other continents ;
- HV load interrupters are easy to find in North America whereas in Europe manufacturers supply only normal circuit-breakers.

The main point for assessing the capacitor bridge scheme is that the scheme for rural electrification along the interconnection lines of electricity networks in the Nile equatorial lakes countries is considering supplying several villages spread out along sections of HV lines that are several hundred km long. Application of this scheme would require the installation of several substations along the line, or else, in order to restrict the number of substations, the construction of MV lines parallel to the HV lines to supply all the villages. The first solution is extremely expensive (installation and maintenance cost) and the network would be complicated as a result of the presence of a large number of substations and unconventional equipment. The second solution involves a very high cost for the MV lines (construction and operation).

Finally, a scheme with capacitor bridge is ideally suited to highly-loaded lines where there are advantages to be gained from reactance compensation, as is the case with the Canadian power lines considered by IREQ. In the case of the project for interconnection of the electricity networks of the Nile equatorial lakes countries, these technical conditions are far from being satisfied and constitute more of a disadvantage for the following reasons.

a) Since the HV lines would have little load for several years to come, a reactance shunt of about 15 MVar (indicative value in 225 kV) would have to be installed for each 2 MVA substation to compensate for the excess capacitive MVar produced by the divider bridge. The scheme would therefore involve a supplementary investment as well as a small increase in losses compared to a conventional substation. Only in the distant future, beyond the present study horizon, could the capacitors of the substations perhaps be used for network rephasing.

b) The natural power factor of the loads in the zones of interest, during the evening peak period, is frequently of the order of 0.9 for the MV supply. When rephasing becomes necessary, the most suitable solution will be the installation of MV capacitors.

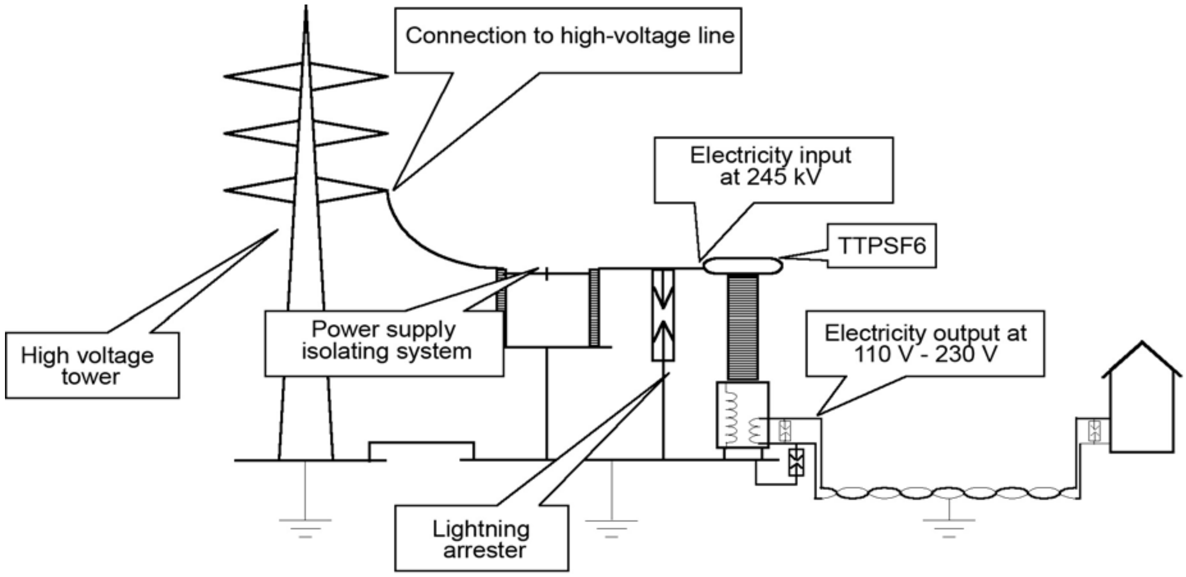
c) The rural electrification source substations are generally located a great distance from the HV line receiving ends. This reduces rephasing efficiency which, in any case, will not be required for the first several years of operation, as explained above.

1.3.3. SF6 SINGLE-PHASE VOLTAGE TRANSFORMERS

This technology was developed by Christian Pans Enregie & Expansion (CPEE) and the University of Liège (ULG Belgium), and was successfully tested in Makola (Congo-Brazzaville) in 2002.

The TTPSF6 is a voltage transformer with gaseous SF6 insulation of standard construction and capable of supplying up to 50 kVA, with the voltage changing directly from the high-voltage of the transmission line (75-245 kV) to the standard low voltages (110-220 V) without the need for substations.

The TTPSF6 can be used to supply electricity to villages located less than 5 km from the HV lines but not connected to a network, thereby enhancing the villagers' standard of living (e.g. guaranteeing proper water supply by electricity supply to a pumping unit, creation of cottage industry or simple industrial activities).



The advantages of this technology are as follows:

- easy handling of the lightweight equipment (1400 kg), so the power supply system can be easily moved,
- direct transformation from 245 kV to 230 V without electrical substations,
- reduced cost for a small supply unit, by avoiding intermediate voltage transformation equipment and by using the standard HV voltage transformers designed for measurement in transport networks (approximate cost of € 250,000 / transformation unit)

This technology is not well-suited to rural electrification along the interconnection lines of electricity networks in the Nile equatorial lakes countries because:

- Its unit power output is very limited (50 kVA max.) compared to the needs of the villages. The energy supplied is in single-phase form. However, a three-phase supply is required for pumping equipment above a certain power level (of the order of 100 kW for a three-phase asynchronous motor with star-delta starting, and water pumping is one of the principal applications of rural electrification.

- Safe operation of the equipment (especially in the event of lightning striking the line) requires a very good earthing system, which is complicated to install in terrain consisting essentially of highly-resistive laterite.
- Like the solution using capacitive coupling, this solution is based on a capacitive voltage transformer which, on a line that is already only lightly loaded (transiting power much lower than the natural power of the line) will increase the reactive compensation requirements and thus lead to extra investment.
- The standardisation of these VTs means that the rural electrification source substations would be only LV. The limit distance of loads capable of being supplied is therefore reduced compared to other rural electrification solutions that also propose MV source substations. The maximum distance of loads with respect to the line is of the order of 5 km.

1.3.4. INSULATED OVERHEAD EARTH WIRES

An innovative solution has been proposed, and applied since 1985. It consists in insulating the overhead earth wire(s) of the HV line pylons using suspended insulators and supplying this (these) wire(s) with MV (20-34.5 kV) from the HV/MV station at one end of the HV line. In this way, distribution transformers can be connected between the overhead earth wire(s) and earth in order to supply villages along the route of the HV line.

1.3.4.1. GENERAL DESCRIPTION

Lines based on insulated overhead earth wires (IOEW) are illustrated in the diagrams below. Diagrams A and B are designed for single-phase power supply while diagrams C and D are applicable when the HV line is protected by two earth wires; they can also supply three-phase loads. Diagram A is applicable to HV lines with a single earth wire. IOEW schemes have been designed by combining two techniques previously applied separately in various countries:

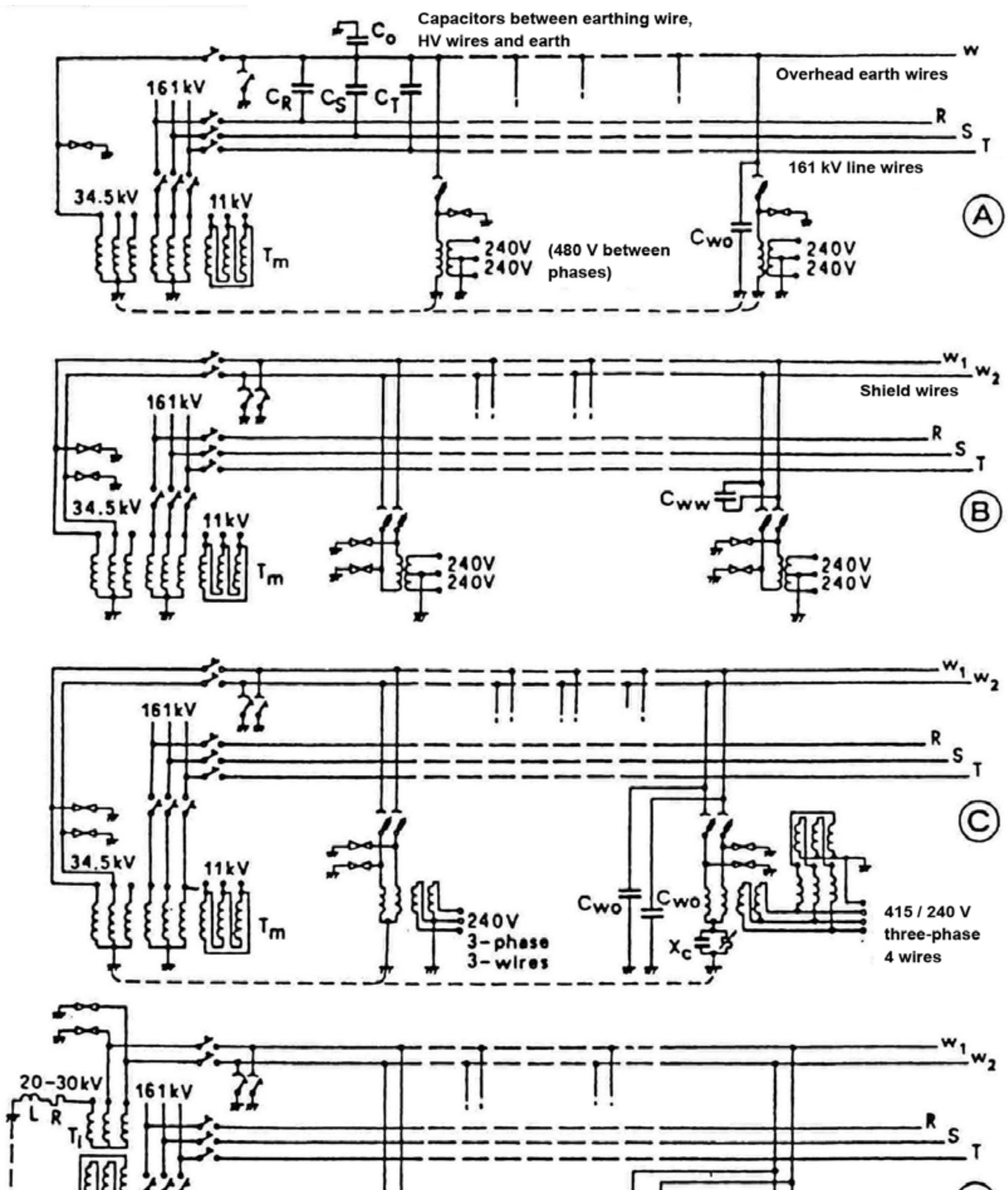
- Use of insulated overhead earth wires on long VHV lines transporting very large quantities of energy, to reduce losses by the Joule effect resulting from induced currents in the steel or alumoweld cables, and/or for carrier-current telecommunications on the wires themselves;
- Construction of single-phase MV distribution lines with a single conductor, with current return via earth, to supply small loads a long way from the power source (rural distribution).

1.3.4.2. COMPARISON OF SCHEMES

Current return via earth (diagrams A, C and D) is the most economical principle when the ground resistivity is not exceptionally high, because the cost of earthing electrodes is low for the current flow considered. Return via earth is a "conductor" available everywhere, of negligible cost (limited to the cost of the terminal electrodes) and great reliability (it is not exposed to any risk of interruption, or insulation failure like conventional cables).

The return circuit via earth has a resistance considerably lower than that of conventional distribution conductors: it is estimated to be 10-4π²f (ohm/km) or 0.05 ohm/km at 50 Hz, corresponding to a 570 mm² cross-section aluminium cable.

The current return via earth schemes A and C are feasible without intervening transformers if the neutral of the MV supply network is directly earthed or if the network is earthed through either an earthing transformer or a low impedance neutral inductance coil. The metal return in scheme B and the MV power return operate with the neutral unearthed or with a high-impedance earth.



In scheme B, known as "metal return single-phase", current return via earth is avoided. This scheme is feasible if the HV line is equipped with two IOEWs used for supplying the MV/LV distribution transformers.

Scheme C, or "V" connection scheme, requires two insulated overhead earth wires supplied by two phases of an MV network with earthed neutral. In the distribution substations, there are two single-phase MV/LV transformers connected between each overhead earth wire and earth. The LV secondary windings are connected in an open-delta configuration ("V" connection) and thus supply a symmetrical three-phase source when the load is zero, allowing a small quantity of three-phase load to be supplied in addition to single-phase loads. The addition of a capacitor (Xc) between the neutral of the "V" connected transformers and earth, chosen in order to compensate for the voltage drop in the reactance of the earth return circuit, can be used to increase the three-phase loads considerably. These loads can thus be supplied on condition that the 2% inverse current limit planned in the LV networks is not exceeded.

The earthing transformer connected to the LV terminals of the "V" connected transformers generates the neutral required for single-phase LV consumers connected between one phase and the neutral.

Scheme D is the "three-phase" scheme. The two insulated overhead earth wires and the earth return conductor form an imbalanced three-phase circuit. The earth conductor resistance is significantly lower than that of any overhead earth wire; the reactance of the earth conductor is generally slightly less than that of metal cables. The capacitance between the two overhead earth wires is much lower than the capacitance between each overhead earth wire and earth. The principle applied is to make the line formed by the two overhead earth wires and the earth return circuit symmetrical by means of simple compensating devices: a resistance in series with a reactance on the earthing circuit (R-L) to bring the impedance to the same level as that of the overhead earth lines and a capacitor connected between the two overhead earth lines (Cww) to raise the capacitance between wires to the same values of the wire-earth capacitance.

The three-phase IOEW line is supplied by symmetrical three-phase voltages by means of an intervening transformer (Ti), or more economically by the tertiary winding of a HV/MV transformer. A winding phase terminal supplying the three-phase IOEW line is earthed through the R-L compensating impedance.

Depending on the load characteristics, in the "three-phase" scheme three-phase MV/LV transformers with an earthed primary terminal, or single-phase transformers, are connected along the line. The IOEW scheme (D) can supply a 100% three-phase load. It absorbs a balanced load from the HV transport network if the distribution is balanced, like a conventional distribution system.

In the three-phase IOEW scheme, the three-phase loads are supplied by conventional MV/LV transformers, which must however be designed to operate continuously with one primary terminal earthed and the other terminals supplied with a voltage with respect to earth equal to the voltage between phases.

Rephasing and anti-ferroresonance capacitors, and earth disconnecting links are used to balance the voltages and for protection against surge voltages by ferroresonance.

1.3.4.3. LIGHTNING BEHAVIOUR OF HV LINES WITH INSULATED OVERHEAD EARTH WIRES

It is known from experience that insulating overhead earth wires in VHV lines, with the aim of reducing energy losses from the overhead earth wires, does not affect their protection efficiency. In this application, the rod gaps that protect the overhead earth wire suspension insulators are set at a short distance (10-50 mm). On the other hand, overhead earth wires are normally earthed at one point of each short insulated section, or else there are numerous transpositions along long sections of insulated cables to limit the resultant voltage surges.

The case of IOEW lines differs from the above cable insulation method in the following ways:

- IOEW are supplied at 10 to 34.5 kV RMS voltage in relation to earth with lengths up to 100 km;
- The insulation must withstand IOEW line handling surges. The rod gaps must be between 150 and 300 mm depending on the IOEW line operating voltage.

The operating voltage of overhead earth wires is very low in comparison with the potential of the ionized path of lightning. It may therefore be expected that the effectiveness of the screen will not be affected. When lightning strikes an overhead earth wire or pylon, the nearest IOEW rod gap is triggered and earths the overhead earth wire, which then acts as if it were earthed.

As the IOEW is supplied by an HV/MV transformer substation, the arc in a rod gap short-circuits to earth. The protection relay then shuts down the IOEW line unless the power arc at the network frequency self-extinguishes rapidly, as can happen if the fault current is low. This behaviour is not a cause for concern as it is quite normal in conventional MV distribution lines.

Studies in the laboratory studies and on operating lines confirm that the secondary arc current in the rod gap is quickly extinguished to prevent damage to the equipment and enable consumers connected to the IOEW line to be quickly re-connected.

IOEW are higher above ground than equivalent conventional MV line conductors. This may cause an increase in discharges due to lightning for a given MV line insulation level, caused by:

- the greater number of direct lightning discharges on the IOEW due to the wider exposure band of the HV line;
- the surges produced by lightning hitting the ground close to the line, as the amplitude of the surge produced in a line is more or less proportional to its height above ground.

For example, the typical 161 kV lines operated by the Volta River Authority (VRA, Ghana) are designed with delta phase conductors and the average span is 385 m; the average height of the overhead earth wires is about 20 m in the field. The average height of the highest phase conductor of standard 34.5 kV MV lines with an average span of 225 m is about 10 m.

Calculations show that increasing the height from 10 m to 20 m causes a 20% - 40% increase in discharges due to lightning strikes hitting the line directly, with currents between 10 kA and 100 kA.

With regard to the surges induced by lightning, it may be assumed that 5% of strikes exceed 100 kA, and that the average duration of the front is 5μs. The calculated discharge rate due to induced atmospheric surges increases by 1-2 per 100 km of line per year when the height of the conductors increases form 10 to 20 m, considering keraunic activity of 4 discharges per square kilometre per year, as estimated for Ghana. These figures are confirmed by statistics for operating lines.

The estimate takes into account the risk of insulation failure caused by contact with bushes, trees or other structures and insulation short-circuits caused by animals such as large birds or snakes. On the other hand, HV line pylons rarely collapse, in contrast to MV distribution line poles. These faults may considerably contribute to the failure rate of MV lines and frequently last a long time (they are not self-cancelling).

1.3.4.4. SELF-EXTINCTION OF ARC IN INSULATOR ROD GAPS

With the above values for the secondary arc current and recovery voltage, self-extinction occurs between the gap rods in less than one second after the IOEW line circuit-breaker has opened if there are no faults in the HV circuit, or after the HV circuit has been successfully re-triggered or fully disconnected, if there is also a fault on the HV circuit. The IOEW line must also be re-supplied automatically or manually, like a normal MV line. In certain rare cases where the secondary arc persists in the overhead earth wires, the rapid earthing switch must be closed in the outgoing substation. Such persistence has never occurred in over 10 years' operation on several existing IOEW lines.

1.3.4.5. ADVANTAGES / DISADVANTAGES OF IOEW TECHNOLOGY

The advantages of this technology are as follows:

- The IOEW scheme (in particular D) can supply a three-phase 100% load.
- Considerable power has to be distributed along an interconnection (up to 12 MW along an interconnection, with the two terminal IOEW being supplied).
- The voltage level at the source substations is MV, which means that sources relatively far from the line (up to 20 km away) can be supplied.
- Lower cost, by avoiding the need to have several sets of HV/MV transformer equipment at each rural electrification source substation along the line (as HV/MV transformation is done at the main substations at the ends of the interconnections). This technology requires no extra investment, due, for example, to reactive energy compensation linked to capacitive-effect rural electrification technologies.

Although this technology is the most suitable for rural electrification along the interconnections of the electrical networks of the Nile equatorial lakes countries, it has the following disadvantages:

- This technology involves calculating the compensating filter of the negative component, which is no simple matter even though these calculation methods are now well mastered and have been validated by numerous full-scale tests using the technology.
- The villages to be supplied, the order of magnitude of their load and the locations for rural electrification source substations along the route must be chosen carefully before work on building the interconnection begins.

- MV networks supplied by IOEW cannot be interconnected directly with conventional MV networks owing to the fact that one phase is earthed. Intermediate transformers are required.

1.4. SUMMARY OF THE VARIOUS RURAL ELECTRIFICATION TECHNOLOGIES

The following table summarises the characteristics of the various rural electrification technologies.

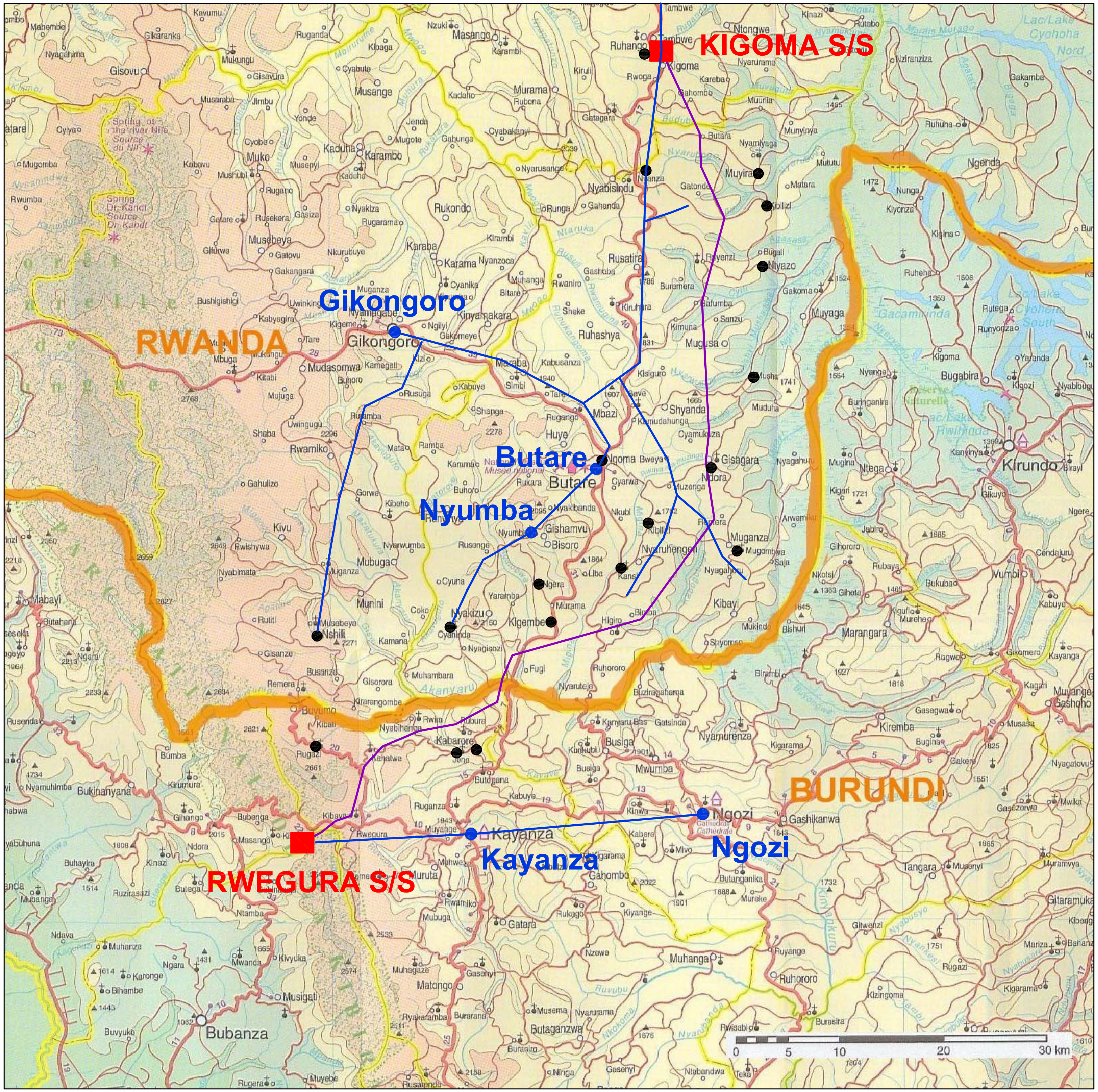
	Maximum power distributed / interconnection [1]	Maximum distance of villages / HV lines	Three-phase / single-phase[2]	MV/LV source substation	Investment cost[3]
Unit	kW	Km			EUR / W
Conventional HV/MV substation	no limit	20	3	MV	0.6[4]
Capacitive coupling	70	5	1	LV	5
Capacitive transformer substation	2 000	20	3	MV	2.5
SF6 single-phase voltage transformers	50	5	1	LV	6
IOEW	10 000	20	3	MV	0.2

It should be borne in mind that solutions involving capacitive coupling, capacitive transformer substations and SF6 single-phase transformers are not the most suited to rural electrification along the interconnections of the electricity networks of the Nile Equatorial Lakes countries.

In contrast, the solution involving insulated overhead earth wires, with the possibility of having three-phase MV source substations, and the classic solution of creating HV/MV substations, are the most suitable. They are the most economical for the order of magnitude of the power to be supplied along the interconnections and the most suited to the villages' energy requirements.

[1] This value is equivalent to the maximum power of a source substation for a given solution.
[2] Three-phase is needed for pumping above a certain power level (of the order of 100 kW for a three-phase asynchronous motor with a star/delta start-up), as water pumping is one of the main functions of rural electrification.
[3] This cost is calculated for an optimum investment, i.e. an installation with the maximum power taken into account. This cost takes into account extra investment for the reactive energy compensation made necessary by rural electrification.
[4] For a 5 MW substation.

RWANDA-BURUNDI INTERCONNECTION
INTERCONNEXION RWANDA-BURUNDI



- Main villages to be connected / Villages principaux à raccorder
- NELSAP Substation / Sous-station HT PAALEN
- NELSAP HV line project / Projet de ligne HT PAALEN
- Main existing or planed HV lines / Principales lignes HT existante ou planifiées

NELSAP	PAALEN
STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES	ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL

FEASIBILITY REPORT / RAPPORT DE FAISABILITE

RURAL ELECTRIFICATION
ELECTRIFICATION RURALE

N° EL RUR 002

Date : April / Avril 2007

Dessiné par: GYI Controlé par: PHK

Référence informatique: P:\BRC\ENE\1 36 0300 – NELSAP interconnexions\FAISABILITE\Electrification rurale\Elec rurale CARTOS

ANNEX N – ECONOMIC STUDIES

RWANDA-UGANDA and UGANDA-KENYA INTERCONNECTIONS

ALTERNATIVE 1 - RESUME

Discount Rate	10%
Fuel Cost Coefficient	1

Alternative 1 Cost-Benefit Analysis

Reserve Cost (MUS$/MW)	**1**		
ADDITIONAL CAPACITY (MW)		**Reserve Benefit (MUS$)**	
Medium Demand Scenario			
Rwanda - Uganda	44	22	41%
Uganda - Kenya	63	32	59%
Low Demand Scenario			
Rwanda - Uganda	46	23	42%
Uganda - Kenya	63	32	58%
High Demand Scenario			
Rwanda - Uganda	54	27	47%
Uganda - Kenya	60	30	53%

	2010	**2013**
INVESTMENT COST (MUS$)		
Rwanda-Uganda Lines	29,8	0
Rwanda Substations	4,2	1,6
Uganda Substations	3,6	8,4
	37,6	**10,0**
Uganda-Kenya Lines		59,1
Kenya Substations		9,7
Uganda Substations		13,8
		82,6
O&M COSTS (MUS$)		
Rwanda - Uganda	**3,9**	
Uganda-Kenya		**5,2**

TOTAL COSTS (MUS$)	
	TOTAL
Rwanda-Uganda	42
Uganda-Kenya	67
TOTAL	109

LOSSES	0,04	**US$/kWh**
	MUS$	
Medium Demand Scenario		
Rwanda - Uganda	2,2	
Uganda-Kenya	6,8	
Low Demand Scenario		
Rwanda - Uganda	1,0	
Uganda - Kenya	7,1	
High Demand Scenario		
Rwanda - Uganda	4,3	
Uganda - Kenya	6,8	

BENEFITS (MUS$)	**TOTAL**	**Rwanda - Uganda**	**Uganda - Kenya**
Medium Demand Scenario	293	122	171
Low Demand	241	104	137
High Demand	446	211	234

B-C or NPV (MUS$)		**Rwanda - Uganda**	**Uganda - Kenya**
Medium Demand Scenario	184	80	103
Low Demand	132	62	70
High Demand	337	170	167

REFERENCE SOLUTION (WITHOUT PROJECT): RWANDA-BURUNDI-DR CONGO SYSTEM GENERATION

ALTERNATIVE 1

SCENARIO: **MEDIUM**

R/B/C Group FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources		Complementary Thermal		Kibuye		Nyemanga		Ruzizi 3		Mule 34		Kabu 16		Bendera		Rusumo		Nyabarongp + Mpanda	
				GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW
2 010	911	186	205	745	148	133	44			4	1,7											29	11
2 011	976	199	219	745	148	198	58			4	1,7											29	11
2 012	1046	213	289	705	148	0	58	0	0	4	1,7							160	43			177	38
2 013	1121	228	309	663	148	0	58	0	0	4	1,7					117	20	160	43			177	38
2 014	1201	244	309	743	148	0	58	0	0	4	1,7					117	20	160	43			177	38
2 015	1288	261	326	683	148	0	58	0	0	4	1,7			147	17	117	20	160	43			177	38
2 016	1386	281	326	745	148	36	58	0	0	4	1,7			147	17	117	20	160	43			177	38
2 017	1485	301	367	611	148	0	58	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 018	1602	325	367	728	148	0	58	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 019	1720	349	384	745	148	101	76	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 020	1837	373	466	507	148	0	76	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 021	1979	402	466	649	148	0	76	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 022	2120	430	473	745	148	45	83	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 023	2289	464	511	745	148	214	120	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 024	2459	498	548	745	148	384	157	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 025	2628	532	586	745	148	553	195	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 026	2832	573	630	745	148	757	240	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 027	3036	614	675	745	148	961	285	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 028	3281	663	729	745	148	1206	339	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 029	3525	712	783	745	148	1450	393	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 030	3769	761	837	745	148	1695	447	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38

SCENARIO: **LOW**

2 010	847	172	189	745	148	89	28			2	1,7											11	11
2 011	895	181	199	745	148	117	39			4	1,7											29	11
2 012	946	191	269	674	148	0	39			4	1,7							160	43			108	38
2 013	1000	202	269	674	148	0	39			4	1,7							160	43			162	38
2 014	1057	213	269	716	148	0	39	0	0	4	1,7							160	43			177	38
2 015	1117	225	269	745	148	31	39	0	0	4	1,7							160	43			177	38
2 016	1184	237	289	726	148	0	39	0	0	4	1,7					117	20	160	43			177	38
2 017	1251	249	289	745	148	48	39	0	0	4	1,7					117	20	160	43			177	38
2 018	1329	263	306	724	148	0	39	0	0	4	1,7			147	17	117	20	160	43			177	38
2 019	1406	276	306	745	148	56	39	0	0	4	1,7			147	17	117	20	160	43			177	38
2 020	1484	290	347	610	148	0	39	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 021	1582	308	347	708	148	0	39	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 022	1680	327	360	745	148	61	51	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 023	1794	349	384	745	148	175	75	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 024	1908	371	466	578	148	0	75	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 025	2023	392	466	693	148	0	75	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 026	2157	418	466	745	148	82	75	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 027	2292	444	488	745	148	217	97	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 028	2449	473	521	745	148	374	130	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 029	2606	503	554	745	148	531	163	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 030	2764	533	587	745	148	689	196	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38

SCENARIO: **HIGH**

2 010	993	204	224	745	148	215	63			4	1,7											29	11
2 011	1082	222	245	745	148	304	84			4	1,7											29	11
2 012	1180	243	315	745	148	94	84	0	0	4	1,7							160	43			177	38
2 013	1287	265	335	745	148	84	84	0	0	4	1,7					117	20	160	43			177	38
2 014	1404	289	376	677	148	0	84	0	0	4	1,7					117	20	160	43	269	41	177	38
2 015	1532	316	376	745	148	60	84	0	0	4	1,7					117	20	160	43	269	41	177	38
2 016	1682	345	393	745	148	63	84	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 017	1831	375	475	501	148	0	84	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 018	2018	412	475	688	148	0	84	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 019	2206	449	494	745	148	131	104	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 020	2393	487	535	745	148	318	144	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 021	2605	529	582	745	148	530	191	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 022	2817	572	629	745	148	742	238	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 023	3077	624	687	745	148	1002	296	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 024	3337	677	744	745	148	1262	354	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 025	3597	729	802	745	148	1522	411	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 026	3917	793	873	745	148	1842	482	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 027	4237	858	943	745	148	2162	553	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 028	4631	937	1030	745	148	2556	640	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 029	5024	1016	1117	745	148	2949	727	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 030	5418	1095	1204	745	148	3343	814	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38

REFERENCE SOLUTION (WITHOUT PROJECT): UGANDA SYSTEM GENERATION

ALTERNATIVE 1

SCENARIO: **MEDIUM**

Uganda FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	MW	Complementary Thermal GWh	MW	Bagasse GWh	MW	Karuma GWh	MW	Mini-Hydro GWh	MW	Kalagala GWh	MW	Murchison GWh	MW	Ayago GWh	MW	Export Kenya 50 MW GWh	MW
2 010	2874	500	629	2980	587	0	0	294	42											-400	-50
2 011	3081	535	639	3038	587	0	10	294	42											-251	-50
2 012	3303	573	713	3038	587	0	10	294	42			371	74							-400	-50
2 013	3541	612	723	3038	587	0	20	294	42			530	74							-321	-50
2 014	3796	655	923	3038	587	0	20	132	42	786	200	240	74							-400	-50
2 015	4069	701	923	3038	587	0	20	165	42	970	200	296	74							-400	-50
2 016	4373	752	923	3038	587	0	20	197	42	1183	200	355	74							-400	-50
2 017	4676	802	932	3038	587	0	29	232	42	1387	200	419	74							-400	-50
2 018	5038	862	998	3038	587	0	95	274	42	1625	200	501	74							-400	-50
2 019	5399	922	1448	3038	587	0	95	159	42	953	200	286	74	1363	450					-400	-50
2 020	5761	982	1448	3038	587	0	95	179	42	1081	200	323	74	1540	450					-400	-50
2 021	6117	1043	1448	3038	587	0	95	200	42	1202	200	360	74	1717	450					-400	-50
2 022	6473	1103	1448	3038	587	0	95	221	42	1322	200	398	74	1894	450					-400	-50
2 023	6885	1174	1448	3038	587	0	95	244	42	1467	200	440	74	2096	450					-400	-50
2 024	7298	1244	1448	3038	587	0	95	268	42	1612	200	482	74	2298	450					-400	-50
2 025	7710	1314	1670	3038	587	0	95	218	42	1293	200	392	74	1869	450	1300	222			-400	-50
2 026	8186	1395	1670	3038	587	0	95	238	42	1400	200	429	74	2045	450	1436	222			-400	-50
2 027	8663	1477	1674	3038	587	0	99	259	42	1518	200	466	74	2222	450	1560	222			-400	-50
2 028	9214	1571	1872	3038	587	0	99	282	42	1677	200	509	74	2424	450	1684	420			-400	-50
2 029	9766	1665	1881	3038	587	0	108	294	42	1747	200	530	74	2525	450	2032	420			-400	-50
2 030	10317	1759	1985	3038	587	0	212	294	42	1747	200	530	74	2525	450	2583	420			-400	-50

SCENARIO: **LOW**

Uganda FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	MW	Complementary Thermal GWh	MW	Bagasse GWh	MW	Karuma GWh	MW	Mini-Hydro GWh	MW	Kalagala GWh	MW	Murchison GWh	MW	Ayago GWh	MW	Export Kenya 50 MW GWh	MW
2 010	2435	420	629	2645	587	0	0	190	42											-400	-50
2 011	2540	436	629	2740	587	0	0	200	42											-400	-50
2 012	2648	453	629	2838	587	0	0	210	42											-400	-50
2 013	2762	470	629	2942	587	0	0	220	42											-400	-50
2 014	2880	489	629	3038	587	0	0	242	42											-400	-50
2 015	3003	508	703	2700	587	0	0	260	42			443	74							-400	-50
2 016	3134	528	703	2800	587	0	0	270	42			464	74							-400	-50
2 017	3266	548	703	2900	587	0	0	280	42			486	74							-400	-50
2 018	3411	570	703	3000	587	0	0	290	42			521	74							-400	-50
2 019	3557	592	903	3038	587	0	0	106	42	622	200	191	74							-400	-50
2 020	3703	614	903	3038	587	0	0	121	42	727	200	217	74							-400	-50
2 021	3854	639	903	3038	587	0	0	138	42	829	200	249	74							-400	-50
2 022	4005	664	903	3038	587	0	0	156	42	930	200	281	74							-400	-50
2 023	4172	692	903	3038	587	0	0	176	42	1040	200	318	74							-400	-50
2 024	4338	719	903	3038	587	0	0	194	42	1156	200	350	74							-400	-50
2 025	4505	747	903	3038	587	0	0	215	42	1265	200	387	74							-400	-50
2 026	4689	778	905	3038	587	0	2	235	42	1392	200	424	74							-400	-50
2 027	4873	808	939	3038	587	0	36	256	42	1518	200	461	74							-400	-50
2 028	5075	842	976	3038	587	0	73	279	42	1654	200	504	74							-400	-50
2 029	5278	875	1013	3038	587	0	110	294	42	1747	200	530	74							-331	-50
2 030	5481	909	1050	3038	587	0	147	294	42	1747	200	530	74							-128	-50

SCENARIO: **HIGH**

Uganda FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	MW	Complementary Thermal GWh	MW	Bagasse GWh	MW	Karuma GWh	MW	Mini-Hydro GWh	MW	Kalagala GWh	MW	Murchison GWh	MW	Ayago GWh	MW	Export Kenya 50 MW GWh	MW
2 010	3164	547	652	3038	587	0	23	294	42											-168	-50
2 011	3447	594	703	3038	587	115	74	294	42											0	-50
2 012	3755	644	777	3038	587	0	74	294	42			530	74							-107	-50
2 013	4090	699	819	3038	587	228	116	294	42			530	74							0	-50
2 014	4455	759	1019	3038	587	0	116	209	42	1232	200	376	74							-400	-50
2 015	4853	824	1019	3038	587	0	116	253	42	1506	200	456	74							-400	-50
2 016	5306	898	1469	3038	587	0	116	153	42	908	200	281	74	1326	450					-400	-50
2 017	5758	971	1469	3038	587	0	116	179	42	1078	200	323	74	1540	450					-400	-50
2 018	6320	1062	1469	3038	587	0	116	212	42	1270	200	382	74	1818	450					-400	-50
2 019	6881	1152	1469	3038	587	0	116	244	42	1463	200	440	74	2096	450					-400	-50
2 020	7443	1243	1469	3038	587	0	116	276	42	1658	200	498	74	2373	450					-400	-50
2 021	8062	1346	1691	3038	587	0	116	232	42	1377	200	419	74	1995	450	1401	222			-400	-50
2 022	8681	1450	1691	3038	587	0	116	259	42	1536	200	466	74	2222	450	1560	222			-400	-50
2 023	9433	1575	1889	3038	587	0	116	294	42	1747	200	530	74	2525	450	1699	420			-400	-50
2 024	10184	1701	1921	3038	587	0	148	294	42	1747	200	530	74	2525	450	2450	420			-400	-50
2 025	10936	1826	2155	3038	587	0	148	226	42	1345	200	408	74	1944	450	2796	420	1579	234	-400	-50
2 026	11846	1978	2226	3038	587	0	219	250	42	1485	200	451	74	2146	450	3133	420	1743	234	-400	-50
2 027	12755	2130	2530	3038	587	0	219	221	42	1310	200	398	74	1894	450	2759	420	3535	538	-400	-50
2 028	13859	2315	2596	3038	587	0	285	245	42	1457	200	442	74	2106	450	3068	420	3903	538	-400	-50
2 029	14963	2499	2799	3038	587	0	488	269	42	1600	200	485	74	2313	450	3370	420	4288	538	-400	-50
2 030	16067	2684	3002	3038	587	0	691	294	42	1747	200	530	74	2525	450	3679	420	4654	538	-400	-50

REFERENCE SOLUTION (WITHOUT PROJECT): KENYA SYSTEM GENERATION

ALTERNATIVE 1

SCENARIO: **MEDIUM**

KENYA LOAD FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	Committed Local Resources MW	Complementary Thermal GWh	Complementary Thermal MW	Coal GWh	Coal MW	Import Uganda GWh	Import Uganda MW
2010	7838	1343	1478	5052	1039	65	89	2321	300	400	50
2011	8491	1456	1628	5052	1039	65	89	3123	450	251	50
2012	9183	1576	1778	5052	1039	65	89	3667	600	400	50
2013	9922	1703	1874	5052	1039	135	185	4415	600	321	50
2014	10711	1840	2174	5052	1039	135	185	5124	900	400	50
2015	11552	1985	2183	5052	1039	142	194	5958	900	400	50
2016	12470	2144	2483	5052	1039	142	194	6876	1200	400	50
2017	13387	2302	2532	5052	1039	178	243	7758	1200	400	50
2018	14492	2493	3132	5052	1039	178	243	8862	1800	400	50
2019	15596	2684	3132	5052	1039	178	243	9967	1800	400	50
2020	16701	2876	3163	5052	1039	200	274	11049	1800	400	50
2021	17987	3098	3763	5052	1039	200	274	12334	2400	400	50
2022	19272	3321	3763	5052	1039	200	274	13620	2400	400	50
2023	20812	3588	4363	5052	1039	200	274	15160	3000	400	50
2024	22351	3854	4363	5052	1039	200	274	16699	3000	400	50
2025	23891	4121	4533	5052	1039	324	444	18115	3000	400	50
2026	25699	4434	5133	5052	1039	324	444	19922	3600	400	50
2027	27506	4747	5222	5052	1039	389	533	21665	3600	400	50
2028	29664	5122	5822	5052	1039	389	533	23823	4200	400	50
2029	31822	5496	6422	5052	1039	389	533	25981	4800	400	50
2030	33980	5870	6457	5052	1039	414	568	28114	4800	400	50

SCENARIO: **LOW**

2010	7585	1299	1429	5052	1039	29	40	2104	300	400	50
2011	8153	1397	1579	5052	1039	29	40	2672	450	400	50
2012	8750	1500	1729	5052	1039	29	40	3269	600	400	50
2013	9381	1609	1770	5052	1039	59	81	3870	600	400	50
2014	10049	1724	2070	5052	1039	59	81	4538	900	400	50
2015	10756	1846	2070	5052	1039	59	81	5245	900	400	50
2016	11516	1977	2175	5052	1039	136	186	5928	900	400	50
2017	12276	2109	2475	5052	1039	136	186	6688	1200	400	50
2018	13173	2264	2491	5052	1039	147	202	7574	1200	400	50
2019	14070	2420	3091	5052	1039	147	202	8471	1800	400	50
2020	14967	2575	3091	5052	1039	147	202	9368	1800	400	50
2021	15988	2751	3091	5052	1039	147	202	10388	1800	400	50
2022	17008	2928	3221	5052	1039	242	332	11314	1800	400	50
2023	18207	3135	3821	5052	1039	242	332	12513	2400	400	50
2024	19405	3343	3821	5052	1039	242	332	13711	2400	400	50
2025	20604	3550	3905	5052	1039	304	416	14848	2400	400	50
2026	21998	3791	4505	5052	1039	304	416	16242	3000	400	50
2027	23392	4032	4505	5052	1039	304	416	17636	3000	400	50
2028	25026	4315	5105	5052	1039	304	416	19271	3600	400	50
2029	26661	4598	5105	5052	1039	304	416	20975	3600	331	50
2030	28296	4881	5705	5052	1039	304	416	22812	4200	128	50

SCENARIO: **HIGH**

2010	8165	1400	1540	5052	1039	545	151	2400	300	168	50
2011	8914	1530	1690	5052	1039	262	151	3600	450	0	50
2012	9715	1668	1840	5052	1039	110	151	4446	600	107	50
2013	10578	1817	2140	5052	1039	110	151	5416	900	0	50
2014	11506	1978	2176	5052	1039	136	187	5918	900	400	50
2015	12506	2151	2476	5052	1039	136	187	6918	1200	400	50
2016	13611	2342	2576	5052	1039	210	287	7950	1200	400	50
2017	14717	2533	3176	5052	1039	210	287	9055	1800	400	50
2018	16074	2768	3176	5052	1039	210	287	10412	1800	400	50
2019	17430	3003	3303	5052	1039	303	414	11676	1800	400	50
2020	18787	3238	3903	5052	1039	303	414	13032	2400	400	50
2021	20404	3518	3903	5052	1039	303	414	14649	2400	400	50
2022	22020	3798	4503	5052	1039	303	414	16266	3000	400	50
2023	23995	4140	4554	5052	1039	340	465	18203	3000	400	50
2024	25969	4483	5154	5052	1039	340	465	20177	3600	400	50
2025	27943	4825	5754	5052	1039	340	465	22151	4200	400	50
2026	30289	5232	5755	5052	1039	340	466	24497	4200	400	50
2027	32634	5638	6355	5052	1039	340	466	26842	4800	400	50
2028	35486	6133	6955	5052	1039	340	466	29694	5400	400	50
2029	38337	6627	7555	5052	1039	340	466	32545	6000	400	50
2030	41189	7122	7834	5052	1039	544	745	35193	6000	400	50

RWANDA-UGANDA and UGANDA-KENYA INTERCONNECTIONS

Discount Rate	10%
Fuel Cost Coefficient	1

Alternative 2 Cost-Benefit Analysis

Reserve Cost (MUS$/MW)	**1**		
ADDITIONAL CAPACITY (MW)		**Reserve Benefit (MUS$)**	
Medium Demand Scenario			
Rwanda - Uganda	65	33	29%
Uganda - Kenya	162	81	71%
Low Demand Scenario			
Rwanda - Uganda	60	30	26%
Uganda - Kenya	174	87	74%
High Demand Scenario			
Rwanda - Uganda	65	32	31%
Uganda - Kenya	143	71	69%

	2010	**2013**
INVESTMENT COST (MUS$)		
Rwanda-Uganda Lines	29,8	0
Rwanda Substations	4,2	1,6
Uganda Substations	3,6	8,4
	37,6	**10,0**
Uganda-Kenya Lines		59,1
Kenya Substations		9,7
Uganda Substations		13,8
		82,6
O&M COSTS (MUS$)		
Rwanda - Uganda	**3,9**	
Uganda-Kenya		**5,2**

TOTAL COSTS (MUS$)

	TOTAL
Rwanda-Uganda	42
Uganda-Kenya	67
TOTAL	109

LOSSES	0,04	**US$/kWh**
	MUS$	
Medium Demand Scenario		
Rwanda - Uganda	3,9	
Uganda-Kenya	21,6	
Low Demand Scenario		
Rwanda - Uganda	3,8	
Uganda - Kenya	22,7	
High Demand Scenario		
Rwanda - Uganda	5,0	
Uganda - Kenya	17,8	

BENEFITS (MUS$)	**TOTAL**	**Rwanda - Uganda**	**Uganda - Kenya**
Medium Demand Scenario	446	131	314
Low Demand	334	89	245
High Demand	554	175	379

B-C or NPV (MUS$)		**Rwanda - Uganda**	**Uganda - Kenya**
Medium Demand Scenario	337	90	247
Low Demand	225	47	178
High Demand	446	134	312

REFERENCE SOLUTION (WITHOUT PROJECT): RWANDA-BURUNDI-DR CONGO SYSTEM GENERATION

ALTERNATIVE 2

SCENARIO: **MEDIUM**

R/B/C Group FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	Committed Local Resources MW	Complementary Thermal GWh	Complementary Thermal MW	Kibuye GWh	Kibuye MW	Nyemanga GWh	Nyemanga MW	Ruzizi 3 GWh	Ruzizi 3 MW	Mule 34 GWh	Mule 34 MW	Kabu 16 GWh	Kabu 16 MW	Bendera GWh	Bendera MW	Rusumo GWh	Rusumo MW	Nyabarongp + Mpanda GWh	Nyabarongp + Mpanda MW
2 010	911	186	205	745	148	133	44			4	1,7											29	11
2 011	976	199	219	745	148	198	58			4	1,7											29	11
2 012	1046	213	289	705	148	0	58	0	0	4	1,7							160	43			177	38
2 013	1121	228	309	663	148	0	58	0	0	4	1,7					117	20	160	43			177	38
2 014	1201	244	309	743	148	0	58	0	0	4	1,7					117	20	160	43			177	38
2 015	1288	261	326	683	148	0	58	0	0	4	1,7			147	17	117	20	160	43			177	38
2 016	1386	281	326	745	148	36	58	0	0	4	1,7			147	17	117	20	160	43			177	38
2 017	1485	301	367	611	148	0	58	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 018	1602	325	367	728	148	0	58	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 019	1720	349	384	745	148	101	76	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 020	1837	373	466	507	148	0	76	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 021	1979	402	466	649	148	0	76	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 022	2120	430	473	745	148	45	83	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 023	2289	464	511	745	148	214	120	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 024	2459	498	548	745	148	384	157	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 025	2628	532	586	745	148	553	195	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 026	2832	573	630	745	148	757	240	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 027	3036	614	675	745	148	961	285	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 028	3281	663	729	745	148	1206	339	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 029	3525	712	783	745	148	1450	393	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 030	3769	761	837	745	148	1695	447	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38

SCENARIO: **LOW**

R/B/C Group FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	Committed Local Resources MW	Complementary Thermal GWh	Complementary Thermal MW	Kibuye GWh	Kibuye MW	Nyemanga GWh	Nyemanga MW	Ruzizi 3 GWh	Ruzizi 3 MW	Mule 34 GWh	Mule 34 MW	Kabu 16 GWh	Kabu 16 MW	Bendera GWh	Bendera MW	Rusumo GWh	Rusumo MW	Nyabarongp + Mpanda GWh	Nyabarongp + Mpanda MW
2 010	847	172	189	745	148	89	28			2	1,7											11	11
2 011	895	181	199	745	148	117	39			4	1,7											29	11
2 012	946	191	269	674	148	0	39			4	1,7							160	43			108	38
2 013	1000	202	269	674	148	0	39			4	1,7							160	43			162	38
2 014	1057	213	269	716	148	0	39	0	0	4	1,7							160	43			177	38
2 015	1117	225	269	745	148	31	39	0	0	4	1,7							160	43			177	38
2 016	1184	237	289	726	148	0	39	0	0	4	1,7					117	20	160	43			177	38
2 017	1251	249	289	745	148	48	39	0	0	4	1,7					117	20	160	43			177	38
2 018	1329	263	306	724	148	0	39	0	0	4	1,7			147	17	117	20	160	43			177	38
2 019	1406	276	306	745	148	56	39	0	0	4	1,7			147	17	117	20	160	43			177	38
2 020	1484	290	347	610	148	0	39	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 021	1582	308	347	708	148	0	39	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 022	1680	327	360	745	148	61	51	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 023	1794	349	384	745	148	175	75	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 024	1908	371	466	578	148	0	75	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 025	2023	392	466	693	148	0	75	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 026	2157	418	466	745	148	82	75	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 027	2292	444	488	745	148	217	97	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 028	2449	473	521	745	148	374	130	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 029	2606	503	554	745	148	531	163	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 030	2764	533	587	745	148	689	196	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38

SCENARIO: **HIGH**

R/B/C Group FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	Committed Local Resources MW	Complementary Thermal GWh	Complementary Thermal MW	Kibuye GWh	Kibuye MW	Nyemanga GWh	Nyemanga MW	Ruzizi 3 GWh	Ruzizi 3 MW	Mule 34 GWh	Mule 34 MW	Kabu 16 GWh	Kabu 16 MW	Bendera GWh	Bendera MW	Rusumo GWh	Rusumo MW	Nyabarongp + Mpanda GWh	Nyabarongp + Mpanda MW
2 010	993	204	224	745	148	215	63			4	1,7											29	11
2 011	1082	222	245	745	148	304	84			4	1,7											29	11
2 012	1180	243	315	745	148	94	84	0	0	4	1,7							160	43			177	38
2 013	1287	265	335	745	148	84	84	0	0	4	1,7					117	20	160	43			177	38
2 014	1404	289	376	677	148	0	84	0	0	4	1,7					117	20	160	43	269	41	177	38
2 015	1532	316	376	745	148	60	84	0	0	4	1,7					117	20	160	43	269	41	177	38
2 016	1682	345	393	745	148	63	84	0	0	4	1,7			147	17	117	20	160	43	269	41	177	38
2 017	1831	375	475	501	148	0	84	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 018	2018	412	475	688	148	0	84	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 019	2206	449	494	745	148	131	104	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 020	2393	487	535	745	148	318	144	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 021	2605	529	582	745	148	530	191	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 022	2817	572	629	745	148	742	238	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 023	3077	624	687	745	148	1002	296	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 024	3337	677	744	745	148	1262	354	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 025	3597	729	802	745	148	1522	411	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 026	3917	793	873	745	148	1842	482	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 027	4237	858	943	745	148	2162	553	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 028	4631	937	1030	745	148	2556	640	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 029	5024	1016	1117	745	148	2949	727	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38
2 030	5418	1095	1204	745	148	3343	814	0	0	4	1,7	456	82	147	17	117	20	160	43	269	41	177	38

REFERENCE SOLUTION (WITHOUT PROJECT): UGANDA SYSTEM GENERATION

ALTERNATIVE 2

SCENARIO: **MEDIUM**

Uganda FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	MW	Complementary Thermal GWh	MW	Bagasse GWh	MW	Karuma GWh	MW	Mini-Hydro GWh	MW	Kalagala GWh	MW	Murchison GWh	MW	Ayago GWh	MW	Export Kenya 50 MW GWh	MW
2 010	2874	500	629	2980	587	0	0	294	42											-400	-50
2 011	3081	535	639	3038	587	0	10	294	42											-251	-50
2 012	3303	573	713	3038	587	0	10	294	42			371	74							-400	-50
2 013	3541	612	723	3038	587	0	20	294	42			530	74							-321	-50
2 014	3796	655	923	3038	587	0	20	132	42	786	200	240	74							-400	-50
2 015	4069	701	923	3038	587	0	20	165	42	970	200	296	74							-400	-50
2 016	4373	752	923	3038	587	0	20	197	42	1183	200	355	74							-400	-50
2 017	4676	802	932	3038	587	0	29	232	42	1387	200	419	74							-400	-50
2 018	5038	862	998	3038	587	0	95	274	42	1625	200	501	74							-400	-50
2 019	5399	922	1448	3038	587	0	95	159	42	953	200	286	74	1363	450					-400	-50
2 020	5761	982	1448	3038	587	0	95	179	42	1081	200	323	74	1540	450					-400	-50
2 021	6117	1043	1448	3038	587	0	95	200	42	1202	200	360	74	1717	450					-400	-50
2 022	6473	1103	1448	3038	587	0	95	221	42	1322	200	398	74	1894	450					-400	-50
2 023	6885	1174	1448	3038	587	0	95	244	42	1467	200	440	74	2096	450					-400	-50
2 024	7298	1244	1448	3038	587	0	95	268	42	1612	200	482	74	2298	450					-400	-50
2 025	7710	1314	1670	3038	587	0	95	218	42	1293	200	392	74	1869	450	1300	222			-400	-50
2 026	8186	1395	1670	3038	587	0	95	238	42	1400	200	429	74	2045	450	1436	222			-400	-50
2 027	8663	1477	1674	3038	587	0	99	259	42	1518	200	466	74	2222	450	1560	222			-400	-50
2 028	9214	1571	1872	3038	587	0	99	282	42	1677	200	509	74	2424	450	1684	420			-400	-50
2 029	9766	1665	1881	3038	587	0	108	294	42	1747	200	530	74	2525	450	2032	420			-400	-50
2 030	10317	1759	1985	3038	587	0	212	294	42	1747	200	530	74	2525	450	2583	420			-400	-50

SCENARIO: **LOW**

Uganda FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	MW	Complementary Thermal GWh	MW	Bagasse GWh	MW	Karuma GWh	MW	Mini-Hydro GWh	MW	Kalagala GWh	MW	Murchison GWh	MW	Ayago GWh	MW	Export Kenya 50 MW GWh	MW
2 010	2435	420	629	2645	587	0	0	190	42											-400	-50
2 011	2540	436	629	2740	587	0	0	200	42											-400	-50
2 012	2648	453	629	2838	587	0	0	210	42											-400	-50
2 013	2762	470	629	2942	587	0	0	220	42											-400	-50
2 014	2880	489	629	3038	587	0	0	242	42											-400	-50
2 015	3003	508	703	2700	587	0	0	260	42			443	74							-400	-50
2 016	3134	528	703	2800	587	0	0	270	42			464	74							-400	-50
2 017	3266	548	703	2900	587	0	0	280	42			486	74							-400	-50
2 018	3411	570	703	3000	587	0	0	290	42			521	74							-400	-50
2 019	3557	592	903	3038	587	0	0	106	42	622	200	191	74							-400	-50
2 020	3703	614	903	3038	587	0	0	121	42	727	200	217	74							-400	-50
2 021	3854	639	903	3038	587	0	0	138	42	829	200	249	74							-400	-50
2 022	4005	664	903	3038	587	0	0	156	42	930	200	281	74							-400	-50
2 023	4172	692	903	3038	587	0	0	176	42	1040	200	318	74							-400	-50
2 024	4338	719	903	3038	587	0	0	194	42	1156	200	350	74							-400	-50
2 025	4505	747	903	3038	587	0	0	215	42	1265	200	387	74							-400	-50
2 026	4689	778	905	3038	587	0	2	235	42	1392	200	424	74							-400	-50
2 027	4873	808	939	3038	587	0	36	256	42	1518	200	461	74							-400	-50
2 028	5075	842	976	3038	587	0	73	279	42	1654	200	504	74							-400	-50
2 029	5278	875	1013	3038	587	0	110	294	42	1747	200	530	74							-331	-50
2 030	5481	909	1050	3038	587	0	147	294	42	1747	200	530	74							-128	-50

SCENARIO: **HIGH**

Uganda FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	MW	Complementary Thermal GWh	MW	Bagasse GWh	MW	Karuma GWh	MW	Mini-Hydro GWh	MW	Kalagala GWh	MW	Murchison GWh	MW	Ayago GWh	MW	Export Kenya 50 MW GWh	MW
2 010	3164	547	652	3038	587	0	23	294	42											-168	-50
2 011	3447	594	653	3038	587	115	24	294	42											0	0
2 012	3755	644	758	3038	587	0	55	294	42			530	74							-107	-50
2 013	4090	699	769	3038	587	228	66	294	42			530	74							0	0
2 014	4455	759	969	3038	587	0	66	209	42	1232	200	376	74							-400	-50
2 015	4853	824	969	3038	587	0	66	253	42	1506	200	456	74							-400	-50
2 016	5306	898	1419	3038	587	0	66	153	42	908	200	281	74	1326	450					-400	-50
2 017	5758	971	1419	3038	587	0	66	179	42	1078	200	323	74	1540	450					-400	-50
2 018	6320	1062	1419	3038	587	0	66	212	42	1270	200	382	74	1818	450					-400	-50
2 019	6881	1152	1419	3038	587	0	66	244	42	1463	200	440	74	2096	450					-400	-50
2 020	7443	1243	1419	3038	587	0	66	276	42	1658	200	498	74	2373	450					-400	-50
2 021	8062	1346	1641	3038	587	0	66	232	42	1377	200	419	74	1995	450	1401	222			-400	-50
2 022	8681	1450	1645	3038	587	0	70	259	42	1536	200	466	74	2222	450	1560	222			-400	-50
2 023	9433	1575	1843	3038	587	0	70	294	42	1747	200	530	74	2525	450	1699	420			-400	-50
2 024	10184	1701	1921	3038	587	0	148	294	42	1747	200	530	74	2525	450	2450	420			-400	-50
2 025	10936	1826	2155	3038	587	0	148	226	42	1345	200	408	74	1944	450	2796	420	1579	234	-400	-50
2 026	11846	1978	2226	3038	587	0	219	250	42	1485	200	451	74	2146	450	3133	420	1743	234	-400	-50
2 027	12755	2130	2530	3038	587	0	219	221	42	1310	200	398	74	1894	450	2759	420	3535	538	-400	-50
2 028	13859	2315	2596	3038	587	0	285	245	42	1457	200	442	74	2106	450	3068	420	3903	538	-400	-50
2 029	14963	2499	2799	3038	587	0	488	269	42	1600	200	485	74	2313	450	3370	420	4288	538	-400	-50
2 030	16067	2684	3002	3038	587	0	691	294	42	1747	200	530	74	2525	450	3679	420	4654	538	-400	-50

REFERENCE SOLUTION (WITHOUT PROJECT): KENYA SYSTEM GENERATION

ALTERNATIVE 2

SCENARIO: **MEDIUM**

KENYA LOAD FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	Committed Local Resources MW	Complementary Thermal GWh	Complementary Thermal MW	Coal GWh	Coal MW	Import Uganda GWh	Import Uganda MW
2010	7838	1343	1478	5052	1039	65	89	2321	300	400	50
2011	8491	1456	1628	5052	1039	65	89	3123	450	251	50
2012	9183	1576	1778	5052	1039	65	89	3667	600	400	50
2013	9922	1703	1874	5052	1039	135	185	4415	600	321	50
2014	10711	1840	2174	5052	1039	135	185	5124	900	400	50
2015	11552	1985	2183	5052	1039	142	194	5958	900	400	50
2016	12470	2144	2483	5052	1039	142	194	6876	1200	400	50
2017	13387	2302	2532	5052	1039	178	243	7758	1200	400	50
2018	14492	2493	3132	5052	1039	178	243	8862	1800	400	50
2019	15596	2684	3132	5052	1039	178	243	9967	1800	400	50
2020	16701	2876	3163	5052	1039	200	274	11049	1800	400	50
2021	17987	3098	3763	5052	1039	200	274	12334	2400	400	50
2022	19272	3321	3763	5052	1039	200	274	13620	2400	400	50
2023	20812	3588	4363	5052	1039	200	274	15160	3000	400	50
2024	22351	3854	4363	5052	1039	200	274	16699	3000	400	50
2025	23891	4121	4533	5052	1039	324	444	18115	3000	400	50
2026	25699	4434	5133	5052	1039	324	444	19922	3600	400	50
2027	27506	4747	5222	5052	1039	389	533	21665	3600	400	50
2028	29664	5122	5822	5052	1039	389	533	23823	4200	400	50
2029	31822	5496	6422	5052	1039	389	533	25981	4800	400	50
2030	33980	5870	6457	5052	1039	414	568	28114	4800	400	50

SCENARIO: **LOW**

2010	7585	1299	1429	5052	1039	29	40	2104	300	400	50
2011	8153	1397	1579	5052	1039	29	40	2672	450	400	50
2012	8750	1500	1729	5052	1039	29	40	3269	600	400	50
2013	9381	1609	1770	5052	1039	59	81	3870	600	400	50
2014	10049	1724	2070	5052	1039	59	81	4538	900	400	50
2015	10756	1846	2070	5052	1039	59	81	5245	900	400	50
2016	11516	1977	2175	5052	1039	136	186	5928	900	400	50
2017	12276	2109	2475	5052	1039	136	186	6688	1200	400	50
2018	13173	2264	2491	5052	1039	147	202	7574	1200	400	50
2019	14070	2420	3091	5052	1039	147	202	8471	1800	400	50
2020	14967	2575	3091	5052	1039	147	202	9368	1800	400	50
2021	15988	2751	3091	5052	1039	147	202	10388	1800	400	50
2022	17008	2928	3221	5052	1039	242	332	11314	1800	400	50
2023	18207	3135	3821	5052	1039	242	332	12513	2400	400	50
2024	19405	3343	3821	5052	1039	242	332	13711	2400	400	50
2025	20604	3550	3905	5052	1039	304	416	14848	2400	400	50
2026	21998	3791	4505	5052	1039	304	416	16242	3000	400	50
2027	23392	4032	4505	5052	1039	304	416	17636	3000	400	50
2028	25026	4315	5105	5052	1039	304	416	19271	3600	400	50
2029	26661	4598	5105	5052	1039	304	416	20975	3600	331	50
2030	28296	4881	5705	5052	1039	304	416	22812	4200	128	50

SCENARIO: **HIGH**

2010	8165	1400	1540	5052	1039	545	151	2400	300	168	50
2011	8914	1530	1683	5052	1039	262	194	3600	450	0	0
2012	9715	1668	1883	5052	1039	142	194	4414	600	107	50
2013	10578	1817	2133	5052	1039	142	194	5384	900	0	0
2014	11506	1978	2183	5052	1039	142	194	5912	900	400	50
2015	12506	2151	2483	5052	1039	142	194	6912	1200	400	50
2016	13611	2342	2576	5052	1039	210	287	7950	1200	400	50
2017	14717	2533	3176	5052	1039	210	287	9055	1800	400	50
2018	16074	2768	3176	5052	1039	210	287	10412	1800	400	50
2019	17430	3003	3303	5052	1039	303	414	11676	1800	400	50
2020	18787	3238	3903	5052	1039	303	414	13032	2400	400	50
2021	20404	3518	3903	5052	1039	303	414	14649	2400	400	50
2022	22020	3798	4503	5052	1039	303	414	16266	3000	400	50
2023	23995	4140	4554	5052	1039	340	465	18203	3000	400	50
2024	25969	4483	5154	5052	1039	340	465	20177	3600	400	50
2025	27943	4825	5754	5052	1039	340	465	22151	4200	400	50
2026	30289	5232	5755	5052	1039	340	466	24497	4200	400	50
2027	32634	5638	6355	5052	1039	340	466	26842	4800	400	50
2028	35486	6133	6955	5052	1039	340	466	29694	5400	400	50
2029	38337	6627	7555	5052	1039	340	466	32545	6000	400	50
2030	41189	7122	7834	5052	1039	544	745	35193	6000	400	50

EVALUATION OF THE COST OF ENERGY NOT SERVED

1.1. INTRODUCTION

There are two decisive criteria for planning electrical systems: discounting rate and cost of energy not served.

The first enables a choice to be made between two types of expenditure providing the same service but with different schedules.

The second is used to define the quality of service expected from an electrical system (production facilities and/or networks) in order to design it in relation to its expected peak power. This is generally referred to as the cost of energy not served per kWh, i.e. per kWh not produced and/or not distributed. No electrical system is in fact perfect. There are always situations in which an electricity company is obliged to cut off its customers because of a failure in its production, transmission or distribution systems. The higher the company's expenditure, in particular for production investments, the better the quality of service will be in the corresponding field.

1.2. IMPLICIT COST OF ENERGY NOT SERVED

There are several methods for estimating the cost of energy not served per kWh. One of the most intuitive involves determining the implicit cost per kWh, which may be done in the following way with regard to production facilities:

a. In the reference situation, the electricity company has a certain number of power plants for which it has invested an amount I. If customers are cut off, the energy not distributed is E (annual average).
b. To improve the quality of service, the company starts up a new production unit and invests the sum of ΔI to do so. This enables it to improve the quality of service, i.e. to reduce E, by the amount ΔE. In this case, the cost of energy not served per kWh is given by the equation: $d=\Delta I/\Delta E$ (ΔI represents the additional investment annuity, which involves a discounting rate).

It can be seen that the new unit will produce much less energy than the existing units, as it will only be called upon in the event of an outage. As the quality of service improves, the cost increases. d is also said to represent the marginal production cost, i.e. the production cost per additional kWh intended to reduce the outage.

1.3. CHARACTERISTICS OF COST OF ENERGY NOT SERVED AND PROPOSED VALUE

a. The cost of energy not served is much higher than the average cost of supplying electricity to customers. A standard that is often used is to consider an cost of energy not served 10 - 100 times higher than the average cost of supply (the factor usually varies, increasing in accordance with the economic wealth of the country in question). This represents a good estimate of the cost of energy not served provided that the sale price of electricity is representative of its real cost. In developed countries, the norm is USD 5-10/kWh. It is considerably lower in developing countries. There, it is less the quality of service of electricity distribution to a minority of privileged people (who are moreover often subsidised by the electricity company, which sells below cost price) that is important than access to electricity, even for only a few hours a day. In this case an cost of energy not served of USD 0.5-1/kWh is often considered.

b. The cost of energy not served also represents the economic value of the kWh assuming that national wealth is entirely dependent upon the electricity supply (but not created by it). This criterion works well in industrialised countries where agricultural production (which often has little connection with electricity) represents only a very small proportion (a few %) of GDP and where everyone has access to electricity. This is obviously not the case in the five countries considered in the present study.

c. Cost of energy not served proposed for the present study

Two parameters could be taken into account to estimate this cost: national wealth and the sale price of electricity, even if the latter is often systematically lower than its real cost because of subsidies.

The table below shows these two parameters for 2005.

Average sale price of kWh, in US cents	Burundi	DR Congo	Rwanda	Uganda	Kenya
HV level	-	-		3.4	10.4
MV level	9.6	8.8	20	4.6	10.8
LV level	7.1	5.8	20	10.8	8.3
GDP/inh, USD (approx.)	110	110	230	280	360

Multiplying this sale price by a factor of 5 would give the following levels:

- Burundi, DR Congo, Kenya, Uganda: .... about USD 0.5/kWh
- Rwanda: .... about USD 1/kWh

If the living standards of these countries are also taken into account, the following costs are obtained. These are close to those adopted in the present study:

- Burundi, RD Congo, Uganda: .... USD 0.8/kWh
- Rwanda, Kenya: .... USD 1/kWh.

With increasing cooperation and integration of the five countries in the energy field, it will be advisable to consider similar planning criteria, and therefore probably a uniform cost of energy not served. For the time being, it is acceptable to propose different cost of energy not serveds for each country. In contrast, once the interconnections have been built, a single cost of energy not served for the entire system may be assumed.

The above analysis should be compared with the value of the cost of energy not served taken into account by KPLC in Kenya, which is USD 0.8/kWh.

1.4. PRACTICAL ILLUSTRATION OF COST OF ENERGY NOT SERVED

In all countries throughout the world, when electricity companies can no longer provide a reliable service (i.e. when there are frequent and/or prolonged power cuts, excessive variations in voltage and/or frequency, etc.), many customers decide to equip themselves with small petrol or diesel generators to overcome the problems of power supply. This phenomenon is particularly evident in city business districts, where small generators often clutter the pavements and contribute to atmospheric pollution.

The economic interpretation of this situation is as follows: supply costs that are not borne by the electricity company are transferred to consumers, who themselves produce the electricity they need instead of buying it from the company. But this transfer is accompanied by very high direct or indirect costs. For example:

- Direct costs:
  - Electricity produced at a much higher cost than that of the company.
  - Importing of generators and fuel, instead of production using natural resources, for example hydropower.
  - Discontinuous service, only a few hours a day.
- Indirect costs:
  - External costs such as pollution and noise, which are normally produced by a power plant outside the town.
  - Relocation of activities that require better quality service. One example is tea producers who have moved from Uganda and settled in Kenya.

The table below compares the costs obtained for Burundi, DR Congo and Rwanda, for small-scale self-generated thermal power. This is two to three times higher than centralised production. It also gives an idea of the cost that the electricity company's customers are prepared to pay to have electricity when the company is unable to provide it.

It should also be noted that certain activities need very high quality service. These customers always buy their own generators even when the quality of service provided by the electricity distributor is usually acceptable. This is the case for example with hospitals, airports, security services, etc. In these situations, diesel generators automatically take over when there is the slightest power cut.

COST PRICE OF SELF-PRODUCED ENERGY USING DIESEL GENERATORS

1. Assumptions				
Installed power of generators		0.5 - 10 kW		
Investment cost		USD 1000/kW		
Working life		5 years		
Cost per kW guaranteed		Production not guaranteed		
Annual maintenance costs		2% of investment cost		
Specific consumption		500 g/kWh		
Use		6 h/day		
Fuel density		0.8		
2. Annual fixed costs per kW				
Investment		USD 270		
Maintenance		USD 20		
Total		USD 290		
3. Proportional costs		Burundi	DR Congo	Rwanda
Cost exc. tax	USD/l	0.880	0.850	0.790
Tax	USD/l	0.170	0.200	0.243
Total inc. tax	USD/l	1.050	1.050	1.033
Cost of fuel				
exc. tax	USD/kWh	0.550	0.531	0.494
inc. tax	USD/kWh	0.656	0.656	0.646
Corresponding annual cost				
exc. tax	USD	1204	1163	1372
inc. tax	USD	1437	1437	1415
4. Total cost		Burundi	DR Congo	Rwanda
Annual cost				
exc. tax	USD/kW	1494	1453	1372
inc. tax	USD/kW	1727	1727	1705
Cost price				
exc. tax	USD/kWh	0.68	0.66	0.63
inc. tax	USD/kWh	0.79	0.79	0.78