Central Solar Fotovoltaica de Pereiro

Projeto licenciamento para obtenção de licença de produção Leilão Solar 2020 – Lote 3

Promotor: Suggestion Power, Lda.

Suggestion Power
Unipessoal Lda

enel
Green Power

Especificações Técnicas

ET1	Ficha Técnica Painel Fotovoltaico
ET2	Ficha Técnica Posto Transformação
ET3	Ficha Técnica Inversores
ET4	Ficha Técnica Seguidor Solar
ET5	Ficha Técnica Caixa de Junção
ET6	Ficha Técnica SPCC
ET7	Ficha Técnica Sistema de Armazenamento (BESS)
ET8	Ficha Técnica Cabo Solar
ET9	Ficha Técnica Cabo CC
ET10	Ficha Técnica Cabo MT
ET11	Ficha Técnica Transformador de Potência

Hi-MO 7

LR8-66HGD

595~625M

- High-performance PV modules for utility power plants
- Advanced HPDC cell technology delivers superior module efficiency and power
- High bifaciality and excellent power temperature coefficient achieves high energy yield
- LONGi lifecycle quality ensures long-term performance

12 12-year Warranty for Materials and Processing

30 30-year Warranty for Extra Linear Power Output

Complete System and Product Certifications

IEC 61215, IEC 61730, UL 61730

ISO9001:2015: ISO Quality Management System

ISO14001: 2015: ISO Environment Management System

ISO45001: 2018: Occupational Health and Safety

IEC62941: Guideline for module design qualification and type approval

LONGi

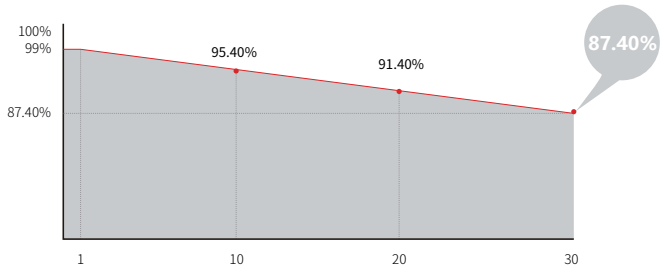
Hi-MO 7

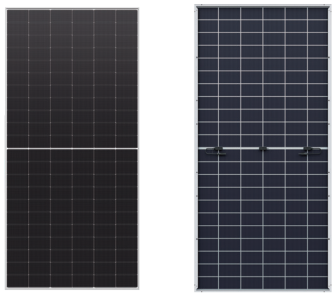
LR8-66HGD 595~625M

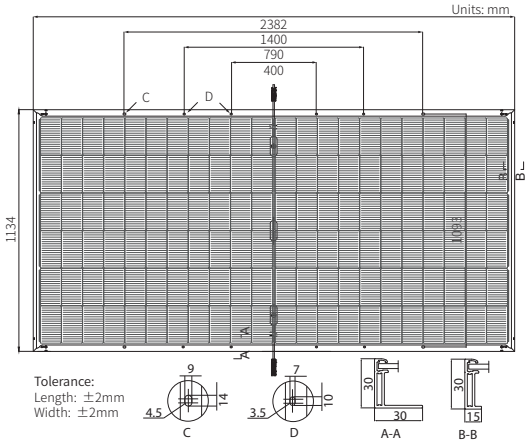
23.1%	0~3%	<1%	0.4%	HALF-CELL
MAX MODULE EFFICIENCY	POWER TOLERANCE	FIRST YEAR POWER DEGRADATION	YEAR 2-30 POWER DEGRADATION	Lower operating temperature

Additional Value

30-Year Power Warranty







Mechanical Parameters

Cell Orientation	132 (6×22)
Junction Box	IP68, three diodes
Output Cable	4mm², +400, -200mm/±1400mm length can be customized
Glass	Dual glass, 2.0+2.0mm heat strengthened glass
Frame	Anodized aluminum alloy frame
Weight	33.5kg
Dimension	2382×1134×30mm
Packaging	36pcs per pallet / 144pcs per 20' GP / 720pcs or 576pcs (only for USA) per 40' HC

Electrical Characteristics

STC : AM1.5 1000W/m² 25°C NOCT : AM1.5 800W/m² 20°C 1.0 m/s Test uncertainty for Pmax: ±3%

Module Type	LR8-66HGD-595M		LR8-66HGD-600M		LR8-66HGD-605M		LR8-66HGD-610M		LR8-66HGD-615M		LR8-66HGD-620M		LR8-66HGD-625M	
Testing Condition	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (Pmax/W)	595	452.9	600	456.7	605	460.5	610	464.3	615	468.1	620	471.9	625	475.8
Open Circuit Voltage (Voc/V)	47.78	45.41	47.98	45.60	48.18	45.79	48.38	45.98	48.58	46.17	48.78	46.36	48.98	46.55
Short Circuit Current (Isc/A)	15.80	12.69	15.85	12.73	15.90	12.77	15.95	12.81	16.00	12.85	16.05	12.89	16.10	12.93
Voltage at Maximum Power (Vmp/V)	39.91	37.93	40.11	38.12	40.31	38.31	40.51	38.50	40.71	38.69	40.91	38.88	41.11	39.07
Current at Maximum Power (Imp/A)	14.91	11.94	14.96	11.98	15.01	12.02	15.06	12.06	15.11	12.10	15.16	12.14	15.21	12.18
Module Efficiency(%)	22.0		22.2		22.4		22.6		22.8		23.0		23.1	

Electrical characteristics with different rear side power gain (reference to 610W front)

Pmax /W	Voc/V	Isc /A	Vmp/V	Imp /A	Pmax gain
641	48.38	16.75	40.51	15.81	5%
671	48.38	17.55	40.51	16.57	10%
703	48.48	18.34	40.61	17.32	15%
734	48.48	19.14	40.61	18.07	20%
764	48.48	19.94	40.61	18.82	25%

Operating Parameters

Operational Temperature	-40°C ~ +85°C
Power Output Tolerance	0 ~ 3%
Maximum System Voltage	DC1500V (IEC/UL)
Maximum Series Fuse Rating	35A
Nominal Operating Cell Temperature	45±2°C
Protection Class	Class II
Bifaciality	80±5%
Fire Rating	UL type 29 IEC Class C

Mechanical Loading

Front Side Maximum Static Loading	5400Pa
Rear Side Maximum Static Loading	2400Pa
Hailstone Test	25mm Hailstone at the speed of 23m/s

Temperature Ratings (STC)

Temperature Coefficient of Isc	+0.045%/°C
Temperature Coefficient of Voc	-0.230%/°C
Temperature Coefficient of Pmax	-0.280%/°C

LONGi

Web: www.longi.com

Specifications included in this datasheet are subject to change without notice.
LONGi reserves the right of final interpretation. (20240705V03)

/ MVPS 4000-S2-10 / MVPS 4200-S2-10 / MVPS 4400-S2-10 / MVPS 4600-S2-10

MV Power Station

4000-S2 / 4200-S2 / 4400-S2 / 4600-S2

Turnkey solution for PV and battery-storage power plants

Robust
- Station and all individual components type-tested
- Galvanized base frame for extreme ambient conditions

Easy to use
- Turn-key solution
- Fully pre-assembled for easy setup and commissioning

Cost effective
- Lower specific costs thanks to high power classes
- Minimal coordination required during planning and installation
- Low transport costs thanks to 20-foot platform

Flexible
- One design for the whole world
- Numerous options

With the power of the robust central inverters Sunny Central UP or Sunny Central Storage UP and the perfectly matched medium-voltage components, the MV Power Station offers high power density and is a turnkey solution available worldwide.

Ideal for use in the new generation of PV and battery-storage power plants with 1500 V_{DC}, the integrated system solution is easy to transport and quick to assemble and commission. The MVPS and all components are type-tested. The MV Power Station combines rigorous plant safety with maximum energy yield and minimized deployment and operating risk.

Now also available with an environmentally friendly SF6-free medium-voltage switchgear – as a sustainable contribution to climate protection.

MV POWER STATION
4000-S2 / 4200-S2 / 4400-S2 / 4600-S2

Technical data	MVPS 4000-S2	MVPS 4200-S2
Input (DC)		
Available inverters	1 x SC 4000 UP or 1 x SCS 3450 UP or 1 x SCS 3450 UP-XT	1 x SC 4200 UP or 1 x SCS 3600 UP or 1 x SCS 3600 UP-XT
Max. input voltage	1500 V	1500 V
Number of DC inputs	Depending on selected inverter	
Integrated zone monitoring	○	
Output (AC) on the medium-voltage side		
Nominal power at SC UP (from -25°C to +35°C / 40°C; optional 50°C)[1]	4000 kVA / 3600 kVA	4200 kVA / 3780 kVA
Nominal power at SCS UP (from -25°C to +25°C / 40°C; optional 50°C)[1]	3450 kVA / 2930 kVA	3620 kVA / 3075 kVA
Charging power at SCS UP-XT (from -25°C to +25°C / 40°C; optional 50°C)[1]	3589 kVA / 3001 kVA	3769 kVA / 3152 kVA
Discharging power at SCS UP-XT (from -25°C at +25°C / 40°C; optional 50°C)[1]	4000 kVA / 3400 kVA	4200 kVA / 3570 kVA
Typical nominal AC voltages with a permanent tolerance of +/-10%	10 kV to 36 kV	10 kV to 36 kV
AC power frequency	50 Hz / 60 Hz	50 Hz / 60 Hz
Transformer vector group Dy11 / YNd11 / YNy0	● / ○ / ○	● / ○ / ○
Transformer cooling method	KNAN[2]	KNAN[2]
Transformer standby power losses, industry standard / Eco design 1 / Eco design 2	● / ○ / ○	● / ○ / ○
Transformer short-circuit losses, industry standard / Eco design 1 / Eco design 2	● / ○ / ○	● / ○ / ○
Max. total harmonic distortion	< 3 %	
Reactive power feed-in (up to max. 60% of nominal power)	○	
Inverter efficiency		
Max. efficiency[3] / Europ. efficiency[3] / CEC efficiency[4]	98.8 % / 98.6 % / 98.5 %	98.8 % / 98.7 % / 98.5 %
Protective devices		
Input-side disconnection point	DC load-break switch	
Output-side disconnection point	Medium-voltage vacuum circuit breaker	
DC overvoltage protection	Surge arrester, type I	
Galvanic isolation	●	
Arc fault resistance medium-voltage control room (according to IEC 62271-202)	IAC A 20 kA 1 s	
General data		
Dimensions (W / H / D)	6058 mm / 2896 mm / 2438 mm	
Weight	< 18 t	
Self-consumption (max. / partial load / average)[1]	< 8.1 kW / < 1.8 kW / < 2.0 kW	
Self-consumption (stand-by)[1]	< 370 W	
Ambient temperature -25°C to +45°C / -25°C to +55°C / -35°C to +55°C / -40°C to +45°C	● / ○ / ○ / ○	
Degree of protection according to IEC 60529	Control rooms IP23D, inverter electronics IP54	
Environment: standard/extreme	● / ○	
Maximum permissible value for relative humidity (condensing / non-condensing)	95% to 100% (2 month / year) / 0% to 95%	
Max. operating altitude above MSL 1000 m / 2000 m / 3000 m	● / ○ / ○	● / ○ / –
Inverter fresh air consumption	6500 m³/h	
Equipment		
DC connection	Lug	
AC connection	Outer-cone angle plug	
Monitoring package	○	
Station enclosure color	RAL 7004	
Transformer for external loads: without / 10 / 20 / 30 / 40 / 50 / 60 kVA	● / ○ / ○ / ○ / ○ / ○ / ○	
Fuses for external transformers: none / 120 kVA / 180 kVA	● / ○ / ○	
MV switchgear: without / 1 panel / 3 panels / 630 A / 800 A 2 cable panels with load-break switch, 1 transformer panel with circuit breaker, arc fault resistance IAC A FL 20 kA 1 s to IEC 62271-200	● / ○ / ○ / ○ / ○	
MV switchgear short-circuit current capability (20 kA 1 s / 20 kA 3 s / 25 kA 1 s)	● / ○ / ○	
Accessory for MV switchgear: without / auxiliary contacts / motor for transformer panel / cascade control / monitoring	● / ○ / ○ / ○ / ○	
Integrated oil spill containment: without/with	● / ○	
Industry standards (other industry standards: see inverter datasheet)	IEC 60076, IEC 62271-200, IEC 62271-202, EN50588-1, CSC certificate	
Type designation	MVPS-4000-S2-10	MVPS-4200-S2-10

● Standard features ○ Optional features – Not available

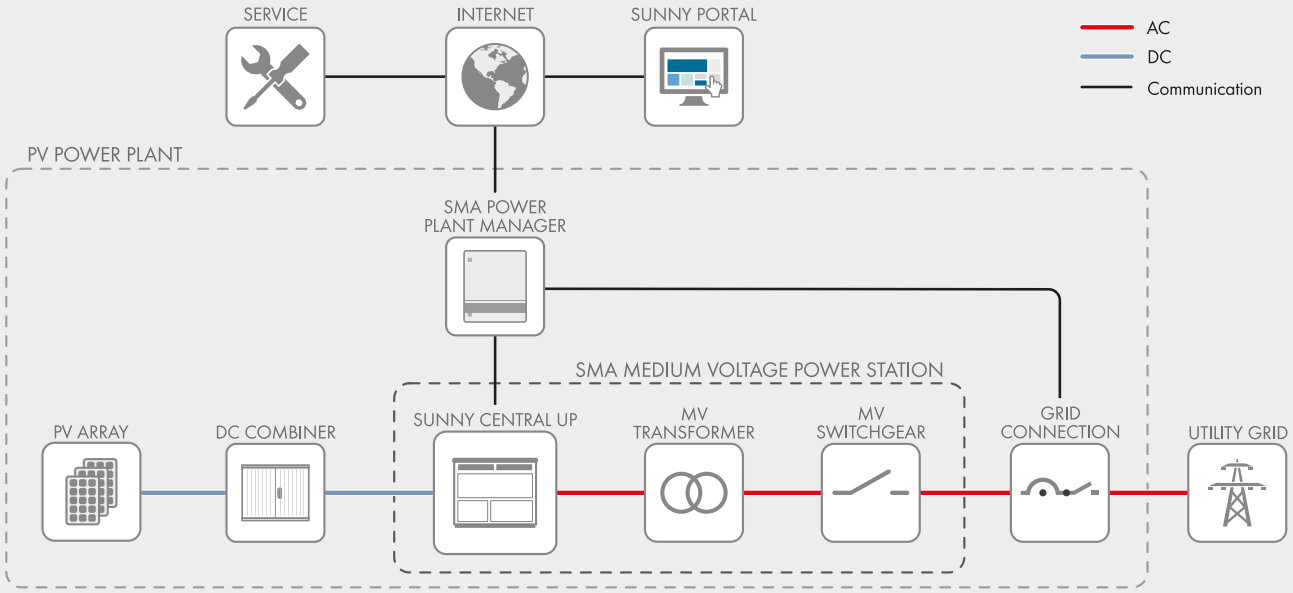
1) Data based on inverter. Further details can be found in the inverter data sheet.
2) KNAN = ester with natural air cooling
3) Efficiency measured at inverter without internal power supply
4) Efficiency measured at inverter with internal power supply

Technical data	MVPS 4400-S2	MVPS 4600-S2
Input (DC)		
Available inverters	1 x SC 4400 UP or 1 x SCS 3800 UP or 1 x SCS 3800 UP-XT	1 x SC 4600 UP or 1 x SCS 3950 UP or 1 x SCS 3950 UP-XT
Max. input voltage	1500 V	1500 V
Number of DC inputs	Depending on selected inverter	
Integrated zone monitoring	○	
Output (AC) on the medium-voltage side		
Nominal power at SC UP (from -25°C to +35°C / 40°C; optional 50°C)[1]	4400 kVA / 3960 kVA	4600 kVA / 4140 kVA
Nominal power at SCS UP (from -25°C to +25°C / 40°C; optional 50°C)[1]	3800 kVA / 3230 kVA	3960 kVA / 3365 kVA
Charging power at SCS UP-XT (from -25°C to +25°C / 40°C; optional 50°C)[1]	3949 kVA / 3302 kVA	4129 kVA / 3453 kVA
Discharging power at SCS UP-XT (from -25°C at +25°C / 40°C; optional 50°C)[1]	4400 kVA / 3740 kVA	4600 kVA / 3910 kVA
Typical nominal AC voltages with a permanent tolerance of +/-10%	10 kV to 36 kV	10 kV to 36 kV
AC power frequency	50 Hz / 60 Hz	50 Hz / 60 Hz
Transformer vector group Dy11 / YNd11 / YNy0	● / ○ / ○	● / ○ / ○
Transformer cooling method	KNAN[2]	KNAN[2]
Transformer standby power losses, industry standard / Eco design 1 / Eco design 2	● / ○ / ○	● / ○ / ○
Transformer short-circuit losses, industry standard / Eco design 1 / Eco design 2	● / ○ / ○	● / ○ / ○
Max. total harmonic distortion	< 3 %	
Reactive power feed-in (up to max. 60% of nominal power)	○	
Inverter efficiency		
Max. efficiency[3] / Europ. efficiency[3] / CEC efficiency[4]	98.8 % / 98.7 % / 98.5 %	98.8 % / 98.7 % / 98.5 %
Protective devices		
Input-side disconnection point	DC load-break switch	
Output-side disconnection point	Medium-voltage vacuum circuit breaker	
DC overvoltage protection	Surge arrester, type I	
Galvanic isolation	●	
Arc fault resistance medium-voltage control room (according to IEC 62271-202)	IAC A 20 kA 1 s	
General data		
Dimensions (W / H / D)	6058 mm / 2896 mm / 2438 mm	
Weight	< 18 t	
Self-consumption (max. / partial load / average)[1]	< 8.1 kW / < 1.8 kW / < 2.0 kW	
Self-consumption (stand-by)[1]	< 370 W	
Ambient temperature -25°C to +45°C / -25°C to +55°C / -35°C to +55°C / -40°C to +45°C	● / ○ / ○ / ○	
Degree of protection according to IEC 60529	Control rooms IP23D, inverter electronics IP54	
Environment: standard/extreme	● / ○	
Maximum permissible value for relative humidity (condensing / non-condensing)	95% to 100% (2 month / year) / 0% to 95%	
Max. operating altitude above MSL 1000 m / 2000 m / 3000 m	● / ○ / –	
Inverter fresh air consumption	6500 m³/h	
Equipment		
DC connection	Lug	
AC connection	Outer-cone angle plug	
Monitoring package	○	
Station enclosure color	RAL 7004	
Transformer for external loads: without / 10 / 20 / 30 / 40 / 50 / 60 kVA	● / ○ / ○ / ○ / ○ / ○ / ○	
Fuses for external transformers: none / 120 kVA / 180 kVA	● / ○ / ○	
MV switchgear: without / 1 panel / 3 panels / 630 A / 800 A 2 cable panels with load-break switch, 1 transformer panel with circuit breaker, arc fault resistance IAC A FL 20 kA 1 s to IEC 62271-200	● / ○ / ○ / ○ / ○	
MV switchgear short-circuit current capability (20 kA 1 s / 20 kA 3 s / 25 kA 1 s)	● / ○ / ○	
Accessory for MV switchgear: without / auxiliary contacts / motor for transformer panel / cascade control / monitoring	● / ○ / ○ / ○ / ○	
Integrated oil spill containment: without/with	● / ○	
Industry standards (other industry standards: see inverter datasheet)	IEC 60076, IEC 62271-200, IEC 62271-202, EN50588-1, CSC certificate	
Type designation	MVPS-4400-S2-10	MVPS-4600-S2-10

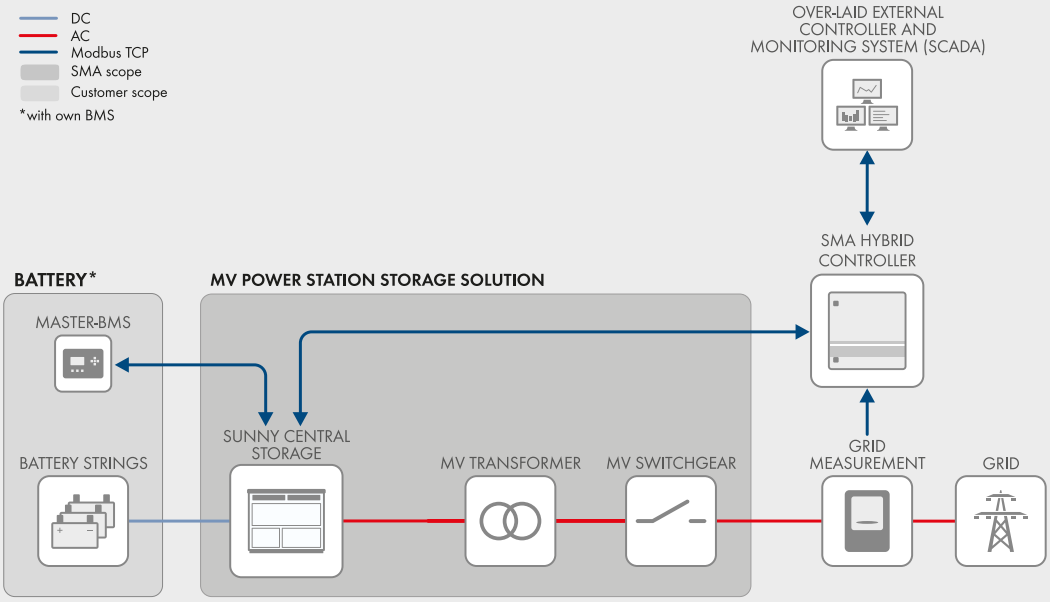
● Standard features ○ Optional features – Not available

1) Data based on inverter Further details can be found in the inverter datasheet.
2) KNAN = ester with natural air cooling
3) Efficiency measured at inverter without internal power supply
4) Efficiency measured at inverter with internal power supply

Plant diagram with Sunny Central UP



Plant diagram with Sunny Central Storage UP



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SC 4000 UP / SC 4200 UP / SC 4400 UP / SC 4600 UP

Efficient

- Up to 4 inverters can be transported in one standard shipping container
- Overdimensioning up to 150% is possible
- Full power at ambient temperatures of up to 35°C

Robust

- Intelligent air cooling system OptiCool for efficient cooling
- Suitable for outdoor use in all climatic ambient conditions worldwide

Flexible

- One device for all applications
- PV application, optionally available with DC-coupled storage system

Easy to Use

- Improved DC connection area
- Connection area for customer equipment
- Integrated voltage support for internal and external loads

SUNNY CENTRAL UP

The new Sunny Central: more power per cubic meter

With an output of up to 4600 kVA and system voltages of 1500 V DC, the SMA central inverter allows for more efficient system design and a reduction in specific costs for PV and battery power plants. A separate voltage supply and additional space are available for the installation of customer equipment. True 1500 V technology and the intelligent cooling system OptiCool ensure smooth operation even in extreme ambient temperature as well as a long service life of 25 years.

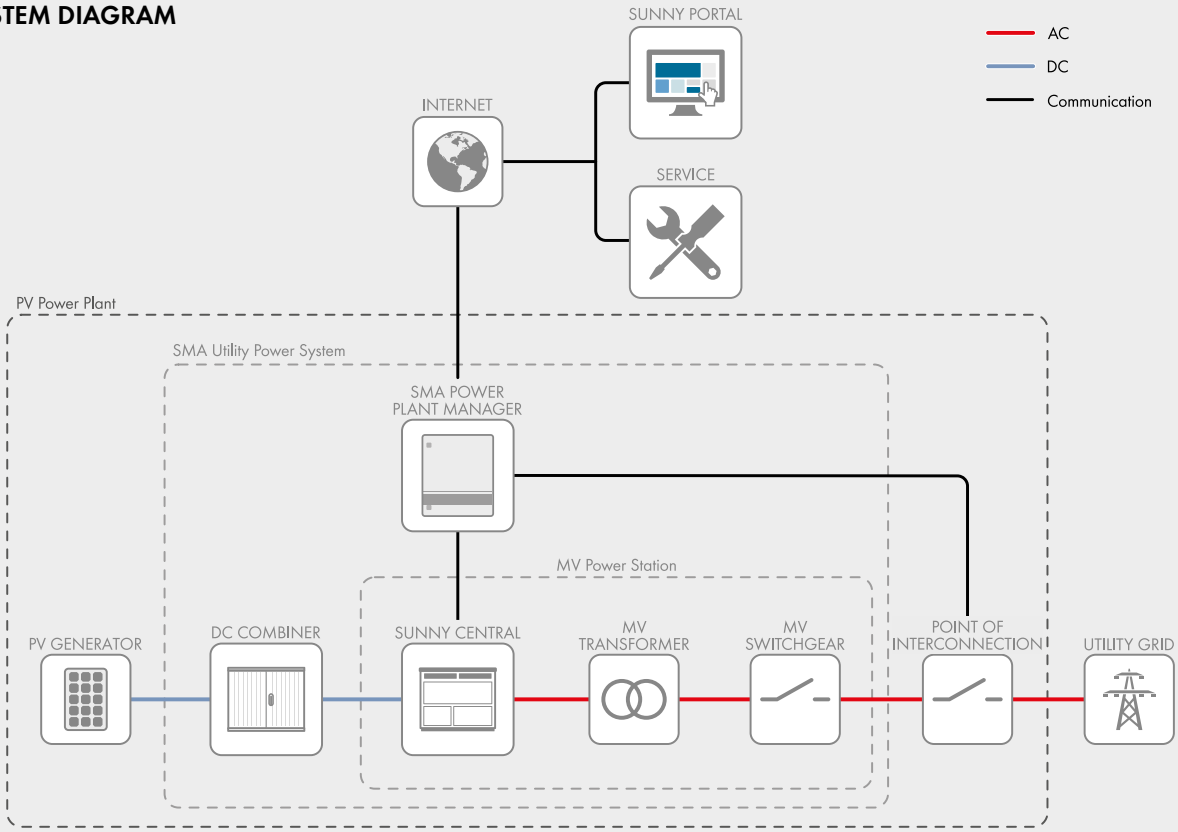
SUNNY CENTRAL UP

Technical Data	SC 4000 UP	SC 4200 UP
DC side		
MPP voltage range V_{DC} (at 25 °C / at 50 °C)	880 to 1325 V / 1100 V	921 to 1325 V / 1050 V
Min. DC voltage $V_{DC, min}$ / Start voltage $V_{DC, Start}$	849 V / 1030 V	891 V / 1071 V
Max. DC voltage $V_{DC, max}$	1500 V	1500 V
Max. DC current $I_{DC, max}$	4750 A	4750 A
Max. short-circuit current $I_{DC, SC}$	8400 A	8400 A
Number of DC inputs	Busbar with 26 connections per terminal, 24 double pole fused (32 single pole fused)	
Number of DC inputs with optional DC coupled storage	18 double pole fused (36 single pole fused) for PV and 6 double pole fused for batteries	
Max. number of DC cables per DC input (for each polarity)	2 x 800 kcmil, 2 x 400 mm²	
Integrated zone monitoring	○	
Available PV fuse sizes (per input)	200 A, 250 A, 315 A, 350 A, 400 A, 450 A, 500 A	
Available battery fuse size (per input)	750 A	
AC side		
Nominal AC power at cos φ =1 (at 35°C / at 50°C)	4000 kVA[12] / 3600 kVA	4200 kVA[13] / 3780 kVA
Nominal AC active power at cos φ =0.8 (at 35°C / at 50°C)	3200 kW[12] / 2880 kW	3360 kW[13] / 3024 kW
Nominal AC current $I_{AC, nom}$ (at 35°C / at 50°C)	3850 A / 3465 A	3850 A / 3465 A
Max. total harmonic distortion	< 3% at nominal power	< 3% at nominal power
Nominal AC voltage / nominal AC voltage range[1] [8]	600 V / 480 V to 720 V	630 V / 504 V to 756 V
AC power frequency / range	50 Hz / 47 Hz to 53 Hz 60 Hz / 57 Hz to 63 Hz	
Min. short-circuit ratio at the AC terminals[9]	> 2	
Power factor at rated power / displacement power factor adjustable[8] [10]	1 / 0.8 overexcited to 0.8 underexcited	
Efficiency		
Max. efficiency[2] / European efficiency[2] / CEC efficiency[3]	98.8% / 98.6% / 98.5%	98.8% / 98.7% / 98.5%
Protective Devices		
Input-side disconnection point	DC load break switch	
Output-side disconnection point	AC circuit breaker	
DC overvoltage protection	Surge arrester, type I & II	
AC overvoltage protection (optional)	Surge arrester, class I & II	
Lightning protection (according to IEC 62305-1)	Lightning Protection Level III	
Ground-fault monitoring / remote ground-fault monitoring	○ / ○	
Insulation monitoring	○	
Degree of protection: electronics / air duct / connection area (as per IEC 60529)	IP54 / IP34 / IP34	
General Data		
Dimensions (W / H / D)	2815 / 2318 / 1588 mm (110.8 / 91.3 / 62.5 inch)	
Weight	< 3700 kg / < 8158 lb	
Self-consumption (max.[4] / partial load[5] / average[6])	< 8100 W / < 1800 W / < 2000 W	
Self-consumption (standby)	< 370 W	
Internal auxiliary power supply	○ Integrated 8.4 kVA transformer	
Operating temperature range[8]	−25°C to 60°C / −13°F to 140°F	
Noise emission[7]	63.0 dB(A)*	
Temperature range (standby)	−40°C to 60°C / −40°F to 140°F	
Temperature range (storage)	−40°C to 70°C / −40°F to 158°F	
Max. permissible value for relative humidity (condensing / non-condensing)	95% to 100% (2 month/year) / 0% to 95%	
Maximum operating altitude above MSL[8] 1000 m / 2000 m[11] / 3000 m[11]	● / ○ / ○	● / ○ / –
Fresh air consumption	6500 m³/h	
Features		
DC connection	Terminal lug on each input (without fuse)	
AC connection	With busbar system (three busbars, one per line conductor)	
Communication	Ethernet, Modbus Master, Modbus Slave	
Enclosure / roof color	RAL 9016 / RAL 7004	
Supply for external loads	○ (2.5 kVA)	
Standards and directives complied with	CE, IEC / EN 62109-1, IEC / EN 62109-2, AR-N 4110, IEEE1547, UL 840 Cat. IV, Arrêté du 23/04/08	
EMC standards	IEC 55011, IEC 61000-6-2, FCC Part 15 Class A	
Quality standards and directives complied with	VDI/VDE 2862 page 2, DIN EN ISO 9001	
● Standard features ○ Optional – not available * preliminary		
Type designation	SC 4000 UP	SC 4200 UP

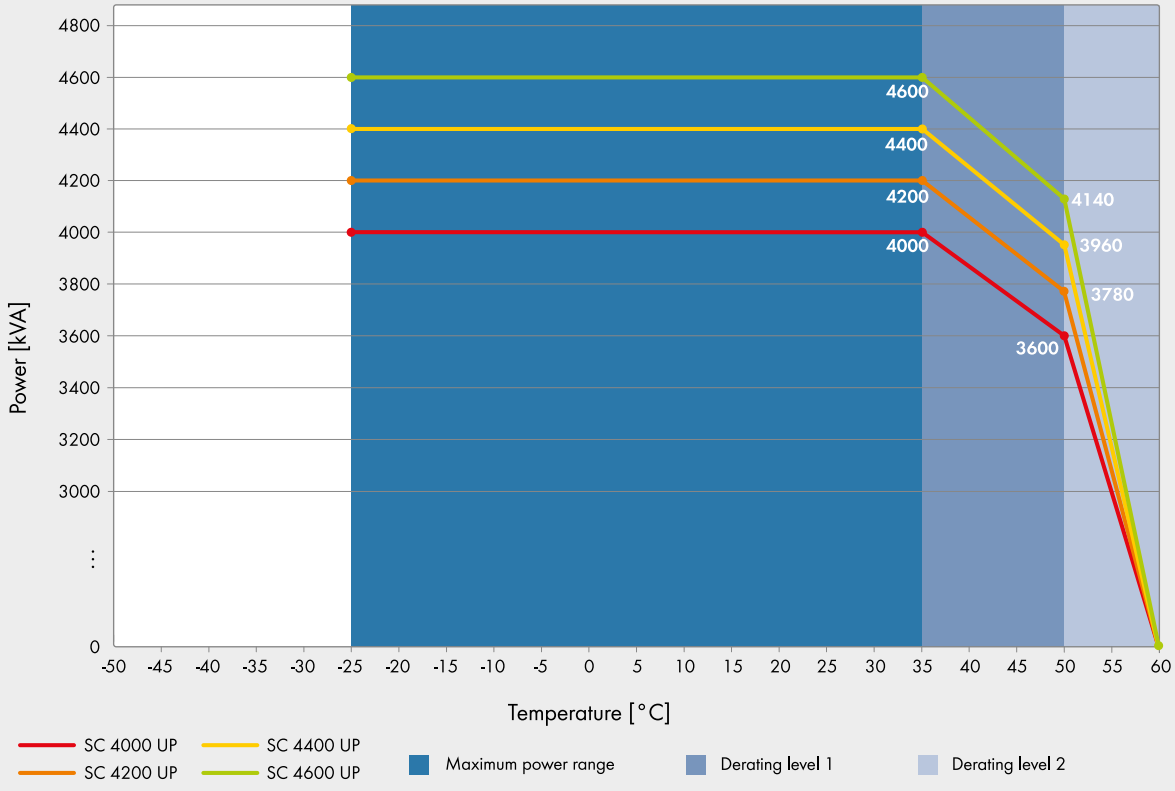
1) At nominal AC voltage, nominal AC power decreases in the same proportion
2) Efficiency measured without internal power supply
3) Efficiency measured with internal power supply
4) Self-consumption at rated operation
5) Self-consumption at < 75% Pn at 25°C
6) Self-consumption averaged out from 5% to 100% Pn at 25°C
7) Sound pressure level at a distance of 10 m
8) Values apply only to inverters. Permissible values for SMA MV solutions from SMA can be found in the corresponding data sheets.
9) A short-circuit ratio of < 2 requires a special approval from SMA
10) Depending on the DC voltage
11) Earlier temperature-dependent de-rating and reduction of DC open-circuit voltage
12) Nominal AC power at 35°C achievable up to a maximum of 1050 V_{DC}
13) Nominal AC power at 35°C achievable up to a maximum of 1000 V_{DC}
14) Nominal AC power at 35°C achievable up to a maximum of 1025 V_{DC}

Technical Data	SC 4400 UP	SC 4600 UP
DC side		
MPP voltage range V_{DC} (at 25 °C / at 50 °C)	962 to 1325 V / 1000 V	1003 to 1325 V / 1040 V
Min. DC voltage $V_{DC, min}$ / Start voltage $V_{DC, Start}$	934 V / 1112 V	976 V / 1153 V
Max. DC voltage $V_{DC, max}$	1500 V	1500 V
Max. DC current $I_{DC, max}$	4750 A	4750 A
Max. short-circuit current $I_{DC, SC}$	8400 A	8400 A
Number of DC inputs	Busbar with 26 connections per terminal, 24 double pole fused (32 single pole fused)	
Number of DC inputs with optional DC coupled storage	18 double pole fused (36 single pole fused) for PV and 6 double pole fused for batteries	
Max. number of DC cables per DC input (for each polarity)	2 x 800 kcmil, 2 x 400 mm²	
Integrated zone monitoring	○	
Available PV fuse sizes (per input)	200 A, 250 A, 315 A, 350 A, 400 A, 450 A, 500 A	
Available battery fuse size (per input)	750 A	
AC side		
Nominal AC power at cos φ =1 (at 35°C / at 50°C)	4400 kVA[13] / 3960 kVA	4600 kVA[14] / 4140 kVA
Nominal AC active power at cos φ =0.8 (at 35°C / at 50°C)	3520 kW[13] / 3168 kW	3680 kW[14] / 3312 kW
Nominal AC current $I_{AC, nom}$ (at 35°C / at 50°C)	3850 A / 3465 A	3850 A / 3465 A
Max. total harmonic distortion	< 3% at nominal power	< 3% at nominal power
Nominal AC voltage / nominal AC voltage range[1] [8]	660 V / 528 V to 759 V	690 V / 552 V to 759 V
AC power frequency / range	50 Hz / 47 Hz to 53 Hz 60 Hz / 57 Hz to 63 Hz	
Min. short-circuit ratio at the AC terminals[9]	> 2	
Power factor at rated power / displacement power factor adjustable[8] [10]	● 1 / 0.8 overexcited to 0.8 underexcited	
Efficiency		
Max. efficiency[2] / European efficiency[2] / CEC efficiency[3]	98.8% / 98.7% / 98.5%	98.9% / 98.7% / 98.5%
Protective Devices		
Input-side disconnection point	DC load break switch	
Output-side disconnection point	AC circuit breaker	
DC overvoltage protection	Surge arrester, type I & II	
AC overvoltage protection (optional)	Surge arrester, class I & II	
Lightning protection (according to IEC 62305-1)	Lightning Protection Level III	
Ground-fault monitoring / remote ground-fault monitoring	○ / ○	
Insulation monitoring	○	
Degree of protection: electronics / air duct / connection area (as per IEC 60529)	IP54 / IP34 / IP34	
General Data		
Dimensions (W / H / D)	2815 / 2318 / 1588 mm (110.8 / 91.3 / 62.5 inch)	
Weight	< 3700 kg / < 8158 lb	
Self-consumption (max.[4] / partial load[5] / average[6])	< 8100 W / < 1800 W / < 2000 W	
Self-consumption (standby)	< 370 W	
Internal auxiliary power supply	○ Integrated 8.4 kVA transformer	
Operating temperature range[8]	−25°C to 60°C / −13°F to 140°F	
Noise emission[7]	63.0 dB(A)*	
Temperature range (standby)	−40°C to 60°C / −40°F to 140°F	
Temperature range (storage)	−40°C to 70°C / −40°F to 158°F	
Max. permissible value for relative humidity (condensing / non-condensing)	95% to 100% (2 month/year) / 0% to 95%	
Maximum operating altitude above MSL[8] 1000 m / 2000 m[11] / 3000 m[11]	● / ○ / –	
Fresh air consumption	6500 m³/h	
Features		
DC connection	Terminal lug on each input (without fuse)	
AC connection	With busbar system (three busbars, one per line conductor)	
Communication	Ethernet, Modbus Master, Modbus Slave	
Enclosure / roof color	RAL 9016 / RAL 7004	
Supply for external loads	○ (2.5 kVA)	
Standards and directives complied with	CE, IEC / EN 62109-1, IEC / EN 62109-2, AR-N 4110, IEEE1547, UL 840 Cat. IV, Arrêté du 23/04/08	
EMC standards	IEC 55011, IEC 61000-6-2, FCC Part 15 Class A	
Quality standards and directives complied with	VDI/VDE 2862 page 2, DIN EN ISO 9001	
● Standard features ○ Optional – not available * preliminary		
Type designation	SC 4400 UP	SC 4600 UP

SYSTEM DIAGRAM



TEMPERATURE BEHAVIOR (at 1000 m)



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IDEEMATEC

IDEEMATEC is the leading developer…

…of single axis tracking systems, headquartered in Germany with more than 12 years of experience and over 2.2 GW of installed systems on 6 continents.

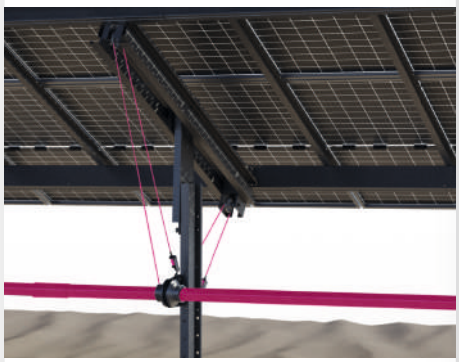
IDEEMATEC's innovative high-span safeTrack H4 tracker™ offers an outstanding design DNA. As first two-in-portrait tracker in the market, powered by its core patented drive technology, IDEEMATEC's solar tracker offers a superior safety and uptime level. Now available **safeTrack H4^{PLUS} bifacial tracker™** for an even higher yield at maximum reduced shading.

Established technology for challenging conditions – suited for sites with challenging soils, high winds, and irregular terrain, IDEEMATEC's safeTrack H4 trackers™ reduce the risk for Engineering, Procurement & Construction Companies by providing project developers and asset owners with the most value added over the entire lifetime of their power plant.

Highest Peak Power Ratio – the safeTrack H4™ flexible string configuration allows for a max. number of modules per tracker and requires only 1 Drive Unit for 360 Modules to provide support for up to 12x 1500-volt strings – **currently the market benchmark**. With only 0.5 pcs. SIGMA foundations per DC string, the high-span safeTrack H4™ reduces tracker installation costs by offering the least amount of posts at the lowest embedding depth.

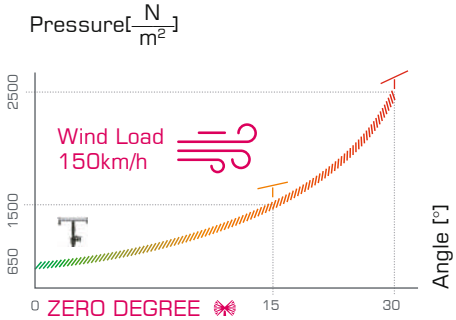
THE DEFINITION OF 2P TRACKING

DISCONNECTED DRIVE



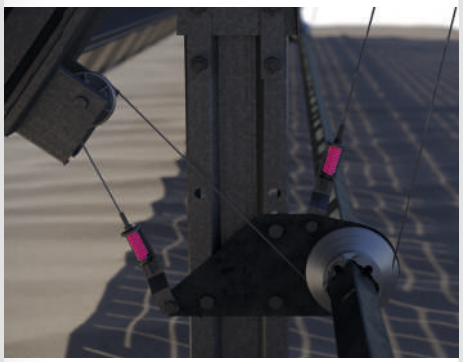
- 2.5 Hz natural frequency
- Zero torsion table
- Galloping excluded

ZERO STOW POSITION



- Up to 300 % less stress
- 360 ° wind protection
- Best in practice stow strategy

DYNAMIC ABSORBERS



- Damping ratio 15%
- 0° stow position safe & stable over entire length
- Dynamic stability in any position

IDEEMATEC

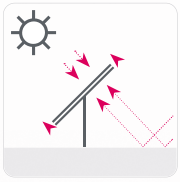
THE LONGEST TRACKER IN THE MARKET

up to 180 meters | 360 modules

H4 PLUS
BIFACIAL

GENERAL MECHANICAL FEATURES

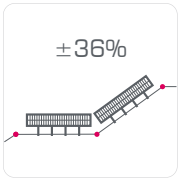
Tracking type	Horizontal single axis tracker – unlinked row
Typical tracker size	2 Portrait II 183 mtr. (max.)
Array height	2.20 m (7'22") Standard
H4PLUS bifacial features	**H4PLUS – tracker height gain compensation**
Tracking range	± 55°
Wind protection	Stow Position 0° / multi damping
Foundations	Sigma shape
Materials	Galvanized steel
Warranty	10 Years II Standard



▲ HIGHER YIELD
MORE RAIL DISTANCE
▼ LESS SHADING

POWER AND CONTROLL SYSTEM

Software	KoRoNa™ by IDEEMATEC
Solar tracking method	Astronomical algorithm II 3D adaptive backtracking
Communication	Full wired II redundant data transfer and control flow
Drive type	High accuracy slew gear – disconnected
Motor type	CE 400V 50Hz/ UL 480V 60Hz
Operating temperature range	-20°C up to +55°C
Warranty	5 Years II Standard

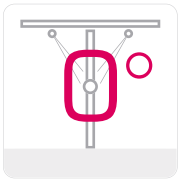


EXTREMELY ADAPTABLE
TO ANY TERRAIN

ONLY 1 DRIVE UNIT
FOR 150 KWP

MODULES AND CONFIGURATION

2P configuration 1500 Volt	Modules Pcs.		Strings	Width	Length
6 Table	336	360	12	72 cell / 78 cell 4.0m / 4.4m	174m / 186m
5 Table	280	300	10		145m / 155m
4 Table	224	240	8		116m / 124m



SAFE AND STABLE
0° STOW POSITION

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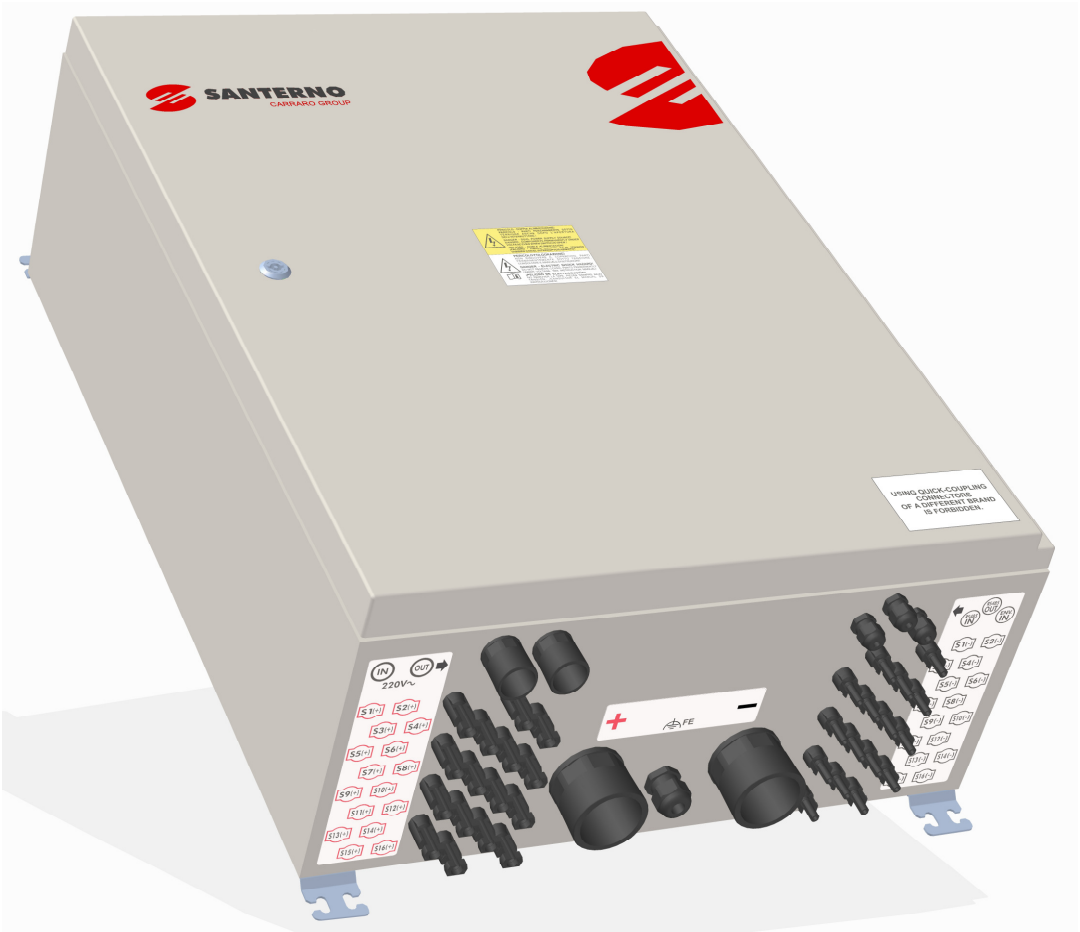
f +39 0542 489722
info@santerno.com
santerno.com

SUNWAY STRING BOX LT - 1500 V
16 inputs

Combiner Boxes



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Cap. Soc. € 2.500.000 i.v.
Codice Fiscale e Partita Iva
03686440284
R.E.A. PD 328951
Cod. Mecc. PD 054138
Cod. Ident. IVA Intracom.
IT03686440284

Elettronica Santerno S.p.A.
Società soggetta all'attività
di direzione e coordinamento
di Carraro S.p.A.

The **SUNWAY STRING BOX LT** series are combiner boxes for PV strings designed in Italy by the technicians of Elettronica Santerno S.p.A. They feature the highest reliability, ease of installation and maintainability.

KEY FEATURES

The main integrated standard functions of STRING BOX SB-16-LT03-1500V are:

- Possibility to connect up to 16 strings
- String fuses protection on each pole
- Load break switch
- Signaling contact for load break switch status
- Signaling contact for SPD status
- Polyester flameproof and UV ray-resistant box
- Lockable enclosure
- Degree of protection IP65
- Suitable both for floating and earthed PV configuration
- Thorough manufacturing with first class materials

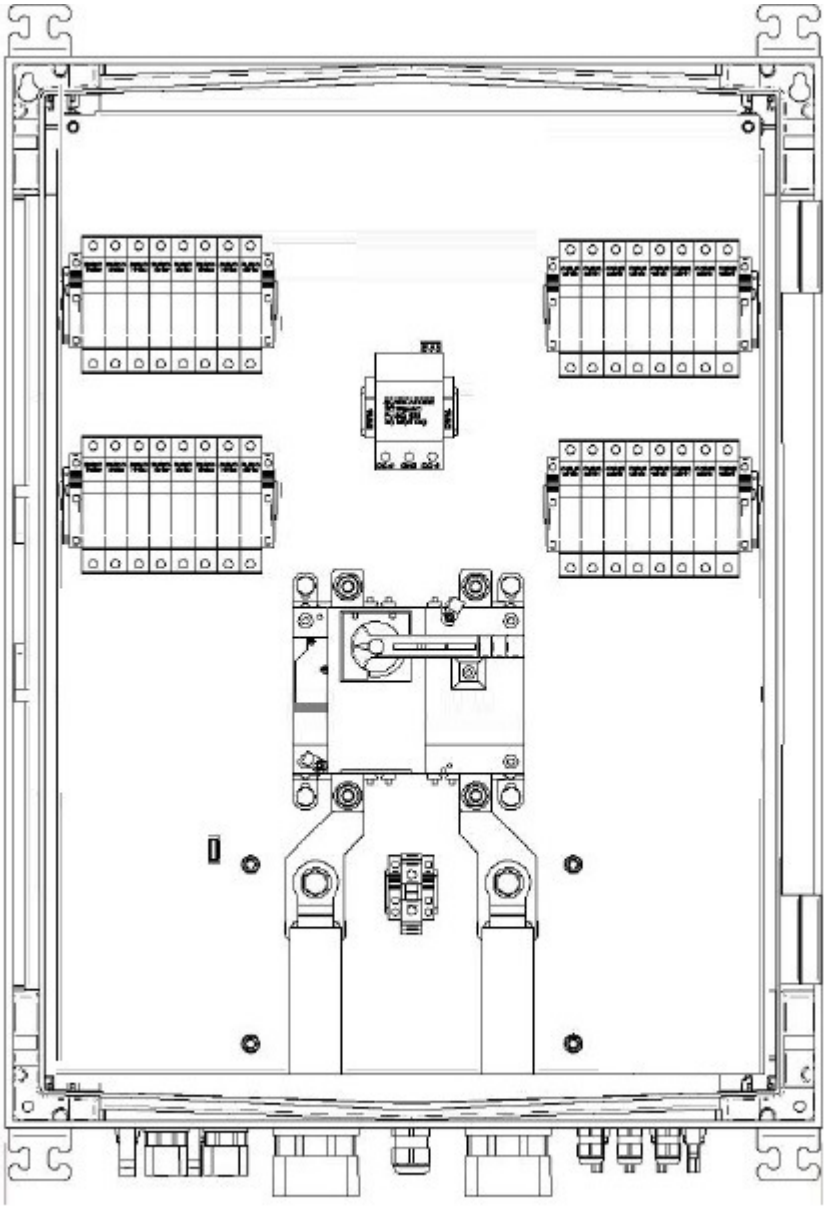
Technical Data

Sunway String Box LT SB-16-LT03-1500V	
Input Ratings	
Max. number of strings	16
Max. DC voltage (max. Udc)	1500 V
String DC fuses size (1)	8 A up to 30 A
Max. input current per channel (Isc) @45°C	20 A
String cable cross-section	4 ÷ 6 mm^2
String connector type (2)	Quick-coupling PV connectors, Amphenol or similar
Output Ratings	
Max. output current (max. OPV) @45°C	160 A
Max. output cable cross-section	1 x 300 mm^2
Max. grounding cable cross-section	35 mm^2
Dimensions and weight	
Dimensions (WxHxD)	915x635x310 mm
Weight	31 kg
Additional features	
Fuse protection	On both poles
Load break switch	Yes
Load break switch status	Clean Contact
Protection against DC overvoltage (SPD)	Yes
SPD status	Clean Contact
Degree of protection	IP65
Lockable enclosure	Yes

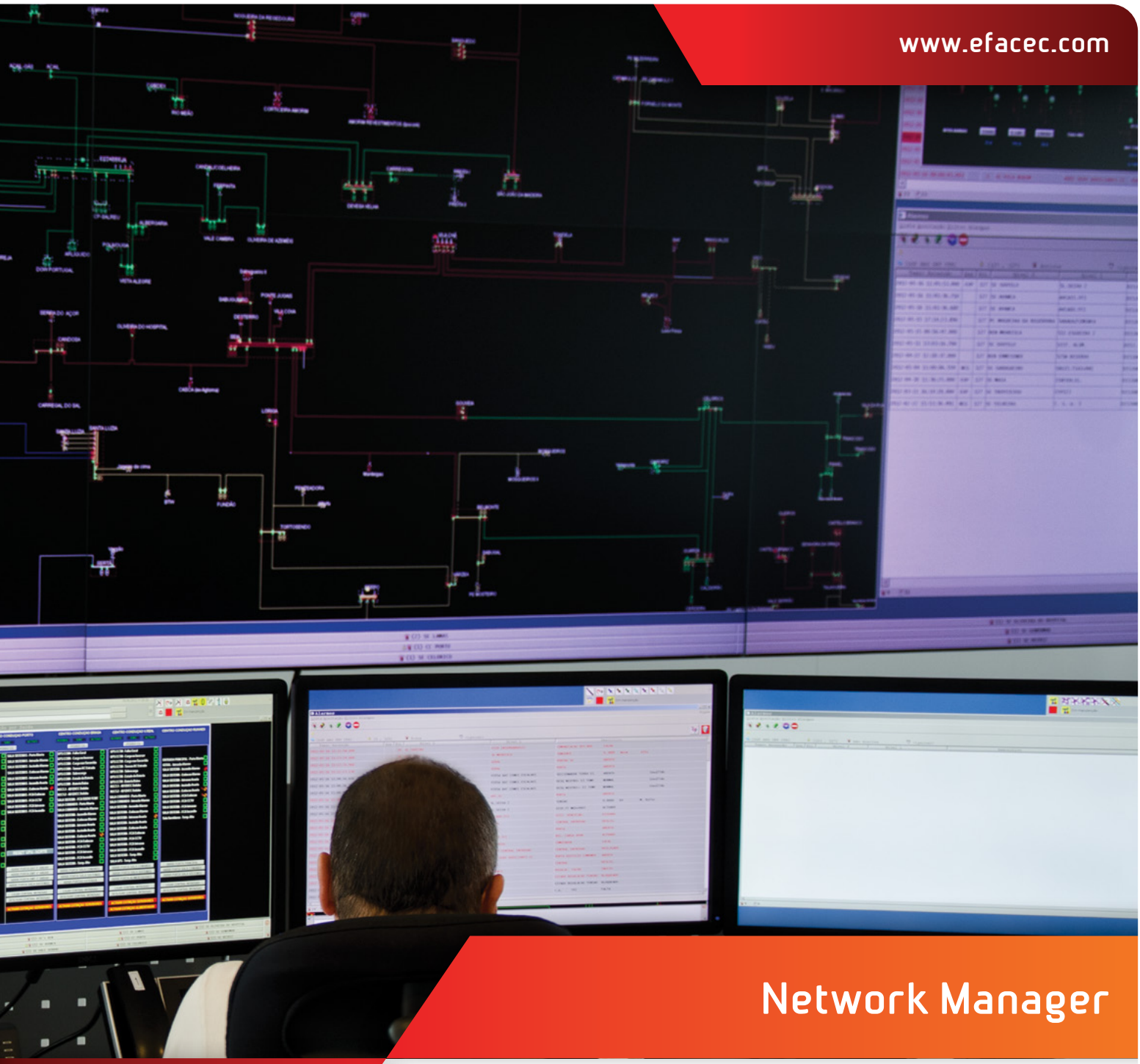
Elettronica Santerno reserves the right to make any technical changes to this document without prior notice.

NOTE
(1) Fuses are not included. Fuse rating to be defined by customer in agreement with PV module manufacturer.
(2) Mating connectors (string side) are not included. Always use mating connectors of the same brand as the connectors installed on the string box. The use of other connectors may damage the product.

Layout



www.efacec.com



Network Manager

SCATEX SCADA
SCATEX DMS
SCATEX EMS
SCATEX OMS
SCATEX ADMS
SCATEX RAIL

efacec

Overview

ScateX# is the unified, yet modular Efacec ADMS, result of more than 30 years of experience in the grid automation. Designed to combine SCADA, Distribution Management System (DMS) and Outage Management System (OMS) capabilities under a single, multi-language platform with a unified user experience, enables utilities to manage the grid for high, medium and low voltage levels with maximum security and return of investment.

Grid dispatcher operators are facing new operational challenges to maintain the same levels of safety in operation while increases the penetration of renewable-based production (mainly wind and solar base) in the different voltage levels of distribution network and the integration in the grid of new distributed resources with flexibility in the control of active and reactive power, electric vehicles, energy storage and controllable loads, coupled with emerging business models (aggregators and flexible operators) that provides the necessary flexibility to the grid.

At the same time, the installation of Advanced Metering Infrastructures (AMI) systems and the increase of network distribution automation provided new strategies of monitoring and control of the distribution network.

ScateX# was designed having modularity as a priority. This enables flexible deploys as single SCADA, single DMS, single OMS or as a fully ADMS either for high voltage, medium voltage or low voltage, protecting the client investment for future evolution of the system.

ScateX# is built upon a real-time cybersecure infrastructure and includes many innovative features that provide quick and easy access to real-time information, improving situational awareness and readily providing enhanced decision support. The set of network, power and outage management applications further leads to efficient operation and network optimization.

Featuring openness, flexibility, expandability and performance, **ScateX#** can scale to meet the needs of large networks and infrastructures, enabling customers to leverage stepwise investment strategies. Moreover **ScateX#** can be tailored to meet the specific needs of each user to deliver unmatched cost/benefit solutions.

Recognizing that straightforward deployment, integration and maintenance is a fundamental requirement, **ScateX#** presents end-to-end engineering and management of the whole infrastructure from control room, through communications infrastructure and remote plant or field equipment. Moreover **ScateX#** includes a complete solution for operator training that enables you to maintain operator team readiness.

Overview of ScateX# Standard Product Assemblies	
SCATEX SCADA	For electrical, oil, gas and water utilities and industries, **ScateX#** Control Center bundles all the features required for advanced network operations and infrastructure management in a highly scalable extensible SCADA platform including advanced network-aware supervision and control applications in a unified user interface for 24/7 system operation and management.
SCATEX DMS	Prepared for smart grid deployments above one million of data points in one reliable and integrated SCADA/DMS solution, **ScateX#** Distribution Management System is the single real-time system access point for distribution network operations. Ready for tomorrow's distribution grid, **ScateX#** DMS combines core SCADA features with advanced power applications to support unified operation, automation, analysis, and reporting. Recognizing the dynamic nature of MV networks, **ScateX#** supports patterns for MV substations providing minimal engineering, installation and commissioning effort through semi-automated modeling features. As the real-time backbone of utility operations and management, the openness of **ScateX#** DMS also enables straightforward integration of external systems such as workforce, asset, advanced metering or customer information systems.
SCATEX EMS	For power generation and transmission companies **ScateX#** Energy Management System provides a real-time and high performance solution that drives systems efficiently, reliably and securely while providing enterprise decision makers with online process and energy information. **ScateX#** EMS combines SCADA operations with advanced applications including conventional and renewable generation planning, automatic generation control or contingency analysis, that constitute invaluable tools for network operators. Its open platform further enables the integration of third-party components and systems such as energy market interface or asset management systems.
SCATEX OMS	Prepared for smart grid deployments above one million of data points in one reliable and integrated SCADA/OMS solution, **ScateX#**/OMS system is an open, modular and distributed system for the control and management of a power system. It targets the distribution utilities as it provides tools that enhance the control over the distribution quality of service, as well as tools that support a fast and safe service restoration to customers upon the occurrence of network outages. **ScateX#**/OMS provides a fully integrated WEB user interface for OMS functionalities, including the interface to the enterprise systems including IVR, AVL and MDM.
SCATEX ADMS	**ScateX#** ADMS is the full featured SCADA/DMS/OMS platform suited for distribution utilities to deliver high reliability, improved customer service and efficient operating costs while maintaining operational safety facing the growth of distributed generation and electric vehicles and the management of an active distribution network. In addition, improved situational awareness must be provided to the operator providing wider integration with the Information Technology (IT) systems of the organization.
SCATEX RAIL	**ScateX#** RAIL bundles SCADA, operations management, power applications, condition monitoring and technical supervision, and providing a framework for seamlessly integrating railway applications and systems. **ScateX#** RAIL enables network operators to efficiently manage the railway electrification system, including substations and catenaries, as well as all associated infrastructure.

Key Features

- Fully integrated SCADA/DMS/OMS platform
- Unified and powerful operations user interface
- Flexible realtime dashboard
- Full set of power management applications
- Full set of outage management applications
- Realtime centralized FDIR
- Realtime mobile integration
- Communication network infrastructure monitoring and management
- Electric vehicle charging infrastructure monitoring and management
- Report designer and server
- Modules to help infrastructure commissioning using test workflows engine
- Energy module to execute LV power flow using energy network configuration
- Operator training system
- System historian
- Flexible and scalable platform
- Open and modular infrastructure
- Advanced engineering system
- Seamless application and systems integration
- High availability and cyber-secure product platform

Benefits

- Immediate situation awareness and intuitive real-time operation
- Improved system reliability and network SAIDI reduction
- Improved network operational efficiency
- Optimised crew/operator maintenance productivity
- Straightforward deployment, integration and maintenance
- Deliver real-time process and operations information throughout the organization
- Tailor-made solutions to meet the exact needs of each project

Modular System and Functional Components

ScateX# has been designed having flexibility in mind. A large set of functional components and services may be combined to be delivered in pre-defined and ready to be deployed packages. These pre-defined packages may be quickly configured for classical customer needs whether is increasing network automation for improved reliability, increasing network efficiency or improving personal productivity. In addition, tailored solutions may be designed to meet specific customer requirements. **ScateX#** is able to be expanded either in scale or in functionality, protecting the customer investment.

Base Modules

- Calculation Engine
- Diagrams Display Engine
- Historical data Engine
- Sequences of Commands Engine
- Temporary Network Elements
- Topology Processing
- Trending
- Tagging Engine
- SCADA Engine
- Hierarchical Model Browser
- Alarms/Events Correlation Engine
- Reports and notifications Engine
- Advanced Alarming
- Map visualization
- Dashboards

Operational Modules

- Automatic feeder generation
- Commissioning Environment
- Switching Orders Management
- Crew Management
- Mobile Integration
- Topological tracing
- Topological coloring
- Distribution Power Flow
- Distribution State Estimation
- Post Disturbance Review
- DTS
- Operational Studies
- Fault Analysis
- Infrastructure Management
- Device Monitoring

Reliability Modules

- FDIR
- Fault Location
- Outage Analysis & Prediction
- Trouble Call Processing
- Load Shedding
- Storm Mode
- SAIDI Indexes
- Resource needs prediction
- Crew Management
- Short Circuits
- Protection coordination
- Peak demand reduction

Optimising Modules

- DER Management
- Load Forecasting
- Distribution Power Analysis
- Feeder Optimisation
- Load Transfer Function
- Volt-Var Control

System Interfaces

- CIM
- Multispeak
- ICCP
- IEC 60870-5-101
- IEC 60870-5-104
- DNP 3.0
- SNMP
- OPC
- MODBUS
- WebServices
- OpenADR
- OCPP

System Integration

- GIS
- Metering Management Systems
- Customer Information Systems
- Asset Management Systems
- Workforce Management
- IVR
- MDM
- NMS
- CRM

Unified User Interface

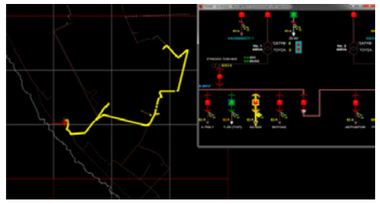
The **ScateX#** platform presents a high voltage, medium voltage, low voltage unified user interface environment for all internal and external applications, thus empowering remote operations and real-time management as well as enabling smooth integration with field and facility operations.

Multiple choices of local and remote user interface are possible, such as control room workstation, video wall, distributed operating stations or web access.

Components and Features	ADMS	OMS	DMS	EMS	RAIL	SCADA
Unified User Interface Environment (UI)						
Core User Interface Components Data lists, events and alarms, tags and pins, trends, model browsers, full vector graphics diagrams with advanced navigation and windowing, video-wall interface, online help, audible, alarms, geographic and map display, reports, dashboards	●	●	●	●	●	●
Network Model-based Components Auto-generated fully functional feeder schematics, coloring, tracing, redlining and dynamic model edits	●	●	●	●	○	○
Integrated Multi-context Interface Real world, study mode and/or engineering mode	●	●	●	●	○	○
Operational Management Components Operational or switching orders interface Management of planned and unplanned occurrences or outages	◐	◐	◐	◐	◐	◐
Multi-language - Up to 4 different languages	○	○	○	○	○	○
IP Video Integration	○	○	○	○	○	○
Cartography Integration and Geolocation	○	○	○	○	○	○
External Application Integration	○	○	○	○	○	○
Web Access Server						
Secure Multi-platform Web-access for UI	●	●	○	○	○	○
Mobile User Interface						
Mobile applications	●	●	○	○	○	○

● - Core feature in product assembly
○ - Optional (Standard component)
◐ - Optional (Component customized according to customer requirements)

Advanced User Interface



The standard user interface module includes a fully-integrated environment including a multi-screen window, menu and layout system featuring unified pick-and-drop, navigation, context menus, cross-application toolbars and shortcut interaction. The same user environment is presented for operational, planning, analysis, review or training purposes.

Standard user interface components include dashboards, data/event lists, real-time or historic trends, object model browsers, alarms management as well as interactive full vector graphics schematics or geographic displays with powerful layering, decluttering and object-oriented features. User interface screens can optionally integrate IP video feeds as well as locally available cartography and geolocation system for integration of field operations.

The powerful tagging, pinning and display engine allows integration of any **ScateX#** or external application directly into the operator user interface. Managing field controllability, system operating modes, alarm generation or getting feedback from condition monitoring, field crews or call centers directly on the display are examples of powerful user interface integration features available.

The display engine further supports synchronized diagram views that, together with the efficient navigation features, enable unprecedented system awareness for operators of large infrastructures.

The full integration of the control center with mobile devices enables switching work orders to be electronically sent to field crews. The crew can directly confirm the switching maneuvers improving the visibility of other crews, increasing safe working.

Multi-context Interface and Operational Work Orders

To efficiently manage planned or unplanned occurrences and field operations **ScateX#** provides an optional user interface solution that allows users to perform side-by-side on-the-fly integration of the real-world context with simulated network environments for network operation or planning.

Operators and managers can thus interactively create, record, validate and execute switching/work orders on their user interface station. Furthermore, operational document workflow management is available for maintenance or other work orders to be executed remotely or by field crews with the assistance of the mobile web-based field crew interface.

Operations Management

SCADA Processing

The **ScateX#** SCADA engine supports hot-standby redundancy, performing all data/event and control direct execution, SBO and sequencing processing in conjunction with the multiple front end communication processors.

The SCADA processor further supports data logging and sequence of events recording together with the advanced alarm engine. Multi-source alarm processing with grouping, filtering, segregation and workflow handling including acceptance, notification and logging is available.

Also included in the core are printer management, the user defined calculation and logic engine for automation purposes and the tagging system host.

The facility of an electronic wallboard is provided by the flexible tagging system at the user interface. The electronic wallboard is therefore available in all types of diagrams including schematic, geographic or geo-schematic diagrams as well as list-based components.

Network Model-based Applications

All **ScateX#** management applications share a single object-based hierarchical model, with geo-referencing capabilities that enables flexible description of information such as resources, assets and connectivity.

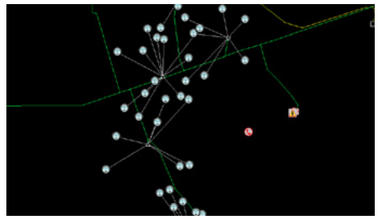
The **ScateX#** user interface environment offers integrated network model-based components that can deliver dynamic coloring, tracing and automatically generated feeder schematics according to the network topology and current operating status.

Directly onto the user interface surface, operators may also update the network topological model according with field or management information through cuts, jumpers, temporary units or similar tagging actions.

Historical Information System

ScateX# HIS supports deep event and data logging storage from all sources including online RTUs, remote IED data records, user actions, alarms, calculations or system diagnostics, and can be deployed over the SCADA servers or at independent database servers.

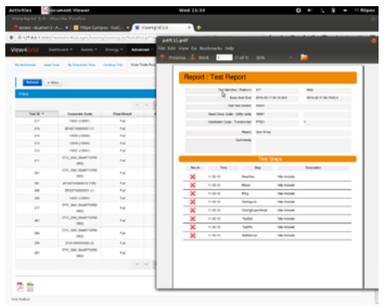
The HIS features snapshot and playback to support post-event review analysis, power application studies or operator training sessions. Historic data can be access through data lists or trend displays, can be fed to other applications such as analysis, forecasting or statistics calculations and exported to external formats



Reports and Alerts

For supervisory accounting and performance management **ScateX#** provides a reports and alerts module that can produce real-time or historic reports based on the output of specific management applications or user-defined statistics.

Report notifications may be sent through email or SMS as well as displayed in dashboards, fully integrated within operation diagrams.



Communication Processors

Distributed front end processors and IP communication adapters run remote communication processing and system/device service access for either operational or management purposes. For inter-control center integration **ScateX#** fully supports ICCP, either in dedicated servers or SCADA server-integrated configurations.

Each **ScateX#** high-availability front end processor node supports simultaneous operation of multiple and optionally duplicated serial or IP channels. A wide set of protocols is available, including IEC, DNP, OPC, SNMP or Modbus, to name a few. All common communication infrastructures including RF, PLC, fiber, microwave or satellite links, SONET, SDH or IP backbones, GPRS/UMTS or WiMAX are supported.

Applications for Operations Management

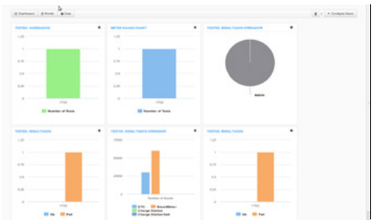
Components and Features	ADMS	OMS	DMS	EMS	RAIL	SCADA
SCADA Engine						
SCADA Processor Data Acquisition and Event/Control Processing, Data logging and Sequence of Events Recording, Alarm engine, User Calculations and Logics, Tagging System, Printer Management	○	○	●	●	●	●
Flexible Tagging System Temporary network elements, Safety tagging and interlock checks, Tagging lockout	◐	◐	◐	◐	◐	◐
Hot-standby and multi-server configurations	○	○	○	○	○	○
Network Model						
Object-oriented Dynamic Network Model and Topology Processor	●	●	●	●	○	○
Outage Monitoring (*) Including unsupplied energy and QoS index calculations according to IEEE 1366	○	○	○	○	-	○
Historical Information System (HIS)						
HIS integrated with SCADA server	○	○	○	○	○	●
Dedicated HIS server	●	●	●	●	●	○
HIS cluster	○	○	○	○	○	○
IED/RTU data file extraction and storage	○	○	○	○	○	○
Study Mode						
Side-by-side study mode for preparing operations and historical playback (sharing all core UI components) Interface identical to real world mode	●	●	●	●	○	○
PAS applications integrated in study mode	●	●	●	●	○	○
Simulation engine integrated in study mode Electrical Network, Telemetry and Telecontrol Simulation	○	○	○	○	◐	◐
Reports and Alerts						
Statistical calculations, reporting engine and dashboards server	○	○	○	○	○	○
SMS/email notifications	○	○	○	○	○	○

● - Core feature in product assembly
○ - Optional (Standard component)
◐ - Optional (Component customized according to customer requirements)
(*) Optional feature to monitor QoS when OMS function is not included.

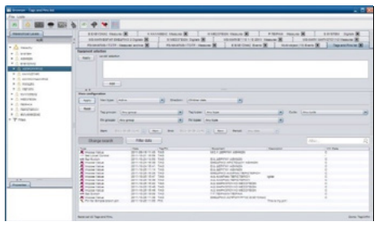
Advanced Applications

Power Applications

Specifically designed for electrical network management from generation through transmission and distribution, Efacec power applications enable operators to optimally manage their networks and assets according to economic, technical and performance requirements.



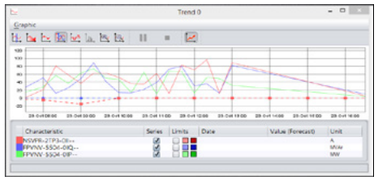
ScateX# Power Application Software (PAS) provides a set of field-proven power management applications for operational support, network optimization and advanced automation having safety as a priority. Algorithm performance allows applications to run in study modes as well as in real-time, either cyclically, on-event, upon user request or as part of control execution verification, instruction and confirmation (VIC) cycles. Algorithm results can be presented directly on the operation surface, in advisory mode through result tables and suggested operation lists or, in fully automatic mode, updating field setpoints or execute controls.



ScateX# was designed to allow fast and safe outage restauration. When an outage occurs, the centralized FDIR automatically generates and executes a switching order to isolate the faulty area maximizing the recovered network. If necessary, the operator may then request to the FDIR additional switching orders that may be electronically dispatched to the crews mobile devices for manual execution. After maneuvers completion the crew may confirm its execution directly in the system by a secure channel.

Low Voltage Power Analysis

In general, the same power analysis tools that are used at higher voltages are applied to low voltage networks. Load profile data is combined with measured values to produce more accurate results.

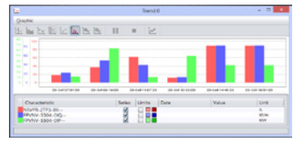


Power application functions may be deployed in multi-server scalable architectures. All PAS applications provide configuration, diagnostic and execution information that can be set, logged or displayed.

Advanced Management Applications

Components and Features	ADMS	OMS	DMS	EMS	RAIL	SCADA
Power Application Software (PAS)						
Operational Applications						
Power Flow	●	○	●	●	○	
State Estimator	●	○	●	●	○	
Reserve Monitoring				●		
Emissions Monitoring				○		
Others, please contact	○	○	○	○	○	○
Automation Applications						
Fault Detection, Location, Isolation and Reconfiguration (FDIR)	○	○	○			
Automatic Generation Control (AGC)				○		
Load Shedding	◐	○	○	○		
Others, please contact	○	○	○	○	○	○
Analysis and Optimization Applications						
Load Profile Modeling	○	○	○	○		
Short Circuit Analysis	●	○	●	●		
Distribution Optimal Power Flow (DOPF)	●		○			
Optimal Power Flow (OPF)				●		
Voltage/VAr Control (VVC)	●	○	○			
Contingency Analysis (CTA)	○	○	○	●		
Unit Commitment (UC)				○		
Economical Dispatch (ED)				○		
Interchange Transaction Scheduling (ITS)	○			○		
Voltage Stability Analysis	○			○		
Watershed Management				◐		
Others, please contact	○	○	○	○	○	○
Forecast Applications						
Short-term Load Forecast	●	○	○	○		
Wind Speed/Direction Forecast	○	○		○		
Renewable Generation Forecast	○	○		○		
Others, please contact	○	○	○	○	○	○
Technical Supervision Software Advanced condition and performance monitoring of process and assets						
Electrical Network Components	○	○	○	○		
Wind Power Generation	○			○		
Hydropower Generation	○			○		
Photovoltaic Generation	○			○		
Communications and Telecontrol Infrastructure	○		○	○	●	
Railway Infrastructure					●	
Others, please contact	○	○	○	○	○	○

● - Core feature in product assembly
○ - Optional feature
◐ - Optional (Component customized according to customer requirements)
(*) Depending on available PAS functions in the system.



Outage Management System

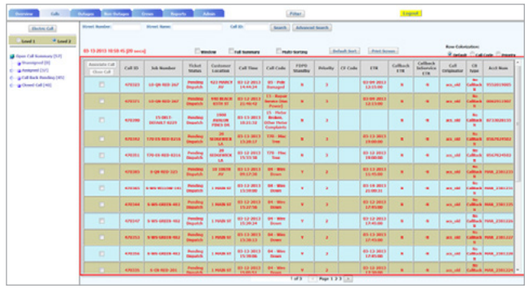
The **ScateX#** OMS system is an open, modular and distributed system for the control and management of a power system. It targets the distribution utilities as it provides tools that enhance the control over the distribution quality of service, as well as tools that support a fast and safe service restoration to customers upon the occurrence of network outages.

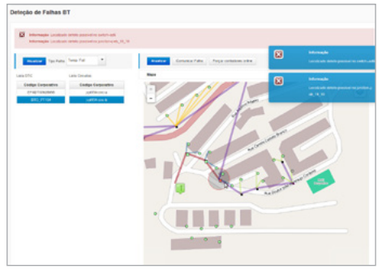
The workstation provides a fully integrated user interface for the operator. It includes bi-directional navigation and highlighting mechanisms between tabular applications and any kind of diagram.

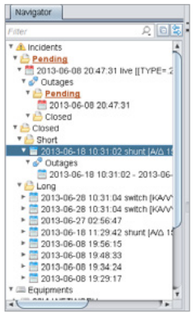
ScateX# OMS provides a fully integrated WEB user interface for OMS functionalities, including the interface to the enterprise systems including IVR, AVL and MDM, customer call handling and management and incident calculation to crew field positioning, outage monitoring capability (with Quality of Service reporting), etc.

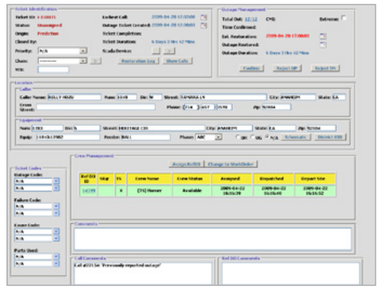
The **ScateX#** OMS system integrates all the outage management functions and applications through a single data model. A single data model allows information from consumers, crews (repair and Survey), and SCADA to be processed in order to locate problem areas quickly.

ScateX# OMS stores and track customer call information, integrates this information with network connectivity updates, and processes this information through the Trouble Call Analysis engine to provide a comprehensive tool for outage management. From managing simple customer outages and tracking routine service work, to handling severe storm situations, **ScateX#**/OMS provides the support needed to restore consumer service, all in real-time.









Outage Management Applications

Components and Features	DMS	EMS	RAIL	CC	RAIL	CC
Outage Management						
User Interface Components Full tagging, context, UI surface integration with SCADA operational user interface	○	●				
Switching Order Integration Work order workflow integration	○	●				
HIS Integration Archiving and reporting	○	●				
Network Model Integration Topology processing	○	●				
Service Operator Interface Secure multi-platform web-access for UI	○	●				
Field Crew Interface Mobile web application	○	●				
Automatic Incident Predictor Trouble Call Analysis (TCA) system	○	●				
QoS Analysis IEEE 1366 indicators or others	○	●				
External Application Integration CIS (Customer Information System)	○	●				
External Application Integration CIS (Customer Information System) IVR (Integrated Voice Response) WfMS (Workforce Management System) AMI (Automated Metering Infrastructure) AVL (Automatic Vehicle Location)	○	●				

● - Core feature in product assembly
○ - Optional (Standard component)

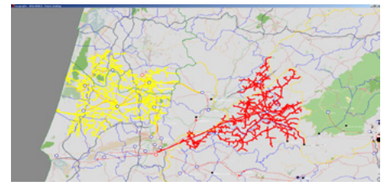
Manageability

A Single System for Network Management

Network management systems handle large amounts of information are increasingly dynamic systems therefore requiring advanced engineering methods and tools, not only for easy setup and deployment, but also for continuous system management and maintenance throughout the system lifecycle. Moreover the value of advanced applications relies on the availability of an up-to-date network model.

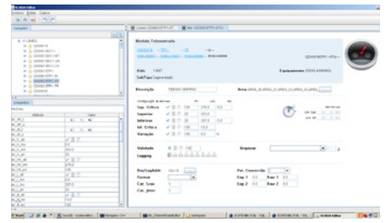
As a single system solution, **ScateX#** enables administrators to maintain a single model for all applications including the SCADA, PAS,OMS, LV and ADMS subsystems. Furthermore users interface the system through a unified UI, reducing system complexity to manageable levels.

Low voltage networks can be several times larger than the higher voltage networks. The maintenance of the network model by the traditional approaches is impossible. It is therefore fundamental to be able to automatically import the network model from another source (ex: a GIS). The **ScateX#** supports incremental network model updates from external systems through CIM.



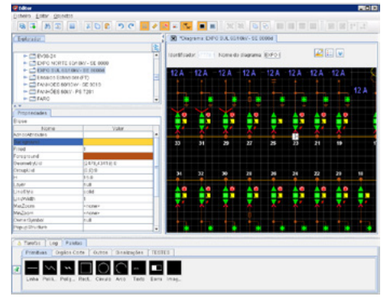
Integrated Engineering Environment

ScateX# supports current engineering requirements with an online integrated interactive CAD environment that includes template-based and object-oriented model editing tools, together with powerful copy/paste, import/export and model validation. The engineering environment supports database and network model design, user programming and diagram editing together with standard symbols with flexible dynamic behavior and templates for industry-specific applications, enabling engineers to customize and adjust the system instead of configuring it end-to-end. Full model version based edition is supported for diagrams, network equipments, network connectivity, SCADA model, communications model for all voltage levels of the network.



To complement the engineering toolset, **ScateX#** offers optional configuration repository server with full configuration history access and bulk/incremental updates as well as optional network simulation server for testing and dynamic validation.

Available for Efacec RTU and field equipment or for selected third-party providers, **ScateX#** can integrate RTU/IED configuration and management through the engineering system.

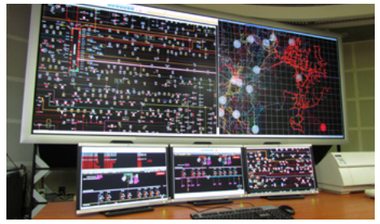


Infrastructure

Components and Features	
System Infrastructure	
Distributed RT-Bus	●
Integrated RBAC, Cyber security and Responsibility Areas	●
Distributed RT Clock Synchronization	●
System Watchdog, Self-monitoring and Diagnostics	●
Disaster Recovery	○
Power Applications System	○
Outage management System	○
Low Voltage management System	○
Front End Processing	
Multi-protocol/channel Processor	●
IEC 60870-5-101/104	○
DNP 3.0	○
MODBUS	○
Others, please contact	○
Configurations	
Front-end processor integrated with SCADA server	○
Independent Front-end processor in single or hot-standby configuration	○
Multi-front-end processors in single or hot-standby configuration	○
Communication Adapters	
IP Communication Adapters	○
ICCP	○
SNMP	○
OPC	○
Others, please contact	○
Configurations	
IP Communication adapters integrated with SCADA server	○
IP Communication adapters over dedicated servers	○

Systems Integration SQL interface, CIM-compliant and SOA/REST Application Adapter	
Geographical Information Systems (GIS) Workforce/Field-crew Management (WfMS) Asset Management Systems (AMS) Customer Information Systems (CIS) Metering Management Systems (AMI/MDM) Video- surveillance Systems Railway/Train Management Systems Wide-area Monitoring Systems Market Management Systems Call Center and Interactive Voice Response Systems Enterprise Resource Planning Systems Other Technical Systems	◐
Engineering System	
Integrated Engineering Environment Integrated Configuration Tool, CAD Environment for Diagram/Symbol Editing, Online incremental/bulk changes, Import/Export Tools, Objects and Templates, Validation tools, etc.	●
Integrated RTU/IED Configuration Management	◐
Application-specific engineering packages Pre-engineered catalogs, symbols, reports, dashboards and templates	◐
Version-managed Repository Server	○
Operator Training System	
Training Session Configuration and Management	○
Session Results, Playback and Resume	○
Operations Management Training	○
Advanced Management Applications Training*	○

● - Core feature in product assembly
○ - Optional (Standard component)
◐ - Optional (Component customized according to customer requirements)
* - Depends on available PAC functions in the system



Extensibility

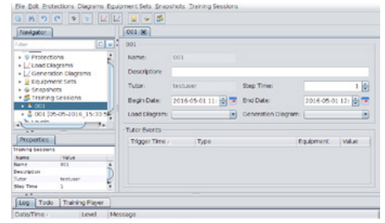
By offering standard file format import/export facilities, SQL interface, Multispeak® and CIM-compatible SOA/REST application adapters, **ScateX#** minimizes the required effort when external applications need to be integrated.

Adapters and data exchange allow users to benefit from seamless integration with external or existing systems such as geographical information, workforce/field-crew management, call center, asset management, customer information, advanced metering, video- surveillance, public information or other technical systems.

Operator Training Simulator

Designed to provide realistic training sessions for **ScateX#** power network operators the Operator Training Simulator (OTS) is a standalone system that includes the electrical network simulation engine for all voltage levels with optional protection and automation simulation engine, including telemetry and telecontrol. The OTS system may also be setup to include any set of power applications, including automation applications and the ADMS subsystem.

The training session management model allows training sessions to be created from historical or current network configurations and snapshots and executed with manual or template-based incident/fault simulation. Training sessions can be recorded for analysis with pause/resume and playback functions.



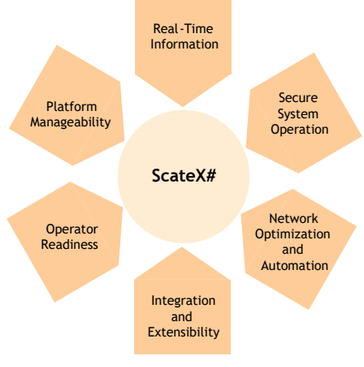
Product Availability

ScateX# is available in fully customizable form according to the specific requirements of each system, but is also readily available in product assemblies that target the needs of specific utility or industry application.

Applications	ADMS	OMS	DMS	EMS	RAIL	SCADA
Remote SCADA and Telecontrol Systems	●		●	●	●	●
Condition Monitoring and Infrastructure Technical Supervision	●	●	●	●	●	●
Plant Local SCADA						●
Transmission Grid Management	●			●		
Distribution Network Management	●		●			
Low Voltage Network Management	●					
Outage Management	●	●				
Renewable Generation Management	●					
Railway Electrification Management					●	

Support

The **ScateX#** flexible and open platform ensures that your system is equipped with future-proof technology and that stepwise investment strategies are not hindered. Efacec further supports users with a full range of services from training and product support, through software customization, to project management, engineering and maintenance that ensure you have the best fitting solution for your requirements considering the full system life-cycle.



Due to the continuous development, the characteristics may change without notice. Not valid as a contractual item.

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efacec

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EMPRESA CERTIFICADA apcer ISO 9001 ISO 14001 OHSAS 18001
CERTIFIED IQNet MANAGEMENT SYSTEM

Sistema de Armazenamento de Energia (BESS)

24,44 MW_{dc} / 97,76 MWh

Memória Técnica

Central Solar Fotovoltaica de Pereiro

Promotor: Suggestion Power, Lda.

Documento

NOME	Sistema de Armazenamento de Energia (BESS)	
REVISÃO E DATA	3	2024-09-03
PROJETO	Central Solar Fotovoltaica de Pereiro	
CRIADO	NM	
VERIFICADO	PM	
APROVADO	PM	
PÁGINAS	11	

Registo de revisões:

REV.	DATA	MODIFICAÇÃO/DESCRIÇÃO DA EDIÇÃO	CRIADO
0	2021-09-03	Primeira Emissão	NM
1	2022-07-14	Alteração de capacadidade do BESS	NM
2	2022-10-03	Alteração de capacadidade do BESS	NM
3.	2024-09-03	Alteração de capacadidade do BESS	NM

Definições e abreviaturas:

ABREVIATURAS	DEFINIÇÃO
ENEL	ENEL GLOBAL POWER GENERATION
EGPE	ENEL GREEN POWER ESPAÑA
BESS	Sistema de Armazenamento de Energia
RES	Energias Renováveis
MW / MWh	Mega Watts / Mega Watts Hora
kV	kilovolts
HV/MV/LV	Alta Tensão / Média Tensão / Baixa Tensão
AC/DC	Corrente Alterna/ Corrente Continua
TSO	Operador de Rede de Transmissão
POC	Ponto de Interligação
SCADA	Sistema de Aquisição, Controlo e Supervisão de Dados
HMI	Human Machine Interface
DEVELOPER	Responsável por entregar, serviços de engenharia e estudos para a definição da engenharia de base e licenciamento
SLD	Diagrama Unifilar

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1. Enquadramento

O presente documento descreve o Sistema de Armazenamento de Energia a instalar na Central Solar Fotovoltaica de Pereiro. O projeto está localizado na freguesia de Giões e União das freguesias de Alcoutim e Pereiro, do concelho de Alcoutim, distrito do Algarve e faz parte do dossier do projeto de instalações elétricas do centro electroprodutor.

2. Normas e Standards

Standard	Nome
IEC 255	Electrical relays
IEC 297	Dimensions of panels and racks
IEC 50178	Electronic Equipment For Use In Power Installations
IEC 60076	Power transformers
IEC 62619	Secondary cells and batteries containing alkaline or other non-acid electrolytes Safety requirements for secondary lithium cells and batteries, for use in industrial applications
IEC 62620	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for use in industrial applications
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems (Parts 1-7)
IEC 62477	Safety Requirements for Power Electronic Converter Systems and Equipment
IEC 61000-4-30	Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods
IEC 61000-6-2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-4	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEC 61000-3-12	Electromagnetic compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase
IEC 60664	Insulation coordination for equipment within low-voltage system
IEC 60721-3-3	Recommendations for environmental conditions in electrical equipment rooms
IEC/EN 62116	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
IEC 61683	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
IEC 60364	Low-voltage electrical installations
IEC 60947	Low-voltage switchgear and control gear
IEC/EN 62109-1\2	Safety of power converters for use in photovoltaic power systems
EN 50530	Overall efficiency of grid connected photovoltaic inverters
ISO 1000	The international system of units (SI) and its applications
ISO 14617	Graphical symbols for diagrams
UL 1741	Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
UL 1642	Standard for Safety – Lithium-ion Batteries
UL 94	Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 9540	Energy Storage Systems and Equipment
UL 1973	Batteries for Use in Stationary Applications
UN 38.3	Transportation Testing for Lithium Batteries

Requisitos de ligação à rede elétrica:

- **RfG 631/2016** – Define os requisitos da ligação de geradores de eletricidade à rede
- **Decreto Lei 172/2006** - Desenvolve os princípios gerais relativos à organização e ao funcionamento do sistema elétrico nacional (SEN), aprovados pelo Decreto-Lei n.º 29/2006, de 15 de Fevereiro, regulamentando o regime jurídico aplicável ao exercício das atividades de produção, transporte, distribuição e comercialização de eletricidade e à organização dos mercados de eletricidade.
- **Portaria n.º 72/2020, de 16 de março** - define os requisitos não exaustivos para ligação dos módulos geradores à Rede Elétrica de Serviço Público e identifica os módulos geradores existentes sujeitos ao seu cumprimento.
- **Decreto Lei 15/2022** - Estabelece a organização e o funcionamento do Sistema Elétrico Nacional, transpondo a Diretiva (UE) 2019/944 e a Diretiva (UE) 2018/2001

3. Localização do BESS

O sistema de armazenamento de energia da Central Solar Fotovoltaica de Pereiro possui uma potência nominal de 24,44 MW_{dc} e 97,76 MWh de capacidade de armazenamento de energia, está conectado a uma central solar fotovoltaica como sistema hibrido.

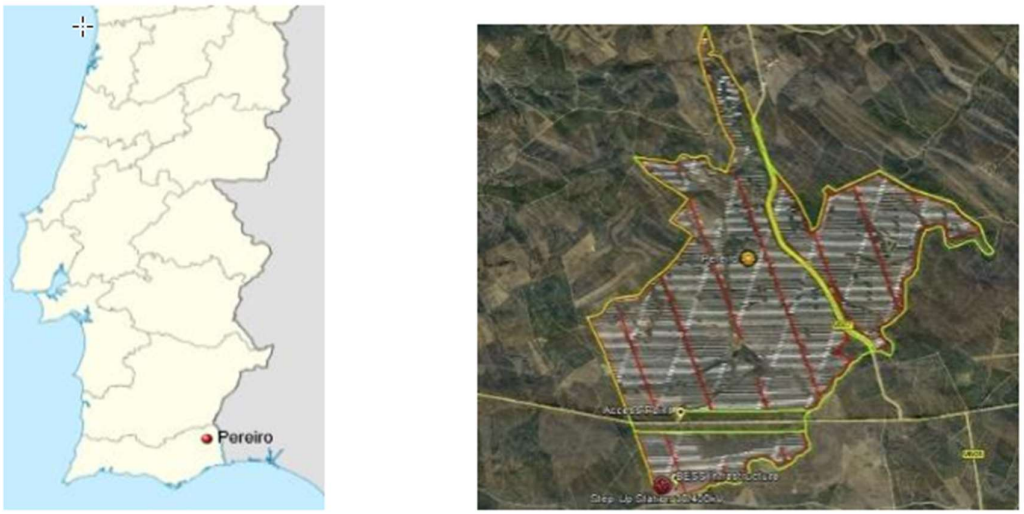


Figura 1 - Localização

Site Conditions			
LOCALITY	Pereiro	SITE ALTITUDE (masl)	255
CITY	Faro	USEFUL AREA AVAILABLE (ha)	0,36
REGION	Algarve	USEFUL AREA AVAILABLE, W[m] x D[m]	3.600
STATE	Portugal		
SITE LATITUDE	37°27'7,46" N		
SITE LONGITUDE	7°38'0,23"O		
Geography			
NORTH - SOUTH	Flat	WEST - EAST	Flat
TERRAIN AVERAGE SLOPE (%)	4,5	TERRAIN AVERAGE SLOPE (%)	1,5
TERRAIN MAXIMUM SLOPE (%)	13	TERRAIN MAXIMUM SLOPE (%)	10
Weather Condition			
MAX YEARLY SOLAR IRRADIANCE	1.127	YEARLY RAINFALL RATE (mm/yr)	438
MINIMUM AIR TEMPERATURE (°C)	-0,8	YEARLY AVERAGE RELATIVE HUMIDITY - Muggy Condition(%)	70
AVERAGE AIR TEMPERATURE(°C)	16,9	YEARLY AVERAGE WIND SPEED (m/s)	3,4
MAXIMUM AIR TEMPERATURE(°C)	40,1	YEARLY MAX WIND SPEED (m/s)	16,6

Tabela 1 – Condições Gerais do Site

4. Layout Preliminar e Funcionalidades do BESS

O sistema de armazenamento é composto por 6 PowerStations FSK, por 24 contentores de baterias de 20 pés, 1 contentor de comando e controlo e 1 contentor de interligação elétrica (MT), tem a seguinte disposição de equipamentos conforme figura abaixo e ocupa uma área de cerca 4476 m2.

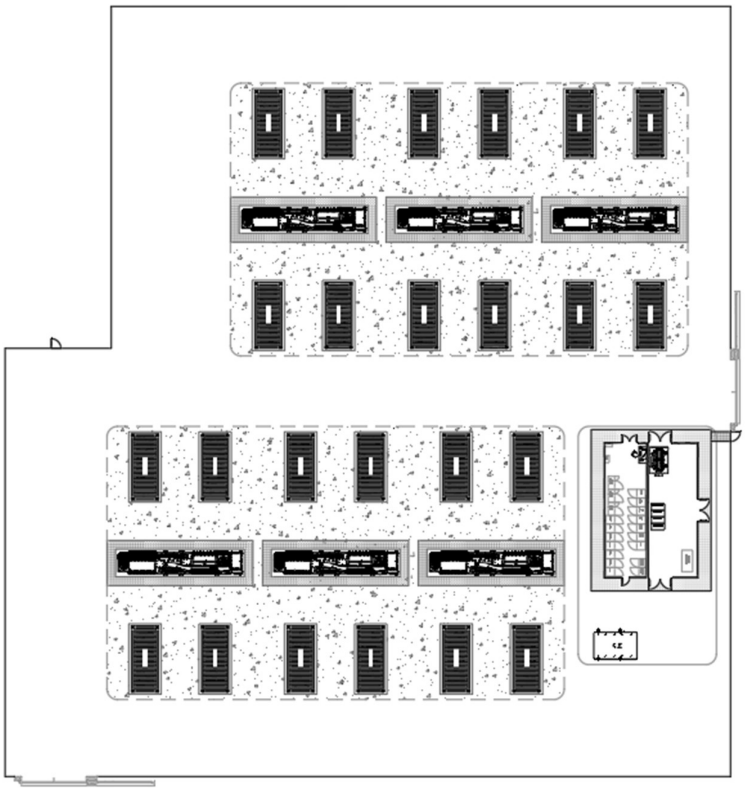


Figura 2 – Layout Preliminar BESS

De seguida apresentamos uma tabela resumo com as principais características dimensionais dos equipamentos:

Nome	Peso (kg)	Número	Peso Total (kg)
Power Station	25000	6	150000
Contentor de Baterias	35200	24	844,800
Contentor de Controlo	15000	1	15000
Contentor Interligação (MT)	15000	1	15000

Tabela 2 – Dimensões de Contentores

Os contentores de baterias terão ainda as seguintes características:

Contentor de Baterias 40 pés	Dados por contentor
Tipo	20 pés
Dimensões (C x L x H), (m)	6,05 x 2,44 x 2,90
Pontos de ancoragem	4
Número de portas de acesso	4
Cor	RAL 7042
Iluminação interna	Sim
Sistema de deteção de incêndio	Sim
Sistema de extinção de incêndio	Sim

Tabela 3 – Características do contentor de baterias

O contentor de baterias de 4,07 MWh, com uma dimensão de um contentor standard de 20 pés tem no seu interior a seguinte disposição de equipamentos.

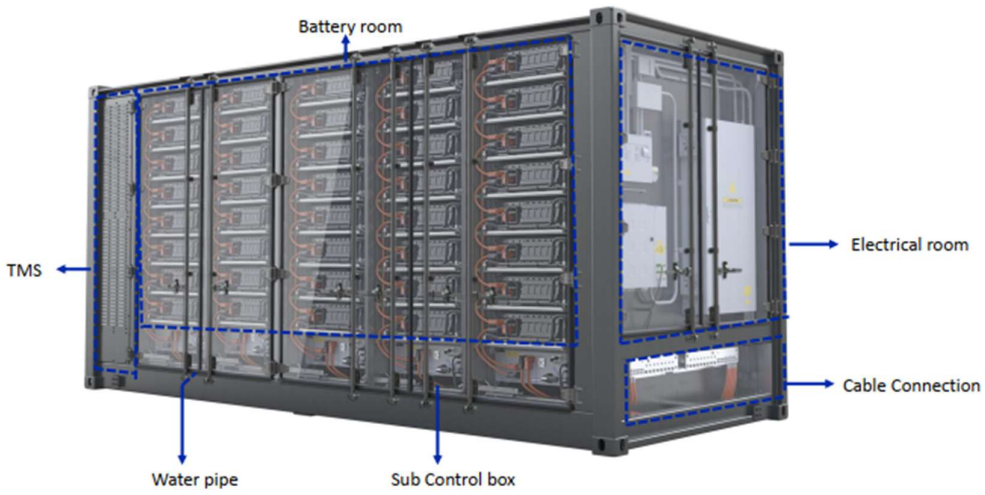


Figura 3 – Layout Preliminar do Contentor de Baterias

O sistema é composto por inversores INGECON SUN STORAGE integrados numa PowerStation FSK de 6,08 MVA, ou equipamentos equivalentes, com ligação em AC a 33 kV após um transformador elevador 0,6/33 KV.

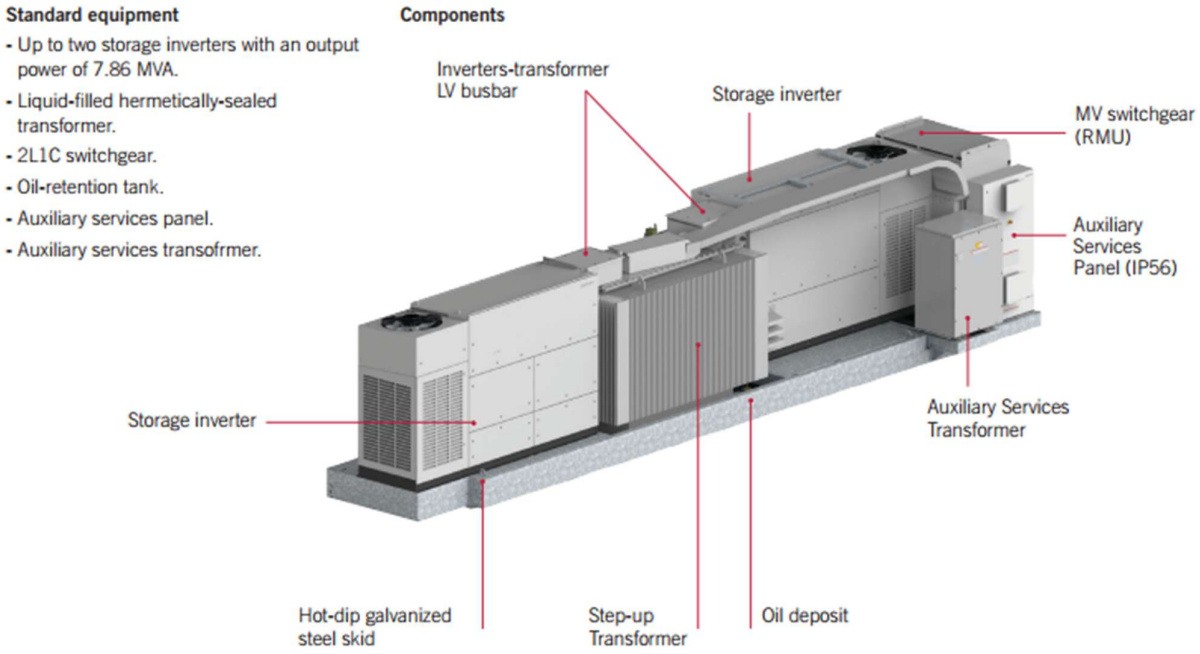


Figura 4 – Power Station

Os contentores de baterias serão instalados conforme figura abaixo:

Figura 5 – Contentor de Baterias

5. Trabalhos Civis

O sistema estará localizado a norte da subestação, e será vedado por uma rede de altura adequada para garantir a segurança de equipamentos. O acesso aos equipamentos instalados será efetuado por um portão de acesso.

O pavimento do Sistema de Armazenamento de Energia será constituído por uma camada de tout-venant compactado, sendo por isso totalmente permeável. Nesse sentido não estão previstos órgãos de drenagem no interior da área de implantação do Sistema de Armazenamento. Os transformadores da solução de Armazenamento de Energia serão assentes numa bacia de retenção que fará a recolha de óleos e os encaminha a uma caixa recetora de hidrocarbonetos.

Os trabalhos de movimentação de terras, a desenvolver no âmbito da construção do Sistema de Armazenamento, serão os necessários à criação uma plataforma nivelada para implantação da infraestrutura. Contemplam a preparação do terreno, com a decapagem e o aterro controlado da plataforma até à cota de fundo de caixa, para posterior aplicação das camadas do pavimento.

Item	Atividade	Quantidades	Unidade
1	Movimentação de Terras		
1.1	Preparação do Terreno	4602	m^2
1.2	Escavação	6250	m^3
1.3	Aterro	12250	m^3
2	Pavimento		
2.1	Tout-Venant	540	m^3
2.2	Brita 8/15	360	m^3
3	Fundações	300	m^3
4	Diversos		
4.1	Vedação	260	Ml
4.2	Portões	2	Ud
4.3	Cama de Areia (valas)	36.4	m^3

Tabela 4 – Mapa de Quantidades Trabalhos Civis

A construção do sistema de armazenamento terá uma duração estimada de 9 meses, conforme figura abaixo.

Sistema BESS	Mês								
	1	2	3	4	5	6	7	8	9
Montagem Estaleiro									
Decapagem									
Fornecimento Materiais									
Trabalhos Civis									
Instalação Mecânica									
Instalação Elétrica									
Comissionamento									
Recuperação Paisagística									
Inicio de Operação									

Figura 6 - Cronograma

Durante a construção deste sistema, estima-se que o número de trabalhadores ronde os 15 trabalhadores em média por mês, e um máximo de 30 em determinadas tarefas.

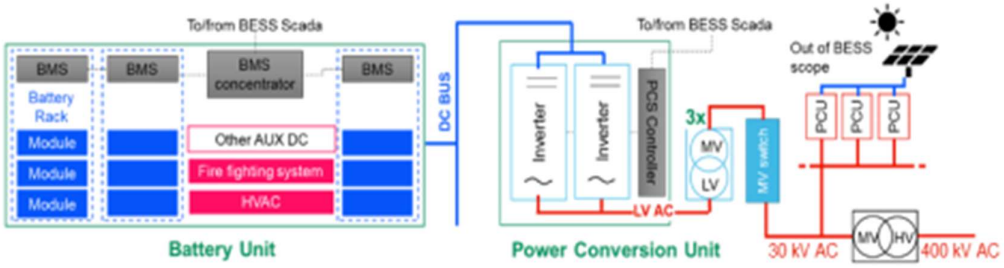
As principais tarefas de construção a efetuar podem ser classificadas da seguinte forma:

- Preparação do terreno
- Terraplanagens, incluindo escavação e aterro, para a construção da plataforma e dos caminhos de acesso
- Abertura e fecho de valas, caminhos de cabos
- Instalação de vedação e portões de acesso
- Construção de maciços de betão armado para o assentamento dos contentores e Power Stations
- Colocação de camada superficial de brita

O abastecimento de água/eletricidade durante a construção será partilhado com o estaleiro principal da central fotovoltaica.
No final de vida útil do sistema, este será completamente desmantelado e removido e a área requalificada.
A gestão de resíduos irá ser incorporada com o sistema de gestão da central.
Não está previsto um sistema dedicado de saneamento na fase de construção e de exploração.

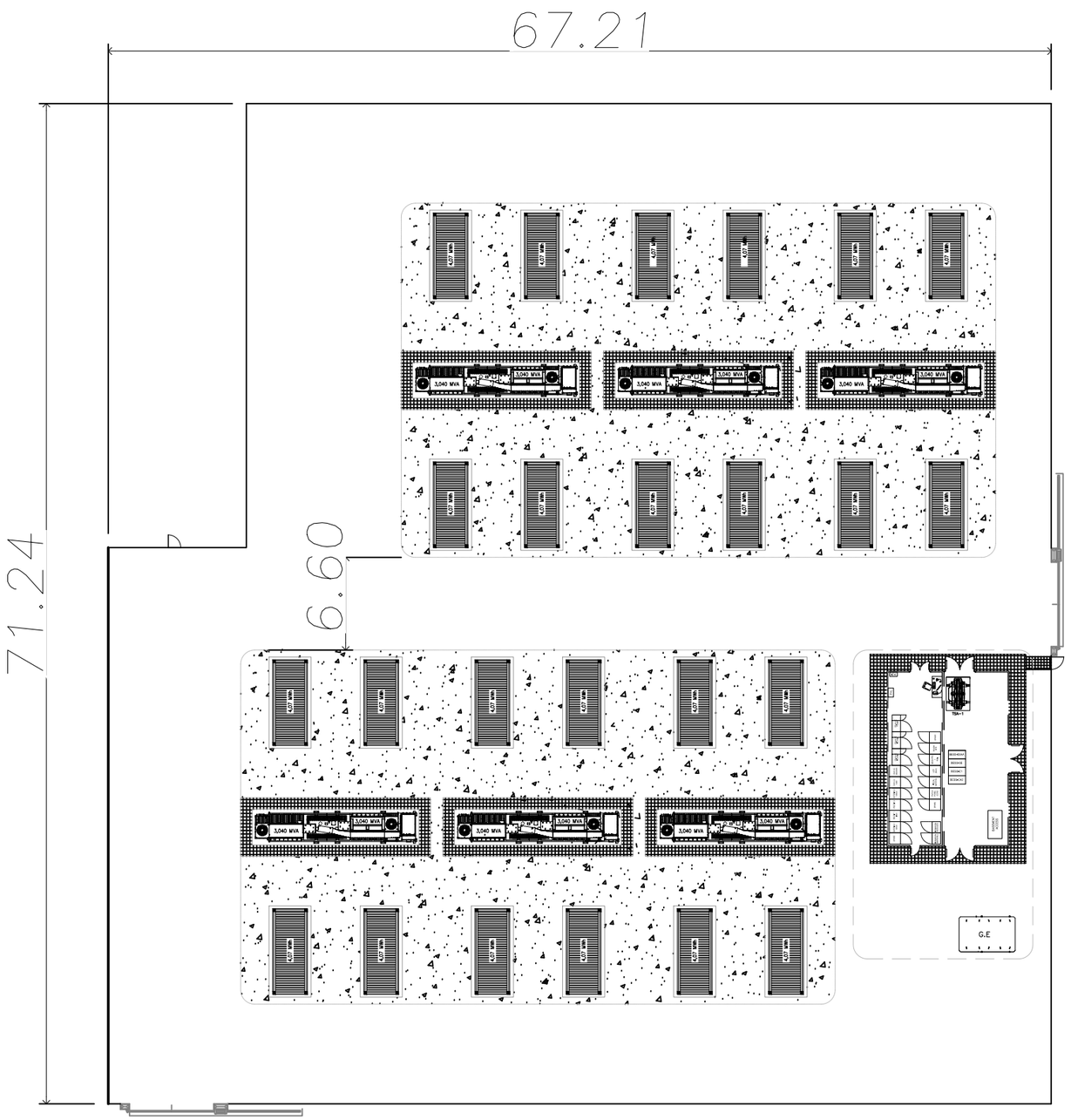
6. Sistema de Controlo

O sistema de controlo do BESS fará o controlo dos módulos de baterias através do BMS (Battery Management System Concentrator), dos Inversores (PCU) em todos os momentos, assegurando no ponto de injeção as funcionalidades pretendidas pelo sistema.



O sistema de controlo da planta localizado na subestação fará a gestão do BESS, do RES e da subestação.

O sistema de armazenamento de energia permitirá, entre outros, atenuar a intermitência de produção de energia da central, otimizar a geração de acordo com o mercado energético, melhorar a previsibilidade e controlabilidade da central, permitir que a central realize serviços de suporte à rede de transporte (como controlo de frequência, regulação de potência reativa, tensão, e cavas de tensão), deslocalizar no período diário alguma da potência disponível para períodos sem recurso solar, e reserva de capacidade.



Legenda

BESS	Taludes / Drenagens
Fundações Equipamento	Gravilha
Limite	Pavimento
Vedação	Estrada gravilha

Area Total: 4476 m2

REV.	DATE	DESCRIPTION	PREPARED BY	CONTRIBUTED BY	VERIFIED BY	VALIDATED BY
00	09-2024	for issue	NM	-	PM	PM

Engineering & Construction

FORMAT: | SCALE: | PLOT SCALE | SHEET: di / of

PROJECT: CSF Pereiro - Sistema de Armazenamento Energia BESS

FILE NAME: LAYOUT PRELIMINAR

CLASSIFICATION: Not For Construction

UTILIZATION SCOPE:

TITLE: PEREIRO SOLAR STORAGE

GRE CODE										
GROUP	FUNCTION	TYPE	ISSUER	COUNTRY	TEC.	PLANT	SYSTEM	PROGRESSIVE	REVISION
GRE	EEC	D	0	0	P	TP	123	790	0004	00

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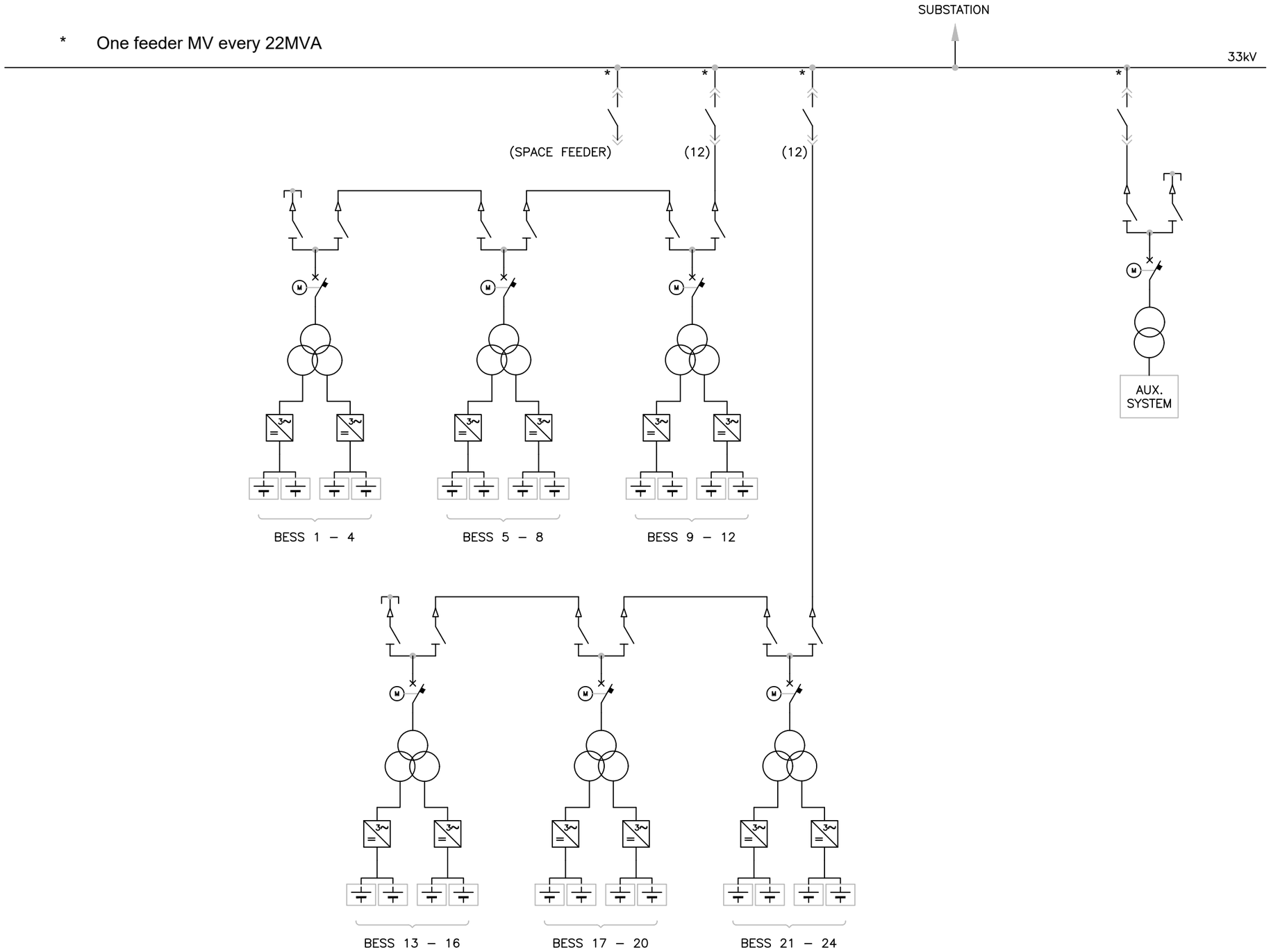
* One feeder MV every 22MVA



REV.	DATE	DESCRIPTION	PREPARED BY	CONTRIBUTED BY	VERIFIED BY	VALIDATED BY
00	09-2024	for issue	NM	-	PM	PM

Engineering & Construction

FORMAT:

SCALE:

PLOT SCALE

SHEET: 1 di / of 1

PROJECT: PEREIRO SOLAR BESS - SLD

FILE NAME: Preliminary SLD CSF Pereiro BESS

CLASSIFICATION: Not For Construction

UTILIZATION SCOPE

TITLE: PEREIRO SOLAR STORAGE 24,44 MWdc / 97,76 MWh

GRE CODE										
GROUP	FUNCTION	TYPE	ISSUER	COUNTRY	TEC.	PLANT	SYSTEM	PROGRESSIVE	REVISION	
GRE	EEC	D	0	0	P	TP	123790	0005	00	

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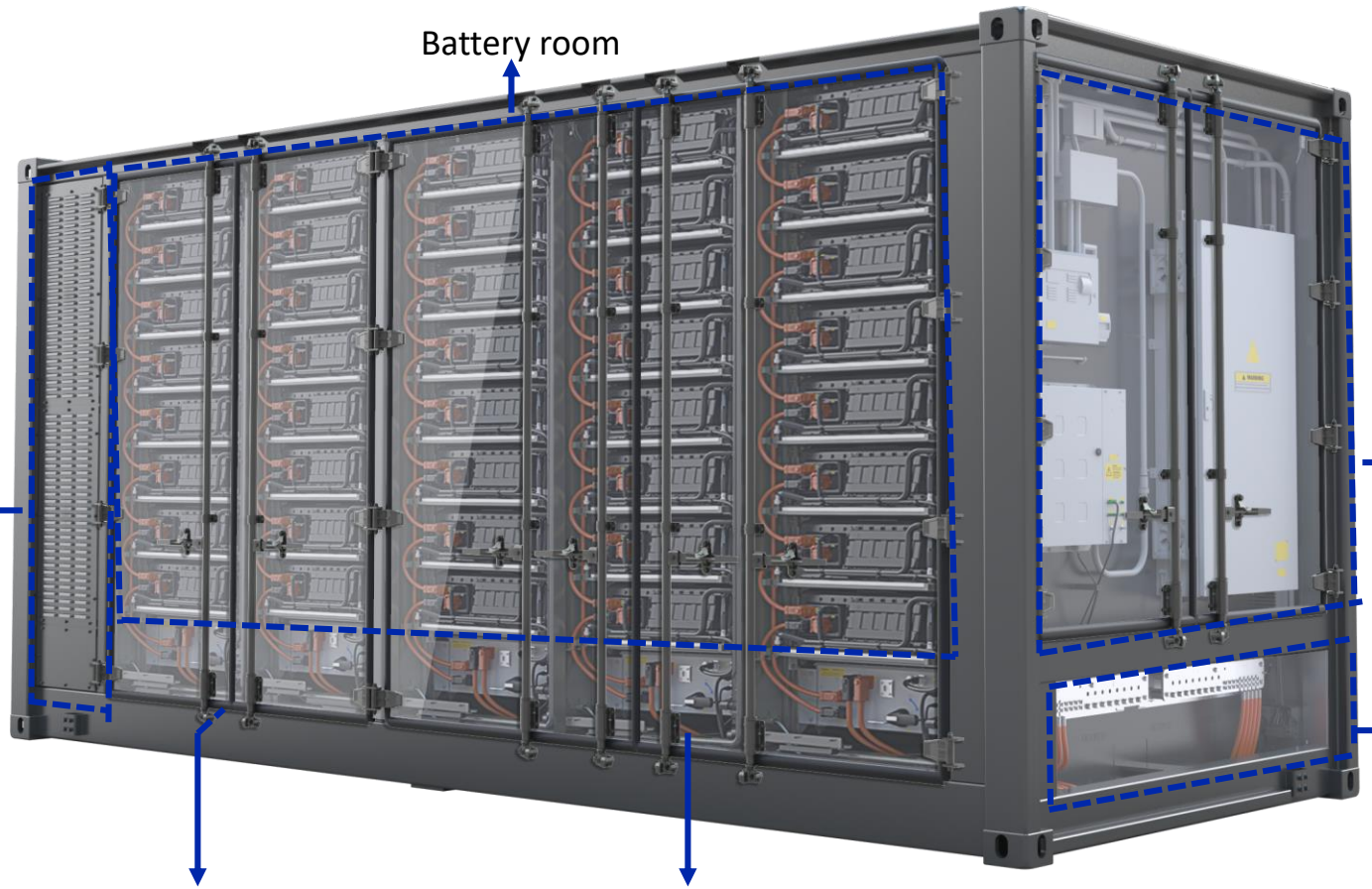
EnerC+ 306 Container Datasheet

Prepared By: Solution Center Team

EnerC+ Product Overview - Container

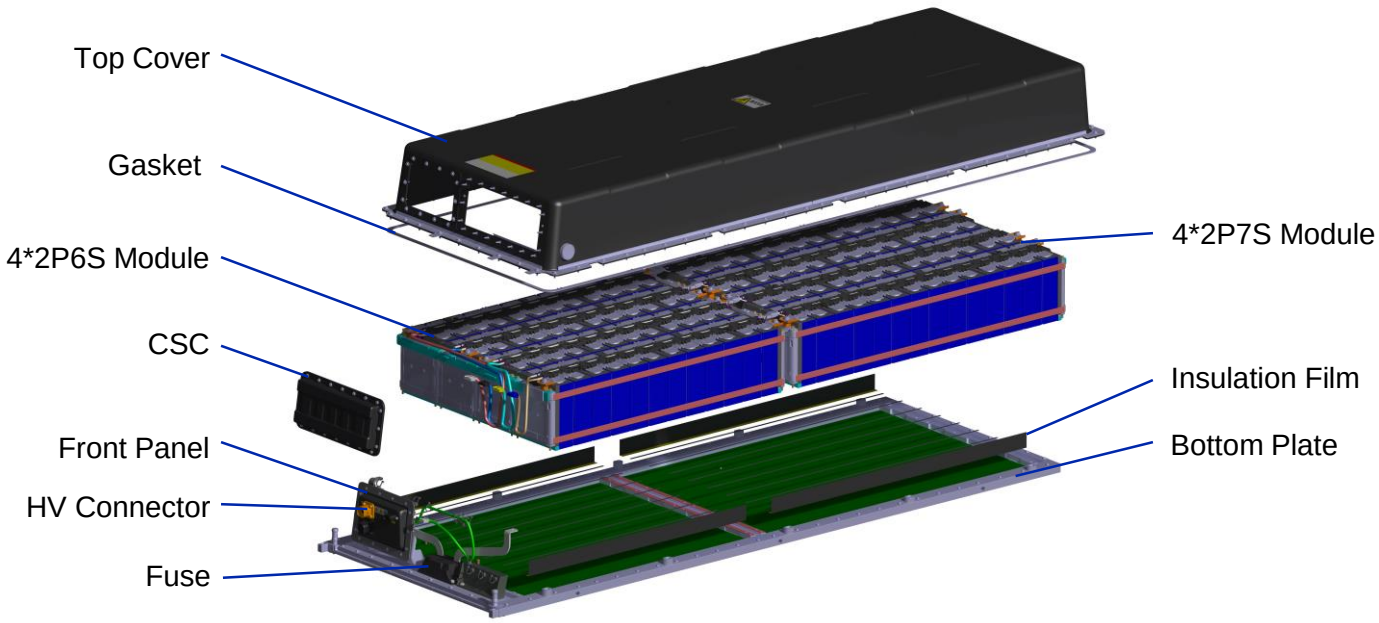


- Standard 20-foot container
- Liquid-Cooling
- High Integrated
- High Safety
- Reliability
- Long-Life
- High Cost Performance

EnerC+ Product Overview - Container

Item	Specification
Configuration	5P2P416S
Rated Energy	4073.47kWh
Cell Capacity	306Ah
Charging/Discharging Power	≤0.5P
End of Life (EOL)	SOH @EOL 70%
Rated Voltage	1331.2V
Voltage Range	1040V to 1500V
Dimension(W* D* H)	2438*6058*2896 mm　8ft*20ft*9.5ft
Weight	~35.2 t
Operation Temperature Range	-25℃ to 55℃
Storage Temperature	-30℃ to 60℃
Application Altitude	≤2000m　(No Derating)
Coolant	50% Ethylene glycol+50% DI water
IP Grade	IP55
Humidity	<95%, No condensing
Color	RAL 7042
Auxiliary power supply	Voltage Range：380~480 (±10%Vac), 3AC+N+PE,50/60Hz, Max：36.7kW 230 (±10%Vac, L+N) ,0.8kW
Noise Class	<92 dB (Distance:1.0m)
Enclosure Coating	ISO 12944, C4 (C5 Optional)
Grounding	Grounding copper braid
Installation	Concrete: anchor bolt
Certification	UL1973 / UL9540A / IEC62619 / IEC62477-1 / IEC61000-6-2/IEC61000-6-4

EnerC+ Product Overview - Battery Module



EnerC+ Product Overview - Battery Module

Item	Specification
Configuration	2P52S
Nominal Energy (kWh)	101.83 kWh
Rated Voltage (V)	166.4 V
Voltage Range (V)	130 ~ 189.8 V
Internal Resistance (mΩ)	≤ 40
Dimension (W* D* H)	830*2235*250 mm
Weight (kg)	~668kg
Charging/Discharging Power	≤0.5P
Operation Temperature Range	-25 ~ 55 ℃
Storage Temperature (℃)	-30 ~ 60 ℃
IP Grade	IP67

EnerC+ Product Overview - Thermal Management System

Item	Specification
IP Grade	IP66
Dimension(W* D* H)	978*628*2400mm
Weight	≤450kg
Coolant flow	50*5 L/min
Coolant	water-glycol mixture with concentration≤50% and anti-freezing mixture (PH value: 6.0~9.0)
Refrigerant type	R134a （3.6kg+5kg）
CAN interface	CAN 2.0
Installation method	Internal installation
Material of Cooling Pipe	Nylon + Aluminum pipe
Power scope	Heating：17.6kW，Cooling : 27.54kW
Current scope	Heating：31A，Cooling : 50.3A
Inrush Current	Starting impulse current≤65A(less than 5s)

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INGECON SUN STORAGE

3Power HV C Series
1,500 Vdc

UP TO 3.93 MVA AT 1,500 V

THREE-PHASE TRANSFORMERLESS BATTERY INVERTER WITH AN EXTRA THERMAL STABILITY AND A GREATER POWER DENSITY

The INGECON® SUN STORAGE 3Power HV C Series is a three-phase bidirectional battery inverter that can be used in grid-connected and stand-alone systems. This one-of-a-kind battery inverter achieves a market-leading power density of 499 kW/m^3, as it provides up to 3,928 kVA in just one power stack.

Latest generation electronics

The INGECON® SUN STORAGE 3Power HV C Series battery inverter features an innovative control unit that performs a more efficient and sophisticated inverter control, as it uses a last-generation digital signal processor.

Liquid Cooling System (LCS)

Ingeteam has already supplied +54 GW of liquid -cooled wind power converters worldwide. It offers a greater thermal stability and a more optimized component usage. The LCS has been designed to refrigerate the IGBTs, the power phases and the IP65 compartment. It features less moving components, so it consumes a lower amount of power and it requires less maintenance works.

The LCS is a closed circuit supplied totally filled and purged, equipped with fast connectors with an anti-dripping system, so it offers zero risk of particle entrance. It has been designed to avoid siphons in order to easily purge it if necessary. The coolant used is a biodegradable glycol water mixture. There is no need of emptying the LCS in order to replace the phases, nor the sensors.

IP65 protection

A secondary liquid cooling system is used to refrigerate the air inside the IP65-protected compartment. A water-air heat exchanger is used for that. This compartment contains the power and control electronics, the DC fuses, the DC and AC protections, the busbars and the power phases.

UP TO 3.93 MVA AT 1,500 V

Three-phase transformerless battery inverter with an extra thermal stability and a greater power density

Power converter stands both, grid-following and grid forming operating modes:

Real power related functionalities

Renewable resources integration:
- Ramp limits.
- Power smoothing / firming / curtailment.
- Time shifting.
- Micro grids.

Grid support / Ancillary services:
- Frequency regulation.
- Synthetic inertia.
- Black start.
- Frequency control / protection.
- Virtual “Synchronous Machine”.

Investment deferral:
- Peak shaving.
- Load shifting / Load following.
- Real power response improvement of conventional power plants.

Power efficiency:
- Time shifting.
- Price arbitrage.
- Real power response improvement of conventional power plants.
- Peak shaving.

Safety and quality:
- “Un-interruptible” Power.
- Grid code compliance.
- Transmission congestion relief / Power quality-reliability.

Reactive power related functionalities

- Voltage control (Q/V).
- Voltage control / protection.
- Fixed power factor (QPF).
- Fixed reactive power output (Qref).
- Limitation of response of Reactive Power.

Standard 5 year warranty, extendable upon request.

Protections

- Short-circuits and overloads at the output.
- Anti-islanding with automatic disconnection.
- Insulation failure DC.
- Up to 24 pairs of fuse-holders.
- Lightning induced DC and AC surge arresters, type II.
- Motorized DC switch.
- Motorized AC circuit breaker.
- Hardware protection via firmware.
- Additional protection for the power stack, liquid cooled, IP65 rated and air cooled by a closed loop.

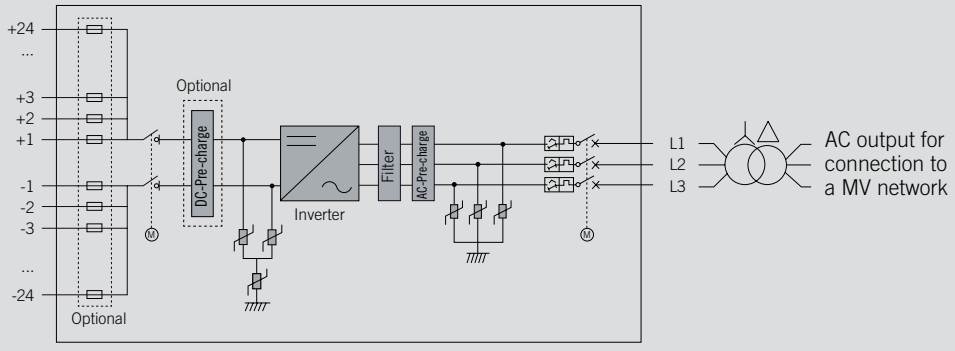
Optional Accessories

- Heating kit, for operating at an ambient temperature of down to -30 ºC.
- DC surge arresters type I+II.
- AC surge arresters type I+II.
- DC fuses.
- Monitoring of the DC currents.
- Grounding kit.

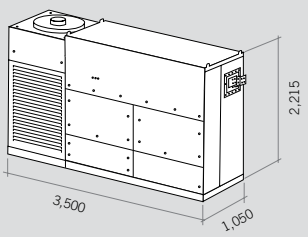
Liquid cooling system

- LCS to refrigerate the IGBTs.
- More optimized component usage: greater thermal stability.
- Less moving components: lower power consumption and less maintenance works.
- No risk of particle entrance.
- Anti-corrosion protection with stainless steel components
- LCS is used in many industries. Thus, it is very reliable, as its components are subject to many validation tests.
- Fast connectors with anti-dripping system.
- Biodegradable glycol water mixture.
- No need of emptying the LCS in order to replace the phases, nor the sensors.

INGECON® SUN STORAGE 3930TL



Size and weight (mm and kg)



2,800 kg

INGECON® SUN STORAGE 3930TL HV

	C600	C650	C690	C730	C750	C800	C840
INPUT (DC)							
Battery voltage range for off-grid mode	854 - 1,500 V	924 - 1,500 V	979 - 1,500 V	1,035 - 1,500 V	1,063 - 1,500 V	1,132 - 1,500 V	1,188 - 1,500 V
Battery voltage for grid-tied mode(1)	938 - 1,500 V	1,014 - 1,500 V	1,075 - 1,500 V	1,136 - 1,500 V	1,167 - 1,500 V	1,244 - 1,500 V	1,305 - 1,500 V
Maximum voltage	1,500 V						
Maximum current	3,357 A						
Nº inputs with fuse-holders	Up to 24						
Fuse dimensions	Up to 630 A / 1,500 V / aR / 100 kA (L/R=5mS) (optional)						
Type of connection	Connection to copper bars						
Power blocks	1						
INPUT PROTECTIONS							
Overvoltage protections	Type II surge arresters (type I+II optional)						
DC switch	Motorized DC load break disconnect						
Other protections	Up to 24 pairs of DC fuses (optional) / Reverse polarity / Insulation failure monitoring / Anti-islanding protection						
OUTPUT (AC)							
Discharge power @1,500 Vdc (35 ºC / 50 ºC)	2,806 kVA / 2,266 kVA	3,040 kVA / 2,454 kVA	3,227 kVA / 2,605 kVA	3,414 kVA / 2,756 kVA	3,507 kVA / 2,831 kVA	3,741 kVA / 3,020 kVA	3,928 kVA / 3,171 kVA
Discharge current @1,500 Vdc (35 ºC / 50 ºC)	2,700 A / 2,180 A						
Charge power @1,500 Vdc (35 ºC / 50 ºC)	2,665 kVA / 2,152 kVA	2,887 kVA / 2,332 kVA	3,064 kVA / 2,475 kVA	3,242 kVA / 2,619 kVA	3,331 kVA / 2,690 kVA	3,553 kVA / 2,870 kVA	3,730 kVA / 3,013 kVA
Charge current @1,500 Vdc (35 ºC / 50 ºC)	2,564 A / 2,071 A						
Rated voltage(2)	600 V IT System	650 V IT System	690 V IT System	730 V IT System	750 V IT System	800 V IT System	840 V IT System
Frequency	50 / 60 Hz						
Power Factor(3)	1						
Power Factor adjustable	Yes, 0 - 1 (leading / lagging)						
THD (Total Harmonic Distortion)(4)	<3%						
OUTPUT PROTECTIONS							
Overvoltage protections	Type II surge arresters (type I+II optional)						
AC breaker	Motorized AC circuit breaker						
Anti-islanding protection	Yes, with automatic disconnection						
Other protections	AC short-circuits and overloads						
FEATURES							
Operating efficiency	98.9%						
CEC	98.5%						
Max. consumption aux. services	7,600 W						
Stand-by or night consumption(5)	185 W						
Average power consumption per day	2,500 W						
GENERAL INFORMATION							
Ambient temperature	-20 ºC to +60 ºC						
Relative humidity (non-condensing)	0-100% (Outdoor)						
Protection class	IP65(6)						
Corrosion protection	External corrosion protection						
Maximum altitude	4,500 m (for installations beyond 1,000 m, please contact Ingeteam's BESS sales department)						
Cooling system	Liquid cooling system and forced air cooling system with temperature control (400V 3 phase + neutral power supply, 50/60 Hz)						
Air flow range	0 - 18,000 m^3/h						
Average air flow	12,000 m^3/h						
Acoustic emission (100% / 50% load)	<57 dB(A) at 10m / <49.7 dB(A) at 10m						
Marking	CE						
EMC and security standards	IEC 62920, IEC 61000-6-1, IEC 61000-6-2, IEC 61000-6-4, IEC 61000-3-11, IEC 61000-3-12, IEC 62109-1, IEC 62109-2, EN 50178, FCC Part 15, AS3100						
Grid connection standards	IEC 62116, EN 50530, IEC 61683, EU 631/2016 (EN 50549-2, CEI 0-16, NTS Spain, VDE-AR-N 4120, VDE-AR-N 4110, Arrêté du 9 juin 2020, Terna A68), G99, South African Grid Code, Mexican Grid code, Chilean Grid Code, Ecuadorian Grid Code, Peruvian Grid Code, IEC61727, ABNT NBR 16149, ABNT NBR 16150, IEEE 1547, IEEE1547.1, DEWA (Dubai), Abu Dhabi Grid Code, Jordan Grid Code, Egyptian Grid Code, Saudi Arabia Grid Code, RETIE Colombia, Australian Grid Code						

Notes

(1) Minimum voltage DC (VDC, min) for Vgrid,max = 1.1 p.u. and Power Factor=1. If Vgrid,max is higher than this value, the minimum voltage should be corrected as VDC, min * Vgrid,max / 1.1. For other DC voltage ranges, please contact Ingeteam's BESS sales department
(2) Other AC voltages and powers available upon request
(3) For P_{out}>25% of the rated power
(4) For P_{out}>25% of the rated power and voltage in accordance with IEC 61000-3-4
(5) Consumption from Battery
(6) Except for the LC filter and the air-water heat exchanger, that are IP54.

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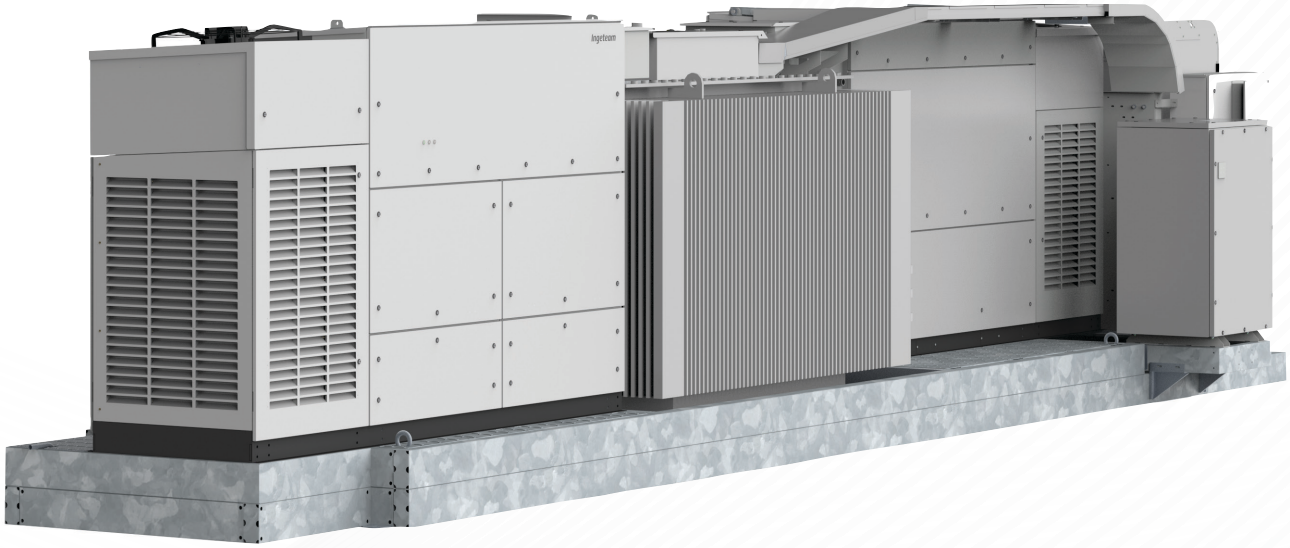
INGECON SUN STORAGE

PowerStation FSK HV C Series
1,500 Vdc



MEDIUM VOLTAGE POWER STATION CUSTOMIZED UP TO 7.86 MVA, WITH ALL THE COMPONENTS SUPPLIED ON TOP OF THE SAME SKID PLATFORM

This medium-voltage solution integrates all the devices required for a multi-megawatt battery energy storage system.

Maximize your investment with a minimal effort

Ingeteam's FSK power station is a compact, customizable and flexible solution that can be configured to suit each customer's requirements. It is supplied together with up to two storage inverters. All the equipment is suitable for outdoor installation, so there is no need of any kind of housing.

Higher adaptability and power density

This power station is now more versatile, as it presents the step-up transformer integrated into a steel platform together with the LV and MV components, including the storage inverters. Moreover, it features one of the market's greatest power densities.

Plug & Play technology

This MV solution integrates power conversion equipment (up to 7.86 MVA), liquid-filled hermetically sealed transformer up to 38 kV and provision for low voltage equipment. The MV Skid is delivered pre-assembled for a fast onsite connection with up to two storage inverters from Ingeteam's INGECON® SUN STORAGE 3Power HV C Series battery inverter family. The full skid is lifted as an single block and it is transported within an open top 40 ft container.

Complete accessibility

Thanks to the lack of housing, the inverters, the switchgear and the transformer can have immediate access. Furthermore, the design of the 3Power HV C Series storage inverters has been conceived to facilitate maintenance and repair works.

Maximum protection

Ingeteam's 3Power HV C Series storage inverters feature an IP65 protection class for their power stacks thanks to a combined water and air cooling system that optimises the operating temperature of the power electronics. Apart from that, they feature the main electrical protections and they deploy grid support functionalities, such as low voltage ridethrough capability, reactive power deliverance and active power injection control.

Medium voltage power station customized up to 7.86 MVA, with all the components supplied on top of the same skid platform

Construction

- Steel base frame.
- Suitable for slab or piers mounting.
- Compact design, minimising freight costs.
- Minimum installation at project site.

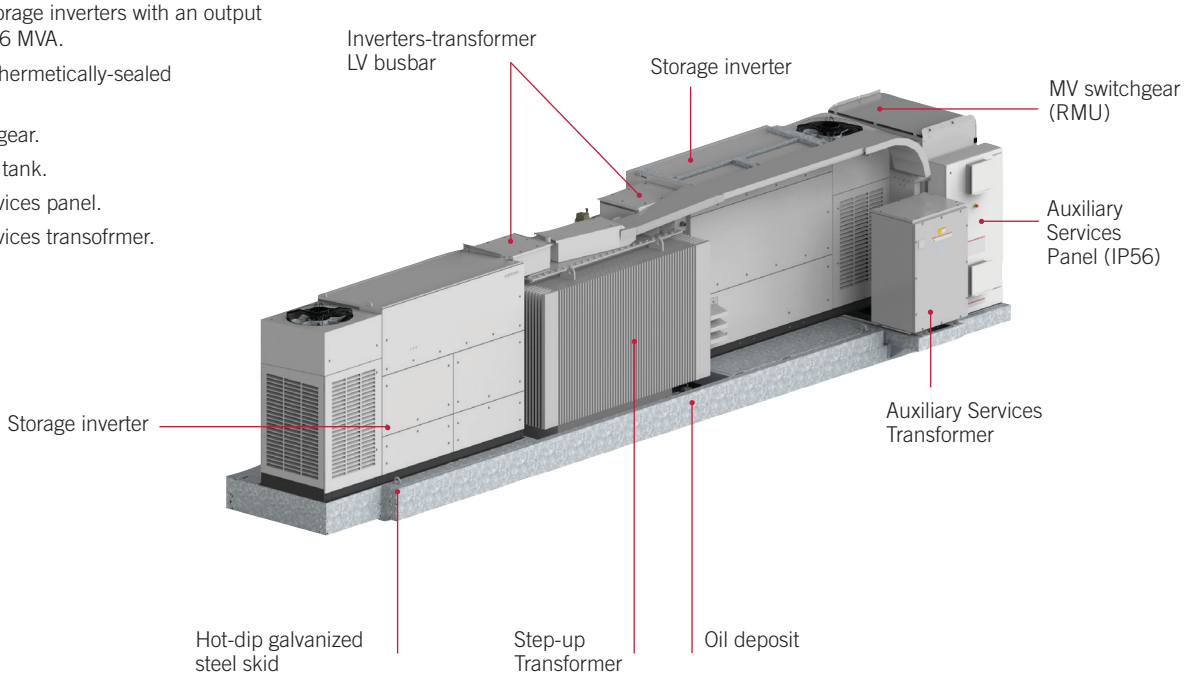
Optional accessories

- Auxiliary services transformer (up to 60 kVA, Dyn11).
- MV Surge arresters.
- Self-powered auxiliary services panel.
- High-speed Ethernet / fibre optic communication switch.
- Energy meter for auxiliary services and/or energy production.

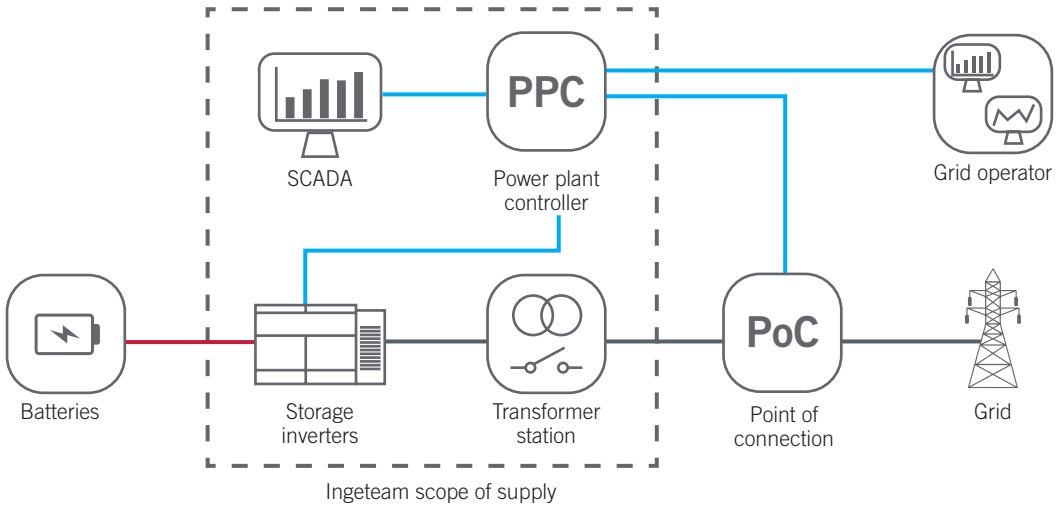
Standard equipment

- Up to two storage inverters with an output power of 7.86 MVA.
- Liquid-filled hermetically-sealed transformer.
- 2L1C switchgear.
- Oil-retention tank.
- Auxiliary services panel.
- Auxiliary services transofrmer.

Components



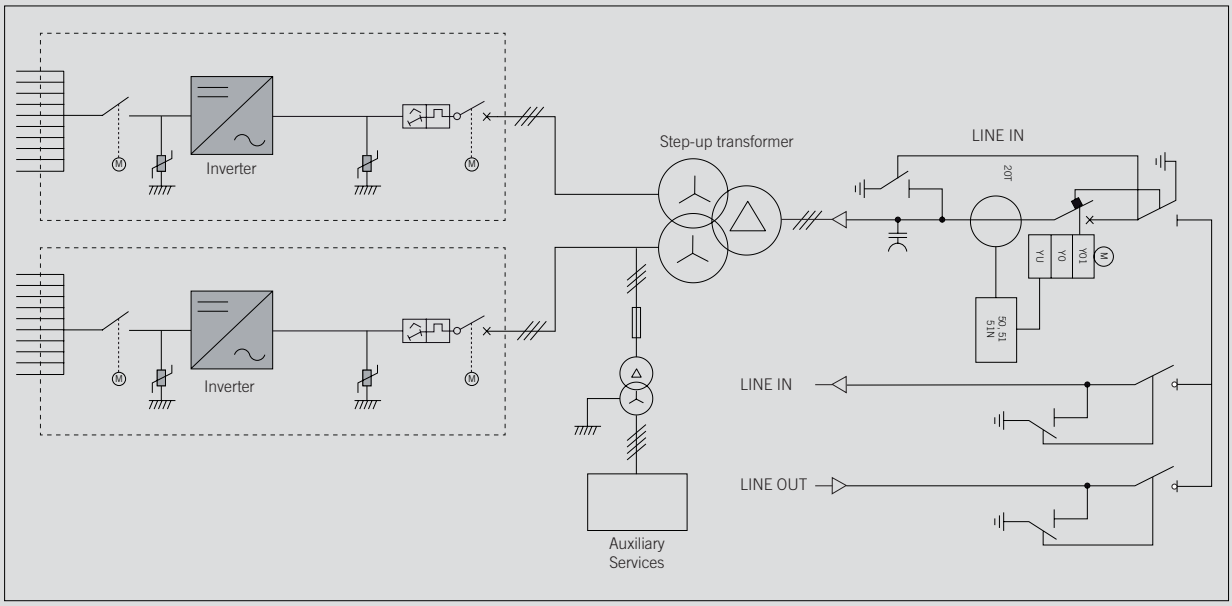
Plant configuration



	2300 FSK HV C Series	4600 FSK HV C Series
GENERAL INFORMATION		
Number of inverters	1	2
Discharge power @1,500 Vdc (35 ºC / 50 ºC)(1)	3,040 kVA / 2,454 kVA	6,080 kVA / 4,908 kVA
Discharge current @1,500 Vdc (30 ºC / 50 ºC)	2,700 A / 2,180 A	
Charge power @1,500 Vdc (35 ºC / 50 ºC)(1)	2,887 kVA / 2,332 kVA	5,774 kVA / 4,664 kVA
Charge current @1,500 Vdc (30 ºC / 50 ºC)	2,564 A / 2,071 A	
Operating temperature range	from -20 ºC to +60 ºC	
Relative humidity (non condensing)	0 - 100%	
Maximum altitude	3,000 masl (power derating starting at 1,000 masl)	
STEP-UP TRANSFORMER		
Medium voltage	36 kV, 50-60 Hz	
Cooling system	ONAN (KNAN optionally)	
Minimum PEI (Peak Efficiency Index)(2)	99.50%	
Protection degree	Readiness for outdoor installation	
MV SWITCHGEAR (RMU)		
Medium voltage	24 kV / 36 kV	
Rated current	630 A	
Cooling system	Natural air ventilation	
Protection degree	IP54	
EQUIPMENT		
Auxiliary services panel	IP54 self-powered LV panel	
Step-up transformer	Oil-immersed hermetically sealed transformer	
MV Switchgear	2L1C RMU as standard (0L1C1L, 1L1C & 0L1C optional)	
MECHANICAL INFORMATION		
Structure type	Hot dip galvanized steel skid	
Dimensions Full Skid (W x D x H)	9,500 x 2,600 x 2,620 mm	11,390 x 2,600 x 2,620 mm
Weight	16 T	25 T
Standards	IEC 62271-212, IEC 62271-200, IEC 60076, IEC 61439-1	

Notes
(1) Data calculated with the inverter model INGECON® SUN STORAGE 3930TL HV C650. For other storage inverter models, please contact Ingeteam's BESS sales department.
(2) For European installations, ECO design according to the EU 548/2014 and EU 2019/1783 standards.

Example of configuration with two HV C series storage inverters



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TÜV SOLAR CABLE (H1Z2Z2-K)

CAVO UNIPOLARE FLESSIBILE HALOGEN FREE PER APPLICAZIONI FOTOVOLTAICHE
FLEXIBLE SINGLE CORE CABLE HALOGEN FREE FOR PHOTOVOLTAIC SYSTEMS

APPROVAZIONI / *APPROVALS:*
Certificate Nr R60113052

1 – 1° isolamento:
copolimero speciale halogen free
1st insulation:
halogen free special copolymer
2 – 2° isolamento:
copolimero speciale halogen free
2nd insulation:
halogen free special copolymer
3 – Conduttore in rame
Copper conductor

COLORI 1° e 2° ISOLAMENTO/
1st and 2nd INSULATION COLOUR

Conduttore trefolo flessibile in rame stagnato
Twisted flexible tinned copper conductor

MARCATURA / *MARKING :*

CET SOLAR CABLE 1Xn,00 mm2 1.0/1.0 kV H1Z2Z2-K TÜV Rheinland Type Approved R60113052 IEC 60332-1 CE

APPLICAZIONI /
APPLICATIONS

CONFEZIONI /
PACKAGING

Dati Tecnici	
Tensione Nominale Uo/U	**1.0/1.0 kV AC – 1.5/1.5 kV DC**
Tensione max.consentita	**1,8 kV DC**
Tensione di Prova	**6.5 kV AC**
Temperatura di Esercizio	**- 40 ÷ +90°C**
Max. temp. conduttore	**+120°C (for 20.000 hrs.)**
Raggio minimo di curvatura	**5 x D cavo (installazione fissa)**
Omologazione	**TÜV Rheinland**
Norme di Riferimento :	**EN 50618: 2014**
	IEC 60228 – EN 50395 – EN 50396 **EN 60332-1-2 – EN 61034-1; -2** **EN 50525-1 – EN 60216-1; -2**

Technical Data	
Nominal Voltage Uo/U	**1.0/1.0 kV AC – 1.5/1.5 kV DC**
Maximum permitted voltage	**1,8 kV DC**
Test Voltage	**6.5 kV AC**
Operating Temperature	**- 40 ÷ +90°C**
Max. core temperature	**+120°C (for 20.000 hrs.)**
Min. bending radius	**5 x D cable (fixed installation)**
Approved	**TÜV Rheinland**
References:	**EN 50618: 2014**
	IEC 60228 – EN 50395 – EN 50396 **EN 60332-1-2 – EN 61034-1; -2** **EN 50525-1 – EN 60216-1; -2**

TIPO	**SEZIONE**	**DIAMETRO MAX FILI CONDUTTORE**	**SPESSORE ISOLANTE 1° / 2°**	**DIAMETRO ESTERNO**	**RESISTENZA ELETTRICA MAX A 20°C *MAX ELECTRIC RESISTANCE AT 20°C***	**REATTANZA (a 50 Hz)**
TYPE	***SECTION***	***MAX WIRE DIAMETER OF CONDUCTOR***	***INSULATION THICKNESS 1ST / 2ND***	***OVERALL DIAMETER***	**RAME STAGNATO *TINNED COPPER***	***REACTANCE (at 50 Hz)***
	mm²	**mm**	**mm**	**mm**	**Ω/Km**	**Ω/Km**
TÜV SOLAR CABLE	**1x2.50**	**0.26**	**0.70 / 0.80**	**5.00**	**8.21**	**/**
	1x4.00	**0.31**	**0.70 / 0.80**	**5.40**	**5.09**	**0.143**
	1x6.00	**0.31**	**0.70 / 0.80**	**6.20**	**3.39**	**0.135**
	1x10.0	**0.41**	**0.70 / 0.80**	**7.40**	**1.95**	**0.119**

Tolleranza sui diametri: in accordo con le norme di riferimento TÜV
Diameters tollerances: according with TÜV standards

SEZIONE	**Portata amperometrica dei cavi PV in funzione del tipo d'installazione(T=60°C)** ***Current carrying capacity of PV cables in accordance to the installation (T=60°C)***		
SECTION	**Cavo singolo – posa in aria** ***Single cable free in air***	**Cavo singolo – posa su superficie** ***Single cables on surfaces***	**Cavi in fascio – posa su superficie** ***To cables adjacent on surfaces***
mm²	**(A)**	**(A)**	**(A)**
1 x 2.5	**41**	**39**	**33**
1 x 4.0	**55**	**52**	**44**
1 x 6.0	**70**	**67**	**57**
1 x 10	**98**	**93**	**79**

Proprietà

La speciale costruzione e i materiali impiegati, consentono al cavo di soddisfare i requisiti più recenti previsti per i sistemi fotovoltaici in accordo alle normative: EN50618 – EN 60216-1-2 – EN 61034. L'isolamento garantisce un elevato potere isolante e notevole resistenza all'invecchiamento termico, nonché proprietà di resistenza all'abrasione ed alla fiamma, resistenza all'ozono, resistenza ai raggi UV ed è facilmente rimovibile dall'isolamento interno per facilitare operazioni di connessione.

Properties

The cable is able to satisfy the latest requirements fixed for PV systems in accordance to the following Reference Standards: EN50618 – EN 60216-1-2 – EN 61034. The special insulation has qualities of high abrasion resistance to high temperature. Moreover the insulation has property of flame retardant and ozone resistance
The cable is UV-resistant and the external sheath can be removed from the inner layer of extruded insulation.

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STABILIMENTO / DIVISION
cet eletric

TÜV SOLAR CABLE (H1Z2Z2-K)
APPENDIX

The H1Z2Z2-K is to be considered Harmonized because has been tested and certified in accordance with the requirements of the harmonized standard EN 50618: 2014 (quoted in the official document of the European Union that lists the harmonized standards to the LVD Directive 2006/95/EC (Low voltage Directive).
Use and type of installation for applications in photovoltaic (HD 60364-7-712). For fixed installation indoors and outdoors. Installation of walls, walkways, pipes, conduits, and similar systems. The cables are suitable for use with Class II.
They are inherently short-circuit and earth fault proof acc.to HD 60364-5-52.

Chemical properties	
Halogen-free	acc. to EN 50525-1 Annex B (EN 50267-2-1, EN 50267-2-2, IEC 60754-1, IEC 60754-2)
Low Smoke Emission	acc. to IEC 61034, EN 61034 (Light Transmittance > 60%)
Weather resistance	*Ozone resistance:* acc. to EN 60811-403 Test Method A, EN 50396 clause 8.1.3 Test Method B *Weathering/UV resistance:* acc. to EN 50618 Annex E, EN 50289-4-17 (Method A), EN ISO 4892-1 /-2 tensile strength and elongation at break after 720h (360 Cycles) of exposure to UV lights
Acid and alkaline resistance	acc. to EN 50618:2014 Annex B: 7 days, 23° C (N-Oxalic Acid, N-Sodium Hydroxide) as for EN 60811-404
Resistance to fire	Flame propagation acc. to EN 60332-1-2 (Single Cable Flame Test) Tested according to CPR: EN 50399 Common test methods for cables under fire conditions Heat release and smoke production measurement on cables during flame spread test, UNI EN 13501-6 Flammability class: **D_{ca}** Smoke emission class: **s2** Drip particle class: **d2** Fume acidity: **a1**

Mechanical properties	
	for insulation and sheath before ageing acc. to EN 50618 Annex B (test acc. To EN 60811-501). tensile strength ≥ 8 N/mm² elongation at break for insulation and sheath ≥ 125 %
Shrinkage test on sheath	acc. to EN 50618, Table 2: <2% (test acc. to EN 60811-503).
Dynamic Penetration Test	acc. to EN 50618
Durability of Print	acc. to EN 50618 (test acc. to EN 50396)
Direct Burial	Impact test resistance of single conductor type USE and USE-2 cables (tested acc. to UL854)
Rodent resistance (optional)	Rodent resistance safety can be optimized by utilizing a special compound *alternative:* braid metallic coatings
Water resistance	AD8 category Tested with successful acc. to EN 50525-2-21 “Annex E” (after immersion for 100 days / 2.400 h to 50°C): • Voltage at 1 kV AC on cable in water at 50°C during 100 days without any breakdown • Mechanical properties on sheath after immersion 100 days at 50°C • Minimum tensile strength after immersion 100 days at 50°C > 7 MPa • Minimum elongation at breack after immersion 100 days at 50°C > 200% • Water absorption on sheath after immersion 100 days at 50°C less than 40% • Insulation resistance tests with a minimum resistivity of 10^{11} Ω.cm measured after 14 days in water at 50°C
Long term resistance of insulation to d.c	acc. to EN 50618, Table 2 test acc. to EN 50395 clause 9: Cable immersed in water containing 1% NaCl for 240h ; water temperature: 85°C ± 5; Voltage applied: 1.8 kV D.C.

Thermal properties	
Lifetime	acc. to EN 50618 : 25 years the cables are designed to operate at a normal max conductor temperature of 90°C, but for a maximum of 20.000 hours a max. conductor temperature of 120 °C at a max. ambient temperature of 90 °C is permitted. (test according to EN 60216-1 and EN 60216-2)
Max.short circuit temperature	250°C (for 5 sec.)
Resistance to cold	EN 50618, Table 2: Cold Bending Test at -40°C acc. to EN 60811-504; Cold Elongation Test at -40°C acc. to EN 60811-505; Cold Impact Test at -40°C acc. to EN 50618 Annex C and EN 60811-506. Damp-Heat Test Acc. to EN 50618, Table 2 (test acc. to EN 60068-2-78) : 90°C for 1.000h and min. 85% humidity

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Zertifikat *Certificate*

TÜVRheinland®

Zertifikat Nr. *Certificate No.*
R 60113052

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0001

Ihr Zeichen *Client Reference*	**Unser Zeichen** *Our Reference*	**Ausstellungsdatum** *Date of Issue*
	0001--28109744 001	30.08.2016 *(day/mo/yr)*

Genehmigungsinhaber *License Holder*
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Cavi e Conduttori Elettrici
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Italia

Fertigungsstätte *Manufacturing Plant*
Enco S.r.l. - Stab. Cet Eletric
Via C. Battisti 34
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Italia

Prüfzeichen *Test Mark*

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Type Approved
Safety
Regular Production
Surveillance
www.tuv.com
ID 1111210371

Geprüft nach *Tested acc. to*
EN 50618:2014

Zertifiziertes Produkt (Geräteidentifikation)
Certified Product (Product Identification)

Lizenzentgelte - Einheit
License Fee - Unit

PV-Cables

Identification	: CET SOLAR CABLE	21
Code designation	: H1Z2Z2-K	
Rated diameter	: 1x2,5mm²; 1x4,0mm²; 1x6,0mm²; 1x10,0mm²	
Rated voltage	: Uo/U: 1,0/1kV AC; 1,5kV DC	
Permitted Voltage	: max. DC 1,8kV; (conductor-conductor, non earthed system, circuit not under load)	
Ambient temperature	: -40°C to +90°C	
Max. core temperature	: +120°C (for 20.000h)	
Material of insulation	: crosslinked special compound	
Material of sheath	: crosslinked special compound	
Color of sheath	: black; red; blue	
Remarks	: Refer to Constructional Data Form for additional Technical Information	

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Dem Zertifikat liegt unsere Prüf- und Zertifizierungsordnung zugrunde und es bestätigt die Konformität des Produktes mit den oben genannten Standards und Prüfgrundlagen. Zusätzliche Anforderungen in Ländern, in denen das Produkt in Verkehr gebracht werden soll, müssen zusätzlich betrachtet werden. Die Herstellung des zertifizierten Produktes wird überwacht.
This certificate is based on our Testing and Certification Regulation and states the conformity of the product with the standards and testing requirements as indicated above. Any additional requirements in countries where the product is going to be marketed have to be considered additionally. The manufacturing of the certified product is subject to surveillance.

Zertifizierungsstelle

Marco Piva

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10/020 h 04.08 ® TÜV, TUEV and TUV are registered trademarks. Utilisation and application requires prior approval.

ISO 9001:2008	**ENCO s.r.l.** **Stab. CET ELETRIC** Via C.Battisti,34 35010 Limena PADOVA ITALY	**MOD-103.50** **DECLARATION OF CONFORMITY** **(EN ISO/IEC 17050-1 - EN ISO/IEC 17050-2)** **Directive 2006/95/EC**	**Rev.: 0** **Date:** **22/02/2011**

CUSTOMER:

DESCRIPTION :

TÜV SOLAR ST

WE DECLARE THAT THE ABOVE PRODUCTS:

- *are made, checked and finally tested according to Construction and Testing Plans and/or specifications and/or standards or anything else is written, for the characteristics of materials and construction quality*
- *Manufactured in conformity with european standards:*
  for the conductor (CENELEC HD 383 / IEC 60228),
  with TUV standards (2 Pfg 1169/08.2007) and therefore are made in conformity to the directives 2006/95/CE (low voltage european directive) (73/23EEC 19/02/73 old) and 93/68 EEC 22/07/93
- *are suitable to be used in the conditions written in yr/our drawings and/or specifications and/or catalogues. In particular:*
  - *suitable for installation indoor and outdoor, mainly directly buried into the ground or in underground pipes*
  - *suitable for installation with or without protection, in pipes embedded or not*
- *all documents, related to the tests made on products, are at your disposal for any request.*

The supplied Solar Cable has an expected period of use for 25 years according with TUV standard, if it is used as indicated in our technical specifications in an ambient temperature up to +90°C.

DATE: 2014.11.10	*THIS CERTIFICATE WAS ISSUED BY MACHINE AND IS THUS VALID WITHOUT SIGNATURE.* *THESE DATA DO NOT ABSOLVE THE PURCHASER FROM CHECKING THE QUALITY OF THE SUPPLYES RECEIVED.ALL SALES OF THIS PRODUCT SHALL BE SUBJECT TO OUR GENERAL CONDITION OF SALE.*

ENCO s.r.l. CAVI E CONDUTTORI ELETTRICI
ENCO s.r.l. ELECTRICAL CABLES AND WIRES

ISO 9001:2015 - Cert. Nr 9125.CET2

Limena, Italy, 2019.06.28

CERTIFICATE OF LONG TERM RESISTANCE OF INSULATION TO D.C. (CABLE IMMERSED IN SALT WATER)

Product: H1Z2Z2-K st

- **Test conditions** ***According to EN 50618 (Table 2 – Ref No.1.5)*****:**

  Cable immersed in water containing 1% NaCl (EN 50395 – Clause 9)

  Length of sample: 5 m

  Duration: 240 h

  Water temperature: 85°C ± 5

  DC Voltage applied: 1.8 kV D.C.

- **Results:**

  No breakdown and no signs of damage

Qualiy Assurance
ENCO SRL

Enco srl cavi e conduttori elettrici
Via Selice, 10/A – 40027 Mordano (BO) Italy
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www.ceteletric.com info@ceteletric.com

Annex E
(normative)

Weathering/UV resistance test

This test is to determine the UV stability of the sheathing material of the cable in the condition as manufactured. This is done by means of measuring elongation at break in the condition as manufactured and after exposure to ultraviolet light and water.

Samples shall be selected, prepared and tested in accordance with EN 60811-501.

Samples shall be exposed to UV light in accordance with the requirements of EN 50289-4-17, method A, for 720 h (360 cycles).

NOTE Additional information on weathering/UV resistance testing can be found in EN ISO 4892–1:2000 and EN ISO 4892–2:2006.

After the exposure, the test specimens shall be removed from the equipment and conditioned at ambient temperature for at least 16 h.

Five exposed specimens and five not exposed specimens are to be tested separately and in close succession for tensile strength and elongation at break. The respective median values are to be calculated from the five tensile strength and elongation at break values obtained for the conditioned specimens and are to be divided by the median values of the five tensile strength and elongation at break values obtained for the unconditioned specimens.

It is required that the tensile strength and elongation at break after 720 h (360 cycles) of exposure is at least 70 % of the values measured on not exposed specimens.

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ENCO s.r.l. ELECTRICAL CABLES AND WIRES

ISO 9001:2015 - Cert. Nr 9125.CET2

Limena, Italy, 2019-06-28

Test according to EN 50525-2-21 "Annex E" (after immersed 100 days / 2.400 h at +50°C)

Object : H1Z2Z2-K

- Resistance Test Voltage (2.5 kV AC): cable immersed in water at 50±2 °C for 24 hours

  Conform - No breakdown

- The increase in weight after 100 days in water at 50±2 °C

Weight variation		
Initial	Final	Variation
1.283 g	1.298 g	+1.169 %

- Tensile strength and elongation at break after 100 days in water at 50±2 °C

Tensile strength (N/mm^2)		
Initial	Final	Variation
12.1	12.8	+5.45 %

Elongation at break (%)		
Initial	Final	Variation
280	240	-14.28 %

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General Cable

Low Voltage Cables	Units	Item1
Product identification and Features		
Cable code		16901C2
Cable type		XZ1-Al (S) All-Ground
Standard		IEC 60502-1
Nominal voltage		1,8/3 kV
N° of cores x C.S.A.		1 x185 mm²
Construction and Dimensions		
Conductor material		Aluminium
Shape		Circular compacted
Class / Standard		2 / IEC 60228
Nominal diameter	mm	15,60
Mica glass tape		NO
Insulation material		XLPE
Nominal radial thickness	mm	2,2
Diameter over insulation	mm	20
Outer sheath material		LSF-OH
Nominal radial thickness / Minimum at any point	mm	4,0 / --
Nominal overall diameter	mm	28,5
Nominal total weight	kgs/km	940
Minimum bending radius (after installation)	mm	285
Electrical Data		
Maximum conductor DC resistance, at 20 ºC	Ohm/km	0,164
Star reactance per phase, at 50 Hz	Ohm/km	0,098
Maximum permanent current rating (*)	A	335 (3) / 295 (4)
Maximum conductor temperature in service / in short-circuit	ºC	90 / 250
Maximum adiabatic short-circuit current rating (0.1/0.5/1.0 s)	kA	55,3 / 24,7 / 17,5

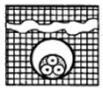
(*) In air, at 30 ºC / Buried, at 20 ºC - 2,5 ºK·m/W - 0,7 m (see more details in ANNEX)
N/A = Not Applicable
Nominal values subject to the usual manufacturer tolerances

Signed by : N. Oliveira
Date : 18/09/2019

General Cable reserves the right to change or modify the specifications and materials depending on future improvements. Based on this, data listed above could be modified due to these changes

General Cable

METHODS DESCRIPTION AND INSTALLATION CONDITIONS

(1)			3 single-core cables, in trefoil touching formation, with effective air renovation.	In free air at 30ºC, solar radiation protected, in accordance with UNE 211435
(2)			3 single-core cables, in trefoil touching formation, buried direct in the ground.	Direct buried at 20ºC - 2,5ºK·m/W - 0,7m, in accordance with UNE 211435
(3)			3 single-core cables, in trefoil touching formation, with effective air renovation.	In free air at 30ºC, solar radiation protected, calculation criteria in accordance with IEC 60287
(4)			3 single-core cables, in trefoil touching formation, buried direct in the ground.	Direct buried at 20ºC - 2,5ºK·m/W - 0,7m, calculation criteria in accordance with IEC 60287
(5)		F	Single-core cables, in trefoil touching formation in free air. Clearance to wall not less than one cable diameter.	In air at 30ºC, solar radiation protected, in accordance with IEC 60364-5-52, Method F (3 loaded conductors)
(6)		D1	Single-core cables, in cable ducting in the ground.	Buried at 20ºC - 2,5ºK·m/W - 0,7m, in accordance with IEC 60364-5-52, Method D1 (3 loaded conductors)
(7)			Single-core cables, in trefoil touching formation in free air. Clearance to wall not less than one cable diameter.	In air at 30ºC, solar radiation protected, calculation criteria in accordance with IEC 60287 (3 loaded conductors)
(8)			Single-core cables, in cable ducting in the ground.	Buried at 20ºC - 2,5ºK·m/W - 0,7m, calculation criteria in accordance with IEC 60287 (3 loaded conductors)
(9)			Aerial Bundled Cables	In free air at 30ºC, solar radiation exposed, in accordance with UNE 211435
(10)			Aerial Bundled Cables	In free air at 30ºC, solar radiation exposed, calculation criteria in accordance with IEC 60287
(11)		A1	Insulated conductors in conduit in a thermally insulated wall.	In air at 30ºC, in accordance with IEC 60364-5-52, Method A1 (3 loaded conductors)
(12)			Insulated conductors in conduit in a thermally insulated wall.	In air at 30ºC, calculation criteria in accordance with IEC 60287 (3 loaded conductors)
(13)		E	Multi-core cable in free air. Clearance to wall not less than 0.3 times cable diameter.	In air at 30ºC, solar radiation protected, in accordance with IEC 60364-5-52, Method E (2 loaded conductors for 2-core cables and 3 loaded conductors for 3-core, 4-core and 5-core cables)
(14)		D1	Multi-core cable in cable ducting in the ground.	Buried at 20ºC - 2,5ºK·m/W - 0,7m, in accordance with IEC 60364-5-52, Method D1 (2 loaded conductors for 2-core cables and 3 loaded conductors for 3-core, 4-core and 5-core cables)
(15)			Multi-core cable in free air. Clearance to wall not less than 0.3 times cable diameter.	In air at 30ºC, solar radiation protected, calculation criteria in accordance with IEC 60287 (2 loaded conductors for 2-core cables and 3 loaded conductors for 3-core, 4-core and 5-core cables)
(16)			Multi-core cable in cable ducting in the ground.	Buried at 20ºC - 2,5ºK·m/W - 0,7m, calculation criteria in accordance with IEC 60287 (2 loaded conductors for 2-core cables and 3 loaded conductors for 3-core, 4-core and 5-core cables)
(17)		C	Single-core or multi-core cable on a wooden wall.	In air at 30ºC, solar radiation protected, in accordance with IEC 60364-5-52, Method C
(18)			Single-core or multi-core cable on an horizontal surface.	In air at 30ºC, solar radiation protected, in accordance with Cenelec HD 516 S2 Table 7

Derating Factors for different installation conditions : Please contact our Technical Department

BV TWENTSCHE KABELFABRIEK

TWENPOWER

MEDIUM-VOLTAGE XLPE CABLES

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Over the years Twentsche Kabelfabriek (TKF) has built up a wide range of products. In doing so. it has accumulated a wealth of experience with a wide variety of materials. Moreover, by carefully structuring the product range, valuable relationships between various product lines emerged, which could be put to efficient use in developing new products.

Twenpower

Both developments have positively influenced production of the Twenpower medium-voltage cable launched by us in 1981. In 1998 TKF was able to optimize the process management with reference to the Twenpower. The increase in effectivity and quality has been put to use in the development of the Twenpower-opto medium-voltage cables.

Twenpower-opto

The Twenpower-opto is a cable featuring glass fibre(s) integrated in the copper screen. Thanks to the integration of this fibre package, this cable allows for effective cable management. By measuring the temperature and the mechanical tension (and in the near future the detection of moisture beyond a specified limit, as well), information is obtained with reference to the anticipated problems and bottlenecks. In addition, the signals from the protective equipment are more reliable owing to the fact that communication runs through one's own cable.

Turnkey projects

TKF also offers the Twenpower and the Twenpower-opto within the framework of Turnkey projects. They are mainly used in public power distribution, the industry and for special versions. Since their launch, TKF has been accumulating experience in the Turnkey version of highly diverse projects for medium-voltage cables.

Technical standard

Normally, the cables are in accordance with Dutch standard NEN 3620, being consistent with the Cenelec harmonisation documents (in particular, HD 620). Current-carrying capacity has been based on NPR 3626. Delivery according to IEC 60502-2 is ofcourse also possible. The correct voltage rating of the cables is Uo/U (Um), with Um being the maximum system voltage.

Correct voltage rating:

'Designation'	10 kV	15 kV	20 kV	30 kV	50 kV
Uo/U	6/10 kV	8.7/15 kV	12/20 kV	18/30 kV	36/50 kV
(Um)	12 kV	17.5 kV	24 kV	36 kV	72.5 kV

Advantages of Twenpower Medium-voltage Cable

- **Dry vulcanized**
- **Lightweight**
- **High current-carrying capacity**
- **Clean to handle**
- **Low dielectric capacity and loss angle**
- **Longitudinally and quasi-transversally watertight or transversally watertight with the potential bonding wire ®**
- **Resistant to water trees**

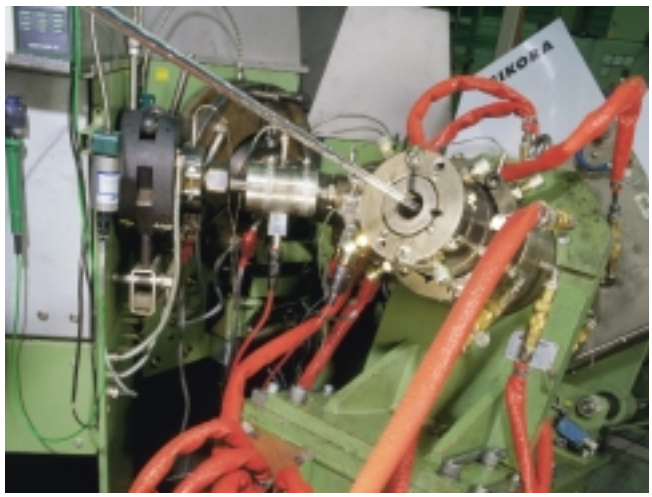
Optional for the Twenpower-opto

- **Cable management using integrated glass fibre(s)**
- **Protective applications**

MATERIALS

The materials used in Twenpower medium-voltage cables ensure excellent properties, both electrically and mechanically, and form a high-quality cable construction when used as elements in integral coherence.

Conductors are circular and made of solid or stranded aluminium, or of stranded copper wires.



Catenary line, three-layer extrusion process using triple-head, finished by a layer thickness check using X-ray

Unloading the insulating material from a hopper immediately above the extruder

On the catenary line the semi-conductive conductor screen, the insulation and the semi-conductive insulation screen are applied in a single three-layer extrusion process at one go. Because vulcanization takes place under nitrogen pressure, the three layers consist of XLPE. In this process, the layer thicknesses are measured individually, to check the thickness and the eccentricity of these layers.

The metallic screen mostly consists of copper wires with a copper counterwound tape to ensure potential bonding. The section of the screen is dictated by the network in which the cable will be used. In view of personal shock protection, the mutual distance between the copper wires has been limited. Should any mechanical cable damage occur, there is a risk of groundwater penetrating the cable.

As a protective measure and to provide a barrier against diffusion of moisture, Dutch standard NEN 3620 specifies cables being longitudinally watertight as the preferred design. This longitudinal watertightness of the screen is ensured by applying semi-conductive swelling fleece under and on top of the copper wires. In combination with the abrasion-resistant PE (ST7) outer sheath, the swelling fleeces also offer a quasi transversal watertightness.
A guaranteed longitudinal and transversal watertightness can only be obtained by applying a closed aluminium complex foil under the PE outer sheath on top of a semi-conductive rubber layer. The potential wire patented by TKF

Permanent monitoring of the process, here by way of visualization of the three-layer system

ensures a contact along the full cable length between the complex foil and the copper wire screen, thus preventing the rubber layer from burning in, should larger short-circuit currents occur.

With three-core cables mechanical protection is provided by a metallic screen consisting of a combination of steel and copper flat wires (or circular wires). The steel wires are galvanized to prevent corrosion.

A red outer sheath of at least 2.5 mm thick provides mechanical protection for the cable when it is being laid and during service. It also protects the metallic screen against corrosion, which can possibly occur as a result of stray currents. Another feature of this sheath is to provide insulation if the metallic sheath is not earthed at either end. The material is a tough, and consequently abrasion-resistant, polyethylene or, for industrial overhead use, a flame-retardant PVC. Alternatively, flame-retardant halogen-free sheath materials (MBZH) can be applied instead.
The sheath carries a markstamp showing such data as the main design characteristics, the supplier, the year of manufacture and a batch number (optional).

Inspections satisfy at least the requirements as laid down in Dutch standard NEN 3620. Besides, a number of additional inspections are carried out at TKF:

- raw material inspection (at TKF or the supplier);
- process inspection (with the use of data collection and trend monitoring);
- finished product inspection (routine test, sample test and type test).

VIEW OF TKF INSPECTION

The medium-voltage cables are - as is true for all other cables produced by TKF - subjected to a comprehensive inspection programme, using various testing techniques. This page gives an impression in pictures of a number of inspection stages.

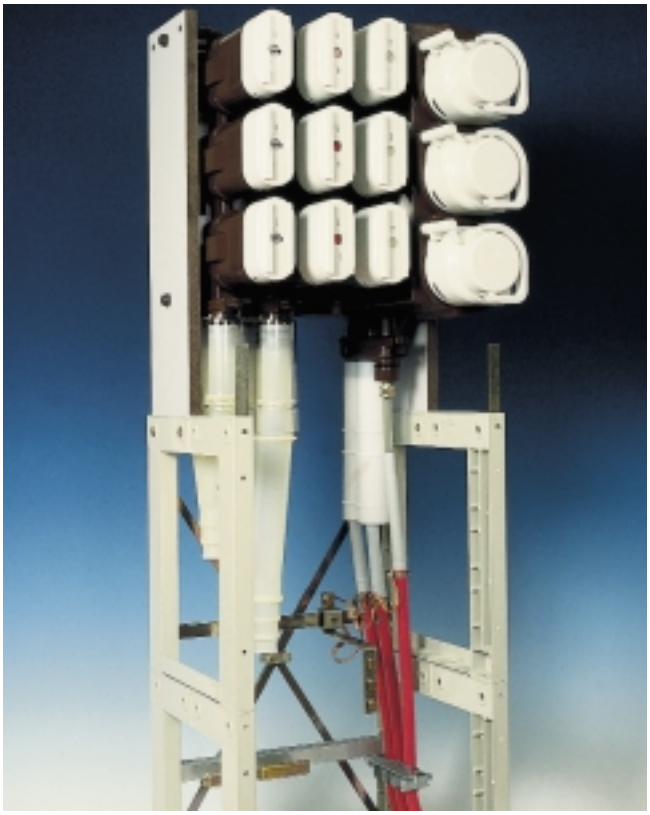
24-hour test: type test of 36/50 kV cable

Mechanical inspection: tensile strength check by means of a tensile strength tester

Increasing the tension in an aged 20 kV cable, often upward of 300 kV, until a disruptive breakdown occurs.

Voltage test and discharge detection in the Faraday cage

Final inspection of medium-voltage cables: conductor resistance check



Twenpower medium-voltage cables pre-terminated to a switchgear

A turnkey project in Eemshaven: fitting of a cable

TWENPOWER VERSIONS

Twenpower medium-voltage XLPE cables are available in various versions, in accordance with specific environmental conditions.

Flame-retardant (mb)
In the event of a fire, there is a risk of the fire spreading through overhead cables. To prevent this from happening, cables can be provided with sheaths made of a flame-retardant material.

Halogen-free (zh)
Halogen-containing materials, such as PVC, can cause highly toxic and corrosive substances to be released in the event of a fire. TKF has developed materials which do not contain any halogens nor heavy metals.

Flame-retardant and halogen-free (mbzh)
Materials which are flame-retardant as well as halogen-free are also some of the possible options.

Chemical resistance
Chemicals are capable of attacking a cable quickly. For instance, if cables are laid in a chemically contaminated environment, Twenpower cables can be provided with additional protection. To this end, TKF can provide cables with a lead sheath. Alternatively, the sheath can be provided with a special chemically resistant coating. This material is capable of resisting a great many chemical substances.

Rodent-resistant
Rodents (such as rats and termites) like to line their nests with materials taken from cables. TKF has the experience required to make sheaths rodent-resistant in order to prevent the cables from being attacked.

UV-resistant
As an option, TKF can supply the red outer sheaths of medium-voltage cables in a version featuring a high degree of resistance to UV radiation.

TURNKEY PROJECTS

The execution of Turnkey cable projects is one of our core activities. TKF is increasingly commissioned to supply power cables within the framework of Turnkey projects. We have focused our organization on meeting these needs, calling upon the various disciplines available within the Twentsche Kabel Holding. In some cases, cooperation is sought with third parties. A list of references may be obtained from our Sales Department.

MINIMUM BENDING RADIUS

MINIMUM BENDING RADIUS (in mm)		
	during laying	installed (once-only)
1-core	12 x (D+d)	10 x (D+d)
1-core with glass fibres	17½ x (D+d)	15 x (D+d)
1-core with lead sheath	15 x (D+d)	75% of 15 x (D+d)
3-core	10 x (D+d)	75% of 10 x (D+d)

D = cable diameter (in mm)
d = conductor diameter (in mm)

MAXIMUM PULLING FORCE

MAXIMUM PULLING FORCE (in N)			
		with the use of a	
		pulling sleeve	pulling head
medium-voltage		KxS	
medium-voltage with lead sheath	U<30 kV	$3xD^2$	KxS
	U≥30 kV	$2xD^2$	

D = cable diameter (in mm)
The factor K for the following conductors is:

Cu	K = 50
Al stranded	K = 30
Al solid	K = 20

S = total surface area of the conductors (in mm^2)

INSTALLATION TEMPERATURE

The minimum installation temperature is 0 ºC, in compliance with the conditions referred to above. This temperature applies to the cable to be installed, not to the ambient temperature. If possible, we recommend that the cable temperature should be raised to ± 5 ºC

MAX. CONDUCTOR RESISTANCE (in Ω/km)				
nominal core c.s.a.* (in mm^2)	Copper conductor		Aluminium conductor	
	DC resistance at 20ºC	AC resistance at 50 Hz and 90ºC	DC resistance at 20ºC	AC resistance at 50 Hz and 90ºC
16	1.15	1.47	-	-
25	0.727	0.927	-	-
35	0.524	0.668	0.868	1.113
50	0.387	0.494	0.641	0.822
70	0.268	0.342	0.443	0.568
95	0.193	0.247	0.320	0.411
120	0.153	0.196	0.253	0.325
150	0.124	0.160	0.206	0.265
185	0.0991	0.128	0.164	0.212
240	0.0754	0.099	0.125	0.162
300	0.0601	0.080	0.100	0.130
400	0.0470	0.065	0.0778	0.103
500	0.0366	0.053	0.0605	0.082
630	0.0283	0.044	0.0469	0.065
800	-	-	0.0367	0.053

*) c.s.a. = cross sectional area

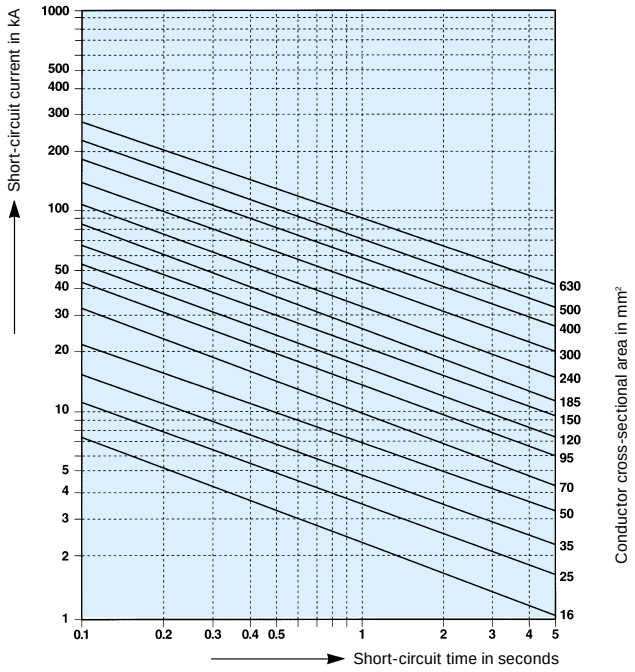
Used abbreviations:

rs	= round stranded copper conductor
Alrm	= round solid aluminium conductor
Alrs	= round stranded aluminium conductor
as	= earthing screen

THERMALLY PERMISSIBLE SHORT-CIRCUIT CURRENTS

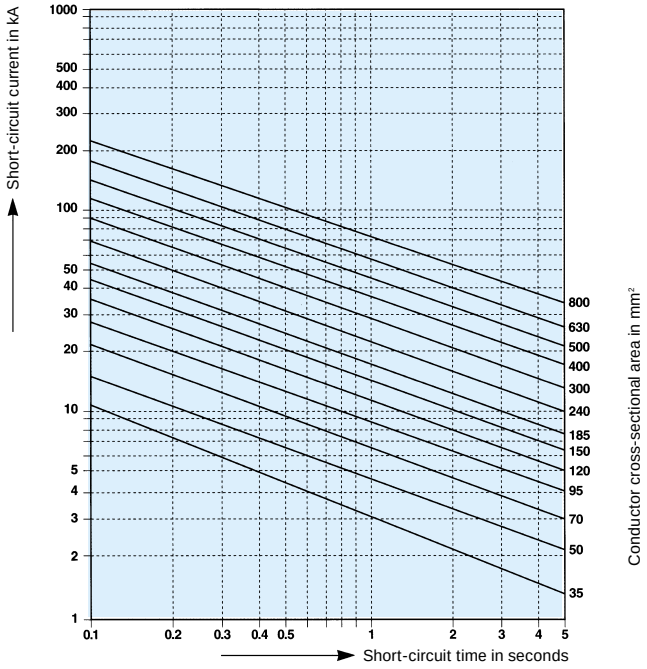
Thermally permissible short-circuit currents for copper conductors, with a final temperature not exceeding 250 ºC, in line with NEN 3620.

$$I_k = \frac{0.143}{\sqrt{t}} .S$$



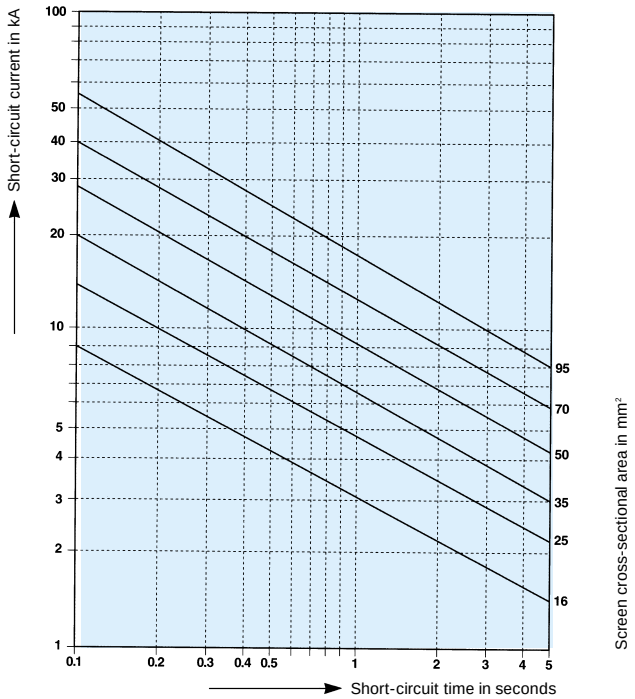
Thermally permissible short-circuit currents for aluminium conductors, with a final temperature not exceeding 250 ºC, in line with NEN 3620.

$$I_k = \frac{0.094}{\sqrt{t}} .S$$



Thermally permissible short-circuit currents of the screen, with a final temperature not exceeding 350 ºC, in line with NEN 3620.

$$I_k = \frac{0.178}{\sqrt{t}} .S$$



The graph alongside has been calculated in line with NEN 3620 for cables with a copper earthing screen only, which is allowed to reach a temperature of 350 ºC. The temperature allowed for an aluminium foil screen is only 160 ºC. Even so, the thermally permissible short-circuit currents for the screen of transversally and longitudinally watertight cables are close to the values applying to copper wire screens. This is caused by the current distribution.

DESIGN OF TWENPOWER SINGLE-CORE MEDIUM-VOLTAGE CABLES

Characteristics
- circular single-core cable
- the conductor screen, the insulation and the insulation screen are applied in a single three-layer extrusion process and vulcanized under nitrogen pressure at one go. The insulation provides, also due to the “dry cross-linking process”, good resistance to water-treeing. It retains, even after ageing, a high electrical strength.
- application: public utilities, industry, non-residential construction and related fields.

Design:

conductor

circular conductor made of stranded copper wires or of solid aluminium. Optionally, an aluminium conductor is also available in a stranded version, for greater flexibility.

conductor screen

semi-conductive polymer layer of at least 0.5 mm thick.

insulation

high-quality XLPE.

insulation screen

semi-conductive polymer layer. This layer is covered by a bedding of conductive swelling tape to ensure longitudinal watertightness.

earthing screen

copper wires with an open pattern counterwound copper strip.

options

longitudinally and quasi transversally watertight design

with a longitudinally and quasi transversally watertight design, swelling tape is applied on top of the earthing screen.

transversally and longitudinally watertight design

with this option, the space between the earthing screen wires is filled with a semi-conductive rubber-based filling sheath. An aluminium foil and a PE sheath are sandwiched on top of the filling sheath, with a copper wire for equipotential bonding to prevent any potential difference between copper screen and aluminium foil.

outer sheath

abrasion-resistant PE (ST7)

options
- armouring of copper flat wire
- lead-sheathed, especially designed for contaminated soils, as found in the petrochemical industry
- designs according to customer specifications.

cable designation

longitudinally and quasi transversally watertight

YMeKrvaslqwd ../.. kV 1 x .. rs+as ..
YMeKrvaslqwd ../.. kV 1 x .. Alrm+as ..
YMeKrvaslqwd ../.. kV 1 x .. Alrs+as ..

transversally and longitudinally watertight

YMeKrvasdlwd ../.. kV 1 x .. rs+as ..
YMeKrvasdlwd ../.. kV 1 x .. Alrm+as ..
YMeKrvasdlwd ../.. kV 1 x .. Alrs+as ..

Twenpower single-core medium-voltage cables rated 6/10 kV with stranded copper conductor.*)									
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 25	16	6.0	14.8	19.7	27	0.8	0.153	0.246	0.22
1 x 35	25	7.1	15.9	20.8	28	1.0	0.144	0.231	0.24
1 x 50	25	8.2	17.0	21.9	29	1.1	0.138	0.224	0.26
1 x 70	25	9.9	18.7	23.6	30	1.4	0.129	0.214	0.30
1 x 95	25	11.5	20.3	25.2	32	1.7	0.123	0.206	0.33
1 x 120	25	13.0	21.8	26.7	34	1.9	0.119	0.200	0.36
1 x 150	25	14.5	23.3	28.2	35	2.2	0.114	0.194	0.39
1 x 185	25	16.1	24.9	29.8	37	2.6	0.111	0.189	0.42
1 x 240	25	18.6	27.4	32.3	39	3.2	0.106	0.182	0.47
1 x 300	25	20.6	29.4	34.3	41	3.7	0.103	0.177	0.51
1 x 400	50	24.0	32.8	37.7	45	4.9	0.099	0.172	0.58
1 x 500	50	27.2	36.0	40.9	48	5.9	0.095	0.166	0.64
1 x 630	50	31.1	39.9	44.8	52	7.3	0.092	0.160	0.72

Twenpower single-core medium-voltage cables rated 6/10 kV with solid aluminium conductor.*)									
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 70	25	9.1	17.9	22.8	30	0.9	0.141	0.226	0.28
1 x 95	25	10.8	19.6	24.5	31	1.0	0.134	0.218	0.31
1 x 120	25	12.1	20.9	25.8	33	1.1	0.130	0.212	0.34
1 x 150	25	13.3	22.1	27.0	34	1.2	0.127	0.207	0.36
1 x 185	25	14.9	23.7	28.6	35	1.4	0.122	0.202	0.40
1 x 240	25	17.1	25.9	30.8	38	1.6	0.118	0.195	0.44
1 x 300	25	19.1	27.9	32.8	40	1.8	0.114	0.190	0.48
1 x 400	50	21.7	30.5	35.4	42	2.3	0.111	0.186	0.53
1 x 500	50	24.6	33.4	38.3	45	2.7	0.107	0.180	0.59
1 x 630	50	27.9	36.7	41.6	48	3.1	0.103	0.174	0.66
1 x 800	50	31.5	40.3	45.2	52	3.7	0.101	0.168	0.73

*) Starting point for the tables is the longitudinally and quasi transversally watertight design.

Twenpower single-core medium-voltage cables rated 8.7/15 kV with stranded copper conductor.*)									
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm^2	mm^2	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 16	16	5.0	16.1	21.0	28	0.8	0.168	0.257	0.16
1 x 25	16	6.0	17.1	22.0	29	0.9	0.159	0.247	0.18
1 x 35	25	7.1	18.2	23.1	30	1.1	0.149	0.232	0.19
1 x 50	25	8.2	19.3	24.2	31	1.2	0.143	0.225	0.21
1 x 70	25	9.9	21.0	25.9	33	1.5	0.134	0.215	0.24
1 x 95	25	11.5	22.6	27.5	34	1.8	0.128	0.207	0.26
1 x 120	25	13.0	24.1	29.0	36	2.0	0.123	0.201	0.28
1 x 150	25	14.5	25.6	30.5	37	2.3	0.118	0.195	0.31
1 x 185	25	16.1	27.2	32.1	39	2.7	0.114	0.190	0.33
1 x 240	25	18.6	29.7	34.6	41	3.3	0.109	0.183	0.37
1 x 300	25	20.6	31.7	36.6	43	3.9	0.106	0.178	0.40
1 x 400	50	24.0	35.1	40.0	47	5.0	0.102	0.174	0.45
1 x 500	50	27.2	38.3	43.2	50	6.1	0.098	0.168	0.50
1 x 630	50	31.1	42.2	47.1	54	7.5	0.095	0.161	0.56

Twenpower single-core medium-voltage cables rated 8.7/15 kV with solid aluminium conductor.*)									
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm^2	mm^2	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 70	25	9.1	20.2	25.1	32	1.0	0.146	0.228	0.22
1 x 95	25	10.8	21.9	26.8	34	1.1	0.139	0.219	0.25
1 x 120	25	12.1	23.2	28.1	35	1.2	0.134	0.213	0.27
1 x 150	25	13.3	24.4	29.3	36	1.3	0.131	0.209	0.29
1 x 185	25	14.9	26.0	30.9	38	1.5	0.126	0.203	0.31
1 x 240	25	17.1	28.2	33.1	40	1.7	0.121	0.196	0.35
1 x 300	25	19.1	30.2	35.1	42	1.9	0.118	0.191	0.38
1 x 400	50	21.7	32.8	37.7	45	2.4	0.114	0.188	0.42
1 x 500	50	24.6	35.7	40.6	47	2.8	0.110	0.181	0.46
1 x 630	50	27.9	39.0	43.9	51	3.3	0.107	0.175	0.51
1 x 800	50	31.5	42.6	47.5	55	3.9	0.104	0.170	0.56

*) Starting point for the tables is the longitudinally and quasi transversally watertight design.

Twenpower single-core medium-voltage cables rated 12/20 kV with stranded copper conductor.*)

nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 25	16	6.0	19.3	24.2	31	1.0	0.163	0.248	0.15
1 x 35	25	7.1	20.4	25.3	32	1.2	0.153	0.234	0.17
1 x 50	25	8.2	21.5	26.4	33	1.3	0.147	0.226	0.18
1 x 70	25	9.9	23.2	28.1	35	1.6	0.138	0.216	0.20
1 x 95	25	11.5	24.8	29.7	37	1.9	0.131	0.208	0.22
1 x 120	25	13.0	26.3	31.2	38	2.1	0.126	0.202	0.24
1 x 150	25	14.5	27.8	32.7	40	2.4	0.122	0.196	0.26
1 x 185	25	16.1	29.4	34.3	41	2.8	0.118	0.191	0.28
1 x 240	25	18.6	31.9	36.8	44	3.4	0.112	0.184	0.31
1 x 300	25	20.6	33.9	38.8	46	4.0	0.109	0.179	0.34
1 x 400	50	24.0	37.3	42.2	49	5.2	0.105	0.175	0.38
1 x 500	50	27.2	40.5	45.4	53	6.3	0.101	0.169	0.42
1 x 630	50	31.1	44.4	49.3	57	7.7	0.097	0.162	0.47

Twenpower single-core medium-voltage cables rated 12/20 kV with solid aluminium conductor.*)

nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 95	25	10.8	24.1	29.0	36	1.2	0.143	0.220	0.22
1 x 120	25	12.1	25.4	30.3	37	1.3	0.138	0.214	0.23
1 x 150	25	13.3	26.6	31.5	38	1.4	0.134	0.210	0.25
1 x 185	25	14.9	28.2	33.1	40	1.6	0.130	0.204	0.27
1 x 240	25	17.1	30.4	35.3	42	1.8	0.124	0.197	0.29
1 x 300	25	19.1	32.4	37.3	44	2.0	0.121	0.192	0.32
1 x 400	50	21.7	35.0	39.9	47	2.6	0.117	0.189	0.35
1 x 500	50	24.6	37.9	42.8	50	3.0	0.113	0.183	0.39
1 x 630	50	27.9	41.2	46.1	53	3.5	0.109	0.177	0.43
1 x 800	50	31.5	44.8	49.7	57	4.1	0.106	0.171	0.47

*) Starting point for the tables is the longitudinally and quasi transversally watertight design.

Twenpower single-core medium-voltage cables rated 18/30 kV with stranded copper conductor.*)

nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 35	25	7.1	25.7	30.6	37	1.4	0.162	0.236	0.13
1 x 50	25	8.2	26.8	31.7	39	1.6	0.156	0.229	0.14
1 x 70	25	9.9	28.5	33.4	40	1.8	0.146	0.219	0.16
1 x 95	25	11.5	30.1	35.0	42	2.1	0.140	0.211	0.17
1 x 120	25	13.0	31.6	36.5	43	2.4	0.134	0.205	0.18
1 x 150	25	14.5	33.1	38.0	45	2.7	0.129	0.199	0.20
1 x 185	25	16.1	34.7	39.6	46	3.1	0.125	0.194	0.21
1 x 240	25	18.6	37.2	42.1	49	3.8	0.120	0.187	0.23
1 x 300	25	20.6	39.2	44.1	51	4.3	0.116	0.182	0.25
1 x 400	50	24.0	42.6	47.5	55	5.6	0.112	0.178	0.28
1 x 500	50	27.2	45.8	50.7	58	6.7	0.108	0.172	0.30
1 x 630	50	31.1	49.7	54.6	62	8.1	0.103	0.165	0.34

Twenpower single-core medium-voltage cables rated 18/30 kV with solid aluminium conductor.*)

nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 120	25	12.1	30.7	35.6	42	1.6	0.146	0.217	0.18
1 x 150	25	13.3	31.9	36.8	44	1.7	0.142	0.212	0.19
1 x 185	25	14.9	33.5	38.4	45	1.9	0.137	0.207	0.20
1 x 240	25	17.1	35.7	40.6	47	2.1	0.132	0.200	0.22
1 x 300	25	19.1	37.7	42.6	49	2.4	0.128	0.195	0.24
1 x 400	50	21.7	40.3	45.2	52	3.0	0.124	0.192	0.26
1 x 500	50	24.6	43.2	48.1	55	3.4	0.120	0.186	0.28
1 x 630	50	27.9	46.5	51.4	59	3.9	0.116	0.179	0.31
1 x 800	50	31.5	50.1	55.0	63	4.5	0.112	0.174	0.34

Twenpower single-core medium-voltage cables rated 36/50 kV with solid aluminium conductor.*)

nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)		capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable		trefoil	flat	
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	Ω/km	µF/km
1 x 240	95	17.1	42.0	46.9	54	3.3	0.124	0.160	0.17
1 x 300	95	19.1	44.0	48.9	56	3.5	0.122	0.159	0.19
1 x 400	95	21.7	46.6	51.5	59	3.9	0.132	0.195	0.20
1 x 500	95	24.6	49.5	54.4	62	4.4	0.127	0.189	0.22
1 x 630	95	27.9	52.8	57.7	66	4.9	0.123	0.183	0.24

*) Starting point for the tables is the longitudinally and quasi transversally watertight design.

Effective Cable Management

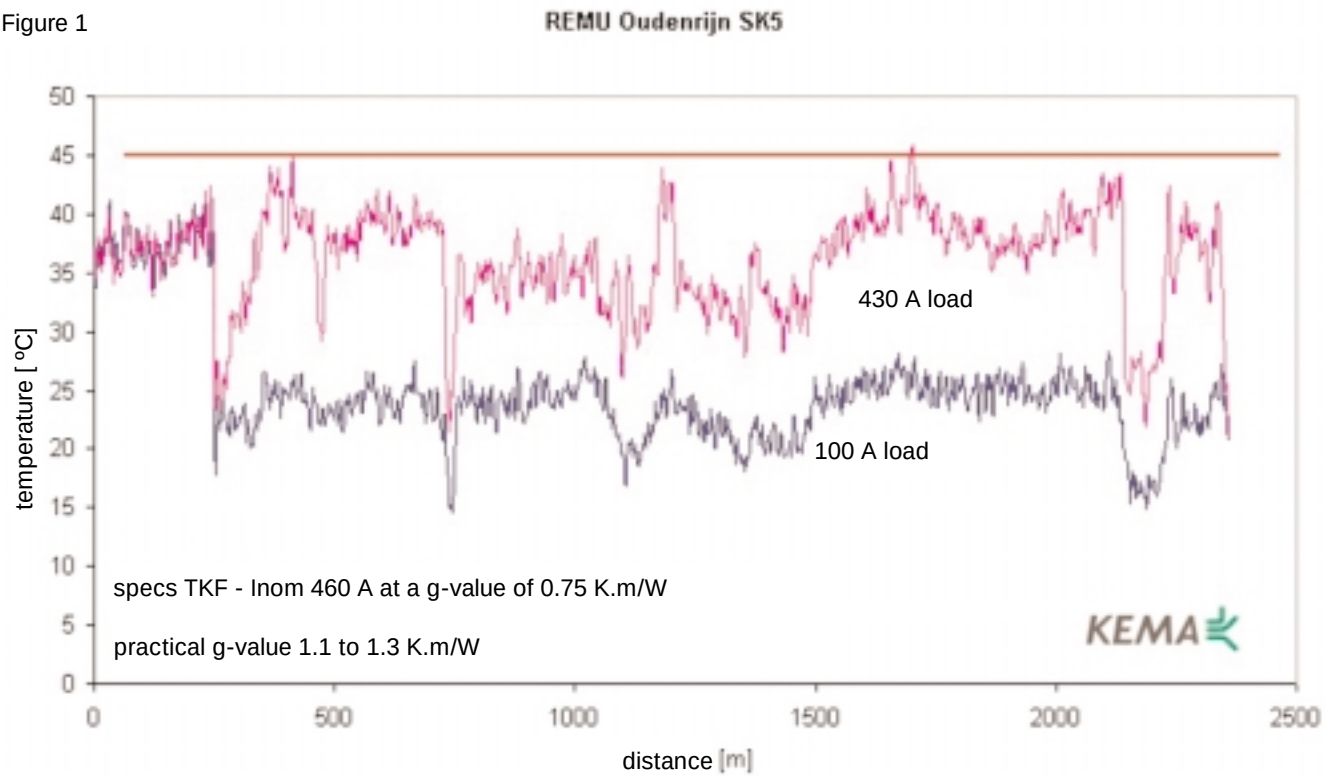
The Twenpower-opto medium-voltage cable can be described as an informative ‘auxiliary line’ for effective cable management (dynamic cable management). This is because this cable is fitted with glass fibres which act as optical sensors.

The application of these optical sensors makes it possible to intentionally load the medium-voltage cable to its limits. An added advantage is that any information about bottlenecks and any possible damage which may reduce the service life of the connection is quickly available. The sensors integrated into the earthing screen allow for accurate measurements and tracing of, among other things, temperature, moisture and mechanical tension in the cable. The measurements, the interpretation of the measuring results and the resultant reports are carried out by KEMA TDP.

Temperature Monitoring

The “Loose Tube” sensor and the available equipment allow - in section lengths up to 30 km - for temperatures and temperature variations to be determined with an accuracy of approx. 2 ºC. The locating capacity is approximately two metres. This way it is possible to determine the maximum (dynamic) load capability of the connection at any given moment, in which bottlenecks such as drillings, transitions in soil type, hot spots and cable connections that lie (partially) parallel are shown clearly. Figure 1 shows the temperature curve in the earthing screen of a YMeKrvaslwd 6/10 kV 1 x400Alrm+ as70+ 2xSM cable along the length of a connection at two different loads. At a 100A load the temperature profile is reasonably flat and the biggest temperature difference is 14 ºC. At a 430A load the temperature profile is far more irregular: the biggest temperature difference is 23 ºC and there is possibly at approx. 2/3 of the connection a bottleneck. Whether these are indeed bottlenecks depends on the soil conditions at the highest peaks.

Figure 1



Compressive and tensile stresses

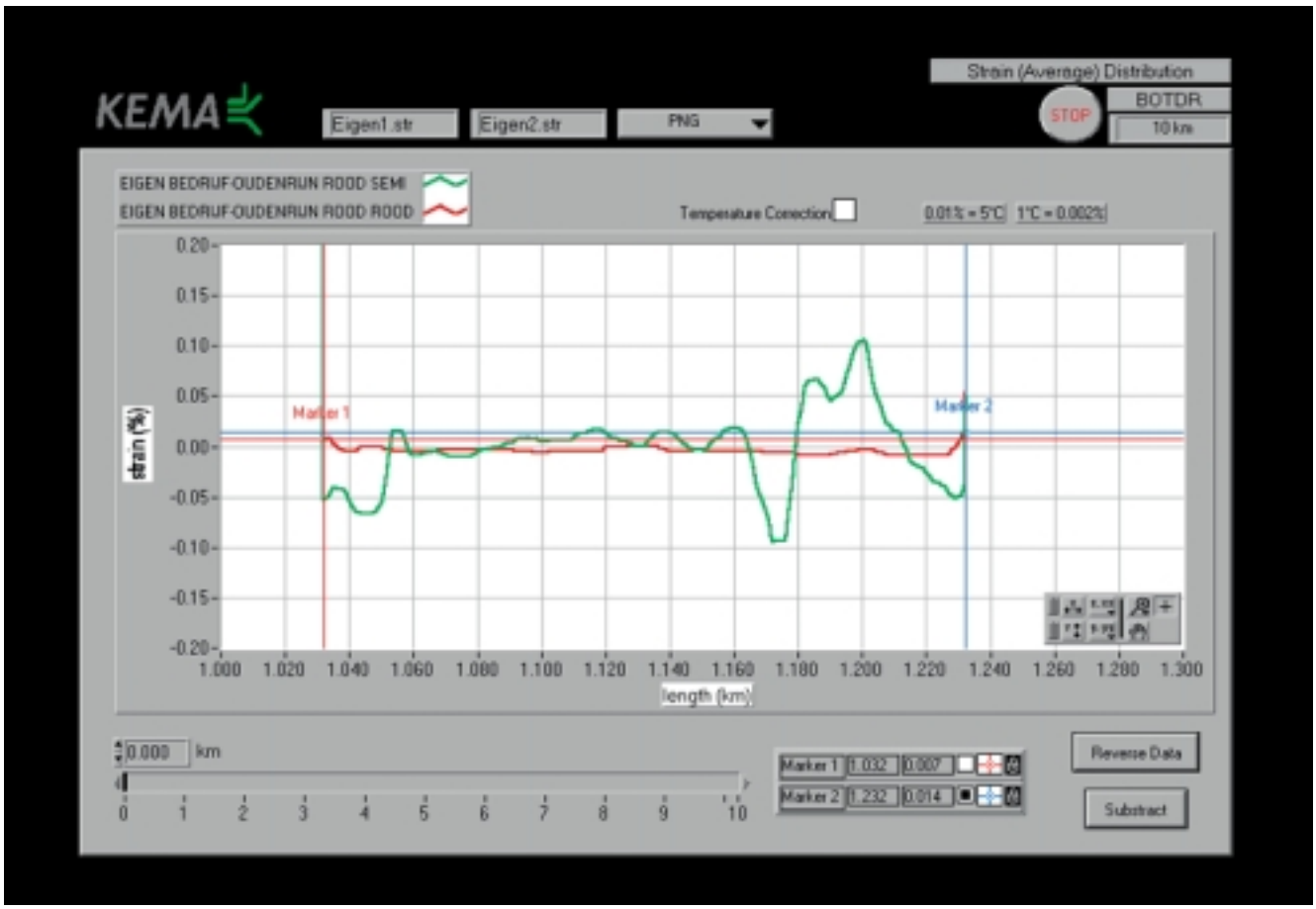
When installing the cable connection, but also at a later stage, due to e.g. ground settlements, excavation work or breaking down of the verge, compressive and/or tensile stresses may occur. The ‘Buffered tight’ sensor and the Brillouin Optical Time Domain Reflectometer (BOTDR) equipment can be used to measure the degree of upsetting or strain with a locating capacity of 8 metres. Figure 2 shows such a measurement. The green line indicates the compressive and tensile stresses in the ‘Buffered tight’ sensor. It is striking that the introduction into both stations has taken quite an effort. The red line shows that there is no mechanical tension present in the ‘Loose tube’ sensor.

Penetration of moisture

There where earthwork does indeed result in sheath damage, but not in mechanical tension, the ingress of moisture may well considerably reduce the service life of the cable section concerned.
A moisture-sensitive sensor provides an indication, which also gives information about the length along which the moisture has penetrated. With the help of these measurement data, it is possible to find out the cause and schedule a repair. Expectations are that this technology will be developed to a sufficient extent at the middle of the year 2001 in order to be applied in actual practice.

The development of optical sensors integrated into medium-voltage cables does not stop here. We are looking forward to taking up new challenges together with you.

Figure 2



DESIGN OF TWENPOWER OPTO SINGLE-CORE MEDIUM-VOLTAGE CABLES

Characteristics:
- circular single-core cable
- the conductor screen, the insulation and the insulation screen are applied in a single three-layer extrusion process and vulcanized under nitrogen pressure at one go. The insulation provides, also due to the “dry cross-linking process”, good resistance to water-treeing and retains, even after ageing, a high electrical strength;
- application: public utilities, industry, non-residential construction and related fields.

Design

conductor

circular conductor made of stranded copper wires or of solid aluminium. Optionally, an aluminium conductor is also available in a stranded version, for greater flexibility.

conductor screen

semi-conductive polymer layer of at least 0.5 mm thick.

insulation

high-quality XLPE

insulation screen

semi-conductive polymer layer. This layer is covered by a bedding of conductive swelling tape to ensure longitudinal watertightness.

earthing screen

copper wires, glass fibres, with an open pattern counterwound copper strip. The glass fibres have a monitoring function. They are protected by means of a special tube made of a high-quality material.

options

longitudinally and quasi transversally watertight design
with a longitudinally and quasi transversally watertight design, swelling tape is applied on top of the earthing screen.

transversally and longitudinally watertight design
with this option, the space between the earthing screen wires and the glass fibres is filled with a semi-conductive rubber-based filling sheath. An aluminium foil and a PE sheath are sandwiched on top of the filling sheath, with a copper wire for equipotential bonding to prevent any potential difference between copper screen and aluminium foil.

outer sheath

abrasion-resistant PE (ST7)

options
- armouring of copper flat wire;
- lead-sheathed, especially designed for contaminated soils, as found in the petrochemical industry;
- designs according to customer specifications.

cable designation

Longitudinally and quasi transversally watertight
YMeKrvaslqwd ../.. kV 1 x .. rs+as ..+ .. x SM
YMeKrvaslqwd ../.. kV 1 x .. Alrm+as .. + .. x SM
YMeKrvaslqwd ../.. kV 1 x .. Alrs+as .. + .. x SM

Transversally and longitudinally watertight
YMeKrvasdlwd ../.. kV 1 x ..rs+as .. + .. x SM
YMeKrvasdlwd ../.. kV 1 x .. Alrm+as .. + .. x SM
YMeKrvasdlwd ../.. kV 1 x .. Alrs+as ..+ .. x SM

Continuous current rating of underground or overhead single-core cables.

nominal core cross-sectional area	earthing of metallic screens	continuous current rating (in A) of 1-core copper and aluminium cable 10-30 kV							
		underground				overhead			
		trefoil		flat		trefoil		flat	
mm²		Cu	Al	Cu	Al	Cu	Al	Cu	Al
16		105	-	120	-	125	-	150	-
25		135	-	150	-	160	-	195	-
35		165	125	175	135	195	155	235	180
50	at either end	190	150	205	160	235	185	280	220
70		235	180	245	195	295	230	350	270
95		280	215	290	230	355	280	425	330
120		315	245	325	260	410	320	485	380
150		350	275	360	285	465	365	550	430
185		395	310	400	320	535	420	925	495
240		455	355	455	365	630	495	730	580
300		510	400	505	410	720	565	825	660
400		560	450	515	435	825	660	880	735
500		630	510	560	480	940	765	985	835
630		700	575	615	530	1070	880	1095	940
800		-	640	-	580	-	1010	-	1055
400	at one end	585	460	635	495	850	675	1050	825
500		655	520	715	565	980	780	1220	965
630		735	590	810	645	1120	910	1415	1125
800		-	665	-	725	-	1045	-	1310

The continuous current rating applies to the following conditions, in line with NPR 3626:

UNDERGROUND

- The soil temperature is 15 ºC;
- The conductor temperature is 90 ºC, max.;
- The depth of laying ranges between 0.8 m and 1.2 m;
- The thermal resistivity of soil (g) is 0.75 K.m/W;
- There is no interference from other heat sources. If they are, however, less than 1 m away horizontally, interference is most likely to occur and the current-carrying capacity should be calculated according to IEC 60287;
- The trefoil configuration is based on:
  - earthing at either end for conductor cross-sectional areas up to 400 mm²;
  - earthing at one end for conductor cross-sectional areas from 400 mm² upwards;
- Calculations for cables laid in a flat formation are based on:
  - transposed cable, earthed at either end, up to 400 mm²;
  - earthing at one end or cross-bonded earthing screens from 400 mm² upwards.
- Cable spacing of 70 mm.

In calculating the current-carrying capacities, allowance has been made for drying-out of the soil. Calculations are based on the double-shell model, starting from the 30 ºC critical isotherm. This fully complies with NPR 3626.*)
For different soil temperatures, for multiple cables running parallel, for different thermal resistivity of soil and for certain groundwater levels, refer to Tables 1, 2 and 3, respectively.

OVERHEAD

- The air temperature is 30 ºC;
- The conductor temperature is 90 ºC, max.;
- The cable is routed freely in air, which means that:
  - the area in which it is installed, should be sufficiently large, or it should be ventilated;
  - the cables are protected from direct solar radiation or radiation from other heat sources;
  - the distance between the cable perimeter and a wall, floor, etc. should at least be 0.3 times the cable outer diameter;
  - if the cables are laid on racks one above the other, these racks should be spaced at 20 cm as a minimum;
  - if the cables are laid in a flat formation on racks or one above the other along a wall, the spacing between the cables should at least equal the diameter of the thickest cable;
  - the racks are open; they are, for instance, made of perforated plate.
- The cables are laid in a flat formation, spacing between the cables should at least equal the cable diameter.

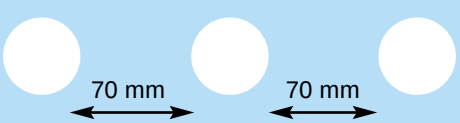
For different air temperatures, refer to Table 4.

*) Another starting point sometimes adopted is the criterion that the sheath temperature must not exceed 45 ºC.
The values related to that calculation will generally be somewhat higher.

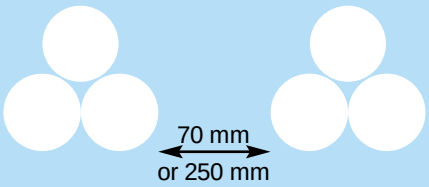
Table 1: Correction factors for different soil temperatures

Soil temperature in ºC	5	10	15	20	25
Correction factor	1.14	1.07	1.00	0.92	0.83

Table 2: Correction factors for different thermal resistivities of soil and/or parallel circuits of single-core cables.



cables in flat formation



cables in trefoil

g	number of parallel cable circuits							
	cables in flat formation			cables in trefoil				
	1	2	3	1	2		3	
					spacing in mm			
K.m/W					70	250	70	250
0.5	1.11	0.89	0.79	1.11	0.87	0.93	0.75	0.82
0.75	1.00	0.80	0.71	1.00	0.78	0.84	0.68	0.74
1.0	0.94	0.76	0.67	0.94	0.74	0.79	0.64	0.70
1.2	0.91	0.73	0.65	0.91	0.71	0.77	0.62	0.68
1.5	0.88	0.70	0.62	0.88	0.69	0.73	0.59	0.65

NOTE: This table is valid for a soil temperature of 15 ºC only. The correction factors have been determined using the double-shell model, starting from the 30 ºC critical isotherm.

Table 3: Correction factors depending on the groundwater level, soil temperature and thermal resistivity of soil (g) for single-core cables.

Groundwater level, in metres	2	3	4	5	
Correction factor	1.10	1.04	1.00	0.99	
Soil temperature, in ºC	5	10	15	20	25
Correction factor for trefoil formation	1.13	1.08	1.00	0.95	0.88
Correction factor for flat formation	1.12	1.06	1.00	0.92	0.85
Thermal resistivity of soil (g) in K.m/W		0.75	1.0	1.2	1.5
Correction factor		1.00	0.95	0.92	0.90

NOTE: The correction factors may be cumulated for different situations and they apply to a single circuit.

Note: Unlike the reduction factors shown in tables 1 and 2, which apply to the 30 ºC fixed isotherm, the critical isotherm for this table has been calculated depending on the groundwater level, the soil temperature and the thermal resistivity of soil. The isotherm calculated for these cases varies from 25 to 50 ºC.

Table 4: Correction factors for different air temperatures*)

Air temperature, in ºC	15	20	25	30	35	40
Correction factor	1.14	1.10	1.05	1.00	0.95	0.90

*) The correction factors also apply to several circuits under the conditions specified in NPR 3626 4.1.

TWENPOWER THREE-CORE CABLES

DESIGN OF TWENPOWER THREE-CORE MEDIUM-VOLTAGE CABLES

Characteristics:
- three circular cores, copper conductor, armoured, longitudinally watertight to a limited extent, flame-retardant PVC outer sheath.
- the conductor screen, the insulation and the insulation screen are applied in a single three-layer extrusion process and vulcanized under nitrogen pressure at one go. The insulation provides, also due to the “dry cross-linking process”, good resistance to water-treeing and retains, even after ageing, a high electrical strength;
- application: industry, non-residential construction and related fields.

Design:

conductors
circular conductors made up of copper wires (compacted).

conductor screen
semi-conductive polymer layer of at least 0.5 mm thick.

insulation
high-quality XLPE

insulation screen
semi-conductive polymer layer. This layer is covered by a bedding of conductive swelling tape to ensure longitudinal watertightness.

earthing screen
copper foil on each core for capacitive loading current in a bedding of conductive (swelling) tape.

filling
interspaces between the three cores are filled to create a circular bedding for further construction.
Rubber-based filling.

inner sheath
PVC

armouring
steel wires + copper wires for short-circuit current (in most cases 50 mm^2 copper wire).

outer sheath
flame-retardant PVC.

options
- lead sheath, especially designed for contaminated soils, as found in the petrochemical industry.
- flame-retardant, halogen-free version

cable designation
VG-YMvKrvasmb ../.. kV 3 x .. rs+as ..

Characteristics of Twenpower three-core medium-voltage cables rated 6/10 kV								
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)	capacitance (at 50 Hz)
		conductor	insulation	armouring	cable			
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	µF/km
3 x 16	16	5.0	13.8	44.2	51	4.4	0.135	0.19
3 x 25	25	6.0	14.8	46.5	53	5.0	0.127	0.21
3 x 35	25	7.1	15.9	49.0	56	5.6	0.101	0.23
3 x 50	50	8.2	17.0	51.6	59	6.5	0.115	0.25
3 x 70	50	9.9	18.7	55.7	63	7.7	0.109	0.29
3 x 95	50	11.5	20.3	59.3	67	8.9	0.104	0.32
3 x 120	50	13.0	21.8	62.8	71	10.2	0.100	0.35
3 x 150	50	14.5	23.3	66.4	75	11.7	0.097	0.38
3 x 185	50	16.1	24.9	70.0	79	13.2	0.094	0.41
3 x 240	50	18.6	27.4	75.8	85	15.8	0.091	0.46

Characteristics of Twenpower three-core medium-voltage cables rated 8.7/15 kV								
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)	capacitance (at 50 Hz)
		conductor	insulation	armouring	cable			
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	µF/km
3 x 16	16	5.0	16.1	49.7	57	5.3	0.143	0.16
3 x 25	25	6.0	17.1	51.9	59	5.9	0.135	0.17
3 x 35	25	7.1	18.2	54.4	62	6.5	0.128	0.19
3 x 50	50	8.2	19.3	57.1	65	7.4	0.122	0.20
3 x 70	50	9.9	21.0	61.1	69	8.7	0.115	0.23
3 x 95	50	11.5	22.6	64.7	73	10.0	0.110	0.25
3 x 120	50	13.0	24.1	68.3	77	11.3	0.106	0.28
3 x 150	50	14.5	25.6	71.9	81	13.0	0.103	0.30
3 x 185	50	16.1	27.2	75.4	85	14.4	0.099	0.32
3 x 240	50	18.6	29.6	81.3	91	17.1	0.095	0.36

Characteristics of Twenpower three-core medium-voltage cables rated 12/20 kV								
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)	capacitance (at 50 Hz)
		conductor	insulation	armouring	cable			
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	µF/km
3 x 25	25	6.0	19.3	56.9	65	6.7	0.142	0.15
3 x 35	25	7.1	20.4	59.4	67	7.4	0.135	0.16
3 x 50	50	8.2	21.5	62.1	70	8.4	0.128	0.18
3 x 70	50	9.9	23.2	66.1	74	9.6	0.120	0.20
3 x 95	50	11.5	24.8	69.7	78	11.0	0.114	0.22
3 x 120	50	13.0	26.3	73.2	82	12.4	0.110	0.24
3 x 150	50	14.5	27.8	76.8	86	13.9	0.106	0.25
3 x 185	50	16.1	29.4	80.4	90	15.6	0.103	0.27

Characteristics of Twenpower three-core medium-voltage cables rated 18/30 kV								
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)	capacitance (at 50 Hz)
		conductor	insulation	armouring	cable			
mm²	mm²	mm	mm	mm	mm	kg/m	Ω/km	µF/km
3 x 35	25	7.1	25.7	71.9	81	10.0	0.148	0.13
3 x 50	50	8.2	26.8	74.4	83	10.9	0.141	0.14
3 x 70	50	9.9	28.5	78.4	88	12.3	0.132	0.15
3 x 95	50	11.5	30.1	82.2	92	13.8	0.126	0.17
3 x 120	50	13.0	31.6	85.6	96	15.3	0.122	0.18
3 x 150	50	14.5	33.1	89.1	99	16.9	0.117	0.19

Continuous current rating of underground or overhead three-core cables.

nominal core c.s.a.	continuous current rating (in A) of three-core cable with Cu conductor. 10-30 kV	
mm^2	underground	overhead
16	105	115
25	135	145
35	160	175
50	185	210
70	225	260
95	270	315
120	300	360
150	335	410
185	380	460
240	435	540

The continuous current rating applies to the following conditions, in line with NPR 3626:

UNDERGROUND

- The soil temperature is 15 ºC;
- The conductor temperature is 90 ºC, max.;
- The depth of laying ranges between 0.8 m and 1.2 m;
- The thermal resistivity of soil (g) is 0.75 K.m/W;
- There is no interference from other heat sources. If they are, however, less than 1 m away horizontally, interference is most likely to occur and the current-carrying capacity should be calculated according to IEC 60287;
- The cables are earthed at either end.

In calculating the current-carrying capacity, allowance has been made for drying-out of the soil. Calculations are based on the double-shell model, starting from the 30 ºC critical isotherm. This fully complies with NPR 3626.*)
For different soil temperatures, for multiple cables running parallel, for different thermal resistivity of soil and for certain groundwater levels, refer to Tables 5, 6 and 7, respectively.

*) Another starting point sometimes adopted is the criterion that the sheath temperature must not exceed 45 ºC.
The values related to that calculation will generally be somewhat higher.

OVERHEAD

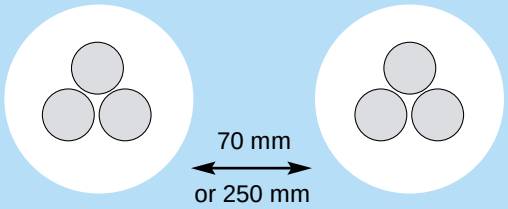
- The air temperature is 30 ºC;
- The conductor temperature is 90 ºC, max.;
- The cable is routed freely in air, which means that: the area in which it is installed, should be sufficiently large, or it should be ventilated;
- the cables are protected from direct solar radiation or radiation from other heat sources;
- the distance between the cable perimeter and a wall, floor, etc. should at least be 0.3 times the cable outer diameter;
- if the cables are laid on racks one above the other, these racks should be spaced at 20 cm as a minimum;
- if the cables are laid in a flat formation on racks or one above the other along a wall, the spacing between the cables should at least equal the diameter of the thickest cable;
- the racks are open; they are, for instance, made of perforated plate.

For different air temperatures, refer to Table 8.

Table 5: Correction factors for different soil temperatures

Soil temperature, in ºC	5	10	15	20	25
Correction factor	1.14	1.07	1.00	0.92	0.83

Table 6: Correction factors for different thermal resistivities of soil and/or parallel circuits of cable.



	number of parallel cable circuits				
g	1	2		3	
		spacing in mm			
K.m/W		70	250	70	250
0.5	1.11	0.87	0.93	0.75	0.82
0.75	1.00	0.78	0.83	0.68	0.74
1.0	0.94	0.74	0.79	0.64	0.70
1.2	0.91	0.71	0.77	0.62	0.68
1.5	0.88	0.69	0.73	0.59	0.65

NOTE: This table is valid for a soil temperature of 15 ºC only. The correction factors have been determined using the double-shell model, starting from the 30 ºC critical isotherm.

Table 7: Correction factors depending on the groundwater level, soil temperature and thermal resistivity of soil (g) for three-core cables.

Groundwater level, in metres	2	3	4	5	
Correction factor	1.10	1.04	1.00	0.99	
Soil temperature. in ºC	5	10	15	20	25
Correction factor	1.12	1.06	1.00	0.94	0.88
Thermal resistivity of soil (g) in K.m/W		0.75	1.0	1.2	1.5
Correction factor		1.00	0.95	0.92	0.90

Note: Unlike the reduction factors shown in tables 5 and 6, which apply to the 30 ºC fixed isotherm, the critical isotherm for this table has been calculated depending on the groundwater level, the soil temperature and the thermal resistivity of soil. The isotherm calculated for these cases varies from 25 to 50 ºC.

Table 8: Correction factors for different air temperatures*)

Air temperature, in ºC	15	20	25	30	35	40
Correction factor	1.14	1.10	1.05	1.00	0.95	0.90

*) The correction factors also apply to several circuits under the conditions specified in NPR 3626 4.1.

TWENPOWER KUDI THREE-CORE CABLES

DESIGN OF TWENPOWER THREE-CORE DISTRIBUTION CABLES

Characteristics:
- three circular cores with solid aluminium conductors, unarmoured, longitudinally and quasi transversally watertight, PE outer sheath.
- the conductor screen, the insulation and the insulation screen are applied in a single three-layer extrusion process and vulcanized under nitrogen pressure at one go. The insulation provides, also due to the “dry cross-linking process”, good resistance to water-treeing and retains, even after ageing, a high electrical strength.
- application: industry, non-residential construction and related fields.

Design:

conductors
circular conductors made of solid aluminium.

conductor screen
semi-conductive polymer layer of at least 0.5 mm thick.

insulation
high-quality XLPE

insulation screen
semi-conductive polymer layer. This layer is covered by a bedding of conductive swelling tape to ensure longitudinal watertightness.

filling
interspaces between the three cores are filled with rubber filling wires. This layer is covered by a bedding of conductive swelling tape to ensure longitudinal watertightness.

earthing screen
copper wires with an open pattern counterwound copper strip. This layer is covered by a bedding of swelling tape to ensure longitudinal watertightness.

outer sheath
abrasion-resistant PE (ST7)

cable designation
YMeKrvaslqwd ../.. kV 3 x ..Alrm+as ..

Twenpower three-core distribution cables are available with glass fibre in the core as an option. This optical sensor is designed for temperature monitoring,
see page 15.

Continuous current rating of underground or overhead three-core cables

Characteristics of Twenpower distribution cables								
nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight	reactance (at 50 Hz)	capacitance (at 50 Hz)
		conductor	insulation	earthing screen	cable			
mm^2	mm	mm	mm	mm	mm	kg/m	Ω/km	µF/km
6/10 kV								
3 x 95	70	10.8	19.2	50.0	57	3.6	0.102	0.32
3 x 150	70	13.3	21.7	53.5	60	4.4	0.093	0.37
3 x 240	70	17.1	25.5	63.0	69	5.8	0.089	0.45
12/20 kV								
3 x 240	70	17.1	29.7	70.3	78	7.1	0.098	0.30

Continuous current rating of underground or overhead three-core cables

nominal core c.s.a.	continuous current rating (in A) of three-core plastic distribution cable with Al conductor 10-20 kV	
mm^2	underground	overhead
95	215	250
150	280	330
240	360	455

UNDERGROUND

- The soil temperature is 15 ºC;
- The conductor temperature is 90 ºC, max.;
- The depth of laying ranges between 0.8 m and 1.2 m;
- The thermal resistivity of soil (g) is 0.75 K.m/W;
- There is no interference from other heat sources. If they are, however, less than 1 m away horizontally, interference is most likely to occur and the current-carrying capacity should be calculated according to IEC 60287;
- The cables are earthed at either end.

In calculating the current-carrying capacity, allowance has been made for drying-out of the soil. Calculations are based on the double-shell model, starting from the 30 ºC critical isotherm. This fully complies with NPR 3626.*)
For different soil temperatures, for multiple cables running parallel, for different thermal resistivity of soil and for certain groundwater levels, refer to Tables 5, 6 and 7, respectively.

*) Another starting point sometimes adopted is the criterion that the sheath temperature must not exceed 45 ºC.
The values related to that calculation will generally be somewhat higher.

OVERHEAD

- The air temperature is 30 ºC;
- The conductor temperature is 90 ºC, max.;
- The cable is routed freely in air, which means that:
  - the area in which it is installed, should be sufficiently large, or it should be ventilated;
  - the cables are protected from direct solar radiation or radiation from other heat sources;
  - the distance between the cable perimeter and a wall, floor, etc. should at least be 0.3 times the cable outer diameter;
  - if the cables are laid on racks one above the other, these racks should be spaced at 20 cm as a minimum;
  - if the cables are laid in a flat formation on racks or one above the other along a wall, the spacing between the cables should at least equal the diameter of the thickest cable;
  - the racks are open; they are, for instance, made of perforated plate.

For different air temperatures, refer to Table 8.

TRANSFORMER CONNECTION CABLE

Characteristics:
- easy to install thanks to a strippable insulation screen.
- single-core flexible cable, circular stranded copper conductor, strippable insulation screen, flame-retardant PVC sheath for overhead cables (flexible PE sheath (LLDPE) for underground cables).
- the conductor screen, the insulation and the insulation screen are applied in a single three-layer extrusion process and vulcanized under nitrogen pressure at one go. The insulation provides, also due to the “dry cross-linking process”, good resistance to water-treeing and retains, even after ageing, a high electrical strength.

Design:

conductor:
circular conductor made up of copper wires (compacted) 1x16 mm² and 1x25 mm².

conductor screen:
as for standard cable.

insulation:
high-quality XLPE

insulation screen:
strippable, 0.8 mm nominal thickness.
Especially for ease of installation when it comes to making short connections, such as in transformer stations involving many terminations.

earthing screen:
wire screen on top of semi-conductive binding.
Mainly used in open-air installations, so no need for longitudinally watertight construction.

sheath:
Flame-retardant PVC

options:
earthing screen made from copper strip.
sheath:
- LLDPE + longitudinally watertight construction (for underground cables).
- PUR (for abrasion-resistant applications).

nominal core c.s.a.	earthing screen c.s.a.	diameter over				weight
		conductor	insulation	earthing screen	cable	
mm²	mm²	mm	mm	mm	mm	kg/m
8.7/15 kV						
1 x 16[1])	2[2])	5.0	15.2[3])	16.6	22	0.59
1 x 16	16	5.0	16.0	18.7	24	0.77
1 x 25	16	6.0	17.4	21.4	30	1.05
12/20 kV						
1 x 25	16	6.0	19.5	22.9	29	1.07

nominal core c.s.a.	designation with sheath of		reactance (at 50 Hz)		capacitance (at 50 Hz)
			trefoil	flat	
mm²	PVC	LLDPE	Ω/km	Ω/km	µF/km
8.7/15 kV					
1 x 16[1])	YMvK	-	n.v.t.	n.v.t.	0.15
1 x 16	YMvK	YMeK	0.158	0.257	0.14
1 x 25	YMvK	YMeK	0.161	0.250	0.15
12/20 kV					
1 x 25	YMvK	YMeK	0.160	0.250	0.13

[1]) especially in combination with certain switchgear.
[2]) copper strip instead of copper wire.
[3]) insulation thickness is not in line with NEN 3620.

LEAD-SHEATED CABLE

Characteristics
- lead sheath
- transversally watertight
- a copper wire screen enveloping the lead sheath if short-circuit currents require this.
- application: all cross-sectional areas of single-core and three-core medium-voltage cables.
- petrochemical industry: if chemically contaminated soil is suspected. Heavier construction, e.g. for submarine cables.

Design:

sheath:
PVC

options:
designs according to customer specifications.

TKF: HIGH-QUALITY CABLES FOR EVERY CONCEIVABLE APPLICATION

The Twentsche Kabelfabriek (TKF), founded in 1930, has grown into a leading producer of high-quality cables and offers a comprehensive range of cables for every conceivable application.

With a market-oriented management we keep a close track of market and technical developments. Decisive product development, focusing on continuous improvement and professionalizing, results in new cable designs, offering exactly those properties meeting the requirements and needs of the market.

TKF's intrinsic quality is clearly reflected in its ample awareness of investing in skilled staff members and ultra-modern production technologies. This quality can also be seen in the quality approach set up in line with the NEN/ISO 9001 standard and in the multitude of cables bearing the KEMA quality insurance label. In addition, TKF possesses the ISO 14001 environmental certificate, in which a continuous improvement process for production, waste processing as well as recycling has been laid down.

A flexible organizational form guarantees fast and punctual delivery: our word is our bond. For many years now TKF has been a constant factor, on which its customers have always been able to build. This goes to show that TKF is a reliable partner for a long-term business relationship, which is to the benefit of all parties concerned.

Should you wish any further information about Twenpower cables as well as our other cables, please contact our Sales Department.

BV TWENTSCHE KABELFABRIEK

TKF: high-quality cables for every conceivable application

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www.tkf.nl

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2000-01

Transformador de Potência

Tipo Core, imersão em óleo, 400 / 30kV

100 / 100MVA (ONAN / ONAF) YNd5.

Tabela de caracteristicas

Descrição		Unidade	MAT	MT
Potência Nominal	ONAF	MVA	100	100
	ONAN	MVA	100	100
Tensões Nominais em Vazio		kV	400	30
Grupo de Ligação		-	Estrela Wye	Triângulo Delta
Regulação	Tipo	-	Em Carga	-
	Gama	-	+10/-10 x 1%	-
Frequência Nominal		Hz	50	
Grupo Vetorial		-	Ynd5	
Corrente CC		kA	50	-