МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ЧЕРНІВЕЦЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ
ІМЕНІ ЮРІЯ ФЕДЬКОВИЧА

Навчально-науковий інститут фізико-технічних та комп'ютерних наук
кафедра електроніки і енергетики

Розрахунок сонячної електростанції 16 МВт (Багдад, Ірак)

Кваліфікаційнийпроект

Рівень вищої освіти - перший (бакалаврський)

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MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
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Educational and scientific institute of physical, technical and computer sciences
department of electronics and power engineering

Explanatory note

ForBachelor degree project

Theme: Sun power station 16 MW calculation (Baghdad,Iraq)

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Chernivtsi –2022

Анотація

У кваліфікаційному проекті представлені результати розрахунку сонячної електростанції потужністю 16 МВт, розташованої в Іраку в місті Багдад. Підібрано сонячні панелі, трансформатори, вимикачі, вимірювальні трансформатори струму та напруги, кабелі та шини, релейний захист та розрядники.

Проект написаний англійською мовою і містить: 56 сторінок, 21 рисунок, 18 таблиць, 17 посилань та 1 аркуш графічної частини формату А3.

Ключові слова: сонячна енергетика, електростанція, трансформатори, вимикачі, інвертор, кабелі, запобіжники, релейний захист.

Annotation

The qualification project presents the results of the calculation of a 16 MW power sun station located in iraq in baghdad city. Solar panels, transformers, switches, current and voltage measuring transformers, cables and buses, relay protection and arresters are selected.

The project is written in English and contains: 56 pages, 21 figures, 18 tables, 18 references and 1 sheet of A3 graphic part.

Keywords: sun power, power plant, transformers, circuit breakers, invertor, cables, fuses, relay protection.

Кваліфікаційний проект містить результати власних досліджень. Використання ідей, результатів і текстів наукових досліджень інших авторів мають посилання на відповідне джерело.

_____ Алі Мохаммед Наеемах Ал-Сааеді

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INTRODUCTION

Energy resources:

It can be classified into two categories:

- nonrenewable energy
- Conventional and fossil fuels
- Their supply is limited and we cannot produce as much fossil fuel in as short a time as we would like
- Most of our electricity is generated on the basis of non-renewable energy resources

Fossil fuels are: coal, oil and natural gas

Renewable energy

- alternative energy
- It can be called sustainable energy
- It includes: biomass, geothermal, hydro, solar, ocean, and wind energy
- They are called renewed because they are renewed or renewed in a short time
- We mainly use renewable energy sources to generate electricity and provide thermal heat for applications.

Advantages of renewable energy:

1. It should never be depleted

2. The fact that it is renewable. We will never run out of renewable energy sources

3. The photovoltaic system is very flexible, reliable and long lasting.

The importance of the photovoltaic system:

1. It works cost-effectively in remote areas where it would be expensive or impossible to throw power.

2. Does not produce any pollution.

3. Reducing the increasing dependence on energy and electricity.

4. Reduce the cost of complying with current and upcoming environmental regulations.

5. Preserving nature for future generations.

6. Improve the stability of power supply.

7. It protects our environment and our general health by preventing or reducing pollutants.

CHAPTER 1. THEORETICAL PART

1.1 Sunlight or solar energy

• Most of the renewable energy comes from the sun.

• Solar energy is a source of energy that includes making use of the radiant light energy that is emitted by the sun and converting it into electricity.

• Solar powered homes are installed with batteries that have the capacity to store energy that can power electrical appliances such as televisions, radios, computers and refrigerators.

What are photovoltaic cells?

• Photovoltaic cells use solar energy to generate energy

• Photovoltaics are used in calculators, satellites, and to power our homes

• Photovoltaic cells have a very high potential to be a major source of energy

• It creates jobs and strengthens the economy because it is a completely new industry

• Photovoltaic cells are highly reliable and cost little to build and operate

Application on photovoltaics:

• Water pumping: Excellent, simple and reliable PV pumping systems 20 years old

• Commercial lighting: PV lighting systems are a reliable and low cost alternative. Security, advertising signage, area, and outdoor lighting are all viable applications of photovoltaic energy

Consumer Electronics: Solar-powered watches, calculators, and cameras are all everyday applications of PV technologies.

• Telecommunications

Residential Energy: A residence that is located more than a mile from the electrical grid can install a PV system at a lower cost than extending the electrical grid.

• (More than 500,000 homes around the world use PV as the only source of electricity).

1.2 Renewable energies in Iraq

Can renewable energies provide a solution to the power outage in Iraq?

The government signed contracts to produce 1,000 megawatts of solar energy in 2018, bringing production to about 2,000 megawatts by 2025.

Countries such as Morocco, the United Arab Emirates and even Jordan have invested extensively in building renewable energy projects.

Iraq is a pioneer in renewable energy research?

Research in the field of renewable energies is not new in Iraq. In 1981, Iraq witnessed the construction of the first center for renewable energies research in the Middle East.However, scientific progress in this field slowed down after 2003, according to researchers at the center.

Some shops in Baghdad and Erbil sell rooftop solar systems to convert sunlight into electrical energy.

Solar panels store energy in their batteries during the day to be used at night

This makes it possible to use solar systems even when the weather is dusty or cloudy, but in a country like Iraq with about 300 sunny days a year, clouds or rain are not a major problem.

Green tariff

There are more than therty companies in iraq that generate electricity from water, solar, wind and biomass.

The constant rise in energy prices is the main reason for the increase in electricity tariffs. The cost of fuel is about 60% in the structure of the electricity tariff in iraq. The development of alternative energy sources will reduce the state's dependence on sharp fluctuations in hydrocarbon prices and, consequently, improve the economic and environmental situation in the country.Iraqi energy is gradually "greening".

The world practice of natural energy recovery is quite dynamic. Compare: in 2005 $ 30 billion was invested in clean energy projects, in 2012 it was already $ 150 billion. Last year the volume of investments in this industry increased by a record 25% and reached $ 200 billion.

The main motivation for investors is undoubtedly the so-called green tariffs and other government preferences that attract considerable capital to the innovation industry. The "green tariff" is to set a separate tariff for electricity produced from renewable sources. The value of the "green tariff" is calculated by the formula: the tariff existing on the electricity market multiplied by a factor set for the production of energy from various renewable energy sources (RES).

In iraq, "green tariffs" were introduced in 2012 to stimulate the production of electricity from renewable sources - wind, solar, biomass and water. The state guarantees investors the purchase of electricity at fixed minimum prices, which, however, are higher than energy tariffs from traditional sources.

The National Electricity Regulatory Commission has approved "green tariffs" for April this year. According to them, in the iraqi wholesale electricity market, one kWh of solar energy costs 522.94 kopecks, wind - 127.11 kopecks, water - 87.16 kopecks. Currently in iraq about 7% of electricity is produced from renewable energy sources, 6% of them are large power plants (cascade of hydropower plants on the Dnieper and others). Many domestic companies operate under the "green tariff", and in all areas (wind energy, solar energy, biogas, small hydropower plants). In particular, wind energy is supplied by 5 enterprises, among them: VEO "Vitroenergoprom", SE "East Crimean Wind Power Plant". Solar energy is produced by 6 enterprises: Kraimia Solar 1 LLC, Kraimia Solar 2 LLC,. In addition, there are up to 30 hydropower plants in iraq and very few companies use biomass as raw material.

It is worth noting that the "green tariff" is not for life, but is valid for a limited time (10 years). After all, its purpose is to enable the investor to recoup the additional costs of installing equipment to generate electricity from RES. When the costs pay off, the investor will have the capacity to produce clean energy and will sell "green energy" on an equal footing with everyone else.

Theoretically, the potential of alternative sources in iraq allows to fully meet energy needs, say experts from the National Agency of iraq for Energy Efficiency .

"The development of renewable energy is one of the government's priorities, because there is an awareness that without this future the country will not be. If we do not learn to use energy given to us by nature, but follow the path of energy development that requires fossil resources it will not work out, "said Deputy Chairman ayadalawy.

Leading ecologists of iraq share the same opinion. For example, the level of solar energy use in Ukraine is high enough for widespread implementation, especially in the south and in the Crimea. It is possible to convert solar energy into electricity in the conditions of our state with the help of heat and photovoltaic equipment, and in almost all areas.

As for wind energy, according to research by the National Academy of Sciences, windmills can be located in iraq, which will provide about 15 million tons of conventional fuel. This is more than the entire domestic nuclear power industry produces today. There is also the potential for use, currently unexplored, of locating offshore wind farms.

All of iraqs southern steppes, whose land is now set aside for agriculture, can in fact be used for wind farms.

The main advantage of small hydropower is the cheapness of electricity generated by hydroelectric power plants. And the lack of a fuel component in the process of electricity generation gives positive economic and environmental effects. Small hydropower plants can become a powerful basis for energy supply in all regions of Western iraq.

A step towards "environmental" business.

Today, investors are showing high interest in the field of alternative energy sources. "The reason for the interest is that today iraq has perhaps the most attractive conditions for investing in renewable energy. In addition to the aforementioned" green tariff ", the field of renewable energy is supported by a number of benefits and preferences," said ayadalawy.

These benefits and preferences are enshrined in the Tax Code and laws of iraq : "On amendments to some laws of iraq to establish a" green "tariff"; "On

Amendments to the Law of iraq" On Electricity "to Stimulate the Use of Alternative Energy Sources" and others.

1.3 Types of solar cells

A solar module is a battery of interconnected solar cells connected under a glass cover. The more intense the light incident on the photocells and the larger their area, the more electricity is produced and the greater the current. Modules are classified by peak power in watts (W). Watts - a unit of power. One peak watt is a technical characteristic that indicates the value of the power of the installation in certain conditions, ie when solar radiation of 1 kW / m2 falls on the element at a temperature of 25 oC. This intensity is achieved under good weather conditions and the position of the Sun at the zenith. To produce one peak watt, you need one element measuring 10 x 10 cm. Larger modules, 1 m x 40 cm, produce about 40-50 Vtp. However, sunlight rarely reaches 1 kW / m2. Moreover, in the sun the module heats up much higher than the nominal temperature. Both of these factors reduce the performance of the module. Under typical conditions, the average productivity is about 6 W • g per day and 2000 W • g per year per 1 Wp. 5 watts-h is the amount of energy consumed by a 50-watt light bulb for 6 minutes (50 W x 0.1 h = 5 W • h) or a portable radio for an hour (5 W x 1 g = 5 W • g).

Although product quality is not always the same, most international companies produce fairly reliable photovoltaic modules with a lifespan of up to 20 years. To date, module manufacturers guarantee this capacity for up to 10 years. The decisive criterion for comparing different types of modules is the price of 1 watt of peak power. In other words, you can get more electricity for the same money, using a module priced at $ 569 with a peak power of 120 WP ($ 4.74 per 1 WP), than with a "cheap" module with a capacity of 90 W, which costs $ 489 (5, $ 43 for 1 Vtp). Nominal efficiency is less important when choosing a system.

Benefits

High reliability

Photovoltaic cells have been developed for use in space, where repairs are very expensive or impossible. Until now, photovoltaic cells are the source of power for

almost all satellites in Earth orbit, because they work without breakdowns and require almost no maintenance.

Low running costs

Photovoltaic cells run on free fuel - solar energy. Due to the lack of moving parts, they do not require special maintenance. Cost-effective photovoltaic systems are an ideal source of electricity for mountain communications stations, sea navigation beacons and other consumers away from power lines.

Environmental friendliness

Because photovoltaic systems do not burn fuel and have no moving parts, they are silent and clean. This feature is extremely useful where the only alternatives for light and power are diesel generators and kerosene lamps.

Modularity

The photovoltaic system can be brought to any size. The owner of such a system can increase or decrease it if his need for electricity changes. As energy consumption and financial capabilities increase, a homeowner can add modules every few years. Farmers can provide livestock with drinking water through mobile pumping systems.

Low construction costs

Photovoltaic systems are usually placed close to the consumer, which means that power lines do not need to be pulled long distances, as in the case of connection to power lines. Additionally, no step-down transformer is required. Fewer wires means lower costs and a shorter installation period.

A solar photovoltaic system consisting of one or more solar panels is a solar power plant that uses a method of directly converting solar radiation into electricity. The panels are placed on a supporting structure or frame on the roof of a residential building or on the ground, a set of batteries, a battery charge-discharge controller, and an inverter if you need to have AC voltage.

Solar panels are assembled from individual solar cells, the principle of which is based on the phenomenon of internal photoelectric effect in semiconductors. Silicon photovoltaic converters use silicon with the addition of other elements that form a

structure with a p-n junction. Moreover, the thickness of the semiconductor does not exceed 0.2-0.3 mm.

1.4 Types of solar modules

Monocrystalline silicon solar modules

Monocrystalline elements have the highest energy conversion efficiency. The main material is pure silicon, from which monocrystalline solar panels are made, well-developed in the field of semiconductor production. Silicon single crystal grows on seeds, which are slowly extracted from the silicon melt. The rods obtained in this way are cut into pieces with a thickness of 0.2 to 0.4 mm. Efficiency - 15-18%

These disks are then subjected to certain production operations, such as:

* Turning, grinding and cleaning;
* Application of protective coatings;
* Metallization;
* Anti-reflective coating.

Polycrystalline silicon solar modules

Polycrystalline silicon is formed when the silicon melt is slowly cooled and controlled. In the production of polycrystalline panels, the extraction operation is reduced, it is less energy-intensive and much cheaper. However, inside the polycrystalline silicon crystal there are areas separated by granular boundaries, which leads to less efficient elements.

The efficiency of a solar panel based on polycrystalline silicon is 10-12%.

Amorphous silicon solar modules

Amorphous silicon is extracted using "evaporation phase technology", when a thin film of silicon settles on the carrier material and is protected by a coating. This technology has both disadvantages and advantages:

* The process of production of solar panels based on amorphous silicon is relatively simple and inexpensive;
* Probably the production of large area elements;
* Low power consumption.

But:

* The conversion efficiency is much lower than in crystalline elements;

* Elements are prone to degradation, distortion.

Photovoltaic systems (FES)

Additional elements in the system are required for acceptable operation of photovoltaic modules: cables, charge controller, inverter, batteries, etc.

Such a system is generally called a solar photovoltaic system, or solar station. There are three main types of solar photovoltaic systems:

- Autonomous systems for individual houses;
- Systems are connected to the network;
- Backup systems.

CHAPTER 2.DESIGN OF SUN POWER STATION

2.1 Area

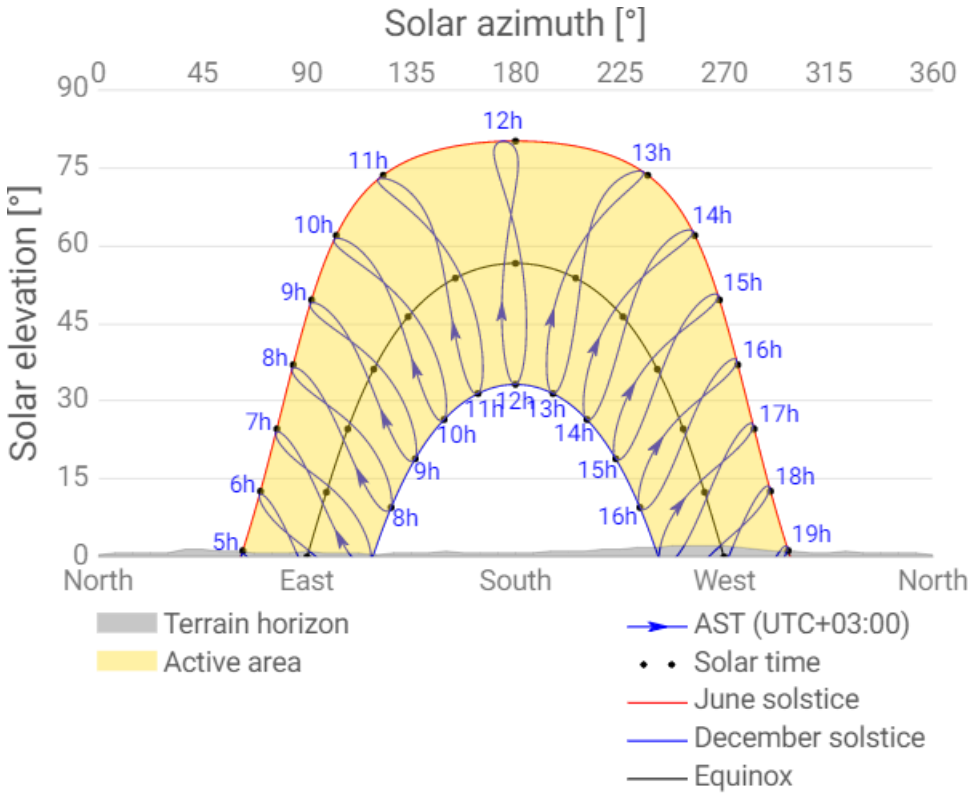


Fig.1 solar azimuth

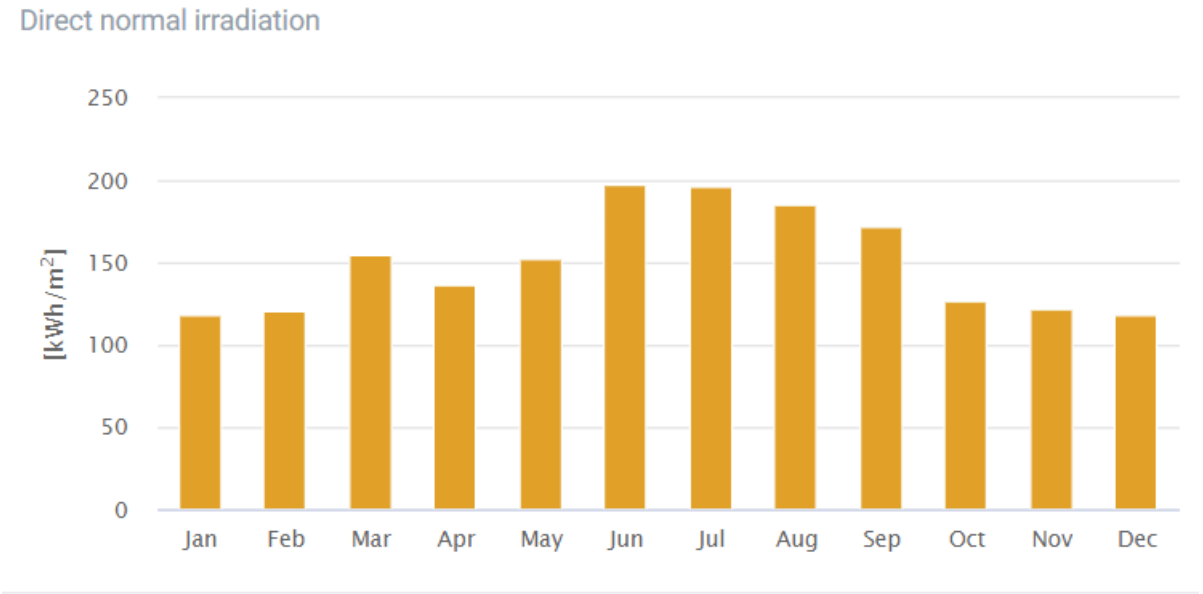


Fig.2 direct normal irradiation Monthly averages

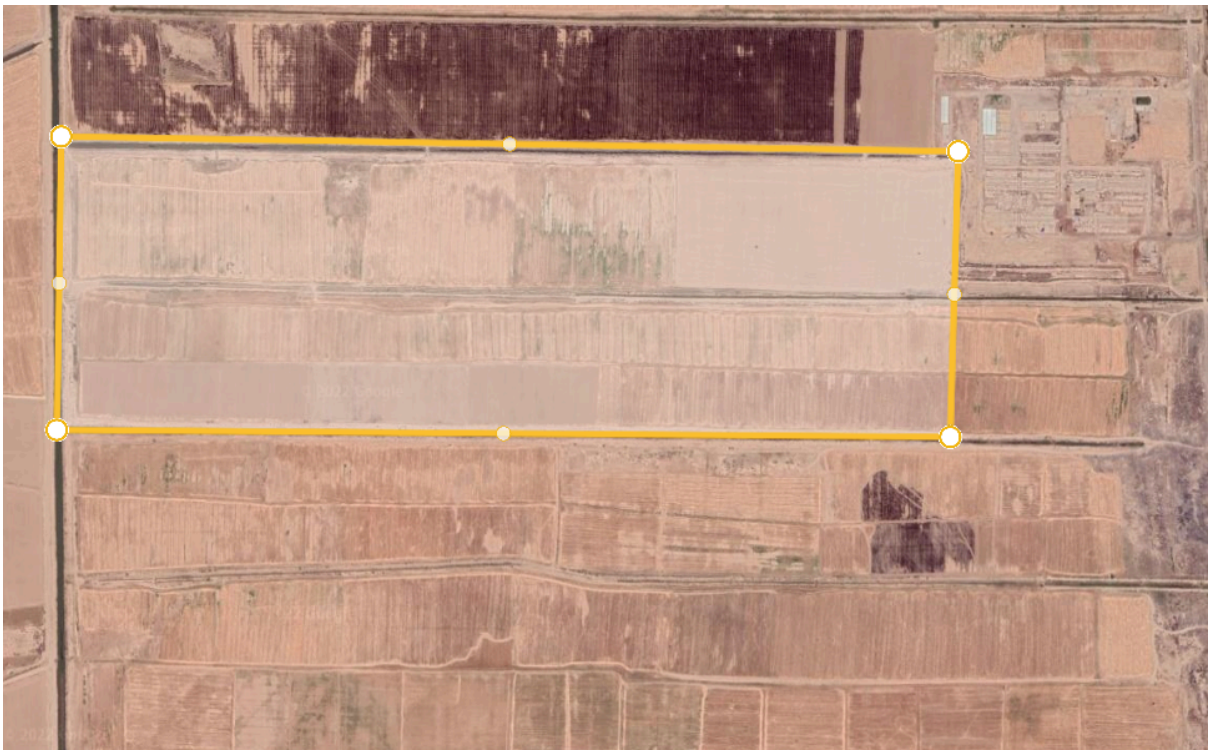


Fig.3 the place which station should build

This area is a promising area, which unfortunately is not

Used correctly, no idle.

Looking at the map, it should be noted that for the construction of solar energy

Power plant, this area is quite suitable because of the development plan

It seems that the city's construction of many high-rise buildings prevented this from being blacked out

The plot is not provided. Therefore, it is only necessary to rely on these factsMake a calculation or don't get involved in getting solar energy Radiant Solar Panels Existing Multi-storey Residential homes.

2.2 Solar panel

And now we need to calculate the number of panels:

n=15MW/0.665MW=22500 panels

Fig.4 sun panels

Manufacturer	Inter energy
Producing country	China
power	665
Panel type	monocrystalline
Module material	pure silicon
frame material	Aluminum
Voltage at maximum power	38.21V
Current at maximum power	17.40A
Open circuit voltage	46.18V

DIMENSIONS:

Length	2384_{MM}
Width	1303_{MM}
Thickness	35_{MM}
Weight	34_{KG}

2.3 Inverter

SMA Sunny HighPower Peak3 (SHP 150-20)

Fig.5 the invertor

String inverter Sunny Highpower PEAK3 (SHP 150-20) from SMA is a powerhouse specially developed for industrial PV plants. This inverter is the solution for large-scale solar panel systems thanks to its high power density. Due to its compact size, it is easy to transport and the installation process takes little time. The SHP 150-20 is a cost-saving solution for industrial solar panel installations.

Power

The Sunny Highpower PEAK3 (SHP 150-20) has a maximum PV generator output of no less than 225000 watts and a DC system input voltages of 1500 Volt. The MPP voltage range is between 880 and 1450 Volt. Maximum input current is 180 amps and the maximum short-circuit current is 325 amps.

The Sunny Highpower PEAK3 is extra economical thanks to a maximum output of 150% thanks to the DC/AC ratio. The Sunny Highpower PEAK3's own consumption at night is less than 5 watts. DC design of this inverter can be combined with a custom Combiner Box.

European efficiency of the SHP 150-20 is 98.8%, with a maximum efficiency of 99.1%.

Safety

The Sunny Highpower PEAK3 features earth leakage monitoring, which is suitable for all power types. In addition, the SHP 150-20 has grid monitoring, DC immersion protection, AC short-circuit resistance and monitored overvoltage protection type II on the AC side and DC side. The degree of protection of the inverter is IP65, which means that it is spray-proof and protects against dust particles.

Thanks to the built-in active cooling by OptiCool™, the risk of damage caused by dust is considerably reduced. OptiCool™ cooling has been intensively tested by SMA where central inverters have been exposed to very fine dust particles over a long period of time. The results were very positive, with no dust being found in the inside of the inverter.

SMA Smart Connected

SMA Smart Connected service ensures easy management and maintenance. Thanks to this proactive service, total costs will be reduced over the entire duration of the project.

Specifications:

SKU	3-150-1500-1-20
Brand	SMA
Manufacturer	SMA
Country of manufacture	Germany
Warranty in Years	5
HS-code	85044088
Type	String
Power class	> 100 kW
Number of phases	3 phase
Max. DC- input capacity (W)	225000
AC-nominal output power	150000
Number of MPPT	1
Degree of protection (IP)	IP65
Suitable for outdoor mounting	Yes
DC Switch	No
Surge protection	Type II DC & AC
Transformer	No
Data logging	No
Display	No
WiFi	No
Ethernet	Yes
Width (mm)	770
Height (mm)	830
Depth (mm)	444
Weight (kg)	98

Technical Data	Sunny Highpower 100-20	Sunny Highpower 150-20
Input (DC)		
Max. PV array power	150000 Wp	225000 Wp
Max. input voltage	1000 V	1500 V
MPP voltage range / rated input voltage	590 V to 1000 V / 590 V	880 V to 1450 V / 880 V
Max. input current / max. short-circuit current	180 A / 325 A	180 A / 325 A
Number of independent MPP trackers	1	1
Number of inputs	1 or 2 (optional) for external PV array junction boxes	
Output (AC)		
Rated power at nominal voltage	100000 W	150000 W
Max. apparent power	100000 VA	150000 VA
Nominal AC voltage / AC voltage range	400 V / 304 V to 477 V	600 V / 480 V to 690 V
AC grid frequency / range	50 Hz / 44 Hz to 55 Hz 60 Hz / 54 Hz to 66 Hz	50 Hz / 44 Hz to 55 Hz 60 Hz / 54 Hz to 66 Hz
Rated grid frequency	50 Hz	50 Hz
Max. output current	151 A	151 A
Power factor at rated power / displacement power factor adjustable	1 / 0 overexcited to 0 underexcited	
Harmonic (THD)	< 3%	< 3%
Feed-in phases / AC connection	3 / 3-PE	3 / 3-PE

Calculation of panels comutation:

In $V_{inv=}$1000 V V=38.21V

In $I_{in=}$180A I=17.40A

N si= 1000/38.21=26 n_{par} =180/17.4=10

n_{pm}=26*10=260 n_m=22500/260=87

we choose not 87 but 90

no of panels

np=90*260=23400

then pow of st become

P=234000*665=15.561MW

2.4 Power Transformers

Oil Type Transformer 750 kVA - 11/0.433kV:

Fig.6 transformer 11/0.433kv

Main information:

Product range	Minera Ground Mounted
Product or component type	Transforme
Transformer type	Oil type transformer
Dielectric liquid	Ester fluid (FR3)
Network type	AC
tandards	AS/NZS 60076
Type of installation	Outdoor
Maximum altitude	< 1000 m
Cooling mode	KNAN (high fire point fluid natural air Natural)
Winding material	Aluminium
Degree of protection	IP65 cable box IEC
Mounting mode	Ground mounted

Complementary:

Directives	2015/2014/548/EC- ecodesign
Phase	3 phases
Rated power	750 kVA
Rated frequency	50 Hz
Rated primary voltage	11 kV
Secondary voltage (at no-load)	No load: 433 V
Insulation voltage to industrial frequency (50 Hz 1 mn)	28 kV primary 3 kV secondary
Rated insulation level	Primary circuit: 12 kV Secondary circuit: 1.1 kV
Lighting impulse whistand voltage (BIL) , 1.2/50 µs	75 kV

Vector group	Dyn11
HV tappings (off circuit)	+/- 2 x 2.5 %
Short circuit impedance	5.00 %
No-load losses	900 W
Load losses at 75°C	7990 W
Temperature rise of windings	80 K (oil) 65 K (winding)
Thermal class	A
Sound power level	64.3 dB at 0.3 m
Electrical connection	Cable high voltage connection Cable low voltage connection
Protective relay	DMCR relay
Height	1570 mm
Width	1510 mm
Length	2098 mm
Total weight	2540 kg
Oil quantity (L)	655 l

Environment:

Maximum ambient temperature	50 °C
Ambient air temperature for operation	20…50 °C for C2
Ambient air temperature for storage	-20…50 °C C2
Environmental certification	0…95 %

Packing Units:

Package 1 Weight	2510.000 kg
Package 1 Height	1650.000 cm
Package 1 width	1510.000 cm
Package 1 Length	2100.000 cm

As in the case of two-winding transformers, the voltage is short

Short circuit is expressed as a percentage.

The inductive resistance of a transformer can be calculated in the same way

The formula, for a two-winding transformer:

$$X = \frac{U_k(\%) \bullet U_{HV}^2}{100 \bullet S_{T\,NOM}}$$

$$X_{T1} = \frac{5 \bullet 11000^2}{100 \bullet 750000} = 8.066\ Ohm$$

66KV Class Three Phase Two Winding OLTC Power Transformer

Fig.7 transformer 66kv

Category: **Power Transformer**

Tags: 66KV OLTC Power Transformer, OLTC Power Transformer, Power Transformers, Three Phase Transformer, Three Phase Two Winding.

Place of Origin:	Beijing, China	Low Voltage:	13.8kv or others
Brand Name:	Daelim Belefic	Rated Power:	6.3- 63 mva
Model Number:	SFZ11	Standard:	IEC ANSI IEEE GOST
Usage:	Power	Certification:	ISO9001
Phase:	Three Phase Three Winding	Product name:	66KV Class Three Phase Two Winding OLTC Power Transformer
Coil Structure:	TOROIDAL	type:	power transformer
Coil Number:	2	Winding material:	Copper\Aluminum
Type of tap changer:	OLTC	Voltage range:	63-66 kv
Connection Symbol:	YNd11or YNd11		

Basic introduction:

Daelim brand 220kv,110kv, and 66kv low-loss series transformer is our independently developed new generation of transformers on the basis of absorption of China and foreign advanced technology, which features low local discharge, low loss, high reliability, strong protection against abrupt short circuit.

Technical Specification:

Rated Power (KVA)	High Voltage (KV)	Low Voltage (KV)	Connection Symbol	Short Circuit Impendence	Loss(W)		No Load Current
					No-load Loss(W)	On-load Loss(W)	
6300	63 66 69	6.3 6.6 10.5 11	YNd11	9	8250	34000	0.63
8000					9830	40400	0.63
10000					11600	47600	0.75
12500					13600	56500	0.53
16000					16300	69500	0.49
20000					19200	84200	0.49
25000					22600	99500	0.42
31500					26800	120000	0.42
40000					31900	140300	0.39
50000					38600	174300	0.39
63000					44400	210000	0.39

$$X_{T2} = \frac{9 \bullet 66000^2}{100 \bullet 10000000} = 39.204\ Ohm$$

2.5 Calculation of cables

The choice of cable products is influenced by many factors, among which are the long-term allowable current and the economic feasibility of using this brand of cable. The choice of cables with a small cross section during operation will lead to their excessive overheating, and as a consequence of the destruction of insulation and failure of the cable, on the other hand the choice of cable too large cross section is economically impractical due to significant costs. In addition, the cable sheath must be selected so as to be resistant to the environment.

The passage of short-circuit currents on the cable causes the cable to heat up, so the selected cable must be tested for resistance to thermal action of short-circuit currents.

In addition, it is necessary to check for voltage losses in this cable, these losses should not exceed 5%.

Method of calculation

We perform technical and economic calculation of the cable cross section for this:

a) find the current that will flow through this cable:

$$I_p = \frac{S}{\sqrt{3} \cdot U}$$

$I_{1.1}$=17.4 A

$I_{1.2}$=174A

$$I_{2.1} = \frac{150}{\sqrt{3} \cdot 0.4} = 650A$$

$$I_{3.1} = \frac{750}{\sqrt{3} \cdot 11} = 118A$$

$$I3.2 = \frac{6750}{\sqrt{3} \cdot 11} = 1175.024\text{A}$$

$$I_4 = \frac{16000}{\sqrt{3} \cdot 66} = 140A$$

b) calculate the economic cross section of the cable by the formula:

$F_{ек}=I_p/j_{ек}$

F_{ck}=174/1.4=124mm^2

j_{ek}=1.4 for aluminum

j_{ek}=2.5 for cupper

ρ=0,01673 Ohm*mm^2/m for cupper

ρ=0,027Ohm*mm^2/m for alumimun

$$I_{2.2} = \frac{750}{\sqrt{3} \cdot 0.4} = 3247\ A$$

$F_{ек2.2a}=I_p/j_{ек}=3247/1.4=2319.3\ mm^2$

$F_{ек2.2c}=I_p/j_{ек}=3247/2.5=1298.8\ mm^2$

- Mssoomm Copper Flat Bar 4mm x 25mm x 1000mm, C110 Copper Bus Bar 99% Copper T2 Cu Metal
- If this item is not FBA, the price is based on the air transportation and the lead time is 7-10 Business Days except for for Chinese National Day holiday and Spring Festival; you could also choose the sea transportation and the price is lower, the lead time is about 30 Natural Days
- The length of this item is 1000mm/ 39.37inch, we can provide any length as you want, and the longest is 6000mm/ 236.22 inch. Our product defaults to round edge copper bars, if you need rectangular copper bars, please let us know
- We could process the bar, including bending, cutting and punching, please message us
- 110 Copper is 99.9% pure copper with an electrical conductivity rating of 100+ % IACS. Conductivity, corrosion resistance, and ductility makes 110 Copper very versatile over a broad range of applications. 110 Copper is anneal resistant
- Copper bar is a high-current conductive product, suitable for high and low voltage electrical appliances, switches, power distribution equipment, buss ducts, etc.

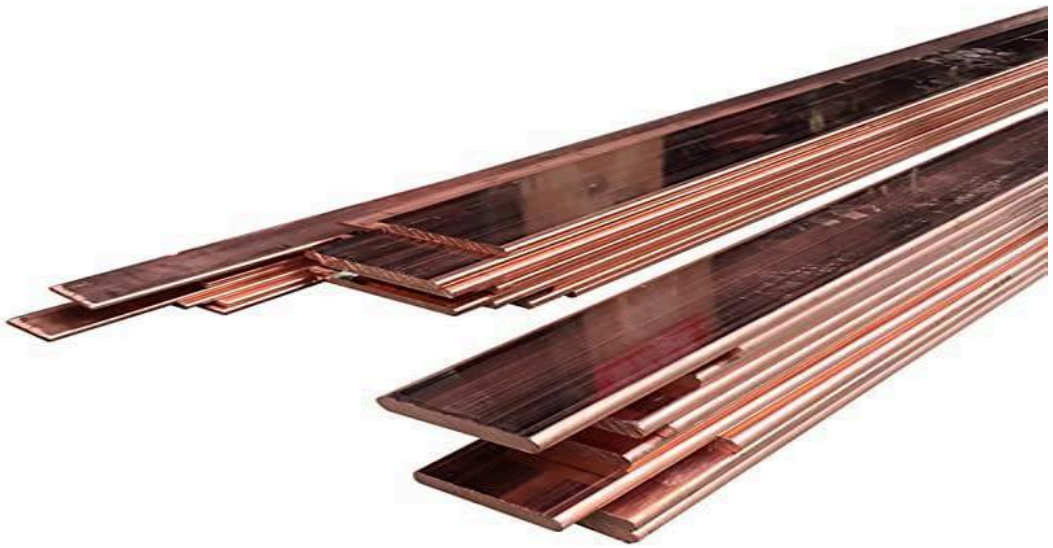


Fig.8 cables of copper

Product Specifications

Ean	0652016973948
Item Weight	1.98 pounds
Number of Items	1
Part Number	MS-ZTP-T4W25L1M
Size	T: 4mm
Style	W: 25mm
UNSPSC Code	30160000
UPC	652016973948

Specification for this product family

Material	Copper 110
Measurement System	Metric
Part Number	MS-ZTP
UNSPSC Code	30000000

F_r=1300 mm^2

$$R = \frac{\rho \bullet l}{F} R_{2.2} = \frac{\rho \bullet l}{F} = \frac{0.01673*400}{1300} = 0.00514\ Ohm$$

$I_{1.1}$=17.4 A

$F_{ек1.1a}=I_p/j_{ек}$=17.4/1.4=12.42 mm^2

$F_{ек1.1c}=I_p/j_{ек}$=17.4/2.5=6.96 mm^2

$R_{1.1}=\frac{\rho.\iota}{F}=\frac{0.027*180}{20} = 0.243\ Ohm$

1AWG=1kcmil=0.5067 mm2

7/0.567=123.5 AWG

TYPE TWO 0.6/1kv Aluminum Core Aerial Bundled Cable ABC Cable

Fig.9 cables of aluminum

Standards:

GB12527-91,IEC502,BS7870-5

Other standards such as BS, DIN, and ICEA upon request.

Constructions:

Conductor:Round, stranded and compacted aluminum conductor.

Insulation:HDPE,XLPE,PVC.

Application:

Aerial Bunch Cables are a compromise construction between Power cables and Overhead conductors. It is preferred to use ABC cables instead of uninsulated conductors at low voltage networks. ABC cables are especially used in areas where the cost of underground networks is expensive and also for the electrification of rural areas like villages. Bundles can include one or two additional conductors for public lighting and control pairs.

Specifications:

Cross Section of Conductor	Min. Nos. of Wires for Conductor	Insulation Thickness	Average Max. O.D.per Single-core	Max.Conductor Resistance at 20°C	Min Insulated Resistance at Rated Working Temperature		Cable Tensile Breaking Force
(mm2)	(mm)	(mm)	(mm)	(Ω/km)	(MΩ.km)		
2x10	6	1	6.5x13.0	3.08	0.0067	0.67	1650

d=4.22 mm

$$F = \frac{d^2 \bullet \pi}{4}$$

$$F_r = \frac{4.22^2 * 3.14}{4} = 13.98\ mm^2 \quad R = \frac{\rho \bullet l}{F}$$

$I_{1.2}$=174 A

$F_{ек1.2a}=I_p/j_{ек}$=174/1.4= 124.28 mm^2

$F_{ек1.2c}=I_p/j_{ек}$=174/2.5=69.6 mm^2

F=150 mm^2

$$R_{1.2} = \frac{\rho . \iota}{f} = \frac{0.027 * 200}{150} = 0.036 ohm$$

N2XS2Y XLPE PE - 6/10 (12)kV Cable

Fig.10 cable of copper

APPLICATION:

Medium voltage cables for distribution networks; also for connection to generation units and plant and process connection. For installation in ground, in water outdoors, indoors and in cable ducts for power stations, industry, and distribution networks.

CHARACTERISTICS:

Voltage Rating Uo/U (Um) 6/10 (12)kV Temperature Rating -20°C to +90°C Minimum Bending Radius 15 x overall diameter.

CONSTRUCTION:

Conductor Class 2 stranded copper conductor Inner Semi-Conductive Layer Semi-conductive material Insulation XLPE (Cross-Linked Polyethylene) Outer Semi-Conductive Layer Semi-conductive material Screen Copper wires Sheath PE (Polyethylene) Sheath Colour Blac.

STANDARDS:

DIN VDE 0276-620, HD 620, IEC/EN 60228, IEC 60502-2

DIMENSIONS

ELAND PART NO.	NO. OF CORES	NOMINAL CROSS SECTIONAL AREA mm²		NOMINAL OVERALL DIAMETER mm	NOMINAL WEIGHT kg/km
		Conductor	Copper Wire Screen		
A9XY10KV1035	1	35	16	28	820
A9XY10KV1050	1	50	16	29	960
A9XY10KV1070	1	70	16	31	1150
A9XY10KV1095	1	95	16	32	1450
A9XY10KV1120	1	120	16	34	1700
A9XY10KV1150	1	150	25	35	2000
A9XY10KV1185	1	185	25	37	2350
A9XY10KV1240	1	240	25	39	2900
A9XY10KV1300	1	300	25	41	3550
A9XY10KV1400	1	400	35	45	4500
A9XY10KV1500	1	500	35	48	5550

ELECTRICAL CHARACTERISTICS

NOMINAL CROSS SECTIONAL AREA mm²		CURRENT CARRYING CAPACITY IN TREFOIL Amps	
Conductor	Copper Wire Screen	In Ground	In Air
35	16	187	197
50	16	220	236
70	16	269	292
95	16	320	358
120	16	363	413
150	25	405	468
185	25	456	535
240	25	526	631
300	25	591	722
400	35	662	827
500	35	744	949

$I_{2.1}$=650A

$F_{ек2.1a}=I_p/j_{ек}=650/1.4= 464.28\ mm^2$

$F_{ек2.1c}=I_p/j_{ек}=650/2.5=260\ mm^2$

$F=500\ mm^2$

$$R_{2.1}=\frac{\rho.l}{F}=\frac{0.027*100}{500}=0.0054ohm$$

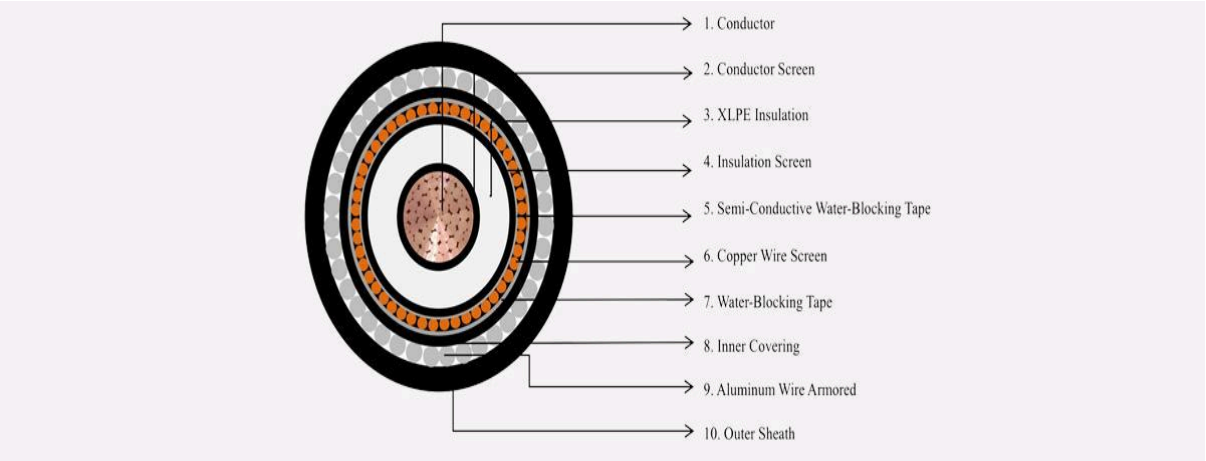


Fig.11 cable of copper

Application:

Extra-high-tension cable is a kind of power cable with the continuous development of cable technology. The cable is generally used as a central link in the large transmission system. It belongs to a high voltage cable with high technical content, which is mainly used for long distance power transmission.

Standard

GB 11017, IEC60840.

Construction:

Al/Cu Conductor, XLPE Insulation, Metal shield layer, Water-blocking layer, Metal sheath, Outer Sheath, Conductive layer.

Features

66KV AWA Armored Power Cable									
Rated voltage	Conductor size	Approx. Conductor dia.	XLPE Insulation thickness	Electric Capacity	Inductance		Loss of insulation	Max. D.C. Resistance	
					Parallel laying	Trefoil laying		Cu	Al
KV	mm2	mm	mm	pf/m	mh/km	mh/km	w/m	Ω/km	
66	240	18.4	19	136	0.757	0.508	0.175	0.0754	0.125
	300	20.6	18.5	147	0.734	0.489	0.19	0.0601	0.1
	400	23.5	17.5	165	0.708	0.465	0.212	0.047	0.0778
	500	26.6	17	182	0.683	0.445	0.234	0.0336	0.0605
	630	30.25	16.5	201	0.657	0.424	0.259	0.0283	0.0469
	800	34.23	16	224	0.633	0.406	0.288	0.0221	0.0367
	1000	41.4	16	265	0.594	0.386	0.341	0.0176	0.0291
	1200	45.28	16	282	0.577	0.375	0.363	0.0151	0.0247

$I_{3.1}$=118A

$F_{ек3.1a}=I_p/j_{ек}$=118/1.4= 84.28 mm^2

$F_{ек3.1c}=I_p/j_{ек}=118/2.5=47.2\ mm^2$

$F=95\ mm^2$

$R_{3.1}=\frac{\rho.l}{F}=\frac{0.027*100}{95}=0.0284ohm$

$I_{3.2}=1175.024A$

$F_{ек3.2a}=I_p/j_{ек}=1175.024/1.4=839.30\ mm^2$

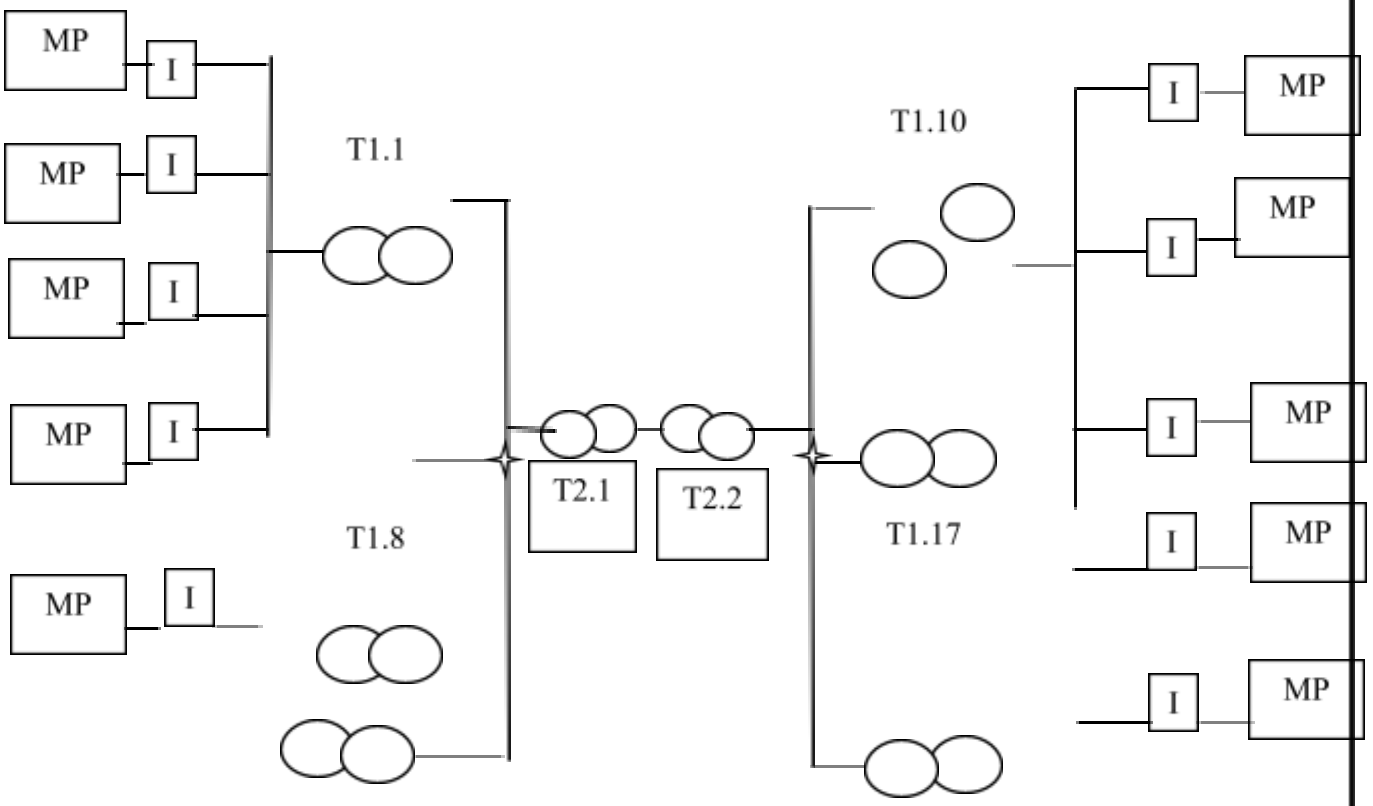
$F_{ек3.2c}=I_p/j_{ек}=1175.024/2.5=470.009\ mm^2$

$F=960\ mm^2$

$R_{3.2}=\frac{\rho.ι}{f}=\frac{0.027*6120}{960}=0.172ohm$

TYPE TWO <u>0.6/1kv Aluminum Core Aerial Bundled Cable ABC Cable</u>

Cross Section of Conductor	Min. Nos. of Wires for Conductor	Insulation Thickness	Average Max. O.D.per Single-core	Max.Conductor Resistance at 20°C	Min Insulated Resistance at Rated Working Temperature		Cable Tensile Breaking Force
(mm2)	(mm)	(mm)	(mm)	(Ω/km)	(MΩ.km)		
4x240	30	2.2	25.6x102.4	0.125	0.0034	0.34	3467



T1.9

T1.18

Fig.11 one-line Scheme

2.6 Calculation of current transformers

$$I_k = \frac{U_{HV}}{\sqrt{3} \bullet \sqrt{\left(\sum r\right)^2 + \left(\sum x\right)^2}}$$

$$I_y = I_K \bullet \sqrt{1 + 2 \bullet \left(k_y - 1\right)^2}$$

k_y=1.2-1.3

$$I_{k1} = \frac{11000}{\sqrt{3} \bullet \sqrt{(0.00514)^2 + (8.066)^2}} = 1343.101\ A$$

$$I_{y1} = 1343.101 \bullet \sqrt{1 + 2 \bullet (0.2)^2} = 1343.101 * 1.03923 = 1395.79150\ A$$

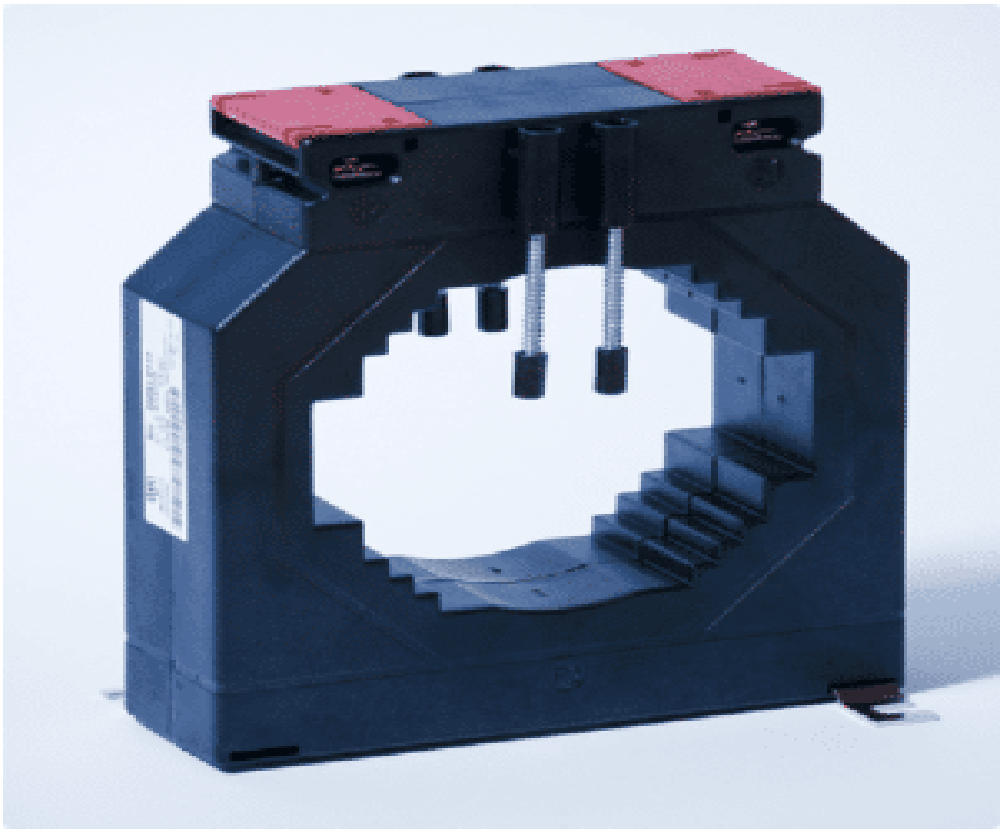


Fig.12 itl plastic case current transformer | 2000/5, 0.5, 15va, m140100h

Description Current Transformers with a ratio of Ip/5, for measurement devices such as ammeters, kilowatt hour meters and multi meters. Ratios ranging from 200/5A to 4000/5A and a plastic case in accordance with Thermal Class E. Capable of being mounted on Busbar or flat fixed on a base the M140100H (Horizontal Busbar Orientation) comes complete with sealable integrated terminal cover.

Electrical Characteristics		Mechanical Characteristics	
0.72 kV	Highest Voltage	Material Thermal Class	E
50/60 Hz	Frequency	Integrated Terminal Cover	Yes
IEC 61869-1 & 61869-2	Standard	DIN Rail Mounting	No
200 - 4000 A	Primary Ratio (Ip)	Busbar / Cable Clamp	Yes
1.5 - 60 VA	Burden	Mounting Feet	Yes
0.2s - 1 %	Accuracy Class	Captured Terminal Screws	Yes

Ratio	Maximum VA @ Class			
	Class 0.2s	Class 0.2	Class 0.5	Class 1
200/5A	-	-	1.5	3.75
250/5A	-	-	2.5	5.0
300/5A	-	-	3.75	7.5
400/5A	-	1.5	7.5	10.0
500/5A	-	2.5	10.0	12.5
600/5A	2.5	3.75	10.0	15.0
750/5A	5.0	5.0	15.0	20.0
800/5A	5.0	5.0	15.0	20.0
1000/5A	5.0	10.0	15.0	20.0
1200/5A	10.0	15.0	15.0	30.0
1250/5A	10.0	15.0	15.0	30.0
1500/5A	15.0	20.0	20.0	30.0
1600/5A	15.0	20.0	20.0	45.0
2000/5A	15.0	30.0	45.0	45.0
2500/5A	15.0	30.0	45.0	45.0
3000/5A	15.0	30.0	60.0	60.0
4000/5A	15.0	30.0	60.0	60.0

$$I_{k2} = \frac{11000}{\sqrt{3}\bullet(0.0284+0.172)} = 31690.883\ A$$

$$I_{y2} = 31690.883 \bullet 1.03923 = 32934.116\ A$$

Lzck322-10 11kv 33kv high voltage split core ct current transformer

Fig.13 lzck322-10 11kv 33kv high voltage split core ct current transformer

LZCK series split core current transformer is suitable forcurrent measurement and microcomputer protection of electrical equipment in 10KV and 35KV AC power system.It is widely used in compact fully insulated ring network switchgears such as ABB-Safe Ring/Safe Plus...and cable distribution boxes.The transformer can be directly installed at the inlet andoutlet cables.The slice is imported silicon material. Thesemicircular ring core and secondary windings arevacuum poured by insulated resin.

PARAMETERS:

Technical parameters	
Standards	IEC60044-1; IEC 61869-2; ANSI C57.13; NTC 2205; GB1208-2006
Rated primary current	30-600A
Rated load	≤10VA
Rated frequency	50Hz or 60Hz
Rated secondary current	5A or 1A
Rated short-time thermal current	40kA, 1S
Rated continuous thermal current	120%I1n
Secondary winding power-frequency voltage	3kV, 1min
Instrument security factor	FS≤10
Mechanical parameters	
Dimensions (W×D×H) (mm)	φ50xφ110x52
Weight (kg)	1.6
Operating conditions	
Operating temperature	-35°C to +55°C
Daily average temp	<+40°C
Altitude	<3500 meters
Condition	No existence of severely begrimed, erosive and radioactive gas in the air. Permission of long-term operation under rated current.

$$I_{k3} = \frac{66000}{\sqrt{3} \bullet \sqrt{(0.172)^2 + (39.204)^2}} = 971.961\ A$$

$$I_{y3} = 971.961 \bullet 1.03923 = 1010.0910\ A$$

66kv current transformer:

Fig.14 66kv current transformer

Quick Details

Place of Origin: Shanghai, China

Brand Name: forlong

Model Number: LJW-10 LJWD-10 current transformer

Usage: Current

Phase:Three

Coil Structure:TOROIDAL

Coil Number:AUTOTRANSFORMER

Supply Ability: Supply Ability

800000 Piece/Pieces per Month

Packaging & Delivery:

Packaging Details

standard export package

Port:

shanghai/Ningbo

Model & specifications:

Type	Rated transformation ratio(V)	Accuracy Classes combination	Accuracy class and rated output COSØ=0.8				1s thermal current(KA)	Rated dynamic current(KA)
			0.2S	0.2	0.5	10p10		
LJW-10 LJWD-10 (LB-10)	5/5	0.2S 0.2 0.5 10P10 0.2S/10P10 0.2/10P10 0.5/10P10	10	10	15	20	0.3	0.75
	10/5						0.6	1.5
	15/5						0.9	2.25
	20/5						1.2	3
	30/5						1.8	4.5
	40/5						2.4	6
	50/5						3	7.5
	75/5						4.5	11.25
	100/5						6	15
	150/5						9	22.5
	200/5						12	30
	300/5						18	45
	400/5						24	60

2.7 Calculation of Circuit Breakers

$$I_{k4} = \frac{66000}{\sqrt{3} \bullet \sqrt{(4.524)^2 + (366.45)^2}} = 102.716\ A$$

$$I_{y4} = 102.716 \bullet 1.03923 = 106.745\ A$$

$w = 2\pi f = 314$

$L_0 = 0.0757$

+0.508 mH(henry)

$C_0 = 136$ pF/m

$$X = X_C - X_L = \frac{1}{Cw} - wL =$$

$$= \frac{1}{(136 * 10^{-12} * 3.14)} - (0.757 + 0.508).10^{-3} * 3.14 * 66 = 390.28 - 23.85 = 366.45$$

R4=0.0754*90=4.524ohm

For I_{k3}***:***

66KV 72.5KV 1200A 1250A 2000A 40kA Outdoor High Voltage HV Dead Tank SF6 Gas Circuit Breaker with Tripolar Operating Mechanism

Fig.15 66KV 72.5KV 1200A 1250A 2000A 40kA Outdoor High Voltage HV Dead Tank SF6 Gas Circuit Breaker with Tripolar Operating Mechanism

Quick Details

Place of Origin:Zhejiang, China

Brand Name:Boerstn

Model Number:LW30-72.5/1200A

Type:High Voltage

Pole numbers:3

Rated Current:1000A/1250A/2000A

Rated Voltage:66KV/72.5KV

Frequency:50Hz/60Hz

Product Name:Outdoor High Voltage HV Dead Tank SF6 Gas Circuit Breaker.

Supply Ability:

50 Set/Sets per Month.

Outdoor Sulfur Hexafluoride (SF6) dead tank circuit breakers,

· Nominal voltage: 72.5kv

· NOMINAL POWER: 1200

· FREQUENCY: 60 HZ

· Withstand voltage lightning impulse: 350KV

· Interruption time: 3CICLOS

· Actuation: TRIPOLAR

· SHORT CIRCUIT CURRENT (ICC):

· AC RMS VALUE COMPONENT:

· 40KA with X / R = 25

· 46KA with X / R = 17

· COMPONENT DC: 39%

· Opening time <33ms

· DURATION OF SHORT CIRCUIT: 3.0 SEC

· SHORT CIRCUIT CURRENT PICO: 104KA

· NOMINAL CLOSING TIME: 65ms

· SEQUENCE OF OPERATION:

· HIGH SPEED reclosing: O-0.3Sec-CO-1min-CO

· RE-CLOSING HIGH SPEED NO: CO-15s-CO

· TRV (VALUE PICO): 137KV

· TYPE OF SERVICE: EXTERIOR (interperie)

· ARC EXTINCTION: SF6

· REGISTRATION OF OPERATION: MUST HAVE A CONTACT NO.DE OPERATIONS

· TENSION CONTROL: 125VDC

· OPERATING MECHANISM: SPRING

· COIL OPENING NUMBER 02

· CLOSING COIL NUMBER 01

· SAFETY POSITION SWITCH: LOCAL-OFF-REMOTE

· ENGINE: 125VDC

· Bushing MATERIAL: PORCELAIN

· Bushing creepage distance 25 mm / KV

· cts INCLUDED IN BUSHINGS: 06 cts 600:5 MR C400 and 03 cts 600:5 0.3B1.8

· SUPPORT STRUCTURE: INCLUDED HOGALVANIZED BY ASTM A 123

· THE SWITCH MUST INCLUDE GAS SF6 FOR FIRST FILLING

· THE SWITCH SHOULD HAVE BEEN TRIALED TO INTERRUPT SUCCESSFUL CURRENTS IN ACCORDANCE WITH IEC 62271-110

· The switch must be class C2 CAPACITIVE CURRENTS FOR SWITCH WITH TENSION FACTOR OF CAPACITIVE (CAPACITIVE VOLTAGE FACTOR) 1.4 According to IEC 62271-100 STANDARD

· SEISMIC QUALIFICATION: HIGH 0.5g per IEEE-693-2005

· DEGREE OF PROTECTION OF CONTROL CABINET: NEMA 4

For I_{k3}:

11kv 630A/1250A/1500A/2000A/2500A Vcb Zn63 (VS1) Indoor Vacuum Circuit Breaker

Fig.16 11kv 630A/1250A/1500A/2000A/2500A Vcb Zn63 (VS1) Indoor Vacuum Circuit Breaker

Basic Info.

Model NO.	vcb
Operation	Energy-storage Type
Arc-extinguishing Medium	Air
Structure	VCD
Type	Circuit Breaker
Certification	CE
Keyword	VSD
Trademark	MSLT or OEM
Origin	Shanghai

Breaking Capacity	Middle Voltage
Speed	High-Speed Circuit Breaker
Installation	Fixed
Poles Number	3
Function	Conventional Circuit Breaker
Name	Circuit Breaker
Rated Insulation	12kv/24kv
Transport Package	Standard Export Box

LW-36 126kV outdoor high voltage SF6 circuit breaker Vacuum Load Circuit Breaker

Fig.17 LW-36 126kV outdoor high voltage SF6 circuit breaker Vacuum Load Circuit Breaker

Place of Origin:Jiangxi, China

Brand Name:L&R

Model Number:LW-36

Type:High Voltage, LW-36

Poles Number:3

Rated Voltage:Other

Product name:66kV SF6 circuit breaker

Rated voltage:126KV

Rated current:2500A~3150A

Standard:IEC60056,IEC60265

Material:Procelain,copper,hot dip Galvanized steel and SF6 air

Rated frequency:50\60Hz

Application: npower station

Mechanical Life:6000

Packing:Wooden Case

Supply Ability: Supply Ability

10 Set/Sets per Month

2.8 Fuses

GE POWER CONTROLS Kemxo 120A 11kV HRC Fuse Link

Fig.18 GE POWER CONTROLS Kemxo 120A 11kV HRC Fuse Link

Item specifics:

Condition:New other (see details)

MPN:BS2692

Brand:GE Power

UPC:Does not apply

Kemxo 120A, 11kV HRC Fuse Link

NOTE: Postage and handling fees cover signature on delivery and insurance.35

Electrical Supplier 11kv to 66kv High Voltage Drop out Fuse

Fig.19 Electrical Supplier 11kv to 66kv High Voltage Drop out Fuse

Breaking Capacity:	High
Usage:	High Voltage
Fuse Tube:	Epoxy Resin
Insulator Material:	Porcelain, Ceramic
Rated Voltage:	11kv to 66kv
Leakage Distance:	250mm

Basic Info.

Model NO.	PD3	Rated Current	up to 200A
Safety Standards	IEC	Certificate	ISO9001
Color	White	Installation	Open Frame
Transport Package	Carton for Electrical Supplier 11kv to 66kv	Trademark	YONGDE
Origin	Zhejiang, China (Mainland)	HS Code	85354000

Fuse: fuse; 175A; 32VDC; automotive

Manufacturer	**MTA**
Type of fuse	**fuse**
Current rating	**175A**
Rated voltage	**32V DC**

Kind of fuse	**automotive**
Colour	**white**

Additional information

- Gross weight: 5.6 g
- Manufacturer part number: 0615175

Count on the high interrupting rating of our most widely used class L fuse

Fig 20 A4BY650 600V 650A L TD FUSE

Ratings:

Volts: 600V

AC: 300VDC

Amps: 200 to 6,000A

(AC): 200 to 2,500A

(DC) IR: 200kA.I.R.

AC: 100kA I.R. DC

Dimensions

Ampere Rating	A		B		C		D		E	
	in	mm	in	mm	in	mm	in	mm	in	mm
200-600	8-5/8	219	2	51	5/16	8	1-5/8	41	2-13/32	61
601-800	8-5/8	219	2-1/2	63	3/8	9	2	51	2-13/32	61
801-1200	10-3/4	273	2-1/2	63	3/8	9	2	51	3-15/32	88
1201-1600	10-3/4	273	3	76	7/16	11	2-3/8	60	3-15/32	88
1601-2000	10-3/4	273	3-1/2	89	1/2	13	2-3/4	70	3-15/32	88
2001-2500	10-3/4	273	4-1/2	114	3/4	19	3-1/2	89	3-15/32	88
2501-3000	10-3/4	273	5	127	3/4	19	4	102	3-15/32	88
3001-4000	10-3/4	273	5-3/4	146	3/4	19	4-3/4	121	3-15/32	88
4001-5000	10-3/4	273	6-1/4	159	1	25	5-1/4	133	3-15/32	88
5001-6000	10-3/4	273	7-1/8	181	1	25	5-3/4	146	3-15/32	88

2.9 Relay Protection

Fig.21 relay protection

SIPROTEC 7SX800:

From Siemens | for the Future | for You. The universal protection relay SIPROTEC 7SX800 has the high development and manufacturing quality of Siemens, is equipped for future challenges and is predestined for beginners and professionals alike. This efficient and compact device protects your feeders, lines and motors in the medium-voltage power grid in the utility and industrial sectors.

SIPROTEC 7SX800 - universal protection relay

SIPROTEC 7SX800 - the universal protection device for all your medium-voltage applications impresses with high performance and an extensive function library. You now only need one device for the various protection types with different configurations already predefined in application templates.

Highlights of SIPROTEC 7SX800

- Slim design with a high number of IOs
- Virtual testing with SIPROTEC DigitalTwin
- IoT connectivity for easy access to your device data and associated fast response times

- Embedded cyber-security features to protect your device and maximize power grid availability
- Intuitive device operation with the web user interface
- Proven engineering tool DIGSI 5

Functions:

- Directional and non-directional overcurrent protection with additional functions
- Detection of ground faults of any type in compensated or isolated electrical power systems using the following functions: 3I0>, V0>, transient ground fault, cos φ,
sin φ, harmonic detection, dir. detection of intermittent ground faults, and admittance.
- Optimized operate times thanks to directional comparison.
- Motor protection functions: Startup time supervision, thermal overload protection for stator and rotor, restart inhibit, unbalanced-load. protection, load-jam protection.
- Stator and bearing-temperature monitoring via temperature sensors with external RTD unit.
- Sensitive ground-fault protection (directional, non-directional) to detect stator ground faults.
- Controlled automatic reclosing of overhead line sections.
- Overvoltage and undervoltage protection.
- Frequency protection and rate of frequency change protection for load-shedding applications
- Underfrequency load shedding in case of underfrequency, taking into consideration changed infeed conditions due to decentralized power generation.
- Power protection, configurable as active or reactive-power protection.

- PQ – Basic: Voltage unbalance; voltage changes: Overvoltage, dip, interruptions; TDD, THD, and harmonics.
- Directional reactive power undervoltage protection (QU protection).
- Control, synchrocheck, and switchgear interlocking protection.
- Circuit-breaker failure protection and reignition monitoring.
- Graphical logic editor.
- Single-line representation.

CHAPTER 3. ECONOMICAL PART

Table of all Material costs:

name	the number of pieces	Price for each piece	COST
monocrystalline solar panel	234000	350$	81900000$
Transformer11/0.433kV	18	7000$	126000$
Transform 66KV	2	50000$	100000$
MVT1.11KV	2	10000$	20000$
MVT2.66KV	2	15000$	30000$
INVERTER(HighPower (SHP 150-20))	90	7500$	675000$
Cable (Mssoomm Copper Flat Bar)	1000m^2	100$	100.000$
Cable (GB12527-91,IEC502)	1500m^2	50$	75000$
Cable (N2XS2Y XLPE PE - 6/10(12)kV)	1000m^2	4000$	400000$
Cable (TYPE TWO 0.6/1k)	1500m^2	40$	60000$
Current Transformers1 (M140100H)	18	350$	6300$
Current Transformers2 (LZCK322)	19	450$	8550$
Current Transformers3	18	250$	4500$
Current Transformers4	2	1300$	2600$
Current Transformers5	2	1500$	3000$
Current Transformers6LJW-10 LJWD-10	2	1200$	2400$
Breaker1.For 11kv	18	12000$	216000$
Breaker2. For 11kv	2	1100$	2200$
Breaker3.For 66kv	2	6200$	12400$
Breaker4. For 11kv	2	5000$	10000$
Breaker5. For 66kv	2	4000$	8000$
FuseBS2692	2	170$	340$
FuseEpoxyResin	18	55$	990$
Fuse200kA.I.R. AC	90	100$	9000$
Disconnector 66KV Porcelain Lightning Arrester	2	320$	640$
protection relaySIPROTEC 7SX800	59	7500$	442500$
total			84122420$

CONCLUSIONS

The suitability of building sun power stations within the selected area has been calculated and proved

Set up by:

- Electrical circuit of sourcing substations 66/11;11/0.69
- The calculation has been done and all the protection devices have been selected.
- Estimation of the main and sub-components of a wind station was done.
- The total prices of wind stations is 84122420$$.

REFERENCES

1. https://globalsolaratlas.info/detail?c=33.036298,44.263916,11&s=33.036132,44.263504&m=site.
2. https://gosolar.com.ua/p1484524703-inter-energy-660.html?source=merchant_center&gclid=Cj0KCQiA3rKQBhCNARIsACUEW_YcGRxL49Voprg87MGuAqcmWRHxGdLH_QOZxtFMbXqswKH3zGVhZScaApMbEALw_wcB
3. https://daelim-electric.com
4. https://www.estg.eu/en-gb/sunny-highpower-peak3-shp-150-20/
5. https://www.amazon.com/Mssoomm-Copper-Flat-1000mm-Metal/dp/B08L9BDHQ9/ref=sr_1_11?keywords=copper%2Bbus%2Bbar&qid=1650618751&sr=8-11&th=1
6. https://www.elandcables.com/electrical-cable-and-accessories/cables-by-standard/hd-620-cable?gclid=Cj0KCQjw4PKTBhD8ARIsAHChzRJK2HTwWob_0bHQLWLLg11HDsW9U5r6g_smZzoQ4SRSYV_JZRUnp4saAkBxEALw_wcB
7. https://www.luxingcable.com/medium-voltage-cables/0-6-1kv-aluminiun-core-aerial-bundled-cable.html
8. https://www.gdrectifiers.co.uk/products/bussmann_square_body_fuses
9. https://www.gfuve.com/split-core-current-transformer/33kv-high-voltage-split-core-current-transformer.html?gclid=Cj0KCQjwg_iTBhDrARIsAD3Ib5jiuTQlL2-vxHXe_XfEqDaar7LQ5grzSYXvCWAFN6lVSFkK9lrI74MaAmKAEALw_wcB
10. https://www.alibaba.com/product-detail/66kv-current-transformer_737875793.html?spm=a2700.7724857.normal_offer.d_title.e44564d72StJZG
11. https://www.cncablegroup.com/product/66KV_AWA_Armored_Power_Cable.html
12. https://new.siemens.com/global/en/products/energy/energy-automation-and-smart-grid/protection-relays-and-control/universal-protection-relay.html

13. https://shooshannelectrical.en.made-in-china.com/product/TKMxamhJVIRd/China-11kv-630A-1250A-1500A-2000A-2500A-Vcb-Zn63-VS1-Indoor-Vacuum-Circuit-Breaker.html
14. https://www.nedco.ca/cnd/Brand/MERSEN/A4BY650-600V-650A-L-TD-FUSE/p/MERA4BY650-QO
15. https://www.tme.eu/en/details/megacompact-175a/other-car-fuses/mta/0615175/
16. https://hzyddq.en.made-in-china.com/product/HotEZGNMZriy/China-Electrical-Supplier-11kv-to-66kv-High-Voltage-Drop-out-Fuse.html
17. https://www.ebay.com/itm/254483214604
18. https://www.alibaba.com/product-detail/66kv-current-transformer_737875793.html

APPENDIX A.

Safety precautions for sun power station workers:

THINK SAFETY

Work a safe distance from power lines. Cover the solar array with an opaque sheet to “turn off” the sun's light. Lockout/Tagout and de-energize AC and DC power sources. Always test circuits to ensure they are de-energized before working on them

Here are our top tips for practicing safety in solar installations.

- Prevent a Fall. As mentioned above, a big risk in installing solar is the potentiality of falling. ...
- Don't Work in the Rain. ...
- Avoid Electric Shock. ...
- Check for Damage. ...
- Do Not Work Alone.

Remain at least 10 feet away from a solar installation. Never walk on solar panels. Never cut conduit or the solar system's electrical wiring. Never break a panel or contact a damaged system.

Like any other source of electricity, solar panels can pose a hazard. If you have panels installed on your roof or elsewhere on your property, please be aware of the risks and keep a safe distance from the electric equipment.

Emergency responders should also be aware of the risks involved with a solar array. (Solar water heating systems are slightly different and are not discussed here.) How do they work?

An array of solar panels generates direct current (DC) electricity. Inverters convert the power into alternating current (AC) that your appliances can use. A system may have many small individual inverters attached to individual solar panels or larger inverters located near the building’s electric meter or main distribution panel.

Most of the electric wires run through conduit along the outside of the building. Typically, an AC disconnect switch is mounted near the electric meter or the home's main distribution panel. Each disconnect switch must be labeled to identify the solar array to which it is connected.

The disconnect switch will only disconnect the home from the solar array. **The panels will still generate DC power and can cause a shock**. If the solar system has a battery backup, it will also continue to produce power.

Remember, as long as the sun is shining, solar panels will stay energized.

Beware of hazards:

A variety of hazards are associated with roof-mounted and free standing solar systems. Be aware of the following:

- Shock or electrocution from contacting wiring
- Inhalation of toxic smoke from burning solar panels
- Roof collapse from weight of solar arrays
- Injury and endangerment of others from walking on, tripping, and falling on solar panels

Prevent injury:

Remain at least 10 feet away from a solar installation.

- Never walk on solar panels.
- Never cut conduit or the solar system's electrical wiring.
- Never break a panel or contact a damaged system.

In case of emergency:

For the general public:

Open the solar array's AC disconnect switches to de-energize the AC side of the solar system. The array will continue to produce DC power as long as there is a light source.

Wait for first responders to arrive and remind them that you have a solar PV system.

For first responders:

Circle the building and follow any solar identified electrical conduit to locate the solar panels.

Open the solar AC disconnect switch if the building or home owner has not already done so. The solar array will continue to produce DC power as long as there is a light source.

Cover solar panels with a black or blue tarp to block any light from shining onto the panels. Make sure the tarp is secured and will not blow away.

Spray water if needed to extinguish fire in a safe manner.

Large solar installations:

Treat a large solar farm as you would an electric substation.

Don’t enter a solar farm without permission from the electric utility. Only enter the facility when the utility confirms that the equipment is de-energized.

If a bystander is inside the area and requires assistance, do not enter until it is safe to do so. Shout instructions to the bystander from a safe distance.

Warn and signal any bystander to remain a safe distance from the area.

Safety guides:

Download and print our guides for solar panel safety.

Effective risk management is vital to ensuring sun panels safety. Site managers and contractors should ensure that all sun panels workers are correctly informed, educated, and knowledgeable about the risks and hazards that can occur during their duties, especially concerning electrical hazards and the risks of working with certain tools and materials.

Contractors and site managers should also endeavor to conduct ongoing task-specific risk assessments to uncover any hazards specific to their sun panels and implement appropriate control measures. Supervision is vital in monitoring operations and identifying areas for improvement and compliance.