# Environmental Impact and Safety Assessment report.

## For

## Photovoltaic Power Plant Project
## Solar Power (Korat 2) Co., Ltd.

## March 2011

# Chapter 1

## Project Details

This report is a summary of preventative measure taken and a revision of the impact on environmental quality and safety issues according to the proclamation of the Ministy of Industry BE 2552, for the 6 megawatt solar power farm project Solar Power (Korat 2) Co., Ltd. The project is located in Don Chomphu Sub-district, Non Sung District, Nakhon Ratchasima Province. In the preparation of this report, the primary and secondary data used for making the analysis was obtained at a regional and provincial level for physical, environmental and biological resources and at the level of sub-district (for human utilization values and quality of life issues), and to study any impact occurring around the project area (within a 1 kilometer radius).

## 1.1 The project location and transportation into the area

### 1.1.1 The project location

The project is located at Moo 11, Baan Jok, Don Chomphu Sub-district, Non Sung District, Nakhon Ratchasima Province. It is situated along the national highway no. 2 (Mittrapap Road) from Saraburi Province to Nakhon Ratchasima Province (furthering up to the north into Khon Kaen Province), at the 35$^{th}$ kilometer which on both sides is the area of Don Chomphu Sub-district. The project is about 14 kilometers from the city of Non Sung District, and occupies an area of approx. 80 rai (as shown in Figure 1.1). The project's border is as follows:

**North:** Lum Khao Sub-district, Non Sung District, Nakhon Ratchasima Province.

**South:** Bing Sub-district, Non Sung District, Nakhon Ratchasima Province.

**East:** Samrit and Tharn Lalot Sub-district, Phimai District, Nakhon Ratchasima Province.

**West:** Lum Khao and Mai Sub-district, Non Sung District, Nakhon Ratchasima Province.

Don Chomphu Sub-district has been divided into 13 villages, as follows:

| | |
|---|---|
| Moo 1 - Baan Don Chomphu | Moo 8 – Baan Si Suk |
| Moo 2 – Baan Som | Moo 9 – Baan Don Sabaeng |
| Moo 3 – Baan Mara | Moo 10 – Baan Don Chomphu Phatana |
| Moo 4 – Baan Sa Phruan | Moo 11 – Baan Jok |
| Moo 5 – Baan Don Ree | Moo 12 – Baan Saen Suk |
| Moo 6 – Baan Mueang Tee | Moo 13 – Baan Mitrapap |
| Moo 7 – Baan Plor Paw | |


**Figure 1.1** The project location in Don Chomphu Sub-district, Non Sung District, Nakhon Ratchasima Province

The data on Don Chomphu Sub-district is derived from the primary data surveyed in the area together with the secondary data derived from various related agencies such as, the provincial development plan, the agricultural development plan (sub-district level), and the strategies for Sub-district Administration Organization development plan. It was found that for the natural resources, the soils are mainly of low quality however, they are suitable for growing rice and sugar cane. There is natural water sources flowing through the area, the most important one is Moon River, which provides water perennially. In addition there are man-made sources which are used for consumption, cultivation: growing vegetables and dry season crops, raising animals as well as catching/raising aquatic animals. All public utilities are available, for ex: electricity, water, telephone, etc. Also business and service units are available in the sub-district: cooperatives, rice mills, shops, and service centers, etc. For economics, it was found that the agriculturists grow rice as the principal occupation and grow secondary farm crops: such as tapioca to supplement income. The agriculturists own 90% of the land. (And have title documents). However, some problems still exist: poor quality soil, lack of grassland for raising animals and animal food sources; water quantity for agriculture is still not enough, and the majority of people still rely on rain water. Natural water sources are shallow in the dry season which makes them difficult to use.

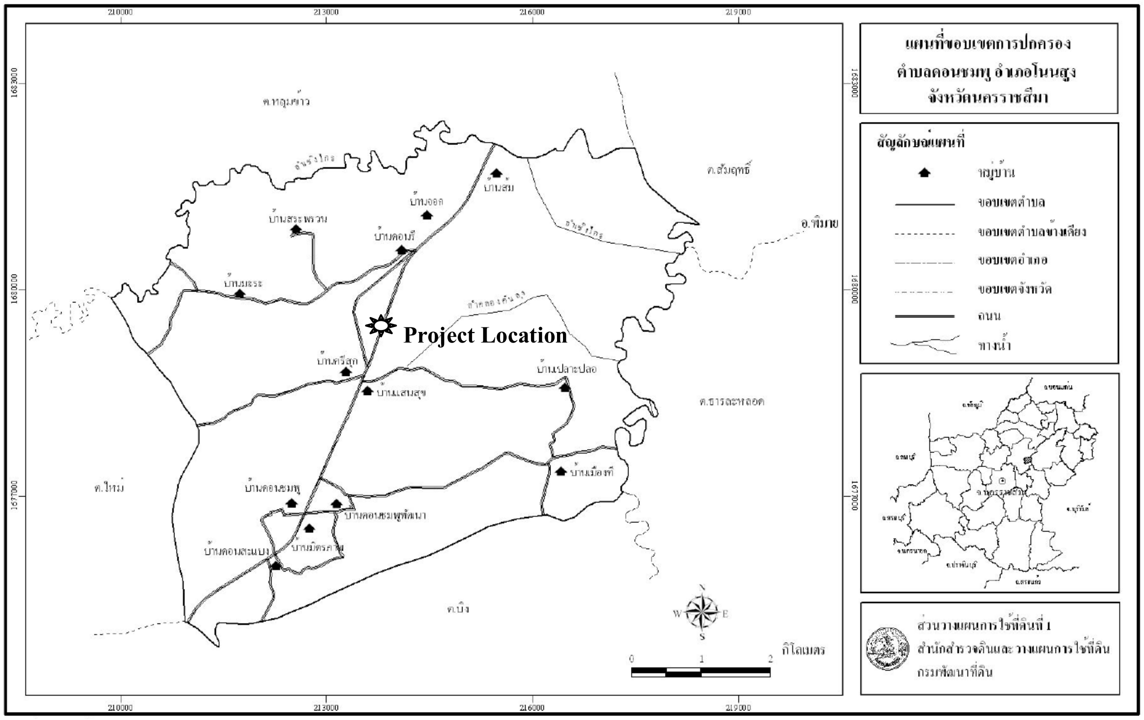



**Figure 1.2** The location of Don Chomphu Sub-district, Non Sung District, Nakhon Ratchasima Province and sharing boarders.

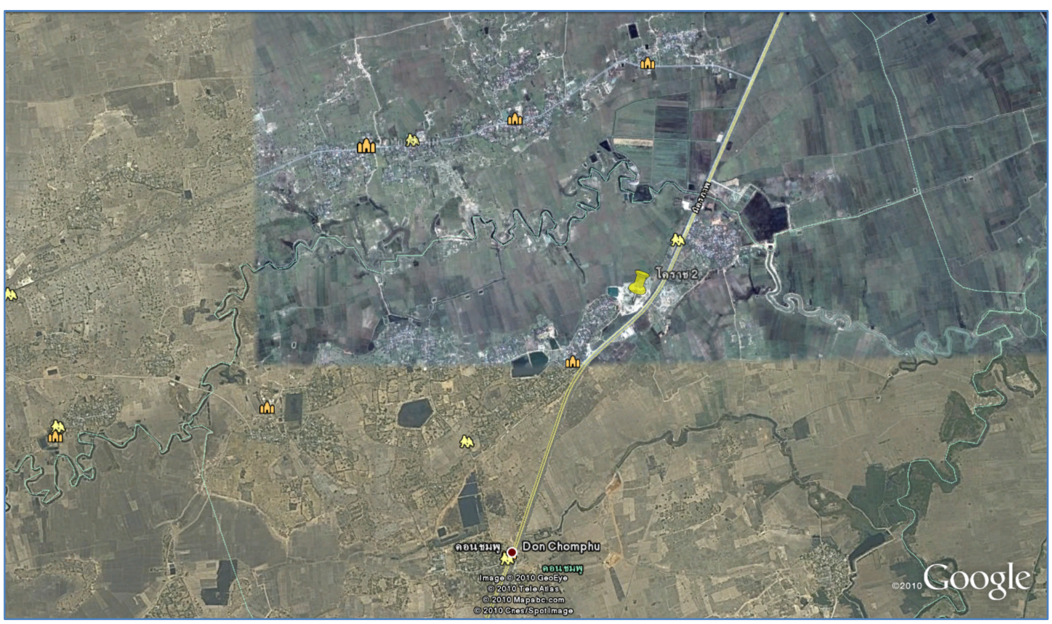



**Figure 1.3** aerial photographs showing the solar power plant’s boundaries

### 1.1.2 Transportation into the project area

Don Chomphu Sub-district is located in the north of Non Sung District, and is far from Non Sung District office about 14 kilometers. The project area is close to the national highway route no. 2 (Mitrapap Road), with the following communication lines:

From Bangkok, use the national highway no. 1 (Phaholyotin Road - Saraburi), break off in the area of $107^{th}$ kilometer into the highway no. 2 (Mitrapap Road) and into Nakhon Ratchasima Province to the $35^{th}$ kilometer burstone. Don Chomphu Sub-district area occupies both sides of the road. The total distance is about 294 kilometers.

Another route: from Bangkok using the highway no 304 passing Min Buri, Chacherngsao, Phanom Sarakham, Kabin Buri, Wang Nam Keaw, Pak Thong Chai to Nakhon Ratchasima, with the total distance of approx. 273 kilometers. Or use the route of Rangsit – Nakhon Nayok which connects with the highway no. 33 to Kabin Buri, and then breaking off into the highway no. 302 through Wang Nam Keaw to Nakhon Ratchasima.

## 1.2 The Characteristic and scope of project implementation

### 1.2.1 Details summary

The project is a 6 megawatt solar power farm.

A solar photovoltaic power farm is basically a clean energy power producer. Solar modules are silicon semiconductor devises that produce electricity when exposed to sunlight. A typical 6 megawatt SPC solar power farm uses 29,160 by 210 watt solar modules; these modules produce DC electricity that is converted to 3 phase AC electricity by 540 by 11 kilowatt inverters. The modules are mounted on steel frames at a 15 degree angle to maximize the electricity production throughout the year. The AC electricity or power is sent to a control center where it is controlled and monitored and then is passed to transformers which boost the power to 22,000 volt and then fed into the PEA national grid system. As the project has no moving parts a solar power farm is very reliable and has a very low maintenance requirement. A solar farm requires no fuel other than free sunlight. The design life of a solar power farm is in excess of 30 years.

1) *Solar cell panel*, production capacity per panel = 210 watts, total 29,160 panels, total production capacity = 6.123 megawatts. The panel type is poly crystalline silicon; module efficiency is approx. 15%.
2) *Inverter/Converter*, size 11kW/set, 540 sets, total 5.94 megawatts, the conversion efficiency is not less than 98%.
3) *System Controller and Data Acquisition* perform the duty of controlling the operation of the electrical current converters.
4) *Electricity distribution system* the distribution system consists of transformers and switch gear, which boosts the output voltage to 22,000 volts to enable connection to the Provincial Electricity Authority (PEA) system. This equipment collects data and shows the value of electricity sold. There are 6 sets of transformers each rated at 1.25 megawatts per set.
5) *Prevention system* used to control safety (this is connected with PEA's monitoring system).

### 1.2.2 Characteristic and factors of the project

The technology used to convert solar energy into electric energy is convenient, easy to use, has long useful life, needs not much maintenance, and is used in every place having sufficient light from the sun as well as the energy production process being clean and environmentally-friendly. However, to acquire the energy and use it in the form of electric energy, solar energy (in the form of sunlight) has to be changed to electric energy first by using the following equipment, solar cell modules, transformers, control and data collection systems, and electricity distributing system.

#### 1.2.2.1 Solar cell

The most popular solar cells are made from silicon. Silicon is an element which is abundant and available in many countries, for ex: in beach sand and in quartz. The solar cell which is made from silicon can be divided according to the characteristics of crystalline structure, into 3 types, as follows:

1) *Single crystalline silicon* This type of solar cell is derived from melting the silicon which has a purity of 99.9999% at the temperature of about 1,500 degrees Celsius, to make it grow as single large-sized crystalline bar by crystal pulling technology (with a diameter of 6-8 inches). Then slice the single crystalline bar into thin sheets called wafer which may be in the form of rectangle or circle with a thickness of about 300 micrometers. The wafers are diffused with phosphorus substance to create P-N junction at the temperature of approx. 1,000 degrees Celsius. After that they will be connected together in a circuit to generate electrical current. Figure 1.4 shows a sample of single crystalline silicon solar cell.

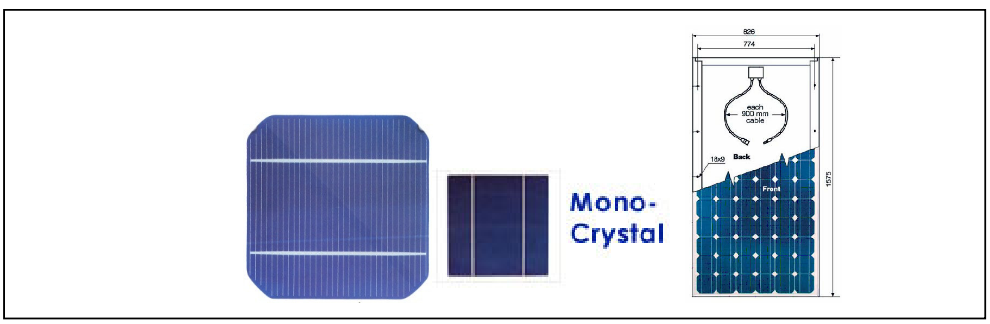



**Figure 1.4** Poly Crystalline Silicon Solar Cell.

2) *Poly crystalline silicon* is a type of solar cell. Poly silicon is the silicon bar derived from the melting and casting of the raw silicon. The production cost is cheaper but the efficiency is slightly lower than that of the single crystalline silicon. Figure 1.5 shows the sample poly crystalline silicon solar cell.

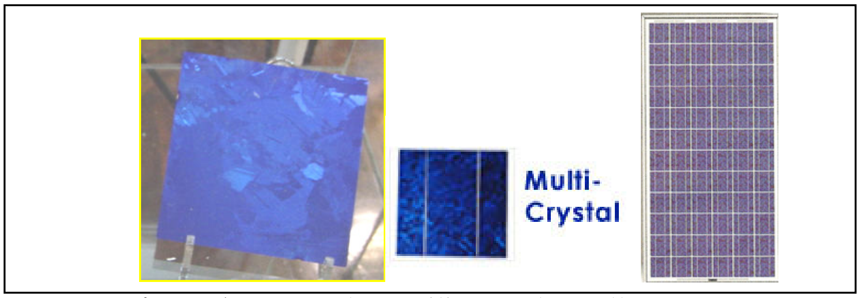



**Figure 1.5** Amorphous Silicon Solar Cell

3) *Amorphous silicon or thin film* the thin film solar cell has absolutely different production methods from the crystalline solar cell. It is produced by flowing silane and Hydrogen gas (SiH4) into a vacuum chamber and coating a glass substrate. At this time the gas combines and accumulates on the base plate, making a silicon film, while boron gas (B2H6) is introduced to make a coating creating a P-type joint, then phosphate gas is introduced to create the N-type joint. After the P and N-type junctions have formed a solar module has been created (as shown in Figure 1.6).

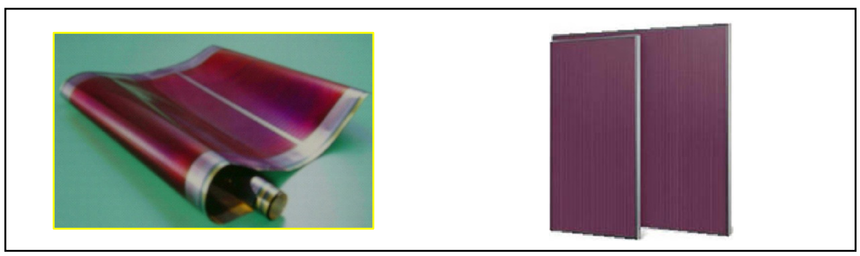


**Figure 1.6** Other Thin Film Silicon Solar modules

4) *Other types of thin film solar modules can be made by using*, for ex: Gallium Arsenide (GaAs), Cadmium Telluride (CdTe), Copper Indium Di-arsenide (CIS), etc. Some of these types of solar modules are made from substances causing pollution and often have the problem of usage duration.

**Table 1.1** Comparing the efficiency of various types of solar modules.

| **Solar cell type** | **Efficiency of cell (%)** | **Efficiency of panel (%)** |
|---|---|---|
| 1. Single crystalline silicon | 15-24 | 10-14 |
| 2. Poly crystalline silicon | 10-17 | 9-12 |
| 3. Thin film silicon | 8-13 | 6-9 |
| 4. Various components | | NA |
| GaAs/InP | 18-30 | |
| CdS/CdTe | 10-15 | |
| CuInSe2 | 10-15 | |

Source : The Electricity Generating Authority of Thailand, 2547

### 1.2.2.2 Solar cell characteristics

Normally each solar cell will produce a short circuit current about 3 amperes and give an open circuit voltage about 0.5 volts. Under standard test condition which is the solar cell test under the condition of solar irradiance value of 1 kilowatt per square meter, air mass index value is 1.5 and cell temperature is 25 degrees Celsius. The main factors affecting electricity production of solar cells are:

- **Solar irradiance (G).** For the application of solar cell, various conditions will not be in accordance with the standard test conditions. Therefore, the solar irradiance value will change all the time, resulting in the quantity of electrical current produced from solar cells being changed according to solar irradiance value. That is, if the solar irradiance value is high, the solar cell will produce a great quantity of electrical current. Conversely, if the solar irradiance value is low, the solar cell will produce a small quantity of electrical current. The relation between solar irradiance value and the value of current and voltage is shown in Figure 1.7. And the occurred current value is calculated from:

$$I_{sc} = I_{sc}(STC) \times G$$

When $I_{sc}$ is electrical short-circuit current value at normal conditions

$I_{sc}(STC)$ is electrical short-circuit current value under the standard conditions

G is solar irradiance value at any conditions (watt/square meter, W/m2)

- **Cell temperature.** The cell temperature is another factor which affects electric energy production of solar cell. That is, for single crystalline solar cell, when the temperature is high, the voltage of solar cell will be lower (2.3 millivolts lower). When cell temperature is high (every 1 degree Celsius), the relation between cell temperature and the value of current and voltage is shown in Figure 1.8, and the relation is according to the equation:

$$\frac{dV}{dT} = -2.3 \ (mV/{}^{0}C)$$

The electric power value (P) in Watt (W) derived from solar cell is calculated from:

$$P = IV$$

And the electric energy value (E), which means the quantity of electric power derived for a period of time (t), which is calculated from

$$E = Pt$$

- **Electrical current produced from a solar cell.** Since the solar cell produces direct current electricity and the quantity of current is irregular because of the change of solar irradiance, in the practical use other components or equipment must be utilized to make the use of electricity from solar cell systems secure and reliable.

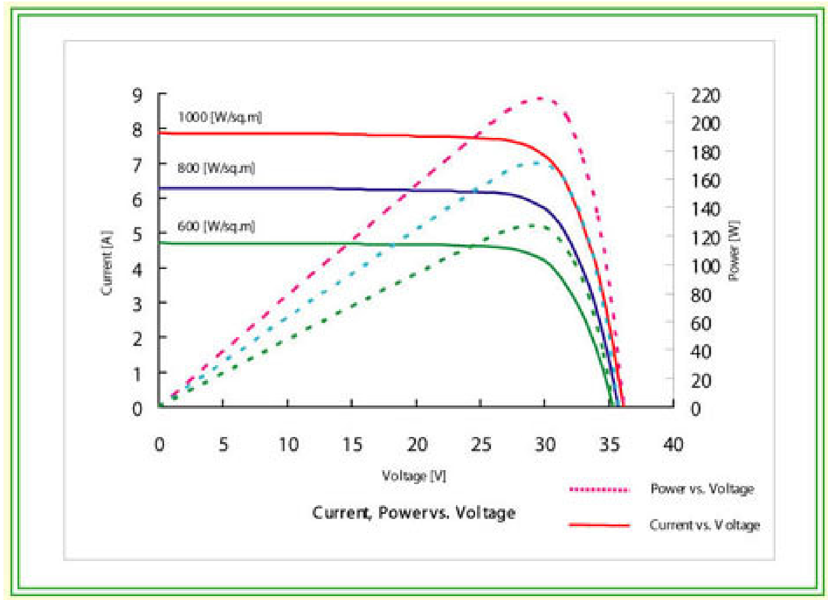
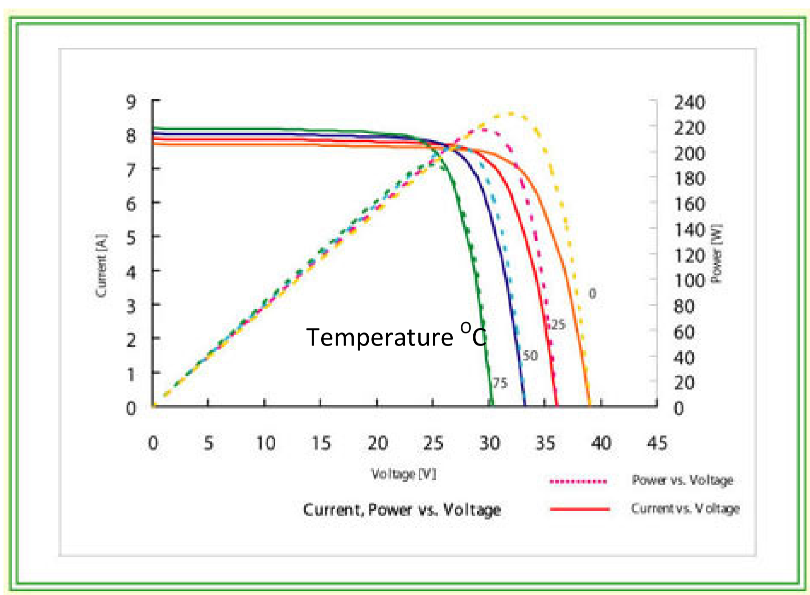



**Figure1.7** Chart showing the relation between solar irradiance value and the value of currents and voltage

Source : Power com Co., Inc. 2004




**รูปที่ 1.8** แผนภูมิแสดงความสัมพันธ์ของอุณหภูมิกับค่ากระแสและแรงดันไฟฟ้า

ที่มา:Power com Co., Inc. 2004

#### 1.2.2.3 Photovoltaic module

This is to connect a number of solar cells together in order to acquire the quantity of electric power needed. For connecting solar cells, the simple principle is that if a large quantity of electrical current is wanted, the solar cells have to be connected in parallel. If high voltage is needed, the solar cells have to be connected in series. Photovoltaic module output is derived by connecting solar cells together in series and connecting many modules of solar cells to be in one row (which is called parallel). If in the system there is connection of many panels, it would be called an array (as shown in

Figure 2.). In general, the solar cell panel characteristics and number used in this system depends on the quantity of load and daily average of sunlight in that area. To install solar modules, it must be done in oblique way in order to receive sunlight in the most perpendicular line. The installation's oblique angle value will equal to that area's latitude. For ex, Thailand is located at the latitude of 15-17 degrees, the installation of solar cell panel will be also made in angular of 15-17 degrees from the horizontal line.

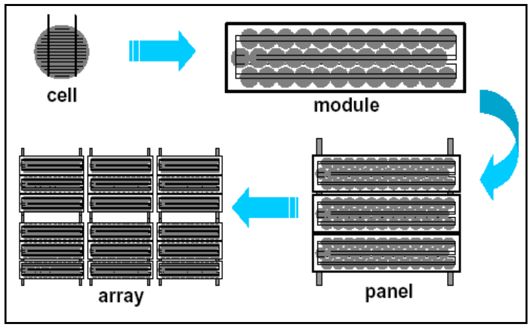



**Figure 1.9** Characteristics of solar cells connection in various forms

#### 1.2.2.4 Inverter/Converter

This is the equipment used for transforming direct current electricity into alternating current electricity. Alternating current electrical can be used to power normal household appliances, for ex: electric rice cookers, refrigerator, TV, electric fans, etc. Using invertors to help transform direct current electricity into alternating current electricity, will always result in some energy loss. However, at present the invertor we use is highly efficient. This is approximately 98% resulting in less than 2% losses. The installation of invertors should be made in a shaded area, having the temperature of not higher than 40 degrees Celsius, humidity not over 60%, good ventilation, and no rats or snakes to cause damages. The examples of invertors or transformer are shown in Figure 1.10.

**Figure 1.10** The examples of transformer

### 1.2.2.5 Photovoltaic Power Generation System

The following are examples of different types of solar systems.

**1)** ***Standalone system*** This type of solar cell system is used as the source for distributing electric energy to the users in remote or isolated areas where the electric lines are not available. The standalone system of solar cells has various sub-forms as shown in Figure 1.11.

***** ***Standalone system of solar modules directly connecting with the load.*** This system is the simplest and most uncomplicated. It is used only with direct current electrical appliances. The system is mainly small, for ex: water pumping system, or used with light bulb or small electric fan, etc.

***** ***Standalone system of solar cell using batteries***. This system can store electric energy to be used during nighttime. However the system is basic and the battery can be easily damaged.

***** ***Standalone system of solar cell with controlling battery charging.*** This system is the same as above but incorporates a battery charge controller to protect the battery. It is more costly and the controllers are not always reliable.

***** ***Standalone system of solar cell used with alternating current load.*** This system is more complicated because the equipment for transforming direct current electricity into alternating current electricity must be used to be utilized with alternating current load, while being able to be used with direct current load also. The system is popular and used in the remote areas having no electricity..

***** ***Standalone system of solar cell having many sources of electricity production or called hybrid system.*** This system not only uses solar cells as electricity production source, there are also other production sources to reinforce the security to the system, for ex: using diesel engine, using wind turbine, etc. Thus making this system rather popular and being extensively used. However, this system is more technically complicated than other systems.

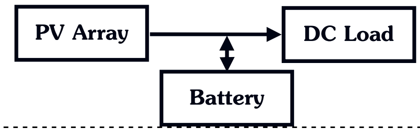
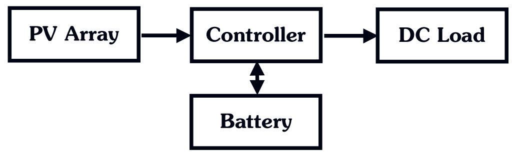
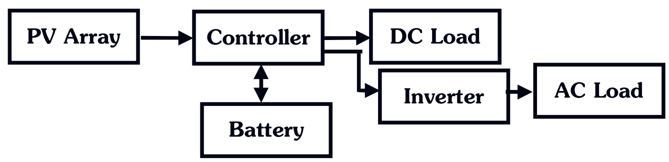
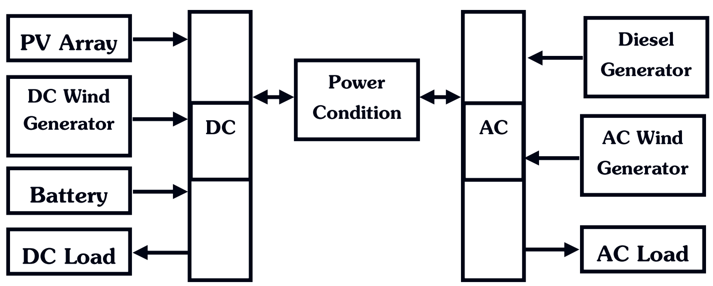
| | |
|---|---|
|  | Standalone system of solar cell directly connecting with the load |
|  | Standalone system of solar cell using batteries |
|  | Standalone system of solar cell having the equipment controlling battery charging |
|  | Standalone system of solar cell used with alternating current load |
|  | Standalone system of solar cell having many sources of electricity production. |

**Figure 1.11** Standalone systems in various forms

**2)** ***Grid connected system*** this type of solar cell system is used by people who need to resell electricity to the grid system. This system only produces power during daytime. This system is popular since during daytime (people going out to work elsewhere), the electricity produced can be sold to the system. During nighttime, electricity can be used from the sending line system. The said quantity of production and electricity use will be calculated to be electricity charge as shown in Figure 1.12.

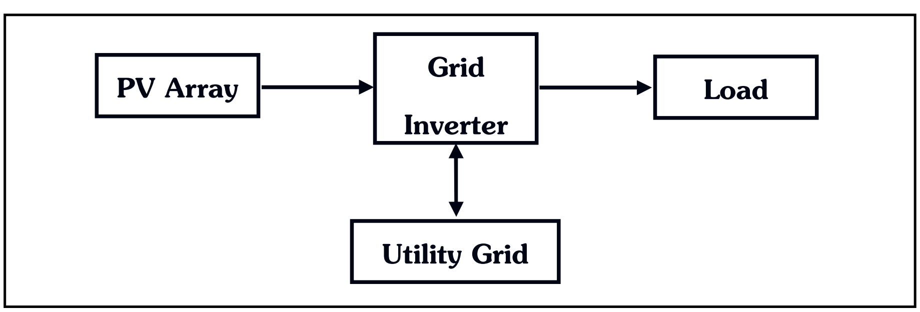



**Figure 1.12** Flowchart of solar cell system type of connecting with the sending lines

### 1.2.2.6 Thailand's potential of solar energy

From the study on Thailand's potential of solar energy, it is found that Thailand has yearly average of solar energy of about 18.2 mega joules per square meter per day. The highest average is 25 mega joules/square meter/day. Observing sunlight brightness during April in the area of upper central linking with some provinces of the northeastern region[1] together with studying the data derived from the weather measurement station, it is found that the radiation of the sun in Thailand has the potential for producing average electricity at 4.6 to 5.3 kilowatts per square meter per day. The total number of hours of the sun's irradiation is 2,200 – 2,900 hours per year or 6 to 8 hours per day[2]. This shows that Thailand has rather high potential of solar energy, thus is suitable for use both in the form of heat energy and electricity production. The map showing Thailand's potential of solar energy is in Figure 1.13.

### 1.2.2.7 Factors affecting the operational efficiency of solar power plant

The important factors causing solar cell to have different operational efficiency in each area, and being utilized to estimate the number of solar panels to be used in each area, are as follows:

- *Panel area*: the larger the solar cell panel, the more quantity of electricity being able to be produced.
- *Brightness of sunlight*: the more sunlight falling on the panels, the more quantity of electricity being able to be produced. However, if there is shade covering the panels, even on only 1 cell, the quantity of electricity produced may be decreased to only a half or lower than a half.
- *Panel placing direction*: the solar cell panel should be placed facing the sun in order for electricity being able to be produced most.
- *Heat*: solar modules work better in cool conditions. If the panel is hot, the electricity produced will be lower.

[1]The Department of Energy Development and Promotion. 2542: 95-96
[2]The Department of Energy Development and Promotion. 2542: 36

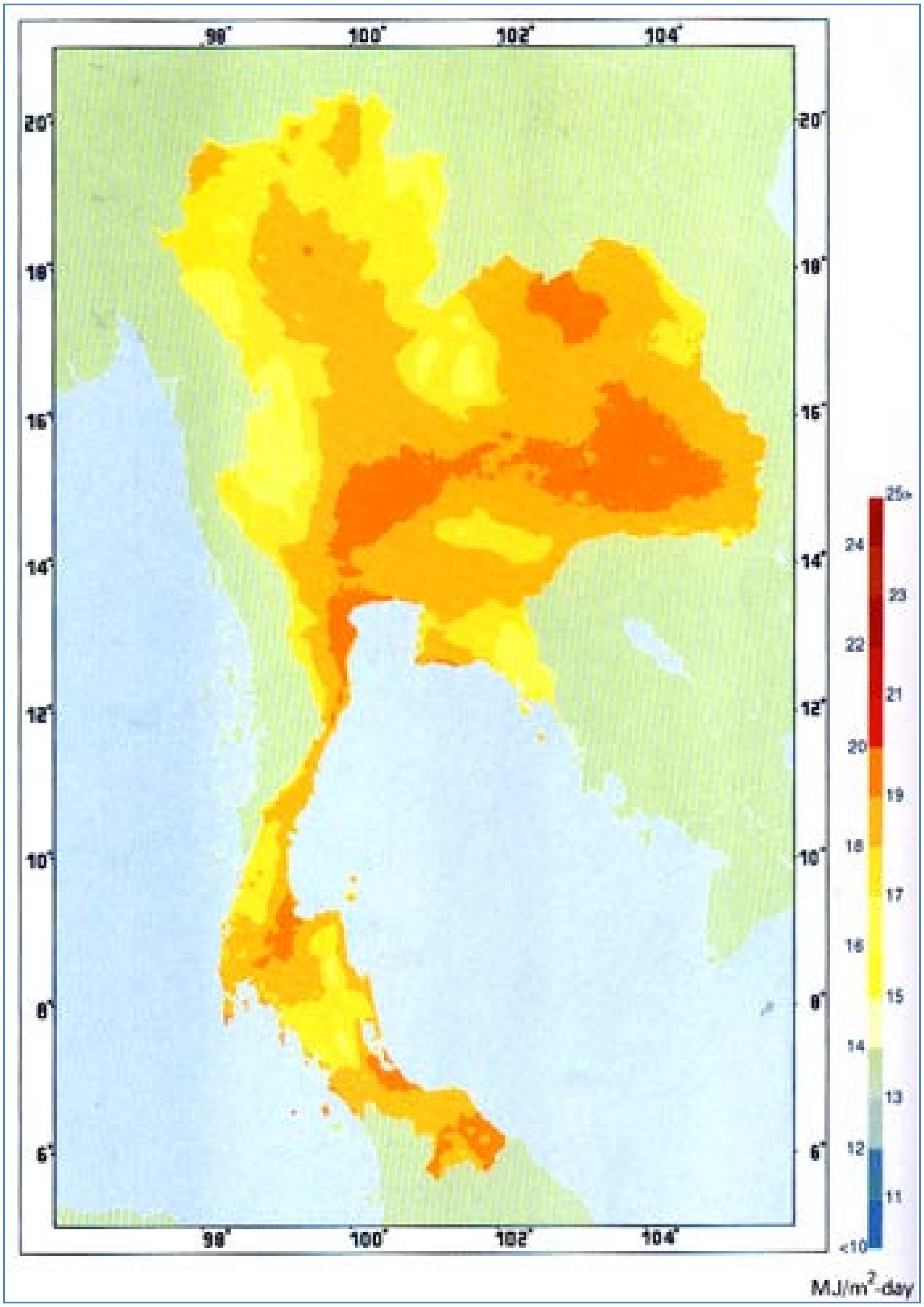



**Figure 1.13** Map showing Thailand's average potential of solar energy throughout the year

Source : The Department of Energy Development and Promotion. 2542: 82

#### 1.2.2.8 PV grid connected system type of electrical currents production from solar cells.

It is the system of producing electricity using solar cells which is designed for producing electricity through the equipment transforming direct current electricity system into alternating current electricity system, directly into the national grid electricity distribution system. Working principles:

1) During daytime, solar cells received sunlight, being able to produce and directly distribute electricity to the load through the equipment transforming direct current electricity system into alternating current electricity system. And the surplus electric energy will be distributed into the electricity distribution system; this can be observed by seeing the electric energy meter rotating backwards.

2) During nighttime, the solar modules will not produce electricity, the electrical current from the electricity distribution system will directly supply the load, this is observed by seeing electric energy meter rotating normally.

The system's important equipment comprises of solar modules, and the equipment to transform direct current electricity into alternating current electricity.

### 1.2.3 Characteristic and factors of the project

The SPC project is a 6 megawatt solar power farm, located in Don Chomphu Sub-district, Non Sung District, Nakhon Ratchasima Province. The project is small size and is a renewable energy project designed to reduce greenhouse gases. This is beneficial to the environment and has other economic advantages. For ex: creating more employment, more revolving funds in the local; on society, for ex: the local people having improving quality of life. SPC has also invested in establishing a solar learning center, to help promote the advantages of clean energy to the people of Thailand.

Nakhon Ratchasima Province has the average light intensity all year round about 20 mega joules per square meter per day. Daybreak is at 5.00 – 6.00 hrs. in the morning, and sunset is at 17.00 – 19.00 hrs.

The solar module is poly crystalline, with a module efficiency of about 15%. The 29,160 scalar modules are confected in a series parallel circuit.

#### 1.2.3.1 The project's element

The project's main elements are shown in Figure 1.14. They consist of the solar modules, invertors main control boards and step up transformers.

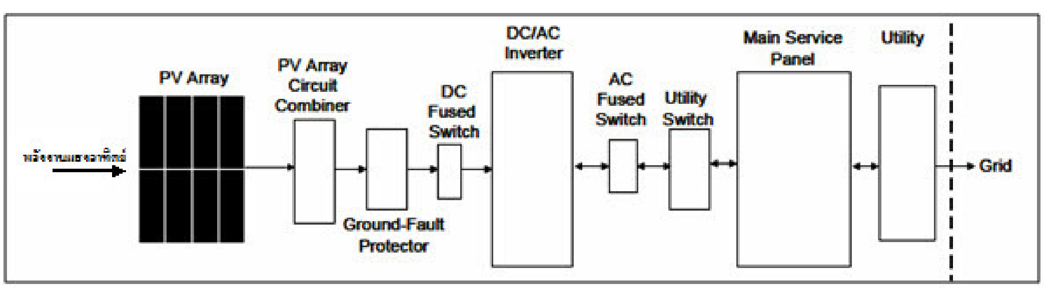
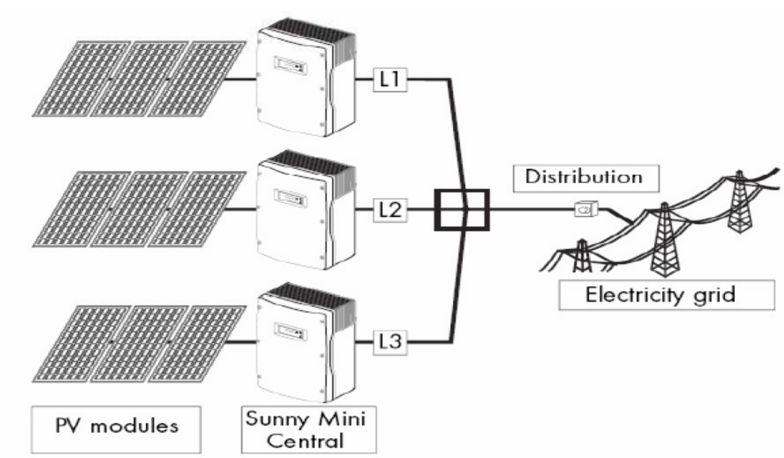



**Figure 1.1** The project's element

### 1.2.3.2 Equipment and machines which are installed in the project

**Solar module**

It is solar modules are made from multi-crystalline silicon, and are rated at 210 watts, a total of 29,160 modules are used they have an efficiency approx. 15%. According to the standard test (JIS C8918, IEC1215): the light intensity which falls in perpendicular angle with the soalr module =1,000 watts per square meter, and cell panel temperature = 25 degrees Celsius (Figure 1.15) and the characteristics of solar module are shown in Figure 1.16.




| PV Module | INVERTER | TRANSFORMER |
|---|---|---|
| **6.123 MWp** | 5.940 MW | 7.5 MW |
| **29,160 Modules** | 540 units | 6 units |
| **210 Wp/Modules** | 11 kW/unit | 1.25 MW/unit |

**Figure 1.15** Solar Module Connections

**1) Inverter/Converter**

We use the SMA company's multi-string inverter, model SMC 11000TL, our project requires a total of 540 sets. The inverter efficiency is 98%. The details of the transformer are shown in Figure 1.17.

**2) System controller and data acquisition**

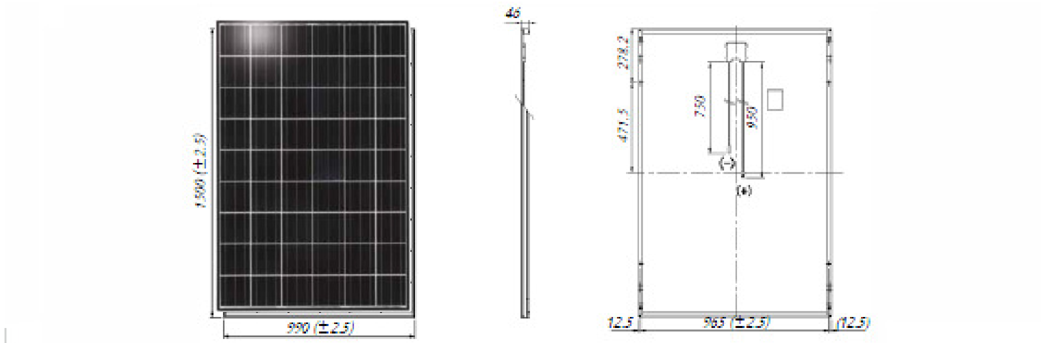
We have installed a very sophisticated system control and data acquisition system. We can also remotely monitor the output and operation of the solar power farm down to the level of individual solar module sub groups.

**3) Electricity distribution system**

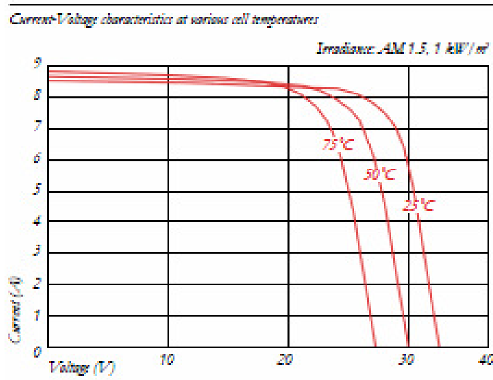
The system consists of transformers and switch gear. We boost the voltage of our system to 22,000 volts to match the PEA grid requirement. We use 6 by 1.25 megawatt oil immersed transformers The system has data acquisition equipment and both PEA and SPC can monitor the amount of power supplied and sold to the grid.

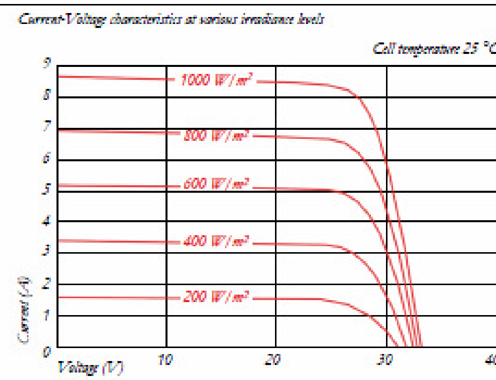
**4) Prevention system**

This system is used for safety control which is connected with PEA's monitoring system.




**ELECTRICAL CHARACTERISTICS**




**ELECTRICAL PERFORMANCE**

| | | |
|---|---|---|
| PV Module Type | | KD210GH-2PU |
| **At 1000 W/m² (STC)*** | | |
| Maximum Power | [W] | 210 |
| Maximum System Voltage | [V] | 1000 |
| Maximum Power Voltage | [V] | 26.6 |
| Maximum Power Current | [A] | 7.90 |
| Open Circuit Voltage ($V_{OC}$) | [V] | 33.2 |
| Short Circuit Current ($I_{SC}$) | [A] | 8.58 |
| **At 800 W/m² (NOCT)**** | | |
| Maximum Power | [W] | 149 |
| Maximum Power Voltage | [V] | 23.6 |
| Maximum Power Current | [A] | 6.32 |
| Open Circuit Voltage ($V_{OC}$) | [V] | 30 |
| Short Circuit Current ($I_{SC}$) | [A] | 6.96 |
| NOCT | [°C] | 47.9 |
| | | |
| Power Tolerance | [%] | +5 / -5 |
| Maximum Reverse Current $I_R$ | [A] | 15 |
| Series Fuse Rating | [A] | 15 |
| Temperature Coefficient of $V_{OC}$ | [V/°C] | $-1.20\times10^{-1}$ |
| Temperature Coefficient of $I_{SC}$ | [A/°C] | $5.15\times10^{-3}$ |
| Temperature Coefficient of Max. Power | [W/°C] | $-9.60\times10^{-1}$ |
| Reduction of Efficiency (from 1000 W/m² to 200 W/m²) | [%] | 6.0 |

**DIMENSIONS**

| | | |
|---|---|---|
| Length | [mm] | 1500 (±2.5) |
| Width | [mm] | 990 (±2.5) |
| Depth / incl. Junction Box | [mm] | 46 |
| Weight | [kg] | 18 |
| Cable | [mm] | (+)950 / (-)750 |
| Connection Type | | MC PV-KBT3 / MC PV-KST3 |
| Junction Box | [mm] | 105x108x20 |
| IP Code | | IP65 |

**GENERAL INFORMATION**

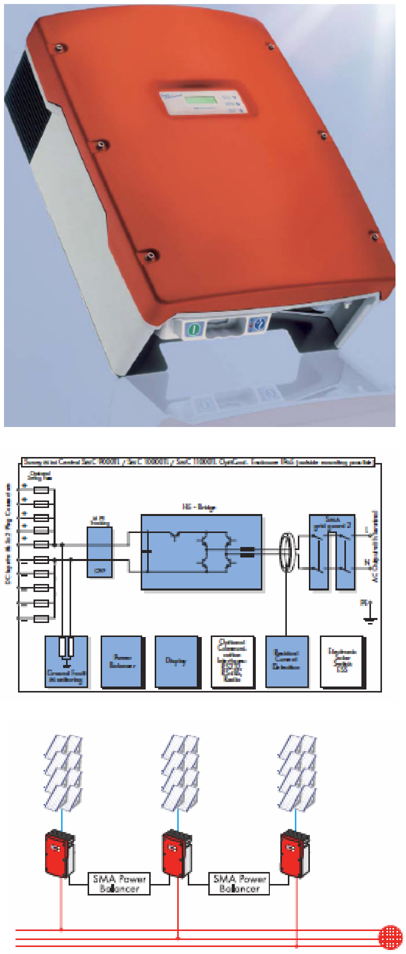
| | |
|---|---|
| Performance Guarantee | 10*** / 20 years**** |
| Warranty | 5 years***** |

**CELLS**

| | | |
|---|---|---|
| Number per Module | | 54 |
| Cell Technology | | polycrystalline |
| Cell Shape (square) | [mm] | 156x156 |
| Cell Bonding | | 3 busbar |

* Electrical values under standard test conditions (STC): irradiation of 1000 W/m², airmass AM 1.5 and cell temperature of 25 °C
** Electrical values under normal operating cell temperature (NOCT): irradiation of 800 W/m², airmass AM 1.5, wind speed of 1m/s and ambient temperature of 20 °C
*** 10 years on 90 % of the minimally specified power P under standard test conditions (STC)
**** 20 years on 80 % of the minimally specified power P under standard test conditions (STC)
***** In the case of Europe

**Figure 1.16** The solar module used in the project



| | SMC 11000TL |
|---|---|
| **Input (DC)** | |
| Max. DC input power | 11400 W |
| Max. DC voltage | 700 V |
| PV voltage range, MPPT | 333 V – 500 V |
| Max. input current | 35 A |
| Number of MPP trackers | 1 |
| Max. number of strings (parallel) | 5 |
| **Output (AC)** | |
| Nominal AC output power | 11000 W |
| Max. AC output power | 11000 W |
| Max. AC output current | 48 A |
| Nominal AC voltage / range | 220V – 240V / 180V -260V |
| AC grid frequency (self-adjusting) / range | 50 Hz / 60 Hz / ± 4.5 Hz |
| Power factor (cos φ) | 1 |
| AC connection / power balancing | single-phase / ● |
| **Efficiency** | |
| Max. efficiency | 98.1 % |
| Euro ETA | 97.7 % |
| **Protective equipment** | |
| DC reverse polarity protection | ● |
| DC load-disconnecting unit ESS | ● |
| AC short-circuit protection | ● |
| Ground fault monitoring | ● |
| Monitored string fuses | ○ |
| Grid monitoring (SMA grid guard) | ● |
| Integrated all-pole sensitive RCD | ● |
| **General data** | |
| Dimensions (W/H/D) in mm | 468 / 613 / 242 |
| Weight | approx. 40 kg |
| Operating temperature range | -25 °C ... +60 °C |
| Operating consumption: operating (standby) / night | < 10 W / 0.25 W |
| Topology | transformerless |
| Cooling concept | OptiCool |
| Installation location: indoor / outdoor (IP 65 electronics) | ● / ● |
| **Features** | |
| DC connection: MC3 / MC4 / Tyco | ○/ ● /○ |
| AC connection: screw terminal | ● |
| LCD display | ● |
| Interfaces: RS232 / RS485 / radio | ○/○/○ |
| Warranty: 5 years / 10 years | ● / ○ |
| Certificates and approvals | www.SMA.de |

**Figure 1.17** Details of the transformer which transforms direct current electricity into alternating current electricity

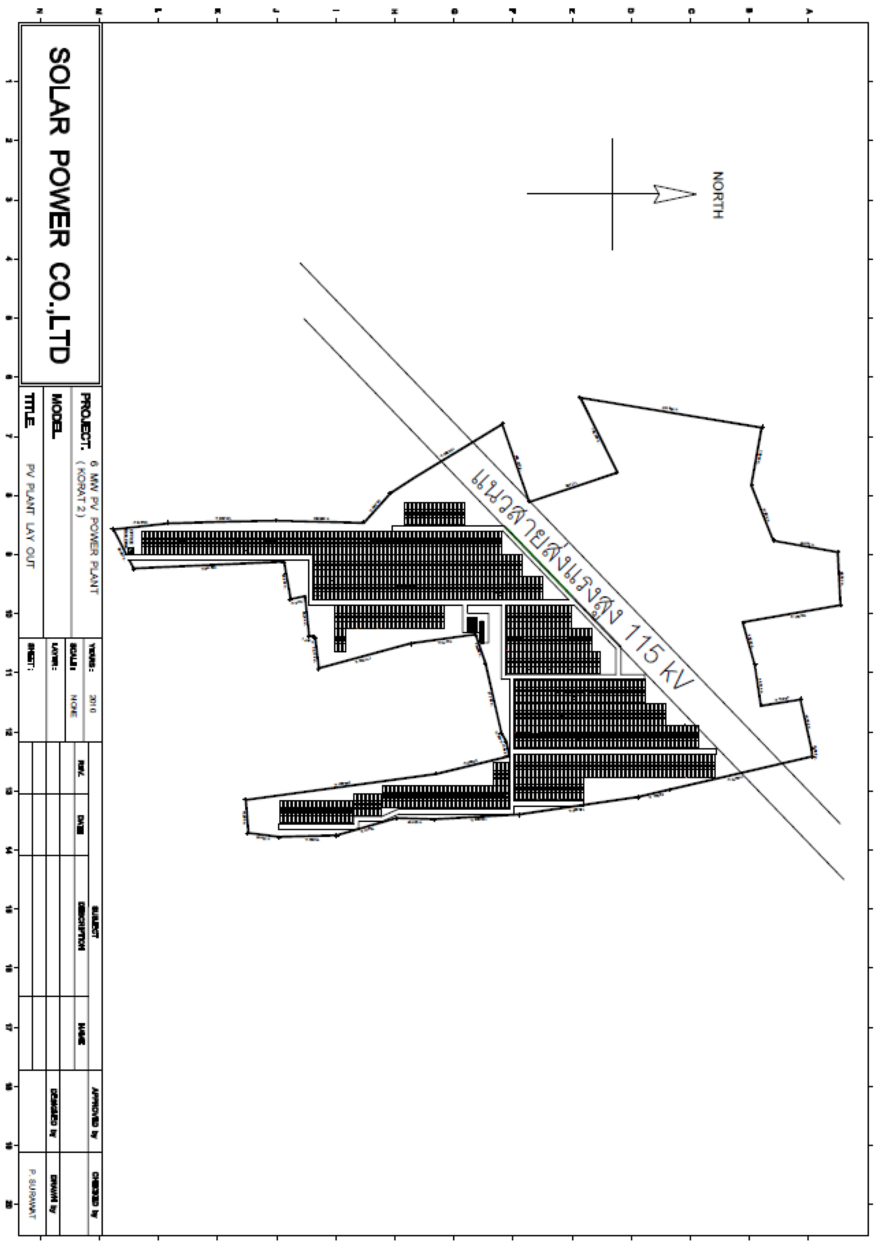



**Figure 1.18** The power plant lay-out showing the project's implementation boundaries.

## 1.3 Water System

Don Chomphu Sub-district uses water from natural water sources. Every village has a rural water supply

### Construction phase

The water used for consumption during the project construction and for the activities of the construction and workers, would be from a shallow artesian well situated within the project area. The project's water use would not affect the nearby community's water use.

**Implementation phase**
Water from the shallow artesian well within the project area would be used.

## 1.4 The project's water use management system / utilization

At present, the community's waste water has no wastewater treatment. For the project, wastewater from construction would be stored and directed into a septic tank situated within the project area.

**Construction phase**
During construction, there is no wastewater.

**Implementation phase**
During implementation, there is no wastewater.

## 1.5 Management of general waste products and dangerous waste

**Construction phase**
Garbage from construction and workers' activities would be collected and disposed of at the official government disposal facility.

**Implementation phase**
Garbage is small quantity since there would be only 16 regular operators stationed at this power plant. Bio gradable Trash would be collected and disposed of at the disposal area or by burying it within the project area (which causes no impact).

All electricity produced will be sold directly to the grid we will not store access power. Any solar modules or other electronic equipment that fails will be disposed of at the approved recycling locations or returned to the manufacturer.

## 1.6 Energy System

Within the area of Don Chomphu Sub-district Administration Organization, there are 1,039 households having access to electricity (100% of total households). All 13 villages have electricity.

The potential of solar cell energy, from the data derived from the Department of Alternative Energy Development and Efficiency, averages 20 mega joules per square meter per day.

## 1.7 Communication system

There are 10 villages having base line telephones. Every village has public phones. Mobile phones are used extensively, rendering convenient communication.

## 1.8 Number of workers and staffs

During construction, there would be about 200 workers. During implementation, there would be approx. 16 operators. There would be no shelters built within the power plant area. A one-story building would be constructed to be used as the system control and administration rooms.