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Building Integrated Photovoltaic (BIPV) in Malaysia: An Economic Feasibility Study

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ABSTRACT

This paper presents the economic feasibility study for the implementation of Building Integrated Photovoltaic (BIPV) system in Malaysian. BIPV is a relatively new technology which is being introduced by the Malaysian government as a step to encourage the use of renewable energy in reducing the dependence on fossil fuel energy which is becoming scarce from time to time. The objective of this study is to evaluate the possibility of BIPV system to be implemented in Malaysia in terms of financial feasibility. As a result of this study, it is found that BIPV faces a stiff challenge which holds the technology to expand further. The current situations make the BIPV system is not feasible economically to be implemented in Malaysia. However, this does not limit the implementation of this technology in future. This problem can be overcome by the support of government by introducing a better policy which might be able to stimulate and create a conducive environment for BIPV to expand.

Introduction

Sun is one of the sources of renewable energy known as solar energy. Solar energy is an electromagnetic energy transmitted from the sun (solar radiation). The amount that reaches the earth is equal to one billionth of total solar energy generated, or equivalent to about 420 trillion kilowatt-hours [1]. Solar energy has been used in many traditional technologies for the centuries and has come into widespread use where electricity is absent, such as in remote location and in space. Solar energy is currently used in a number of applications such as heating (hot water, cooking), electricity generation (photovoltaic, heat engines), desalination of sea water. Its application is spreading as the environment costs and limited supply of other power sources such as fossil fuels are realized [2]. Solar radiation reaches the earth's upper atmosphere at a rate of 1366 W/m^2. Of all the energy that reaches to earth, about 20% of it is consumed by the atmosphere where clouds reflect over 30% of this energy. At sea level, the ideal amount of solar power is about $1000W/m^2$. Once the light of the sun has traveled through the atmosphere of the earth, it exists in the form of infrared or visible radiation [3]. Solar energy is a basic need of living plants and human being on the earth. It is intermittent in nature, eco friendly and non polluting energy. Solar energy can be used for direct conversion into electricity (photovoltaic conversion) and into thermal energy.

Sintering is a processing technique which is performed to produce density-controlled materials and components from metal or ceramic powder by applying thermal energy [2]. It also acts as a thermal treatment process in powder metallurgy. Small particles of a material are bonded together by solid-state diffusion in the sintering process. As material synthesis and processing has become crucial in recent years for materials development, the importance of sintering is increasing as a metal processing technology. Unlike other processing technologies, various processing steps and variables need to be considered for the production of sintered parts. For example in the shaping step, one may use simple die compaction, isostatic pressing, slip casting or injection molding, according to the shape and properties required for the end product.

One of the applications of solar energy is solar electricity. Solar electric technology converts sunlight directly into electricity. The basic building block of solar electric technology is the solar or photovoltaic cell. A photovoltaic or in short PV, converts the sunlight (proton) directly into electricity. A solar PV cell is exposed to light (photon), electrical charges are generated and this can be conducted away by electrical conductor as direct current (d.c). This process of converting light (photons) to electricity (voltage) is called photovoltaic effect. The electrical output from a single PV cell is small, usually around $0.6V_{d.c}$. Therefore, multiple PV cells are connected together to provide more useful electrical outputs. PV cells connected in this way are encapsulated usually behind a glass to form a weatherproof PV module. A single PV module could be made to generate power between 10Wp to 300Wp [4]. Multiple PV modules then could be connected together as PV string or PV array in order to provide sufficient power for common electrical uses. In order to utilize the electrical energy generated in alternating current (a.c) form, the direct current (d.c), generated by the PV array, is converted into a.c by the electronic equipment called inverter.

The solar electricity can be used in many applications. However, it depends on the application requirements. The solar modules can be customized in many sizes, depending on the applications. The solar modules are a good sources of electricity because they are reliable, simple to operate and do not require fuel. However, since they are also expensive to make, these advantages have to be carefully balanced against their high cost before purchase [5]. One of the main restriction or consideration when applying the photovoltaic system is the location.

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Location plays an important role because it determines the availability of sunshine for the entire year, acceptable light intensity and tilt arrangement. Mostly, the application of solar electricity is installed in remote area compare to urban area. The remote areas do not have grid utilities, beside supply of fuel for generators, is unreliable and expensive. The advantages of solar electric system are [6, 7]: (i) inexhaustible and unlimited fuel source, (ii) no pollution to the environment and there is no waste. It does not pollute our air by releasing carbon dioxide, nitrogen oxide, sulphur dioxide or mercury into the atmosphere like many traditional forms of power generation, (iii) the use of solar energy indirectly reduces health costs, (iv) solar energy systems are virtually maintenance free and last for decades, (v) the system operates silently, have no moving parts, do not release offensive smells, and (vi) the use of solar energy reduces our dependence on foreign and/or centralized sources of energy, influenced by natural disasters or international events and so contributes to a sustainable future.

On the other hand, the disadvantages of solar electric system are: (i) the initial cost is the main disadvantage of installing a solar energy system, largely because of the high cost of the semi-conducting materials used in building, (ii) the cost of solar energy is also high compared to non-renewable utility-supplied electricity, (iii) solar panels require quite a large area for installation to achieve a good level of efficiency, (iv) the production of solar energy is influenced by the presence of clouds or pollution in the air, and (v) similarly, no solar energy will be produced during nighttime although a battery backup system and/or net metering will solve this problem.

Since independent in 1957, Malaysia is transforming to a developing country. The energy consumption has increased to 2.8MWh in 2002 [3]. However, this figure is increasing continuously for the following years and the increasing energy also leads to increasing of carbon emission and global warming. In order to mitigate such problems, Malaysian government is promoting the use of renewable energy as one of the alternative to reduce global warming. One of the most promising renewable energy that suits to Malaysian environment is the solar energy. Malaysia has identified photovoltaic systems as one of the most promising renewable sources.

A great deal of efforts has been undertaken to promote the wide applications of PV systems. With the recent launch of a PV market induction programme known as SURIA 1000 in conjunction with other relevant activities undertaken under the national project of Malaysia Building Integrated Photovoltaic (MBIPV), the market of PV systems begins to be stimulated in the country. As a result, a wide range of technical, environmental and economic issues with regard to the connection of PV systems to local distribution networks becomes apparent [8].

However, this type of technology is considered new in Malaysia but it is widely applicable. Public are less informed on the viability and economical perspective of BIPV system in Malaysian environment. This includes the functionality of the system, setup requirements, initial cost, payback period, financial allocation and others. Beside that, the question on applicability of BIPV system in Malaysian environment needs to be considered. Even though, the public is understood about the system, BIPV still needs an enormous support in order to keep rolling. Therefore, the objective of this paper is to present the economic feasibility of Building Integrated Photovoltaic (BIPV) system for Malaysian environment.

Sizing the BIPV for a single storey house

This section basically shows how to size a system for a single storey house. The sizing works are divided into two categories which comprise of stand-alone and grid connected system. The sizing of both systems is tailored to the energy consumption of the residents. The calculations include sizing the PV array, determine the charge controller and inverter that are used, quantities of batteries required and other miscellaneous work. A photovoltaic expert had been approached in order to obtain correct calculation and availability in Malaysian market.

- **Sizing the System**

Properly sizing a stand-alone or grid connected system is very important. The goal is to determine a reasonable size for a system. Too large a system will leave the surplus power while too small a system will force home owner to run a backup supplied too much. However, this may depend on owner financial capabilities or needs. In this study, the electricity consumption of a single storey house is analyzed, thus a market survey had been done in order to get the actual energy consumption of different domestic appliances such as TV, DVD player, air conditioning and others. The energy consumption rate is based on estimation only because different consumer had different needs.

The first step is to estimate the average daily power demand of each appliance in the house. Owners need to know the power consumption of each appliance before any calculation starts. After that, start by adding up the average daily energy use for every piece of electric appliances. Energy use is calculated by multiplying the equipment's power consumption (watts) by the duration (hours) it is run on an average day. The estimated average power consumption for a single storey house in Malaysia is about 21 kWh/day [16].

- Selecting the PV module, Sizing the Array and Inverter

The selected module for this system is *SHARP NU-SOE3E (Single-Crystalline Silicon with 180 W)*. The main reasons for selecting the module are based on several criteria, as (i) the single crystalline silicon solar cell is the highest efficiency (around 13.7%) among the photovoltaic systems, (ii) complete with bypass diode to minimize the power drop cause by shade, and (iii) the availability in Malaysia. The average sunny hours per day in Malaysia is about 4.5, therefore 32 modules are required. In Malaysia, the average temperature is about 40°C at noon resulting PV temperature to become 60°C [4].

Thus, the efficiency becomes 82.5% [6, 17-18]. Module maximum input power is 5.760 kWp, the maximum DC Power (P_{max}) is 6.2 kWp, the maximum input current (I_{pv}) is 19 Amp. Therefore, for PV module, the maximum power current is 7.60 Amp. The maximum DC Power (P_{max}) is higher than the maximum input power of modules, while the maximum input current (I_{pv}) is higher than the maximum power current of module, thus it is safe to be used. The nominal power output of the designed system is 180 x 32 modules in array ≈ 5.76 kWp.

Cost Estimation

After sizing the desired system, the cost is estimated. In this section, the cost estimation is presented for stand-alone and grid connected systems. Cost estimation enables the user to plan which system capacity is suitable for their usage. However, the cost estimation only includeds the initial cost of the system. The operating cost, maintenance costs and replacement costs are excluded. An estimated initial cost for stand-alone system is about RM 230,200. Table 1 shows the estimated cost of parts and components used in the stand-alone system. The main contributor for the total cost is PV module which represents

65.68% of the total cost, followed by batteries which represent 20.85% of the total cost. The cost of charge controller represents 6.95%, while mechanical structure holds 5.21%. Electrical works such as wiring, fuse connection represent 1.30% of the total cost.

On the other hand, an estimate of initial setup cost for grid-connected system is about RM 155,500. The cost of parts and components used in the grid-connected system are summarized in Table 2. As mentioned earlier, the PV module is the main contributor of the total cost, followed by inverter which carries 10.13% of the total cost. The mechanical structure, electrical and grid-meter have less influence to the total cost.

After sizing the requirement for grid-connected system, the specification of the grid connected system is summarized in Table 3. The selected brand is based on quality and availability in Malaysia. On the other hand, the specification of the stand - alone system is shown in Table 4. As shown in Tables 3 & 4, it is quite obvious that, the stand alone system is much complex than the grid-connected system.

The stand-alone system consists of two extra components which are batteries and charge controller. The charge controller is used to regulate the charging cycle and voltage of the batteries. On the other hand, the grid-connected system does not need to store any electricity as the shortage of electricity will be overcome by utility grid. Beside that, the electricity generated can be sold back to power supply utility company. Thus, grid-connected system saves the energy and reduces in emission of CO_2 and No_x to the environment. In terms of costing, the setup cost for grid-connected system is slightly lower than the stand-alone system. The higher setup cost of stand-alone system is mainly contributed by the complexity of the system.

Feasibility of BIPV system in Malaysia

In recent years, Malaysia has one of the fastest growing building industries worldwide, where the corresponding energy demand would significantly increase in the next coming years. Conducive conditions such as forecast increase in electricity demand, available building spaces and the huge untapped solar energy potential point clearly towards an implementation of the BIPV (building integrated photovoltaic) technology in Malaysia. Considering the synergies and benefits of BIPV application, the technology will have an important and sustainable impact to the buildings market and is able to substitute part of the conventional fossil-fired electricity generators.

- **BIPV Status in Malaysia**

Malaysia lies entirely in the equatorial region with an average daily solar radiation of 4,500 kWh/m^2, with sunshine duration of about 12 hours [9-11]. Ambient temperature remains uniformly high throughout the year. Thus, Malaysia can be classified as a conducive country to implement solar system (BIPV) which receives sunlight throughout the year. The National Electricity Board (now Tenaga Nasional Berhad) initiated the use of PV system for rural electrification in the early 1980s. The first of these was the installation of stand-alone PV systems for 37 houses in Langkawi, followed by other housing projects in Tembeling and Pulau Sibu. Later in the 1990s, two rural electrification pilot projects of 10 kWp and 100 kWp, respectively were implemented in Sabah with the support from the New Energy and Industrial Technology Development Organization (NEDO) of Japan. In the late 1990s, the Ministry of Rural Development has undertaken the provision of photovoltaic system for rural electrification. The total capacity for stand-alone systems in Malaysia, including Sabah and Sarawak, in the year 2000 was 1.5 MWp, however, some of the installations have been dismantled [12-15].

Until late 1997, the grid-connected system started to role as a pilot project that initiated by TNB with funds from TNB & MESITA. TNB Research (TNBR) installed 3.15 kWp BIPV on the roof of college of engineering building, Universiti Tenaga Nasional (UNITEN) as one of the six pilot systems of the R&D project. The driver of this project is mainly due to motivation by Kyoto Protocol, Germany Rooftop and Japan Sunshine programs. Currently, there are 21 application of BIPV system installed in that contribute to 462.78 kWp in Malaysia. Moreover, Malaysia has a target of 1.5 MWp of grid-connected system in 2010 [3].

On 12th May 1998, Pusat Tenaga Malaysia (PTM) was registered as a not-for-profit company. On 25th July 2005, the MBIPV project was officially launched by Minister of Energy, Water and Communications. The main principle is to reduce the long-term cost of BIPV technology within the Malaysian market, which will subsequently lead to sustainable and widespread BIPV technology applications in order to avoid greenhouse gases (GHG) emission from the country's electricity sector under MBIPV project. On the 27th November 2006, the Suria 1000 program was introduced to the public. The main goal of Suria 1000 is to allow Malaysians to have their own BIPV system in their house to generate their own electricity and get it grid connected. Through Suria 1000, the government is giving the public rebates up to 75% to make it more affordable [8]. However, this needs to go through a bidding process. The successful bid depends on how much money spent by the bidder where the lesser subsidized by government.

- Industry overview

The potential of BIPV market is seen encouraging since the price for conventional fuel had increased for the past few years. However, this price will still increase as the fossil fuel will depleted soon. The utilization of solar energy through PV has a huge potential, offering several advantages. The integrated PV can displace other material and replace conventionally building material, this off-setting the PV cost. A variety of roof tiles and sheet materials are also available in the international market, and there are purpose-designed mounting and integration systems available to improve appearance and weather proofing as well as making the installation process easier.

When, BIPV capacity is appropriately sized, it can displace purchase of electricity, with possibility to export the surplus to the grid. The technical potentials of BIPV in the residential and commercial sectors are huge. Considering only the lower PV capacity value of 1 kWp for every 10 m^2 of available building roof surfaces in these sectors, the technical potential is around 11,000 MWp or 11 GWp, which could provide more than 12,000 GWh of solar generated electricity. Today, this would cover 20% of the national energy demand. Thus, the potential of BIPV is remain solid, however a lot of works need to be done in order to stimulate the public mind as an essential facility.

The climate for business opportunities in the field of PV is encouraging. Malaysia is currently promoting the continued diversification of industrial base towards high-end manufacturing and the development of the value-added service sectors as part of the move towards a knowledge-based economy. In the Malaysian Investments Act 1986, alternative energy sources like the development and production of fuel cells, polymer batteries, PV components and solar cells are specifically mentioned. Tax reductions for new companies provide attractive incentives for start-up. Nevertheless, the incentives have to be reviewed when considering a local production of either PV inverters or modules. Malaysia is now encouraging high-tech electronic products for which attractive incentives are being offered to promote investments and reinvestments in technology and capital intensive projects.

The local PV manufacturing facilities can benefit from the existing infrastructure and well established manufacturing sector in Malaysia such as the precision machining and the production of electronic assemblies and sub-assemblies, components, moulds, tools and dies, metals and plastics, and automated machinery and equipment. Supply for the mounting structure or any metal part is readily available. The industry is well established and produces high quality materials. Custom-made products can be ordered without problems. Thus, frames for the modules made of extruded aluminum can be easily produced.

A survey had been conducted by PTM on the current competency level of existing local PV service providers (17 companies) and one module manufacturer (BP Solar) in Malaysia. Valuable information concerning the companies and their level of know-how were obtained. Based on the survey, there are only two companies so far that provide very good services to their clients and include training and education for their employees. However, there are many companies that lack capability to improve their service and quality. Thus, comprehensive installation and maintenance guide, training material and courses are needed. Such activities (capacity building) are important and will enhance the development of the industry.

The other important step is to provide the market with quality installation, reliable products and basic awareness for the clients hence this will improve the public confidence on the technology. Some important feedbacks from the survey conducted among the local PV service providers and manufacturers are: (i) government needs to be committed on BIPV policies and implementation, (ii) sharing of experiences among the field experts based on their own process and implementation, problems faced and immediate solutions, (iii) consumer groups and industry players need to be represented with opportunity to highlight concerns and to be adequately addressed, (iv) development of a group of experts who understand the PV industries, and (v) competent and reliable after sales services.

- **Challenges Faced by BIPV Application**

There are four major challenges faced by the implementation of BIPV in Malaysia, i.e.,:

1. High cost of BIPV system

Even though, solar energy is abandoned in Malaysia but still having problems to implement BIPV system thoroughly. The main problem identified for lack of BIPV penetration and integration in the Malaysian market is the initial high cost of the technology. In comparison to other countries and markets, the cost of BIPV in Malaysia is significantly higher per Wp. This is due to taxes, the small market, and the inexperienced consumers and service providers. The high costs have its roots in the import costs of the products and the miniscule market that it serves. The absence of a significant market does not encourage local production of BIPV products or components and hence, the continued dependence on imports. The small market presence of PV systems, mainly off-grid and stand alone products, do not create the critical mass of service providers.

2. The capacity of local services providers is weak

The small number of service providers, many are technically and financially strapped, can only offer limited services. Because of these limitations, the quality of the services is also considered low. Thus, comprehensive installation and maintenance guide, training material and courses are needed. Such activities (capacity building) are important and will enhance the development of the industry. The other important step is to provide the market with quality installation, reliable products and basic awareness for the clients hence this will improve the public confidence on the technology.

3. Suitable policy, fiscal and financial framework is absent

Although Malaysian government has indicated the preference for Renewable Energy as an alternative source of energy, there are limited fiscal and financial frameworks that directly support the widespread application of BIPV systems. Buy-back policy from utility favors biomass and mini hydro generation sources, which are comparatively more than 500 times larger than a typical BIPV system. The obstacles identified above have a compounded effect that restrains the widespread application of the technology in Malaysia. There is no known financial incentive provided for BIPV. A customized financial incentive program for BIPV is necessary to encourage the development of PV in Malaysia. Unlike Biomass, BIPV is much smaller and applicable to different market segments such as commercial complexes and domestic consumers. Hence, the current fiscal regime, which is embodied in the Malaysian budget, does not provide specific incentives to encourage and increase the take up rate of BIPV.

Lack of public awareness

The publicity of BIPV is less and not effective. Malaysians are less concern about benefits of utilizing solar energy. The lack of awareness on the potential, both environmental and long term economic benefits, led the public to believe that technology is exotic and not directly benefits except for special cases. Beside that, public is more concern on relevant payback period compare to environment issues. Currently, the public need not to allocate extra money to invest into BIPV system where they feel it is not an essential technology that will affect their daily life. Moreover, the public feel comfortable with current electricity tariff.

conclusions

The feasibility of BIPV system in Malaysia depends on a lot of factors. In order to implement BIPV successfully in Malaysia, a lot of works are required to be executed. The high setup cost, lack of professional expertise, financial constraints and less equipment manufacturers had create barriers to the industry. However, there is still ample of space to improve as to expand the local PV market. As an example, the help of government is essential such as reduce the import tax, create a PV policy for getting financial aids from bank and others.

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REFERENCES

[1] H Solangi, K.H., Islam, M.R., Saidur, R., Rahim, N.A. & Fayaz, H. 2011. A review on global solar energy policy, *Renewable and Sustainable Energy Reviews*, 15: 2149-2163.

[2] Shaari, S. & Bowman, N. 1998. Photovoltaics in buildings: a case study for rural England and Malaysia, *Renewable Energy*, 15: 558-561.

[3] Mekhilef, F., Saidur, R. & Safari, A. 2011. A review on solar energy use in industries, *Renewable and Sustainable Energy Reviews*, 15: 1777-1790.

[4] Henemann, A. 2008. BIPV: Built-in solar energy, *Renewable Energy Focus Green Building Supplement*, November/December, pp. 15-19.

[5] Simon Roberts 1991. Solar Electricity: A practical guide to designing and installing small photovoltaic systems. Hertfordshire: Prentice Hall International.

[6] Mary, D.A. and Robert, H. 2001.*Clean Electricity from Photovoltaics*. London. Imperial College Press.

[7] Roger, A.M. & Jerry, V. 2004. *Photovoltaic Systems Engineering*. Florida: CRC Press.

[8] Seng, L.Y., Lalchand, G. & Lin, G.M.S. 2008. Economical, environmental and technical analysis of building integrated photovoltaic systems in Malaysia, Energy Policy, 36: 2130-2142.

[9] Gan, P.Y. & Li, Z. 2008. An econometric study on long-term energy outlook and the implications of renewable energy utilization in Malaysia, Energy Policy, 36: 890-899.

[10] Zaki, W.R.M, Nawawi, A.H. & Ahmad, S.S. 2010. Economic assessment of Operational Energy reduction options in a house using Marginal Benefit and Marginal Cost: A case in Bangi, Malaysia, Energy Conversion and Management, 51: 538-545.

[11] Oh, T.H., Pang, S.Y. & Chua, S.C. 2010. Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth, Renewable and Sustainable Energy Reviews, 14: 1241-1252.

[12] Ong, H.C., Mahlia, T.M.I. & Masjuki, H.H. 2011. A review on energy scenario and sustainable energy in Malaysia, Renewable and Sustainable Energy Reviews, 15: 639-647.

[13] Mohamed, A.R. & Lee, K.T. 2006. Energy for sustainable development in Malaysia: Energy policy and alternative energy, Energy Policy, 34: 2388-2397.

[14] Chua, S.C. & Oh, T.H. 2010. Review on Malaysia's national energy developments: Key policies, agencies, programmes and international involvements, Renewable and Sustainable Energy Reviews, 14: 2916-2925.

[15] Wong, J., Lim, Y.S., Taylor, P. & Morris, S. 2011. Optimal utilisation of small-scale embedded generators in a developing country - A case study in Malaysia, Renewable Energy, doi:10.1016/j.renene.2011.02.01.

[16] Loke Kuan Haur. 2007. Feasibility study of building integrated photovoltaic (BIPV) for Malaysian environment. *BME Thesis*. Universiti Tenaga Nasional.

[17] Cheng, C.L., Jimenez, C.S.S. & Lee, M.C. 2009. Research of BIPV optimal tilted angle, use of latitude concept for south orientated plans, Renewable Energy, 34: 1644-1650.

[18] Close, J. 2001. BIPV for the high-temperature, high-rise, high-density cities of S. China: The related projects of PV HKU research group to facilitate BIPV application, Solar Energy Materials & Solar Cells, 67: 449-458.

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Table 1. The costing of 6.48 kWp stand-alone system

Component	Unit Price (RM)	Quantity	Price (RM)
PV Module	4,200	36	151,200
Charge Controller	8,000	2	16,000
Battery	4,000	12	48,000
Electrical	3,000	1	3,000
Mechanical Structure	12,000	1	12,000
Total			230,000

Table 2. The costing of 5.76 kWp grid-connected system

Component	Unit Price (RM)	Quantity	Price (RM)
PV Module	4,200	32	134,400
Inverter	16,000	1	16,000
Grid-meter	100	1	100
Mechanical Structure	4,500	1	4,500
Miscellaneous- wiring, fuse, grid meter, etc.	3,000	1	3,000
Total			158,000

Table 3. Specification of grid-connected system

Component	Requirement	Quantity
PV Module	- Single Crystalline Silicon type - Bypass diode - Max Power 180W - System voltage 24V	32
Inverter	• Max input power 6.2 kWp • Max input current 19 Amp	1
Mechanical Structure	• Supporting structure for mounting PV module	1 Lot
Miscellaneous	• Electrical equipment such as fuse, over-voltage protection, cable, grid meter, etc	1 Lot

Table 4. Specification of stand-alone system

Component	Requirement	Quantity
PV Module	- Single Crystalline Silicon type - Bypass diode - Max Power 180W - System voltage 24V	38
Inverter c/w Charge controller	- Max input power 7.2kWp - Max input current 22 Amp	1
Batteries	- System voltage 12V - Capacity 135 Ah	6
Mechanical Structure	- Supporting structure for mounting PV module	1 Lot
Miscellaneous	- Electrical equipment such as fuse, over voltage protection, cable, grid meter, etc	1 Lot