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APEC Low Carbon Model Town Solar Photovoltaic Agricultural Development Mode Study Final Report

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1) The progress of global solar industry development

Energy and environment issues have become the most important topic for global economy and social sustainable development. Fossil fuels which include petroleum, coal and natural gas etc., produce large amount of emissions and it's facing serious depletion problem. Thus, develop clean and renewable energy to limit these emissions has reached the world's consensus. Therefore, the usage of clean energy has increased rapidly since 21st century, it has gradually become the alternative energy instead of supplemental energy not only in APEC parties but also in non-APEC parties. Clean energy with its environmental friendly and sustainability advantages has entered its golden period of development.

Solar photovoltaic power generation utilize photovoltaic effect of solar cell semiconductor materials, the PV system converts sunlight radiation into electricity directly. In the past decade, the photovoltaic industry maintained a stable high speed growth rate in the world. Europe, America and Japan has begun to develop large scale of solar photovoltaic projects since 2000, while the solar photovoltaic technology had been proven as a safe, inexhaustible, flexible installation, no location limitation and completely environmental friendly energy generation method. At the same time, due to diversified installation solutions of solar system, the combination of solar system with buildings or agricultural facilities are also been studied in those mature solar markets.

In 2015, the new installed capacity of clean energy power generation has taken the dominance position in the global energy market. The growth speed of new installed capacity for wind energy power generation or solar power generation has exceed the growth speed of fossil fuel power generation or nuclear power generation. The cumulative installed capacity of wind power generation has soared to 427.4 GW, which with 63.6 GW of new installed capacity in 2015. The total number of installed capacity for solar power generation reached to 227.1 GW, which with 52 GW of newly installed in this year. Clean energy with its safe, abundant source and environmental friendly advantages is strongly competitive with traditional energy. The world energy system will switch from conventional structure to an innovative structure with higher clean energy proportion. Solar energy is the main form of distributed energy generation utilization, the technology efficiency and project economy improving steadily, therefore, solar energy can be seen as the most reliable energy source in the future.

Table 1: Top 10 Economies for Installations and Total Installed Capacity In 2015

Top 10 Economies In 2015 for Annual Installed Capacity			**Top 10 Economies In 2015 for Cumulative Installed Capacity**		
1	China	15,2 GW	1	China	43,5 GW
2	Japan	11 GW	2	Germany	39,7 GW
3	USA	7,3 GW	3	Japan	34,4 GW
4	UK	3,5 GW	4	USA	25,6 GW
5	India	2 GW	5	Italy	18,9 GW
6	Germany	1,5 GW	6	UK	8,8 GW
7	Korea	1 GW	7	France	6,6 GW
8	Australia	0,9 GW	8	Spain	5,4 GW
9	France	0,9 GW	9	Australia	5,1 GW
10	Canada	0,6 GW	10	India	5 GW

2) The development progress of solar industry in major economies

Solar energy industry, as a cutting edge emerging industry in the world, the development is highly rely on the government supporting regulations. The most representative example is European Union, its leading market position mainly benefit from their different types of supporting policies for solar energy.

The initial solar market demand around the world was launched by the solar subsidy policy released by German government in 2004. Other developed none Member economies like Spain or Italy also becoming the leading economies of the global solar industry by providing subsidy policies thereafter. The total solar installation capacity in the European Union has taken a high proportion of 85.12% of the global solar capacity by the end of 2008, and it remained at this high level for certain years, which clearly demonstrated the great attention for the solar energy payed by the European Union member economies.

However, due to the negative effect caused by the European Debt Crisis in the late of 2011, the leading economies of solar industry i.e. Germany and Italy were cut down their clean energy subsidy dramatically, this also caused the European solar market demand shrunk immediately. As a result, in 2013, there were only 10.25 GW new installed solar systems in the European Union, which is 27.70% of the world' new installed capacity , nearly 58% drop compare to the number in 2008. The first stage of global solar market demand is suspended.

The European Union solar market volume turn to steady since 2010, the development of emerging solar markets lead by China, Japan and U.S. started to accelerate. Especially after the nuclear power plant accident during the Great

East Japan earthquake in 2011, solar power generation were considered as the major alternative energy solution in the world. Several of solar supporting policies were released by China, Japan and the United States., which include the initial investment subsidy, feed-in tariff and tax reward. All these governments are targeting to build up a prosperous domestic solar power generation market, in order to improve the environmental impact. Applying solar energy is the way to solve the energy safety issues, promote the economic growth and release the production capacity. The proportion of Member economies in the global solar market keep growing during this period. The cumulative solar power generation capacity in China has increased from 0.6% of the global market in 2008 to 30.4% in 2015, as the largest solar market in the world. While the solar market in Japan taken the second position of the world for 11GW in the same year, followed by 7.3GW from United States. The rise of emerging solar market has advanced the globalization of solar industry, and removed the industry dependence from the European market.

Solar photovoltaics technology had several breakthrough in cost reduction, power generation stability and conversion efficiency which benefited from the continued development of solar industry in the past 15 years. Particularly in certain developed regions, the power generation from solar system has achieved grid parity, they realized that normal return of investment for power generation projects without government subsidies is very important. The success project in developed economies showed the feasibility and positivity of implementing solar power generation system in developing or undeveloped economies, for instance, Indian and Africa.

According to the International Energy Agency (IEA) forecast, the rapid decreasing cost of solar module or solar power generation system has push the solar photovoltaic technology become an essential power source in the coming years even decades, which opens a bright new prospect of energy utilization for human beings. The power production of PV system will reach about 16% of the global power supply by the year of 2050.

3) The development progress of solar technology in agriculture sector in Member economies and Non-Member economies

Solar photovoltaic technology utilization is diversified and flexible, not only as the on grid power plant build in the desert or rural areas with abundant solar radiation, but also to conjunct with different type of buildings and provide clean

energy supply for the specific architecture as Building Integrated Photovoltaics (BIPV). Meanwhile, the residential solar system invested by family unit, can also save their daily energy cost by clean energy power generation, even acquire power generation income by selling electricity to the power company. In the latest 2 to 3 years, the combination of solar technology with agriculture facilities, i.e. solar greenhouse, solar fishpond, solar planting equipment, and solar pump are also flourishing in various regions. Solar agriculture, gathers solar power generation, smart temperature control, modern planting and breeding technology, which can provide clean power to fulfill the demand of lighting and thermostat, also to drive mechanical facilities like rolling blinds machine, water and fertilizer integrated pump, plant protection equipment and ventilation machine. Especially in remote and undeveloped areas that without power supply or hardly to be covered by the traditional power grid. To use solar photovoltaic with agriculture facilities is capable to achieve energy self-sufficient, also to promote the technical improvement and mechanize in agriculture sectors.

Solar agriculture, is to apply the solar power generation technology into the modern agriculture circumstance. This is a new agriculture concept by combining the renewable energy generation with greenhouse production and husbandry breeding through engineering technical method. It was widely spread among the world, especially in Member economies.

Based on the activities of agriculture production, the solar agriculture can be categories as follow:

- **Solar Greenhouse Technology -**The technology is based on the scientific assessment of the lighting demand for greenhouse plant, the roof or the wall of the greenhouse which is using traditional materials (glass, agricultural film or PC board, etc.) can be totally or partially replaced by solar modules for lighting purpose. The power produced from the PV greenhouse will be able to supply the demand of the greenhouse itself or it can connect to the power grid as a distributed generation power plant. The PV greenhouse technology combined recourse with energy efficiently, it has become a new development focus in greenhouse gardening, mushroom planting and seedling areas. There are some solar greenhouse pictures showing below:

Solar greenhouse for vegetable planting and seeding (outside).

Solar greenhouse for vegetable planting and seeding (inside).

Solar panels on the traditional agricultural greenhouse.

- **Solar Cultivation Plant -** It integrates the modern clean energy engineering with the traditional cultivation facilities. PV modules will be installed on the top of the cultivation factory's roof in order to improve the energy supply for the traditional cultivation activities. Promoting solar energy usage on cultivation plant in Member economies could enhance the clean energy utilization. Below shows the photos of solar cultivation plants.

Rooftop Solar Cultivation Plant (outside).

Rooftop Solar Cultivation Plant (inside).

Sunshade Solar Cultivation Plant 1.

Sunshade Solar Cultivation Plant 2.

- **Solar Fishpond -** There are two major implementation methods for solar fishpond. One is to install solar modules on the top of the fixed bracket which is above the aquatic farm or fishpond water surface, the other one is to install floating solar power generation system directly in the water, and provide clean energy supply.

Fixed bracket solar Fishpond (low bracket):

Fixed bracket solar Fishpond (high bracket):

Floating Solar Fishpond:

- **Solar Pump System -** It refers to alternating current water pump, combine with solar power generation devices. It provides several of mobile pumping services, which include irrigation for farmland and gardening, drinking water supply for residential and cultivation usage, oxygen enrichment for aquaculture farm and fishpond. The Solar pumping system operate automatically by following the sunrise and sunset, no manual operation required and no traditional power supply needed, the system can work independently and steadily. It can also tackle the water saving and energy conservation issues while secure the farmland irrigation demand.

- **Solar Poverty Alleviation -** It defined as using sustainable and stable solar power generation to provide 20-25 years long fix electricity sells income by one sum of initial investment, in order to support the poverty family in rural areas without steady earnings. Solar energy project can apply on installation of residential or village level small scale solar power system, or on centralized middle or large scales ground mounted solar power plant in the open area, and can combine with other agricultural and forestry form to create “solar+” application models. Apply solar poverty alleviation in rural areas with sufficient solar radiation resource, also need to match with special funding policies, from both fund raising stage to favorable interest rate and payback terms. Solar poverty alleviation project is mainly used and popular for the Chinese market.

Family level solar power generation system.

Village level solar power generation system.

Within Member economies, such as China; Japan; and the United States, have proceed numerous research and studies for solar application in agriculture sectors.

China

China is the largest solar manufacture and power generation economy, and it is also one of the biggest agriculture economies in the world, which with huge number of agriculture population. Thus, China has unique advantages and unlimited potential market to develop solar technology application in agriculture sector. Along with the development of solar industry, the solar developers in China has also made plenty attempt and experiments.

According to incomplete statistics, China holds over 3.33million hm^2 agriculture greenhouses, mainly located in the agriculture concentrated areas like Shandong, Jiangsu and Jiangxi provinces. These provinces are also solar radiation abundant areas that can provide sufficient sunlight for plants and solar facilities. The agriculture solar application in China was nearly emerged since 2010, and there were over 400 solar greenhouses, solar aquaculture and solar cultivation plant projects under operation in different provinces by March 2014. The agriculture and aquaculture solar projects approved by Chinese government in 2013 has reached to 2.9GW, and the number of approved projects was almost doubled in 2014. The solar agriculture still kept a strong momentum in 2015, and the large capacity of solar agriculture projects has become another special feature for both solar and agriculture industry in China.

There were also several outstanding companies emerged among the development progress of the agriculture solar application in China, whom focused on research and development for the solar system technology applied in the different agriculture sector. One of these technology, for example, the linkage solar tracking system, by using wind-blinds structure, provide uniform sunlight to the plants under the solar system, mitigates the shading areas caused by the solar panels installed upon the plants. It established the model of “upper side power generation, down side plants cultivation”, which had successfully planted series of corps and vegetables like rice, soybean, ginger, buckwheat, garden pea, carrot, corns, etc.

By the end of 2014, the 100MW solar aquaculture pond power plant project in Jinhu county, Jiangsu province which has commenced power generation. The project was built on 2779 acres undeveloped mud flat, where is hardly to be developed by lending to local farmers for crop planting. Eventually, the project investor acquired the land tenancy and invited the research institute from Agriculture Science Academic of Jiangsu province, also electrical engineering institute to study the specialty of the land and provide technical designing for

both agricultural operation and solar power plant. After flattening repairing and consideration of agricultural solutions, the investor finally decided to develop a solar aquaculture pond on the field. Up to the data from power generation monitor, the 100MW solar aquaculture pond power plant has generated power of 177,725 MWh by end of June 2016. Following the agriculture solution provided by the Agricultural Science Academic, the mud flat was reformed as a 50-70 centimeters deep aquaculture pond especially suitable to cultivate high value aquacultures like crayfish and crabs.

Beside the solar greenhouse, solar aquaculture, solar husbandry, and solar pump, the Chinese government is also pushing forward the solar poverty alleviation policies since 2013, based on the "20 years fixed income after single initial investment" economic feature of solar power plant. The policies are focusing on the poverty population in the rural areas, by installing solar power systems on the whole village bases, in order to increase $500 USD annual income each for total 2 million poverty families without labor force. The solar poverty alleviation policies raise capital by providing poverty alleviation fund and preferential bank loan, then hold project bidding to select construction and operation entity, to constructed residential power plant at 3kw-5kw, village size power plant at 100kw, and large scale power plant at over 20MW, then eventually, provide stable and precise poverty alleviation support.

Japan

For a long time period, The Japanese government is highly valued the protection of farmland, all the domestic farmland is prohibited to develop for other purpose except agriculture usage. After the nuclear power plant accident during the Great East Japan earthquake, the calling for energy structure adjustment becoming more and more strongly from Japanese society. Therefore, in 2014, the Japanese government granted permission for the renewable energy utilization on the farmland, under the precondition of no negative effect on normal agriculture activities. In Japan, the solar technology application in agriculture sector is mainly focus on the solar greenhouse, especially for the pipe frame plastic greenhouse. The T. Furuno University of Japan has studied on the pipe frame solar greenhouse since 2009, researchers installed several 0.078 square meter amorphous thin film solar module for an experimental pipe frame greenhouse (4m*8m*2.4m), the power generated from the solar thin film can perfectly drive the window system of the greenhouse. Researchers also compared the different layout of the same volume (30 pieces, 12.9% of the greenhouse roof area) thin film solar modules, by using vertical straight line layout and interval layout, the total power generation volume is almost identical, but the lighting status within the greenhouse under the interval layout is

obviously better than the straight line layout, which produced better quantity and quality experimental opinions.

Besides, the Japanese Agriculture Cooperatives (JAC) also established more than 90 experimental spots around Japan, mainly study the effect caused by solar power generation system on different crops in different areas and different solar radiation status. One of these spot in Chiba prefecture, taking place of 600 square meter, installed 25KW solar power generation system on greenhouse rooftop and elevated bracket. To ensure the traffic for harvester and tractor, the solar panels were installed on the 3.5 meters high elevated bracket, with 1.5 meters aluminum alloy helical underground in width of 6 meters. During the designing stage, the JAC selected IBC solar cell with intention, and customize ordered 1.04*0.42 meters small size solar module from China, to avoid too much sunlight block in the parts area, or to ponding large size waterfall hit on the crops leaf during rainy days. The project has operated over 2 years, over 15 major agriculture products in Japanese market had joint the experiment. It is proven that the solar panel can provide positive effect for soil conservation after a 24 hours continuous land humidity and temperature monitoring. The JAC has summarized the lighting demand and saturation point for each single agriculture plant. The experimental demonstrate that rhizome plant like carrot can even growth stronger under the solar farmland, while light-loving plant like corn will get some negative impact, and merely consequence for other corps and plant. The project initial investment is around $ 88.2 thousand USD, or $ 3 USD per watt, and will take 8 years to payback the investment, under the current $ 0.274USD/ kWh agriculture tariff in Japan.

Except for solar greenhouse projects, Japan arranged several solar project implementation on water recently. Due to the dramatic deviation amount of precipitation among a year, Japan has constructed plenty of agriculture and industrial reservoirs, also the river regulating reservoirs to adjust the water volume. These reservoirs are normally owned by the local government and private entity. Lending the reservoir's water surface to solar power generation companies can reserve the yearly maintenance cost. The 2.3MW project "Million Solar Power Station Overwater in Kasai City Hyogo Prefecture" started on grid electricity supply to Kansai Electric Power (KEPCO) since June 11th 2015, the predictable annual power generation volume is 2680 MWh, equals to 820 normal families electricity consumption in a year.

United States

As an important part of the economic in United States, agriculture always draws high intention and heavy policy support from the United States government. Farmers in the United States of America were encouraged to invest in renewable energy in their farmland to support their role of protecting the land, air, and water. According to the first USDA On-Farm Energy Production Survey (USDA, 2011), the United States Department of Agriculture (USDA) has proved that the solar panels have been the most prominent way to produce on-farm renewable energy.

Agriculture hosted some of the first terrestrial photovoltaic (PV) applications of solar energy in United States as it found uses for solar in remote locations around ranches and farms. Early on, solar electric made economic sense for a number of low power agricultural needs when running utility lines to a specific location was either not possible or too expensive. Kerosene, diesel, and propane have traditionally been used in agricultural operations to power generators when grid connection was not available. However use of these fuels has problems: cost of transporting fuel, volatility of fuel costs, fuel spillage, noisy generators, noxious fumes, and high maintenance needs. For many agricultural needs, solar energy provides a good alternative. Modern, well-designed, simple-to-maintain, and cost-effective solar systems can provide energy that is needed when and where it is needed.

Today, distributed generation, backup in the case of utility grid outage, and net metering present further opportunities for grid-connected solar energy use in agricultural settings. Larger solar installations have been developed; still, in agriculture solar energy generation has been small when compared to wind energy generation in the United States While small solar PV installations that below 10 kilowatt (kW) and small commercials 10kW-40kW, and large commercial PV installations range from 40kW-1MW are more and more popular in various agriculture sectors in the United States due to moderate initial investment volume and shorter installation period.

Traditionally, solar energy in agriculture has been associate d with off-grid applications. Today many applications in the United States are off-grid systems, but in States where interconnection and net metering policies are available, on-grid systems are more welcomed by the farm owners; the number of farms, ranches and especially wineries that are offsetting part of their energy needs with PV panels has been increasing over the years. A number of these efforts are linked to green and carbon neutral initiatives. For agriculture, a "remote" location where an off-grid PV system is used can be several miles away or as little as 50 feet from a power source. It all depends on the location, the application, the economies, and the original energy fuel used. Water pumping, a major agricultural application, is among the principal off-grid, non-domestic PV V power system applicationns14. Stand-alone systems around the farm or ranch are also excellent for uses that don't require a lot of power.

Generally, the agriculture applications of solar energy in United States can by categorized as below usage:

- **Crop and Grain Drying:** using solar dryers to dry crops and grain protect and reduce losses, dry faster and more uniformly, and produce a better quality product than open-air methods. The basic components of a solar dryer are an enclosure or shed, screened drying trays or racks, and a solar collector. In hot, arid climates the collector may not even be necessary. The southern side of the enclosure itself can be glazed to allow sunlight to dry the material. The collector can be as simple as a glazed box with a dark colored interior to absorb the solar energy that heats air. The air heated in the solar collector moves, either by natural convection or forced by a fan, up through the material being dried. The size of the collector and rate of airflow depends on the amount of material being dried, the moisture content of the material, the humidity in the air, and the average amount of solar radiation available during the drying season.

There is a relatively small number of large solar crop dryers in the United States. This is because the cost of the solar collector can be high, and drying rates are not as controllable as they are with natural gas or propane powered dryers. Using the collector at other times of the year, such as for heating farm buildings, may make a solar dryer more cost-effective. It is possible to make small, very low cost dryers out of simple materials. These systems can be useful for drying vegetables and fruit for home use.

- **Space and Water Heating:** livestock and dairy operations often have substantial air and water heating requirements. Modern pig and poultry farms raise animals in enclosed buildings, where it is necessary to carefully control temperature and air quality to maximize the health and growth of the animals. These facilities need to replace the indoor air regularly to remove moisture, toxic gases, odors, and dust. Heating this air, when necessary, requires large amounts of energy. With proper planning and design, solar air/space heaters can be incorporated into farm buildings to preheat incoming fresh air. These systems can also induce or increase natural ventilation levels during summer months. Solar water heating systems can provide low to medium temperature hot water for pen cleaning. Commercial dairy farms use large amounts of energy to heat water to clean equipment, as well as to warm and stimulate cows' udders. Heating water and cooling milk can account for up to 40% of the energy used on a dairy farm. Solar water heating systems may be used to supply all or part of these hot water requirements.

- **Greenhouse heating:** another agricultural application of solar energy is greenhouse heating. Commercial greenhouses typically rely on the sun to supply their lighting needs, but are not designed to use the sun for heating. They rely on gas or oil heaters to maintain the temperatures necessary to grow plants in the colder months. Solar greenhouses, however, are designed to utilize solar

energy for both heating and lighting. A solar greenhouse has thermal mass to collect and store solar heat energy, and insulation to retain this heat for use during the night and on cloudy days. A solar greenhouse is oriented to maximize southern glazing exposure. Its northern side has little or no glazing, and is well insulated. To reduce heat loss, the glazing itself is also more efficient than single-pane glass, and various products are available ranging from double pane to "cellular" glazing. A solar greenhouse reduces the need for fossil fuels for heating. A gas or oil heater may serve as a back-up heater, or to increase carbon dioxide levels to induce higher plant growth.

- **Remote Electricity Supply:** solar electric, or photovoltaic (PV), systems convert sunlight directly to electricity. They can power an electrical appliance directly, or store solar energy in a battery. A "remote" location can be several miles or as little as 50 feet (15 meters) from a power source. PV systems may be much cheaper than installing power lines and step down transformers in applications such as electrical fencing, lighting, and water pumping.

- **Water Pumping:** photovoltaic (PV) water pumping systems may be the most cost-effective water pumping option in locations where there is no existing power line. When properly sized and installed, PV water pumps are very reliable and require little maintenance. The size and cost of a PV water pumping system depends on the local solar resource, the pumping depth, water demand, and system purchase and installation costs. Although today's prices for PV panels make most crop irrigation systems too expensive, PV systems are very cost effective for remote livestock water supply, pond aeration, and small irrigation systems.

- **Photovoltaic Applications in Aquaculture:** closed aquaculture systems need pump and aerators to provide oxygen, to move water into and through the system, and to purify the water. Solar-generated electric power, known as photovoltaics (PV), can be used to meet the power needs of an aquaculture operation. The basic components of a PV system for aquaculture are not unlike any other system used for pumping water continuously: a) solar array, a sufficient number of modules to meet electrical demand. b) Battery bank, while marine and golf cart batteries can be used in small PV systems, industrial-grade storage batteries are far better suited when electrical demand is constant. c) Charge controller, to keep the batteries from overcharging or becoming completely discharged. d) Pump controller, the current booster that interfaces between the PV array and the water pump (and aerators). It provides optimum power to the pump and can start the pump in low light conditions. e) Inverter, transforms the direct-current (DC) power from the solar panels to alternating current (AC) power.

The Agriculture sector in United States was an early adopter of solar energy as a

remote energy source since early 2000's, and many of those initial applications are still cost effective today due to low maintenance costs and the high cost of extending electricity to remote locations. As solar energy has entered the on-grid market lately, while United States has grown as the most active and mature solar market in the world, agriculture is no longer limited to small off-grid applications, more and more agricultural businesses are taking advantage of policy incentives for substituting part of their energy needs with fixed cost solar energy.

The agriculture solar application in developed regions like European also made their own trail and exploration.

Since2008, the Wageningen University from Netherland keep trying to develop new material that can reflect near-infrared radiation (NIR), and penetrate the photosynthetically active radiation (PAR). The material can also attach to the glass of agriculture greenhouse with circular lighting surface design, so that to concentrate the NIR from sunlight at the focus point, then to generate electricity by the solar panel installed at the focus point. The monitoring data demonstrated that the greenhouse applied with such material can generated 20kWh/m^2 annually, and even expected to be improved to 31kWh/m^2 by optimized designing, so that to satisfy the energy demand for the whole greenhouse. However, since it is difficult to construct the circular lighting surface for the greenhouse, the Netherlands' greenhouse researcher considered to use Fresnel lens material, to concentrate the direct light from solar radiation in the greenhouse and install photovoltaic/photothermic equipment at the focus point to produce power or heat, while the shattered light in the solar radiation can penetrated into the greenhouse and effect on the plantings. Such greenhouse, as reported could generated 20kWh/m^2 or 440MJ/ m^2 annually, under the natural condition in Netherland (only 47% of direct light in the solar radiation), and reduce the energy consumption of the greenhouse by 75%.

Italy, located in the southern part of Europe, with unique natural gift of abundant solar radiation, has built large volume of solar greenhouse. By the end of 2014, there were 6% of the total solar power installation capacity comes from solar greenhouse. After comparing the proportion of solar modules installed on the solar greenhouse and annual planting experiment, it proves that the solar module installed on the greenhouse should not exceed 9.8% of the total rooftop area in order to avoid negative effect to the tomato cultivation. While the installation area surpass 50% of the rooftop, it will block 63% of the sunlight in the greenhouse, and will not be suitable for tomato planting. Therefore, the Italian government established following regulations for solar greenhouse. 1) For the solar greenhouse with installation capacity over 200KW, the revenue comes from agriculture planting must higher than the power generation revenue. 2) No greenhouse is allowed to install solar module more than 50% of the rooftop area. 3) The investor need to clarify the plants to be cultivated in the

greenhouse and provide correspondence designing before the design and construction of the solar greenhouse.

- **The supporting policies for solar PV technology in agricultural sector in different economies**

As an emerging industry, the fast development of photovoltaic technology, including the extension of installation capacity, rapid cost reduction, are all highly rely on the various industrial supporting policies from different economic parties. Thus, the solar power generation industry is a policy-sensitive industry, changes in government subsidies are critical to the impact of solar industry. However, The same supporting policies in different economies could also lead to different effects according to the condition of different economies, and the regulations need to be established based on the local circumstance thoroughly. The development status of solar industry in the past decade demonstrate the major supporting policies launched in active market as below:

- Setup feed-in tariff
- Provide Initial investment subsidy or grant;
- Tax reduction and tax credit;
- Acceleration of asset depreciation;
- Green certificate and carbon trade mechanism;
- Other supporting subsidies;

1) Japan: feed-in tariff and tax reduction

The Japanese government approved “Renewable energy special measures act” in year 2012. And the renewable energy feed-in tariff was formally effective in July 1st 2012. The policy spurs the booming of renewable energy market in Japan, particularly for solar photovoltaic, then Japan becoming the 3rd largest solar market in the world. Feed-in tariff for solar power generation are showing below:

Project Scale	**⩾10kW**	**＜10kW**
PPA duration	**20 years**	**10 years**
July 2012 – Mar 2013	$ 39.6 US cents/kWh (without tax)	$ 41.6 US cent/kWh (with tax)
April 2013 – Mar 2014	$ 35.6 US cents/kWh (without tax)	$ 37.6 US cent/kWh (with tax)
April 2014 – Mar 2015	$ 31.7 US cents/kWh (without tax)	$ 36.6 US cent/kWh (with tax)
April 2015 – June 2015	$ 28.7 US cents/kWh (without tax)	$ 34.7 US cent/kWh (with storage) / $ 32.7 US cent/kWh (without storage)
July 2015 – Mar 2016	$ 26.7 US cents/kWh (without tax)	
April 2016 - present	$ 23.8 US cents/kWh (without tax)	$ 32.7 US cent/kWh (with

		storage) / $ 30.7 US cent/kWh (without storage)

Besides, the Japanese government also set up the conversion efficiency standard for the solar modules that used in the Japanese market, which is no less than 13.5% for monocrystalline and polysilicon modules, and no less than 7.0% for Si-based film, also no less than 8.0% for chemical compound modules.

On the tax credit side, the investor will receive income tax reduction from the investment of up-stream renewable energy manufacture equipment. For investment over $ 15.8 k USD, if the investment return is higher than 5% (higher than 15% for investment over $ 990k USD), the tax bureau and economic industry bureau of Japan, after pre-estimation, will provide tax credit as of 5% of the total investment volume during the project duration, such tax credit is only adaptable for the projects that complete construction before March 31st 2016. And for project constructed between April 1st 2016 and March 31st 2017, the tax credit will be 4% of total investment value, or 50% of tax payable reimbursement instantly.

2) The United States Financial subsidies and green certificate trade

The solar market in the United States has kept strong growth momentum since2010, the total market volume in the economy exceed 10GW by the end of 2013. Such growth was mainly benefit from the strong supporting policies from both federal government and states governments. On the top of the net metering method, the United States federal government also established series of supporting policies: Investment Tax Credit (ITC), Renewable Electricity Production Tax Credit (PTC), accelerated depreciation, cash grant. These policies provided a favorable financing environment for the renewable market, especially solar sector, and cultivated several innovative business model like solar system rentals, Power Purchase Agreement (PPA), and widely benefited the solar investors, stakeholders and consumers. The most popular and effective policies from the federal government of United States are the famous PTC and ITC.

PTC: The federal renewable electricity production tax credit (PTC) is an inflation-adjusted per-kilowatt-hour (kWh) tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year. The duration of the credit is 10 years after the date the facility is placed in service for all facilities placed in service after August 8, 2005. In December 2015, the United States federal government extended the

expiration date for this tax credit to December 31, 2019, for wind facilities commencing construction, with a phase-down beginning for wind projects commencing construction after December 31, 2016. The Act extended the tax credit for other eligible renewable energy technologies commencing construction through December 31, 2016. The Act applies retroactively to 1 January 2015. Applying the inflation-adjustment factor for the 2016 calendar year, the production tax credit amount is as follows:

- $0.023/kWh for wind, closed-loop biomass, and geothermal energy resources
- $0.012/kWh for open-loop biomass, landfill gas, municipal solid waste, qualified hydroelectric, and marine and hydrokinetic energy resources

ITC: The federal Business Energy Investment Tax Credit (ITC) has been amended a number of times, most recently in December 2015. The table below shows the value of the investment tax credit for each technology by year. The expiration date for solar technologies and wind is based on the date of the construction begins. For all other technologies, the expiration date is based on the date of the system is placed in service (fully installed and being used for its intended purpose). In December 2015, several amendments to this credit which apply to solar technologies and PTC-eligible technologies has been made. Notably, the expiration date for these technologies were extended, with a gradual step down of the credits between 2019 and 2022.

Eligible solar energy property for ITC includes equipment that uses solar energy to generate electricity, to heat or cool (or provide hot water for use in) a structure, or to provide solar process heat. Hybrid solar lighting systems, which use solar energy to illuminate the inside of a structure using fiber-optic distributed sunlight, are eligible. Passive solar systems and solar pool-heating systems are not eligible. The credit is equal to a certain portion of the expenditures and the portion range are as follow:

Year	12/31/16	12/31/17	12/31/18	12/31/19	12/31/20	12/31/21	12/31/22	Future Years
Proportion	30%	30%	30%	30%	26%	22%	10%	10%

The federal government of United States also provided an accelerated depreciation accounting method, which allows investors to finish the depreciation accrual within 5 years for a 30 years duration renewable asset, so that the renewable asset owners can save income tax by centralized the depreciation cost at the beginning 5 years of project operation. It is even

allowed to accrual 50% of the asset depreciation in the first year of production before year 2013.

Beyond the federal government, most of the states government in United States also released their own renewable supporting regulation according to the custom conditions in each state. And the most success regulation is the green certificate trading scheme among several states. The Renewable Portfolio Standard (RPS), is the most popular renewable energy adjustment policy that regulate the proportion of renewable energy supplied in the power grid by certain time frame with legal force. By end of 2012, there were total 16 states including Washington D.C. had joint the RPS trading system. Besides, most of the states are also joint the Renewable Energy Certificate (RECs) trade, which is a market-based instrument that represents the property rights to the environmental, social and other non-power attributes of renewable electricity generation. RECs are issued when one megawatt-hour (MWh) of electricity is generated and delivered to the electricity grid from a renewable energy resource. And supported by several different levels of government, regional electricity transmission authorities, nongovernmental organizations (NGOs), and trade associations, as well as in United States case law. RECs provide a way for purchasers to demonstrate claims of renewable electricity. Compliance purchasers (those with a mandated renewable obligation) purchase RECs to demonstrate that they have met requirements. Voluntary purchasers need to substantiate their self-imposed renewable targets and their marketing claims (e.g., “This product was made with 100% wind power”). In both compliance and voluntary markets, RECs are the way to show you are using renewable energy

3) China, feed-in tariff, distributed generation subsidy, land tenancy policy

On 1 January 2006, the Chinese government released the “Renewable Energy Law”, which demonstrated the renewable energy industry in China has entered into the fast development period. The solar photovoltaic industry in China, also reformed from solar module processing for export trading, to the largest solar power generation market in the world. Such reformation is mainly caused by two major supporting policies:

Firstly, the initial investment subsidy policies:” Golden Sun Project” and “BIPV Application Project” between year 2009 and 2012. The subsidy terms and results during this period are as follow:

	The Golden Sun Project		BIPV Application Project	
Year	**Capacity**	**Initial Investment Subsidy (CNY /W）**	**Capacity**	**Initial Investment Subsidy (CNY/W）**
2009	98 projects for 201MW	BIPV: 14.5 Off-grid system: 20	111 projects for 91MW	BIPV: 20 BAPV: 15
2010	50 projects for 272MW	BIPV: 11.5 Off-grid system: 16	99 projects for 90.2MW	BIPV: 17 BAPV: 15
2011	140 projects for 690MW	c-Si solar project: 9.0 a-Si solar project: 8.5	106 projects for 120MW	BIPV: 12
2012	167 projects for 1709MW	BIPV: 5.5 Off-grid system: 7	128 projects for 225MW	BIPV: 9 BAPV: 7.5

Secondly, the solar feed-in tariff regulation published in July 2011, which regulated the fixed electricity price for solar photovoltaic in different resource condition areas. Thereafter, the solar power installation capacity in China start explosive expansion. The feed-in tariff policy particularly support the construction of solar power generation project in the western part of China, where the solar radiation resources are extremely abundant. While the cost of solar system decreased along with the solar market expansion in China, the feed-in tariff standard was also adjusted downwards accordingly. The initial investment subsidy for BIPV and distributed generation projects were also switched to electricity generation credit after 2012, same as PTC policy in United States, the electricity generation credit provides $6.42cent/kWh for the production from BIPV and distributed generation solar project. Besides, at the different level of Chinese government, province, city and district level are also provided solar subsidies respectively, such series of supporting regulations strongly stimulated the solar market in China into a historical high stage. The feed-in tariff standard is demonstrated below.

Resource Level	FIT standard（CNY/kWh）				Distributed Project:	
	Project approved before July 2014 and constructed before end of 2011	Project approved after July 2011, or constructed before end of 2011	Project approved before 2015 and constructed before June 2016	Project approved after 2016 or constructed after June 2016	Subsidy for self-consume power	Subsidy for grid-connection power
I	1.15	1.00	0.90	0.80	On grid solar FIT plus 0.42 (CNY/kWh)	Coal fire power price plus 0.42 (CNY/kWh)
II			0.95	0.88		
III			1.00	0.98		

On the tax credit side, the solar power producer can receive 50% tax reimbursement while selling the electricity since 2013. The policy was planned to be expired by the end of 2015. However, the policy was extended to the end of 2018. The commercial solar power producers can also receive tax exempt for the first 3 years of operation, than 50% tax reduction in the following 3 years.

For the land tenancy of solar agriculture projects, it is strictly prohibit to develop the agricultural land for non-agricultural propose. In the specific provinces, for instance Inner Mongolia, the investor of solar greenhouse can also receive tax credit as of 30% of initial investment, the similar regulation was also applied in other provinces with different tax credit levels.

4) Supporting policies for solar industry in other economies

- **Australia**

Australia is also through the way of providing FIT subsidy for solar projects, instead of an economy wised FIT standard, each state of Australia determined their own FIT combining with the net metering method. The tariff level in different states are as follow.

States	Rooftop system $/kWh	Ground Mounted System $/kWh	Duration
NSW	＜10kw = 0.6103	＜10kw = 0.6103	7 years
QLD	＜5kw = 0.0868	＜5kw = 0.0868	20 years

SA		＜30kw = 0.5967	20 years
VIC	＜5kw = 0.6103	＜5kw = 0.6103	15 years
ACT	＜10kw = 0.3094	＜10kw = 0.3094	20 years

- **Indonesia**

The Indonesian ministry of energy and mineral resources (MEMR) released the first round of solar feed-in tariff in July 2016, in order to support the development of total 250MW solar power generation projects. The FIT policy was established after the unsuccessful solar concession auction in2013, it mainly targeting to brighten the infant solar industry in Indonesia by direct electricity subsidy. The Indonesian government will provide PPA with duration of 20 years, and the solar power producer will receive FIT between $0.145-0.25/kWh, and the specific value will be determined by the detail condition in different areas. The FIT will cover total volume of 250MW solar power generation projects, with single project capacity limitation of 20MW. Following the “first apply first receive” procedure, the Java island has already applied FIT for 150MW solar power generation project as the most, however, with the lowest FIT level of $0.145/kWh.

- **Chinese Taipei**

Chinese Taipei released “renewable energy development regulation” in 2009, they set up subsidy for 6.5GW – 10GW of renewable energy projects. The renewable energy fund was also established to secure the financing of subsidy. Legislation for the obligation of grid connection and power purchase for the renewable energy under standard FIT. The FIT for solar power generation projects in Chinese Taipei was set up in 4 categories under 20 year’s duration PPA. The rooftop distributed generation solar system is most encouraged, and the FIT for such kind of project is much higher than ground mounted solar projects. The Specific tariff standard are as follow.

Type	**Capacity (kW)**	**Period1 US cents/kWh**	**Period2 US cents/kWh**
Rooftop	≥1~＜20	22.1397	21.5229
	≥20~＜100	18.509	17.9871
	≥100~＜500	17.299	16.8242
	≥500	16.7532	16.3023
Ground Mounted	≥1	15.7565	15.3294

- **Thailand**

The Thailand government approved Alternative Energy Development Plan (AEDP), which plans the renewable energy development roadmap for the future 15 years. The AEDP also set up a target that the whole power system in Thailand shall contain 20.3% of alternative energy (14.1% of renewable energy) by 2022. The Thailand government turn to emphasize the development of solar photovoltaic after year 2013, it has made Thailand becoming the largest solar market in northeast Asia. The feed-in tariff provided by Thailand government for different scale of solar projects are showing below.

Project Scale	**FiT value**	**FiT duration**
0-10kW small scale project	6.69 THB/kWh	25 years (for project installed on rooftop in 2013)
10kW-450kW middle scale project	6.55 THB/kWh	25 years (for project installed on rooftop in 2013)
450kW-1MW power station	6.16 THB/kWh	25 years (for project installed on rooftop in 2013)
Over 1MW large scale power station	5.66 THB/kWh	20 years
Community solar system	9.75 THB/kWh in first 3 years, 6.5 THB/kWh from year 4 to year 10	Decrease gradually

- **Germany**

German was the pioneer in the solar market in the world. The German government has provided supporting policies for solar industry back to year 1997.The most famous policy is the 'one hundred thousand solar rooftop project'. In 2000, the renewable energy law 'Erneuerbare-Energien-Gesetz' (EEG) was approved in Germany and kept improving amendment from time to time following the development status of solar industry. Germany government also provide solar FIT for a duration of 20 years. In 2010, the distributed solar power generation in the economy was already scaled up, the FIT under EEG was deducted dramatically, and most of the subsidies for solar power generation were cancelled. After EEG-2014 released in2014, the payment model and FIT level of solar power generation was adjusted once again. Currently, the solar FIT in Germany was categorized by 5 levels, the policies decreasing year by year:

Euro Cents/kWh	＜10KW	10-100KW	100KW-1MW	1MW-10MW	> 10MW
2011	24.3	23.3	21.98	18.33	17.94
2012	19.5	16.5		13.5	no FIT
Aug-13	12.08-14.08	14.04	12.52		no FIT
Mar-16	10.71-12.7				

- **Challenges and opportunities for four types of agricultural solar application projects**

Photovoltaic and agricultural integration, represented the future of green innovation development, strengthen the fundamental of economic. Brought new vitality to the traditional agriculture industry and widened the solar application market.

The solar agriculture application, not only as a kind of clear power source, but also provide preconditions for the mechanization of agriculture operation. With the supply of stable, low cost clean energy, the farmers can manually adjust the temperature and humidity even the climate atmosphere within the greenhouse, in order to stimulate the growth of plantings. It secures the cultivation environment by installing pest killing lamps, and automatic water pump powered by solar energy, so that the quantity and quality of the crops or livestock can be improved. Beyond the power solution for the agriculture facilities in the rural area, the solar applications can also achieve land conservation and cost saving by vertical utilization, and comprehensive benefit of the agriculture project by adding power generation and ecology optimization. The cross sector operation can also attract capital investment, which expand the character of agriculture operators and conjunct with wide range of industrial commercial entities, merging the latest internet technology, information technology, smart control and modern agricultural science, and eventually, significantly raise the income of agricultural populations. During the process of agriculture modernization, and promotion of new business model urban city in different economies around the world, the development of agriculture solar application is not only an impetus for agriculture sector, but also the reformation method for urbanization.

Nevertheless, the development history of agriculture solar application is still a short period of time. Most of the relevant technologies and business models are still at the primary stage, and require continued improvement and investment. First of all, the impact for the quality of sunlight and the ground light environment in the solar greenhouse is still ambiguous, there is no general standard for the installation of

solar modules to regulate and instruct the suitable installation angle, interval, height and the way to integrate with other ventilate and control systems. Also the management solution for the agriculture solar application projects, including fabrication process, function areas division, roadway planning, human resource and logistic, all these factors are still need further practice and innovation. Secondly, with objective of service and optimize agriculture population, how to motivate and guide the farmers to participate the agriculture solar application project and tackle the relationship between project stockholders, those are unavoidable, critical and complex issues. these problems need high governing skills and well-designed regulation circumstance, and the agriculture solar application can only performing effectively by correctly set up the rolls and responsibilities for local farmers and project investors.

2. The development, construction, operation and maintenance of four different types of agricultural solar application projects

All the agriculture solar applications including solar greenhouse, solar cultivation plant, solar aquiculture, solar poverty alleviation and other application forms, can all generally categorized as below scenarios.

- Ground mounted grid connect solar plant;
- Distributed solar power generation system;
- Residential solar power generation system;
- Solar equipment utilization.

For the solar equipment utilization, photovoltaic system is simple to be applied by purchasing the standard or customized solar equipment from the supplier based on the demand of the agriculture operation. The other three models above, will all need to go through the project development, construction, and long term operation & maintenance stages. The project idea will be only realized after the power purchase agreement (PPA) was signed between project owner and electricity purchaser , or received FIT and other subsidy approval from the local government and power grid company, or just get all the administration approval in the case of project owner will digest all the power generated from the solar application.

- **The analysis for the development status of four types of agricultural solar application projects.**

Project development is the very first stage of agriculture solar application. The development work mainly including the natural resources investigation, local policies, administration procedure study, and the local power system research. Then eventually arrange the project team and organize the project design and working plan. The upfront investigation could be conducted by following below process:

Investigation preparation: pre-communication with the local stake holder, confirm the project location, scale and land situation, the preferred model of agriculture solar application, specific factors need to be awarded, the local grid connection conditions and governing regulations.

Field study: observation of the land conditions, sunlight shadows, current living plants, animals and the seasonal variations.

Research on the field study results: confirmation on the project scale and area, confirmation on the features of the land (whether allowed to construct solar applications), and designing of the grid connection solution.

After the preliminary feasibility study and judgement of the project based on the upfront field study, the project development stage will move to the administration approval procedures:

1) Complete the detail of the project feasibility study report, including basic project information, technical feasibility study, project financial assessment, comparison of the combination solution of solar and agriculture, and summarization of the project advantages and social benefits.

2) Administration approval for project application, land tenancy, grid connection, FIT or subsidies application by correspondence government department. Complete the environmental assessment report, and receive full project construction approval certificates.

3) Project registration at the local government, and acquire legitimate status for the project, preparation for the practical project designing.

The project designing work majorly includes the blueprint design, key equipment and facilities selection, logistic and procurement arrangement, construction timeframe planning, and grid connection preparations.

Since the development of agriculture solar application projects will normally involve electricity, agriculture, forestry and aquiculture sectors, and the way to acquire land tenancy became a tricky issue particularly in the regions that lack of understanding of agriculture solar application. Ambiguous governing department and unclear administration process for investors to apply the land tenancy for agriculture solar projects is one of the major barriers for the agriculture solar application project development.

During the study on the agriculture solar application policies within Member economies, it shows that the land conservation and ecology environment protection, in most of the cases, is the very first concern from the government in the agriculture solar application regulations.

In China, the control of the agricultural usage land development is clear and strict, it is absolutely forbidden to develop the agricultural usage land for any

none-agricultural purpose. Thus, the agriculture solar application investors will need to confirm the agricultural activity first, and as the major activity to be conduct on the land during the application process. Due to the defiance forestry areas in the economy, the agriculture solar application projects carried out close to the forestry land mostly to ensure that the feature of the land won't be changed, and only the un-utilized areas is allowed to be developed to solar power generation projects. The Japanese government managing the land tenancy by a serious of rules including "Urban City Planning Regulation", "Basic building law", "Agricultural land low" and "Forestry law" etc. According to the "Urban City Planning Regulation", the development of the land including change the feature of the land by constructing buildings or objective with special purpose, the large scale land development over the defined project size, will need large scale land development certificate. If the project development will attach to the forestry land, several administration approvals will be needed upfront, i.e. the forestry land development certificate, logging permission and environmental impact assessment report, also the specific implementation solutions based on the land conditions and geography status, some local government will even provide construction guidance on the agricultural land and green field preservations.

However, such land regulatory policies are still not systematized and practicable, it has huge difference in different economies. Thus the agriculture solar investors will need provide detail and thorough local study before project development to avoid compliance issues and land dispute.

- **The construction status analysis for four types of agricultural solar application projects**

The construction of solar power generation project, is a complex engineering system, especially for agriculture solar applications, that require to construct of install solar power generation facilities on greenhouse, fishpond of cultivation plants, raises the difficulty of project designing and construction. In general, the construction of solar power generation project is composed of 6 major tasks: bidding management, security management, quality management, schedule management, cost control and materials management. Compare to normal solar power generation project, agriculture solar application will need more considerations due to the increased construction difficulty , like how to preserve the corps and secure the sunlight for the plantings, how to high raise the solar panels by installation special designed bracket, which will cause additional cost and management efforts for the project construction.

The technical requirements for four different types of agricultural solar application projects.

The construction work of agriculture solar application project can be divided into three parts: ground construction, electrical installation, and grid connection test and project verification.

The ground construction majorly include ground clearance, road construction, bracket groundwork, bracket concrete construction, cable trench ditching and lining cutting, booster station ground work, water and environmental protection facilities, flood prevention constructions, etc. These fundamental ground construction directly impact the stability and reliability of the solar power generation system. The electrical installation mainly include bracket installation, solar module installation, cable connection, connection and installation of the junction box, converter and voyage transformer. As the critical influence factor for the solar power generation system, the quality of electrical installation, determines the operation status of the power station, also stands for the technology advances of the whole project. Grid connection and project verification include solar module debugging, module matrix debugging, and eventually the debugging for the whole power generation system. Then process the project quality check and grid protection function test. The project owner will need to apply for the grid connection verification and submit requested documents, the project will only realize the grid connection after the project get approved by the grid connection verification committee.

The feature and difficulty analysis for four types of agricultural solar application projects during construction process.

The engineering structure design for solar greenhouse need to base on the plants in the green house, especially for the solar module layout and bracket installation method, which will determine the general engineering structure and in-house circumstance of the project. Besides, the integration of the irrigation system, humidity and temperature adjustment facilities, cover coating, insect prevention equipment, lighting, heating and air conditioning facilities, all request high engineering demand and comprehensive consideration for the project at the designing and construction stage. Firstly, the bracket for the solar greenhouse are installed at high altitude, which create operation difficulty for the installation of solar module, connection of cable and long-term maintenance. Thus the safety method for high altitude working and tread prevention actions must be carried out during the project construction, even the long-term operation period. Secondly, the steel

structure for the bracket is more complex than normal bracket used in ground mounted solar power plant. Most traditional manufactures may not capable to produce the customized designed bracket used for the solar greenhouse, which may require additional designing work for engineering institute and special raw material procurement, it will extend the construction period and increase the project investment. Besides, special EPC supplier will be needed in the construction stage of the solar greenhouse, since the solar modules are not only perform as power generation unit, but also the roof top or wall of the greenhouse. The EPC supplier will need to secure the stability of water prevention effect for the project during the construction. Lastly, due to the climate environment within the greenhouse has higher temperature and humidity, the steel material used in the project need to have better anticorrosion features.

Solar application in aquiculture mainly follow the depth of the water to select the correspondence type of bracket. When the depth is less than 3 meters, the bracket will normally be raise up, and the floating bracket will more commonly applied when the depth of the water is more than 3 meters. In the raise up case, since the single column standing may cause the slope of the bracket, thus the double bundled column stand will be more preferred to provide enhanced sustenance and secure the position of the bracket. In addition, due to the solar application in aquiculture has higher humidity and salty circumstance than greenhouse conditions, the selected steel material must have much better anticorrosion features. For the floating solar modules, the variation of the water level need to be investigated previously, and provide the engineering design based on the local hydrologic status, to avoid the damage of solar power generation system caused by the dramatic change of water level.

Solar pumps are mostly applied in the rural area that without sufficient power supply and transportation, it also difficult to maintain due to the limited project scale and cost consideration. Therefore, the solar pump projects are mostly well designed and installed for a certain areas at the beginning stage, with abundant parts and reserves stored so that the project operators can replace the malfunctioned parts and repair the facilities by themselves.

New technology application in agricultural solar projects. (i.e. double-glass PV module, tracking support system .)

Currently, there are two technical mature and economic feasible technologies that widely applied in the agriculture solar applications: double glasses solar module and tracking support system.

The double glasses solar module as a totally symmetry structure, are formed with glasses as front and back board, and two layers of EVA inside to adhere the solar cells in the middle, so that to improve the light transparency of the module. The technology are trapped by the high initial cost at the early developing stage, and following the rapid cost reduction during the technology maturity, more and more project with special function demand are preferred to select the double glasses module. Like projects installed on the lake, mud flat, seashore, soar greenhouse and solar cultivation plant. These projects can acquire better light transparency and reduce the gas corruption by using double-glass solar modules, even to avoid PID (Potential Induced Degradation) effect. And such efforts are all caused by the designing of the double-glass solar module which is no back board, no frame and double side transparent glasses, this can avoid vapors corrode, less dirt retention, enhancing the bending resistant and eventually extent the product longevity, reduced the maintenance cost. These advantages can highly improve the power generation efficiency and the stability of the agriculture solar application project.

The tracking support are comparing to the common fixed bracket. The solar power generation system can achieve the best power generation efficiency while the sunlight is vertically towards the solar panel. However, since the earth planet has been in the revolution and rotation all the time, thus the direction of the sunlight also keep changing during the day time, therefore, fixed bracket cannot ensure the solar panel absorb the sunlight effectively. The designing purpose of the tracking support system is to adjust the solar panel following the direction change of the sunlight, so that to improve the power generation efficiency. The technology now are mainly including single axle tracking system and double axles tracking system, and the single axle system also split for horizontal tracking system and inclined tracking system. The tracking support system is more popularly applied in solar greenhouse and aquiculture solar projects. Since the growth status of the plants are more related to the temperature status than the sunlight. While the sunlight reach certain level, the photosynthesis of the plant will suspend and even sharply dropped and falls into dormancy preservation. Generally, in the solar radiation abundant area, the photosynthesis of the plants are more active during the dawn and sunset, while the sunlight is weak. During the sunlight strong period morning, noon and afternoon, the plant will turn to dormancy preservation status, which may waste even 70-80% of the sunlight during the daytime. Utilizing the tracking support system to track the

strong sunlight from morning to afternoon, can increase the power generation volume while benefit the plants cultivation, which is one of the most favorable agriculture solar application methods for the time being.

- **The operation and maintenance status analysis for four types of agricultural solar application projects**

After the grid connection of the agriculture solar application project, the operation and maintenance will become the major tasks, which directly impact the stability and longevity of the project generation. It also linked to the project's unit production cost, investment return and final yields. Those are the key parameters to evaluate whether the solar and agriculture technology are integrated with mutual benefit and supporting effect.

The operation and maintenance work mainly include: a) Monitoring the project operation status, record the generated power volume and receiving the grid dispatch orders through monitoring system. b) Inspect and check the project operation conditions and malfunctions, includes checking of the solar module, bracket, electronic devices (junction box, converter, DC transformer, AC transformer) etc. c) Following the dispatch and maintenance orders from the power grid to perform the electronic devises adjustment and shut down operations.

Solar greenhouse, solar aquiculture and solar husbandry cultivation farm, compared to common ground mounted solar power plant, are more demanding at the operation and maintenance process. These agriculture solar applications are difficult to clean due to the height of the bracket, and hard to be inspected because of the complex and large area of geography conditions, which man cost a lot by using conventional manual operation and maintenance solution. Therefore, drones and cleaning robot are more suitable for the inspection and cleaning work of the agriculture solar application projects.

In the foreseen future, the smart 'Online to Offline' operation and maintenance method will be wide applied, which is combine with online 'concentrated inspect and remote diagnosis', and offline 'onsite maintenance and on-demand services', so that can minimize the operation and maintenance cost and reduce the power generation lost. Such operation and maintenance model covers 3 key components: scientific operation and management system, smart online operation platform and professional maintenance team. The scientific 'Online to Offline' operation and maintenance system established based on years of operation and maintenance experiences is the fundamental of the whole model, also the guidance of the process

control, which can introduce the quantification measurement for the operation and maintenance work. Throughout the smart online operation and maintenance platform, the solar agriculture application project can achieve refining administration, reflect the operation status and locate the malfunction points by real-time data, the whole maintenance process can be clearly controlled online and secure the power generation. The professional maintenance team recruited with specific purpose, is targeting to fulfill series of professional tasks i.e. the onsite project maintenance, inspection, online/offline diagnose and system optimization. Combing with the online real-time operation data and rich site experiences, equipped with professional tools and instruments, to provide speed, precise and efficient services, and conduct high standard management for the agriculture solar application projects.

3. The best business model and financial risk control plan for agricultural solar application projects

- **Analysis of Standard financing solution for the agriculture solar application project.**

Solar power generation project, in normal cases, will need sizable initial investment, and the financing leverage is indispensable. At present, the popular financing method in the market (for both project finance and company finance) including bank loan, debt finance, stock market finance, financial leasing, funds, crowdfunding, securitization and a few of innovative finance models.

Bank Loan

Bank loan is the major finance channel for renewable energy project, with undoubtable advantage of low financial cost. If the renewable energy project are fully carried out by own reserves, the annual return of the project may limited at 10%; if the project investment could be 70% financed by the bank loan at an interest rate of 7%, the own reserves investment return rate could achieve around 30%, which will create high attraction for renewable energy investors. However, for most of the private renewable investors, the bank loan is difficult to acquire and the finance volume is limited. The bank loan will only be released by certain mortgage asset accepted by the bank: mortgage or guarantee from non-renewable energy asset, or, mortgage or guarantee from other renewable energy asset and future cash inflow.

Debt Finance

One of the attractive model for renewable energy in the finance market is debt portfolio. The most outstanding debt equipment of renewable energy around the world is the MidAmerican Energy founded by Berkshire Hathaway of Warren Buffett. The MidAmerican Energy has issued a serious of debt portfolio since 2011, and managed acquisition of several large scale public utility size solar power plant. In the second quarter of 2013, the MidAmerican Energy issued their biggest one debt financing with total sum of 1 billion US dollars.

Stock Market Finance

Stock market is one of the conventional finance markets for renewable energy developers, influenced by the warmer United States stock market and bully booming Chinese stock market, plenty of listed renewable energy companies initiated directional add-issuance. The stock market became another active finance channel for the renewable energy industry.

Financial Leasing

Financial leasing is the lessor signed leasing contract with lessee, is the purchase agreement contract with the equipment supplier, then the supplier will deliver the equipment to the lessee, and lessor will use the cash follow generated by the equipment to pay the rental to the lessor, eventually, when the rental period ended, lessee could negotiate with lessor for a settle price to acquire the ownership of the equipment. Financial leasing actually transferred the ownership, risks and reward from an asset by the way of rental. It is a finance solution to acquire the right of use for an asset but not the ownership, it combined the feature of finance and services.

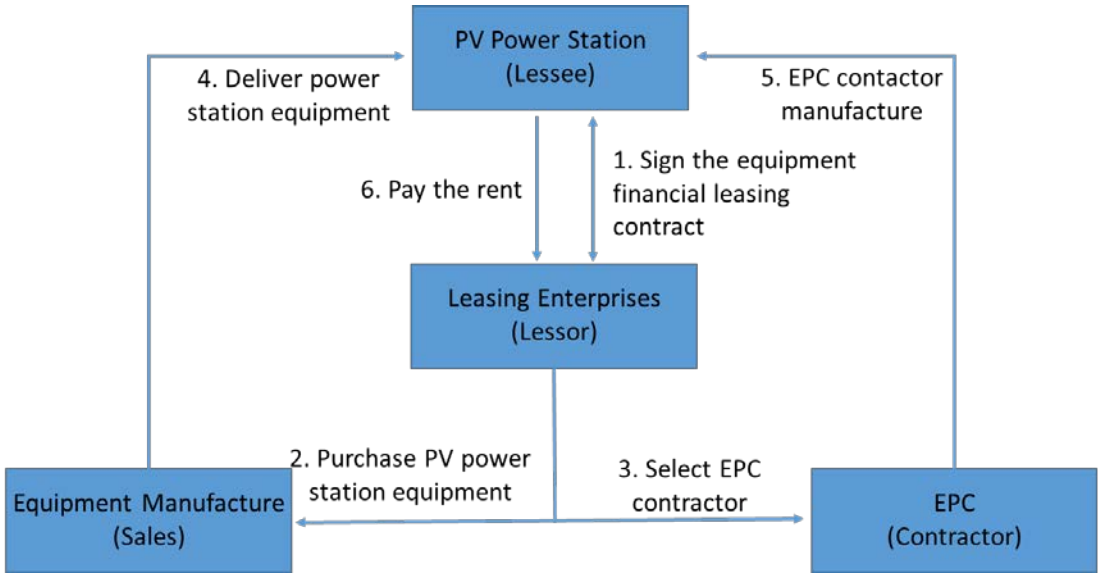
The development and operation of renewable energy project can generate fixed revenue, and adapt to the financial leasing. Moreover, financial leasing can also optimize the balance sheet and business model for the renewable energy operator, and let the operation entity keep a high creditability while applying high level of leverage, so that can improve the capital utilization rate, stimulating the power generation asset, which may become the breakthrough finance solution for the renewable energy operators. The financial leasing can be also arranged by below two major forms:

a) Direct leasing. As described above, the project operator could provide partial investment at the project construction state, and signed a leasing contract with the leasing company also provide the preferred supplier list. The leasing company will purchase all or most of the equipment, and rent to the project operator. The project operator, after paying the rental during the leasing period, could negotiate with the leasing company for a settle price to acquire the ownership of the equipment. This is the most standard leasing model.

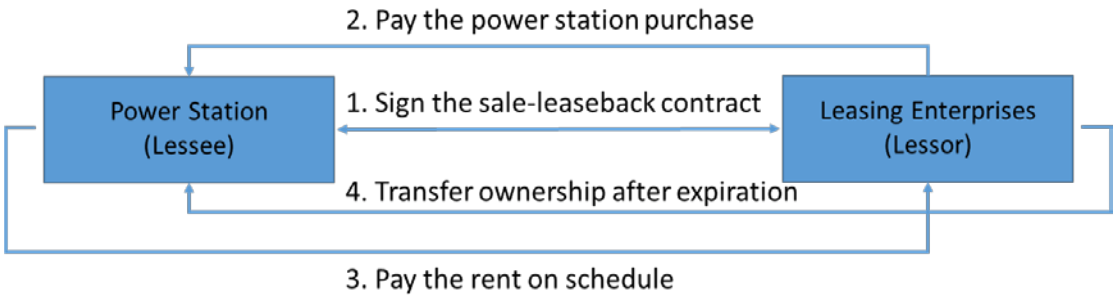
b) Sale and leaseback. After the project was well constructed, completed grid connection and start power generation, the ownership of the project can be transferred to the leasing company by sum of payments, the leasing company will

lease the right of operation back to the project operator. The leasing company will collect lease payment according to the leasing agreement, and the project operator will regain the ownership of the project after finish all the leasing payment and pay off the project residual value. This method can benefit the renewable energy operator by liquidating the fix asset, raise the liquidity, equity capital or acquisition capital also to refine the financial statement. However, due to the leasing is based on a built up renewable energy asset, it is similar to the mortgage loan.

These two model of financial easing are demonstrated as below:



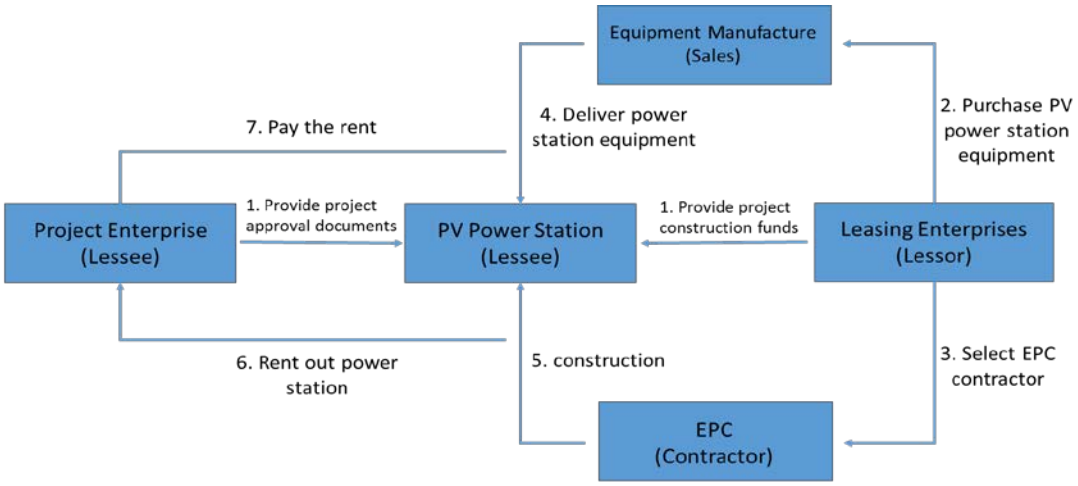
Direct Leasing



Sale and leaseback

The Direct leasing, follow the demand of the project developer/operator, can be further developed as leasing and share mixed model. Where the project developer is

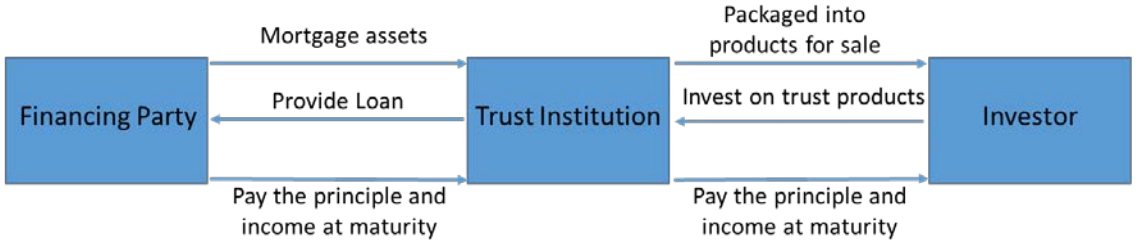
responsible to provide whole project administration approval document, the leasing company will finance the whole project initial investment. The leasing company will hold most of the share of the projects after the project completion, and rent back the project operation right (to the project developer or third party operator) after a certain volume of guarantee payment from the project developer. The leasing company will collect the lease payment according to the leasing contract.



Leasing and share mixed model

Trust fund

The features of renewable energy, asset-heavy, fixed income and comparable controllable project risk, are all matched with the demand of trust fund. In the mature financial market, like United States the solar power station are trying the trail of trust fund. Following the Real Estate Investment Trust (REITs), the PV REITs is also emerging, which may become a major finance model after 2016. However, in the developing financial market, like China, the REITs still lack of legal foundation and guiding regulations, which create barriers for such way of finance.

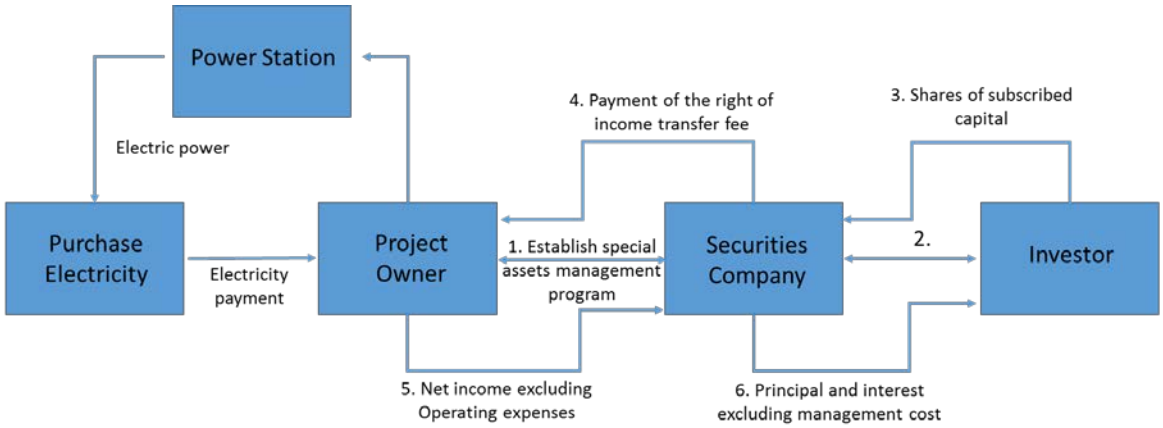


Securitization

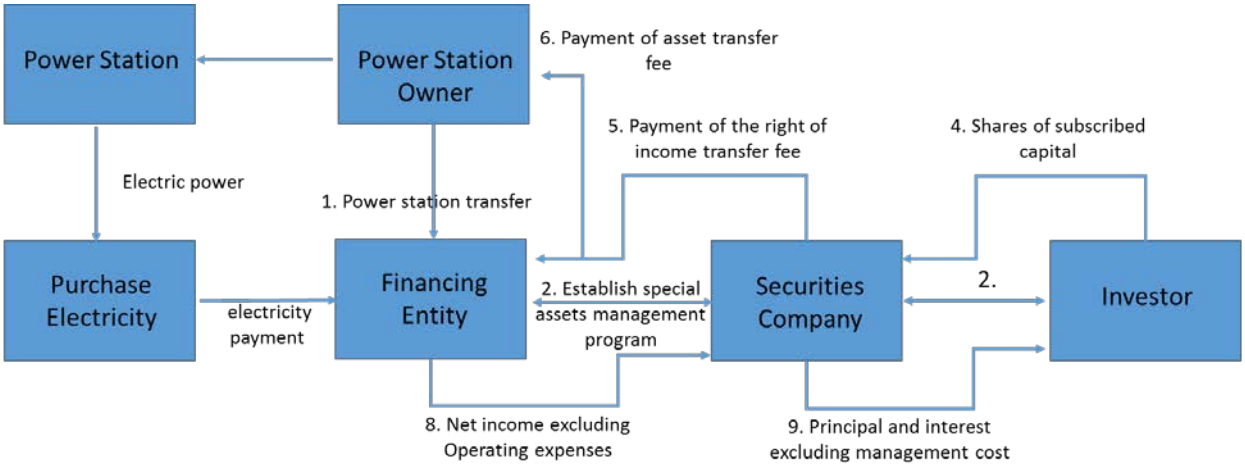
The securitization normally refers to obtain liquidity from the fixed assets with

predictable income, by issuing security in the capital market and acquire finance, so that to maximize the company liquidity. The securitization of renewable energy project, is to sale out the future energy production revenue in form of security on the capital market and acquire capital recollection. The securitization is a widely accept financial instrument around the world, and there are three major securitizations showing below:

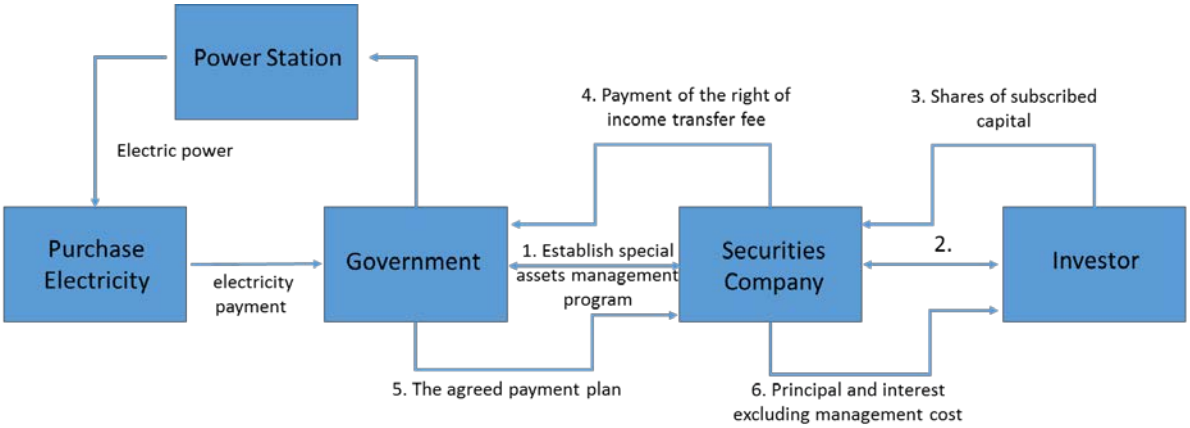
a) Project yield securitization: Setup special asset management program by security company, and issue the security based on the specific project yield, the investors will purchase the share of the asset management program and acquire partial of the future project yield according the share volume, such share can also be traded in the secondary market or mortgaged. This model, however, requires high credit worth of the project owner.



b) Company securitization: Setup special asset management program by security company for a special purpose entity established for financing, and issue the security based on one or several project's future revenues that owned by the financing entity. The investors will purchase the share of the asset management program and acquire partial of the financing entity's future yield according the share volume, such share can also be traded in the secondary market or mortgaged.



c) BOT model: The BOT model is mainly considering the demand of government invest project, similar to the installment payment loan. Since the financing entity of the project is highly related to the local government finance, which is normally with higher creditability and there are already mature operation model. However, due to the project supervision regulation the securitization approval period are also longer. The security company will establish special asset management program, signed contract with the governmental project owner, and issuance asset based security.



Other innovative financing solutions

Recent years, accompanied with the rapid development of internet technology and financial market, several innovative finance methods like internet financing, crowed funding, Yield Co also provided exploration trail for the new finance channel of renewable energy project. However, such solutions are still immature, and not

capable to finance the large scale renewable energy project. We expect more innovative finance solution to be developed in the future and tackle the capital barriers for the renewable energy developers.

- **Business model and profitable analysis for agricultural solar application projects.**

Take a common solar power generation for example (agriculture solar application follows the same logic), with 70% of initial investment supplied by the bank loan, 7% loan rate for 12 years period, 5% project residual value, annual depreciation rate 7%, VAT 17%, income tax 25%, project construction period 1 year, operation period 20 years. Provide IRR sensitivity analysis based on 3 key variable parameters: initial investment, annual power generation house and FiT level. Set up 10% IRR as investment benchmark, to evaluate the economic feasibility in different regions with different unit cost, solar radiation resource and solar subsidy regulation. The results are as below：

1) IRR allocation for unit investment at $1.15 USD /W

Hrs/yr / FiT $c/kWh	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600
12.3											8.9%
12.9										9.3%	10.2%
13.5									9.6%	10.5%	11.4%
14.2								9.8%	10.8%	11.7%	12.7%
14.8						9.0%	10.0%	11.0%	11.9%	12.9%	13.8%
15.4					9.0%	10.0%	11.0%	12.0%	13.0%	14.0%	15.0%
16.2				9.2%	10.3%	11.3%	12.3%	13.4%	14.4%	15.4%	16.4%
16.9			9.3%	10.4%	11.5%	12.5%	13.6%	14.7%	15.7%	16.8%	17.8%
17.7		9.3%	10.4%	11.6%	12.7%	13.8%	14.9%	15.9%	17.0%	18.1%	19.1%

According to above table, while the annual utilization hours of the solar power generation project achieves 1200, the FiT need to achieve $17.7US cent/kWh to support 10% project IRR. And the FIT will only need around $12. US cent/kWh to support a 10% project IRR while the annual utilization hour achieves 1600. The ladder allocation of the IRR baseline (highlighted in yellow) demonstrated that the utilization hour and FIT is a negative linkage. And the high utilization hour and high FiT level is one of the necessary factor to support an acceptable IRR level.

2) IRR allocation for unit investment at $1.23 USD /W

Hrs/yr / FiT $c/kWh	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600
12.3											
12.9											
13.5										9.1%	10.0%
14.2									9.4%	10.3%	11.1%
14.8								9.5%	10.4%	11.4%	12.3%
15.4							9.6%	10.6%	11.5%	12.5%	13.4%
16.2					8.9%	9.9%	10.9%	11.8%	12.8%	13.8%	14.7%
16.9				9.0%	10.1%	11.1%	12.1%	13.1%	14.1%	15.1%	16.1%
17.7			9.1%	10.1%	11.2%	12.2%	13.3%	14.3%	15.3%	16.3%	17.3%

The above table demonstrated that while the initial unit investment reaches $12.9US cent/kWh, the FIT at $17.7US cent/kWh can only support attractive project investment where the solar radiation resources can provide 1250 annul utilization hours. If the FIT dropped to $14.1US cent/kWh, only the project locate in the areas of 1600 annual utilization hours could achieve 10% IRR. In general, the initial unit investment volume increased slightly, the economic feasible project scale will shrink a lot, which means, the cost reduction of the agriculture solar application equipment will remain as the key development focus in the coming years.

3) IRR allocation for unit investment at $1.38 USD /W

Hrs/yr / FiT $c/kWh	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600
12.3											
12.9											
13.5											
14.2											
14.8											9.6%
15.4										9.8%	10.6%
16.2								9.3%	10.1%	11.0%	11.9%
16.9							9.5%	10.4%	11.3%	12.2%	13.1%
17.7						9.6%	10.6%	11.5%	12.5%	13.4%	14.3%

The third analysis result table shows that the unit investment of agriculture solar application project achieves $1.38 USD /W, in the area with annual utilization hour around 1400 hours, will still need a FIT level above $17.7US cent/kWh to support 10% project IRR and $15.4US cent/kWh for even areas with 1600 utilization hours. This is actually very common fact situation in lack development regions, where somehow, are usually accompanied with rich solar resources. In such circumstance, despite the annual utilization hours, the strong government and financial subsidiary will become the necessary precondition for the development of agriculture solar application projects.

- **Social benefits and other beneficial results analysis in four types of agricultural solar application projects.**

Agriculture solar application projects not only can secure the investment return by both revenue yield from power generation and agriculture production, but also can improve the soil condition, promote agricultural product quality, increase farmers' income and government tax revenue, and create comprehensive social benefit.

Take the 30MW agriculture solar ground mounted power generation solar project in China, Quzhou, Jiangsu province for example, the project created outstanding social benefit after the operation. The soil land under the solar panels was reinforced against the soil erosion and fertility improved to plant economic plant and saplings. The project is taking an area of 780 acre, and the annual rental fee is $123 USD/acre, the 270 farmer families around the project can receive additional $354 USD per year. Meanwhile, the project also hired 70 local residents for agriculture planting and provide $ 4,492 USD /year for each resident. The project owner, despite the power generation income, also acquires investment return and social benefit by agriculture products and scientific education exhibit. The local government, by pushing forward the project application, draws $36.9 million USD direct investment, and annual tax revenue of $ 0.9 million USD from the project. The project is also developed as sightseeing view, for tourist visit on the solar power generation system. And eventually, by the annual 30 thousand MWh electricity generation, the project can save standard coal of 9000 tones and reduce 26.7 thousand tons of CO2 emission, 330 tons of SO2 emission. Beautified the surrounding environment while refining the energy supporting structure.

4. Suggestion of supporting polices and the best project practice plan for different types of agricultural application projects

- **Comparison analysis for different types of agricultural solar application projects, and the summary of successful reasons.**

Solar Greenhouse

Solar greenhouse by utilizing the rooftop of the agriculture greenhouse, no extra ground field needed and zero impact for the soil land, which can preserve the precious farming land resources. Firstly, the greenhouse can also select location based on the condition of the soil land, for the wasted or the water evaporation fast areas under strong sunlight, are normally difficult to be developed as agricultural farm land and no other better utilization solution. To construct solar greenhouse on such area can solve the land utilization issue. Secondly, since the plants in the solar greenhouse need to be decided following the professional institute instruction and market demand, which is more business effective compare to the individual farmer family activities, thus, farmers could concentrate on the solar greenhouse to conduct agriculture and marketing activities, from sales company and develop online business platform, to improve the value-add and modernization of agriculture business. Thirdly, since the solar greenhouse can highly improve the planting condition and environment, it is very suitable for cultivating high value-add economic agricultural products, like flowering straw and tree saplings. Fourthly, after the construction of solar greenhouse, the infrastructure for the area: road pass, power supply will be improved accordingly, combined with the special planting in the greenhouse, provided condition to develop agricultural sightseeing and trip visit project, to improve the general project revenue. Besides, the experts also mentioned that since the solar greenhouse will place the solar panel at high altitude, is shall also install equipment such as shock absorber, to tackle the wind resistant issue.

Solar Cultivation Farm

Solar cultivation farm mainly combines the solar power generation with conventional husbandry farming house. The security and stability of the solar power generation system will be the top concern for such project, it is also one of the most

possible safety accidents that caused by animal bitten on the power cable. In addition, compare to the solar greenhouse, the husbandry cultivation farm will produce animal excrement waste, it need to be cleaned and processed in order to avoid corrosion on the key solar power system component. During the project designing stage, a scientific layout of the solar panel on the rooftop can also help to create overshadow and cooling for the animals.

Solar Aquaculture

Similar to the solar greenhouse, solar aquaculture also need consider the best utilization method for the land field at the first place. And then to select the most adaptable aquaculture product based on the research on the local climate and water conditions. Moreover, since the solar power system on the water may cause the PID effect and difficult for operation and maintenance, it is suggested to consider more advanced technology like double glasses solar module, and automatic cleaning parts, to secure the power generation efficiency and save the operation and maintenance efforts. Install shock absorber to solve the wind resistant issue is also recommended.

Solar Pump

Solar pump are mostly applied in the rural area that without sufficient power supply and transportation. It difficult to maintain due to the limited project scale and cost consideration. Therefore, the solar pump project are mostly well designed and installed for a certain areas at the beginning stage, with abundant parts and reserves stored. The selection of high quality supplier and high quality products will directly impact the solar pump's facility efficiency and duration. Besides, for the facilities installed at alpine regions, the winterization processing is necessary, the underground pipeline need to be buried deeper than normal designs, in order to ensure no water stored in the pipe during the winter to avoid the break caused by the frozen.

Solar Poverty Alleviation

Solar poverty alleviation is mainly carried out by the Chinese government, it is still on the trial stage. From the current implementation effect, there are several successful experiences summarized as below: a) the alleviation support must be accurate, arrange pre-investigation to allocate the poverty target, set up documentation and allocate the power generation income. b) All the relative government departments need to coordinate with the project, including power grid, financing instituted, and

construction entity. To secure the investment capital, construction quality, grid connection and payment in place. c) Encourage the participation of private companies, provide tax credit or land tendency reward for the companies joint the solar poverty alleviation activity to improve their motivation.

- **Summary of the opinions from experts interview, propose policy optimization recommendation for agricultural solar application projects.**

Tax Credit

Following the current taxation regulation, exempt land using tax for project directly developed for agriculture, forestry, husbandry or aquaculture production; and collect tax for land using and agriculture resources occupation. Agriculture solar power station, as an emerging land development method, the capital input and output volume is much higher than conventional agriculture industry. It is recommend that the agriculture combined ground mounted solar plant could also exempt for the tax of land using and agriculture resources occupation

Land Tendency

Under the precondition of basic farming land and high quality agriculture resources preservation, it provide leasing policy to construct agriculture solar application projects on common farm land and facility agriculture areas. Under precondition of forestry area protection to secure soil and land conservation, permission to develop forest-solar power generation project in low density forestry area, provide special approval and administration procedures.

Establish technical and construction standard for agriculture solar application industry

To ensure the combination of agriculture operation and solar power generation, it is recommended to establish industrial standard based on the respective solar radiation resources and planting demand. On the project construction side, identify the height and interval requirement of solar panels installation is important. Establish mandatory investment feedback standard for agriculture solar application project, firstly setup bench mark return rate according to the average agriculture economic level in the area, then multiplied by specific factors calculated based on the different type of solar application.

Enhance the basic theory research for the solar application in agriculture sectors

The fundamental theory research work for the agriculture solar application still need to be intensified. Such as how does the lighting environment in the greenhouse after installation of the solar panels influence the cultivation of plants, animals and aquaculture, establishment of the lighting-growth formula model from both lighting intensity and timing prospect, the impact on soil land and water condition caused by the change of lighting environment. The above factors are aiming to find out the best practice model for the combination of solar and agriculture technologies.

- **Estimate the best practice for different types of agricultural solar application projects**

Solar Greenhouse

1. **Qingdao Jimo Solar Energy PV Town 200MW Distributed Photovoltaic Power Generation in Combination of Modern Agriculture**

The project locates in the pudong central community area of Jimo, Qingdao city, Shandong province. Developed by Nesisolar with total $ 30.7 million USD investment for 20MW solar power generation on the greenhouse facilities, annual power generation 24,000 MWh, it has already completed the grid connection. The project was developed under the model of “commercial initiate, government support ”, by installation of the ‘Online to Offline’ trace of source devices, far-infrared heater, solar module, atomization migration system, natural gas tricycle generation faculties, to build up full agriculture industrial supply chain with cultivation, planting, processing, logistic, sales scenarios, and covers several kinds of agriculture products like mushroom, tea, nursery stock and vegetables.

The project was designed as distributed power generation and centralized grid connection model, the power generated from the project will be totally acquired by the power grid company. It provides 500 job opportunities, this improved the annual income for the local residents. The project will save 7,480 tons of standard coal per year, and reduce CO2 emission by 19,000 tones, SO2 108 tones, dust 75 tons annually. The project not only improved the utility efficiency of the land, but also dramatically increased the economic output per unit, and attracted capital investment.

2. Tonking Group Intelligent Photovoltaic Plus Agriculture Power Generation Project

The project is located in Jiangshan City Quzhou, Zhejiang province, China. it applied with double axles tracking system, combined with forestry and agriculture planting, construct total installation capacity of 30MW and annul power generation of 40,000 MWh under a total investment of $ 46.2 million USD on 1,000 acers area. The power generation from the project will be fully purchased by the power grid, and the project is predicted to save 376417.5 tons of coal during25 years of project lifetime, and reduce 978685.5 tons of CO2 emissions. The project applied with smart solar

controller and special solar PID module with wireless communication devices and smart management system, the whole system, which was developed by HUAWEI.

The project installed double axles tracking system, it realized 'east-west and south-north' double direction panel tracking. The solar system, compare to the normal design, it with slightly higher cost, but 20% better conversion efficiency (extent annul utilization hours from 1000 to 1200). The total power generation during the project life cycle could improve 20-35%, with more than 20% of additional income. The project also applied the best sunlight transparency, with only 20-35% of shadowing areas. The tracing system provide balanced sunlight to the plantings, and the project is foresee to get payback within 8 years.

Solar aquaculture

1. **Jianhu Multi-energy Complementary Micro Grid Power Generation System Project**

This solar aquaculture project was built in Jianhu, Jiangsu province, China. The total investment for the project phase I is $ 36.8 million USD for 20MW installation capacity. The project construction started from 15th October 2011, and completed grid connection on 29 December 2011. The project phase II and phase III for 10MW capacity each was constructed straight after the phase I. Phase II & III are taking

place of 770 acers and $27.7 million USD investment, the project construction started on April 10th 2013, and the grid connection finished on July 10th 2013. The 20MW phase IV project started to construct on March 20th 2014, and begin to power generation on June 30th 2014, with total investment of $ 24.6 million USD. 6MW project Phase V was constructed during October 10th 2014 to December 28th.

The Jianhu series project was constructed on the water surface of fishpond. The project was designed with widen solar panel intervals, and formed good ventilation conditions to keep low temperature power generation environment. The power generation volume from Jianhu project are superior among the other solar power generation projects in the area. The project produced electricity of 24,650 MWh in 2012 and received $ 5.3 million USD sales revenue, 36,150 MWh and $ 7.38 million USD revenue in 2013, 56,184.6 MWh and $ 10.6 million USD revenue in 2014, 48,935 MWh and $ 8.8 million USD revenue in the first 7 months in 2015.

2. Okegawa 1.18 MW aquatic solar power station in Japan.

The 1.18MW aquatic solar power station invested by Japanese western holding group in Saitama near Tokyo, was built on a 30 square kilometers reservoir, and utilized 43% of the surface area to install log-raft bracket and 4536 pieces of 260 watt power panel at 12 degree slope angle and centralized converter. The project applied with the floating solar system developed by French supplier. The log-raft bracket was made of high density polyethylene and without any metal parts, and can be easily matching up. The project was built within 6 weeks and the installation of log-raft bracket and solar panels spent 3 weeks each. The river circumstance around the reservoir provide well cooling condition for solar power generation, and the project can generate around 10% more electricity than same size rooftop project. The project invested around $ 3.35 million USD and the power generation will be purchased by Tokyo power company at $ 38 US cent/kWh.

Solar cultivation farm

Jiangxi Xinyu 400KW swine house solar power system

In June 2014, the Kequn eco cultivation based in Xinyu city, jiangxi province, China, together with Jiangxi Ruijing company, invested 400KW solar power generation system built on 4000 square meters swine house. The solar power system, not only produce electricity, but also can improve the living conditions of the swine house. The power generated by the system will mainly use to drive the air conditioner, processing and lighting facilities, and made the cultivation farm become energy self-sufficient. The solar power generation system without noise and smile, while improved the cultivation environment and effective dramatically.

Solar Pump

Funing 37 KW solar pump irrigation system in Yunnan Province

The Anlan village in Funing Xinhua town, Yunnan province, China, is a complex landscape mountain rural area. The major economic activities for the local residents is agriculture planting for sasanqua, corn, rice and oranges. However, the unique landscape makes the irrigation condition extremely terrible. To tackle the irrigation issue, the local government invested over $ 0.154 million USD and installed 37KW solar pump system, with 130 meters delivery lift and 200 cubic meters daily irrigation capacity.

Solar Poverty Alleviation

Solar poverty alleviation project in Honghe county Yunnan province, China. Installed solar power generation system for 300 poverty families for 3kw each. The total investment of $ 1.4 million USD was funded by local financial for $ 0.9 million USD, and $ 0.46 million USD subsidized loan for the local residents. Each family can receive $ 461.5 – 507.7 USD per year from the annual electricity production of 3600 kWh by the 3kw solar power generation system.

Solar Poverty alleviation project in Lixin county, Bozhou, Anhui province, China. 3kw family level solar power generation system and 60 kw village level power station with comprehensive funding from local government and subsidized loan. Total 15 thousands of family level solar power systems and 90 village level of solar power stations to be built by end of 2017, with additional annual income $ 462 for each poverty families.

5. Research and analysis the forecast of future development potential of agricultural solar application projects in Member economies.

- **Analyze and foresee the future development trend of agricultural solar application projects.**

Although the agriculture solar application study has already carried out within and without the Member economies for years, and it has obtained certain results in solar greenhouse, solar husbandry cultivation, solar aquaculture and solar pump field. However, as an emerging and combining sector, it still stayed at the early development stage. The conflict with land field utilization, hold back the development of solar agricultural technology and usage. Nevertheless, such issues will not stop the growth of the agriculture solar application. The mix of clean energy with modernized agriculture is the bright innovation path for the future global energy restructure and scientific agriculture application. Just as the rapid developing solar industry in the past decade, the agriculture solar application will enters to a booming stage in the coming years. Particularly in the well-developed solar market, the new utilization model, new concept equipment and technology will be further explored, and attracted agriculture dominate economies to absorb the mature experiences and carry out new agriculture application projects.

- **Major development directions and politic suggestions of agricultural solar application projects proposed for Member economies.**

Within Member economies, each level of government, research institute, enterprises and financial instituted should first recognize the idea of agriculture solar application, since the technology can provide clean energy and improve the agriculture efficiency no matter for developing or developed economies. The utilization model of agriculture solar application is different based on different economic conditions and solar radiation resources in each economy. According to the current experiences and examples, the promotion of agriculture solar application must with support and coordination from the government, and there are three major suggestions concluded below:

1. **Enhance government support.** The agriculture solar application is still a cutting edge application areas for the solar power generation industry. There are only few developed economies has achieved grid parity for solar power generation. The rest of economic parties still need supporting policies and subsidies to cultivate the sector. However, all the supporting conditions must be reduced frequently and have deadlines, so that the development and cost decline from the industry to the market can be improved. And then eventually to achieve grid parity and large scale development.

2. **Land Tendency.** The most special feature of agriculture solar application is to improve the utilization rate of land. Construct solar power generation facilities with no influence on agriculture operation. However, as emerging business, how to clarify and manage the land tendency issue among the project activity of agriculture solar application, are still remain unsolved. Each Member economy shall study the local land resources and agriculture status to estimate the best solution, in order to provide regulated land tendency administration while motivating the implementation of agriculture solar application.

3. **Promote technical exchanges and communication.** All the Member economies, among the globalization momentum, shall push forward the economic integration, and share the technology benefit around the world. Through product, technology, talent exchange, to weaken the technology development barrier, and lower the manufacture costs. Remove the investment and trading barriers and embrace the global development trend of clean energy. Each economy shall also establish communication platform from both official and nongovernment view. Arrange conferences and inspect vesting, to share the result and experiences of agriculture solar application from each economy and seek cooperation opportunities from the communication, and eventually promote the integration and coordination among different Member economies.

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