# The Analyses & Investment Opportunities in

# Photovoltaic Industry

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# I. Global Trend of Photovoltaic Industry

Solar energy industry is one of the most blooming industries in the energy sector. Since photovoltaic electricity provides the most effective renewable energy resource without consuming fossil fuel, the main advantage of the introduction of photovoltaic systems is its accessibility of clean and environmentally friendly electricity.

In recent years, many developed countries have given efforts to the issues of “global warming” and “zero carbon emission”. The installation of PV systems in the industrial countries has increased widely as result from supports given by the countries’ incentive programs. Such installation of PV has been strongly promoted in 46 countries, including Germany, Japan, USA, Spain, and Italy. The European region leads in the amount of countries with most PV installed, followed by Asia and Pacific region (with such as Australia, China, Japan, Korea, Taiwan and Thailand), and the USA. Seeing this continuous increase in demand for PV, it is not hard to foresee the exponential growth that PV industry will have in the near future.

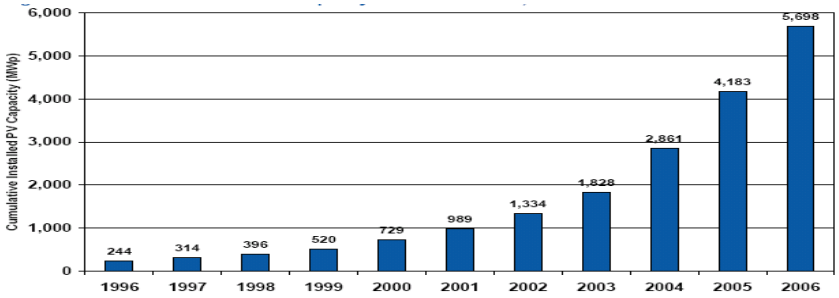
PV system was designed in the early 1980s as a provision of power supply to remote areas. After the successful application of on-grid technology in Germany and Japan, installation of PV system has been widely adopted for electricity generation purposes. The PV market sharply increased from 2001 to 2006, at a growth rate of 38.4%, according to the survey report by the International Energy Agency (IEA). The accumulated installation on the application of the new energy has reached to 4.6GWp in 2005 and 6.3 GWp in 2006. The top 20 member countries in IEA dominated the world market (87%, or a total of 1.5GWp in 2006). This growth in PV installation reached an record high of 2.82 GWp in 2007 and a cumulative installation at 9.1 GWp. In other words, in 2007, there has been a 62% growth increase over the previous year.

Market research of revenues in the solar industry has been based on the production volume (GWp) and real installation amount (GWp). However, the installation cost varies according to different system structures, resulting in dissimilar sales revenues when comparing data from different market research institutions. According to the IntertechPira.com projects published in 2007, overall, revenues from the solar energy industry will grow form US$14.5 billion in 2006 to US$18.6 billion in 2007. Based on this brisk annual growth rate, it is highly possible that its revenue will achieve US$36.4 billion in 2010 and reach over US$100 billion in 2020 as shown on the table below. The overall growth rate will achieve 23~28%; and the revenues from solar cell and modules will dominate more than half of the market. Spain, USA, and developing countries such as China and India will be the major markets in the future, whilst Germany and Japan will enjoy a market of stable growth.

| Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| Value<br>Billion USD | 14.56 | 18.65 | 23.48 | 29.35 | 36.40 | 44.78 | 54.62 |

The worldwide PV market started booming in 2000, with Europe, Japan, and the US as its first installers. In 2004, 645.2MWp was installed in Europe with the growth rate of 300%, and later in 2005, 941.5MWp have been installed, resulting a growth rate of 41.7%. In 2007, Germany (47%), Spain (23%), USA (8%), and Japan (8%) dominated the market growth. These PV leaders also contributed major achievements in solar industry research and development.

Installation Growth in 1996~2006

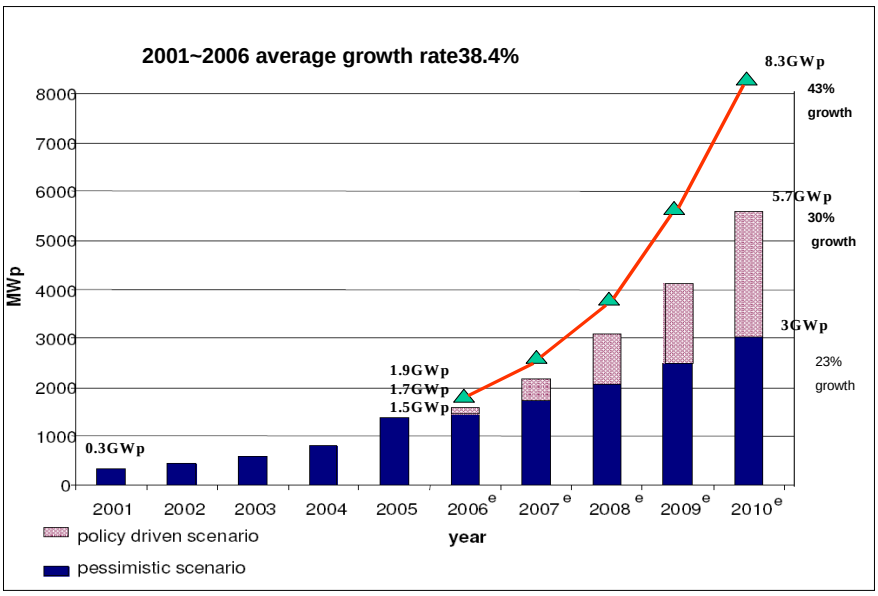



Reference：IEA (October 2007)；IntertechPira (2007)

The growing demand of the PV system installation drives the rapid development of PV industry as a whole. Meanwhile, PV applications have also been diversified. Market statistics showed that the hiking trend comes from the on-grid electricity generation. The installation capacity has been increasing continuously since 2000. The cumulative installation in 2006 has reached 6.3 GWp with a growth rate of 19％ compared to 4.6 GWp in 2005, and the average growth rate achieved 38.4％ from 2001 to 2006. As an obvious observation, continuous expansion of PV market is expected. Installation capacity is estimated to be over 3.0 GWp in 2010, according to data released by the European Photovoltaic Industry Association (EPIA) in February of 2007. With a strong policy support, the installation will achieve

5.7 GWp, or 30% growth rate. In addition, an optimistic forecast released by Navigant, in April 2007, predicts the capacity will reach 8.3 GWp, at a remarkable growth rate of 43%.

Average growth rate of 38.4% in 2001~2006

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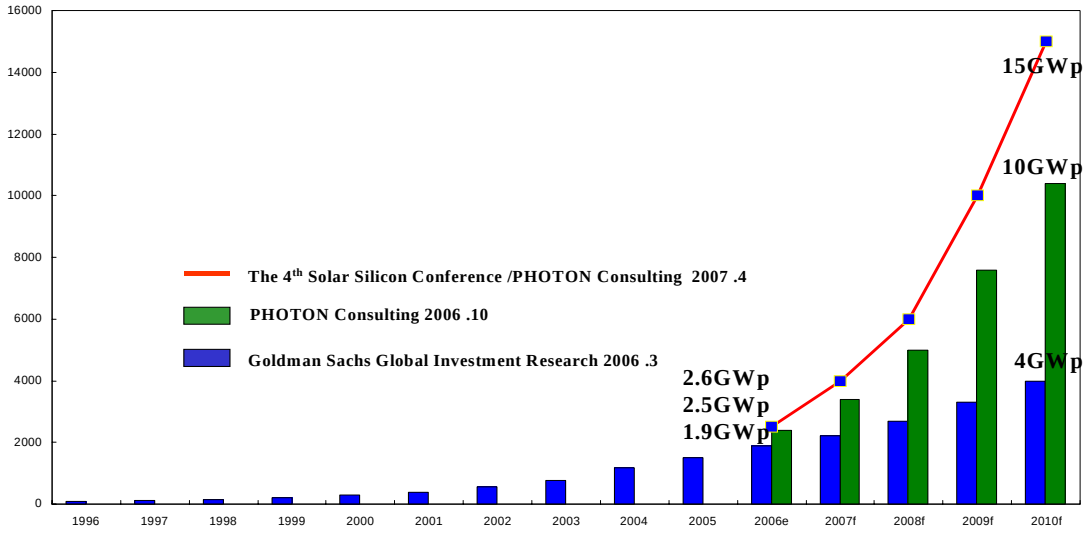
Reference：New Rising Era for PV Integration in Buildings, EPIA, February 2, 2007.
Photon consulting, 4th Solar Silicon Conference, April 3, 2007, Munich
Navigat Consulting Co., Intersolar (2007), ITRI (2007)

The global production for PV cells is on a continuous increase in order to meet the strong demand of grid-connected systems. Cell production capacity increases over 1,000 MWp per year. The global production capacity in 2005 reached 2,300 MWp with production output of 1,782 MWp. Despite the fact that tightened supply of high purity and low cost silicon has limited the expansion of cell production in 2006, PV production capacity still arrived

at 3,210 MWp with real production of 2,520 MWp (growth rate of 40%) in the same year.

The average growth rate from 2000 to 2006 was of 43.7%, while in 2007, with a production of 3,436 MWp and growth rate of 36% over 2006. In terms of cell production, Goldman Sachs reported 4GWp in 2010 (or 20% growth) and PHOTON consulting reported 10~15 GWp in 2010 with a growth rate of 40~60%.

Forecast of production capacity in 2010




Reference：ITRI(2007)/ Goldman Sachs / PHOTON(July 2007)

# II. The Status Quo of Photovoltaic Industry in Taiwan

## (I) Supply and Demand of the PV Industry

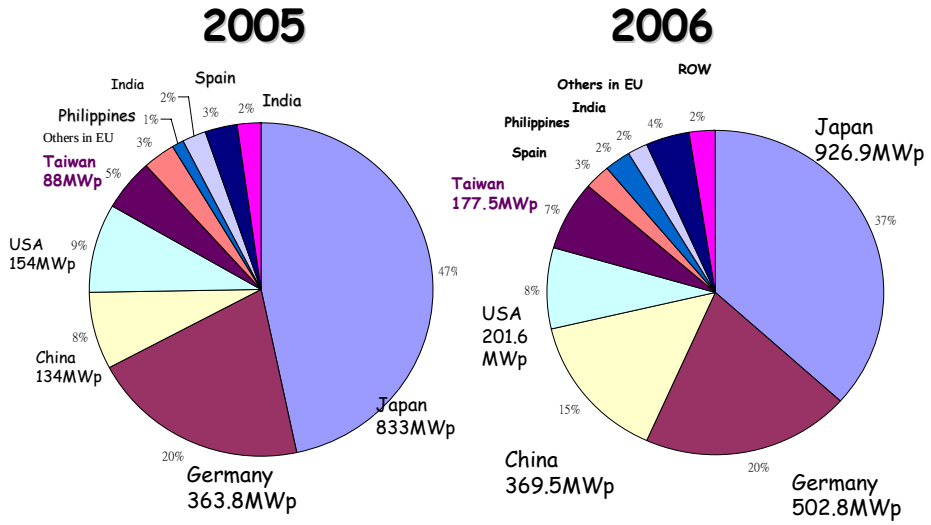
---Production capacity of solar cell industry in Taiwan

The solar industry in Taiwan started in 1987 with the production of amorphous silicon cell, but it wasn't until 2003 when the solar industry experienced a booming investment a response to the market demand in Europe and Japan. New PV companies sprung, covering all production aspects of the supply chain, such as wafer, cell, module, and system installation.

PV industry in Taiwan has shown rapid growth in sales revenue reported by the Industrial Economics & Knowledge Center (IEK) from the Industrial Technology Research Institute (ITRI). The industry revenue achieved NT$7 billion (€145 million) in 2005 and in 2006 had over NT$21.2 billion (€441 million) with an astonishing growth rate of 300% (equivalent to 2% of global share) . Recent reports reveal that the revenue for 2007 has reached NT$53 billion (€1.1 billion) and optimistically predict a revenue of over NT$100 billion, NT$150 billion (6% of global share), and NT$400 billion (approx. €8.3 billion, 7% of global share) will be for the years 2008, 2010, and 2015 respectively.

The investment in PV industry in Taiwan is still a hot issue. Capacity expansions for PV companies in 2008 are expected to bring an accumulated production in Taiwan of over 2 GWp. Although some existing companies are suffering from poly-silicon shortage, PV market can still expect new companies joining the sector, with stronger focus on thin film solar cell, including products such as silicon thin film, CIGS, and CdTe.

The cell production from Taiwan has reached 88 MWp in 2005. A significant growth in cell production has been reported in 2006 at 177.5 MWp. Taiwan has shown its ambitious production expansion to the world market. Total cell production in 2007 has reached 360 MWp (top $4^{th}$ in global output). PV News reported that Taiwan occupied a 10% in the global market share when Motech achieved its production of 176 MWp, ranking as the top 6th company in world in PV production (after Q-cell, Sharp, Suntech, Kyocera, and First Solar). Since the Taiwanese solar cell industries are facing the supply problem of poly-silicon, companies such as CPC, Taiwan Polysilicon Co., Universal Semiconductor Co., Muto Silicon Co. have announced to start their own business in poly-silicon production. It will need some years before these companies establish factory and start production. Green Energy Co., Sino American Silicon Products Co., and Wafer works are the main players in the supply of solar wafers in the local market. On the other hand, Mospec Semiconductors Co. has also been reported to start their production in the near future. In general, production in PV industry is in its steady growth, yet also worth noticing that the future expansion of solar cell production depends heavily on silicon supply.




**Source：ITRI(2007) & PV NEWS (2007/06)**

Global Cell production in 2005~2006

Reference：ITRI (2007) / PV NEWS (June 2007)

## ---**-Crystalline Silicon solar cell industry**

The supply of poly-silicon is the major concern for wafer manufacturers in Taiwan. MEMC, Hemlock, Solargiga, and DC Chemical are the main wafer suppliers for Green Energy, Sino American, and Wafer Works for their total demand of over 700 MWp. Solar cell businesses dominate solar industry in Taiwan, both in the production of crystalline solar cell and thin film. The investment on Si solar cell began in 2004 with turn-key solutions from Germany, where intensive research and development resources were being encouraged and invested to improve the efficiency on Taiwanese local production equipments. The total production capacity is estimated to reach historic record of 1.7 GWp for crystalline cell and 198 MWp for thin film

solar cell in 2008. Capacity for module will be in the range of 228 MWp in 2007. The total capacity of Taiwanese PV industry will be over 4 GWp in 2010.

PV production equipments and facilities are the most capital intensive aspects of the solar industry. Local equipment providers are finding the niche in this field yet only occupying a small percentage in the revenue. In 2004, over 12 companies started their own activity in solar cell production equipments, such as Mirle Automation Co., Delta Electronics Inc., CS Manufacturing Ltd., Contrel Technology Ltd., Gallant Precision Machining Co., Kenmec Mechanical Engineering Co., Ching-Hung Machinery & Electrical Industrial Co., Song Jaan Technology Co., Marketech International Co., Atma Champ ent.Co., Schmid Automation Asia Co., Youtech Corporation. They focus on the development of diffusion furnace, cutting machine, etching station, plasma etching machine, IR back furnace and laminator. At this point, it is crucial for companies to find cooperation with foreign partners, especially in joining the forces of technology development, for it shall result in cost reduction and R&D schedule reduction.

### ---Thin film solar cell and contracted photovoltaic system

The investment for thin film started in 2005. In 2008, more than 10 companies will launch their mass production such as Sinonar Solar, Formosun Technology, Next Power, Nano Win Tech, Green Energy Technology, Sunner Solar, Sun Well Solar, Kenmos Photovoltaic, Arima, and Chi-Mei. Most of them have introduced their well-established technology and turn-key solutions from Applied, Ulvac, Oerlicon and Nano PV. However, they still put a lot of efforts to build up their own know-how. The expected

output in 2008 will be over 198 MWp. As the market outlook for thin film cell will occupy more than 20% of total market (2 GWp), technology developments to improve cell efficiency will be a great challenge for these companies.

Taiwan has smaller and fairly newer activities in the production of crystalline solar cell. The emerging investment focuses on GaAs wafer, concentration module, and tracking system. Winfoundry Co., Arima EcoEnergy Tech.Co., Compoud Solar Tech Co., have all initiated their business for GaAs wafer production; while Everphoton Energy Co., Arima EcoEnergy Tech.Co., and Delta Electronics Inc. focus on the production of components, tracking systems and focusing parts.

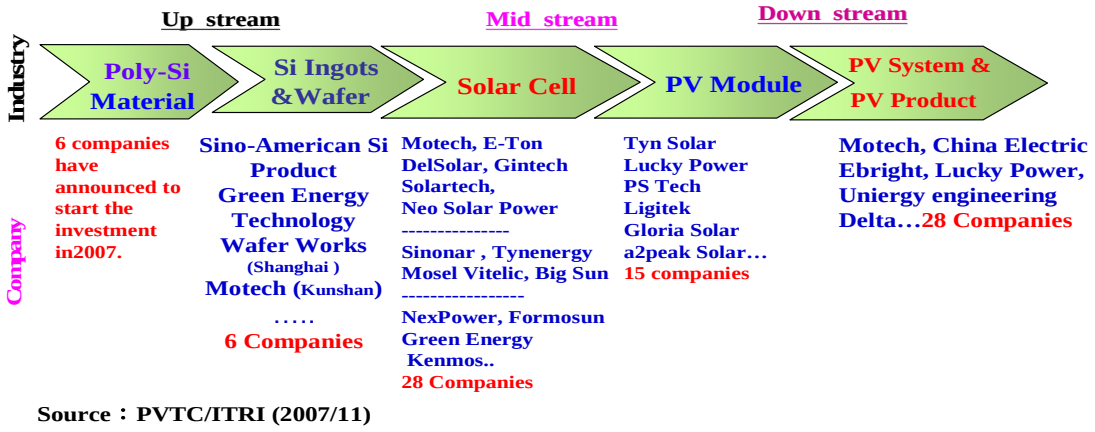
## (II) Gap in Industry Supply Chain, Investment Niche and Prospective Foreign Investor

More than 70 companies represent the PV industry in Taiwan with sales value of NT$53 billion (US$ 1.65 billion) in 2007. These companies cover wafer processing, multi-crystal growth furnace, wire sawing, wafer polishing, crystalline cell production, thin film cell, modules, and system installation (as shown on the table below).

Cell production dominates the PV industry in Taiwan. The total revenues for cell production have increased from NT$1 billion in 2003, to NT$14.8 billion in 2006, and will reach over NT$100 billion in 2010, later estimated to grow over NT$240 billion in 2015 (BAU). The sales revenues grow relatively as production capacity expands. Revenues for poly-Si increased from NT$50 million in 2003 to NT$10 billion in 2007, and forecasted to expand to NT$31 billion in 2010. Only a small growth in module business was observed for the limited about of capital (NT$100~300

million) has been invested for its production. However, the sales have increased from NT$ 200 million in 2003 to NT$ 3.7 billion in 2007. Research reports predict it will reach a NT$ 18.2 billion in 2010 and NT$ 45 billion in 2015 if the market still remains the momentum. PV system installation is a local market oriented business, in which industry and market growth depends on government incentive programs. Analysis indicates that it will reach over 2.5billion NTD in 2010.

Observing the supply chain from PV industry analysis, research shows that poly-Si and wafer supply are the key issues to the growth of Taiwan PV industry in the world market. Intensive and innovative technology improvement and efforts to cut down the cost are the major challenges that Taiwanese PV industry face.




Supply Chain of PV Industry in Taiwan

Although PV manufacturers have expanded their capacity exponentially, Taiwan has limited local PV equipments makers. Over 50% of the equipments can be supplied by local equipment providers. However, the market share is not significant. For example, the equipment investment for production line of 30MWp could be in the range of NT$250 million. For 30 production lines, the revenues can be over NT$ 7.5 billion. For a production line of thin film solar cell, the cost will be over NT$1.5 billion (30MWp).

Sales Revenue for PV Industry in Taiwan

| Supply chain | 2004 | 2005 | 2006 | 2010(f) | 2015(f) |
|---|---|---|---|---|---|
| Ingot/Wafer | 2.0 | 6.4 | 46.0 | 310 | 771 |
| Solar Cell | 26.0 | 55.0 | 148.0 | 1,000 | 2,488 |
| PV Module | 1.1 | 4.4 | 12.0 | 182 | 453 |
| PV Product | 4.0 | 4.4 | 4.8 | 7 | 11 |
| PV System | 0.5 | 1.0 | 1.2 | 25 | 307 |
| Total Value, 100 million NTD | 33.5 | 70.0 | 212.0 | 1,524 | 4,031 |

Reference: ITRI (April 2008)

The booming investment in Taiwan's PV industry has resulted in expansion of production and growth of revenues. However, securing the supply of silicon, improving cell efficiency, reassuring local supply of equipments for Si cell and thin film production are still to be solved to meet the requirement of global market and company competitiveness. Gaps in industry supply chain includes production of Poly-Si materials, potential investors like Tokuyama, REC, Hemlock, MEMC, Wacker Chemie, Elkem, DC Chemicals, LDK, Mitsubishi and Sumitomo. These companies own know-how and dominate the worldwide supply for Si. Most of the Taiwanese cell makers have signed long term contract with these suppliers to secure Si materials. Alternative way will be part of their strategic partners.

Another gap in the supply chain is the acquirement of equipment for the entire production line with turn-key solutions. Cooperation with leading companies in the directional crystalline furnace, block cutter, wire saw machine, diffusion furnace, PECVD, simulator will yield the highest efficiency. Major suppliers for these equipments are GT solar, Spire Solar, and Schmid for directional crystalline furnace; Meyer Berger, HTC for block cutter and wire saw machine; Centrotherm, Semco, and Despatch for diffusion furnace; Shimadzu, Roth&Rau for PECVD, Berger Lichttechnik, NPC, Spectra-Nova for simulator for efficiency measurement.

Equipments for module production need less capital (around 60 to 80 million NTD for 10MWp). The gap in module production lies in laminator. The leading companies are Schmid, GT Sola, etc. The investment in equipment development will benefit not only in the cost for local cell makers but also in a good way to penetrate into world equipment market.

## (III) Major Suppliers in Taiwan

### 1. Taiwan's Mature Industrial Infrastructure

The outstanding infrastructure of IT, TFT-LCD display, and optical disks industries in Taiwan has contributed to the modernization of recent living standards. These indispensable production and innovation makes Taiwan as the inevitable partner in the world industry. The imbedded characteristics in Taiwan such as global logistics management, scale up capability, and marketing management provide the best basis for the investment of PV industry. The current players in Taiwan, with past excellent experiences in semiconductor industry like Green Energy Tech. Co., Neo solar, Dell Solar, Next Power, Chi-Mei, etc., enroll in major roles in this industry. Some of the

companies have different strategic partnerships with well-known research institutes such as the University of New South Wales (UNSW) in Australia. Other significant example would be Dell Solar working with Delta Electronic (its parent company) for the improvement of cell efficiency.

## 2. Vertical integration of supply chain

To solve the problem of poly-Si supply, the PV industries approach with versatile strategy such as long term contract, integration toward upstream and/or downstream. It is also the global trend to integrate the benefit inherent in each sector of the supply chain to keep global competitiveness. Meanwhile, early research for next generation of solar cell is a further alternative for sustainable operation.

The globalization of PV companies has been accelerated as a result of severe competition in world market and cost pressure. Companies like Motech, E-Ton have diversified their business into poly–Si field. Motech invested AE Poly Silicon Company for silicon supply. E-Ton focuses not only on crystalline solar cell but also on joint venture with partners for thin film. E-Ton acquired Adema (USA) for module production, which is also one example for the integration of supply chain. Green Energy Technology has also invested in thin film sector and will launch the production soon.

Strategies to secure supply of poly-silicon have been developed with long term contract, joint venture, stock common sharing, and strategic alliances. The high dynamic activity of PV industry will be the basis for cost advantage to occupy high percentage of global market share. For poly-silicon production, Siemens process（Silane & TCS）is still the main stream. The Siemens process provides silicon of over 90% of world’s market share. Fluid bed reaction (FBR) method shares only 9% of the silicon market. Newly developed methods such as the physical metallurgical method will be

expected with low production cost and may take over 7% of the market in 2010.

### 3. Evaluation of the production capability for poly-silicon：

Siemens process： The process starts with silane & TCS. It is a mature process but requires massive investment on equipments and facilities (approximately US$ 100 million in needed for an investment of 1,000 ton). The production is estimated at US$60/Kg, but for every kilogram of poly silicon produced, 120~180 kWh will be needed for such production. Also, handling of the byproducts is an issue. The leading companies are Hemlock, Wacker, REC, Tokuyama, and MEMC. Currently, the possibility for technology transfer to Taiwan is low. However, companies in Taiwan such as Universal Semiconductor Co., Taiwan Polysilicon Co. (invested by San Fu Chemical Co.) have started the project for future plant building.

Fluid bed reaction (FBR)：Silane or TCS will be processed into granulate form. In this process, it is important to trace impurities contamination. The process provided lower production cost (30 USD/Kg). However, FBR is still in the pilot production stage through the world. Wacker reported that FBR needs less electricity for production (only 1/3 of Siemens process). Major companies are MEMC, REC, and Wacker. The AE Polysilicon (USA), invested by Motech, is working on such process.

Silicon reduction method： The process started with silicon halide and sodium or zinc as reduction agents. This process shows great cost advantage. Reduction with sodium is in the stage of pilot production. However, due to its production danger, safe handling of the chemical active sodium is the firs priority to be solved before mass production. Key companies are Silicon Research Inc., Taiwan Semiconductors Co., and Muto

Silicon Co. The Japanese company Chisso, focused on zinc reduction method, is also in the development of silicon reduction method but currently only at the pilot stage.

Physical metallurgy： This process integrates wet chemical method with physical casting process, characterized by very low cost (US$ 20~40/Kg). Many companies, research institutes in EU, Russia, and China are now working in this field. However, real mass production is not yet reported due to the difficulty in trace element control. Companies like Elkem Solar, JEF, Dow Corning, and Nippon Steel are very aggressive in the process. Big Sun Co., in Taiwan is working with a team from Russia to secure long term silicon supply.

In 2010 the cell production capacity will be over 4,000 MWp and the consumption of silicon will be lowered to the range of 7~10 g/Wp. If the consumption of silicon based on 10 g/Wp, Taiwan needs over 400 k tons of silicon (if measured by utilization of 70%, it needs 280 k tons). Even if the seven large PV companies in Taiwan have been successful in their mass production, the total silicon capacity for Taiwan still cannot meet the demand from local cell makers. It has been reported that the supply and demand for silicon will reach a balance in 2010. However, the balance will be affected by high oil price and decreased installation cost. For Taiwanese PV suppliers, the supply of silicon will be a nightmare if the security cannot be solved in the near future. Taiwanese companies are encouraged to form strategic partnerships with world leading companies in the different areas of PV, specifically international alliances for the production of environmentally friendly silicon.

Another important sector in the PV industry is the establishment of equipment development capability. Taiwan has established a high standard

in the machinery industry whose technologies could be applied for PV production. Companies such as Mirle Automation Co., Delta Electronics Inc., CS Manufacturing Ltd., Contrel Technology Ltd., Gallant Precision Machining Co., Kenmec Mechanical Engineering Co., Ching-Hung Machinery & Electrical Industrial Co., Song Jaan Technology Co., Marketech International Co., and Atma Champ Ent. Co., have been successfully penetrated into the equipment market. Investments in the development of core equipments (PECVD, diffusion furnace, and solar simulator) are still attractive investment areas for foreign partners in terms of global market.

# III. Optimal Choices for Foreign Investors

Potential sectors for foreign investment attraction include：production of poly-silicon, high efficient Si crystalline solar cell and thin film solar cell, and the production of equipments for high efficient solar cell. Main qualified technology resources come from EU, Germany, Japan, and U.S.A.

## (I) Production of Poly-silicon

Poly-silicon shortage will affect capacity expansion and production cost (gross margin) tremendously. Public information showed that the main silicon source for Taiwanese companies are AE Polysilicon, DC Chemical & Nitol for Motech；M.Setek, Adema, LDK, for E-Ton； MEMC for Green Energy；DC Chemical, Solargiga for Wafer Works, MEMC also for GinTech；MEMC, DC Chemical and Hemlock for Sino American Silicon Co. However, the limited supply of silicon cannot meet full operation of these companies. At least 7 local companies have announced their investment projects for silicon production, such as Taiwan Polysilicon Co.（Tainan Science park）, Universal Semiconductor Co（Li-Jo Industrial Park）, EverSol Co.（Taichung Science Park）, and Muto silicon Co (Pin Don Industrial Park). The CPC and Formosa Plastics Co. are working on the feasibility study for investment. The production of poly-silicon needs years of experience in the operation of chemical process and is a capital intensive business. Cooperation with foreign leading company will accelerate the establishment of such production plant.

## (II) High Efficiency Solar Cell and Thin Film Solar Cell Technology

Motech, E-ton, Delsolar, Neo Solar, GinTech, etc. have devoted great efforts in building highly efficient solar cell for their own technology edges. For the thin film, there are more than 10 companies in the production stage, such as Arima, Chi-Mei, Sininar Solar, Formosun, Next Power, Green

Energy, Nano Win, Sunner, and Kenmos Photovoltaic Co. Their technology originated from turnkey solution provided by Applied (USA), ULVAC (Japan), OERLIKON (Switzerland) and Nano PV (USA) production lines. Current efficiency will achieve 6~8%. However, the cost driven market will pressure the development for higher efficiency and lower prices. It is highly recommended to introduce the next generation of the production technology from leading company for its high efficiency (over 10~12%).

## (III) Production Equipments for Solar Cell

World leading companies such as Centrotherm, Roth & Rau, and Schmid dominated the world market with the production of Solar cell equipment. Several of the Taiwanese solar cell manufactures have been their customers, like, Motech, Delsolar, and E-Ton possess integrated equipment from these suppliers. Centrotherm provided whole lines for Gintech Energy Co., Solar Energy Co., and others with 200~300 million NTD. Top Green Technologies Inc., imported production from Schmid. The thin film maker Nex Power adopted ULVAC production line；Green Energy with Applied, Sun Well Solar with Oerlikon line. These leading companies have established their own know-how with core technologies. They penetrated the market as integrators and solution providers. With the advantage of close to world largest market in Europe, the solution providers located mostly in Germany, Switzerland and Italy.

The investment of Taiwanese equipment industry for PV is only at its early stage. As the pressure for lower production costs come into topic, the equipment industry has focused on the latest cutting edge solutions. Some companies have even started the development for cleaning, and etching equipments.

Also, development for automatic testing machine, small PECVD, machine interface technique and other automation tools have been qualified by solar cell customers. With the advantage of on-site services and customization, Taiwanese PV equipment industry excels in fine machinery and flexible production line machinery. However, strategic alliance with leading equipment providers in Europe, Japan, Switzerland and USA will be strongly supported.

The cost structure of solar cell is based on cell efficiency and silicon material cost. Although most of the Taiwanese cell companies started with turnkey solution from foreign countries improvement of cell efficiency should be implemented with his own technology, cooperation with leading companies for high efficient solar cell, thin film solar cell (multi-junction), concentrated PV, organic solar cell and dye sensitized solar cell will be encouraged.

To accelerate the development of PV industry in Taiwan, the Ministry of Economic Affairs (MOEA) has set up policies such as “strategic alliance with silicon providers to secure silicon supply”, “Investment in R&D for high efficient solar cell”, “mass production technology for thin film solar cell”, “development of CIGS thin film solar cell technology”, “Improvement of module reliability”, and “development of domestic market” to encourage further growth and development of PV industry in Taiwan. The Taiwanese PV industry has shown its ambitious activity in the capacity expansion. With the excellent basis of semiconductor industry, Taiwan’s PV industry will be the next star in the world competition.

However, the supply of silicon is the bottleneck of PV industry. Although some companies have invested in the production project, real output is still not available on the market. Introduction and technology alliances with foreign leading companies will be highly recommended.

# IV. Successful Examples of Cross-national Strategic Alliance and Foreign Investment in Taiwan

The investment boom in PV industry in Taiwan has attracted more than 70 companies, including foreign companies. Taiwanese PV industry has become an important partner for foreign investors in the global market. Many foreign investors have taken Taiwan as their gateway to Asia market. Different forms of cooperation, joint venture, technology alliance are being developed as this report is taking place.

## (I) NanoPV (USA)

The major technology advantage that NanoPV possesses is the production of high efficient solar cell with nano-micro crystalline. The CEO of NanoPV, Dr. Anna Selvan John, is a pioneer in this field. NanoPV has shown their mature capacity of mass production in solar cell, transparent conductive TCLO technology, and Nano crystalline–Si:H, with cell efficiency over 8%-10%. Currently NanoPV has established its own sales channels in USA, EU and Asia. NanoPV is one of the PV supply chain integrators with his own technology and equipments.

NanoPV signed with Kenmos Co. in June 2007 to establish a thin film company. Capital investment in Kenmos Photovoltaic Co. was NT$ 2 billion. The joint project will set up a production at 10 MWp capacity. Once the production starts its mass production in Q3 of 2008, the capacity will be expanded to 30MWp. With high efficient nano crystalline solar cells as their main product released to the market, the capacity shall achieve 200 MWp in 5 years. Kenmos Photovoltaic Co. will become one of the largest thin film providers in Asia. NanoPV will provide Kenmos total solution with whole production line. Kenmos has started the equipment installation in June 2008. After successful production Kenmos will be the first case of joint venture in Taiwan.

## (II) Abakus energiesysteme GmbH(Germany)

With headquarter in Koln, Germany Abakus energiesysteme gmbh is specialized in the module production and PV system engineering. Abakus has accumulated many experiences in the large PV systems (MWp scale) famous live illustrations include Mont Scenic education Center in Gelsenkirch and Lehrter train station in Berlin. Abakus is one of the leading companies in PV system installation technology.

Abakus has looked for partners in Asia, especial in China, Korea and Taiwan. It started a branch office in Taipei as their first activity in Taiwan in 2004. Later, they integrated PV with building designers. Their first job was a construction of PV demonstration system in KenDin area for TaiPower Co.

To further invest in Taiwan for the integration of supply chain, Abakus formed the module company a2paeak power Co. in December 2006 within Aspire Industrial Park. The total investment achieved NT$ 80 million. a2paeak power Co. has established its production line and capable of mass production. The company focused its business on German and Asian markets. Abakus is planning to set up a R&D center for Asian market. They have shown their successful story of system design, engineering and cooperation with local investors.

# V. Industrial Investment Incentives

Since 1980 the Taiwanese government has allocated budgets for the development of PV technology and recognized PV as the focus project. Taiwan has implemented the subsidy program for PV installation to enhance domestic market since 2000. In 2007, the Executive Yuan set the target for PV industry and PV installation, as well as the government's policy for developing PV industry. In 2025, the PV installation will achieve 1 GWp, i.e. 1.8％ of total electricity capacity. Once the Renewable Energy Development Bill would be approved by the legislators, feed-in-tariff and installation of PV on public buildings will be enforced. The policy will emphasize on both PV industry development and PV installation.

## (I)Tax Credits for the Installation of Renewable Energy System

Tax reduction: By purchasing equipments for energy saving or clean energy purpose, 7% of the equipment cost (total equipment cost must be over 600k NTD) will be compensated for incoming tax in 4 years.

## (II) Incentive Programs for Investment in Renewable Energy Industry

For the investment in renewable energy equipments accelerated depreciation for equipment cost for max. 2 years will be granted.

Loan interest bonus: total interest will be subsidized total rate not over the sum of basic interest plus 2.45%.

Subsidy for research and development provided by MOEA (project base).

Besides the special incentive programs for renewable energy investment, the government has set up the general incentive program to speed up the growth of PV industry in Taiwan. The Taiwan Government offers a number of preferences to assist companies in the PV industry and to encourage foreign investments. These measures include tax preferences, R&D subsidies, low interest loans, personnel training, etc.

**Preferences to Encourage Foreign Investment in Taiwan**

| Item | Preference | Contact |
|---|---|---|
| Tax | ※Emerging important strategic industry (investment tax credit for shareholders or 5 year tax free)<br>※Personnel training expenditure (business income tax credit based on 35% of the training expenditure of the same year)<br>※R&D expenditure (business income tax credit based on 35% of the R&D expenditure of the same year)<br>※Accelerated depreciation of facilities (maximum depreciation period: 2 years)<br>※Tax credit for the purchase of facilities and technology investment<br>※Tax free for import facilities<br>※Income tax free for technology transfer or technology cooperation<br>※Tax preference for the establishment of operation headquarters | Ministry of Economic Affairs<br>http://www.moeaidb.gov.tw<br>E-mail：service@moeaidb.gov.tw<br>Tel：886-2-2754-1255 |

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|---|---|---|
| R & D Subsidy | ※Industrial Technology Development Program（ITDP）<br>※Small Business Innovation Research Program（SBIR）<br>※Industrial Technology Development Alliance Program（ITDAP）<br>※Strategic Service-Oriented Industry R&D Program（SRD）<br>※Information Technology Applications Program（ITAP）<br>※Industrial Technology Innovation Center Program for Local Enterprises（MNCD）<br>※Industrial Technology Innovation Center Program for Foreign Enterprises（MNCF） | Department of Industrial Technology, MOEA<br>http://doit.moea.gov.tw/<br>Tel：886-2-2321-2200 |
| | ※Leading Innovative Product Development Program<br>※Enterprise R&D Alliance Program<br>※Enterprise Operation Headquarters Service solution@moeasmea.gov.tw | Industrial Development Bureau, MOEA<br>http://www.moeaidb.gov.tw<br>E-mail：service@moeaidb.gov.tw<br>Tel：886-2-2754-1255 |
| Low-Interest Loans | ※Industrial R& D Loan | Ministry of Economic Affairs<br>http://www.moeaidb.gov.tw<br>E-mail：service@moeaidb.gov.tw<br>Tel：886-2-2754-1255 |
| | ※Low-Interest Loans for Mid- and Long-Term Capital | Council for Economic Planning and Development, Executive Yuan<br>http://www.cepd.gov.tw/<br>Tel：886-2-2316-5300 |
| | ※Project Loans for Small and Medium Enterprise | Small and Medium Enterprise Administration, MOEA<br>http://www.moeasmea.gov.tw<br>E-mail：solution@moeasmea.gov.tw<br>Tel：886-2-2368-6858 |

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|---|---|---|
| | ※Bank Draft and Loan Preferences for Development Fund, Executive Yuan | National Development Fund, Executive Yuan<br><br>http://www.df.gov.tw/<br>E-mail：df@df.gov.tw<br>Tel：886-2-2389-0633 |
| | ※Low-Interest Loans for Science Parks | Science Park Administration<br>http://www.sipa.gov.tw/<br>Tel：886-3-577-3311 |
| Personnel Training | ※International Experts Recruitment | HiRecruit Services<br>http://hirecruit.nat.gov.tw/<br>E-mail：hirecruit@taitra.org.tw<br>Tel：886-2-2370-9687 |
| | ※Military Training Service Application | Military Training Project Office<br>http://rondi.mnd.gov.tw<br>E-mail：mndsys@iii.org.tw<br>Tel：886-2-2736-8088#3414 |
| | ※R&D Substitute Service | R & D Substitute Service Program Office, Ministry of the Interior<br>http://rdss.nca.gov.tw<br>E-mail：rdss@mail.nca.gov.tw<br>Tel：886-2-2736-6066#206 |

**Source: Organized in the Present Study, May 2008**

# VI. Industry-Academia Collaboration in Taiwan

Integrating the efforts from the government, corporations, and industry associations, Taiwan is actively pushing forward the development of the PV industry. In 2007 the Taiwan Phovoltaic Industry Association (TPVIA) was founded to facilitate the development of PV in Taiwan. Cooperation projects between government, universities, research institutes and private companies are strongly encouraged by government policy.

**Cooperating Institutions for the Development of PV Industry in Taiwan**

| Institution | Website |
|---|---|
| National Science Council | www.nsc.gov.tw |
| Department of Investment Services, MOEA | www.dois.moea.gov.tw |
| Industrial Development Bureau, MOEA | www.moeaidb.gov.tw |
| Bureau of Energy, MOEA | www.moeaec.gov.tw |
| Taiwan External Trade Development Council | www.taiwantrade.com.tw |
| Industrial Technology Research Institute | www.itri.org.tw |
| Taiwan Photovoltaic Industry Association | www.tpvia.org.tw |
| Application for Subsidies Program | www.solarpv.org.tw |
| Taiwan Lighting Fixture Export Association | www.lighting.org.tw |
| Ching Yun University | solar.ee.cyu.edu.tw/ |
| National Sun Yat-Sen University | www.dop.nsysu.edu.tw/ViewInfo.asp?id=258 |

Source: Organized in the Present Study, May 2008