MSc Program
Renewable Energy in Central and Eastern Europe

Long Term Global Perspectives for Building-integrated Photovoltaics (BIPV) System in Cities with Focus on Malaysia

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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August 21, 2011

Affidavit

I, Mary Poh Lee TAN, hereby declare

1. that I am the sole author of the present Master Thesis, " Long Term Global Perspectives for Building-integrated Photovoltaics (BIPV) System in Cities with Focus on Malaysia'",

93 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and

2. that I have not prior to this date submitted this Master Thesis as an examination paper in any form in Austria or abroad.

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Abstract

The research is aimed at determining the market dynamics of solar energy worldwide, in particular the BIPV market with focus on Malaysia's potential for domestic and international expansion, The market development of PV is very dependent on the policy, technology development and transfer and economics of PV products. State of the art technologies would therefore be analysed by researching public and academic documents. Policy incentives used for stimulating PV market will also be reviewed.

The study endeavour to provide historical development and opportunities for building BIPV products in major countries such as Germany, Italy, France, Spain, China, Malaysia and the US. It will also identify and quantify the range of BIPV markets for various types of roofing, building facades, glazing, sunshading, skylighting, architectural fabrics, and shutters that form a solar production medium.
The various national and international approaches and policy implemented to subsidize the continued expansion of the PV industry in the above mentioned countries, including the legal and regulatory regimes that stipulate requirements for the aesthetic appearance of BIPV products would also be reviewed.

The economic progress of BIPV, including historical cost, learning curves for modules world wide and comparative cost of PV generated electricity cost with that of electricity from non-renewable sources would also be assessed.

Lastly, the possible strategic partnerships with building component manufacturers, contractors, developer and architectural firms underpin the ability of PV manufacturers to enter into the multi-billion Euro building construction market would also be analysed, especially for the Malaysian scenario.

A combined methodology using both quantitative and qualitative instruments would be employed. BIPV markets are examined through literature and internet research. This involved examining the building component markets and PV technologies as adapted to become part of a number of building component market segments, World market values are analysed in terms of aggregates of market in Germany, Italy, France, Spain, China, USA and Malaysia, where appropriate. The market growth rates of individual BIPV sectors are projected using statistical data from

governments, published documents, scientific research reports, trade journals and news.

Current status of government support systems are reviewed in terms of their impacts on the overall market for PV capacity and potential for enhancing or limiting BIPV market expansion, especially in Malaysia.

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List of abbreviations and symbols

AC	Alternative Current
a-Si	Amorphous Silicon
BIPV	Building Integrated Photovoltaics
BOS	Balance-of-systems
CAGR	Compound Annual Growth Rate
CdTe	Cadmium Telluride
CIS	Copper Indium Diselenide
c-Si	Crystalline Silicon
DC	Direct Current
EEC	Renewable Energy Sources Act
EPIA	European Photovoltaic Industry Association
FiT	Fit-in tariffs
GHG	Green House Gas
GW	Gigawatt
GWh	Gigawatt Hour
IEA	International Energy Agency
ITC	Investment Tax Credit
ICBEST	International Conference on Building Envelope Systems and Technologies
km	Kilometer
kW	Kilowatt
kWh	Kilowatt Hour
kWp	Kilowatt Peak
MBIPV	Malaysia Building Integrated Photovoltaics
PTC	Production Tax Credit
PV	Photovoltaics
SEMI	Solar Energy Manufacturing Industry
SIRIM	Standards and Research Institute of Malaysia
TNB	Tenaga National Berhad (National Utility Company)

1 Introduction

Every country faces two critical challenges in the world's growing energy needs, i.e., climate change and energy security. The World Energy Outlook 2010 predicts the share of fossil fuels will decline from 81% in 2008 to 74% in 2035 and the global energy demand will continue to increase. This is based on broad policy commitments that have been announced by some countries and these policies are expected to shape the future energy demand in the world.

In recent years, the growth of the photovoltaic sector is on an increasing trend. However, the deployment of this technology is still low in building sectors due to the complex and long administrative procedures, high cost of installation, lower performances of the PV systems, and no extra or low incentives to integrate building PV systems.

In view of the above, many countries are adapting their national incentive programs (feed-in- tariff) in order to provide higher support for this kind of installations compared to ground-based systems and make BIPV projects more attractive for investors. This is seen in the case of French and German markets. Spain, the second PV market in Europe is also evaluating the possibility to differentiate those types of systems in their support program.

BIPV refers to the installation of PV modules which supplies electric power on surface of external supporting structure. Those PV modules can replace part of such traditional structures such as roof slab, tile, window, building elevation and rain-proof shelter, including to function as PV/thermal system, in combination with illumination and sun shade. Present applications of BIPV are widely seen on exposed walls, sun-shading shelters, patios, tiles, roofs, sound-proof walls, including private apartments, schools, hospital buildings, airports, platforms of subway stations and large workshops. Hence BIPV s a multifunctional building component for electricity generation, shading systems, weather protection, noise protection, heat insulation and sunlight modification.

Buildings are responsible of 40% of the European energy consumption and therefore responsible of the 1/3 of the GHG emissions. There are many ways to reduce energy consumption as for example:

- Better designs (making better use of the sun light, windows and corridors designs, etc.)
- Proper materials (higher isolation, double glassing windows, reduction heat losses, etc.)
- Integration of renewable energy sources (concept of positive energy buildings) as thermal collectors for sanitary water, heating and cooling and PV modules for electricity generation among others.
- Last but not least, the behaviour of the occupants and possible acceptance for lower comfort levels.

Photovoltaic technologies have a long term potential of providing sustainable energy for the world's energy needs. Generally, they are silent, clean in operation, reliable, low maintenance and robust with expected lifetime of about 20 to 30 years. They can also be easily adapted or extended for many locations due to their modular structures. Solar electricity can also replace fossil fuel use with many environmental benefits. Building Integrated Photovoltaics (BIPV) offer an attractive application in the use of photovoltaic on buildings. Photovoltaic has tremendous potential in this area with several advantages when integrated into the fabric of a building. Some cost savings can be realized when PV panels replaced conventional building material. Furthermore, BIPV needs no extra land and electricity is generated at the point of use and therefore transmission losses are reduced. When it is used for domestic electricity supply, purchase of electricity is displaced and excess supply of electricity from PV can then be supplied to the grid.

The price of PV has declined significantly over the years, and the potential for further cost reduction is very promising. Some experts believe that as conventional fuel price rise and PV prices fall, generation costs of PV may reach parity with some fossil energy sources in as little as a few years.

1.1 Motivation

The PV industry is making the transition from an expensive renewable technology to being a major factor in the world energy supply. Despite a bleak world economy, the annual market value of installed PV product in on an upward trend.

Most established technologies and companies have made impressive strides in producing solar cells and sheets as well as improving product reliability with significant reduction in production costs. The practice of building BIPV is now a regular occurrence in many countries, including Malaysia. This has inspired me to assess as to whether BIPV has a natural economic edge to other renewables.

1.2 What is the core objective / the core question?

This thesis reviews BIPV applications in Malaysia as one route towards diversification of the Malaysian energy infrastructure. By analyzing the potential of BIPV's penetration in Malaysian urban areas. This study addresses the questions of (i) Is BIPV feasible in Malaysia? (ii) What are the pros and cons if the Malaysian government chooses BIPV and (iii) How can barriers be overcome to implement BIPV?

In terms of potential of BIPV in Malaysia, an installation in Kuala Lumpur would yield about 1100kWh/kWp per year (Alamsyah et al, 2004). The potential of BIPV in the residential, commercial and industrial sector in Malaysia is huge. Approximately 2.500.000 households are suitable for BIPV in the residential sector. Some houses have obstacles on its roof, therefore making PV not suitable. A rough building evaluation assumes about 1/5 are not suitable due to architectural constraints.

A typical roof surface of a bungalow is approximately 10 m^2. About 5% of the total residential sectors are flats or apartments which are not suitable for BIPV. Most commercial business is located in urban areas and is a potential for PV application. About 10% of the 45.000 buildings that can be considered for BIPV in Malaysia are not suitable for BIPV due to shading or obstacles on the roof. Shopping mall and a business park are assumed to have 1000m^2 available for BIPV. The industry sector is normally in the peripherall of the urban centers. Hence they offer large roof areas (mainly flat roof) averaging 2000m^2. Once again, 10% of the buildings are not suitable because of influencing factors (shading, construction not able to carry additional weight).

Hence, the total available surface for BIPV is approximately 110,000,000 m^2 (Residential = $2.5 \times 10^6 \times 10$ m^2, Commercial= $4.0 \times 10^4 \times 1000$ m^2 and Industry = $2.1 \times 10^4 \times 2000$ m^2).

Considering only the lower value of 1 kWp for every squaremeter of available building roof surfaces in these sectors, thepotential is around 11.000 MWp or 11 GWp which could provide more than 12 TWh solar energy. This represents 20% of the national energy demand. At today's pricesof RM25,000/KWp (or RM25 million/MW) the total BIPV. BIPV remains in its infancy or as a novelty in Malaysian cities as demonstration projects.

The recently promulgated Renewable Tariffs in Malaysia is a landmark of Malaysian government's endeavour to contruct a harmonic society and transition to sustainable patterns of development. It supports a reduction in consumption of fossil fuels and seeks to stimulate renewable alternatives. Aiming for the enhancement of this Renewable Tariffs, this study also analyses contents and limitations of this tariffs. Correlative recommendations for further improvement are given based on successful cases in other countrires. Several suggestions on actions are provided for policy-makers on the development of solar power, especially BIPV in Malaysia. The paper also endeavours to study as to whether Malaysia is applying appropriate technologies and support incentives in harnessing and converting the vast energy resources in developing in time for meeting growing demand for energy and reduce production from conventional reserves, especially from oil and gas. Also whether the technologies have adverse implications and whether the energy services generated from BIPV will be sustainable and affordable. Lastly, when will Malaysia reach grid parity

1.3 Structure of work

A combined methodology using both quantitative and qualitative instruments would be employed. BIPV markets are examined through literature and internet research. This involved examining the building component markets and PV technologies as adapted to become part of a number of building component market segments, World market values are analysed in terms of aggregates of market in Germany, Italy, France, Spain, China, USA and Malaysia, where appropriate. The market growth rates of individual BIPV sectors are projected using statistical data from governments, published documents, scientific research reports, trade journals and news. Historical development of PV in major countries covering policy and financial incentives will also be explored.

Current status of government support systems are reviewed in terms of their impacts on the overall market for PV capacity and potential for enhancing or limiting BIPV market expansion, especially in Malaysia.

This paper is aimed at presenting the current status of PV and BIPV industry in countries such as Germany, Italy, France, Spain, China, USA and Malaysia. This included historical development of PV and BIPV in those countries as well as its corresponding policy and financial incentives.

Chapter 2 examines world market values in terms of aggregates of market in Germany, Italy, France, Spain China, USA and Malaysia, where appropriate. The global growth rates of BIPV segments are projects using statistical data from research companies, statements by public officials and builidng component manufacturers. Present levels of government support systems are considered in terms of their impacts on the overall market for PV capacity and potential for enhancing (or limiting) BIPV market expansion.

Chapter 3 focuses on the economic and technological development of BIPV systems with emphasis on Malaysia's SURIA 1000 program (BIPV).

Chapter 4 provides an overview of the Malaysian market penetration into the BIPV market. It also touches upon the achievement of the BIPV project in Malaysia.

1.4 Citation of Literature

Most of the data and information are obatined from the MBIPV website, EPIA publications as well as IEA-PVPS publications and websites. As some of the market data differs with different sources, the most reliable sources were quoted to the extent possible.

2. Historical Development of PV and BIPV in Major Countries Covering Policy and Financial Incentives

2.1 Germany

2.1.1 Present Status of Germany's PV & BIPV Industry

The German market is currently the largest market for BIPV in Europe. In 1999, BIPV technology was promoted in the country through its 100.000 programme. The German market developed faster than other markets, securing in 2004 the largest PV markets in the world through guaranteeing FIT and interest free loans. Due to its early focus on BIPV, Germany now has a high level of expertise in BIPV installer, designers, architects and manufacturers as well as a high level of awareness among the end users. In addition, the recent amendments in Germany's Renewable Energy Act, the EEG (Erneuerbare Energie Gesetz) ensures that Germany will remain one of the largest markets for BIPV in the world.

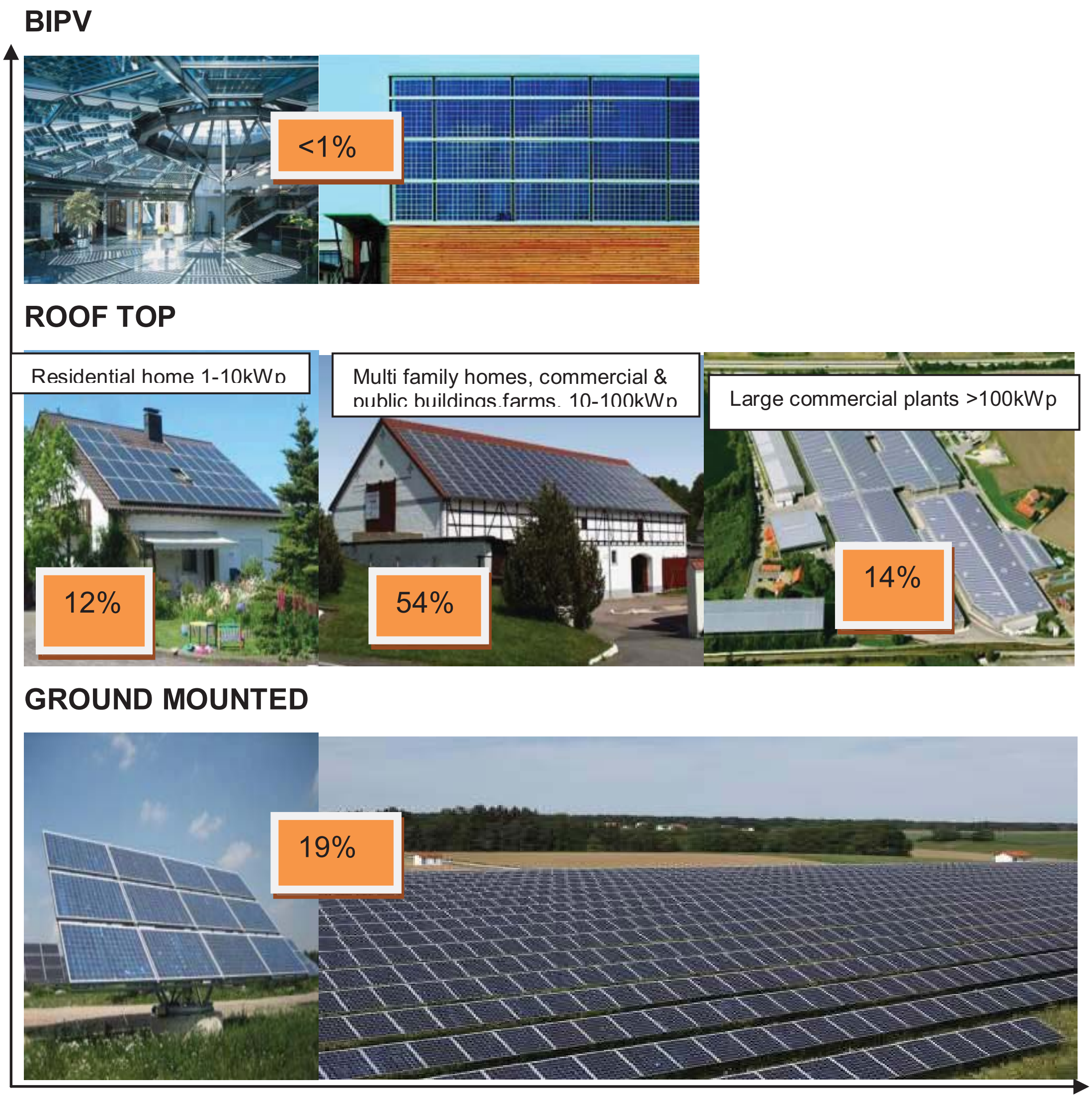
Germany was the most important solar PV market in 2009 with 45% of the world's total installed capacity, which compensated for the substantial decline of the Spanish market after the boom of 2008.

The cumulative installed PV capacity in Germany at the end of 2009 was about 9,8 GW, with about 3,8 GW of PV being installed during the year, double that of 2008. The 11% decline in Government FiTs for plants connected to the grid after January 2010 motivated many developers to finish their projects before the end of 2009. About 159.850 new PV systems with a total capacity of 3,8 GW were recorded.

In 2010, Germany recorded a 7,4 GW installed solar which was lower than anticipated. In the second half of 2010, there was a slowdown in the PV market due the Fukushima's nuclear crisis, there have been calls to speed up the move towards renewable energy and this might contribute towards a positive impact on solar.

2.1.2 Main Applications of PV in Germany

In 2009 about 4,5 MW of stand-alone PV systems were installed for industrial applications. Apart from rooftop installations which account for about 80% of the market, there are several large ground-mounted facilities such Lieberose a 53 MW PV systems (with First Solar modules and Juwi as developers), Strasskirchen a 54 MW systems (with Q-Cells modules and Q-Cells International as developer) and Finsterwalde I, a 41 MW PV installations (with Q-Cells modules and Q-Cells International as developer) (Source: http://www.renewableenergyfocus.com/view/14432/renewable-power-generation-a-status-report)



Source: BIPV- Keynote-ICBEST, Fraunhofer Institute Solar Energy Systems, Germany

Figure 1: Photovoltaic Market Segments and % Share in Germany (2009**)**

2.1.3 Related Policies for Germany's PV & BIPV Industry

The Renewable Energy Sources Act (EEG) is the main driving force for the PV market in Germany. In order to stimulate a stronger PV price reduction, the yearly degression rate of the EEG PV feed-in tariff was raised in 2008. For example, the yearly degression rate was changed to 8% from 5% for roof-top PV systems smaller than 100kW installed capacity. In 2009, the resulting tariffs were 0,3194 Euro/kWh for ground mounted systems. For roof-top PV systems smaller than 30kW, 100kW, 1 MW and larger than 1 MW, tariffs are 0,4301Euro/kWh, 0,4091Euro/kWh, 0,3958 Euro/kWh and 0,33Euro/kWh respectively. A mechanism was also introduced to adapt the degression rate in relation to the PV market growth rate. Therefore, if the market deviates from a pre-defined corridor, the degression rate is increased or decreased accordingly by 1% the following year. A corridor of between 1000 MW and 1500 MW was set in 2009. If the system size is below 30kW installed capacity, the PV system owner is eligible for a reimbursement for own consumption of the PV electricity.

Furthermore, PV deployment in Germany receives support from other sources, in addition to the EEG. Such as local fiscal authorities provide tax credits for PV investments and the state owned bank KfW-Bankengruppe provides loans for PV for individuals, including local authorities.

In a nutshell, FIT and fiscal instruments such as investment incentives and operational incentives were employed in Germany. In addition, Germany has in place the Environment and Energy Saving Program as well as the Joint Task for the Promotion of Industry and Trade.

2.1.4 Forecast for Development Trend of Germany's PV & BIPV

Renewable energies achieved a share of 16,1% of domestic electricity production in 2009, surpassing the initial 2010 target of 12,5%. The 2020 target of 20% has now been extended to 30%.

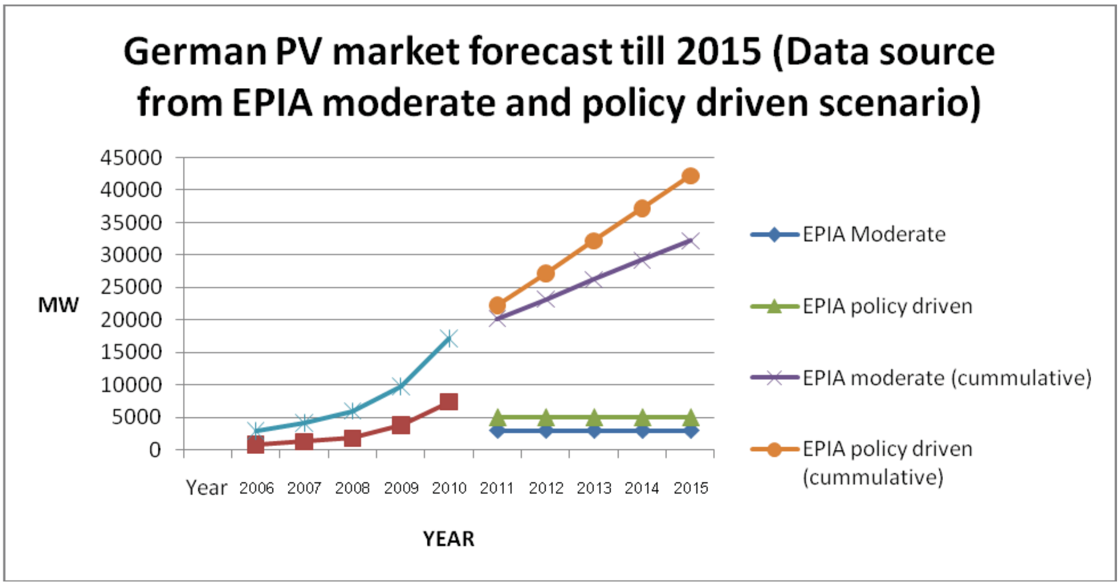


Figure 2: German PV market forecast till 2015 (Data sourced from EPIA, May 2011)

Table 1: German PV market forecast till 2015 (Data source from EPIA moderate and policy driven scenario)

	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EPIA Moderate	MW						3000	3000	3000	3000	3000
	MW	843	1271	1809	3806	7408					
EPIA policy driven	MW						5000	5000	5000	5000	5000
EPIA moderate (cummulative	MW						20200	23200	26200	29200	32200
	MW	2899	4170	5979	9785	17193					
EPIA policy driven (cummulative	MW						22200	27200	32200	37200	42200
National target (2015)	MW										34279

(Source: EPIA, May 2011)

Germany continues to attract investors with its lowest PV systems prices on the market and low FiTs in the region with an average price of Euro 0.26 per kWh produced. A further decrease in January 2011 further reduced Germany's FiTs to much lower levels than other EU countries. The 'corridor' concept which adapts the level of FiTs in accordance to market growth will lead to a further reduction in FiTs by 3 to 15 % by mid-2011. EPIA forecasted a cumulative capacity of 32.200MW by 2015 under the moderate scenario and 42.200 MW under the policy driven scenario.

Market segmentation of German installations in 2009 are as follows: BIPV <1%, 1-10kW range:12%, from 10-100kW range: 54% and >100kW: 14% and ground mounted: 19%.

2.2 Italy:

2.2.1 Present Status of Italy's PV & BIPV Industry

The Italian market reached 717 MW of PV power in 2009. This amount doubled the 2008 market size of 338MW and Italy's market size was second to the German market. About 1.2 GW of cumulative installed PV power was registered in the country.
Since 2007, Italy's PV market has boomed. This is mainly due to the government boosting production incentive, attracting the world's biggest PV module makers such as China's Suntech Power Holdings Co, Trina, Yingli Green Energy and U.S. firm First Solar.

In 2010, Italy was the world's second-biggest solar market in terms of new installed photovoltaic capacity.

Italy added about 2,300 MW of photovoltaic capacity in 2010 to reach a total of about 3,400 MW total capacity at the end of last year. Due to Italy's high retail electricity prices and high solar irradiation. Its consumer market is seen as the first major electricity market with the potential for grid parity to be reached.

2.2.2 Main Applications of PV in Italy

The grid-connected centralized PV power systems accounts for 43% (up from 33% in 2008) of 1.2 GW installed capacity of grid-connected centralized PV power systems. Whereas 57% of the total installed capacity constituted the grid-connected distributed PV systems. However, off-grid PV applications are decreasing due to decommissioning of systems installed in the early 1980s.

The residential sector witnessed the highest growth becoming the largest sector for BIPV. Due to the implementation of high feed-in tariff for BIPV systems, especially for small-scale systems, which have increased consumer adoption of the technology.

2.2.3 Related Policies for Italy's PV & BIPV Industry

In 2009, the Conto Energia Programme was the driving force that stimulated the PV market of Italy. Primo Conto Energia, the first stage of the programme was completed in 2009 with 5.733 PV plant installations (equivalent to about 165MW). Nuovo Conto Energia, the second stage, was implemented by governmental decree in February 2007. Both stages resulted in 71.284 PV plants with a total capacity of 1.142 MW.

From June 2011, the PV FiTs was reduced at the end of each month. In the first month, they will be cut to a greater extent, between 4 to 11%. Subsequent months will be reduced by 2 to 5%, depending on the size of installation. From the same time onwards, a cap will be introduced to support PV which will apply only to big PV systems during a transition phase until the end of 2012. Installations consisting primarily of EU made components will receive a support premium.

The FiTs are clasified into new categories as shown below:

i) Roof-mounted solar power plants with a capacity of up to 1 MW are considered as ‘small systems”

ii) >1MW are large-scale and solar farms on open ground with a capacity of 200 kW and above are regarded as big systems.

During the transition phase, the support fund cap applies only to large-scale systems. Funds are capped at Euro 580 million for the period from June 2011 to the end of 2012. Based on the research done by EuPD, the amount of Euro 580 million would be sufficient for an additional capacity of about 2.7 GW. A total amount of euro 1.3 billion will be made available for small and large systems from 2013 to 2016. This represents a total additional capacity of almost 10 GW which is equivalent to about 2.5 GW annually. For comparison, in 2010 at least 5 GW of photovoltaic was installed in Italy.

In future, if the grid operators fail to connect a fully installed PV system to the grid within 30 days, they will need to pay compensation to the operators.

Tariffs will also be cut by 5 to 10 €ct/kWh every six months in 2012. In 2013, they will rise again at first but all other support measures, such as tax benefits or investment subsidies will be abolished. A flexible degression based on the rate of installation, similar to the German systems will be applied from the second half of 2013.

In the case of Italy, FiT and net metering law were the driving force for the PV industry.

2.2.4 Forecast for Development Trend of Italy's PV & BIPV

The lack of specific tariffs for BIPV, including adminstrative and bureaucratic hurdles have restrained growth in the county although it should have been a haven for BIPV, with good climatic conditions and high investment capability. Nevertheless, with the introduction of the Conto Energia laws, whereby very high FITs for BIPV and a clear cut definition for BIPV installation were granted in 2007, boosted the BIPV Italian market. The scheme also provided end users with several payment options and supportive legislation for utilizing the BIPV tariffs. The market has since then grown rapidly in 2007 and is anticipated to continue this high growth rate in the future. These very attractive investment returns have created a "rush" for installtions. In order to control this tremendous growth, the above mentioned revised solar policy was announced. The aim of the policy is to continue the development of solar without an increase in the electricity prices for rate payers. It might seems like Italy's best solar days are over.

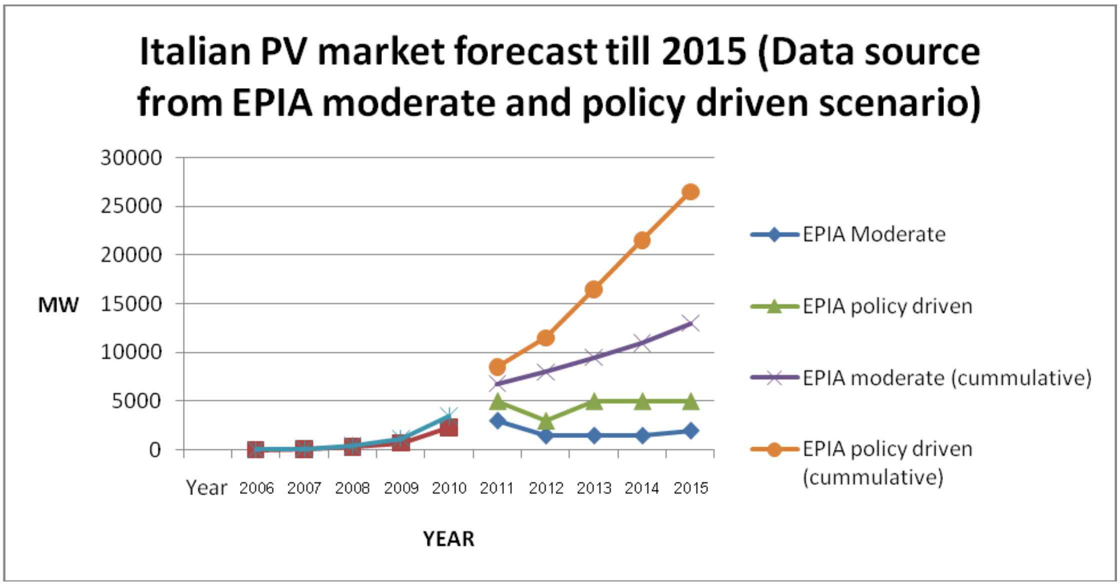


Figure 3: Italian PV market forecast till 2015 (Data sourced from EPIA, May 2011)

Table 2: Italian PV market forecast till 2015 (Data sourced from EPIA moderate and policy driven scenario)

	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EPIA Moderate	MW						3000	1500	1500	1500	2000
MW	MW	10	70	338	717	2321					
EPIA policy driven	MW						5000	3000	5000	5000	5000
EPIA moderate (cummulative)	MW						6800	8000	9500	11000	13000
	MW	47	117	456	1173	3494					
EPIA policy driven (cummulative)	MW						8500	11500	16500	21500	26500
National target (2015)	MW										5500

(Source: EPIA, May 2011)

EPIA reported that the future of the PV market in Italy remains unclear due to the Government's decision to implement a new regulations for installations connected after 31st. May 2011. Nevertheless, the market is estimated to reach a cummulative amount of 13.000 and 26.000 MW of installations respectively under the moderate scenario and the policy driven scenario.

2.3 France

2.3.1 Present Status of France's PV & BIPV Industry

About 220 MW of PV were installed in France (mainland France, Corsica and the four French overseas departments Guadeloupe, Guyane, Martinique and Réunion) in 2009. This gives a twofold increase compared to 2008, and more than threefold increase compared to 2007. With the adjustment of the government's FiT on 10 January and 14 March 2009, the country expects an increase of up to 500 MW over the coming year. The increase could have been even higher if the government had not cut its tariff for rooftop installation and defined strong architectural conditions for plants to qualify as BIPV.

2.3.2 Main Applications of PV in France

Almost 40% of the total capacity installed in mainland France in 2009 composed of large-scale roof-mounted modules, and large surface-area farm building applications.

2.3.3 Related Policies for France's PV & BIPV industry

In order to increase the distribution rate of renewable energy to 23% by 2020, the French government is pursuing dissemination policies for renewable energy and its FiT base price is the highest amongst countries with PV systems. Its FiT for BIPV is divided into Simple Integrated and Fully Integrated BIPV. During January and August 2010, the fully BIPV base price for residential, health care and school building is 0.58€/kWh and for commercial and industrial building is 0.50€/kWh. It is the highest FiT in the world. The simple BIPV base price is 0.42€/kWh. The building application market in France, including BIPV and rooftop constitute more than 80%.

However, as the cost to state utilities in on the increase, solar has hence come under increased scrutiny. The new French framework was designed to achieve its goal of 5.4 GW by the year 2020. A flexible FIT for 20 years has been introduced. This FIT system changes every quarter according to volumes installed and a reverse FIT (based on auction) system for large rooftop and ground mounted systems where lowest bid wins was also introduced.

The feed-in tariff was also complemented by other measures such as income tax credit applied to 50% of PV module and other equipment costs and capped at 8000

Euro per income tax paying person (16000 Euro per couple), and the ongoing ADEME-FACE support for off-grid systems.

In summary, FIT and compensation scheme are implemented in France:

Table 3: France mainland FiT policies (2010 - 2011)

		01-01-2010 30-08-2010 (€/kWh)	01-09-2010 31-12-2011 (€/kWh)	Remarks
Simplified BIPV	All	0.42	0.37	
Fully BIPV	Residential<3kW	0.58	0.58	
	Residential>3kW	0.58	0.51	
	Health care and school building	0.58	0.51	9% tariff degression applied till 2014.
	Commercial and Industrial	0.50	0.44	
Rooftop	All	0.42	0.37	
Ground mounted system	In the sunny south (<250kW)	0.314	0.276	
	In the cloudy north (>250kW)	0.377	0.332	

Table 4: France Corsica and Overseas region FiT policies (2010 - 2011)

		01-01-2010 30-08-2010 (€/kWh)	01-09-2010 31-12-2011 (€/kWh)	Remarks
Rooftop	All	0.4	0.352	9% tariff degression applied till 2014.
Ground Mounted System >250kW	All	0.4	0.352	

(Source: Solar and Energy, BIPV Technology and Market Forecast (2009-2015), March 2011)

In summary, the PV market in France is supported by the solar power FiT, beneficial credit term and tax incentives.

2.3.4 Forecast for Development Trend of France's PV and BIPV

The BIPV-specific FITs introduced in France in 2006 has transformed the French BIPV market into a hotspot for manufacturers. The French market has since then grown into being the second largest market for BIPV in Europe, after Germany. It had been challenging for manufacturers to meet the high demand from the French market as it has only started focusing on the BIPV market and still trying to establish a strong manufacturing and consumer base. In addition, design and installation expertise are also lacking in the French BIPV market.

France's "Grenelle of the Environment " has a significant role in influencing the trend in which the PV market is going to evolve in future. In connection with this initiative, an installed PV capacity of 1100 MW by 2012 was expected.

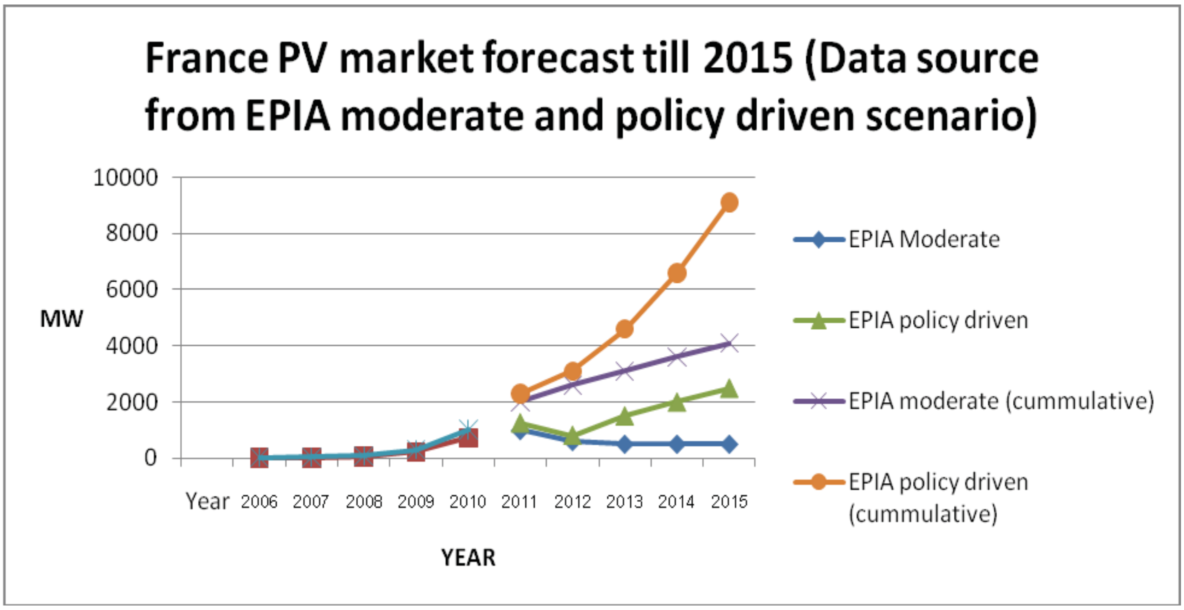


Figure 4: France PV market forecast till 2015 (Data sourced from EPIA, May 2011)

Table 5: France PV market forecast till 2015 (Data sourced from EPIA moderate and policy driven scenario)

	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EPIA Moderate	MW						1000	600	500	500	500
MW	MW	8	11	46	219	719					
EPIA policy driven	MW						1,250	800	1500	2000	2500
	MW						2000	2600	3,100	3,600	4100
	MW	30	41	87	306	1025					
EPIA policy driven (cummulative)	MW						2300	3,100	4,600	6,600	9100
National target (2015)	MW										2151

(Source: EPIA, May 2011)

In view of the strict cap/corridor system implemented in France, a tendering system is in place for systems larger than 100kW with a yearly cap of 300 MW. All this regulations have led EPIA to forecast an annual market of 500MW by 2015 under the moderate scenario, as shown in the above table. The French PV annual market is also forecasted to grow to 2.5GW by 2015 giving a cumulative capacity of 9.1 GW under the policy-driven scenario. In the future, the French market will most likely continue to be characterised by the particular importance accorded to BIPV applications.

2.4 Spain

2.4.1 Present Status of Spain's PV & BIPV Industry

In 2009, about 17MW was installed as compared to 2.7 GW and 0.5 GW in 2008 and 2007 respectively. The Spainish PV market collapsed in 2009 due to the FIT being radically and restrospectively cut back.

Spain had emerged as a major solar PV market in 2008. In 2008, Spain surpassed Germany to become the fastest growing solar PV market in the world with over 2.7 GW of newly installed solar PV capacity. In response to the swift growth of the Spainish PV market, the Goverment introduced an annual cap eligibility for guaranteed FIT. In 2009, a 500MW cap was set for newly installed solar PV capacity. As a result of this policy change, the Spanish Solar PV market collapsed in 2009.

2.4.2 Main Applications of PV in Spain

At present, the distribution of PV instalations in Spain is about 99% grid-connected systems and 1% off-grid systems, with more than 50.000 PV systems installed.

2.4.3 Related Policies for Spain's PV & BIPV industry

Significant changes were made to the support scheme for PV in Spain in late 2008. The Royal Decree 1578/2008 classifies the PV installations into Type 1 and Type II with subtype 1.1 (installations less than 20 kW) and 1.2 (installations more than 20 kW).

Type I are for PV roof-top plant or plants developed for similar surfaces and Type II are those installations not covered under under Type I and its subtypes, which are essentially ground-based PV plants. Installed power capacity limits of 2 MW and 10 MW were also set for Type I and Type II respectively. Quotas on the number of PV power installed per year were also introduced (267 MW for roof-top systems and 133 MW for ground-based systems in 2009).

The following tariffs were implemented:

Table 6: Spain FiT

For the 1st year	Type of installation		Tariffs cent Euro/kW
	Type I	Subtype 1.1	34
		Subtype 1.2	32

	Type II		28

In Spain, the PV market is supported by its FiT law. In addition, there is in place a building codes for solar as well as initiatives for solar PV and research and development (R&D) for solar PV.

2.4.4 Forecast for Development Trend of Spain's PV & BIPV

Following the introduction of liberal FITs for PV installations and supportive schemes like soft loans and PV subsidies for large commercial buildings, the Spanish BIPV market took off in 2004, hanging on the fringes of the open-field PV market which experienced an upward growth trajectory as a result of strong government subsidies. The Spanish BIPV market has experienced less growth than the general PV market due to the focus on open-field PV. However, this is anticipated to change, following the decision by the government to revise its tariffs for PV by giving more importance to BIPV and scaling down its open-field tariffs for PV. This would led to a focus on BIPV from both consumers and manufacturers, when the tariffs came into effect in mid 2009.

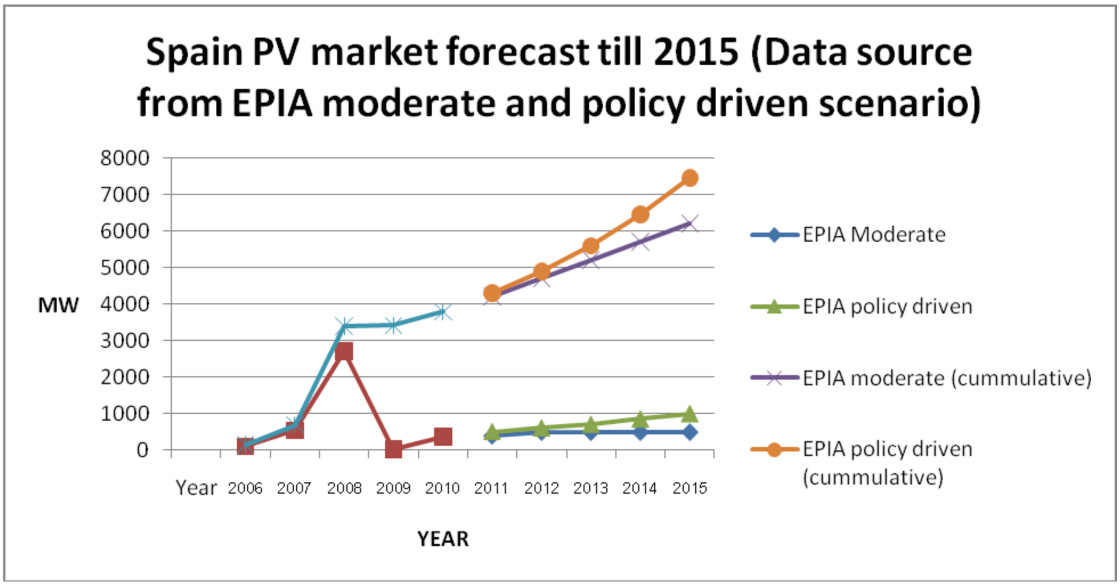


Figure 5: Spain PV market forecast till 2015 (Data sourced from EPIA, May 2011)

Table 7: Spain PV market forecast till 2015 (Data source from EPIA moderate and policy driven scenario)

	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EPIA Moderate	MW						400	500	500	500	500
MW	MW	102	542	2708	17	369					
EPIA policy driven	MW						500	600	700	850	1000
EPIA moderate (cummulative)	MW						4200	4700	5200	5700	6200
	MW	148	690	3398	3415	3784					
EPIA policy driven (cummulative)	MW						4300	4900	5600	6450	7450
National target (2015)	MW										5918

(Source: EPIA, May 2011)

With the current regulation (Royal Decree 1565/2010 and Royal Decree-Law14/2010), the future of Spain PV market is unclear for the ground-mounted PV installations. The new law supports the development of the roof-top PV market only. A major setback of this is the introduction of a limit (for the next three years) on the number of hours for which the producer will receive the full tariff. EPIA forecasted a market of 5918 MW of PV by 2015.

2.5 China

2.5.1 Present Status of China's PV & BIPV Industry

China is the world's largest producer of solar cells and modules with a 50% of global total production. The cost of PV has declined sharply since 2009, and there are some important developments in China's policies for domestic PV market. A national PV subsidy program to promote the use of BIPV applications and rooftop systems was introduced in March 2009 by the Ministry of Finance together with the Ministry of Urban and Rural Development.Subsequently, a second national PV subsidy program, the Golden Sun Demonstration Program was implemented to subsidize 600 MW of PV for the following two to three years. This includes both grid-connected and off-grid applications. Currently, about 200 BIPV systems have been

implemented and about 10 utility-scale ground mounted systems, with the largest installed capacity being 20 MW.
Furthermore, in 2009, China introduced a FIT subsidy for a 10 MW Dunhuang project where the tariff was determined through open bidding and an additional 280MW projects were offered for bidding in 2010.

All these government incentive programs contributed to the surge in China's PV market. The estimated domestic implementation of PV systems in China during 2009 is about 160 MW to 220 MW and by the end of 2009, a cumulative installed capacity of about 300MW to 360 MW was reported. In 2010 another 40-500MW was installed and it was forecasted that PV installations will increase to 1 GW in 2011.

In a nutshell, China's PV market was supported via subsidies for solar in rural areas, R&D support for solar PV, implementation of solar PV pilot projects and provision of solar PV support measures.

2.5.2 Main Applications of PV in China

A 10MW BIPV grid-connected system was built by Astroenergy of China's Hangzhou Province for the new Hangzhou East Railway Station. The installation covered 148.000 square meters and produce an estimated 9.818.600 kWh per year of electricity. The system costs CNY 270 million (Euro 30 million). The railway station is scheduled for completion in late 2011. 8.2MW of the installation of the project was subsidized by China's revamped Golden Sun initiative and the remaining 1.8 MW of the project was funded under the National Solar Photovoltaic Building Demonstration Project program.

50% of the total costs of the project was funded under the Golden Sun program. This included connection and distribution cost and provided an additional generation subsidy of CNY 4-6 /watt (Euro 0.44-0.66/watt). The Golden Sun Program started in 2009 with an initial target of 500MW of PV installations through 2013. Following the COP16 Conference in Cancun, Mexico, the Chinese government modified and increase the target to 1 GW of installed capacity annually starting in 2013. The Golden Sun Program is an initiative of China's Ministries of Finance, Science and Technology, Housing and Urban/Rural Affairs, and of the National Energy Administration.

Another large BIPV project is the Shanghai's Honggiao Station, the newest high speed rail station on the Beijing-Shanghai rail line. Xinhuanet reported that this project was funded and developed by the China Energy Conservation and Environmental Protection Group (CECEP). The station utilizes awning roofing on both sides of Honggiao Railway Hub with coverage of 61.000 sq m and includes more than 20.000 solar panels. 6,3 million kwh of electricity is produced annually from the 6.688 MW solar system. This is able to meet the needs of more than 12.000 Shanghai households. This solar project is meant to contribute towards the advancement of solar power in China as well as to encourage the construction of eco-friendly rail stations in China. The total project costs 160 million yuan (($23.6 million) and the solar system is expected to reduce carbon emissions by 6.600 tons and cut coal consumption by 2.254 tons.

2.5.3 Related Policies for China's PV & BIPV Industry

The second national solar subsidy program, the "Golden Sun" program provided upfront subsidies for qualified demonstrative PV projects from 2009-2011. The first solar subsidy program, the BIPV subsidy program also provides upfront subsidy for grid-connected rooftop and BIPV systems. The following summary shows some key features of the two programs (source: The Golden Sun of China: PV Group).

	BIPV Program	**Golden Sun Program**
Applications	Grid connected rooftop and BIPV systems	Grid connected rooftop, BIPV, and ground mounted systems
		Off-grid systems in rural areas
System Size	>= 50KW	>= 300KW
Subsidy	RMB15/W for rooftop systems	50% of total cost for on-grid systems
	RMB20/W for BIPV systems	70% of total cost for off-grid systems
Other Terms	Conversion efficiency minimum requirement: 16% for monocrystalline, 14% for multicrystalline, and 6% for	For grid connected systems, on-site consumption is encouraged. Excess electricity would be sold to the utility. Buy back rate is

	thin film	based on local benchmark coal-fired grid price.

So far, these two subsidy programs are the most concrete form of policy support for PV offered by China national government for PV. These clearly demonstrate China's determination to support the adoption of PV. In addition, it is also anticipated that a nationwide Feed-in Tariff (FIT) subsidy for large-scale PV systems will be promulgated. However, the timing and details of the FIT subsidy is still quite uncertain. Nevertheless, it is certain that all national subsidies are mutually exclusive and a PV project can only qualify for one of them.

China should learn a lesson from its wind industry, whereby after struggling for many years and with 12 GW installed capacity, China's wind industry was finally able to welcome a new FiT for wind power plants. Whether or not the new FiT will boost investment in wind is yet to be seen. As for PV, solid groundwork to establish a national FiT system still needs to be built by the Chinese government. Time is needed for the policies to be evolved and as such in the near term, a national upfront subsidy combined with localized FiT subsidy by provincial and municipal government could be an effective approach.

2.5.3.1 Implications and Interpretations of China's Policy

The question arises as to how much installations can these national subsidies drive in the next two or three years? The Golden Sun program set a cap of 20MW for each province, which also includes installations under the BIPV subsidy. Assuming all 34 provinces (including autonomous regions and municipalities directly under the central government) will participate in this program a total subsidized installations by year 2011 will be capped at 680MW.

Based on today's system cost, national subsidy offered by either program alone is not enough to ensure a reasonable return on investment. Therefore, PV developers will need to rely on additional subsidy from regional and local governments. It was reported in the press that Chinese government will set an installation target of 1 GW in the next two to three years and would probably not encourage the development of PV projects that require long distance electricity transmission in the near future.

Unlike Germany, China currently still lacks experience in the design, installation, maintenance and operation of grid-connected PV systems. In addition the country is in urgent need of developing technical guidelines and standardization for system integration. Grid operators and many government officials may not be familiar with PV technology. An efficient planning and permitting process need to be established by the government. The Golden Sun program demonstrates China government's commitment in expediting the development of PV, but also indicate that government wants to take cautious steps and to gain experience from these demonstrative projects.

Secondly, China still has over one million households that live without basic electricity services. Bringing electricity to these people through small hydro, wind, biomass and PV is still one of China government's priorities. This priority is clearly demonstrated in the Golden Sun program whereby 70% upfront subsidy for off-grid PV systems in rural areas is provided.

In recent years, China has made great effort in increasing the country's wind capacity but the wind industry is facing tough challenges. Most wind system operators are struggling to make a profit and about a quarter of installed capacity are not connected to grid. This is mostly due to technical difficulties with grid connection, lack of experience in grid operation and lack of standardization.

Finally, China government has realized the importance of developing a modern grid system for the long term success of renewable energy. Over-capacity installation without a balance development of the gird infrastructure is not a sustainable practice. The national grid authority is planning to invest up to RMB 4.000 billion in a Smart Grid system by year 2020 (The Golden Sun of China: PV Group)

2.5.4 Forecast for Development Trend of China's PV & BIPV

The Chinese government has set a target to install 20GW of solar energy capacity by 2020.

China has advanced in research and development of BIPV system due to the changing field of PV power generation. On 1 April 2008., Article 40 of the 'Energy

Conservation Law of the People's Republic of China' was promulgated. It encourages the adoption of energy-saving materials and devices and to use renewable energy resource system in the energy conservation reform of newly-built and existing constructions. Article 61 states that enterprises that use energy-saving technologies and products listed in the law are eligible for tax incentives.

It was reported in the press that the Chinese government is tendering for bids to develop 13 solar projects with a combined capacity of 280MW in the western region of China. The move follows last year's bidding for a 10 MW solar power plant in Dunhuan, Gansu Province.

Currently, BIPV captures considerably small market in China and is mainly used in some demonstrative projects which enjoy government subsidies. This is clearly regulated by the Ministry of Construction of China that 50% of design standards should be applied in newly-built constructions. It is predicted that the area of energy-saving constructions will exceed 2.16 billion m^2 from 2006 to 2010, with newly-built area of 1.6 billion m^2 and rebuilt area of 560 million m^2. Hence the BIPV market will have a bright prospect in future.

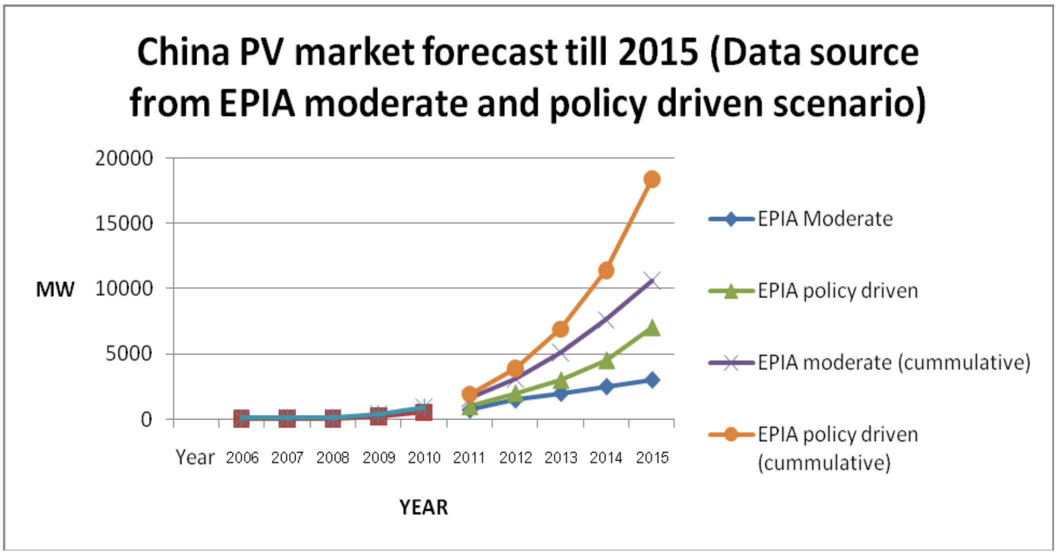


Figure 6: China PV market forecast till 2015 (Data sourced from EPIA, May 2011)

Table 8: China PV market forecast till 2015 (Data source from EPIA moderated and policy driven scenario)

	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EPIA Moderate	MW						750	1,500	2,000	2,500	3,000
	MW	12	20	45	228	520					
EPIA policy driven	MW						1,000	2,000	3,000	4,500	7,000
EPIA moderate (cummulative)	MW						1,600	3,100	5,100	7,600	10,600
	MW	80	100	145	373	893					
EPIA policy driven (cummulative)	MW						1,900	3,900	6,900	11,400	18,400
National target (2015)	MW										5,000

(Source: EPIA, May 2011)

China's Golden Sun program boosted the domestic PV market in 2010 with an installed capacity of 520 MW. This contributed to a cumulative capacity of 893MW. Unfortunately, the anticipated national FiT for PV was not implemented as PV generation cost is still considered too high. To date, two rounds of bidding have taken place at national level, with the first round of 576 MW of projects being awarded. In the second round in November 2010, 272 MW projects were approved due to the government control as well as to ensure fewer project defaults.

China is on its way of being a gigawatt market in 2011. The various national and provincial programs, including China's annual National People's Congress (NPC) focus on the importance of renewable in its 12th Five Year Plan (2011-2015). EPIA reported that total PV installations in China to grow by between 750 MW and 1 GW in 2011. A 5 GW was also set by the NPC as an official minimum PV target by 2015, with a longer term target of 20 to 30 GW by 2020, provided right market conditions and regulatory frameworks are in place.

China's search for the right policy was mooted by the China PV Policy Roadmap that lays out a recommended PV installation roadmap and detailed government subsidy spending up to year 2020. It also recommends that China government should learn from international best practices and establish a PV incentive mechanism that best fits China's unique situation.

The Roadmap recommends that China government implements direct investment subsidy (i.e. upfront subsidy) to open up China's domestic market for PV. Both the BIPV subsidy and the Golden Sun subsidy as mentioned above fall into direct investment subsidy model. However, it is disappointing to see that neither program offers enough subsidy to ensure a profitable operation given today's system cost. Additional assistance from regional and local governments still need to be sought by PV developers.

The Feed-in Tariff has been very successful in driving PV installations in many countries, but it may not be the best fit for China's current situations. The installation of grid-connected PV systems is still in the very early stage in China. China lacks solid foundation to establish an effective national FIT system and the vast differences between China's regional electricity tariff and cost of PV electricity adds to its many challenges the country is facing.

2.6 USA

2.6.1 Present Status of US's BIPV Industry

In 2009, the US solar market grew 36% as compared to 62% growth in 2008. US is ranked third largest solar PV market, with Germany taking the lead and Italy second. California continues to take the led as the base load state market for the US with 53% of on-grid installations of PV and is anticipated to maintain a strong position in 2010 as well.

As changes in the roles of utility companies in the US, new market entrants, and lower cost of PV modules from Asia became more predominant, solar companies doing business in the US will need to be able to adapt to these challenges promptly as well as being responsive to frequent adjustmens in the fragmented incentive and regulatory environment.

2.6.2 Main Application of PV in the US

The US market is noteworthy for its widespread use of tracking sytems. The market is regulated by bidding procedures which award very competitive projects. The large majority of PV applications in the USA are PV systems below 1 MW.

In terms of PV systems installed, the systems division of Sun Power was the leading company in the year 2009. In California, Chevron Energy and SPG Solar was second position. Amongst residential installers in California, REC Solar, Solar City and Real Goods Solar are the leaders in the field.

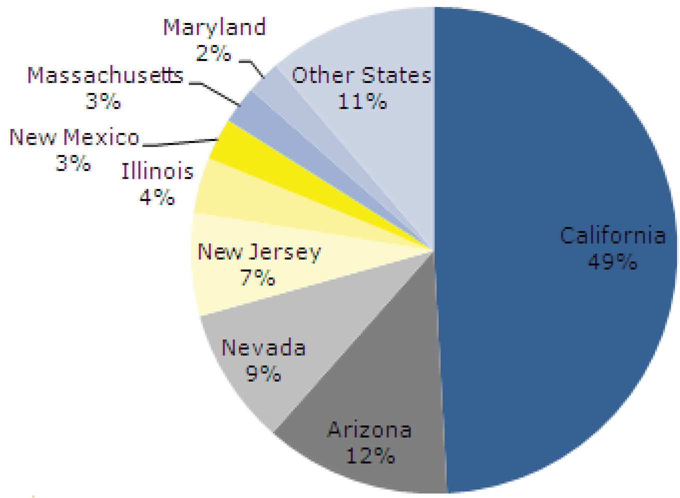


Figure 7 : US PV Order Book (2010-2014) Source: Solarbuzz Reports (July 28, 2010)

The above figure 7 shows that California has the greatest PV market share in the USA.

2.6.3 Related Policies for US's PV & BIPV Industry

The US government introduced in 2008-2009, the extended Production Tax Credit (PTC) and Investment Tax Credit (ITC) as part of the stimulus plan for PV development. The PTC offers a 30% tax rebate for manufacturing facilities producing renewable energy products. The ITC provides tax credit to commercial and residential solar PV installers. The act has created a staggered credit system, where the size of the credit that can be claimed increases based on the electricity generated by the solar panels and its contribution to the average monthly electricity usage by the individual.

Against the backdrop of supportive policies from the federal and state governments, the cumulative solar PV installed capacity is expected to grow from 1,650 MW in 2009 to reach 9,499.2 MW by 2015, growing at a CAGR of 34%.

The US market is driven by the federal 30 percent investment tax credit, which expires at the end of 2016 and it does not have a FIT system, nor any federally mandated goal for solar. The tax credit includes a 30 % treasury cash grant which was extended through 2011. There are also state renewable portfolio standards as well as state and municipal rebate programs. Through this, the development of the U.S. solar market has moved towards large utility-scale projects and the U.S. is projected to be the top solar market by 2015.

There are still utility barriers to be resolved, including regulatory restrictions on the use of Power Purchase Agreements (PPAs). A Renewable Portfolio Standard was enacted to promote PV in Washington D.C. and sixteen other states in the US. A fragmented regulations and incentive environment were created due to the large number of state policy initiatives. Respective states are working on stimulating local markets, resulting in dispersed funding sources. This means that the US market does not bear the same level of risk compared to countries whereby single national policy is in place. Nevertheless, Federal incentives are having a much larger role in stimulating demand in the next two years.

USA's PV market was also supported through the Solar America Initiative (SAI) which was created in January 2006. It was aimed at making solar cost competitive by 2015. The government of USA has also implemented investment tax credit (ITC), including long term extension investment tax credit, net metering law and interconnection standards to boost the PV market.

2.6.4 Forecast for Development Trend of US's PV & BIPV

Within the next five years, the PV market will grow to between 4.5 -5.5 GW which is about ten times the size of the 2009 market with an annual growth rate of 30% per annum. The main drivers of this surge in demand will be a much more aggresive positioning in the utility segment in meeting the need to achieve the Renewable Portfolio Standard obligations, the development of new state markets together with the return of the corporate segment and steady growth in residential demand supported by cuts in price of modules. The US projects amounting to 12 GW are in the pipeline.

Very high solar irradiation and the high electricity prices in some states such as California, PV is bound to be competitive relatively fast.

In addition, the recent introduction of SunShot program by DOE in February 2011 is aimed at reducing the cost of solar power by 75% in 10 years. The target of US$ 1/ power installed watt will make solar power cost competitive with fossil fuels, and will eliminate the need for expensive subsidies of solar power. The focus is on advances in materials and manufacturing efficiency. The US$ 27 million program is to fund research in new manufacturing techniques for the solar cells and the related electronics needed for solar panel installations, such as inverters.

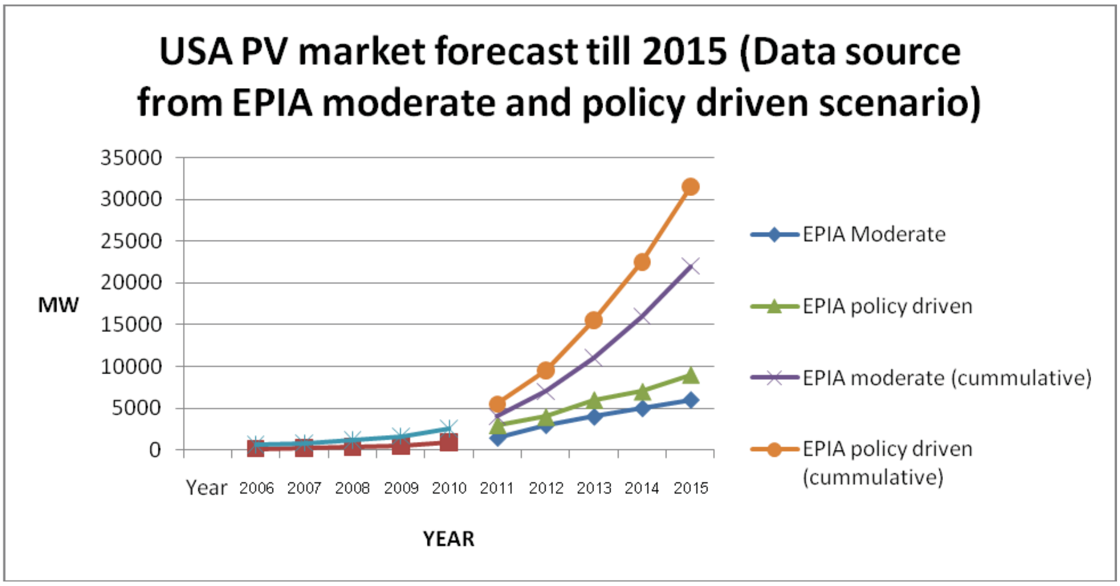


Figure 8: USA PV market forecast till 2015 (Data sourced from EPIA, May 2011)

Table 9: USA PV market forecast till 2015(Data source from EPIA moderate and policy driven scenario)

USA	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EPIA Moderate	MW						1500	3000	4000	5000	6000
MW	MW	145	207	342	477	878					
EPIA policy driven	MW						3000	4000	6000	7000	9000
EPIA moderate (cummulative)	MW						4000	7000	11000	16000	22000
	MW	624	831	1173	1650	2528					
EPIA policy driven (cummulative)	MW						5500	9500	15500	22500	31500
National target (2015)	MW										9499

(Source: EPIA, May 2011)

The US PV market is led by California with a 60% of the total installations. EPIA report 2010 forecasted a major growth in the coming years. PV is expected to becoming competitive rapidly due to the very high solar irradiation and high electricity prices in California. About 15 GW of projects are already in the pipeline for decision to implement.

Sustained growth in US PV installations is driven by a confluence of factors, including state-level policies, the Grant In Lieu of the Investment Tax Credit (Sec.1603), and the 100% first-year bonus depreciation for eligible property under the Modified Accelerated Cost-Recovery System (MACRS). Eligibility for both the Sec 1603 Grant and the 100% bonus depreciation expired at the end of 2010, but were extended with over 600 MW(AC) of new utility-scale projects expected to be implemented in 2011. This sector is expected to grow and residential market share is expected to decline to significantly less than 25% (Source: IAE-PVPS Annual report 2010).

2.7 Malaysia

2.7.1 Present Status of Malaysia's PV & BIPV Industry

A total of 11 MW of installed PV capacity was recorded at the end of 2009, of which 90% constituted off-grid PV systems. 287kW of grid-connected and about 2 MW off-grid PV systems were installed during 2009. The largest grid-connected PV system commissioned in Malaysia in 2009 has a capacity of 71.5 kW and it is at the new Energy Commission head office in Putrajaya.

As at the end of 2010, the cummulative installed grid connected PV capacity was 1.566 kW. (this figure includes 468 kWp baseline (i.e., PV systems installed not within the MBIPV project and some have been dismantled). These baseline installations are mainly funded by the Malaysian Electricity Supply Industry Trust Account (MESITA) and Tenaga Nasional Berhad (local energy utility company) or by the grant from Intensified Research in Priority Areas (IRPA). Some of these pilot grid connected systems have PV integrated into the builiding structure. Listed below are the pilot grid connected systems (Sopian K, Harris A.H, Rouss D and Yusof M.A):

i) 3.5 kW rooftop of College of Engineering Tenaga Nasional (UNITEN),

ii) 6.5 kW ground based at the Solar Energy Research Park, University Kebangsaan Malaysia (UKM)

iii) 15 kW PV installation system at the International Islamic University (UIA),

iv) 5KW Solar Hydrogen Eco-House, University Kebangsaan Malaysia (UKM)

v) 8kW BP petrol station along the KESAS highway (this PV system has been dismantled)

vi) 3.19 kW BIPV project in SIRIM funded by the Ministry of Science, Technology and the Environment of Malaysia through the Industrial Grant Scheme

vii) The Prototype Solar House has 3 PV systems integrated into 3 different roofs (Monocrystalline module1.05 kW, 1.02 amorphous silicon PV module/thin film and 1.12 kW polycrystalline module

viii) 362kW system at Bukit Jalil operated by the Technology Park Malaysia (TPM). It comprises of 4826 fixed mounted roof modules. This system is coupled with a UPS battery bank and a generator backup.

The PV installation at TPM is claimed to be the biggest in Asia Pacific region. It also demonstrated Malaysian capability in handling and managing large PV installations. Other BIPV installations are found at SIRIM Berhad, TNB's nursery, universities and a private school.

At present, the driving force for the grid-connected PV market is implementation of the financial incentive programmes under the national MBIPV Project (i.e. the SURIA 1000 Programme, Demonstration and Showcase incentive Programmes). The SURIA 1000 Programme involved a bidding process, spread over six calls which completed at the end of 2009.

The extension of fiscal benefits included pioneer status and investment tax allowance for generation of energy by solar PV until 31st December 2015, and import duty and sales tax exemption for equipment used in the generation of solar PV electricity is extended to 31st December 2012 (IEA-PVPS annual report 2010). At the end of 2010, these incentives have collectively generated 2.530 kW of planned grid-connected PV systems. Although the off-grid PV market is the current main market, it is expected that the grid connected PV market will dominate the market upon the introduction of the FiT incentives.

2.7.2 Main Applications of PV in Malaysia

The application of PV in Malaysia were seen in the early 1980s in rural electrification projects, communication providers and oil and gas suppliers using solar energy. The 9th Malaysia Plan (2006-2010), promoted solar hybrid systems for remote schools, rural areas and islands. The off grid capacity of Malaysia at the end of 2009 was 10 MW peak.

2.7.3 Related Policies for Malaysia's PV & BIPV Industry

The Malaysia Renewable Energy Act 2011 (Act 725) enacted on 2 June 2011 is a landmark of Malaysian Government's endeavour to establish a sustainable strategy for energy development. It supports a reduction in consumption of fossil fuels and seeks to stimulate renewable alternatives.

The 10th Malaysia Plan (2011-2015) includes a comprehensive National Renewable Energy Policy and Action Plan that focused on increasing energy efficiency initiatives. Under the FIT scheme, a tariff rate of Ringgit Malaysia (RM) 1.25 to 1.75 (€0.31 to €0.44) per kilowatt-hour over a duration of 21 years. Of which RM 1.75 for Building Integrated Photovoltaics (BIPV) systems for residential buildings, RM1.50 (€0.38) for PV rooftop installations and RM1.25 for solar power plant installations. The Pusat Tenaga Malaysia (Malaysia Green Technology Corporation), calculated that the simple payback period as 11.2, 10.1 and 8.6 years respectively for the various installations. It is to be noted that this scheme only covers Peninsula Malaysia and not East Malaysia "The Malaysian Building Integrate Photovoltaics Project (MBIPV) provides a test bed for building integrated PV projects. The financial incentive programs administered by the project have already exceeded its target of 1,545 kilowatts-peak (kWp) with the awarded capacity at 2,054 kWp.

The following Table 10 shows the renewable tariffs in Malaysia:

Table 10: Renewable Tariffs in Malaysia

Renewable Tariffs in Malaysia						
14-Apr-11						
			4.191	1.370	1.369	
	Years	MYR/kWh	€/kWh	CAD/kWh	USD/kWh	Degression
Solar PV						
<4 kW	21	1.23	0.293	0.402	0.402	-8.0%
>4 kW<24 kW	21	1.20	0.286	0.392	0.392	-8.0%
>24 kW<72 kW	21	1.18	0.282	0.386	0.386	-8.0%
>72 kW<1,000 kW	21	1.14	0.272	0.373	0.372	-8.0%
>1 MW<10 MW	21	0.95	0.227	0.311	0.310	-8.0%
>10 MW<30 MW	21	0.85	0.203	0.278	0.278	-8.0%
Bonus for rooftop	21	0.26	0.062	0.085	0.085	-8.0%
Bonus for BIPV	21	0.25	0.060	0.082	0.082	-8.0%
Bonus for local modules	21	0.03	0.007	0.010	0.010	-8.0%
Bonus for local inverters	21	0.01	0.002	0.003	0.003	-8.0%
Biomass						
<10 MW	16	0.31	0.074	0.101	0.101	-0.5%
>10 MW<20 MW	16	0.29	0.069	0.095	0.095	-0.5%
>2 MW<30 MW	16	0.27	0.064	0.088	0.088	-0.5%
Bonus for gasification	16	0.02	0.005	0.007	0.007	-0.5%
Bonus for steam generation >14% effic.	16	0.01	0.002	0.003	0.003	-0.5%
Bonus for local manufacture	16	0.01	0.002	0.003	0.003	-0.5%
Bonus for municipal solid waste	16	0.10	0.024	0.033	0.033	-1.8%
Biogas						
<4 MW	16	0.32	0.076	0.105	0.105	-0.5%
>4 MW<10 MW	16	0.30	0.072	0.098	0.098	-0.5%
>10 MW<30 MW	16	0.28	0.067	0.092	0.091	-0.5%
Bonus for gas engine >40% effic.	16	0.02	0.005	0.007	0.007	-0.5%
Bonus for local manufacture	16	0.01	0.002	0.003	0.003	-0.5%
Bonus for landfill or seweage gas	16	0.08	0.019	0.026	0.026	-1.8%
Minihydro						
<10 MW	21	0.24	0.057	0.078	0.078	0.0%
>10 MW<30 MW	21	0.23	0.055	0.075	0.075	0.0%
Renewable Energy Bill passed 5th April 2011.						
http://www.parlimen.gov.my/files/billindex/pdf/2010/DR472010E.pdf						
For details see:						
http://www.mbipv.net.my/content.asp?higherID=0&zoneid=6&categoryid=34						
http://www.mbipv.net.my/dload/presentation-FiT%20Updates-27Jan2011.pdf						
FIT is expected to cost 1% of average electricity bill.						
Average solar PV yield in Malaysia: 1,000-1,500 kWh/kWDC/yr.						
Not applicable in Sarawak or Sabah. Different tariffs will apply in Sabah.						
Renewable target: 5.5% by 2015.						

(Source:Gipe Paul, April 28,2011)

The above FiT of Malaysia seems to fit some of the five key characteristics of FiT best practices as indentified by SEMI PV Group which is listed as follows:

(i)Technology Differentiation:

Feed-in tariffs need to be tailored to target different technologies with specific rates. Policies that offers a single payment rate to all technologies have not been successful in creating generation portfolio that include solar electricity. Technologies with proven performance and/or potential to be further developed need to be favoured. Such technology differentations are addressed in the above mentioned FiT for Malaysia.

(ii) Generation Cost Based Rates:

A clear best practice for feed-in tariff designs that are intended to support solar market growth is that the FiT rate should reflect the generation cost of PV electricity, plus a reasonable profit, rather than be structured relative to conventional energy or prevailing retail electricity rates. This ensures that the incentive level will be sufficient to drive demand. In the case of the Malaysian FiT, the FiT is expected to cost 1 % of average electricity bill.

Accurately set, cost-based rates reduce price risk for developers, increae revenue certainity, reduce financing costs, and attract a broader base of investors.

(iii) Purchase and Interconnection Requirements:

Feed-in tariffs are powerful policies not only because they guarantee a known price and mitigate revenue risk, but also because they require that solar electricity plants must be connected to the grid, and that any electricity fed onto the grid must be purchased. These mandatory purchase requirements significantly increase investor security by reducing market and operating risks. A well-defined payment mechanism also needs to be defined. This characteristic also fits into Malaysia's FiT.

(iv) Fixed Price & Long-Term Payments

Fixed tariffs, especially when paired with long-term, generation cost-based payments significantly lower investment risk and policy cost. Hence fixed tariffs over the period of the power purchase agreement (PPA) coupled with a long duration of validity of the PPA are essential.

(v) Predictable Declines and sun-setting

Although feed-in tariffs can both be adjusted upward and downward, the overall trend should be downward in order to place pressure on PV prices. Further tariff adjustment schedules that occur after a certain (announced) period of time are preferable because they are more transparent and predictable than capacity-based declines or through frequent review by policy makers. In this context, degression rates are provided in the Malaysian FiT.

Malaysia's PV market is supported via FiT, incentives for end users or companies generating energy from renewable energy, including incentives for third party distributor.

2.7.4 Forecast for Development Trend of Malaysia's PV & BIPV

The recently approved feed-in tariffs will spear head Malaysia to becoming one of the few ASEAN countries which is actively implementing changes towards clean energy. Initiatives such as power purchase agreements (PPA) and financial incentives for renewable energy projects are already in place in the country.

It is envisaged that about 65MW of grid-connected PV systems would be commissioned by the end of the 10th Malaysia Plan in 2015.

The PV industry in Malaysia seems promising as foreign investments pours in, in the next five years. The FITs will be the main driver for the grid-connected systems for the PV market in the country. Currently, the off-grid PV systems dominate the grid-connected systems with 10 MW versus 1 MW as at end off 2009. Off-grid PV systems are mainly government funded.
As of 2009, Malaysia is the world's fifth largest PV producer, mainly due to First Solar in Kulim and Q-Cells in Sepang. Malaysia is expected to be the third largest, after China and Germany due to the increase in the production capacity for First Solar to 1.4 GW and the operation of Sunpower Fab 3 in Malacca (Source: MBIPV website).

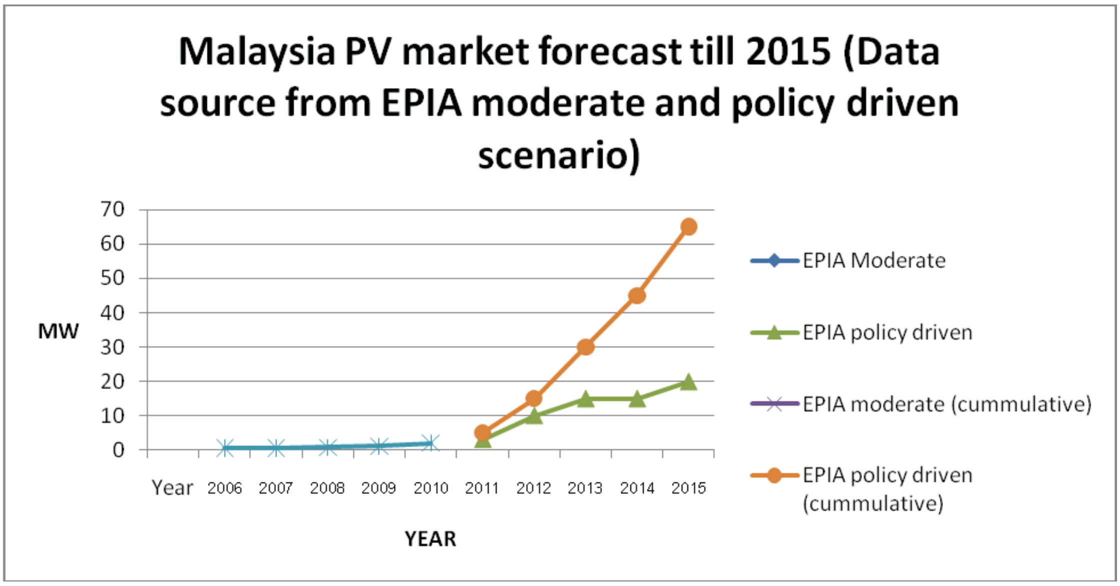


Figure 9: Malaysia PV market forecast till 2015 (Data sourced from EPIA 2010)

Table 11: Malaysia PV market forecast till 2015 (Data sourced from EPIA moderate and policy driven scenario)

	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EPIA Moderate	MW										
	MW										
EPIA policy driven	MW						3	10	15	15	20
EPIA moderate (cummulative)	MW										
	MW	0.486	0.641	0.779	1.063	2					
EPIA policy driven (cummulative)	MW						5	15	30	45	65
National target (2015)	MW										65

(Source: Report IEA-PVPS T1-19: 2010)

The Government of Malaysia is committed to develop the solar PV market as well as the solar industry for achieving both energy security and economic growth. Malaysia aims to install at least 1,250 MW of grid-connected PV systems by the end of 2020. By the year 2013, the total annual PV production capacity is estimated to reach 4.200 MW (wafer, solar cell, module and 6.000 tonnes of polycrystalline silicon). The country is also targetting to reduce its carbon intensity by up to 40% by 2020. (Source: IEA-PVPS annual report 2010).

2.8 Overview of BIPV Global Market

There are a lot of opportunities for manufacturers involved in building integration, especially in the area of product differentiation. A market study was carried out by EuPD Research, whereby they surveyed 39 manufacturers of photovoltaic modules and components, 22 project planner, engineers and architects, and 23 project developers and installers from Europe and the U.S. France was found out to be the country with the most potential for BIPV. Followed by Germany, Italy, the U.S. and Spain. The markets which experts considered to be the most important future BIPV markets run parallel to those country markets which are considered to be the most important general PV markets. In these top five markets, the BIPV capacity was estimated to grow from around 200 MW in 2009 to 1.300MW in 2014. China, Japan, Switzerland, the United Arab Emirates, the Netherlands and Scandinavia follow next on the top five list.

Global BIPV installations is expected to maintain their growth traction during 2010 to 2015. Extension of the downward trend in the system prices and strong government support to the sector are key driver for the growth of BIPV. Global instalations are projected to reach to 2.525 MW in 2015 from 182 MW in 2009. This market growth of BIPV is through political supports for BIPV with FiT systems by national governments and advanced technology on thin film solar cell.

GTM research forecasted an installed solar PV capacity of 20 GW by 2013 which is equivalent to about US$ 60 billion in revenue and the cost of solar PV panels is projected to fall to US$ 1.20/W. Based on the assumption that the BIPV constitute 1% to 2% of the PV market, the forecasted BIPV installation market and growth forecast is represented in the figure 10 below:

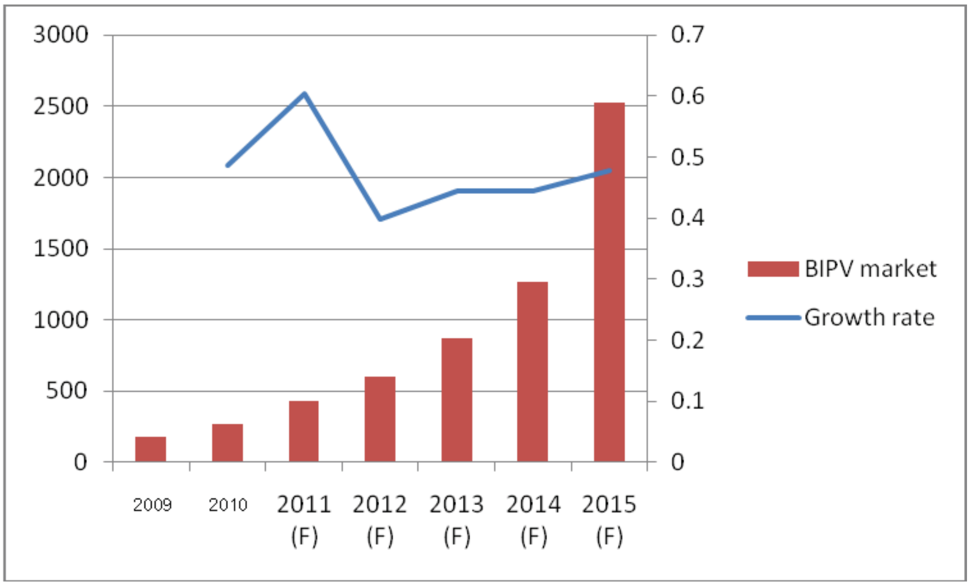


Figure 10: Worldwide BIPV installation market and its growth rate (2009-2015) (Source: adapted from Solar and Energy, BIPV Technology and Market Forecast (2009-2015), March 2011)

France is considered a showcase market for BIPV in 2010, encouraged by a significantly more attractive FiT for integrated systems compared to conventional rooftop and field systems. Germany, as a BIPV market, currently has no preferred FiT for roof or façade integrated systems acting as an incentive. About one or two percent of the installations in Germany are integrated into buildings.

The BIPV-dominated markets in France and Italy show that the FiT is crucial for BIPV market developments. The more attractive the tariff for integrated systems, the greater is the share of BIPV on the market. However, it is currently apparent in France that there is always room to tweak a FiT, even one that clearly favors building integration.

The French government introduced a scale for the FiT based on the degree of integration and the location of the system. The most lucrative is a fully integrated system when integrated in residential, educational or health care institutions. In these cases, the operators receive 58 euro cents per kilowatt-hour (kWh). For other buildings (office buildings and industrial, commercial, and agricultural buildings, and so forth) the new tariff is 50 euro cents per kWh. Systems with “simplified building integration” receive 42 cents/kWh. Ground-mounted systems will continue to benefit from the tariff of 31.4 cents/kWh. For ground-mounted systems with a capacity greater than 250 kilowatts, the tariff will now vary from 31.4 euro cents per kWh for metropolitan areas in the sunniest areas to 37 euro cents per kWh for the less sunny areas.

The FiT is not the only driving force behind BIPV systems as the Directive by the European Union (EU) will also have its effect on the BIPV market. According to the Directives, all new buildings in all EU member states will have to be 'nearly-zero-energy buildings' by 2020. BIPV is therefore important for meeting the future standard of low-energy buildings and this spells good future prospects for BIPV systems, in terms of increased installations. In addition with the decrease in cost of modules and a higher standard of knowledge on the part of architects, systems designers and others involved in building these BIPV systems contributed towards an increase in demand for BIPV as well.

Inspired by the French model, a number of countries have penned initiatives aimed at promoting the BIPV market. China is one such country. BIPV manufacturers such as Astroenergy Solar, Canadian Solar, Guangdong Golden Glass Technologies, QS Solar, Suntech Power and Trony Solar founded the BIPV China Committee, a PV-related organization promoting the integration of PV technology into building constructions. Reason for the establishment of such an organization is that China is seen as one of the largest building construction sites in the world and therefore the largest BIPV market in the world. Statistics show that more than half of all the world's building construction is in this Asian country of 1.3 billion inhabitants. Based on the data from the Ministry of Housing and Urban-Rural Development of the People's Republic of China, this represents some two billion square meters annually.The BIPV China Committee are working with local cities on technical standards for BIPV on new building as well as working closely with architecture/construction companies on BIPV solutions in new buildings.

The following figure 11 shows the main applications of the PV industry, of which 77% are grid-connected distribution.

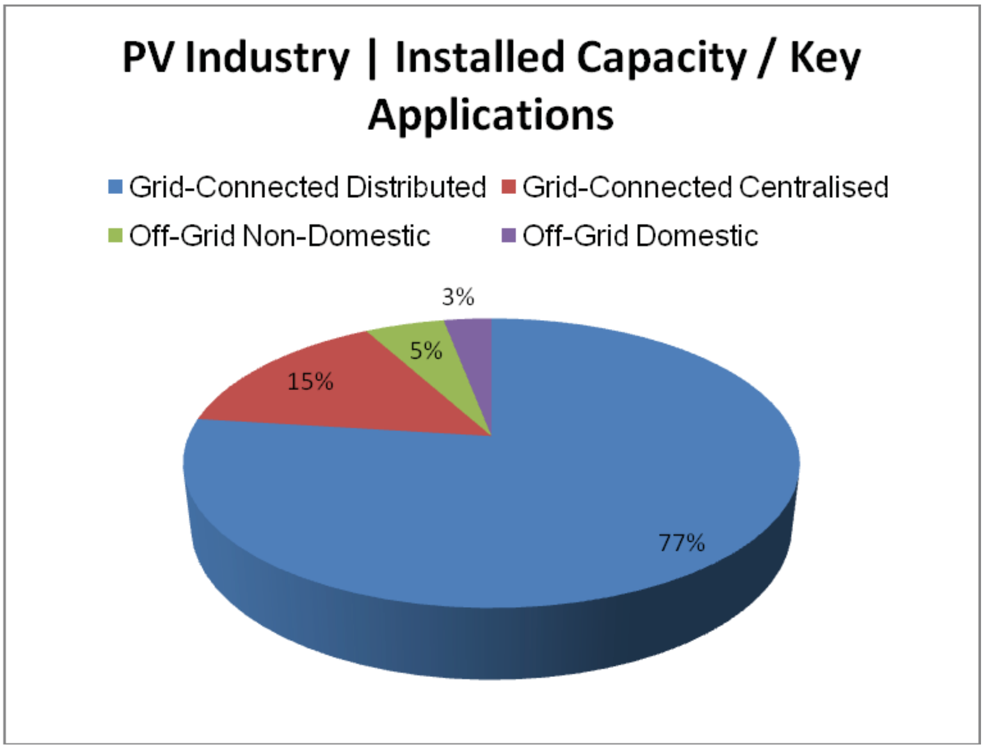


Figure 11: Key applications of the PV industry (Source: Frost & Sullivan, BIPV-keynote-ICBEST)

2.9 PV Future Outlook

In 2010, the European solar PV market was dominated by the FiT reductions in Germany, as well as the declining trend of module prices that began in 2009. The European governments are tightening their policies to reduce the economic burden of their incentive plans as a result of the saturated European solar PV market. This created additional pressure on solar PV firms, on top of the continued reduction of module prices.

Hence the global solar PV market competition will be driven by production-based module price reductions. The emerging solar PV market is expected to come from the Asian market as they have lower production and financing costs. In view of the foregoing and to reduce the risks, the European and North American solar PV manufacturers need to strategize to expand their global portfolio to balance their manufacturing costs, including catering to the high demand of solar PV markets globablly.

The governments in Asia are setting up programs to explore the potential of solar as a resource for their countries. The solar PV market in China is expected to experience high growth rates, owing to the BIPV and the Golden Sun initiatives. In addition, the low cost of manufacturing solar PV components in China will support the growth of this industry. It is also expected that solar PV FiT will be implemented alongside existing subsidies to support solar PV power projects. These tariffs will be the driving force to drive investments in this sector, therefore encouraging solar PV capacity installations to reach the proposed solar PV targets (as per its national policy) by 2020. India, Australia and Malaysia is an emerging solar PV markets in Asia Pacific. The Malaysian has implemented the SURIA 1000 program and the FiT regulations in April 2011. Against this backdrop, the Asia Pacific solar PV market are expected to make significant contributions to the globabl solar PV market owing to the improving policy scenario in the major countries.

In 2010, the USA emerged as the fourth largest solar PV market in the world after Germany, Spain and Japan, and it is one of the fastest growing global market. The country's cumulative solar PV power installed capacity increased from 624 MW in 2006 to 1.650 MW in 2009. The growth of PV installations in the US market has been largely facilitated by support mechanisms provided by the federal and state governments, as well as by technological developments by solar PV manufacturers. California leads the market with the highest level of PV installations in the country. The state has grown its market rapidly due to its ambitious subsidy policies for the development of solar PV. Due to proactive policies supporting solar PV development from the state government in California, it will remain a leading state in the US solar PV market in the next couple of years.

The US government introduced in 2008-2009, the extended Production Tax Credit (PTC) and Investment Tax Credit (ITC) as part of the stimulus plan for PV development. The PTC offers a 30% tax rebate for manufacturing facilities producing renewable energy products. The ITC provides tax credit to commercial and residential solar PV installers. The act has created a staggered credit system, where the size of the credit that can be claimed increases based on the electricity generated by the solar panels and its contribution to the average monthly electricity usage by the individual.

Against the backdrop of supportive policies from the federal and state governments in the US, the cumulative solar PV installed capacity is expected to grow from 1,650 MW in 2009 to reach 9,499.2 MW by 2015, growing at a CAGR of 34%.

Thus, in the policy-driven global solar PV market, there are various market trends in different regions. The upcoming major solar PV players cannot be predicted due to increasing competitiveness among market players in terms of cost efficiencies, technological advancements and market demand. In order to survive in the developing solar PV market, companies should strategize to diversify their operational and sales portfolio, while increasing their margins and market share.

3 Economic and Technological Developments of BIPV system in Malaysia

3.1 Demonstration projects in Malaysia (SURIA 1000)

The Malaysia Building Integrated Photovoltaic (MBIPV) project, SURIA 1000 is a national development programme implemented by the Ministry of Energy, Green Technology and Water Malaysia under the 9th Malaysia Plan (2005-2010). The project has a total fund of US$24.5 million. It was funded by the Government of Malaysia, Global Environment Facility and the private sector. SURIA 1000 works on bidding process which spreads over 6 calls with the final call ending at the end of December 2009.

The achievements of the first 6 calls are are follows (Source: Malaysia National PV status report 2009)

i) A total of 1.260 kW in PV capacity was achieved against a target of 790 kW.

ii) The price of PV module drop 58% from a 1998 baseline of US$ 8,79 per W to US$3,71 per W for grid connected PV system there was a drop of 71% from the 1998 baseline of US$21,21 per W to US$6,19 per W.

iii) By the final call, bidders are willing to pay 70% of total BIPV price which is an increased from 46,7% in the 1st call.

3.2 Major Players in BIPV

After more than 20 years of R&D and fancy showcase projects of leading solar technology and material developers such as Dyesol, Schott Solar, Scheuten Solar, Sunpower and Suntech, the BIPV sector is finally beginning to gain a market niche. New products such as curtain walls, windows and roofing shingles that incorporated

PV modules into actual building materials are now readily available from developers in the BIPV supply chains.

Earlier generations of PV for buildings had lesser aesthetic values as solar panels were mounted directly onto the roof of the building. This was replaced by BIPV systems, where the PV modules replace parts of the building envelope, providing functional systems and lower costs. Recent development of thin-film PV technologies is able to integrate PV onto buildings seamlessly and they are reckoned to have a significant competitive advantage over conventional solar technologies with their super flexibility, light weight and improved ability to perform in variable lighting conditions.

The success of creating new BIPV markets will depend on the following (GTM Research report, July 2010_ www.pvglaze.com/PV_GTM_BIPV.pdf)

- Concerted efforts by players in the BIPV supply chain to work together towards the design and integration of solar into the building envelope.
- Costs in €/W_p as well as the building industry's preferred metric of €/m^2 of product and power availability.
- Development of specific standards and building codes.
- Availability of federal and local incentives to ensure cost effectiveness.
- Added value of consumers and architects, and
- Ease of production and the scale at which a production plant becomes economically feasible.

The following table 12 shows the supplier, solar technology employed and applications for BIPV products.

Table 12: Solar Technology and Applications Matrix for BIPV Products

Supplier	Product	Solar Technology	Application	Benefits and Outlook
Applied Solar	Solar Blend^{TM} tile	Monocrystalline silicon	Commercial flat & low-slope roof	BIPV tile integrate seamlessly with concrete tiles.
Arch Aluminium	Active Solar Glass	OPV	Semi transparent	50% Visible light transmission.

& Glass			glass BIPV products	
Ascent solar	Flex Power Light™ Modules	CIGS	Facades and roofing	5 m long and delivers 123 W_p (11% module efficiency).
Bluescope Steel	-	OPV	Metal roofing	Commercialization from 2011
Corus	-	OSC	Metal roofing	Commercialization from 2011
Dow Solar	Power House™ Solar Shingle	CIGS	Roofing	15.54% efficiency. Commercialization from 2011.
Eagle Roofing	Eagle Solar Roof	Monocrystalline silicon	Commercial and residential roofing	Designed in collaboration with Suntech
Heliatek GmbH	-	OPV	Facades and roofing	10% efficiency
Lumeta Inc	Solar S and Solar flat tiles	Monocrystalline silicon	Commercial and residential slope roofing	Integrates with conventional clay and concrete flat tiles.
Power film	Power film laminate	Amorphous silicon	Metal and membrane roofing	5% efficiency
Schott Solar	InDAX 225 module	Polycrystalline silicon	Pitched roof-new or retrofit	60 cells per module which provides 210-230W_p and 25 years warranty
Sharp	ND-62-RU	Monocrystalline silicon	Roofing facade	1 module replaces 5 standard concrete tiles
Sky Shades	Tension fabric	OPV	Shade on steel roofs	7.9% efficiency
SRS Energy	Sole Power Tiles	Amorphous silicon	Roofing	Uses thermoplastic olefins
Solarmer	XPV™	OPV	Windows	45% transparency with 3%

Energy				efficiency
Sunpower	Sun tile	Monocrystalline silicon	Roofing	High efficiency, roof-integrated solar tiles blends seamlessly flat and s-tile roofs.
Suntech Power	Just Roof™ Light Thru™	Monocrystalline silicon	Residential roofing, facades and windows	Replaces conventional roofing materials and provides a weatherproof roof surface, installed base of more than 4.000 systems in last 15 years.
Wurth Solar	STARfix III systems, ARTLine Invisible system	CIS	Sloping roofs, curtains and facades	First company to offer colored CIS modules. Mainly in Europe.

Source: GTM Research 2010

3.2.1 PV manufacturers

The top 15 most successful firms in terms of panel production, manufacturing costs, efficiency are ranked as follows:

1. First Solar (U.S.)	9. Solar Frontier (Japan)
2. Trina Solar (China)	10. SunPower (U.S.)
3. Yingli Green Energy (China)	11. Sharp (Japan)
4. Suntech Power (China)	12. Canadian Solar (Canada)
5. REC (Norway)	13. EGing Photovoltaic Technology (China)
6. Astronergy (China)	14. Abound Solar (U.S.)
7. Solibro GmbH (Germany)	15. Solarfun (China)
8. LDK Solar (China)	

Source: GTM Research 2010

3.3 Photo-Voltaic Technology

Photo voltaic technology is a renewable technology which converts the suns energy into electrical energy. PV technology was originally developed at the bell labs in 1956 and is derived from the Greek prefix “Phos” meaning light and Volta after Alexander Volta a pioneer in the field of electricity. PV has been around for many years and has been used in applications such as providing power for remote telephones and remote research units for many years, these applications are often low in electrical demand. Other applications such as PV’s used to power the electrical demand for satellites have helped blaze a trail towards PV use into a more efficient, robust, rounded economically viable technology.

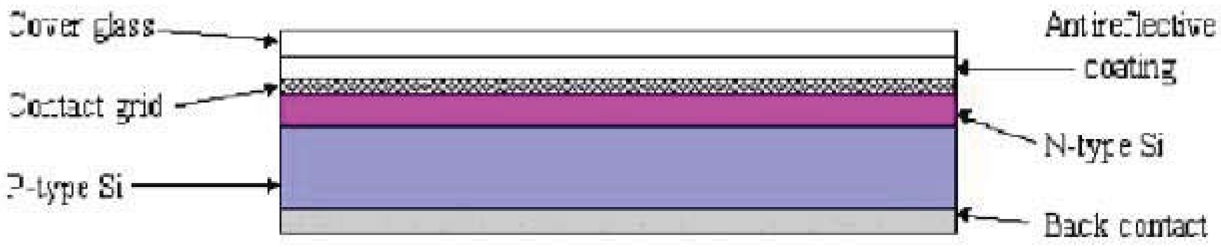
3.3.1 How does PV work

The principal behind PV technology is the ability of the photons contained within the suns rays to cause electrons to be moved to a higher energy level or orbit so that they are free and are capable of conduction. The energy required for an electron to jump to the next energy level is commonly known as the band gap energy denoted generally by Eg. Materials have their own Eg value and silicon which is the material used in most PV applications has a band gap energy of 1.12eV.

PV's are made from semi-conducting material which has been doped with a different atom or impurity. Within the PV there are two layers, there are know as the p-type and the n-type layer or the positive and negative layer. The materials used in the manufacture of silicon have four electrons in the outer electron shell. The impurity is added to the base material such as silicon which has either one electron more in the outer shell or one electron less. The commonly used term for this process is called doping. The result of doping is the creation of places within the crystalline structure of the base material which have an excess electrons (n-type) and places where there is a missing electron or a deficiency (p-type). The missing electron is known as a hole or in other words a positive charge carrier, while the extra electron acts as a negative charge carrier.

The most common material used in the manufacture of PV is the element silicon which is one of the most abundant elements on earth. Some of the other material used in the manufacture of PV are cadmium and gallium. The PV is composed of the p-type material on one side and the n-type material on the other side, this creates what is known as a p-n junction. Current flows in the PV cell when an electron is promoted through the absorption of a photon. The interaction of photons and the atoms in the PV are essential to the operation of the PV, with out sunlight then there is not excited electrons and thus no current.

The amount of energy the photon must contain in order to excite an electron must be greater than the band gap energy Eg which is specific to the material. The energy contained with a photon is a function of the frequency of light and planks constant h (6.626*x 10-34). This it can be said that the efficiency of the PV module is dependent on the intensity of light (W/m^2) intercepted by the cell. The stronger the light (the higher the intensity) the more chance of the absorption of a photon to create an electric current. The efficiency of the system is governed by the percentage of incoming photons which cause absorption. Most of the photons absorbed by the cell do not contain greater than the Eg value required and thus only increase the temperature of the cell.



BIPV technology differs somewhat from other application of PV where there are different criteria. One of the most important considerations of BIPV technology is its ability to be both a building façade as well as an electricity producing technology. This can be a used as a very strong economic motivating factor as the perceived cost of the system is reduced due to the elimination of the need for other cladding. Design of BIPV really requires an all encompassing approach towards building design, the various energy systems used within the building and their interaction together. In this way the maximum benefits of BIPV can be reaped.

The amount of electrical power which can be obtained from a BIPV system is directly related to the availability of solar radiation, this means the orientation, the tilt and angle and the area of PV façade are of critical importance. The system should be design so that the demand profile of the building is matched as close as is possible to the supply profile from the system. This will have direct effects on the necessity for Balance Of System components such as battery’s and inverters. The economic viability will be highly dependent of the cost of electricity from the utility company and the electric loads within the building.

As with the other integrated renewable technologies an understanding of the basic principles of BIPV is essential to produce a BIPV design which does justice to potential of BIPV at the particular site and building in question.

One of the key factors which positively influences the case for BIPV in commercial applications is the ability of the BIPV in some applications to closely match the supply and demand profiles both daily and throughout the year.

The three main types of materials used in for PV modules are

i) Monocrystalline or single crystalline silicon
ii) Polycrystalline or multi crystalline solution
iii) Thin film

Polycrystalline silicon is manufactured using either the ribbon growth method where silicon is grown as wafers or sheets which are around the same thickness as that necessary for PV cell manufacture. Alternatively a block of polycrystalline silicon is sliced to produce the size of wafer required. Unlike monocrystalline cells the atomic structure of polycrystalline is not regularly ordered. Polycrystalline consists of small grains of monocrystalline spread throughout the polycrystalline. This means that as the flow of current or electrons is reduced thus the efficiency of polycrystalline is lower than that of monocrystalline cells. Conversion efficiencies of around 9 to 12% of likely although real efficiencies are likely to be much less.

Thin film cells are made by depositing thin semi conducting layer onto a substrate material such as glass, metal or plastics. The light absorptivity of thin films is much higher than for crystalline materials, thus the deposited layer can be very thin. The thickness of the deposited layer is from a few micrometers to as little as one micrometer. Generally the thinner the deposited layer the cheaper the manufacturing costs. Spraying is often the technique used for depositing the thin layer of the semi conducting material. The manufacturing process for thin films as opposed to monocrystalline or polycrystalline cells is much faster and uses considerably less energy. Thin film cells have much lower efficiencies than crystalline materials. This is a result of the non crystalline structure of the semi conducting layer. Much has been talked of how thin film technologies can produce low cost environmentally friendly electricity.

Amorphous silicon (a-Si) is by far the most commonly used thin film material. A-Si has a disordered atomic structure. The main problem with a-Si apart from the low efficiencies (real efficiencies of around 4% are likely) is the tendency for a-Si cells to suffer from degradation on exposure to sun, wind, rain and atmospheric pollutants.

A-Si is likely to lose around 10 to 15% of their electricity producing capacity within the first few months. A-Si cells tend to oxidise and are thus much less durable than their crystalline counterparts.

Cadmium Telluride (CdTe) is a polycrystalline semi conducting compound made from Cadmium and Tellurium. The absorptivity of CdTe is high, thus CdTe can be as thin as 1 micrometer and can absorb around 90% if the solar spectrum. CdTe is also relatively cheap to manufacture. The deposition of CdTe is usually carried out by spraying, screen painting or high-rate evaporation. A conversion efficiency of CdTe is likely to be slightly higher than for a-Si. CdTe suffers from most of the same problems as a-Si such as reliability problems and degradation or exposure to the environment.

3.4 The PV Value Chain

The following describes the players in the value chain of the PV industry:

i) Production of silicon – process and refine silicon into semi conductor grades silicon as the feedstock.

ii) Producers of ingots and wafers – casts silicon into ingots and subsequently slice ingots into thin silicon wafers.

iii) Cell producers – applies coatings and electrical contacts to the wafers or thin films to convert them into light absorbing conductors.

iv) Module manufacturers – frames and laminates the assembled cells and installs the electrical contact points to produce the module.

v) Component manufacturers – manufactures other electrical and non-electrical components that make up the PV system. This include the mounting structures to hold the PV modules, inverters to convert DC to AC, power controllers, meters, connectors, electrical cabling and battery storage devices.

vi) Installers and system integrators – designs and installs a complete PV system for operation.

3.4.1 Characteristics of the Value Chain

Profit margins are highest in the upstream activities of the value chain and generally decline as activities move downstream. The following shows a typical profit margin across the value chain:

i) Manufacturing polysilicon – 50% to 60%
ii) Manufacturing wafer – 35% to 40%
iii) Manufacturing PV cells – 25% to 30%
iv) Manufacturing PV modules – 5% to 10%
v) Manufacturing inverters -- 25% to 30%
vi) Installing PV system – 20% to 25%

3.5 Building Integrated PV

As the market of BIPV for small sized residential and general building has been growing, at present 2010, the crystalline silicon PV module accounts for 76.5% and thin film solar cell accounts for 23.5% in BIPV market. However, since the application of BIPV is widely expanded to large scaled warehouse, factory, parking lot, railroad, airport, tall building, and highway soundproof from small-sized residential house and commercial building, the market share of thin film solar cell is gradually increasing and then it is expected to grow up to 51.6% in 2015 according to a study conducted by Solar and Energy. This is because thin film solar cell has many advantages compared to the current crystalline solar cells: See through property, adjustable optical transmittance, excellent building appearance, potential capability applying flexile products on a variety of places, and the less sensitivity to the degradation of light intensity depending on the angle of sunray and the increasing temperature of module.

In the past, it would be difficult to find proponents of solar panels for their aesthetics. As such, of the main criticisims leveled against solar panels (by architects, at least) is their unsightly appearance. In addition to their visually unappealing nature, a number of functional issues make them less than ideal. That is they are difficult to make waterproof, they are not designed to be self-cleaning, and most of them were not manufactured with the ideas of future recycling in mind. Therefore, future advances in the solar power industry is dealing with these issues and ensuring that modules can be smoothly integrated into design and construction in the form of BIPV.

The criteria for PV cells to be considered BIPV instead of conventional solar panels are that BIPV modules must meet the standards for and perfectly serve the function of the part of the building that they are meant to replace, so as to access the most generous FiT in most countries. Hence, if a module is designed to be a roof tile, then when it is removed, the roof should leak when it rains. The purpose of a rooftile, is to keep the rain out. It should also meet all the other requirements and standards that roof tiles are normally subject to: such as they must be durable and resistant to wind, they should prevent the accumulation of dirt, and they should be ‘walkable‘ so that ordinary roof maintenance can be carried out when required, If all these criteria are not met, then the module is not a good rooftop BIPV.

In view of these requirements for functional flexibility and the fact that in many cases BIPV is used for parts of a building which may not be ideally situated for full solar irradiation, this is where amorphous/thin film PV comes into play as it is more malleable and less subject to inefficiencies due to shading and heating.

The following figure 12 shows the market trend for thin film and c-Si which spells good prospect for thin film in the BIPV market.

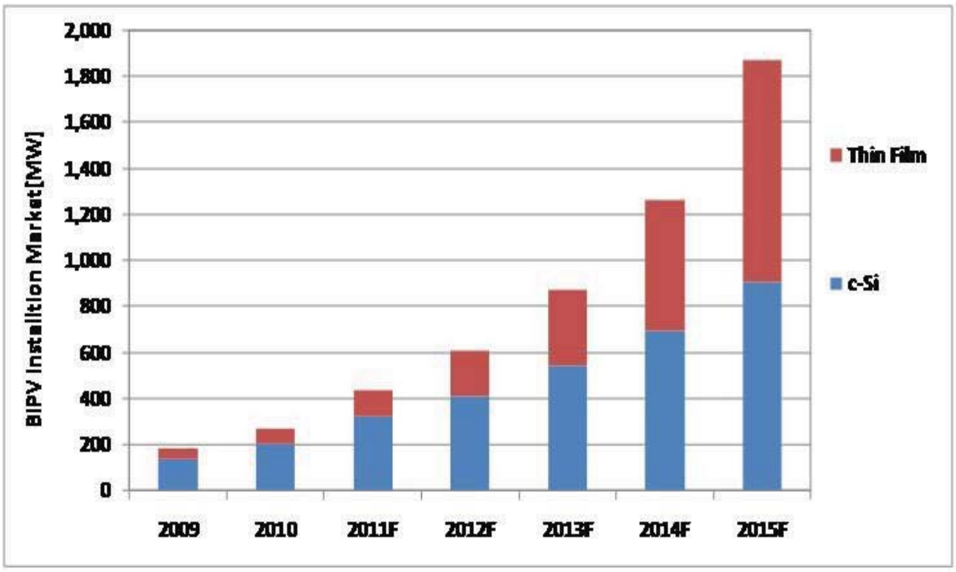


Figure 12: BIPV Installation market and market share forecast by technology (crystallline/thin-film) (2009~2015),(Source: Solar&Energy, BIPV Technology and Market Forecast (2009~2015)

BIPV are photovoltaic modules that are substituted for traditional functional and aesthetic building construction materials (such as roofing, window overhangs, skylights and/or exterior facades). For example, a conventional building facade could be replaced with a skin of BIPV tiles in order to harvest sunlight for electricity.

3.5.1 How do Building Integrated Photovoltaics work

The photovoltaic effect begins with sunlight, composed of photons, striking a photovoltaic (PV) cell. Some of the photons are absorbed by a semiconductor material and the light energy is converted to electrical energy in the form of a current.

PV materials are classified as either crystalline, polycrystalline or thin-film in form and represent the three types of technology on the market today.

Silicon - A Highly Abundant Element

Silicon is used in more than 90% of all PV applications, including BIPV. Silicon PV cells are defined as either single-crystal silicon, polycrystalline silicon or thin-film amorphous silicon.

The distinctions between the three types are their sunlight-to-electricity conversion efficiency, manufacturing methods and cost. Conversion efficiencies are routinely improving and vary from manufacturer to manufacturer with a general rule of thumb for conversion efficiency ranging from 12-15% for single crystal, to 11-14% for polycrystalline and 5.5-7.5% for amorphous silicon

Visually these three cell types are different too. Single-crystalline is dark blue, polycrystalline is a sparkling multi-colored blue and thin-film as a reddish brown to black color. Some manufacturers offer special order colors such as gold, green and magenta as well – but these color variations come with loss in performance efficiencies.

Single cells are interconnected, encapsulated, laminated and framed to form a module, which are strung together and fitted into panels, and panels are located together to create an array. BIPV systems can either be interfaced with the existing utility grid or designed as a stand-alone system. Depending on the application and energy use predicted, battery storage may also be desirable. Maintenance for these types of systems is similar to that of traditional PV (i.e. cleaning).

3.5.2 The History and Future of BIPV

BIPV has history as far back as 1980 (ancient history when it comes to technology) when they were demonstrated as an add-on for roofs. BIPV building materials designed to be integrated into the building envelope first arrived on the scene in the 1990's.

Currently, these multifunctional building materials are most effectively integrated into building preliminary design when issues like solar access, orientation and tile, electrical characteristics, sizing, etc can be addressed and optimized.

There are three major types of BIPV that may be considered for integration into buildings:

-Glazing (glass) and laminates
-Cladding for building envelopes
- Solar roof tiles

In the future, BIPV may be as simple as painting an existing surface with a "solar cell paint" that is being developed by a UK university.

Also, as BIPV is a relatively new concept, at preliminary design stages, compliance with local codes should be discussed with the authority having code jurisdiction since many codes and standards do not yet explicitly state requirements for BIPV specifically.

3.5.3 Cost of BIPV

The cost of BIPV depends on the type of system implemented (pitched or flat roof, façade or glazing) and the PV technology used in manufacturing it. Avoiding the cost of conventional materials does help absorb the incrementally larger cost of a BIPV system (compared to a standard PV system) which could range from $6.50/watt for single-crystal to $6.25/watt for polycrystalline or $5.50/watt for amorphous silicon.

According to the National Institute of Building Sciences' Whole Building Design Guide (WBDG) current manufacturers and suppliers for these types of systems include Atlantis USA Sunslates™, bp solar, Energy Photovoltaics, Inc., RWE SCHOTT Solar, SolarFrameWorks Co. and UNI-SOLAR.

Many more resources, including computer-based PV design and sizing tools, are listed on the Whole Building Design Guide website.

While in elevated PV systems the module costs are about 75 % of the total costs (value at the beginning of 2009), the module costs of BIPV systems are only 38 %, as gathered from Manfred Starlinger of Colt International. The above figure 13 shows the distribution of costs of a PV shading plant with a single axis tracking system.

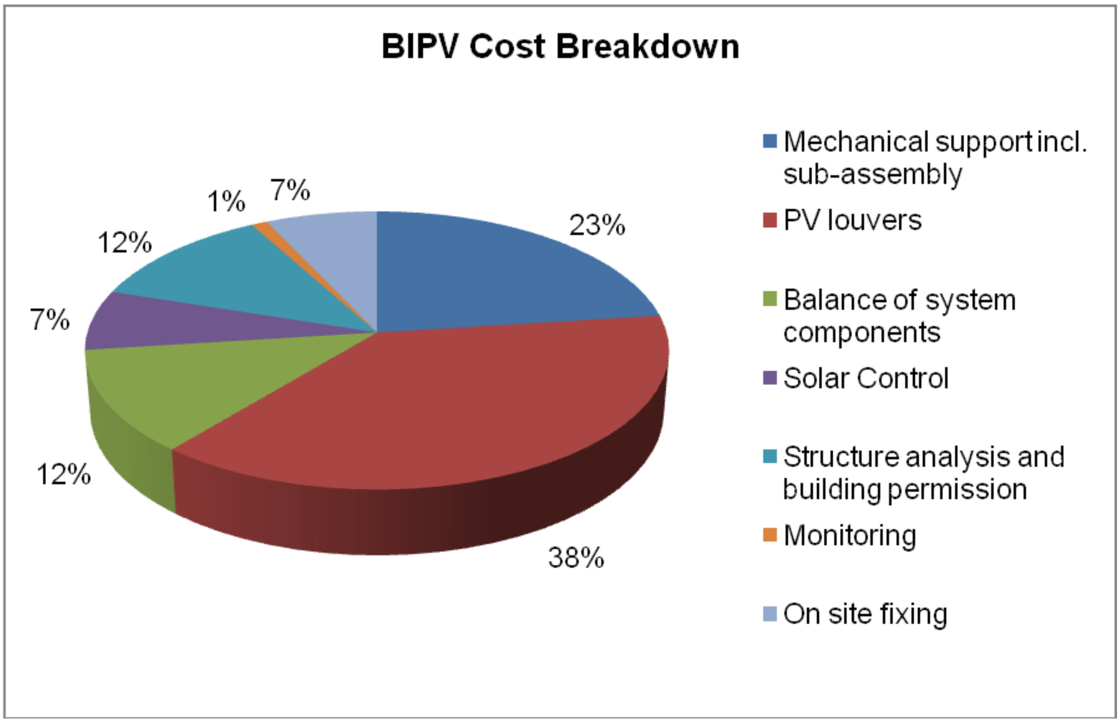


Figure 13: BIPV Cost Breakdown (Source: Starlinger Manfred from Colt International)

3.6 BIPV versus Conventional PV in a nutshell

Provided that the cost of newer BIPV technologies continues to fall, and that the building under consideration is new construction or is going to be a major renovation, BIPV is most likely to be considered first. Conventional PV panels win out where the building is older and the installation is a retrofit, and where price is a consideration. PV technology that is most likely to be considered in the retrofit market is BIPV roofing, especially for homes that need roof replacements.

The following Table 13 is a summary of the Pros (+) and Cons (-) of BIPV and conventional solar PV.

Table 13: Pros and Cons of Conventional Solar PV and BIPV

Conventional solar PV	Building integrated PV (BIPV)
+Relatively commonplace throughout the world, and therefore plenty of infrastructure	+Value-added. Well-designed BIPV generates electricity while improving the climate performance of home/building
+Durable and time-tested–will continue to function at more or less rated capacity for up to 25 or 30 years	+Can replace almost all external building materials and thereby reduce the long-term over-all costs of a building via operational cost savings and reduced embodied energy
+Industry standards have been developed and are well-known to experienced installers	+Aesthetically pleasing–can be seamlessly integrated into the building envelope to give a sleek, modern look to a building
+Efficiency of panels has been steadily increasing while the price has been decreasing	
+Can easily be installed on top of a roof on a building that does not require any structural overhaul	
-Big, rectangular, visually unappealing to some people.	-Smaller market, many technologies are still under development and are not price-competitive on the retail scale with conventional panels
-Does not 'add-value' to a home's functionality besides electricity production	-Infrastructure, standards not in place, expertise needs to be built up
-Placement options are limited–generally either on top of a roof or possibly ground-mounted.ground-mounted.	-If some forms of amorphous PV are used in building, the productivity of the PV may decline in as little as 10 years–amorphous generally has a life span that is shorter than crystalline PV

3.7 Learning Curves For Modules Worldwide

As gathered from figure 14 below, the module costs follow a learning curve, i.e., with a doubling of the cumulative output, the PV module cost decline by 22 %.

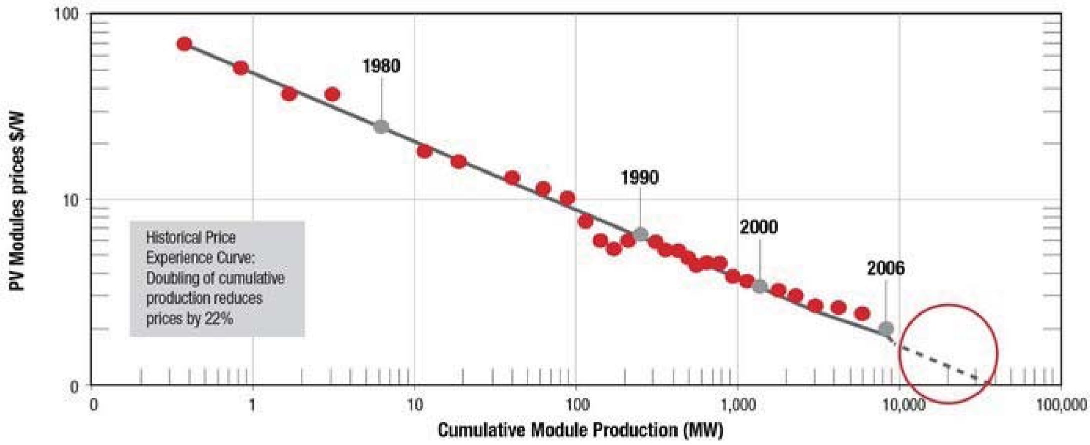


Figure 14: Historical Price Experience Curve (Doubling of cumulative production reduces prices by 22% (Source: Lutz Steiner Martha)

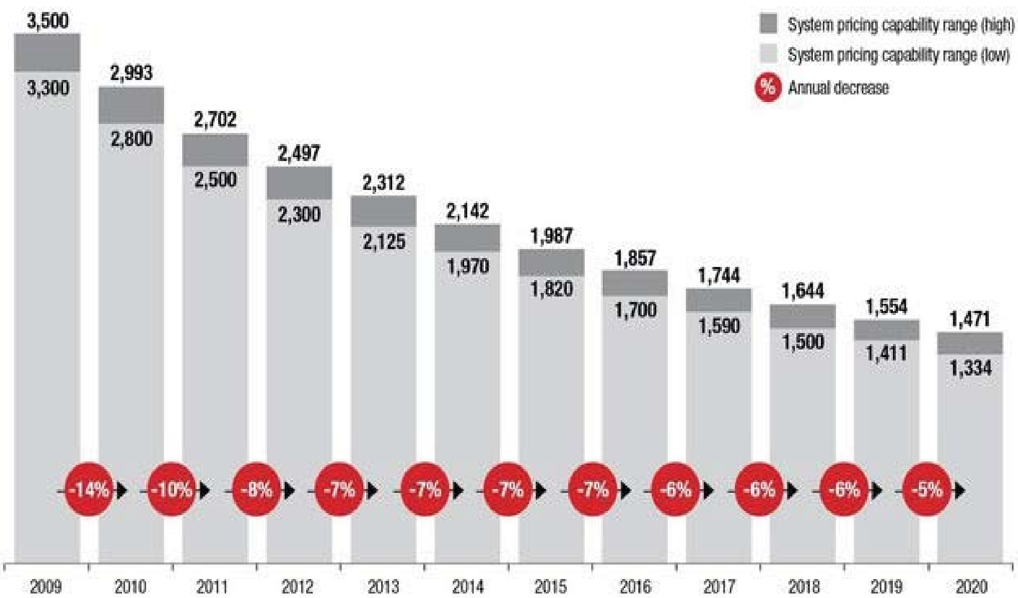


Figure 15: Annual decrease of PV system costs until 2020 (Source: Lutz Steiner Martha)

Lutz-Steiner predicts the costs of PV system to drop by half from about 3.000 €/ kW in 2010 to less than 1.500€/ kW in 2020. The values as shown in the above figure 15 have been confirmed by a survey conducted by the German Meine Solar GmbH, whereby 500 owners of turnkey solar power plants in Germany were interviewed. In 2008, the average price in Germany amounted to 4.300€/ kW as compared to a price of 3.450€/ kW for the year 2009. This represents a reduction of about 20% for turnkey installed PV within a year. The average price for 2010 is about 3.000€./ kW.

The decline in the prices of module and system is partly due to the price collapse for silicon. The price for polysilicon is about one sixth of the price at the beginning of 2008, which is about US$55/kg. It was reported that the Chinese company Yingli plans to produce at less than US$25/kg in 2011. Furthermore, the cost per watt could also be optimized by the developmentof thinner wafers and a higher yield of ingots. Another factor that will drive the cost further down, is the development of micro-cells, whcih can be manufactured at a fraction of the cost of traditional PV cells. They use 100 times less silicon to generate the same amount of electricity.

Solar cells constitute 65-75% of the total cost to manufacture a module. Therefore any change in cell prices will have a direct impact on the price of a solar module. The average global PV module price has reduced from $4.66/W (per Watt) in 2004 to $2.01/W in 2010. There was a 2.8% increase in the average module price in 2008 as the global demand exceeded supply. The average selling price of modules continued its declining trend in the last couple of years due to a reduction in production costs and increased competition. The average module price dropped by 50.9% from 2008 levels by 2010, with the increasing presence of low cost Asian producers, and the price drop was worsened by the repercussions of the global economic crisis. The advent of new technologies and the streaming of production processes will further reduce the price of a module and improve the conversion efficiencies of a solar cell. The average selling price of a solar module will decline further and is expected to reach $1.49/W by 2015 as market participants will lower their module prices to maintain or improve their market share in the global modules market. (Source: Solar buzz).

3.8 The BIPV market development

The question that arises is who is going to trigger the demand of BIPV systems, after having understood the great potential in terms of area availability and the capability of the PV industry to keep a steady growth whilst reducing production cost and increasing production capabilities.

It is therefore to underline the difference between BIPV (the PV modules are fully integrated in the building structure and fulfil the function of traditional building material as heat insulation, rain protection, shading, etc. besides of course electricity generation) and Building Adapted PV, BAPV (the PV modules are installed on top of the existing building structure and no additional function is provided).

Till to date, the pure BIPV market is driven by special support schemes, designed in such a way that BIPV systems are rewarded with a higher tariff per kWh generated than for BAPV systems, thus acknowledging the added effort and extra cost of integrating PV as part of the building envelope. This is particularly the case for France and Italy, countries where BIPV represents over one third of the annual market. Malaysia is offering bonus for its FiT for BIPV systems. In other countries like Germany and Spain where support schemes have not differentiated between both types of systems, BIPV still represents a very marginal share (less than one per cent) being installed only in those very special cases in which cost is not an issue.

In these business models, the customers are normally individuals (house owners) who, motivated by the financial incentives from the government, request architects and/or installers to install a PV system. However, the situation in which architects and contractors suggest that the client makes use of PV systems is not yet happening. The reason is that most architects and contractors are still not aware of the great potential of photovoltaics, its multifunctional aspects and the variety of designs and products available on the market.

3.9 Barriers for the diffusion of PV in the building sector

Considering the potential market of BIPV, which has already been analysed, we know that the construction sector will play a key role in the development of the PV sector. Thus, PV manufacturers need to increase the dialogue and to improve the cooperation with architects, contractors and installers. The objective is to develop the most suitable products which take into account architects' needs in terms of aesthetics and design and fulfil the needs of builders and regulators in terms of electrical and mechanical characteristics, fire protection and standardised sizes, among many others.

Based on this need for an increased cooperation with related stakeholders, the European project Sunrise has been running for the last three years, understanding firstly the current barriers for the development of PV in the building sector and secondly identifying and developing solutions to overcome them.

The Sunrise project, led by EPIA, counted representatives of the architects' community through UIA (International Union of Architects), the construction industry through FIEC (European Construction Industry Federation), the electrical contractors and installers through AIE (European Association of Electrical Contractors) and the PV industry through EPIA (European Photovoltaic Industry Association) and WIP-Renewable energies.

The project, through the experience of its members in the building sector and in close contact with CEBC (European Consortium of Building Control), identified the following barriers:

- Legal & administrative barriers defined as problems concerning the policies of different parties involved in the introduction of PV. Some examples are the complex planning procedures for the installation of a PV system, especially concerning existing buildings and the fact that BIPV is not allowed on listed buildings which are officially designated as being of special architectural, historical or cultural significance. In this case, special permission is needed from the local planning authority
- Technical barriers related to the structural problems that engineers, architects and installers encounter when designing, engineering and installing PV systems into the building envelope. These problems occur because of the missing link between engineers and architects/technical requirements. Many roofs and facades are not designed to support the additional weight, nor do they have the right orientation, or else there is some shade due to the building itself or buildings close by which require substantial modifications when installing PV systems. A better consideration of the architects on the use of renewable energy sources from the design phase would avoid this situation. The lack of standards for PV (e.g. fire risk) and the variety of national and regional building regulations and certifications throughout Europe also presents an important bottleneck because of the difficulty of introducing BIPV on the market

- Perception barriers defined as the lack of knowledge and misleading statements in the media that underestimate the added value of PV systems thus hindering their integration into buildings. The perception of PV technology is usually outdated, which consequently leads to a bad image. Some statements read, for instance, "PV modules need more energy to be manufactured than the energy they can deliver during their entire lifetime" or "PV module efficiency is too low, we should start using this technology when the efficiency is closer to 100 per cent." These barriers could be easily removed by providing real and updated information not only to the construction sector but to public authorities and all citizens in general
- Market barriers related to the cost of BIPV and to the lack of knowledge concerning the added value of PV products for the building sector. Very often, PV systems are not considered in the initial building design because of the high cost of the components. It is a fact that PV modules are expensive when compared with more traditional building materials which BIPV can replace such as roofing tiles, laminated glass, parapet units and of course low cost traditional bricks. However, what is neither sufficiently realised nor taken into account is the fact that PV modules can generate electricity. This means that the total energy consumption of a building will be decreased and therefore the material itself (PV module) will (ultimately) pay back its initial investment cost. Furthermore, the added value of BIPV as a multi-functional building component is not known

Another important market barrier, which has been specifically addressed by the Sunrise project, is the language and terminology used by different sectors. Whereas solar module prices are indicated in Euros/Wp and stakeholders in the solar sector can easily calculate the estimated electricity production based on the power and location (kWh/kWp), the construction sector, and specifically architects would rather prefer to use Euros and kWh/m².

3.10 Bridging the gap between the construction and PV sectors

As previously mentioned, one of the elements that complicates the cooperation between the PV industry and the building sector is the fact that they use different terminology. At least when it comes to building integrated PV the PV industry should adapt to the customs of the building sector. Instead of talking about the installed PV capacity in the first place, the predicted annual energy generation in kWh should be communicated as the main figure. The value of kWh is widely spread, which is not the case for the unit kWp outside the PV industry. This transition is not easy and straightforward, since the value of kWh/year raises expectations from the user. A standard procedure for this transition needs to be defined that also has to consider various solar cell technologies (crystalline, thin film etc.).

Under the Sunrise project, a toolbox has been developed in order to facilitate the estimation of 'how much electricity is generated by a PV system?' without needing expertise on PV system technology. Many simulation tools can be easily found in the market for PV system designs and energy output calculations. However, what makes this tool special is that electricity production is calculated based on the module area (m²) and no longer on the system power (Wp). Furthermore, the user does not need to know the efficiency of the modules or irradiation levels in the location. It has been designed with excel so it is of easy use and accessible for anyone.

It is important to note, though, that the tool is not meant to be used for professional calculations because it is based on average irradiance data and the characteristics for each type of technology are based on average module efficiencies. Besides, the tool covers a limited number of locations in Europe and offers a limited number of system designs.

The aim of the tool is to bring photovoltaics closer to architects by facilitating their understanding of the technology and presenting its potential. The partners of the Sunrise project have made this a first step in order to improve relations between both sectors and removing existing market barriers.

Other activities have been undertaken aimed at overcoming perception barriers, such as the brochure 'Building Integrated Photovoltaics – A new design opportunity for architects' which presents the many different applications of BIPV and their multifunctional aspect. The toolbox and the brochure, as well as other publications presenting solutions to overcome existing bottlenecks, are available free on the Sunrise project website (www.pvsunrise.eu).

Source: www.pv-tech.org

European population : 497,659,814

Total ground floor area : 22,620.9 km²

BIPV potential (roof & façades) : 12,193 km²

BIPV potential (roof & façades) : 1,425 TWh/a

Expected electricity demand in 2020 : 3,525 TWh/a

Potential share of BIPV in 2020 : 40%

Considering the current population in EU-27, over 1,500 GW could technically be installed in Europe with an annual electricity production of about 1,400TWh. This would represent 40% of the total electricity demand by 2020 – a large potential which would also be true for other continents. The technical potential for BIPV is huge and space availability does not represent any limitation for the growth of photovoltaics.

4 Malaysian Market Penetration

Before analyzing the market penetration for BIPV products in Malaysia, it is necessary to briefly review trends in Germany. The German Renewable Energy Sources Act of 2004 pays PV system owners a standard 20-year FiT rate PV on buildings. A premium is applied to BIPV facade systems of €0.05 more for every kWh generated. In general, German companies are trendsetters in BIPV products and applications. Inspite of these incentives and innovative applications, about 1% of the PV installations in Germany are building integrated.

The modest BIPV market penetration in Germany is not due to a lack of products or the low value of the electricity generated but mainly due to the pace of building development in Germany does not match well with the rapid growth of the PV market. With limited new building construction available for PV, hence the preferred PV installation has been sizable ground mounted arrays on farmland.

The situation for BIPV in Malaysia is similar to that in Germany, The relative size of the BIPV market is a tiny fraction as well.

The following six major global PV companies benefit from the different incentives provided by the Government of Malaysia for local manufacturing.

First Solar, a US manufacturer of thin film modules (CdTe), was the first international PV company to establish local manufacturing and benefited from the conducive environment of a highly trained workforce, relatively cheaper electricity cost and land cost compared to other countries.

Table 14: International PV companies in Malaysia

Company	Origin	Location	Manufacturing	Capacity/year	Employee	Start of Operation
First Solar	USA	Kulim	CdTe modules	800MW	1.200	2008
Q Cells	Germany	Selangor	Ingots, wafer and solar cells	800MW 500MW	3.500	2009
Sunpower	USA	Malacca	Ingots, wafer and solar cells	1.000MW	5.500	2010
Tokuyama	Japan	Bintulu	Polysilicon	3.000 ton	500	2011
Flextronics	USA	Johore	PV module assembly	200MW 250MW	1000 1400	2010 2011
MEMC	USA	Sarawak	Solar Wafering	600MW	2400	2012

4.1 Commercialization of BIPV

Malaysia initiated the SURIA 1000 project to promote and educate the public on the use of solar especially grid connected PV systems. This project obtained strong support from the government and this initiatives also received good response from the public. The Malaysia Building Integrated Photovoltaic (MBIPV) Project is aimed at inducing the long-term cost reduction of the PV technology via integration of the PV technology within building designs and envelopes. This has also supported setting up of local facilities to build solar panels with the intent to reduce cost of installations. The energy supplier, Tenaga Nasional Berhad (TNB) is also supportive to these efforts especially in the use of solar PV and hybrid variants for rural electrification.

Most of the PV technology used in Malaysia is acquired from the global market. Ongoing research in this area is being carried out to look into various ways to improve the performance of PV panels, including reducing the cost of production.

The key Malaysia company, Solarplus Technologies (M) Sdnm Bhd, is engaged exclusively in the design, manufacture and marketing of solar power hot water systems for domestic, commercial and industrial purposes. This activities will reduce the cost of production in the long term through the increase in demand economices of scale and competitive local manufacturing.

Several long-term strategies were adopted for Malaysia to reduce the cost of BIPV. This includes a) establishment of BIPV information services awareness and capacity-building programs, b) developmentof BIPV market enhancement and infrastructure, c) improvement of policy and financial frameworks supportive for BIPV market sustainability and d) establishment of competitive local BIPV manufacturing industries and R & D

4.2 Grid parity in the Malaysian Context

Grid parity is achieved when cost of electricity generated by a rooftop photovoltaic cell system is equivalent to that purchased from an electrical utility. This is expected to mark a major inflection point for the PV market that will deliver a huge increase in growth. Nevertheless, when grid parity does arrive, it is unlikely to generate a sudden rise in solar installations due to the high upfront costs and the long-term return of investing in a rooftop PV system. However, growth is anticipated to moderate during the years when grid parity arrives in various regions of the world as the industry enters a more mature phase as well as with the acceptance of the thin films in the PV sectors.

Due to the high electricity price in comparison with other European countries and a high number of sunshine hours, it is expected that grid parity will be reached in Italy first, probably by 2012. Germany is the next closest nation in reaching grid parity. This is mainly attributed to the nation’s low-cost solar systems and high cost of electricity. PV experts predicted that Germany will achieve grid parity by 2018.

In the case of Malaysia, the nation is blessed with abundant sunshine and the average irradiance is 1500kWh/m^2. Estimates for the urban areas are important for BIPV applications. It can be seen from the figure 16 below, that the region Klang valley (Kuala Lumpur, Putrajaya, Seremban) has the lowest irradiance value. The highest irradiance is found around Penang (Georgetown, north-west coast) and Kota

Kinabalu. Figure 16 shows the annual average daily global solar irradiation for Malaysia

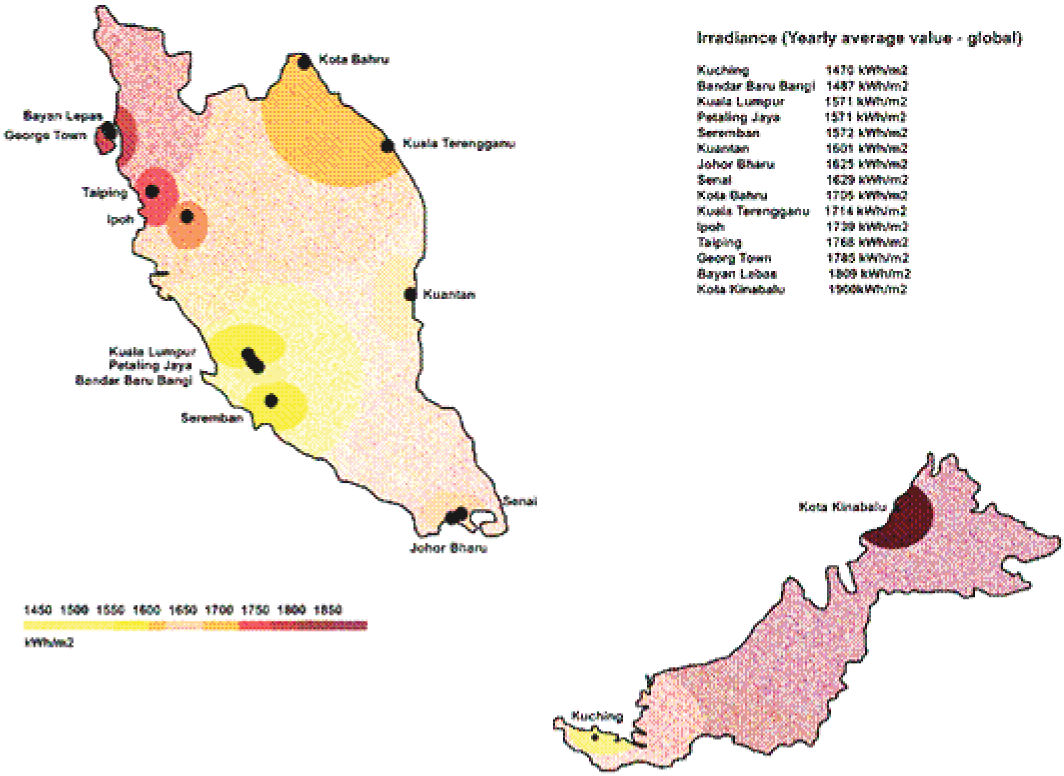


Figure 16: Solar Irradiation Map of Malaysia

Ideally, the orientation of a PV panel must face south towards the equator. Malaysia being close to the equator offers an advantage for innovative architectureal ecstatic design with varieties of building orientations and shading considerations. In Malaysia, per year depending on the locations. Areas located at the northern and middle part of the Peninsula and the coastal part of Sabah and Sarawak give higher yield.

According to a study carried out by MBIPV, the nation is expected to reach grid parity by 2026 with thin film (TF) and with c-Si, grid parity will be attained by 2028.

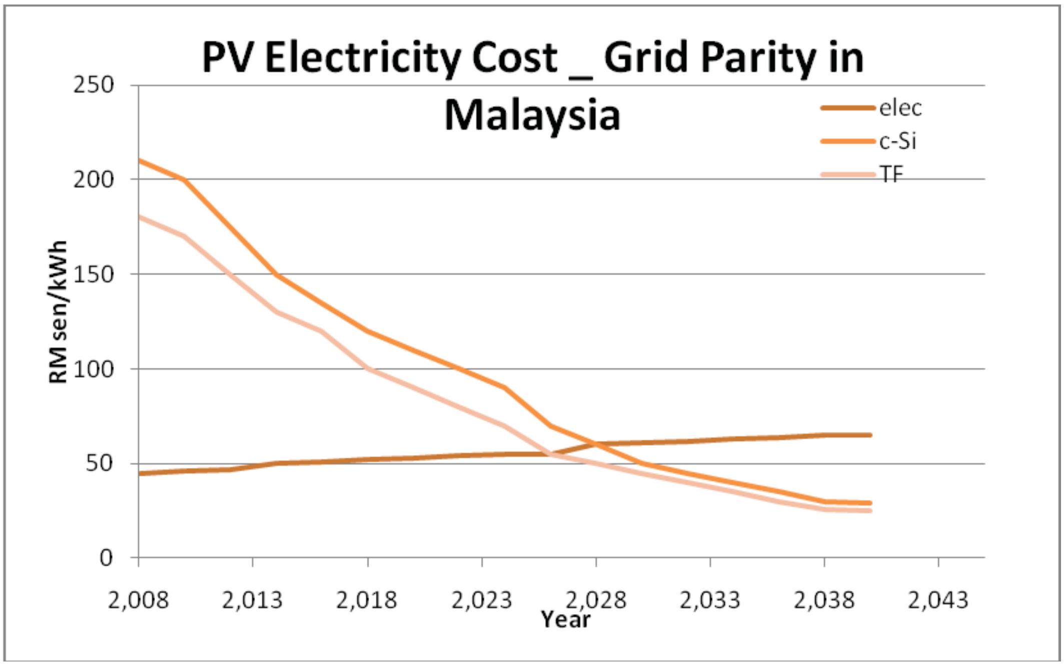


Figure 17 Grid Parity in Malaysia (Source: Adapted from Ruoss D, 2008)

Factors that will drive grid parity are as listed below:

i) Irradiance level (higher irradiance the better and grid parity is achieved faster).

ii) Escalating production cost of conventional electricity.

iii) Economics of scale in production.

iv) Huge upscale in polysilicon production which leads to significant price reduction of silicon.

v) Trend toward thin film which is cheaper but lower efficiency.

vi) More cost effective production methods and improvement of efficiency.

4.3 Prospects & Development Plan of BIPV in Malaysia

i) The MBIPV project had created an enabling environment that leads to a sustainable BIPV market in Malaysia and technology cost reduction.

ii) When capacity of BIPV is appropriately sized, it can displace purchase of electricity with the possibility for exporting the surplus to the grid.

iii)The technical potential of BIPV in the residential and commercial sectors are huge. The technical potential is about 11.000MWp or 11 GWp which could provide more than 12.000GWh solar generated electricity, when the lower PV capacity value of 1kWp for every 10 m^2 of available building roof surfaces are considered. This would represent 20% of the national energy demand.

iv) The climate for business opportunities in the field of PV is promising in Malaysia. The Government is promoting the continued diversification of industrial base towards high-end manufacturing and the development of the value-added services sector as part of the move towards a knowledge-based economy. Alternative energy sources such as the development and production of fuel cells, polymer batteries, PV components and solar cells are specifically mentioned in the Malaysian Investment Act 1986. Attractive incentives such as tax reduction for start-up of new companies was introduced. However, the incentives have to be reviewed when considering a local production of either PV inverters or modules. Malaysia is also encouraging high-tech electronic products for which attractive incentives are being offered to promote investments and reinvestments in technology and capital intensive projects. The electronics cluster would be built around the semiconductor sector.

v) BIPV Information Services, Awareness and Capacity Building Programs to enhance the level of understanding and awareness through an extensive education and campaign and capacity building program. Activities such as establishing information services, seminars, workshops and capacity building program to improve the level of competency and quality of work of the service providers, architects, engineers and developers. Information resource centre, database and website were established to provide the end users the required information for installing BIPV technologies.

vi) BIPV Market Enhancement and Infrastructure Development to address the technical feasibility and economic viability of BIPV technology through the cell production and the industrial equipment sector (module and inverter manufacturing).

vii) The existing infrastructure and well established manufacturing sector in Malaysia such as the precision machining and the production of electronic assemblies and sub-assemblies, components, moulds, tools and dies, metals and plastics, and automated machinery and equipment provide support to the local PV manufacturing facilities, in terms of providing supply for the mounting structure for PV systems. Therefore, frames for the modules made of aluminium can be easily manufactured.

viii) The local electronic industry is well established and can supply components to the inverter manufacturers. State-of-the-art materials are available without inherent restriction to the supply chain. A local production of inverter is foreseeable in the short to mid-term.

ix) To establish and operate a solar PV module manufacturing unit economically whereby wafers are imported, a long-term market perspective of about 6MWp per year is required

4.4 Malaysia’s Strategies for BIPV Development

i) Implementation of a number of demonstration projects. Through this wider level of acceptance and better understanding of the technology and its benefits were reaped. The demonstration projects also paved the way for providing first hand experience for improvements in the training and skills of the stakeholders, including increasing efforts in R&D activities. Relevant standards were updated and new guidelines drafted to provide technical assistance to the industry.

ii) BIPV Policies and Financing Mechanisms Program was aimed at enhancing the capacity of policy makers in setting up appropriate, proactive and integrated plans and policies that will facilitate the development of a conducive business environment for BIPV and therefore enhancing further cost reduction of the technology.
Malaysia adopted on 5 April 2011, a system of Advanced Renewable Tariffs and renewable energy targets differentiated by technology. Targeted new renewable by 2020 is 3.000MW, including 1250 MW of PV.

iii) Industry and R&D Enhancement Program is targeted at systematically strengthening and organizing the human resource capacity in R&D and manufacturing. Joint ventures and partnership with international companies had upgraded local companies, R&D institutions and the technical infrastructure for testing and certification facilities were established to ensure high quality commercial BIPV products for the local and international market. This has resulted in an increase in demand, economies of scale and competitive local manufacturing, including a decrease in the cost of BIPV systems and components for an installation in Malaysia as shown in the figure 18 below.

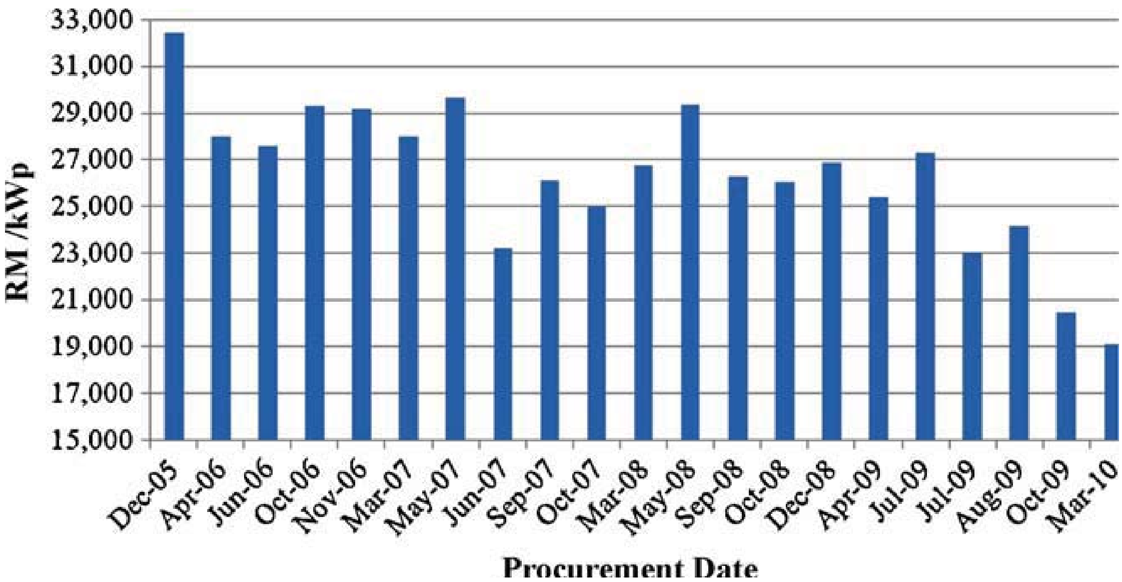


Figure 18: Average BIPV price/kWp from 2005 to 2010 (source: MBIPV website, PV market, PV system cost)

4.5 Current Barriers

The major barrier is the huge upfront cost PV technologies and limited R&D investment. Commercialisation of this technology is encouraged through the generation of market demand or by guaranteeing the existence of a future market. A stable and consistent policy and a favourable environment, which is conducive to strategic deployment programs, ensuring that quality standards are adopted, designing appropriate tariffs, improving the technical adaptability of the county, greater absorption capacity and incentivizing large scale R&D and demonstration projects are being implemented, to sufficiently address the environmental and developmental objectives of Malaysia.

The types of barriers that Malaysia is facing can be categorize as follows:

i) Economic and market
ii) Lack of favourable environment
iii) Institutional
iv) Social acceptance
v) Technical and lack of adequate skills and training

4.6 Achievement of BIPV project in Malaysia

The MBIPV has made important contributions to removing barriers for BIPV, especially in awareness creation and capacity building in terms of benchmarking, best practices, monitoring, including demonstration of BIPV technology and cost reduction. The MBIPV project helps to integrate decision-making concerning PV and renewable energy among government, agencies and institutions, utilities, academia and industry as well as consultancies, architects, developers and other professionals. Four international PV companies set up their operation in Malaysia during the MBIPV project.

The subsidised energy prices are a barrier to increased use of PV and RE in Malaysia. Therefore, there is not much that the MIPV project can contribute directly to remove that barrier except for providing relevant policy recommendations which has been in place since April 2011.

The MBIPV strengthens its flow of information towards other ongoing RE and energy conservation activities in Malaysia in order to facilitate common understanding and coordination among stakeholders.

5 Suggestions and Recommendations

Distictive tariffs and increasing awareness about the benefits of BIPV are the main drivers of demand for BIPV. Nevertheless, more suitable and standardised products are required in the market. One of the challenges in future for industry participants is the decline and withdrawal of incentives. The future offers good prospects for BIPV, provided legislative incentives are in place.

In order to meet the energy targets set by the European Union (EU), member states should try to adopt renewable energy, especially in buildings.

The Energy Performance Buidlings Directive (EPBD,2002/91/EC) and its amended version required countries to reduce the energy consumption of buildings and increase the proportional usage of renewable energy. The EU directive may induce the introduction of amended regulations for new construction, which will improve the BIPV market.

The respective Government needs to creat greater awareness about the long-term benefits of BIPV to overcome scepticism over high installation costs. The high initial investment required for installing BIPV systems make it a more expensive option to using grid-based electricity and traditional construction materials. Therefore, the decision to integrate PV with buildings remain independent of construction and design choices. In order to embrace BIPV into the process of design and construction, there needs to be greater symbiosis between the PV and the construction industry. The public needs to be educated that early adoption of BIPV is beneficial in the long run even though the payback period on BIPV installations may be long.

A wider range of products needs to be made available, specifically for building integration. Planners in the construction industry from both the public authorities and private sector need to be made aware of these not just as a PV material but also as an alternative construction material. This can be done through showcase development and adoption of updated building codes that have provisions for the usage of such material, without incurring external choice or a troublesome process. Awareness campaign by both PV manufacturers and local governmetn need to be conducted to install awareness about BIPV as a building materials amongst local installers, architects and homeowners. Partnerships or working agreements with architects and construction companies also need to be made to hasten BIPV's adoption as a recognized building material by regulators.

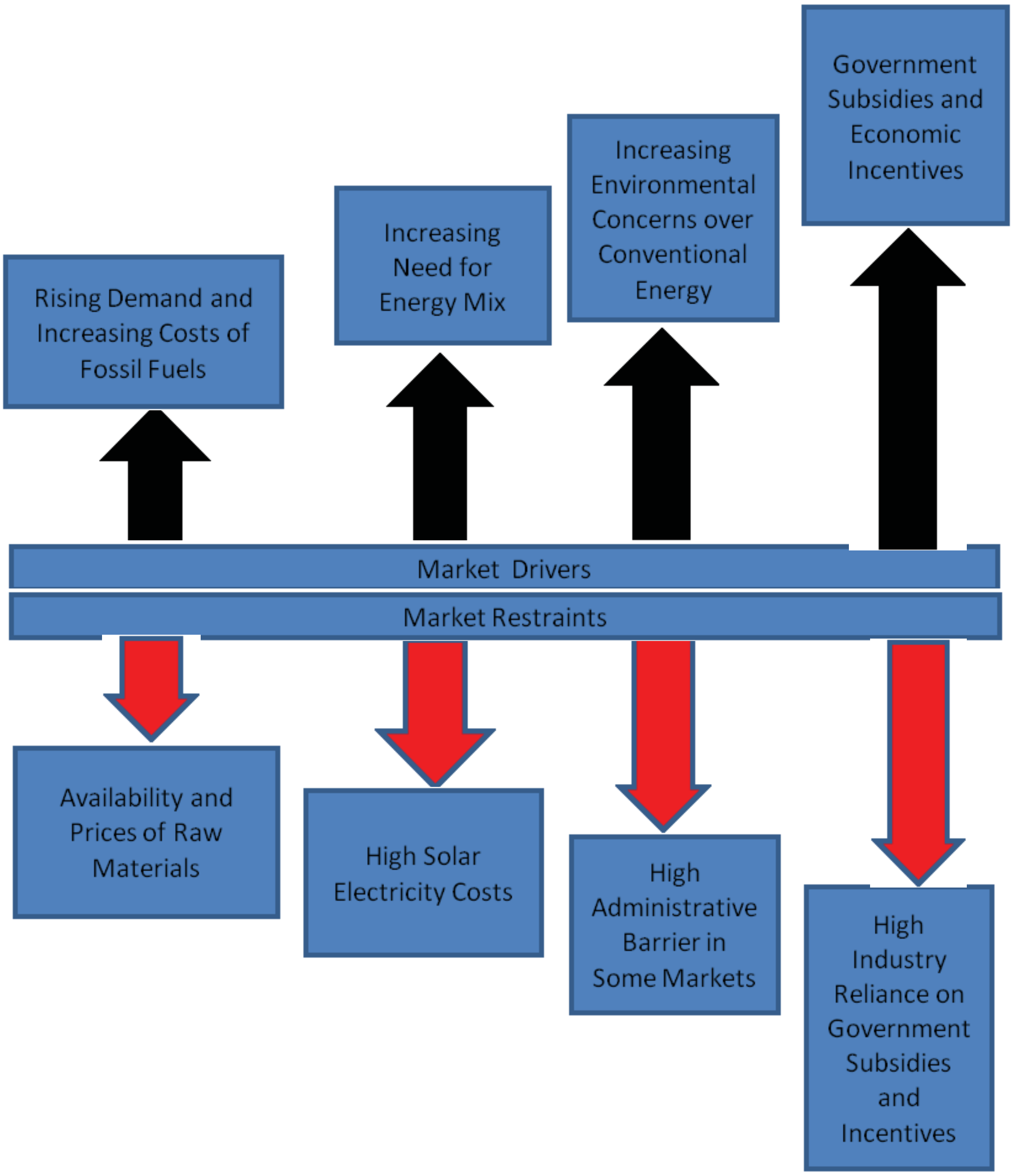


Figure 19: The PV Industry Force Field Analysis (World, 2010) Source: Frost and Sullivan, BIPV-Keynote-ICBEST

Length of the arrow denotes degree of impact

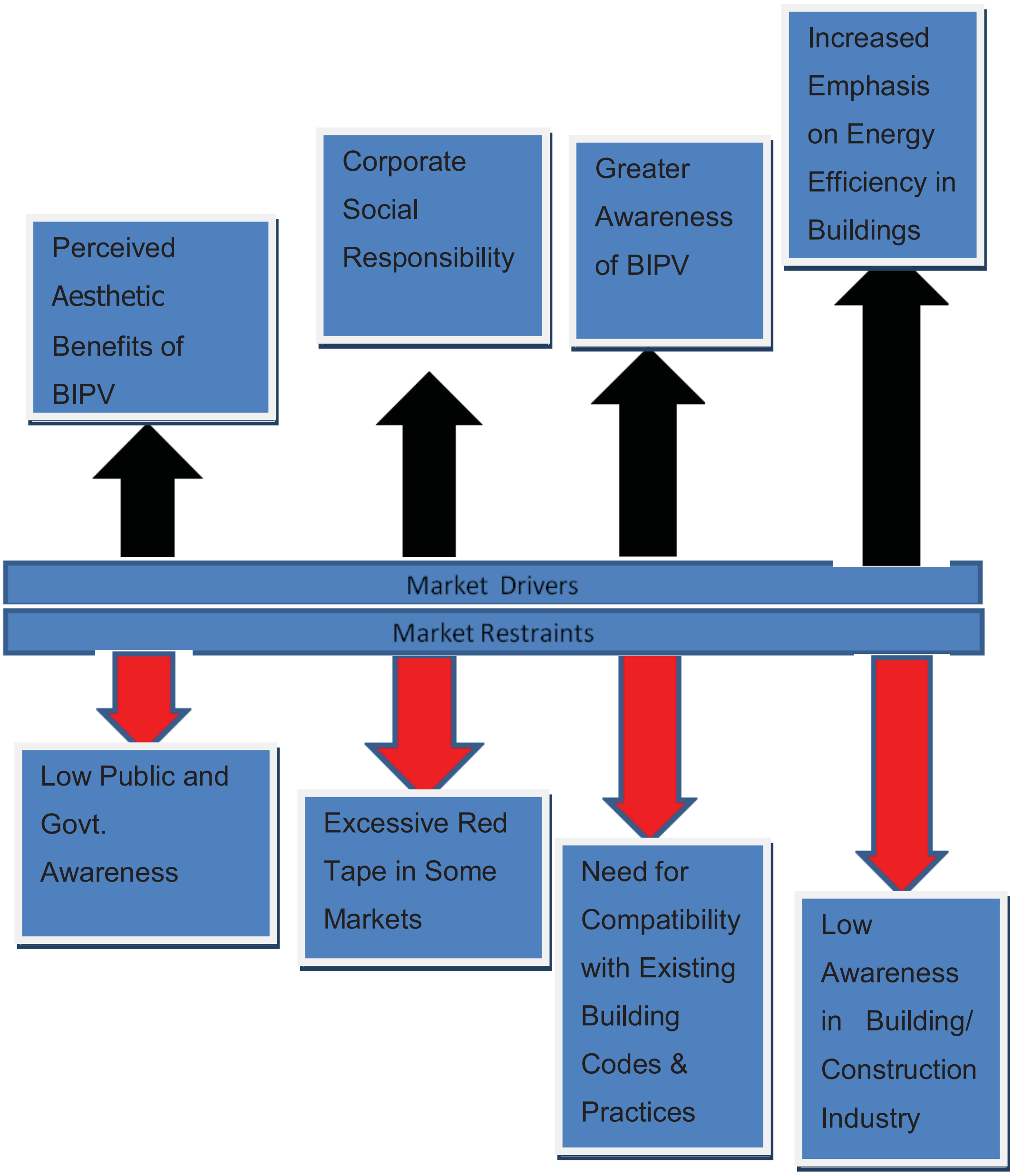


Figure 20: The BIPV Market _Drivers and Restraints Specific to BIPV Market (Source: Frost and Sullivan, BIPV-keynote-ICBEST)

Length of the arrow denotes degree of impact

6 Summary and Conclusions

The overall BIPV policies in China did not have dramatic change from 2009 to 2011 but the subsidy amount has been decreasing. Nevertheless, domestic Chinese companies still put effort in applying for qualification which explains the government's optimistic outlook for BIPV subsidy. Hence, severe competition between BIPV players in the Chinese market has driven down the overall PV market price. In addition, due to the nuclear crisis in Japan as a result of the recent devastating quake, the Chinese government has adjusted the development direction of power stations, Many originally approved nuclear power related projects in China have been put on hold indefinitely. This is also seen in Germany, the world's largest photovoltaic market, as it idled seven nuclear reactors, whcih led in a jump forward in electricity prices. This could be a turning point for renewable energy as speculation heats up about the potential global nuclear power capacity of about 50 to 60 GW to be either delayed or outright cancelled. There have also been calls from Germany, France, China and other countries to switch to renewable energy faster. China announced that it is looking to double its solar energy goals and more countries, including Malaysia are expected to go down this path in the near future. As a result of the nuclear meltdown in Japan, many countries are rethinking their plans about nuclear energy. This has created a high level of uncertainty, which may turn out to be a net positive for solar in the long run. This implies that forecasting the PV/BIPV market till 2015 is very difficult, as visibility is extremely low under current political conditions. Neverthess, the forecast made in this paper is based on the scenario set by EPIA under policy driven and business as usual without taking into account the implications of the nuclear meltdown in Japan.

To reach gird parity, historical evidence shows that the development of the PV and BIPV market is partly offset by technological progress which needs to be encouraged by regulations to improve market performance, temporary subsidies, tax incentives or other mechanisms if it is to occur in a timely fashion.

It can be concluded that FiT were found to be expensive in the short term but they are able to develop a market quickly as in the case of Germany, Spain, Italy and France and to put sufficient pressure on the supply side to achieve cost reduction. The condition for this positive market development was that FiT are not set too high.

A good FiT system must capture the willingness to pay of the citizens, Subsidies should also be the difference between the real system costs and the amount the consumer is willing to pay. Hence The crucial success factors are the initial subsidy should be set at the difference between cost and willingness to pay. Adjustments of subsidies should be planned to allow for market evolution. It is therefore imperative that continuity of the FiT system be maintained until the cost and willingness to pay converge. Subsidies set too high will not exhaust the willingness to pay and the market will expand rapidly and will not be sustainable. The willingness to pay should be increased over time either by decreasing the costs or increasing consumer preference by greener cultural attitudes. Coordinated policies are crucial in order to avoid over subsidized markets and stop-and-go policies should be avoided. The Spanish market was over-subsidized between 2002 and 2004 which led to the collapse of the Spainish PV market in 2009.

The following tables 15 and 16 show analysis on the PV support framework and special BIPV promotion policies in Germany, Italy, France, Spain, China, USA and Malaysia.

Table 15: PV Support Framework Analysis:

Support Measures	**GER**	**ITA**	**FRA**	**ESP**	**CPR**	**USA**	**MAL**
FiT	Yes	Yes	Yes	Yes	No	No	Yes
Investment Grants	Reg	Reg	Reg	Reg	Reg	Reg	Yes
Beneficial Credit Terms	Yes	Partial	Yes	No	Partial	Yes	Yes
Fiscal Incentives	No	Partial	Yes	Partial	Yes	Yes	Yes
Quotas/Tradable Green Certificates	No	No	No	No	No	Yes	No
Net Metering	No	Yes	No	No	No	Yes	Yes
Sale of Electricity	Yes	Yes	No	No	Yes	Yes	Yes
Market Control	Variable	No	Fixed	Fixed	No	No	Fixed

Table 16: Special BIPV analysis of BIPV promotion policies

Administrative Process	**GER**	**ITA**	**FRA**	**ESP**	**CPR**	**USA**	**MAL**
BIPV support measures	No	Yes	Yes	No	Yes	Yes	Yes
PV obligations on building requirements	No	Yes	Yes	Yes	No	Yes	No
RES obligations on building requirements	Partial	Yes	Yes	Yes	Partial	Yes	Yes
National roadmap zero or low energy building	Partial	No	Yes	No	Yes	Partial	Partial

In the Malaysian context, the Malaysia energy sector is still heavily dependent on on renewable fuels such as crude oil, natural gas and coal as a source of energy. Based on the national economic growth, the energy consumption in Malaysia is expected to be in uptrend of 6-8% annually. These non-renewable fuels are gradually depleting and contributing huge amount of greenhouse gas emission. Malaysia is geared to embrace and displace non-renewable energy with renewable energy in the future. The implementation of various policies and programs by the government of Malaysia has increased the awareness of the importance of the role of renewable energy, especially solar PV in a sustainable energy system. Malaysia has the potential to be one of the major contributors of renewable energy in the world. Despite great effort by the government to utilize solar PV, they are not utilized to the maximum potential in Malaysia. To achieve a fuel mix for 2020 to be secured and environmentally sustainable, Malaysia needs great effort in attaining greater efficiency in energy conversion, transmission and utilization. It is forecasted that Malaysia will reach grid parity between 2026 and 2028.

In can be concluded that BIPV has attractiveness that includes the following facets:

i) Energy consumed on-site

ii) Minimal transmission loss

iii) No land requirement

iv) Use of building to get the PV material off the ground

v) Architectural design element

vi) Green energy is built into the building

vii) Modern, ecological statement by the building

viii) Reduction in need for other building materials

ix) PV material is protectec no need for fences, in the case of ground mounted PV.

It is undeniable that Asia is set to be the increasing manufacturing base of solar PV equipments, and this includes Malaysia which has shown good prospects for such activity. This is attributed to the rising level of installations in Europe and major technological advancements in the USA, solar PV manufacturers are targeting Asian countries as places in which to diversify their manufacturing base. Asian solar PV manufacturers such as Yingli Solar, Suntech Power and Trina Solar, have emerged as major solar PV players, globally. China has therefore emerged an attractive option for investments for solar PV manufacturers, including Malaysia. Low labour costs and less costly materials such as glass and aluminium are the major drivers for the reduction of solar PV manufacturing costs. Project financing is also much easier in China as well as in Malaysia as compared to European and North American countries. In addition, China as well as Malaysia government policies to increase investments in renewable power, encourage manufacturers to scale up their production facilities. While European and the US companies are facing tough cost and margin pressures, the Asian companies are benefiting locally from their low production and financing costs.

In the case of the development of BIPV markets, the main drivers and restraints specific to BIPV markets are that building industry is primary customer for BIPV, BIPV components need to follow the characteristics of the building market as much as possible, planning and installation is a considerable cost factor for integrated components, costs have to be considered when developing new BIPV technologies and high technology is needed for true building integration. Hence, standard BIPV products are still rare in the industry. In addition, BIPV products tend to be unique for each building, material manufacturers therefore find it hard to design and produce standard building products for mass production. Currently, only a few manufacturers are able to come up with standard BIPV products such as solar shingles and it is no doubt that the development of specific BIPV products will allow for easier integration and better aesthetics. Hence future technology advances could change the prospects of BIPV products.

As future buildings become more dependant on electricity, EU legislation supporting large deployment of RES and moving towards energy-effcient buildings with RES and PV becoming very close to competitiveness with retail electricity prices, hence these spell unlimited potential for BIPV in the future.

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