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Solar Photovoltaic

Contemporary Scenario and Emerging Trends

As concerns about global climate change become more salient with growing population, depleting natural energy sources and subsequent rise in traditional energy prices, the search for alternative sources of power generation has become a prominent social and economic issue.

Though new sources of energy are yet to prove as cost competitive as traditional sources, such as coal and natural gas, local governments across countries have rolled out incentives for private players to invest in the 'renewable energy' sector, thus driving innovation and creation of cost-effective solutions.

Q1 2012

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Introduction

Wind energy proved to be the first technology to emerge as a competitive alternative to natural gas, and even coal in some cases. The realisation that this energy source is viable and commercially profitable has lead to a substantial scale of investment on a global scale.

Riding on the back of wind energy's global success, many in venture capital, private equity, and the energy industry are now wondering what the next 'wind' will be. The answer that promptly comes to everyone's mind is 'solar energy'.

Though still in the fledgling phase, and with various technological and development barriers still to overcome, a host of solar applications and technology approaches are competing to be the next renewable to be able to stand on its own, to make this source of energy commercially and socially viable.

One such technology, Photovoltaics (PV), has received substantial attention as a potential candidate for the next renewable to 'make it'. The PV industry has experienced breakneck growth globally and witnessed significant investment in enhancing manufacturing capacity and overall product quality.

The PV technology is unique because it makes sense to deploy at smaller scales, thus making it a viable distributed generation technology. This capability enables PV to potentially convert any entity into a power generator, thus leading to a certain level of independence from price fluctuations of traditional utility. This capability also makes PV a disruptive and unorthodox approach to power generation, which greatly complicates the more centralised nature of current power production. Simultaneously, PV is being deployed as a standalone technology (though still at a smaller scale than wind or other traditional sources). These capabilities combined with the fact that its generating capacity coincides closely with peak load hours and time of year (midday and summer) make it additionally attractive.

Executive Summary

Europe maintains leadership, with Germany as the World's largest market

With a cumulative installed PV capacity of almost 10 GW, including around 3.8 GW of installed capacity in 2009, Germany continues to lead the global PV market. However, the recently announced Feed-in Tariff[1] (FiT) cuts are expected to significantly affect the development of the national industry in the long run. The additional reduction of the FiT in 2010 makes Germany the most competitive PV market with the lowest PV system costs in the world.

In the medium-term, Italy appears to be one of the most promising markets with an additional 711 MW installed in 2009. Besides high sun irradiation, the new Conto Energia (Energy Bill), which was expected to be announced in spring 2010, would continue to support the strong momentum of the Italian market.

Czech Republic recorded strong growth in 2009 with the installation of 411 MW. However, due to unsustainable support schemes, the market is expected to shrink significantly in 2010 and 2011.

Owing to strong political will, Belgium made its entry into the top 10 markets with 292 MW installed in 2009. Due to a revision of the financial support scheme in early 2010, the market is, however, expected to slow down slightly.

France follows with 185 MW installed in 2009, with an additional 100 MW installed but not yet connected to the grid. In spite of huge potential, this clearly demonstrates the importance for France to solve grid connection issues in order to allow the market to develop.

In Spain, the set-up of a market cap in 2008, combined with the effects of the financial crisis, restricted the market to a very low 69 MW installed in 2009. Finally, Greece, Portugal and to some extent the UK are showing interesting potential for growth in 2010 and beyond.

Japan and USA as leading markets outside Europe

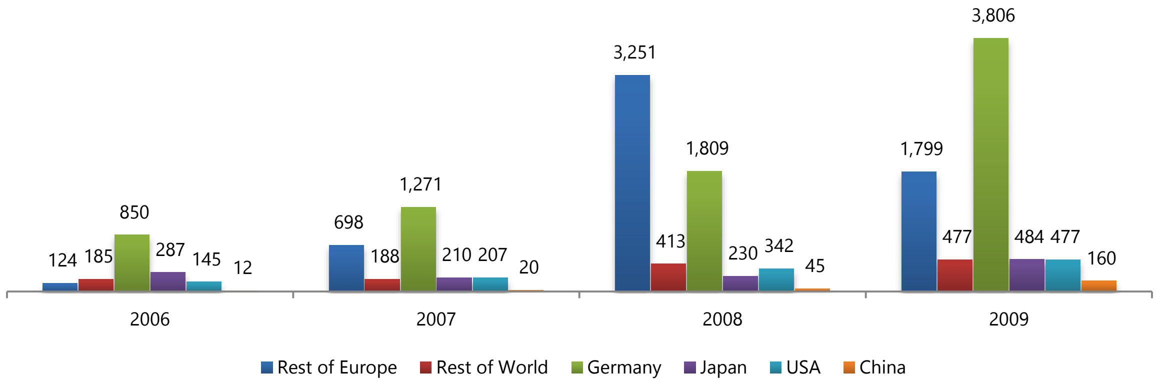
Outside Europe, Japan positions itself as the third largest market with 484 MW and shows an important growth potential thanks to favourable political support. The USA market finally took off significantly with around 475 MW installed in 2009 and appears to be a potentially large player in the coming years. China and India are also expected to boom in the next five years with enormous market potential and impressive projects in the pipeline. Canada and Australia showed significant market development in 2009 and are open to the development of new markets. Brazil, Mexico, Morocco, Taiwan, Thailand, South Africa and many others are also seen as promising countries.

[1] Feed-in Tariff - The price per unit of electricity that a utility or supplier has to pay for renewable electricity from private generators. The government regulates the tariff rate.

Global PV Market – Installed Capacity Development

The Global PV market witnessed a 15% growth in 2009 as compared with 2008, in spite of the economic crisis. As a result, the total power installed globally grew by 45% to 22.9 GW. This higher-than-expected growth in 2009 was mainly driven by German PV market, which doubled from 1.8 GW in 2008 to around 3.8 GW installed in 2009, representing more than 52% of the world PV market. The Italian market installed 711 MW, making it the second largest market world-wide.

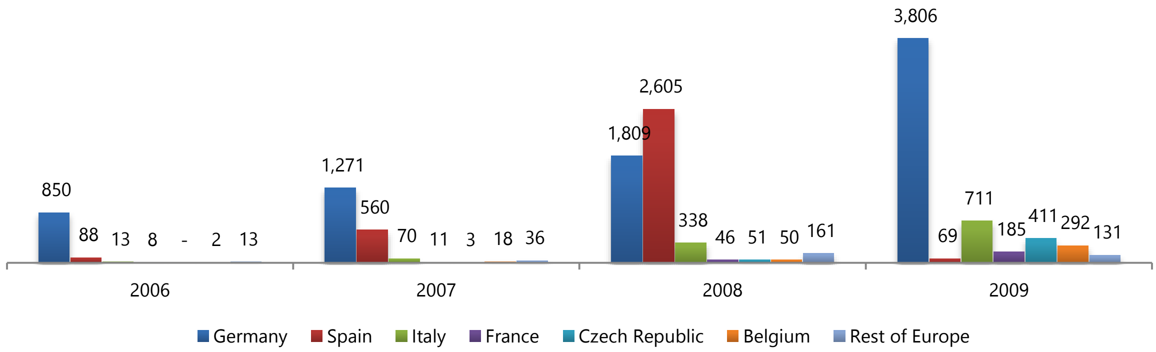
Figure 1: World PV Market (MW, 2006-2009)



Source: European Photovoltaic Industry Association (EPIA)

Outside Europe, the market developed significantly with 484 MW installed in Japan and 477 MW (including 40 MW of off-grid applications) in the USA. China emerged as a new player in 2009 with about 160 MW installed, and India with around 30 MW. In these countries, the long-term potential of the market is yet to be confirmed.

Figure 2: European PV Market (MW, 2006-2009)



Source: European Photovoltaic Industry Association (EPIA)

The EU represented 5.6 GW or 78% of the World PV market in 2009. And in Europe itself, the German market clearly dominates with 68% of the EU market. The emergence of Italy as a major market for PV, combined with the ramp-up of France and the impressive growth of the Czech Republic and Belgium, compensated the slowdown of the Spanish market.

One major change in 2009 was the emergence of new markets outside Europe, with Canada and Australia starting to develop, while Japan and the USA both presenting a significant potential in becoming new solar power markets in the coming years.

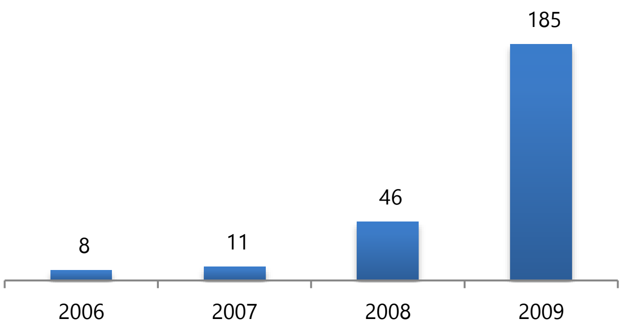
European Perspective, by Key PV Markets

France

With its well-designed FiT for Building Integrated Photovoltaics (BIPV), the French PV market is dominated by BIPV applications for residential and commercial applications. The FiT revision that occurred in January 2010 strengthened the conditions to apply for the highest BIPV tariffs to avoid abuses.

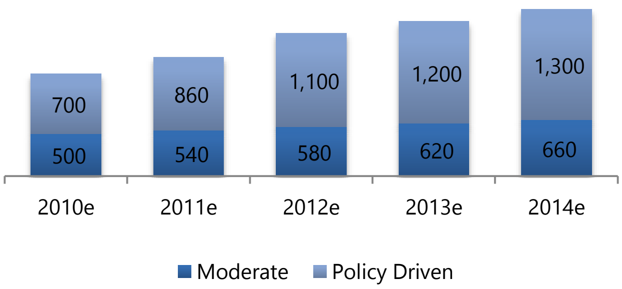
For ground-mounted systems, the French law introduced a correction coefficient that takes the difference of irradiation into account. Depending on the latitude, the northern regions can receive up to 20% of additional FiT in comparison with southern regions.

Figure 3: PV Market in France (MW, 2006-2009)



Source: European Photovoltaic Industry Association (EPIA)

Figure 4: Estimated PV Market in France (MW, 2010-2014)



Source: European Photovoltaic Industry Association (EPIA)

In 2009, 285 MW were installed but only 185 MW were connected to the grid due to long and slow administrative procedures. This situation has lasted for at least two years now and could put the brakes on PV deployment in France. Assuming this situation could finally be resolved in 2010, expectations for the 2010 French market are pegged at between 500 MW and 700 MW installed.

In the Moderate scenario[2], the French market could reach 660 MW of new installations in 2014. In the Policy- Driven scenario[3] and with a simplification of administrative procedures,

[2] The Moderate scenario: This scenario is based on the assumption of a 'business-as-usual' market behaviour which does not assume any major enforcement of existing support mechanisms but takes into account a reasonable follow-up of the FiT aligned on the systems prices.

the market could grow to 1.3 GW installed and connected to the grid in 2014. Under this scenario, the French PV market would become a leading country in the deployment of PV energy in Europe and worldwide.

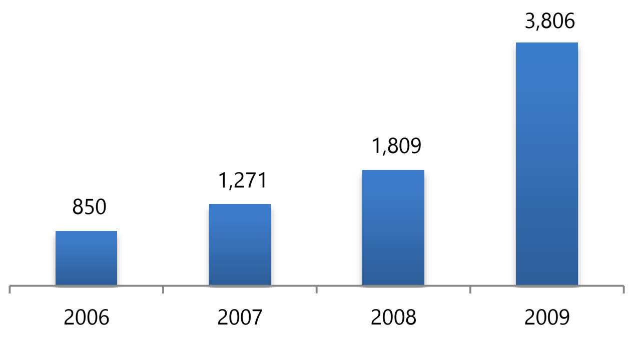
Moreover, the focus on BIPV, with stringent rules, is likely to support the development of innovative rooftop products and specific building applications.

[3] The Policy-Driven scenario: In this scenario, EPIA expects the follow-up and/ or introduction of support mechanisms, namely Feed-in Tariffs, accompanied by a strong political will to consider PV as a major power source for the coming years. This must be accompanied with a removal of non-necessary administrative barriers and a streamlining of grid connection procedures.

Germany

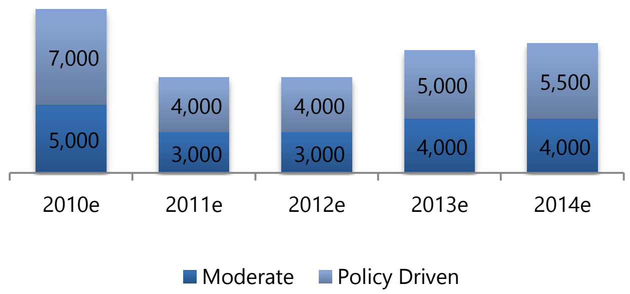
Germany regained its number one position as the largest PV market worldwide in 2009. The combination of a proven FiT scheme, good financing opportunities, a large availability of skilled PV companies, and a good public awareness of the PV technology, largely contributed to this success.

Figure 5: PV Market in Germany (MW, 2006-2009)



Source: European Photovoltaic Industry Association (EPIA)

Figure 6: Estimated PV Market in Germany (MW, 2010-2014)



Source: European Photovoltaic Industry Association (EPIA)

Once an exemplary support mechanism in Europe, the German FiT remains however a privileged scheme allowing sustainable market and industry development. The reinforcement of the net-metering premium which came into force in July 2010 with the EEG (FiT law) revision, would further contribute to the sustainable deployment of PV applications for households.

After the decline in FiT rates in January 2010, the German parliament voted in favour of lowering the rate further effective July 2010. With 16% lower FiT rates for rooftops, 11% for reconversion areas, 15% for the other installations and no more FiT for PV installations on agricultural land, the new law is expected to considerably affect the market in the coming years. In addition, the 'Corridor' concept (that adapts the FiT annual decrease to the market size of the previous year) was modified in an attempt to better control the market growth.

It is estimated that the German PV market could reach between up to 5 and 7 GW in 2010, and come back to around 3 GW to 4 GW annually from 2011 onwards. It is estimated that the market could stabilise in the 3 to 5 GW annual installations level by 2014, if the present support scheme is maintained, with adequate decline in FiT rate in line with the expected price decrease. The balance between segments will change in the coming years due to the halt of installations on agricultural lands. The self-consumption measures could favour local consumption for households and commercial buildings.

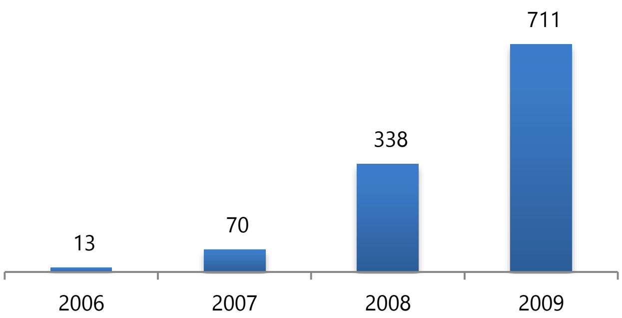
However, the substantial deductions in FiT could also jeopardise the development of the German industry, shifting the market to non-European low-cost manufacturers and potentially destroying jobs by thousands in the German industry. The €100 million of subsidies for PV research in Germany is a step in the right direction to ensure the competitiveness of the European PV industry in the coming years.

Italy

Besides high sun irradiation, Italy offers a very attractive support scheme, mixing net-metering and a well segmented FiT. In January 2009, the Italian government extended the net-metering to PV systems up to 200 kW. This meant that the PV system owner could value the electricity he produces at the same price as the electricity he consumes from the grid.

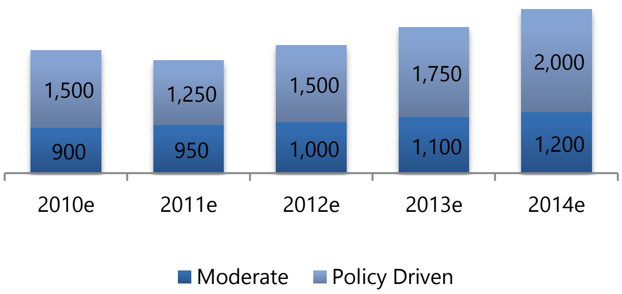
If, over a period of time, there is excess electricity fed into the grid, the PV system owner gets a credit for the value of the excess of electricity. This measure can be considered as quite attractive for the residential, public and commercial sectors. On top of the value of the electricity itself, the PV system owner also gets a premium FiT on the total electricity produced by the PV system. Under the current FiT propositions made for the new Conto Energia, EPIA expects a continuous growth of the Italian PV market, possibly reaching the 1 GW mark in 2010, under the grace period of the current Conto Energia.

Figure 7: PV Market in Italy (MW, 2006-2009)



Source: European Photovoltaic Industry Association (EPIA)

Figure 8: Estimated PV Market in Italy (MW, 2010-2014)



Source: European Photovoltaic Industry Association (EPIA)

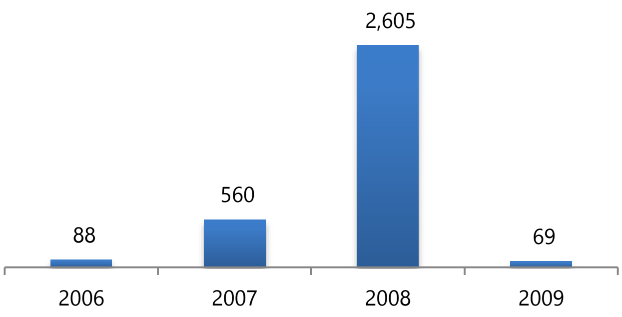
The future growth of the market will depend on the streamlining and harmonisation of administrative procedures, combined with an adapted decrease of the FiT in the third Conto Energia to cope with the expected price decrease.

With 711 MW installed in 2009, Italy took the second place in Europe and in the world, and could become the second GW market in 2010. According to the latest market development in the country, the market is expected to reach 1.5 GW and maybe even up to 2 GW in 2014.
The higher tariffs for building integrated PV systems (BIPV) also supports the development of innovative products and applications for roof mounted systems.

Spain

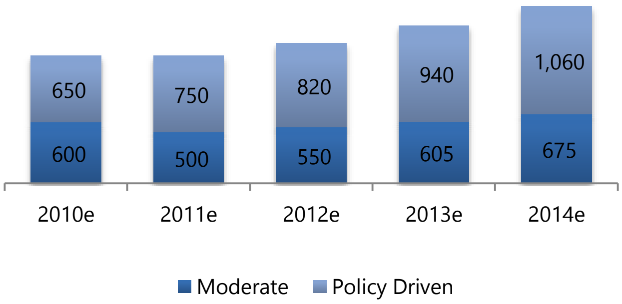
World leader in 2008 with 2,600 MW installed, the Spanish market went down to a very low 69 MW installed in 2009. Lack of new installed capacity was due to complex administrative procedures and delays related to the new market-cap, combined with the decline in prices that forced many developers to delay their already approved projects. The economic crisis also proved to be a major deterrent in 2009, impacting project financing.

Figure 9: PV Market in Spain (MW, 2006-2009)



Source: European Photovoltaic Industry Association (EPIA)

Figure 10: Estimated PV Market in Spain (MW, 2010-2014)



Source: European Photovoltaic Industry Association (EPIA)

The 2009 market remained concentrated in the large commercial and ground-mounted systems, with little place for households in the cap. In a Moderate scenario, the market could reach about 700 MW in 2014. In the Policy- Driven scenario, EPIA expects that removing such a barrier could help developing the households market and drive installations up to 1 GW in 2014.

The expected decrease in the FiT in 2010 could delay the market recovery but EPIA expects a 600 MW market in 2010 with many installations coming from the allocated projects from 2009.

Spain already experienced power generation overcapacities due to the electricity demand decline related to the economic slowdown. Despite high sun irradiation and PV potential, this has led the government to reduce the potential for PV and other renewable energy sources, which limits de facto the high potential of this market for the coming years.

Types of PV systems

Grid-connected

This is the most popular type of solar PV system for homes and businesses in the developed world. Connection to the local electricity network allows any excess power produced to be sold to the utility. Electricity is then imported from the network outside daylight hours. An inverter is used to convert the DC power produced by the system to AC power for running normal electrical equipment. In countries with a premium FiT, payment for the electricity generated is considerably higher than the usual tariff paid by the customer to the utility, so all the electricity produced is often fed into the public grid and sold to the utility. This is the situation in countries such as Germany and Spain.

Off-grid

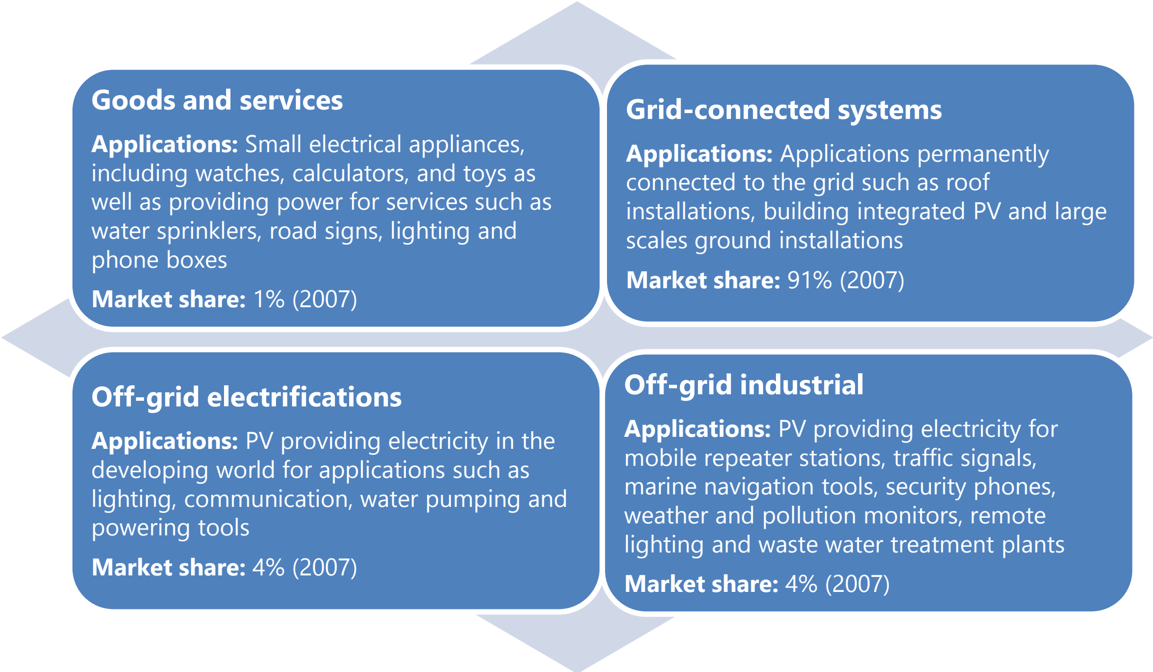
Where no mains electricity is available, the system is connected to a battery via a charge controller. This stores the electricity generated for future use and acts as the main power supply. An inverter can be used to provide AC power, enabling the use of normal electrical appliances. Typical off-grid applications are repeater stations for mobile phones, electrification for remote areas (mountain huts) or rural electrification in developing countries. Rural electrification generally refers to either a small solar home system covering basic electricity needs in a single household, or larger solar mini-grids, which provide enough power for several homes.

Hybrid system

A solar system can be combined with another source of power - a biomass generator, a wind turbine or diesel generator - to ensure a consistent supply of electricity. A hybrid system can be grid-connected, stand-alone or grid-support.

Market Sectors

Solar Photovoltaic Market Sectors



Source: Photovoltaic Market Presentation, Photonic Energy (April 2010)

Goods and Services

As demand for a mobile electricity supply increases, it is likely that the consumer goods market will continue to grow in absolute terms (although its relative share will decline), especially with the introduction of innovative low-cost solar electricity technologies such as organic solar cells.

Grid-connected Systems

Grid connectivity is the backbone of the industry, with countries identifying PV as the technology of the future and having established or setting up, support programmes. While in 1994 only 20% of new PV capacity was grid-connected, this had grown to about 90% by 2007.

Off-grid Electrification

For subsistence level communities, the initial stumbling block is often the capital cost of the system. Although numerous rural development programmes have been initiated in developing countries, supported both by multi-and bilateral assistance programmes, the impact so far has been relatively small. However, it is expected that this market segment will capture a substantial part of the global PV market share in the coming decades.

Off-grid Industrial

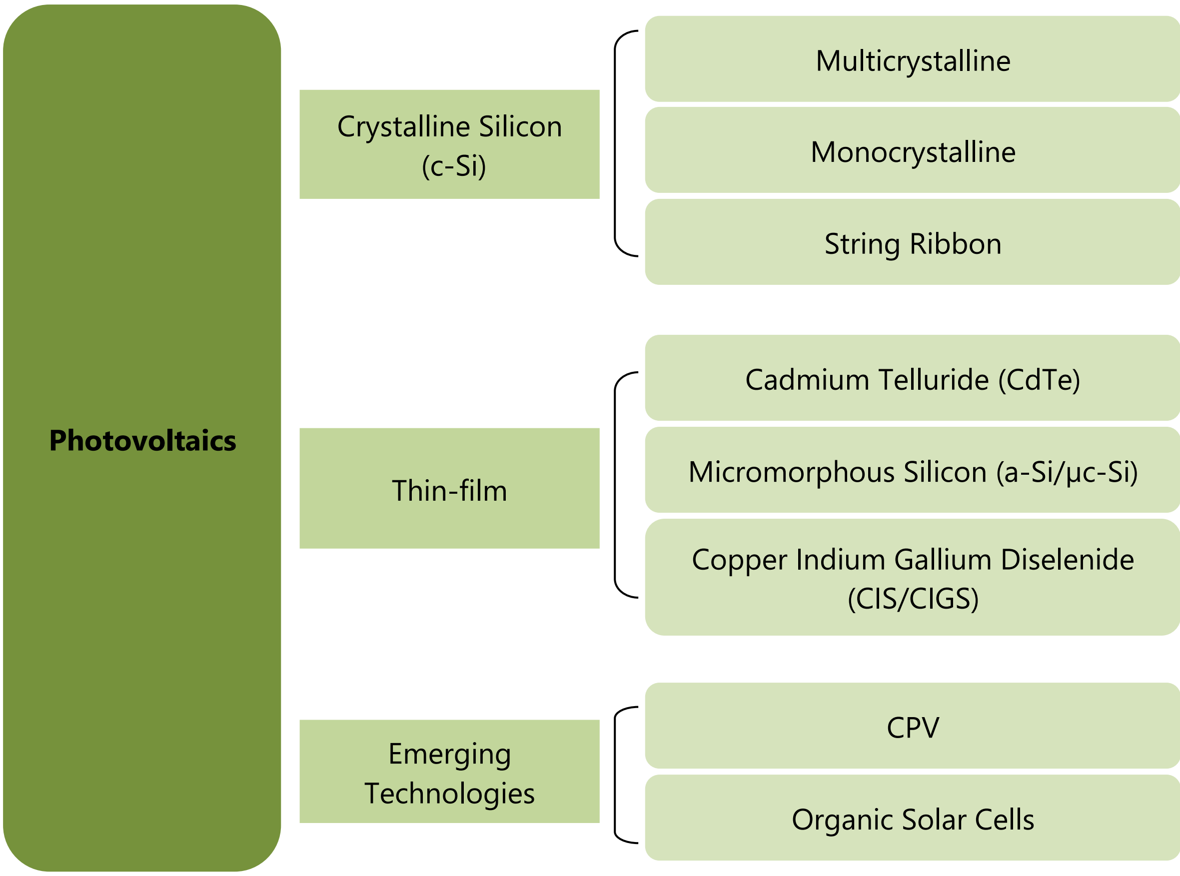
Industrial PV systems offer high reliability and minimal maintenance. This dramatically reduces operation and maintenance costs, particularly in very remote or inaccessible locations. The demand for off-grid industrial PV systems is expected to continue to expand in the future, especially in response to the continued growth of the telecom industry. Mobile telephone masts and repeater stations offer a particularly large potential, especially in countries with low population densities. Providing communications services to rural areas in developing countries as part of social and economic development packages will also be a major future market opportunity for photovoltaics.

Technology – An Overview

PV systems directly convert solar energy into electricity. The basic building block of a PV system is the PV cell, which is a semiconductor device that converts solar energy into DC electricity. PV cells are interconnected to form a PV module, typically up to 50-200 W. The PV modules combined with a set of additional application-dependent system components (such as inverters, batteries, electrical components, and mounting systems), form a PV system. PV systems are highly modular, i.e. modules can be linked together to provide power ranging from a few watts to tens of MW.

Extensive R&D in the field has led to the availability of a portfolio of PV technology options at different levels of maturity. Commercial PV modules may be divided into two broad categories: wafer-based c-Si and thin films. Additionally, there are a range of emerging technologies, including concentrating photovoltaic (CPV) and organic solar cells, that possess significant potential for performance increase and cost reduction.

Figure 11: SPV Technologies



Crystalline Silicon

Despite capacity limitations for feed stock material manufacture, PV production is growing at a rapid rate and c-Si technology continues to maintain its dominant position, with 85-90% of the global annual market in 2009. Planned expansion programs by almost all existing manufacturers and new capacities being created by fresh entrants are likely to result in a significant increase in world manufacturing capacity for feed stock material (polysilicon). Major capacity expansion programs both at the material and product levels coupled with productivity improvements and technology developments are likely to sustain the leading position of c-Si technology for a considerably longer time.

Issues of concern in c-Si mainly pertain to high production costs of polysilicon and high material content of silicon wafers. With physical limitations in reducing these parameters below certain levels, the ultimate cost per peak Watt is more likely to saturate around $1/W while it could be less for other technologies (mainly Thin-Film).

Thin Film Technology

In Thin Film solar cell / module technology, very thin layers of a chosen semiconductor material (ranging from nanometre to several micrometers in thickness) are deposited on to either coated glass or stainless steel or a polymer.

Amorphous silicon thin film solar cell is the earliest device developed in this area. Other types of thin film cells that followed are Cadmium Telluride (CdTe) and Copper Indium Gallium Diselenide (CIGS) solar cells. New developments in this field include 'Micromorph' Cells (a combination of amorphous and microcrystalline silicon materials) that have yielded higher efficiencies and have better stability features.

Concentrator Technologies

This technology uses an optical concentrator system which focuses solar radiation onto a small high-efficiency cell. CPV technology is currently being tested in pilot applications.

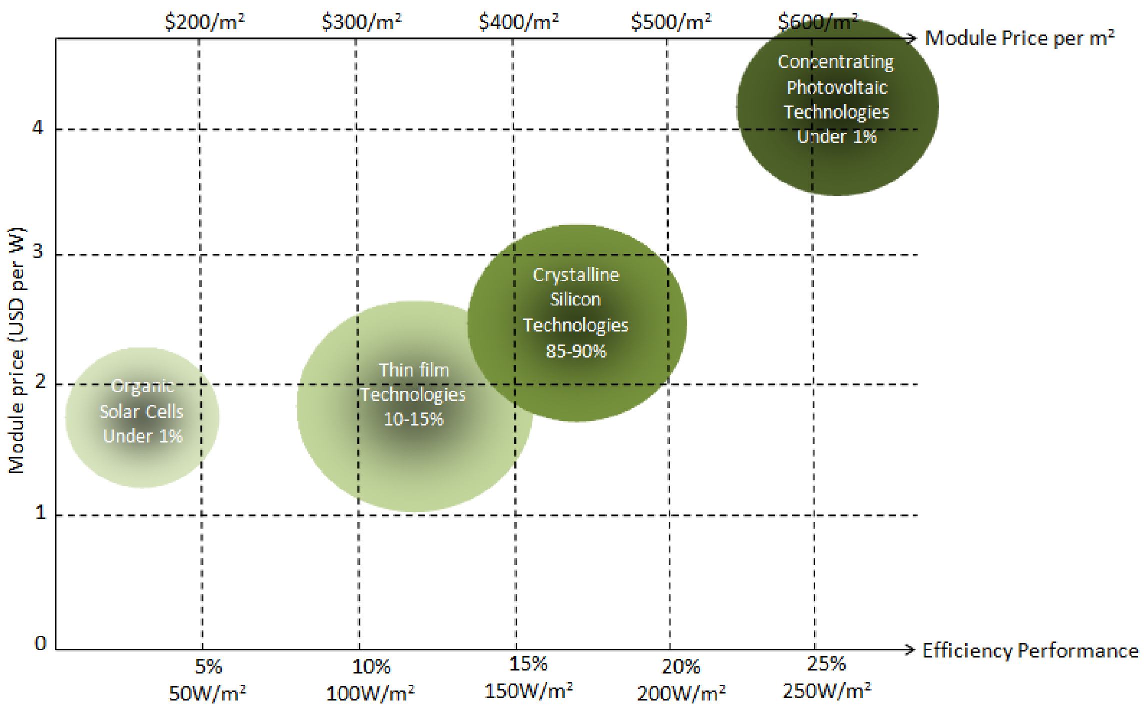
Organic Solar Cells

Such novel PV concepts aim at achieving ultra-high efficiency solar cells via advanced materials and new conversion concepts and processes. They are currently the subject of basic research.

Technology – Performance and Cost

The large variety of PV applications allows for a range of different technologies to be present in the market, from low-cost, lower efficiency technologies to high-efficiency technologies at higher cost. The lower cost (per watt) to manufacture some of the module technologies, namely thin films, is partially offset by the higher area-related system costs (costs for mounting and the required land) due to their lower conversion efficiency. The following figure gives an overview of the cost and performance of different PV technologies.

Figure 12: Performance and price of different PV technologies



Source: 'Technology Roadmap – Solar Photovoltaic Energy', International Energy Agency (October 2010)

Conversion efficiency, defined as the ratio between the produced electrical power and the amount of incident solar energy per second, is one of the main performance indicators of PV cells and modules.

PV systems can be connected to the utility grid or operated in stand-alone applications. They can also be used in BIPV or be ground-mounted, for example, in large-scale, grid-connected electricity production facilities.

Table 1: Efficiencies of different PV technology commercial modules

Wafer-based c-Si		Thin films		
sc-Si	mc-Si	a-Si; a-Si/µc-Si	CdTe-Te	CIS/CIGS
14-20%	13-15%	6-9%	9-11%	10-12%

Source: 'Technology Roadmap – Solar Photovoltaic Energy', International Energy Agency (October 2010)

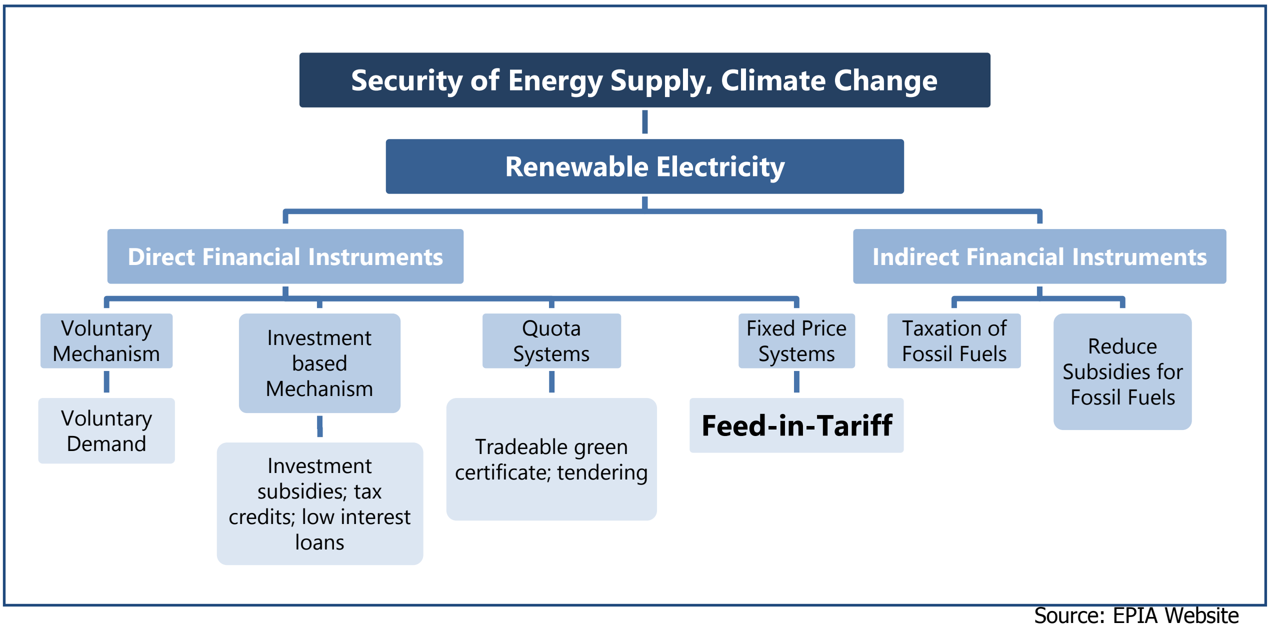
The investment costs of PV systems are still relatively high, although they are decreasing rapidly as a result of technology improvements and economies of volume and scale. High investment costs, or total system costs, represent the most important barrier to PV deployment today.

Total system costs are composed of the sum of module costs and the expenses for the balance-of-system, including mounting structures, inverters, cabling and power management devices.

While the costs of different technology module types vary on a per watt basis, these differences are less significant at the system level, which also takes into account the efficiency and land-use needs of the technology. Total system costs are sensitive to economies of scale and can vary substantially depending on the type of application.

Support Mechanisms

Structure of Support Mechanisms



Source: EPIA Website

In order to accelerate the reconstruction of the electricity supply system, it is necessary to implement powerful and efficient tools supporting the use of solar power. Like every other industry, the solar power sector will only move forward if sufficient investments are committed to provide for its expansion. Over the past few years, the solar industry has been very successful in drawing the attention of the financial world to this young and dynamic market. However, both industry and governments need to ensure that the financial world maintains its interest in renewable energy in order to make sure that the necessary financing is in place to keep up the current rate of expansion.

There are different ways to support renewable electricity, including awareness building and removing barriers such as limited access to the electricity grid. Experience has shown that a well designed FiTs the most suitable form to support PV electricity.

Feed-in Tariff

Contrary to quota system, in FiT schemes, a price for each kWh that is produced is fixed. The basic idea behind a FiT is very simple.

Producers of solar electricity

- Have the right to feed renewable electricity into the public grid
- Receive a tariff per generated kWh, reflecting the benefits of solar electricity compared to electricity generated from fossil fuels or nuclear power
- Receive the tariff over a fixed period of time

Feed-in tariffs: A temporary measure to develop the market

Feed-in tariffs are a temporary measure to develop the competitiveness that results from economies of scale. Competitiveness with conventional electricity sources will be reached in different regions at different times. Therefore, FiT systems need to be adapted to national conditions. However, it is important that tariffs are paid over a period of roughly 20 years from the day the system is connected to the grid because the costs will be related to the initial investment. In a few years, investment costs will be low enough to be paid off without using the support of feed-in tariffs.

Feed-in tariffs: Who pays for it?

The feed-in program works independently from the state economy, and the extra cost which each electricity consumer has to pay in order to increase the share of renewable energy in the national electricity portfolio is very small. This also means that every electricity consumer contributes to the restructuring of the national electricity supply network away from a fossil-based one and towards a sustainable and independent structure. In the past, many programs were financed through government budgets; however, the disadvantage of this approach is that if the money ran out, or was curtailed, the program could be stopped. FiT models which are financed through regular electricity bills do not suffer from this drawback.

Feed-in tariffs: The driver of cost reduction

The costs for solar electricity have been declining consistently since the technology was first introduced to the market. Even so, in most cases solar electricity cannot yet compete with grid electricity generated from fossil fuels. Although, it is expected that prices for electricity generated from fossil fuels will keep rising, it is still very important to maintain a strong momentum in bringing down the costs for solar electricity.

For this reason, the FiT in Germany is reduced each year, but only for newly installed PV systems. Once a PV system is connected to the grid, the tariff remains constant over the complete period of 20 years. Through this annual reduction, there is therefore constant pressure on the PV industry to bring the costs for solar electricity down each year in order to keep the market attractive.

Feed-in tariffs: The driver of high-quality solar electricity systems

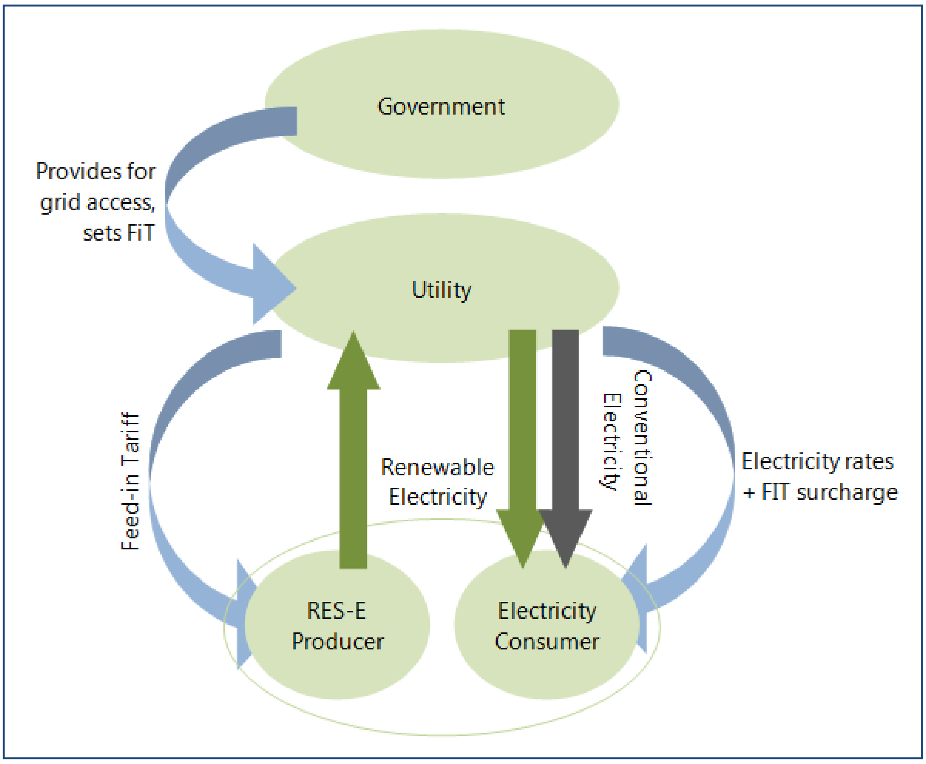
Many solar electricity support programs are based on an investment subsidy in order to reduce the barrier of high up-front capital costs. The drawback of such an approach is the missing incentive to invest in high quality solar electricity systems and to ensure their efficient operation and maintenance. If the customer receives a fixed payment per installed capacity unit, there is no incentive to go for high-quality products, which usually mean a higher price, or to operate the system at the highest possible level. With feed-in tariff, the return on investment is heavily dependent on the performance of the PV system. The customer gets his return on investment with each kWh that is fed into the grid. Therefore, maximizing the power output of the PV system over its whole lifetime is essential to the customer, ensuring that the PV system will be well operated and maintained.

Feed-in tariffs: Investment security

A FiT guaranteed by law over a sufficient period of time serves as an excellent security for the customer's bank in order to finance the system. The PV system itself, combined with the guaranteed FiT over 20 years in Germany, is usually sufficient to receive a loan from a bank. Of course it took some time for banks to become familiar with PV systems and the implications of the feed-in tariff. Nowadays the financing of PV systems via bank loans in Germany is no longer a time-consuming activity but very common and straightforward.

Germany's FiT Program – a Successful Evolution

FiT in Germany – Basic Principles



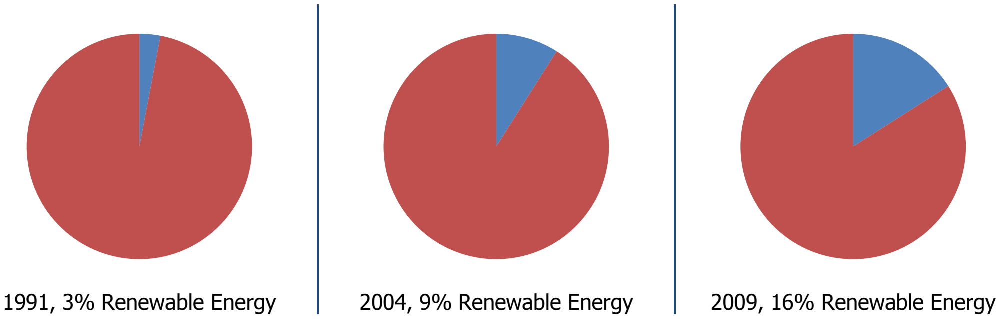
Source: EPIA Website

The first real Feed-In Law in Germany was the Stromeinspeisungsgesetz (StrEG) introduced in 1990, otherwise known as the Electricity Feed-In-Law. This bill required utilities to connect renewable energy generators to the grid, and to buy the electricity produced at a rate of 65-90% of the average tariff charged per unit to end-users.

In 2004, Germany brought in the era of modern FiT programs. The program paid a fixed rate for every kilowatt hour (kW/hr) generated by a solar PV system for 20 years from the date of commissioning, and included a digression schedule which annually lowered FiT rates to offset anticipated declines in the cost of solar PV systems. The initial rates introduced in 2004 were attractive enough to drive a multi-GW annual solar PV installations market in Germany.

Surprisingly, the program has been efficient at maintaining adequate, but not excessive project returns over several years. Germany's long-term experience with FiT is partly credited with spurring its tremendous renewable energy growth, as depicted in the graphs below.

Figure 13: Renewable energy growth in Germany with a feed-in-tariff, 1991-2009



Source: 'Feed-in Tariffs (FIT): FAQs for State Utility Commissions', The National Association of Regulatory Utility Commissioners (June 2010)

Germany points to the success of its FiT in its higher level of installed renewable energy capacity than its European counterparts, but this growth came at a cost of a 3% rate increase for consumers in the lifetime of the program. Even now, critics insist that renewable energy growth in Germany has many positive externalities. FiT-supporters assert that it has resulted in robust job creation in the renewable energy industry, pointing to Germany's leadership in renewable energy components and supply production. In addition to job creation, the FiT has achieved support because it enables communities to build their own systems and make a profit, accruing more visible benefits locally. The German renewable energy market may be headed for a change, however.

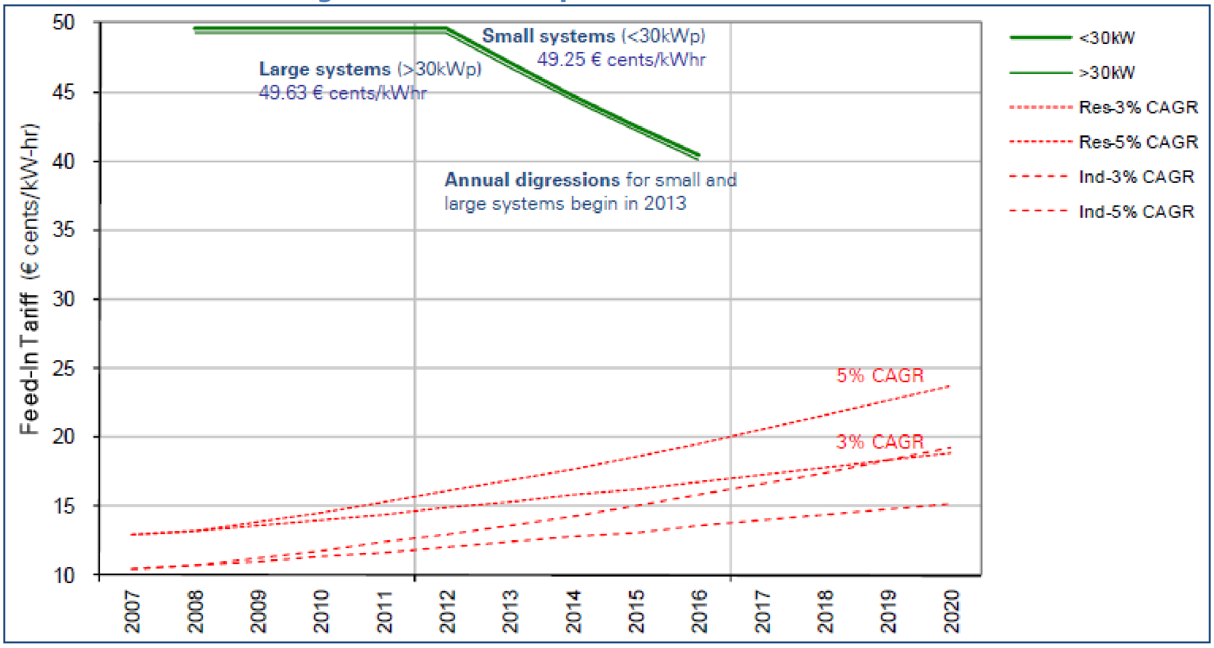
A large decline in PV system costs in 2009 led the German parliament to propose a 16% payment reduction for PV in March 2010, meant to reduce unnecessary costs to the consumer. The governments from the 16 German states, called for relaxed payment cuts of no more than 10%, likely to protect German PV producers and manufacturers that would be affected by the payment reductions. The payment reduction may be stalled as the federal-state debate persists, and consequently speculation and uncertainty about its effects on the economy, jobs, and the global PV market will continue. Regardless, it would seem that German consumers will bear FiT costs for many years to come, as current solar FiT payments are nearly eight times higher than the market electricity price at 39 eurocents per kW, and FiT generators remain utterly dependant on these subsidies to survive.

Feed-in Tariffs Activity Overview

Czech Republic

Region	Historical View	Recent Activity	Outlook
Czech Republic 2010: ~1.2GW 2011: ~260MW	▪ Adopted FiT program in 2005, but installations started to pick up starting in 2009 and surged to new highs in 2010	▪ Bill to cut FiT rates by 50% passed in the lower house, but not yet ratified ▪ Senate approves 3 year, 26% tax on FiT revenue	▪ A sharp drop off in solar PV installations in 2011 as investors shy away from FiT reneges is expected

Figure 14: Czech Republic – FiT Rate Schedule



Source: German EEG reports, EuroStat, and Deutsche Bank estimates

The Czech Republic initiated a FiT program in 2005. Installations began gaining traction in 2008 when ~51MWp were installed. The program is very simple and offers a very high FiT rate for all systems (categorized as <30kWp and >30kWp) in order to compensate for weak solar irradiance.

High FIT rate for all systems

The Czech Republic's solar PV FiT program offers €49.63 cents/kWhr for systems <30kWp, and €49.25 cents/kWhr for systems >30kWp. These rates begin annual digressions of 5% in 2013.

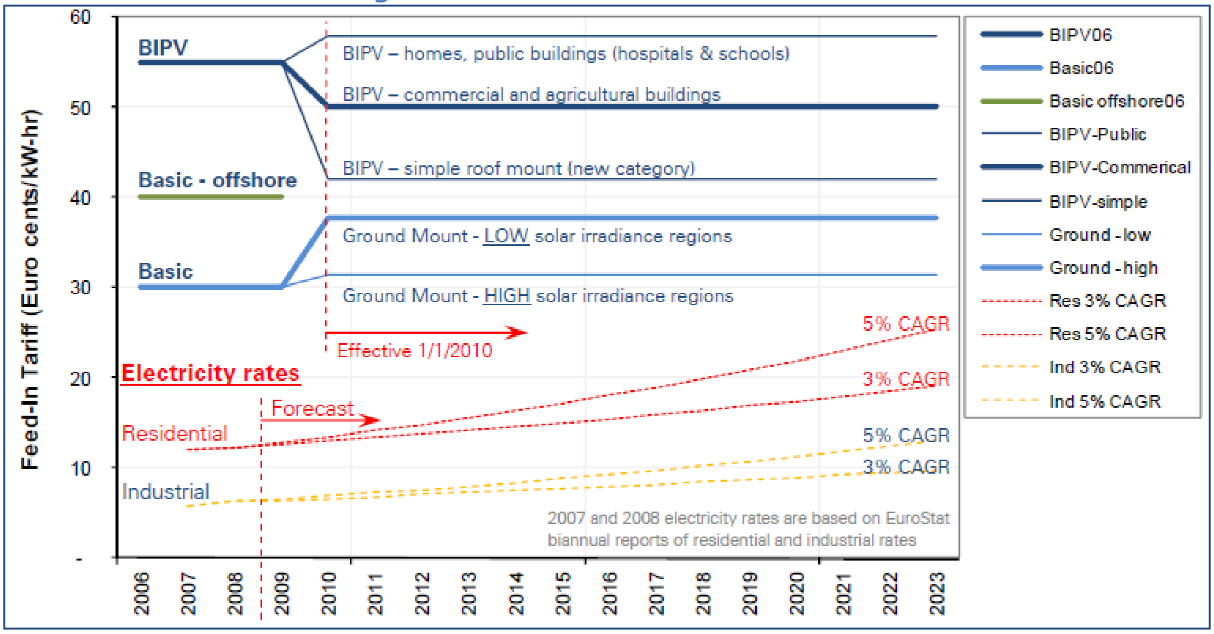
Incentivizing all systems

The program is designed to incentivize all types of solar PV installations. As the market evolves, there would be adjustments to the FiT program (similar to Germany) to potentially incentivize particular types of systems, and manage project returns and installation rates.

France

Region	Historical View	Recent Activity	Outlook
France 2010: ~555 MW 2011: ~500 MW	▪ Adopted FiT program in mid-2006 ▪ Rooftop/BIPV get best rates ▪ Focus on aesthetics	▪ Enacted FiT rate cut for ground mount installs on 1 Sep'10 ▪ 4-month moratorium on new solar PV connections to slow growth ▪ May impose a soft cap of 500MW	▪ The French government will likely cut FiT rates in March 2011 (when install moratorium is lifted) ▪ Likely to mandate an installation cap at an annual 500MW

Figure 15: France – FiT Rate Schedule



Source: German EEG reports, EuroStat, and Deutsche Bank estimates

France adopted a revised FiT rate structure in July 2006, which was in effect until the end of 2009. These FiT rates were adjusted annually for inflation (at 60% of the previous year's inflation rate), leading to higher rates than those originally set in mid 2006.

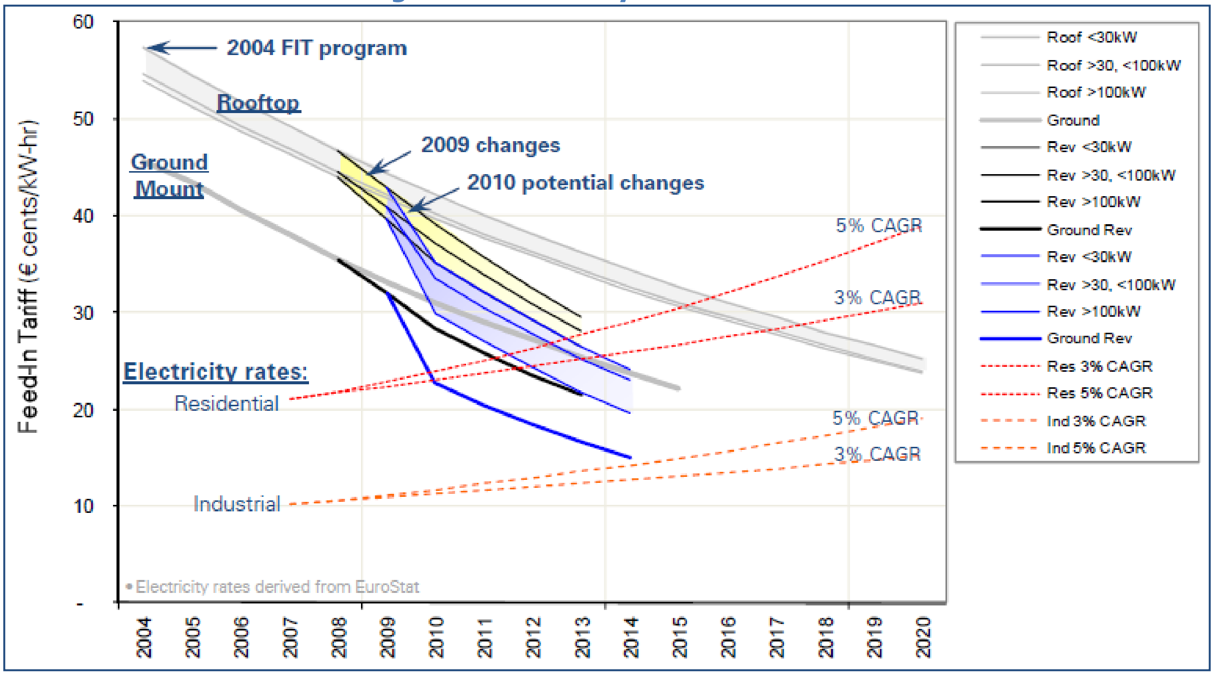
France adopted a new FiT rate structure for implementation in January 2010 after raising the prospect of a new rate structure in Sep 2009. However, there was no mention of an annual adjustment for inflation, or caps that could limit installations. The new FiT rates will remain unchanged until 2012, but a digression schedule (like Germany) could be introduced at that time.

France enjoys relatively low electricity costs within the EU community due largely to the fact that more than 75% of electricity is generated by nuclear power and most of the balance comes from hydroelectricity. Low electricity prices mean that convergence with the price of electricity generated from solar PVs is still far away.

Germany

Region	Historical View	Recent Activity	Outlook
Germany 2010: ~7.1GW 2011: ~5.8 GW	▪ Longest history of FiT incentives ▪ Adopted a very attractive FiT program in 2004 ▪ Revised its FiT program in 2009 to curb installation growth	▪ Midyear FiT cuts effective 1 Jul'10 (~13%), and 1 Oct'10 (~3%) ▪ Restrictions in the use of farm land for open field installations ▪ Talks of multiple FiT cuts in 2011 and the potential for a cap (3GW)	▪ Midyear FiT cuts effective 1 Jul'10 (~13%), and 1 Oct'10 (~3%) ▪ Further growth will become increasingly more challenging ▪ Ground mount power-plants to drop sharply in 2011 ▪ More midyear FiT cuts likely in 2011, but no hard cap

Figure 16: Germany – FiT Evolution



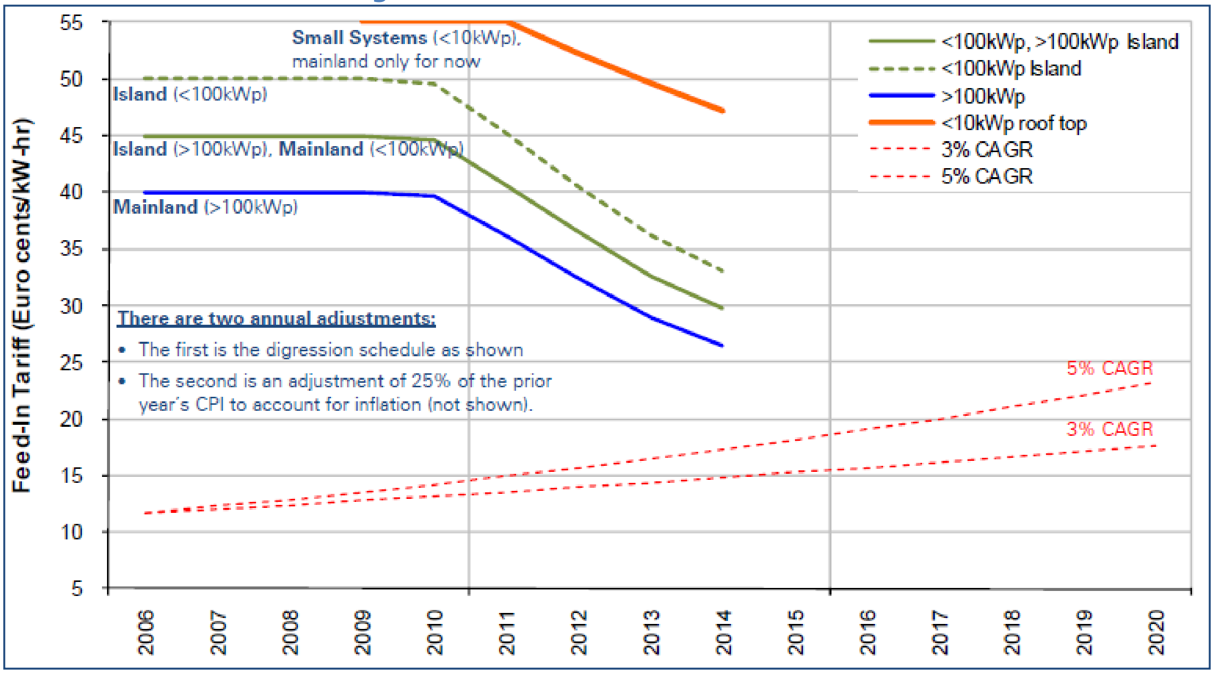
Source: German EEG reports, EuroStat, and Deutsche Bank estimates

In the above graph, under the hypothetical scenario, FiT rates for smaller systems could equal residential grid rates by 2013. This would mark a key convergence in that FiT rates for residential installations could be scaled back more substantially, ensuring only that adequate project returns are provided in what would be a final withdrawal of a segment of the market from FiTs. Ultimately, segments could begin to roll off of FiTs entirely, as the program was likely intended to enable.

Greece

Region	Historical View	Recent Activity	Outlook
Greece	▪ Adopted FiT program in 2007, with plans for nearly 750MW over four years; however, installations have stalled due to macro factors	▪ Austerity measures weighing on all projects ▪ Green project fund passed, but having little impact on solar PV	▪ Macro factors weigh in on Greece; ▪ Is not expected to be a meaningful end market in 2011

Figure 17: Greece – FiT Rate Schedule



Source: German EEG reports, EuroStat, and Deutsche Bank estimates

Greece adopted its initial solar PV incentive program in June'06, providing attractive FiT rates as well as other incentives, which when coupled with an abundance of sunlight, should have driven a large market. However, very slow processing of applications and restricted credit has severely limited solar PV generation potential in Greece.

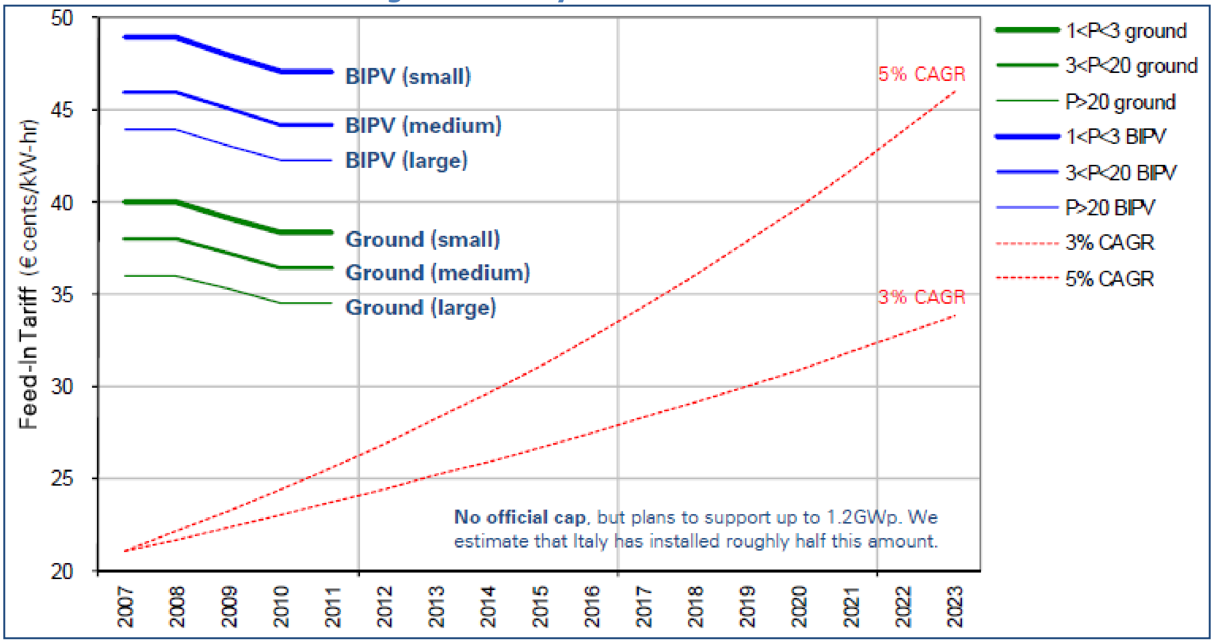
Greece adopted a new FiT rate schedule in January'09 which provided a digression plan for existing FiT rates. With ~3.0GWp already in queue at the end of 2009, this delayed digression schedule is expected to help stimulate solar PV demand in 2011. This, however, presupposes that bureaucratic delays abate.

In June'09, the Greek government adopted a new FiT rate schedule for residential systems (<10kWp), offering a very attractive rate of 55.0 € cents/kWhr, and a 5%/year digression starting in 2012.

Italy

Region	Historical View	Recent Activity	Outlook
Italy 2010: ~1.3GW 2011: ~1.4 GW	▪ Adopted FiT program in 2007 with 2% digression scheduled for 2009 and 2010 ▪ Italy has a ~3GWp installing goal over 3 years (2010 - 2012)	▪ Planned 2011 FiT cuts to be implemented in three phases, with ground mount systems seeing larger cuts than rooftop	▪ More FiT cuts likely to be announced for 2012, along with talks of a cap ▪ Installations are expected to grow y-o-y as FiT rates remain relatively attractive

Figure 18: Italy – FiT Rate Schedule



Source: German EEG reports, EuroStat, and Deutsche Bank estimates

Italy offers very attractive FiT rates which favour smaller systems (similar to France), but high solar irradiance makes Italy an economically attractive market. As in Germany, precipitous module ASP declines through 2009 drove high project returns.

In November'09, Italy's three industry associations, namely GIFI (Italian Photovoltaic Industry Association), APER (Italian Renewable Energy Association) , ASSOSOLARE (Italian National Photovoltaic Industry Association) proposed new FiT rates to take effect beginning in 2011 citing a rapid decline in solar PV system installation costs. Should the Italian government align its new FiT rates to the rates suggested by the trio of industry associations, it would imply a nearly 20% cut. This would continue to offer attractive enough project returns to drive substantial market growth provided bureaucratic impediments are removed.

Spain

Region	Historical View	Recent Activity	Outlook
Spain	▪ Adopted one of the most attractive FiT programs in 2006 ▪ Surge in installations led to severe cuts and 500MW hard cap	▪ Announced planned FiT cuts: 5% for small rooftop, 25% larger rooftop, and 45% for power plants ▪ Threats of retroactive FiT cuts did not pass	▪ Spain still not recovered from the sharp pull back in 2009 ▪ Given growing burden of funding the FiT program, Spain is not expected to be a meaningful market in 2011

United Kingdom

Region	Historical View	Recent Activity	Outlook
United Kingdom 2010: ~100MW 2011: <150MW	▪ Adopted FiT program in early 2010 ▪ 41.3 £ cents/kWh down to 29.3 depending on size of system	▪ Adoption of new FiT rates have led to robust growth, but not likely to break over 200MWpi in 2011	▪ Installations in the UK are expected to grow y-o-y, but at a moderate pace (and still relatively small)

Challenges facing the PV Industry

Polysilicon Costs

One of the main hurdles to PV growth is the cost of polysilicon which accounts for approximately half of total production costs of a PV module. Polysilicon has been highly volatile in the last few years, with prices varying by up to a factor of ten. Only the top surface of the silicon wafer generates the current, while the rest of this expensive material in the wafer is wasted by only functioning structurally. Although manufacturers are developing increasingly thin silicon wafers, advancement is slow, and currently available technology places limitations on how thin the wafers can be manufactured. Solutions to minimize the use of silicon will reduce production costs and improve overall efficiency.

Grid Parity

Although the PV industry has been steadily reducing costs while concurrently increasing efficiency and production volume, power from PV is still above grid parity, which means solar energy is still dependent upon government support such as subsidies and incentives to be competitive with conventional electricity supply. As producers aim for and achieve prices closer to grid parity, PV will become increasingly competitive with other electricity sources.

Partial Shading

Obstructions either on the solar panel or between the solar panel and sunlight create the effect of partial shading, which impairs the performance and efficiency of PV panels. Advancements are being made to minimize partial shading and increase efficiency.

PV Efficiency

Although efficiencies of the conventional and still dominant polysilicon-based technology have increased, PV efficiencies are still relatively low compared to the potential for utilization of the sun's energy. Additionally, polysilicon material production is energy-intensive, and there are physical limits to materials utilization efficiency inherent in the wafer fabrication process.

DC Generation

PV generates DC electricity, which can be stored and recovered as DC using batteries, capacitors, etc. Some other storage technologies, and integration with the grid, involve conversion to AC power. Additionally, some uses require different voltages than can be generated by PV. AC/DC conversion systems and voltage transformers add costs. Solutions need to be developed to maximize electricity generation and control costs.

Insolation Implications

'Insolation' is the incident sunlight over time at any location and is influenced by a number of different factors including, the diurnal (day-night) cycle, seasonal daylight cycles, cloud cover, dust, snow, leaf fall and other solids accumulations at various times and places. The vast majority of current solar capacity is located in Europe, which has relatively low insolation levels. There are great possibilities to develop solar energy in many parts of the world where there is a high potential to harness solar energy based on good insolation. Most of these regions do not have much PV presence, and there is a significant opportunity to expand into these regional markets. Also, solutions are being developed to enhance insolation mechanically, such as with mirror arrays, sun-tracking systems, and surface coatings that help collect light arriving at different incident angles.

Dispatch-ability

The limited dispatching capability of PV (ability to supply electricity to a local user or the grid when demanded) is related to insolation patterns. The solution and challenge, as with most other renewable electricity sources, is to develop appropriate storage systems and integration with a multi-faceted grid system.

Value Chain and Positioning Types

When analyzing PV projects, four dominant value chain positioning types become apparent. The players range from the highly integrated and nation-wide players, to the niche, geographic and application market of local solar PV installers. While in reality there are a whole host of strategies being applied in this burgeoning market, the four described below are the most adopted and successful ones.

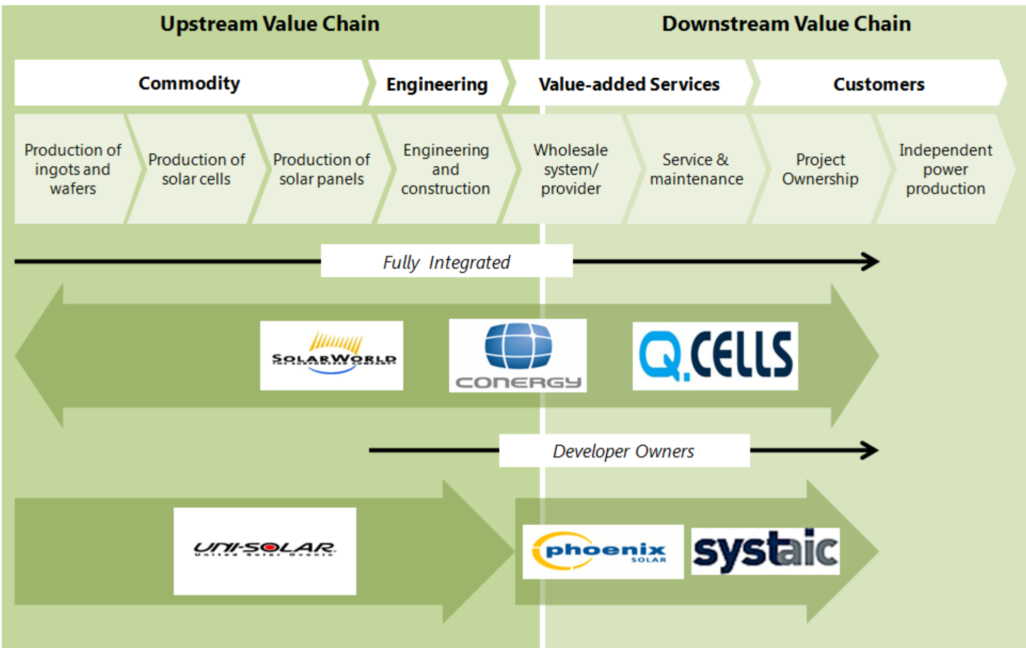
Fully Integrated

Currently, SolarWorld and Q-Cells are amongst the truly integrated solar PV providers in Germany, and are active in all stages of the value chain from being technology integrators to designing and installing projects and even owning projects in some situations. The figure below illustrates the positioning of the two companies on the value chain.

Though they are active in all these roles simultaneously, they also undertake projects and act as role players in providing technology, only developing projects, or selling the projects off to a customer or third party owner. By acting as fully integrated 'Solar Service Providers', the companies leverage their wide range of competencies, lowering project cost, and simplifying projects for the customers (requesting the projects). This also means that they have the flexibility that allows them to fill voids in projects, play multiple roles, and be insulated from competitors who may only operate in specific roles or niche markets.

Additionally, such companies have the advantage of being able to link up direct market intelligence gained through operations between demand-pull of the PV market and react to it through expanding capacity and thus ensuring they meet market demand with internal PV module supply.

Figure 19: Value Chain Illustration of Fully Integrated and Developer Owner Models



Source: EOS Intelligence Research and Analysis

Developer Owners

The next tier down from being fully integrated PV solar service providers, are a group of developer's who do not have technology integration capabilities, but are well versed in all phases of project development and often own and operate projects.

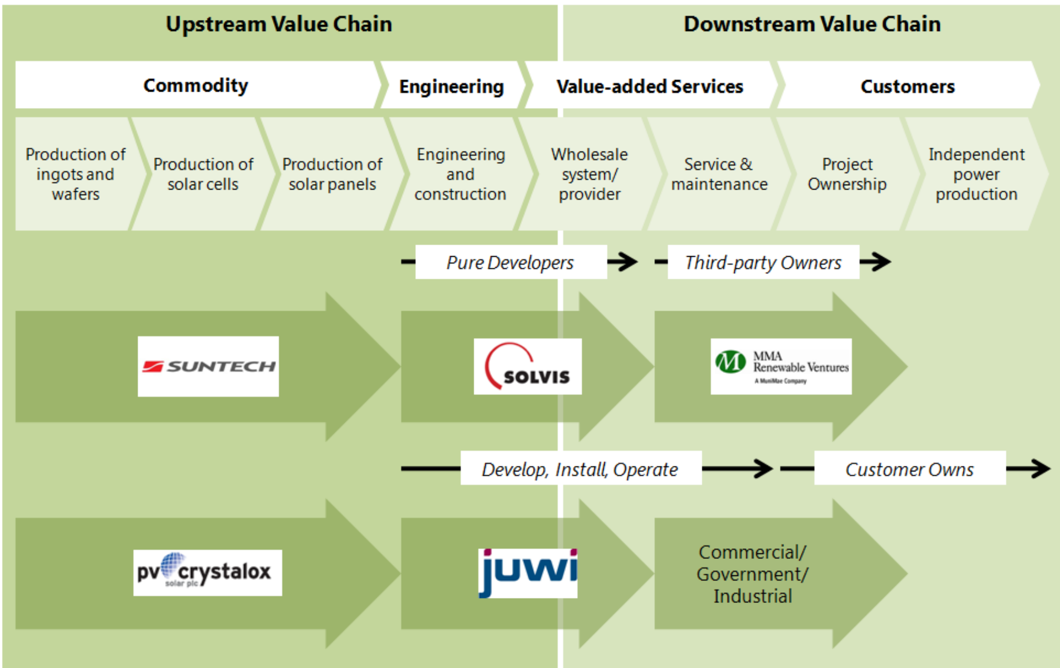
The key aspect to this positioning model is that gradually as the developers' relationship with technology providers becomes crucial and they establish exclusive relationships with chosen technology providers, acting as indirect technology promoters. Under these arrangements, technology providers assure developers access to modules at a certain price and developers only design systems utilizing the PV modules being provided by the technology supplier.

The consequence of this could be competition among developers to secure favourable positions with major technology suppliers if supply of PV modules becomes stressed, thereby resulting in stronger partnerships, and effectively squeezing out players in both roles who have not entered into partnership agreements.

Segmented Market

Under this market, niche players fill 1-2 positions within the market. Many of the larger technology suppliers operate in this mode, where pure developers create PV system designs for customers, procure the necessary technology, install the system and then sell it to a third party owner, who is typically a financier. The concerned third party owner then usually offers the electricity generated by the system to the customer through what is usually a long term (10 or 20 yrs) power purchase agreement at a fixed rate. The Renewable Energy Certificates (REC) or green tags created for each kWh generated are then usually owned by the third party financier, who also typically secures a long term REC purchase agreement with a utility for a predefined duration.

Figure 20: Value Chain Illustration of Segmented and Customer-owned Models



Source: EOS Intelligence Research and Analysis

Part of this business transaction usually involves a rent-to-own clause which would allow the power purchaser (customer) to buy the entire PV system at a later date a reduced cost, from the third party financier.

This model was formed partly as a result of many of the technology providers, developers, and financier/operators coming from other industries and having very specific competencies in these roles, but not necessarily in this specific industry.

Customer Ownership

Though it appears to be phasing out, the model of developers designing, installing, and operating PV systems is still prevalent. This approach has been used extensively by the government organisations as they benefit from particularly generous production incentives and utility rebates.

Commercial entities usually engage in this for a variety of reasons, including the federal, state, or local tax incentives, but often companies with a strong interest in clean energy development will own projects to gain experience.

Many technology suppliers such as Kyocera and Sharp have chosen to build and own their own PV systems as they are the technology suppliers and use this approach as an opportunity to showcase their products at manufacturing facilities and corporate headquarters.

Key Value Chain Trends

Expansion Along the Value Chain

Expansion along the value chain in the PV industry has occurred to some degree, as firms seek to gain reduce risks of module price and supply fluctuation and capture economies of scale. A total of 61 such transactions were reported in the solar industry between July 2008 and March 2009.

This consolidation is likely to end the current fragmentation of the solar PV market and facilitate the emergence of larger industry players. Companies having large production capacities at their disposal will benefit from the consequent economies of scale. This will result into a further decrease of the manufacturing costs.

An alternative approach to value chain expansion is strengthening partnerships between players by signing agreements of exclusivity. This has occurred most frequently between technology integrators and developers. Akeena Solar, a small US-based developer, entered into an agreement with Kyocera, one of the top world manufacturers and suppliers of PV modules.

The Rise of the PPA (and expansion into ownership)

The Power Purchase Agreement Model (PPA), driven primarily by heavily reliance on this approach by SunEdison in California, USA, is proving to be the PV system ownership model of choice. This is primarily due to the attractiveness for PV customers in this model. It requires no capital outlay for the purchaser of the electricity. Additionally, it reduces uncertainty in energy prices for the user, as the PPA rates are usually predetermined and are either flat or increasing slowly at an agreed upon schedule. These characteristics make the PPA more attractive than dealing with variable prices of utility supplied generation.

Third-party Ownership

The third party ownership has grown in tandem with the rise of the PPA model. Here companies with experience in finance such as Morgan Stanley, GE Finance, and MMA Renewable Ventures finance the upfront costs of a PV project and secure future cash flows from the project through the PPA model with the customer who is having the PV system installed. This allows for specialization and project development efficiency to occur as players who are most experienced fill the individual roles, technology integration, design, installation, and financing, along the project development value chain. These third party financiers, take on the project risk related to changes in subsidies or regulatory policy, but gain the incentives being offered along with the payments from the PPA. Additionally, these players typically have access to cheaper and a wider variety of capital than the project developers, who would otherwise own the projects, do.

Country Focus – Germany

Overview of the German PV Market

World's Largest Market

Germany is the world's strongest PV market with 3.8 GW of new PV installations and a 52.8% share of newly installed capacity worldwide in 2009. The corresponding investment volume for the same period amounted to around €10 billion, generating an accumulated end-of-year PV capacity of 9.8 GW. This is equivalent to a 42% total share of globally installed PV capacity, making Germany home to nearly half the solar modules in operation worldwide.

Strong Government Commitment to Further PV Growth

The German federal government has targeted an accumulated national PV capacity of 42 GW by 2020 and expects grid parity in the private consumer segment in 2013. The estimated PV share of total electricity consumption is expected to rise from the 2008 level of below 1% to 10% in 2020.

Thriving Industry and Value Chain

There are 70 manufacturers of silicon, wafers, cells, and modules. In addition, there are over 200 PV material and equipment suppliers, more than 100 balance-of-system component manufacturers, and hundreds of project development, system integration and installation companies. These currently employ around 64,000 people in the German PV industry. With solar cell production in Germany at 2,456 MW in 2009 and module production for the same period at 2,065 MW, PV manufacturers generated turnover of €8.6 billion.

Increased Export and Revenue Levels

Owing to excellent export conditions and strong international demand for 'Made in Germany' PV products, German manufacturers have been able to consistently increase their export share in recent years, from 14% in 2004 to 47% in 2009. PV equipment suppliers generated turnover of €2 billion and an export share of 79% in 2009, boosting total PV industry exports to €5.6 billion for the year.

Planning for the PV Future

In order to meet strong future growth, the German PV industry made net investments in German production capacities of around €1.8 billion in 2009. A further investment of €1 billion in R&D is planned for the period through 2013, twice as much as the sum invested in the last four years.

German PV Market Drivers

More than 700,000 PV systems have already been installed in Germany. The EPIA has estimated PV capacity in Germany to increase by about 5 GW per year for the next five years, which would sustain Germany's position as the world's largest market.

Landmark Legislation

2010 marks the ten-year anniversary of the landmark EEG, the jewel in the crown of Germany's ambitious green policymaking. Green sector growth is underpinned by long-term FiT guarantees for the production of CO2–free electricity. Its proven success has led to the implementation of similar pieces of legislation in more than 40 countries worldwide. The EEG guarantees owners of PV installations a fixed FiT for 20 years: between 24.26 and 33.03 EUR cents/kWh subject to type, size, and if the installation is connected in the final quarter of 2010. Depreciating feed-in tariffs and the absence of a market cap ensure stable market growth at competitive price levels.

Strong governmental support is provided by the German development bank (KFW). The bank's Environmental Protection Loan Program provides attractive loans at below market interest rates for up to 20 years for privately owned companies and private household installations. These typically invest in small rooftop PV systems, further adding to the dynamics of this exciting market segment.

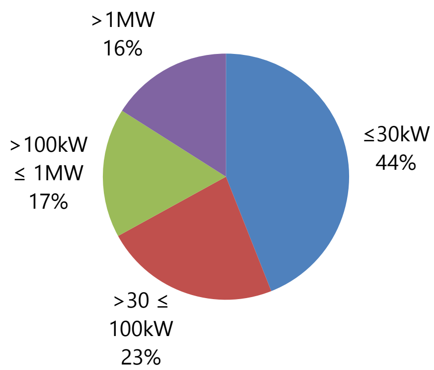
Integrated Market Structure

The presence of highly experienced project developers, system integrators, and over 10,000 installers provides the essential backbone for a mature sales structure necessary for rapid market growth. The high number of installers and strong competition levels are responsible for creating the lowest installation and balance-of-system costs in the world. This has resulted in the lowest system prices globally. Industry-specialized banks in the private sector and extensive state funding also help safeguard long-term demand for PV technology.

Premium Product Demand

Systems below 100 kW represent the largest segment by far, with 67% of installed capacity in 2009. These are rooftop systems mainly owned by private users who express a stated preference for high-quality, premium products with a local manufacturing presence. As such, manufacturers in Germany provide a 'Made in Germany' product and enjoy a significant competitive advantage.

Figure 21: PV Market Segmentation in Germany (2009)



Source: 'The Photovoltaic Industry in Germany', German Trade and Invest (January 2011)

Grid Parity Forecast

The development of average system prices shows that decentralized PV electricity production is expected to enjoy competitive parity with electricity from the grid for private consumption by 2012/2013. Achieving price competitiveness will provide a further boost to the flourishing German PV market. EEG degression reflects this market development, and now provides added incentive for own consumption of electricity.

Excellent Export Base

Foreign markets are a major driver of the PV industry in Germany. The country's excellent export conditions allow it to play a role in meeting global PV demand. A number of factors are central to this success. Chief among these are Germany's central location at the heart of Europe; rapid access to major and emerging markets (including France, Italy, Benelux, Spain, UK, and Switzerland).

Cutting-Edge R&D Landscape

Strong, long-term cooperation with Germany's research institutes has helped the German PV industry to attain its leading position in the world market. Germany is home to state-of-the-art infrastructure and some of the world's leading research institutions (for example, Fraunhofer ISE Freiburg, ISET Kassel, HMI Berlin, and FSZ Jülich) who are fully capable of meeting the latest R&D challenges in PV for all technologies across all stages of production.

Table 2: Leading R&D Institutions for Solar Photovoltaic Technology in Germany

Institution	Si Feedstock	Wafer-Based Cell Technology	Thin Film Technology	Dye & Organic Cell Technology	Process and Production Technology	Systems	Location
HMI - Hahn Meitner Institute			✓	✓	✓		Berlin
ISE - Fraunhofer Institute for Solar Energy Systems		✓	✓	✓	✓	✓	Freiburg
ISC - Konstanz International Solar Energy Research Centre	✓	✓			✓		Konstanz
IPV - Institute of Photovoltaics Research Centre Jülich			✓		✓		Jülich
ZSW - Centre for Solar Energy and Hydrogen Research			✓		✓	✓	Stuttgart Widderstall
ISFH - Institute for Solar Energy Research		✓			✓		Hameln

Source: 'The Photovoltaic Industry in Germany', German Trade and Invest (February 2009)

Three distinct research areas are of particular interest: high-efficiency silicon cell and module development, thin-film solar technology (e.g. CIGS), and the nascent organic PV segment. System technology optimization and grid integration are also areas of particularly intensive R&D activities, which range from new inverter technologies to cutting-edge energy storage options.

The partnership between science and industry increases competitiveness and creates mutually beneficial synergies. Ready access to cutting-edge production technologies and processes help significantly reduce costs.

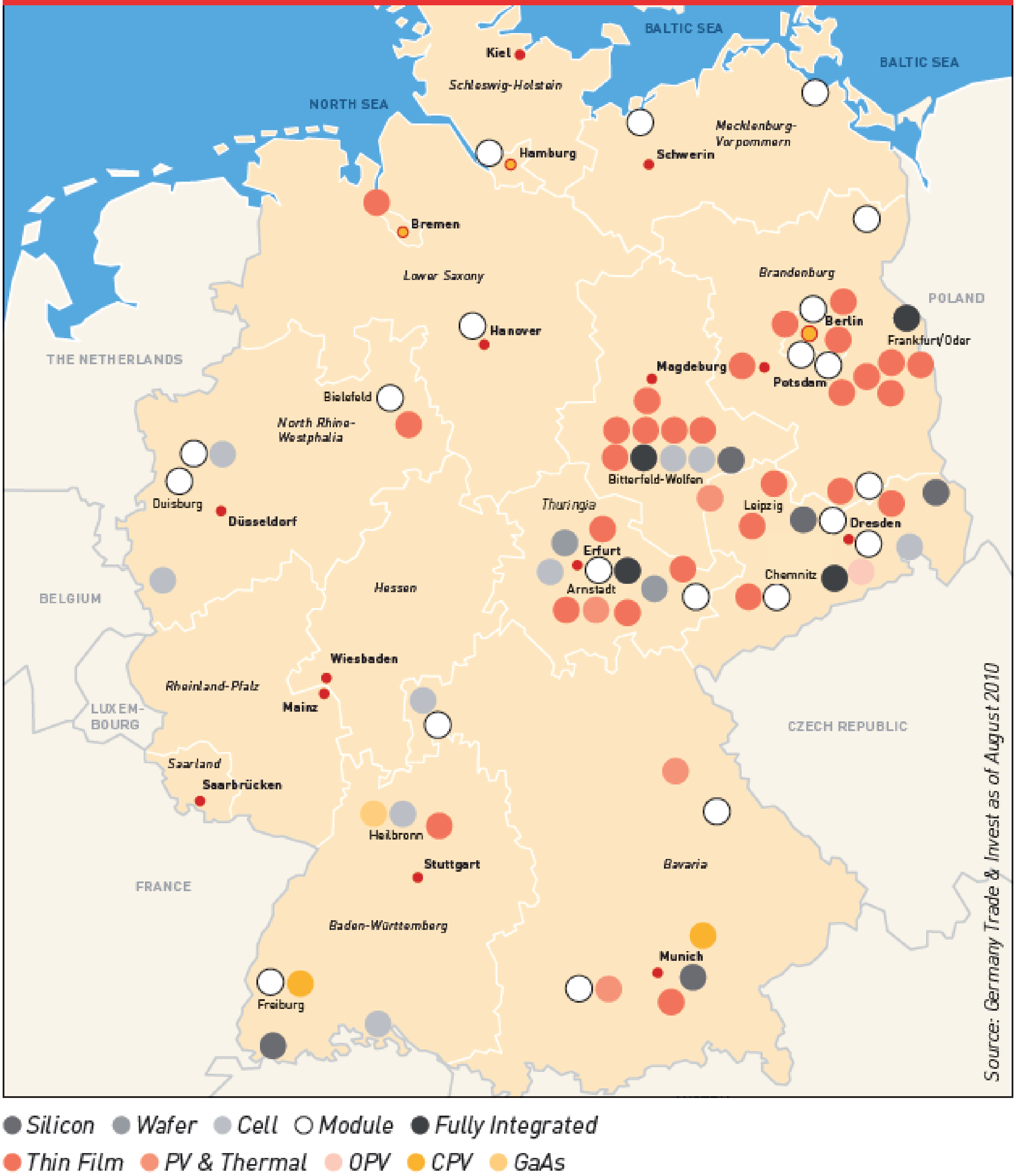
R&D investments in the PV industry of around €1 billion are planned through 2013, twice as much as the amount invested in the last four years. An impressive 143 solar patents were registered in Germany in 2008.

Cluster Effect

Germany's unique industry cluster has created an environment in which operators from all sectors are able to prosper in close proximity to other industry players and investors, academic institutions, and research centres. Germany is setting the international standard as a PV industry location, with the PV cluster providing industry actors with swift and easy access to all parts of the PV value chain. Germany's PV cluster has the added advantage of enjoying density levels around twice those of comparable industry clusters (e.g. automotive, chemicals, pharmaceuticals). The complementary SME landscape in all PV technologies offers broad partnership opportunities with established German PV manufacturers. 90% of all PV companies cooperate with others within the cluster. On average, PV cluster companies typically partner with around six other companies and research organizations.

Cluster participants benefit from economies of scale for supply and utility delivery as well as the opportunity to play an active role in joint R&D projects with other companies in close cooperation with universities and leading research entities (including various Fraunhofer institutes, the Helmholtz Centre Berlin, FZ Jülich, and ZSW Stuttgart).

PV Manufacturers in Germany



Source: 'The Photovoltaic Industry in Germany', German Trade and Invest (January 2011)

Opportunities for Manufacturers

A significant number of the world's leading PV manufacturers, such as First Solar, Bosch, and Solar- World are already taking the advantages of Germany's optimal PV investment environment and its positive cluster effects.

Access to World's Largest Market

Local manufacturers profit from direct access to the world's largest PV market. This guarantees flexible market reaction times, eliminates lengthy or expensive transportation and long-term inventory, and allows foreign exchange rate hedging.

The concentrated presence of the whole PV value chain (from large suppliers to end customers) has created highly developed sales channels facilitating distribution and easy access to the customer.

Moreover, companies active in the world's biggest market can take advantage of leveraged brand awareness afforded by the 'Made in Germany' quality seal.

Optimal Export Support

Other European and international PV markets are served by Germany's sophisticated distribution infrastructure. To support these structures and networks, the German government provides excellent export conditions especially tailored for renewable energy, e.g. in the form of special governmental export credit insurances.

Table 3: Investment Opportunities for PV Manufacturing Companies

Industry Segment	Segment-specific Benefits
Wafer/cell production	▪ Transfer of and access to automation and process knowledge from semiconductor and microelectronics industry
Module production (wafer-based)	▪ Market access to largest customer segment (≤ 30kW rooftop) with preference for premium modules ▪ Higher selling price of premium modules 'Made in Germany' ▪ Easier customization (e.g. BIPV) ▪ Swift market reaction time (no delay through shipping) ▪ Access to automation expertise
Module production (thin-film)	▪ Excellent materials & chemicals, glass and customized equipment supplier infrastructure & expertise ▪ Swift market reaction time (no delay through shipping)
3rd generation PV production (OPV)	▪ Chemical industry and material science infrastructure & expertise ▪ Chemical company partnering opportunities ▪ Specialized venture capital companies
Glass production	▪ Largest module manufacturing cluster in Europe ▪ Sand pits with low iron sand ▪ Excellent power and gas infrastructure
Other module material & component production	▪ Foils: highly developed chemical infrastructure ▪ Semiconductor materials: materials expertise, largest semiconductor hub in Europe ▪ Cables & junction boxes: plastics and electronics expertise ▪ Frames: excellent metal sourcing conditions
Inverter production	▪ Power electronics, system integration and smart grid knowledge base ▪ Own-consumption drives introduction of innovative products (e.g. integration of energy storage and monitoring systems)
PV mounting system production	▪ Metal & plastics processing infrastructure ▪ Excellent material sourcing conditions ▪ System integration knowledge base
Energy storage device production (e.g. battery)	▪ Promotion of storage technologies through 'own consumption bonus' for PV rooftop systems ≤500kW ▪ Chemical industry and material science infrastructure & expertise ▪ Strong material supplier presence ▪ Marketing and distribution partnership opportunities

Equipment production	▪ Strong and diversified client base with constant innovation need ▪ Excellent tooling, machine component, and materials supplier infrastructure & expertise ▪ Easy access to and transfer of technologies and processes from traditionally strong industries (e.g. automotive, chemicals and microelectronics)

Source: 'The Photovoltaic Industry in Germany', German Trade and Invest (January 2011)

Access to PV Manufacturing Know-how

The close proximity to and cooperation with world class R&D institutions, universities, and leading material and equipment suppliers (covering everything from cell related wet chemistry and vacuum deposition to automation and turnkey lines) help manufacturers to optimize production technologies and processes. The ready availability of superior facility and process engineers also helps save time and slash costs during ramp-up and maintenance phases.

Experienced PV Labour Pool

Germany provides quick and easy access to a flexible labour pool drawn from Germany's strongest industries (such as mechanical engineering, chemistry, semiconductor and microelectronics industries), with a solid PV-related education and training background. Competitive labour costs and high productivity rates combine to guarantee new businesses optimal levels of professionalization and competitiveness from the outset.

Full Service Infrastructure

Diverse partnership opportunities, state-of-the-art cross-sectional infrastructure, regional networks and experienced authorities guaranteeing fast authorization processes provide a stable investment environment for new manufacturing facilities in Germany.

Financial Support

Furthermore, financial incentives of up to 50% of investment costs (depending on location, company size and investment volume) plus incentives reducing operational costs (R&D and labour) are provided by the EU and the German government to support foreign investors.

Opportunities Beyond Manufacturing

Sharing Expertise

Companies seeking to engage in PV service segments like R&D, PV systems planning, project development and implementation can source know-how from the largest pool of specialists in these fields worldwide. Company R&D centres not only profit from cluster knowledge transfer, but also from information sharing with other R&D centres and companies. Generous public R&D support schemes facilitate the development and implementation of new products and technologies.

Market Demand and Infrastructure

Downstream companies, including system integrators and project developers, benefit from continuous market demand and a supportive policy framework. Banks offer attractive financing and local authorities support this industry, guaranteeing fast grid access and making grid parity in several years a realistic goal. Established sales channels and a mature sales structure facilitate distribution and provide easy end customer access.

Extensive Network for Service Providers

Companies focusing on services for PV plants such as maintenance, monitoring, insurance, as well as technical and commercial operations benefit from the large pool of existing PV installations in Germany. Supervising the official German PV plant directory, the German Federal Network Agency provides primary data on newly installed PV plants, making it easy for service providers to identify their customer base and to test and measure new equipment and services on a large scale.

Table 4: Investment Opportunities for Non-Manufacturing PV Companies

Industry segment	Segment-specific benefits
R&D Centre	▪ Large pool of experienced scientists and university graduates in PV-related subjects ▪ Generous public R&D support schemes
System Integration	▪ Global acceptance of reference projects located in Germany ▪ Among the lowest installation costs and shortest realization times in the world ▪ Strong presence of experienced installers
Project Services	▪ Large pool of developers and engineers with unique project development experience ▪ Access to experienced private and institutional equity investors ▪ Access to grid integration expertise ▪ Large customer base for services like insurance, monitoring, and O&M
Factory Services	▪ Large base of engineering companies ▪ Easy access to processing and automation expertise

Source: 'The Photovoltaic Industry in Germany', German Trade and Invest (January 2011)

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About EOS Intelligence

EOS Intelligence is a professional services firm that delivers bespoke research solutions targeted at corporate planners and decision makers, and institutional investors.

Our knowledge resources, spread across sectors such as automotive, consumer goods, energy and healthcare enable us to support a wide range of research and intelligence needs, spanning strategy assessments, supply chain rationalization and investment analyses.

We work closely with corporate and consulting firms, and provide them with customised business research and intelligence solutions that significantly contribute to their strategic and functional decision making.

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