THE RESULTS CENTER

#127 • GERMAN SOLAR FEED-IN TARIFF

Editor's note: The Results Center takes great pride in making its case studies as accessible and accurate as possible. Research for this case study included a week-long research tour in Germany – Berlin, Frankfurt/Oder, Leipzig, Munich, Stuttgart, and Freiburg - visiting policy leaders, learning from leading solar scientists, and making site visits to both cutting-edge and massive installations. As the program evolves and additional details become available, EcoMotion will provide updates to subscribers.

Outline

1. Executive Summary

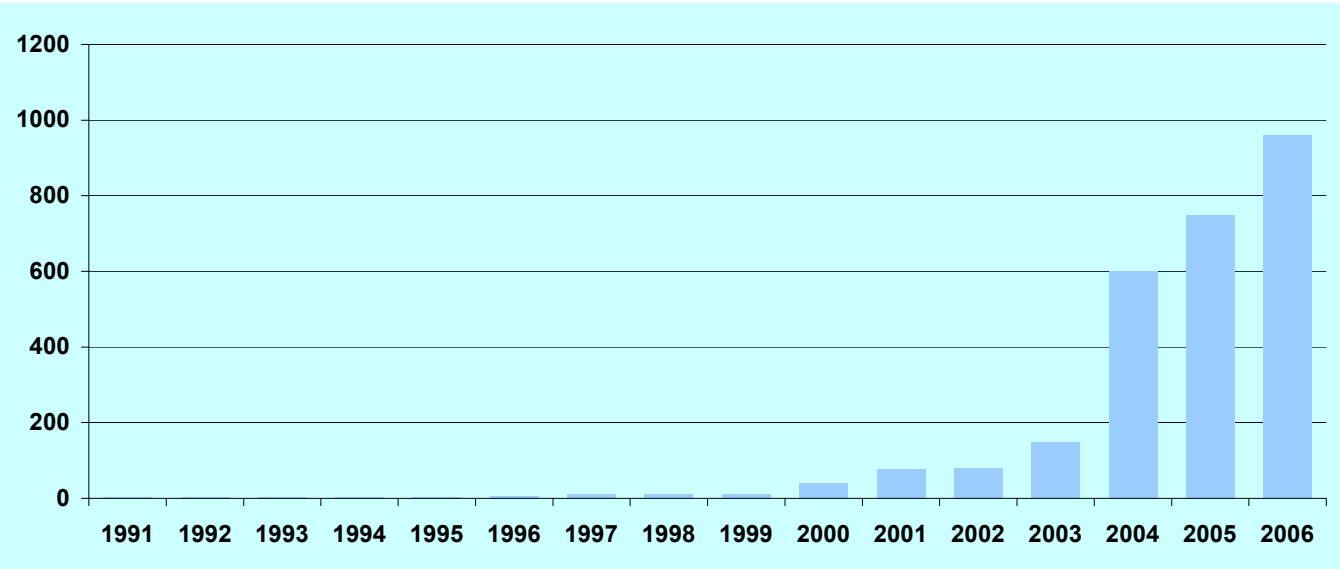
The German "Feed-In Tariff" has resulted in Germany's preeminence in solar energy. In a matter of years, the German government and its utilities have fostered an enviable renewable energy industry, having installed fully 52% of the world's total solar-electric capacity. Despite relatively low "solar insolation" – about equivalent to Anchorage, Alaska – Germany has created a solar photovoltaics industry that has attracted over ten billion dollars of public and private-sector investment, and that currently employs 35,000 Germans who work in all facets of solar R&D, poly-silicon manufacture, wafer and cell production, and photovoltaic (PV) module assembly. An additional 18,000 Germans work in the growing and similarly advanced solar thermal industry.

The year 1991 marked the inception of the "feed-in tariff" – a mechanism whereby homeowners and businesses can feed as much renewable electricity into the grid as they can and want. At that time, and spurred by the European Union's commitment to climate protection and the Kyoto Protocol, the German government legally regulated the "feed-in" of electricity from independently generated renewable energies to the electric power grid under the auspices of the Electricity Feed Act. The law provided critical support for renewables and began the German solar revolution. The feed-in mechanism is simple: "grid operators" throughout the country are required to buy renewables at fees fixed by federal law.

The German government felt the special treatment of a simple feed-in tariff was especially important to meet its climate protection goals, and that the higher prices paid for renewable energy were fair and reasonable since those for conventional sources of power do not internalize the full environmental costs. In 1999, the Electricity Feed Act mechanism for solar was dramatically strengthened and Germany's "market stimulation policy" turned its focus toward a new 100,000 Solar Roofs Program.

Then in April of 2000, the German government passed the Renewable Energy Sources Law which provided highly attractive, varying, and "degressive" incentives for different forms of renewable energy. The law – known as the EEG in Germany – dramatically stimulated the German photovoltaic market. In fact, it led to a huge surge in Germany's solar capacity and worldwide leadership in the field. The incentives are designed to aggressively incentivise the solar industry initially and then to gradually decline over time as PV costs shrink and subsidies are no longer required.

Germany's Annual Photovoltaic Installed Capacity (MW)



Unlike the "net metering" provisions that are common in the United States, and that limit solar system size to annual consumption of a particular meter, the feed-in tariff allows for participants to maximize solar production at a particular site. Furthermore, the rate is fixed for 20 years, making the economics of each investment clear to investors and clearly profitable for all participants. Utilities are also pleased to participate, as German law allows them to earn the same rate of return as they would reap from a traditional power plant.

In 2004, the EEG was further enhanced with an increased tariff structure, resulting in dramatic impacts vividly presented in the installed capacity bar chart: In 2004, 600 MW of photovoltaics were installed. In 2005, the installations grew to 750 MW, only to be eclipsed in 2006 with the installation of 960 MW of photovoltaics. Ironically, the Germans called this relatively flat demand "market stagnation," and expect to get back to 20-30% annual market growth. (For comparative purposes, total U.S. installations in 2006 were on the order of 140 MW, about 15% of the German total.)

As mentioned earlier, Germany receives on average just 3 - 4 hours insolation each day: that's just 40-50% of what Southern California receives. So how did it become the top producing solar nation in the world? EcoMotion found that the answer lies in very deliberate policy based on the multiple benefits of solar production to the German economy, notably fulfilling renewable energy and climate commitments while bolstering economic development, particularly in the former East Germany.

Germany's aggressive solar commercialization has not only led to more than a terawatt hour of photovoltaic generation in 2006, but has also spurred a thriving solar industry. While solar remains a small fraction of total German electricity generation and use, it is an important part of its broad renewable strategy, and Germany, unlike most industrialized countries, is ahead of schedule fulfilling its renewable energy and climate protection commitments.

This case study looks into the national initiatives that have rapidly spurred the development of Germany's domestic solar electric market and which have resulted in its international solar preeminence – one that is the envy of many parts of the world. As a result of Germany's success, other countries including, Spain, Italy, and South Korea have instituted similar tariff mechanisms.

2. Program Design

EUROPEAN GOALS AND RATIONALE

The German photovoltaic market began to take off in 1999 in response to the commitment of the European Union (EU) to reduce carbon dioxide emissions from 1990 baselines by 25% by the year 2005 as specified in the Kyoto Protocol. The European Commission's white paper, "Energy for the Future: Renewable Sources of Energy," as well as relevant resolutions adopted by the European Parliament, provided recommendations for EU nations that are reflected in the German approach.

Another paper "Energy Policy for Europe" was a framework proposal that presented a long-term renewable energy roadmap. It called for an overall binding 20% renewable energy target, with a minimum target of 10% from renewables for transport fuels. Pathways were presented to bring renewables for electricity, heating and cooling, and transport, into the economic and political mainstream.

The EU Commission specifically adopted the Energy Policy for Europe's recommendation for a feed-in tariff to spur renewable generation. And it went a step further, advocating an entrepreneurial and transparent separation of electricity generation, transmission and distribution. The EU believes that this is vital to the creation of a competitive market in the electricity sector that includes renewables. The Commission also made explicit recommendations that would prevent grid operators from discriminating against any grid users in favor of their own subsidiaries or shareholders.

THE GENESIS OF THE GERMAN FEED-IN TARIFF

The genesis of the solar feed-in tariff approach - with its clear and potent incentives - is especially interesting. How did renewable and solar advocates gain the requisite political support for a solar feed-in tariff that would ultimately compel grid operators to pay solar electricity producers ten times what they'd pay conventional generation producers? While certainly complex and involving many perspectives and professionals, according to the industry association solar was generally "under the radar" of most legislatures. In the mid and late 1990s, there were big issues on the world stage – the Iranian hostage crisis, Tiananmen Square, and domestically German reunification and the development of the Green Party.

In addition to geopolitical events that took center stage in Berlin, there was already a "high consciousness about climate issues" in Germany. Just as nuclear was being heavily criticized – even before Chernobyl – solar was a solution, it became a powerful symbol of a sustainable energy supply. Solar was skillfully guided by a number of advocates who effectively tapped into the "rainbow coalition" to support solar. Herman Scherer and others carefully guided solar through the political system, leaning on a rightist politician from Bavaria to broaden support for what became the Renewable Energy Sources Law. The challenge was major: While cost of electricity production at central power stations was about $0.07/kWh, by 2003 solar advocates were promoting and achieving solar feed-in tariffs that were nearly ten times that.

During the same time frame, a social research study found that Germans found a surcharge of $1.35 – $2.70 a month (one to two Euros a month) was within their "comfort level." It was a price that was acceptable to the general public to support renewable energy. Currently, 0.3% of all electricity

consumed is solar, causing a 0.7% price increase for consumers. Fees for other renewables add to this rate increase level.

By 2000 and then 2001, politicians understood the value of the new industry in Germany. There was clearly a new industry born. Photovoltaics brought jobs into the desert of unemployment in Eastern Germany, an important economic development angle cemented Government support for solar and other renewables.

German Power Industry Notes

Germany is the largest electricity producer and consumer within the European Union.

German total grid capacity of 120,000 MW (California is about 60,000 MW).

Brown and hard coal provide 50% of the country's generation, nuclear: 30%.

Concurrent goal to shut down 7,300 MW of nuclear power by 2015.

German total consumption 491 TWh; average price of $0.26/kWh.

EU promoted "liberalization" of electric utilities in the 1990s. Germany resisted.

Vattenfall Europe – Swedish utility subsidiary -- one of Germany's four big utilities.

Federal grid agency regulates grid utilities with more than 100,000 customers.

Germany has 917 regional utilities and "stadtwerke".

Smaller utilities are regulated by one of the 16 German federal states.

GERMAN RENEWABLE ENERGY GOALS

The German government's fundamental renewable energy goals are:

- Sustainable development of energy supply, climate, nature and environmental protection.
- To increase the share of renewable energies in gross electricity consumption to at least 12.5% by 2010 and at least 20% by 2020.
- To increase the share of renewables in primary energy consumption – including all fuels from building and industry energy use to transportation – to 4.2% in 2010 and 10% in 2020.
- To reduce external costs of energy supply.
- To increase supply security by means of reduced dependence on energy imports, thus helping to prevent conflicts over fossil energy resources.
- To promote technological development in the field of renewable energies.

THE MARKET STIMULATION APPROACH

The intent of the Renewable Energy Sources Act, or EEG, has been to stimulate the market for renewable energy. This has involved strategically setting incentives high to catalyze the market, providing significant research and development grants to advance solar technologies, and then phasing out the special incentives as the solar market is transformed.

The "feed in tariff" rates specified in the EEG were determined based on a goal of making renewable energy installations cost-effective but, as in America and many other countries around the world, renewable energy in Germany has been held back by several competitive disadvantages.

First, the unaccounted for externalities of conventional power generation keep their prices artificially and comparatively low and so in most cases, the costs of renewable energy sources are still much higher than those of conventional energy sources. A German researcher summarized the situation, "Most of the social and ecological follow-up costs associated with conventional electricity generation are currently not borne by the operators of such installations but by the general public, the taxpayers and future generations. The Renewable Energy Sources Act merely reduces this competitive advantage which conventional electricity generators have vis-à-vis operators generating electricity from renewable energy sources which cause only limited external costs."

Second, government subsidies continue to support conventional sources.

Third, renewables – particularly solar – do not yet enjoy the economies of scale that would bring their prices down. For this reason, the purpose of Germany's solar strategy is not only to protect the operation of existing installations but also to stimulate a dynamic development in all fields of electricity generation from renewable energy sources. In combination with measures aimed at "internalizing" external costs, the purpose of the pricing regime is to bring the prices for renewable energy sources more in line with conventional energy sources.

While the feed-in tariff simplifies the terms of solar installations for all Germans and has been an unquestionable success that is clear and visible, behind the scenes, Germany has also invested in a major solar research and development initiative. That initiative has been equally important in driving down costs and helping Germany to take the leading role in solar developments while also spurring an entire industry and economic development phenomenon. Though it is difficult to quantify the actual amount of investing because of multiple funding sources and recipients, and tremendous overlap of cost allocations across renewable technologies, Germans are reporting that billions of dollars have been, and continue to be, invested in advanced renewables technologies, all aimed at bringing the costs down so that penetration can increase.

RESEARCH AND DEVELOPMENT

Beginning in 2002 and 2003 Germany began to invest heavily in solar research and development with emphases on basic material research for silicon, advanced solar systems, a major emphasis on thin films – silicon and non-silicon based, and module development. This work continues today at dozens of labs and research facilities throughout the country.

The German government – notably the Ministry for the Environment -- has invested significant funds with private industries over the past five years. Some analysts believe the government's contribution to be as high as five billion dollars. These funds have been spent on research grants, product development, advertisement, and financing. The European Commission has also supported solar and other renewables with grants, particularly for job creation activities in the former Eastern Germany.

In 2005 Germany launched the Photovoltaics 2005 Pioneer Program to specifically address three areas:

- Solar cell cost reduction through the reduction of manufacturing costs and efficiency improvements.
- Cost reduction, technical optimization, and reduction of barriers to deployment in building applications.
- Photovoltaic technologies for decentralized, off-grid power production.

In 2006 Germany launched a new PV R&D support program called Innovation and New Energy Technologies. The country's photovoltaic uptake created a large demand for PV material, and thereby an opportunity to create revised guidelines for the solar manufacturing and development sectors. The

Innovation and New Energy Technologies Program was characterized by three basic strategies:

- To achieve more competition, growth, and employment in Germany to ensure that modern energy technologies are introduced into the market more rapidly
- That the internationally pledged progress in climate protection can be achieved at the lowest possible cost
- To stimulate the use of cutting-edge technology to eventually replace power plants beginning in 2010.

"Clusterforschung"

One of the unique and highly successful aspects of solar R&D in Germany has been the rise and use of a structural concept known as "clusterforschung," essentially public/private research cooperatives. Eicke Weber, director of the Fraunhofer Institute in Freiburg, discussed how his laboratory, like many other solar research establishments, relies on project funding for technologies that "are quite close to market." Unlike federal laboratories in the United States with tenured professionals, in Germany, labs vie for research efforts funded by industry - either with or without government support. Of Fraunhofer's 600 employees, only 200 are retained in secure positions; the remainder must constantly hone their skills and produce new technologies that are ready, or near ready, for commercialization.

PROGRAM EVOLUTION

The German Solar Program has been through a dramatic evolution, with marked escalation in an eight-year period, what the Germans call "market stimulation." Solar incentives began in 1999, and by 2006, Germany had installed over 2,500 MW of photovoltaic capacity, 55% of the world's total. The timeline that follows summarizes this rapid technological deployment:

Summary Timeline

1991:	Feed-in tariff structure legislated by Electricity Feed Act
1991:	1,000 Solar Roofs Program launched
1999:	100,000 Solar Roofs Program launched
2000:	Renewable Energy Sources Law (EEG) legislated
2003:	100,000 Solar Roofs Program completed, 346 MW installed
2004:	REL compensation increased; 600 MW installed
2005:	750 MW installed, 100,000 solar systems installed
2006:	960 MW of solar-electric generation, 90,000 solar systems installed
2007:	German solar-electric generating capacity reaches 2,500 MW

1991 Electricity Feed Act

The central element of the Electricity Feed Act was an obligation on the part of "the competent grid system operator" to purchase the electricity generated and payment of a fee per kilowatt-hour in accordance with fixed rates, the so-called "feed-in tariff." This legislation, known in German as the

"Stromeinspeisungsgesetz," provided a mechanism for independent power producers of all kinds to support the German electricity grid.

1991 – 1995 1,000 Roofs Program

In 1991 the government launched the 1,000 roofs program based on a feed-in tariff of $0.115 cents.

1999 Hundred Thousand Roofs Program

In January 1999, the 100,000 Rooftops Solar Roofs program began with the mission of installing 300 MW of power by 2003. The feed-in tariff was a central element of this plan. The grid operator was obligated to purchase the electricity generated and pay a fee per kilowatt-hour in accordance to the fixed rates dictated by law. Low-interest loans (1.91%) were issued by the German KfW Bank (Kreditanstalt für Wiederaufbau).

In Freiburg, Germany – now considered the solar capital of the world - more than 10,000 customers registered for the program before the start of the initiative. The German government was so overwhelmed by this response that it had to slow down the application acceptance process to allow solar panel producers to meet the demand.

2000 Renewable Energy Sources Act

The Electricity Feed Act was enhanced by the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz - EEG) in 2000, with its special focus on renewable energy resources. It significantly increased the incentives for solar system. The Renewable Energy Sources Law guidelines provided three fundamental provisions:

1) PV owners under the EEG were to be given priority access to the electricity grid
2) Grid operators were obliged to purchase electricity from the EEG electricity producers
3) EEG initiated a fixed tariff price for renewable electricity under a degressive tax plan.

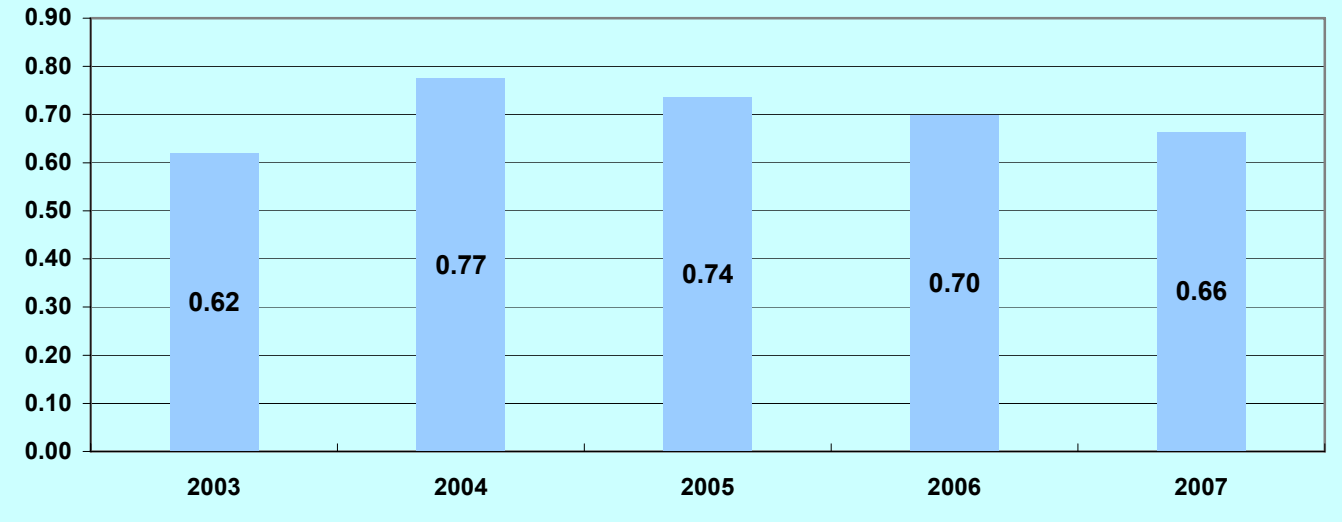
2004 EEG adopts new tariff structure

The end of the 100,000 Roofs Program -- in which 67,500 rooftop systems were installed -- marked the beginning of a new tariff structure in August 2004. The amendment of the Renewable Energy Act (EEG) differs from the original text in many points, bringing clarification or introducing new provisions. Several articles reinforce consumer protection and aim at increasing transparency and reducing the costs inherent to the system. The greatest change of the new EEG was the differentiated tariff structure that categorizes tariff amounts by system size and placement.

German Solar Feed-In Tariff 2004 Prices - Price per Kilowatt-Hour

System Size:	<30 kW		30 - 100 kW		>100 kW	
Location:	**Euro Cents**	**US Cents**	**Euro Cents**	**US Cents**	**Euro Cents**	**US Cents**
On Buildings and Noise Protection Walls	49.21	66.43	46.82	63.21	46.30	62.51
Façade integrated bonus	5.00	6.75	5.00	6.75	5.00	6.75
Open Land, Ground-mounted systems	37.96	51.25	37.96	51.25	37.96	51.25

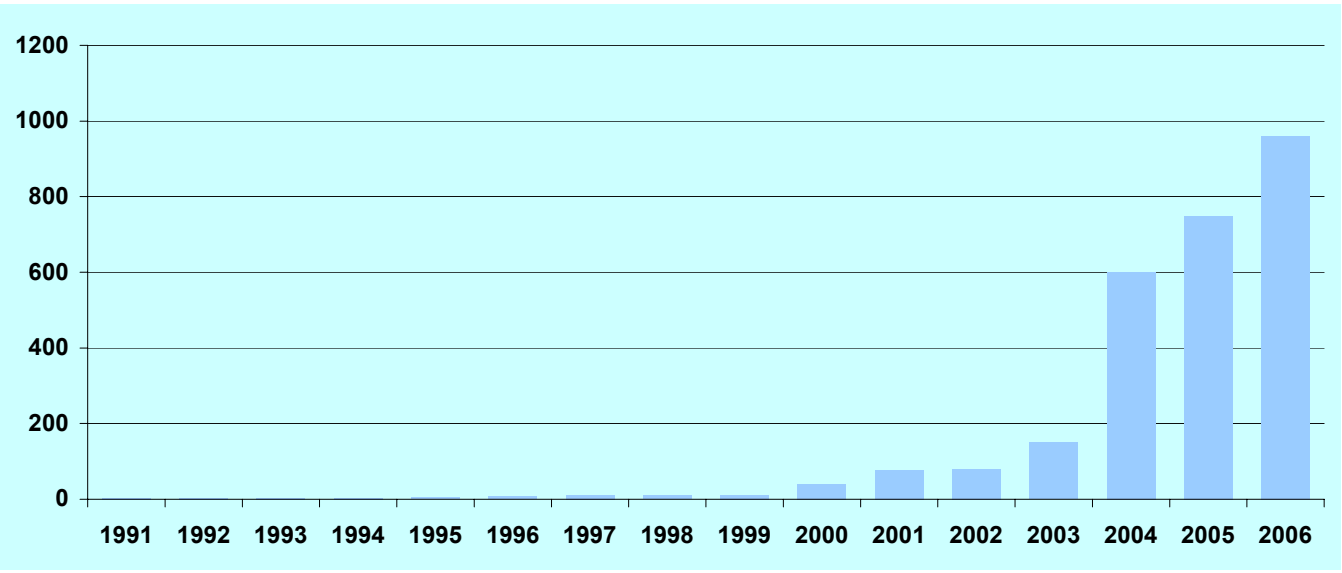
German Solar Feed-In Tariffs in US Dollars



2005 – 2006 **Germany becomes world leader**

In 2005, 750 MW of photovoltaic capacity was installed and the German Solar Program was the fastest growing major PV market in the world, generating over 1 billion kWh (over one terawatt-hour) of solar electricity. Then in 2006, Germany's PV market grew 16% from 2005 to 960 MW, accounting for 52% of the world photovoltaic market. That year Germany topped Japan in total photovoltaic megawatts installed.

German Annual Photovoltaic Installed Capacity (MW)

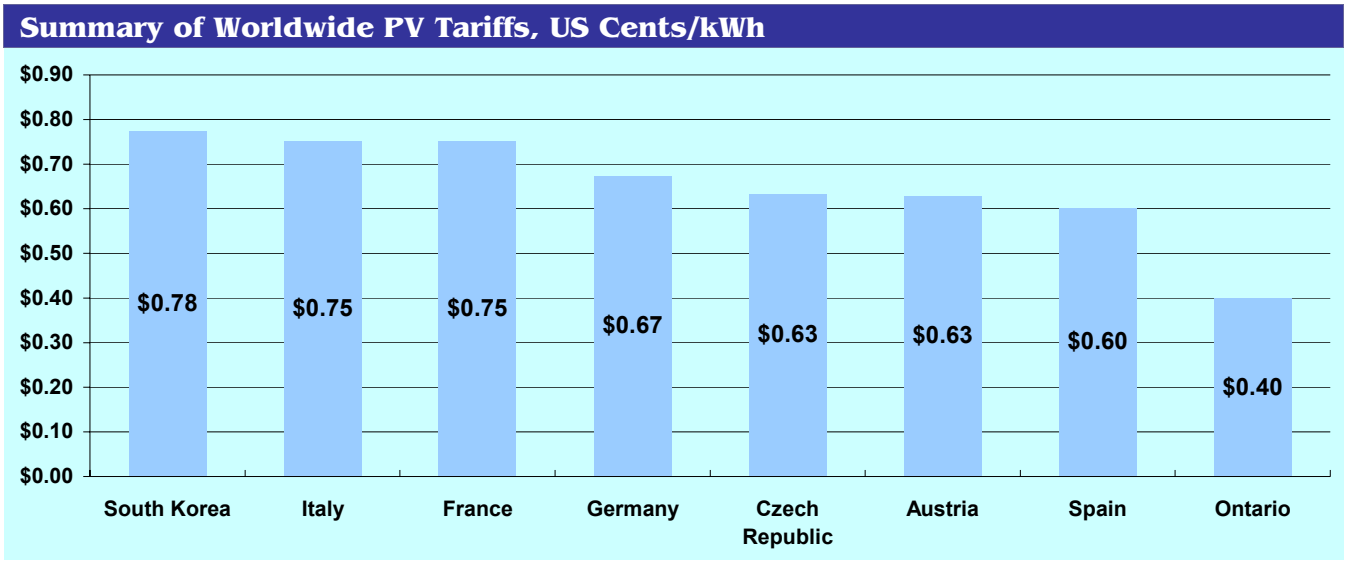


COMPENSATION STRUCTURE

No limits: A fundamental program design issue relates to how much compensation any customer or investor can receive through the EEG. In Germany, net-metering – which limits the size and output of a solar system to a specific meter on an annual basis – is not used. Instead, in Germany, a second

meter is installed to measure the amount of electricity produced by the household or commercial property. This power is fed into the grid, irrespective of actual use on site.

Minimum fees: The Renewable Energy Sources Act obliges German electric utilities to purchase electricity generated from renewable energies - which is not yet economically competitive - as a priority and to pay plant operators and system owners legally fixed minimum fees. These minimum fees are based on actual and projected generation costs and are "degressively" structured. They are designed to take account of technology advances and production efficiencies and economies, resulting in cost reductions over time. The law specifies that the rates will be reviewed periodically, assuring that they will be updated in short intervals to reflect actual market and cost trends.



The fixed, long-term, and calculable feed-in fees are a defining program feature. Today an investor receives $0.51 – 0.66/kWh of solar electricity for a period of 20 years. The table above shows that the German model is catching on, and that others – notably South Korea, Italy, and France – actually have higher incentives.

Ratepayer Funded: While utilities, or "grid operators," in Germany are obligated to purchase independently generated renewable energy, it is the ratepayers who pay for these "public benefit programs" on their utility bills As in California and other states, the tariffs are paid by German ratepayers through an EEG surcharge placed on every kilowatt-hour of renewable energy provided to the end-user. The mechanism to spur renewables is based on a power system user-pays principle: Those with high electricity consumption pay more than those with low consumption.

Rates Vary for Different Renewables: To facilitate major improvements in technological efficiency, the compensation rates specified in the Renewable Energy Sources Act vary, depending on the energy sources, the sites and the installation sizes involved. Wind resources, for example, receive less than half the feed-in tariffs that solar receive. The intent of the law was simple: to determine appropriate incentives to spur the market.

Degressive Incentive Payments: Like the California Solar Initiative with its ten-steps of declining incentive levels, the German solar feed-in tariff is based on "degressive" (declining) incentives. Currently, the lock-in prices for building mounted systems have been dropping at a rate of 5% per year. A system owner that bought a system last year is assured of payments for 20 years. Someone who bought a system this year also locks in for 20 years of payments, but at a rate 5% lower.

German officials report that there is a debate is over the rate of incentive decline for solar. Some suggest that it should be 7% from 2009 on, and 8% beginning in 2011. Similarly, incentives for ground-mounted systems, that are currently declining at 6.5% per year, are expected to drop at a rate

Actual & Anticipated Degression Rates

Status	Building	Ground
Current	5%	6.5%
Anticipated in 2009	7%	8.5%
Anticipated in 2011	8%	9.5%

of 8.5% annually beginning in 2009, and then 9.5% annually beginning in 2011.Currently the solar feed-in tariff is being evaluated as required by the legislature every four years, with a full-blown report due to be presented in Berlin at the end of 2007. For photovoltaics, this evaluation is being spearheaded by ZSW, a leading solar research laboratory in Stuttgart.

STEP-BY-STEP PARTICIPANT PROCESS

Marketing and outreach: Given the consumer interest in solar, coupled with the highly attractive feed-in tariffs and simple process, little program marketing been required. The EEG has been promoted by the German government and by contractors.

The Participant Process

- Interested party (customer) contacts solar contractor (electrician)
- Contractor provides quote to the customer
- If accepted, contractor contacts local utility for an additional meter
- Meter measures solar system output
- Customer bills local utility

GERMAN SOLAR INDUSTRY FEDERATION

The German Solar Industry Federation (Bundesverband Solarwirtschaft/BSW) provides an interactive, government-sponsored website for consumer advice, consultation, case studies, and financing options. The website goes through five steps to ensure customer knowledge and comfort with solar.

1) **Solar Promotion**

   Operating as an online consultant, the website's Solar Promotion Advisor helps a prospect formulate the optimal financing of a solar plant. The customer enters the data into prescribed fields and from there the site makes appropriate recommendations.

2) **Solar Styles Advisor**

   The second step involves determining the solar style: The site presents aesthetic options as well as practical information pertaining to solar shapes and building. This step helps participants find architects and other specialized technical services in the solar industry.

3) **Case Studies**

Another step involves case studies of different solar plants across the country. These listings – of households, businesses, industries, and farmers – provide proof of concept and reinforce the notion that others have made similar and successful solar investments.

4) **Contractors List**

A list of solar contractors is provided by region to help prospects connect with local installation experts.

5) **Financing Estimator**

The KfW Bank supports the EEG with favorable loans for solar installations. Current loan rates are 4.7%. The on-line financing estimator gives the customer the ability to clearly see his or her cash flow after a solar investment.

Shares of German PV Systems 2006

Sector	Size	Percent
Multifamily, public buildings, farms, commercial plants	10 - 1,000 kW	50%
Ground mounted systems	>1,000 kW	10%
Small systems	1 - 10 kW	40%

3. Program Impacts

RESEARCH AND DEVELOPMENT ACCOMPLISHMENTS

The effects of Germany's solar R&D investment are multiple and quite enormous. For instance, research projects have resulted in "rear-contact cells" with efficiencies of 21%. Germany's proactive approach toward PV research and development has resulted in solar cell output 20% more effective than that of other countries. Researchers have achieved 18.8% efficiency of large area screen printed solar cells, this done by Solar World in Munich.

German scientists and businessmen are even developing schemes for solar panel recycling, finding the most cost efficient means for their reuse of solar wafers after a planned most productive 20-year life. The country is also deeply involved with amorphous photovoltaics, as well as effectively using PVs to support uninterruptible power supply units in the event of a grid failure. The German government is also supporting technological developments like concentrating solar plants designed for export.

Germany's manufacturing capabilities for solar have advanced from the refinement of the basic raw materials – notably poly-silicon – to the finished modules and inverters. In each case, the government has spurred marked improvements, not only paving the way for a more and more renewable energy future, but also positioning Germany as a world leader.

Poly-silicon is used to form ingots of poly-silicon crystals. These are sliced into wafers, that in turn form cells – that collect electrons – and then cells are mounted into modules. German production of solar cells was 58 MW in 2002. It increased to 510 MW in 2006. Germany has also experienced a major rise in solar production companies, fueled in part by EU economic development incentives, with especially attractive incentives for job creation in the eastern parts of Germany. Similarly, module production grew from 40 MW in 2002 to 330 MW in 2006. There is about 10 MW of current thin-film production.

POLY-SILICON SHORTAGES

One of the key limiting factors in the worldwide rise of solar power has been poly-silicon shortages. Computer and chip manufacturers have had priority access to limited supplies of this semiconductor material. In 2006, Wacker, one of the world's largest suppliers of silicon for semiconductors and solar cells, enhanced its production to 6,200 tonnes. It plans to increase its production to 9,000 tonnes by 2008. By 2010, Wacker's poly-silicon output is expected to be second highest in the world.

PARTICIPATION, CAPACITY AND GENERATION: CHRONOLOGY

1999 - 2003

The 100,000 solar rooftop program resulted in the installation of 65,700 PV systems from 1999 – 2003 resulting in 345.5 MW of capacity. Low-interest loans (translated as "soft loans") were provided for 30,284 systems, supporting 237.4 MW of capacity. By 2003, and at the close of the 100,000 roofs initiative, the photovoltaic market size increased more than tenfold from 12 MW in 1999 to 150 MW.

German Installed PV Capacity

	Annual	Cumulative
1991	3	3
1992	3	6
1993	3	9
1994	3	12
1995	4	16
1996	7	23
1997	12	35
1998	10	45
1999	12	57
2000	40	97
2001	78	175
2002	80	255
2003	150	405
2004	600	1005
2005	750	1755
2006	960	2715

2004

After the EEG was amended in 2004 and the incentive prices were dramatically increased, the German Solar Feed-In Tariff really took off. In 2004, 600 MW of photovoltaics were installed, many times the amount for the previous year.

2005 - 2006

In 2005, the program grew again, this time by 25%. The year resulted in 750 MW of solar-electric generation and Germany becoming the fastest growing major PV market in the world, generating 1.28 billion kWh of solar electricity.

In 2006, 960 MW was installed, accounting for 55% of the world photovoltaic market. Germans installed 90,000 solar systems in 2006. BSW estimates that the year's installed capacity represents 6,750,000 square meters of solar modules, a significant solar area. In 2006, Germany also installed 3.5 MW of off-grid PV systems for traffic signals, etc.

2007 Summary

Overall, approximately 300,000 German customers have participated in the rise of Germany photovoltaics, 98% of which are grid connected.

As a result of this dramatic rise, Germany now operates more solar-electric generating capacity (2,500 MW) than the installed wind-generating capacity of Britain, Italy, France, or the Netherlands. And by the beginning of 2007, Germany's annual solar generation was approaching 2 TWh, nearly one-half of one percent of German electricity consumption, a small and growing piece of Germany's solar and economic future.

ECONOMIC DEVELOPMENT

According to the German Solar Industries Association (BSW), the German development model has resulted in highly attractive statistics. One of the most profound is that more than $13.5 billion have been invested in PV systems in Germany in one way or another. The table below, prepared by EcoMotion, projects a similar order of magnitude from gross assumptions, with an estimated $13.3 billion paid out in incentives.

Estimated Private Sector Capital Costs (Millions of US Dollars)

	Annual MW	Rooftop Systems	Ground-Mounted	Façade Integrated	Total Investment (USD)	Total Investment (Euros)
1991	3	$7.50	$4.80	$2.40	$14.70	10.89
1992	3	$7.50	$4.80	$2.40	$14.70	10.89
1993	3	$7.50	$4.80	$2.40	$14.70	10.89
1994	3	$7.50	$4.80	$2.40	$14.70	10.89
1995	4	$10.00	$6.40	$3.20	$19.60	14.52
1996	7	$17.50	$11.20	$5.60	$34.30	25.41
1997	12	$30.00	$19.20	$9.60	$58.80	43.56
1998	10	$25.00	$16.00	$8.00	$49.00	36.30
1999	12	$30.00	$19.20	$9.60	$58.80	43.56
2000	40	$100.00	$64.00	$32.00	$196.00	145.19
2001	78	$195.00	$124.80	$62.40	$382.20	283.11
2002	80	$200.00	$128.00	$64.00	$392.00	290.37
2003	150	$375.00	$240.00	$120.00	$735.00	544.44
2004	600	$1,500.00	$960.00	$480.00	$2,940.00	2,177.78
2005	750	$1,875.00	$1,200.00	$600.00	$3,675.00	2,722.22
2006	960	$2,400.00	$1,536.00	$768.00	$4,704.00	3,484.44
Total	2,715	$6,787.50	$4,344.00	$2,172.00	$13,303.50	9,854.44

Assumptions: *Rooftop systems comprise 50% of capacity; ground mount 40%, façade integrated 10%*
$5 USD/DC watt for rooftop solar; $4/watt ground-mount; $8/watt façade integrated

JOBS AND ECONOMIC DEVELOPMENT

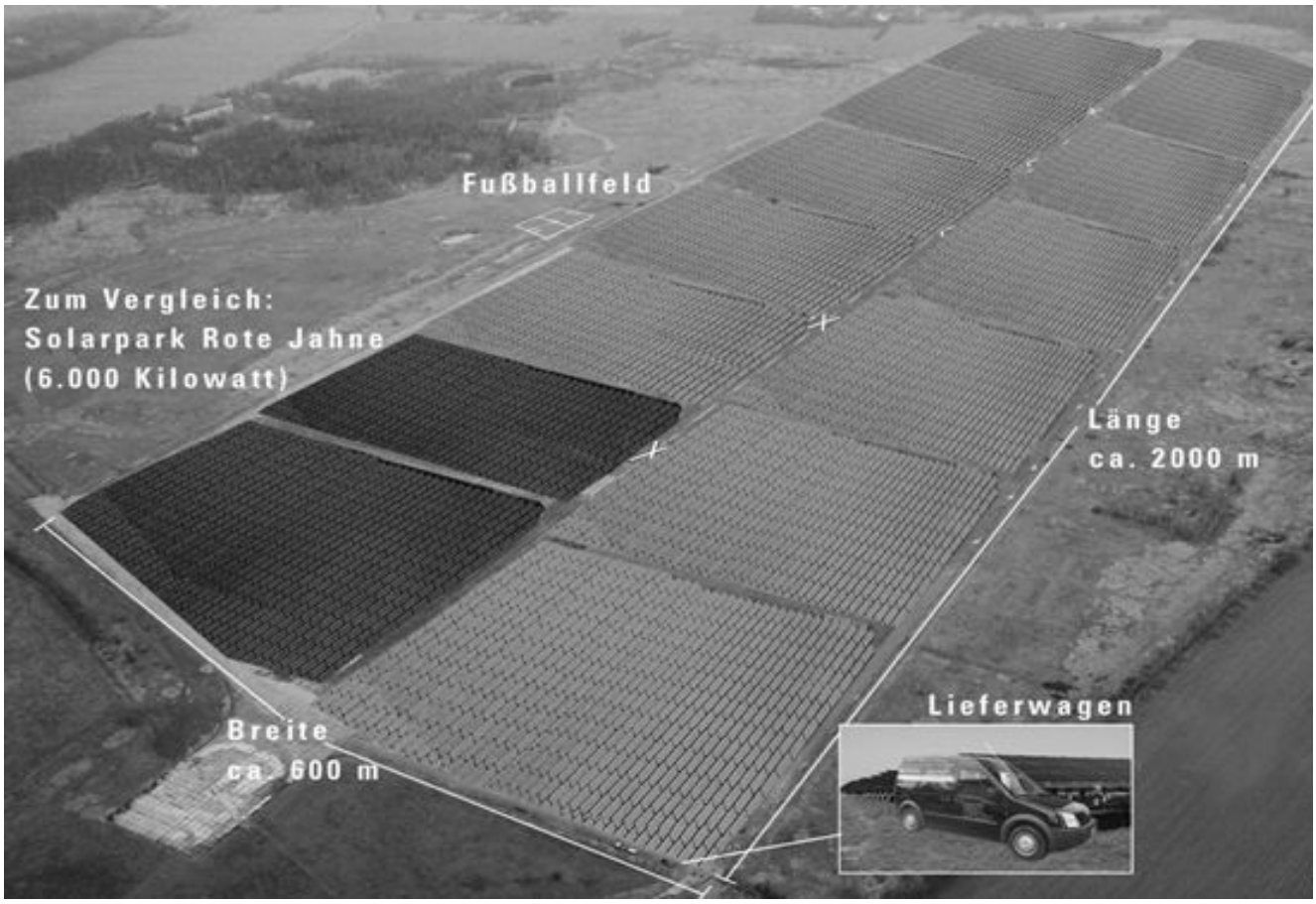
Some 5,000 – 7,000 companies currently make up the German solar industry. This has resulted in 35,000 jobs in the photovoltaic business, complemented by another 18,000 jobs in the solar thermal arena. Overall, approximately 170,000 Germans are employed in the renewable energy arena. More than $1.35 billion have been invested in manufacturing plants. By 2006, more than 40 German companies produced silicon, wafers, cells, modules and inverters.

The investments are bearing fruit. Government R&D – coupled with other factors – has resulted in a drop in PV system costs of 25% from 1999 – 2003. Taking a slightly longer-term perspective, there has been a drop in PV system costs of 60% from 1991 – 2003. By 2010, there are projections that the German “development model” will result in 100,000 solar jobs.

MARKET TRANSFORMATION EFFECT

A most profound program impact is the market transformation that has taken place. Despite poly-silicon shortages that hamstrung the industry, PV prices have decreased and are projected to decrease by 85% over the thirty-year period from 1990 – 2020. This primes the pump. By 2010 – in a mere three years – Germany's installed photovoltaic capacity is projected to be 4,500 MW.

The World's Biggest Photovoltaic Plant



Construction is currently underway for a 40-megawatt solar power system near Leipzig. The photo above simulates the completed project. Currently 10 MW of capacity is installed. The "Waldpolenz" solar park and is being developed by "the juwi group," one of the country's leading renewable energy companies. The location is a former Red Army air base, spacious enough to allow the 544 acres of space (approximately 200 soccer fields) needed for about 550,000 thin-film modules. First Solar is supplying the modules for the Waldpolenz solar park. Most of the 550,000 modules will be produced in Frankfurt/Oder, the location of the world's biggest and most modern manufacturing plants for thin-film cells. The investment cost for Waldpolenz is about $175 million. Construction began in February 2007 and slated to be completed in December 2009 in several construction phases. The plant is expected to generate 40 million kWh and to avoid the release of 25,000 tons of CO2 annually.

4. Environmental Benefits

Germany is known for its advanced environmental perspectives, taking “cradle to grave” approaches for products, and lifecycle views for investments. Their Renewable Energy Sources Act was designed to promote the market introduction of emission-free and sustainable energy sources to substitute for conventional energy sources. Several times, the Act refers to externalities, the unpaid costs of conventional power generation. The law speaks to the need for Germany to take action to support clean and sustainable sources.

Germany’s renewable energy targets are 12.5% by 2010 and 20% by 2020. In 2000, the nation had a tally of 6.3% renewables. In 2005, 62 billion kWh (TWh) or 10.2% of electricity generation in Germany came from renewables, of which 43 TWh/year was covered by the Renewable Energy Sources Act. By 2006, renewables were providing 11.6% of the power need. According to German experts, renewables’ share in Germany’s total electricity supply could be 25% by 2020, surpassing national goals.

Photovoltaics – the focus of this background paper – play a small role, providing only 2.8% of the renewable power generated. Even though photovoltaic capacity in Germany has soared, it accounts for a relatively a small proportion of total electricity production. This proportion is expected to increase from the current 0.5% to a probable 4% by 2020.

In 2005, a saving of around 58 million tons of CO2 was possible as a result of renewable energies in electricity generation. According to studies by the Federal Environment Ministry (BMU), CO2 savings of around 72 million tons can be provided by renewable sources of electricity by 2010, and 111 million tons by 2020.

5. Program Cost

There are many ways to look at “program costs” for the feed-in tariff, from the consumer standpoint, from the standpoint of ratepayer funded incentives, taxpayer supported government incentives for R&D, marketing and subsidizing low-interest loans, and private investment s in the solar industry. This section takes a look at the level of incentives passed through the feed-in tariff for solar, examines the rate impact of this policy, and then touches on government expenditures to support economic development through market stimulation and high-tech research and development.

COST TO UTILITIES

The following table shows the order of magnitude of incentive payments for photovoltaics in Germany. EcoMotion has extrapolated this data from gross capacity results, using a 75% derate factor for conversion of nameplate capacity to actual AC generation, an assumption of an average of 3.5 hours a day for solar insolation, and 365 days a year.

Based on this estimation of incentive payments, Germans have received approximately $3.6 billion in feed-in tariff incentives over the past 15 years, with annual payments climbing above one billion dollars in 2005. Some German researchers project that by 2010 the annual solar sales volume may be as high as $20 billion.

Actual data from Germany shows that in 2005 solar producers were paid an average of $0.7155 /kWh, for a total of $916.65 million (679 million Euros). This correlates quite well with estimates presented in the table above which shows 2005 payments of 721 million Euros.

COST TO CONSUMERS

The rate impact of the feed-in tariff has been carefully evaluated. In 2005 renewable plant operators received feed-in tariff fees totaling $5.45 billion. Most of this was for wind and biomass plants; solar

provided only a small fraction. German researchers believe that the marginal cost for this production was $3.24 billion, adding a $0.76 surcharge to each kWh used.

Estimated Solar Feed-In Tariff Incentive Payments

	Annual MW	Annual kWh	Cumulative MW	Cumulative kWh	Incentives in Euros	Incentives in US Dollars
1991	3	2,463,750	3	2,463,750	1,305,788	$1,762,813
1992	3	2,463,750	6	4,927,500	2,611,575	$3,525,626
1993	3	2,463,750	9	7,391,250	3,917,363	$5,288,439
1994	3	2,463,750	12	9,855,000	5,223,150	$7,051,253
1995	4	3,285,000	16	13,140,000	6,964,200	$9,401,670
1996	7	5,748,750	23	18,888,750	8,705,250	$11,752,088
1997	12	9,855,000	35	28,743,750	12,622,613	$17,040,527
1998	10	8,212,500	45	36,956,250	15,669,450	$21,153,758
1999	12	9,855,000	57	46,811,250	19,586,813	$26,442,197
2000	40	32,850,000	97	79,661,250	35,256,263	$47,595,954
2001	78	64,057,500	175	143,718,750	66,159,900	$89,315,865
2002	80	65,700,000	255	209,418,750	95,757,750	$129,272,963
2003	150	123,187,500	405	332,606,250	156,694,500	$211,537,575
2004	600	492,750,000	1005	825,356,250	412,628,850	$557,048,948
2005	750	615,937,500	1755	1,441,293,750	721,665,225	$974,248,054
2006	960	788400000	2715	2,229,693,750	1,105,566,750	$1,492,515,113
Total	2,715	2,229,693,750	2715	5,430,926,250	2,670,335,438	$3,604,952,841

Assumptions: *75% derating orientation, inverter loss, etc.; 3.0 avg daily hours insolation; 1 euro/1.35 USD*

The rate impact of the Renewable Energy Sources Act is about $2.16 per month for the average home that consumes 3,500 kWh per year. Germans point out that this rate impact is about equal to the price of “750 grams of bread or a liter of fuel.” Note that the rate impact covers all renewables, notably wind and biomass. This includes $0.0019/kWh for photovoltaics, a price increase for consumers of less than a percent, approximately 0.7%.

A study conducted by the Federal Environment Ministry predicts that given continuously rising volumes of electricity covered by the Renewable Energy Source Act, the monthly costs for a household resulting from the Act will increase to a maximum of $3.78/month by the middle of the next decade and will then decrease. The rate impact – or cost premium for renewables – will decrease as the cost of conventional electricity generation increases and most feed-in fees decrease every year.

6. Lessons Learned

There are a number of policy options for promoting solar.

Policy options for promoting solar include tariffs, quotas, standards and mandates. Solar systems can result from assessment districts and taxes as well. With the feed-in tariff, the price is set by law and the market determines the quantity. With quotas like the California Solar Initiative the law determines the quantity but prices are undetermined. The German Feed-In Tariff is well known for its simplicity, keeping transaction costs low. According to one German official, "Grid operators just have to take it, no matter how much, or when!"

The solar feed-in tariff has been an unquestionable success.

The Renewable Energy Sources Act has proven - also by international comparison - to be a most successful instrument for the market introduction of technologies for renewables use. The secret for success, according to Maike Schmidt who is leading the nation's evaluation of the photovoltaic feed-in tariff, is "cost effective remuneration." By providing clearly attractive incentives, combined with simple rules, the requirement that grid operators purchase the renewable energy, and long-term payments of 20 years, the feed-in tariff has been a simple and highly attractive business proposition for solar plant owners.

The feed-in tariff has proven to be a powerful market force.

The dynamism of the German feed-in tariff is unquestionable, dramatically eclipsing the incentive models used in the United States. Following Germany's lead, similar feed-in tariffs are now in use in Spain, Italy, Greece, France, and South Korea. Leaders in Germany cannot help but reflect on the California Solar Initiative (CSI). "The CSI is "producing a generation of frustrated homeowners in California." Only those that are passionate about being green are willing to invest, versus the much larger share of citizens that would welcome a good business proposition. Further, Germans point to 30-40% growth rates with solar and explain that it has had the benefit of "an intelligent support system," compared to California's "very cumbersome and difficult" solar structure.

The feed-in tariff has spurred solar development

In a country where half the region has lower insolation levels than Anchorage, Alaska it is actually profitable to own a solar system and this has become a business enterprise for many homeowners as well as companies. A continuing trend here has been the development of solar PV fields as retirement options. Investors borrow a large sum of cash to finance big systems which can provide positive cash flow for years to come.

Continued research is necessary in order to provide potential customers with more marketable and affordable photovoltaic products.

Because Germany is not a sunny country, long-term success in solar will be eclipsed by other countries. Therefore, the country hopes to expand its exports of solar technology and become the leader in PV products. Germany invests in over eight different research sectors such as Silicon Wafer, Crystalline Silicon, and Amorphous Silicon amongst others. And the proof is clear: prices for PV systems have decreased by 25% from 1999 – 2003; 60% from 1991 – 2003. Since June 2006, the German Solar Industries Association reports that solar prices have fallen 10%.

You don't need full sun to harvest solar electricity.

At today's incentive levels solar is a cost-effective means of generating peak power. As the costs of conventional fuels rise, and the costs of solar production falls, the picture will look brighter. German cities with half the average insolation of Southwestern United States cities have become world leaders. The chart below shows the relative insolation of a number of German cities. But even these are not particularly attractive by Southern California standards.

German "Insolation" (On Average, about like Anchorage, Alaska)

Select Cities	Avg Annual Hours of Insolation	Avg Daily Hours of Insolation
Freiburg	1300.00	3.56
Saarbrucken	1300.00	3.56
Stuttgart	1200.00	3.29
Nürnberg	1200.00	3.29
München	1150.00	3.15
Frankfurt	1100.00	3.01
Dresden	1100.00	3.01
Magdeburg	1100.00	3.01
Berlin	1100.00	3.01
Kassel	1100.00	3.01
Köln	1050.00	2.88
Bremen	900.00	2.47
Schwerin	900.00	2.47
Hannover	<900	<2.47
Hamburg	<900	<2.47

Poly-silicon shortages have hamstrung the German solar industry and will continue to be a factor until 2008.

The lack of poly-silicon in Germany has delayed production. Investments in new poly-silicon plants have been made, alleviating the current shortage. Because microchips and semiconductors contain small amounts of poly-silicon compared to modules of solar arrays, chip manufacturers will be able to pay a premium for the high grade poly-silicon they require. Many analysts predict that the poly-silicon shortage will last until 2008, slowing the pace of solar installations in Germany.

Germany is raising the bar.

While solar power production in Germany represents less than a single percent of the country's power generating capacity, Germany is clearly raising the bar and challenging the world to follow suit. Within the highly dynamic renewable energy arena in Germany, solar constitutes only a small fraction but has resulted in world solar leadership, tens of thousands of new jobs and a robust clean-tech industry well worthy of close examination and like replication.

7. References

1) "Germany: Growth Dynamics of the World's Largest PV Market," Presentation to EcoMotion's 2007 German Solar Research Tour, October 1, 2007, Jan Knaack, Project Manager, German Solar Industry Association, Bundesverband Solarwirtschaft e.V. (BSW), Stralauer Platz 34, 10243 Berlin, Germany. Plus personal communications.

2) Maike Schmidt, "The Renewable Energy Sources Act and its Influence on Production and Research," Presentation to EcoMotion's 2007 German Solar Research Tour, October 4, 2007, ZSW, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Systemanalyse Industriestrasse 6, 70565 Stuttgart, Germany.

3) Hansjorg Gabler, Zentrum fur Sonnenenergie und Wasserstoff-Forschung Baden-Wurttemberg, "Phototovoltaic Solar Technology in Germany – Status and Trends," presented to the EcoMotion Solar Research Tour, ZSW Stuttgart, October 4, 2007, plus personal communications.

4) Dr. Eicke R. Weber, Director, Fraunhofer Institut Solare Energiesysteme, Freiburg, presentation to the EcoMotion Solar Research Tour, October 4, 2007, plus personal communications.

5) Elmar Niewerth, Solarmarkt, Chief Executive Officer, personal communications, June 2007.

6) "A Photovoltaic Future," Bundesverband Solarwirtschaft (The German Solar Association), Solarwirtschaft.de, February 2007.

7) Marcus Maedl, former Regional Manager, SunTechnics Energy Systems, Inc., California, personal communications.

8) German Solar PV Technology Development and Application presentation given to the China New Energy Chamber of Commerce of ACFIC, January 2007.

9) Global Trends in Policy and Investment, Energy Research and Development, Germany Analyses, energytrends.pnl.gov, site visited April 2007.

10) Maegaard, Preben, "Sensational German Renewable Energy Law and its Innovative Tariff Principles," keynote address at the 2000 EuroSun conference in Copenhagen, Denmark.

11) Gipe, Paul, "Germans Investing Billions in Solar Electricity in 2004: Ontario Lags Well Behind", Wind-Works.org, September 2004.

12) Bernd Wenzel, "What Electricity from Renewable Energies Costs," Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, January 2007.

13) Stryi-Hipp, Gerhard, "Experience with the German Performance-based Incentive program", Solar Power 2004 Conference, San Francisco.

14) juwi international February 2007 press release.

15) Waldpolenz site visit, EcoMotion 2007 German Solar Research Tour, October 2007.

16) Testimony of Rhone Resch, President of Solar Energy Industries Association (SEIA) before the United States House of Representatives Committee on Ways and Means, April 19, 2007.