THE RAMIFICATIONS OF INCENTIVE & TECHNICAL POLICIES: A US-EU COMPARISON

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ABSTRACT

Over the past several years, the European PV market growth has outpaced that of the US, and the installed cost in the EU has been consistently below that of the US. Although there are many reasons for this, the primary ones are the financial mechanisms that support the industry in each, and the differences in technical requirements between them.

In this article we compare/contrast technical issues such as code requirements and their associated labor/equipment costs, incentive program structures and how they affect the maintenance and reliability of systems, and other related issues.

Because of the wide range of differences both within the US and within the EU, we limit the bulk of this analysis to a comparison between the California and German PV programs. In doing so, it becomes clear that government support in each case has greatly promoted PV, but the German system has done so more effectively.

1. INTRODUCTION

Over the course of the last several years, the worldwide deployment of photovoltaic systems has increased dramatically. Although global installations are on the rise, the European markets have grown at a more rapid pace than those in the US. There are several possible reasons for this difference: financial, technical, and cultural, among these. This study examines the disparity between the two markets by focusing on the technical differences between European and US requirements, and quantifies their impact on the expediency of installation and final cost of installed PV to the end user. The goal of this work is to generate increased discussion so the industry can better understand how differences in both technical requirements and financial incentive structures manifest themselves, and how these impact the US market.

Because of the lack of homogeneity within both the EU and the US, this analysis takes the most successful program in each for comparison: that of Germany and California. In terms of GDP and population, these two are comparable. In 2001, Germany's GDP was US$1.85 Trillion (1) while California's was US$1.36 Trillion (2); Germany's 82.3 Million residents compares to California's 34.6 Million (3). Yet, the projected amount of STC megawatts of PV installed in California for 2004 will be dwarfed by that of Germany by a factor of 30 MW to 300 MW (4).

2. FINANCING MECHANISMS

Most governments in developed countries find value in promoting PV. To this end, financial incentives are commonly used to spur the industry's growth. However, these resources are typically quite limited, thereby heightening the importance of using these in the most efficient and cost-effective way possible. The way Germany and California have each formatted their measures is substantially different, as are the forms success has taken in each program.

2.1 The California Program

The government of California has elected to support PV through a series of decreasing front-end rebates based on a estimated peak AC output power. The system's rated array output (or the PTC rating) and inverter efficiency are used

to arrive at an adjusted output value. The value of the rebate is dictated by the California Energy Commission, and is typically set to reduce by $0.20US every six months. The money comes from a relatively static pool of funding that is not self-replenishing.
The intent of this structure is to encourage homeowners to buy a PV system sooner rather than later thereby taking advantage of greater State refunds. Additionally, it assists buyers to lower their initial cost since this is often proven to be a barrier to end-user adoption.

Because there are no limits to the number of systems that can be rebated in a given six-month period, it is difficult to control the burn-rate of the rebate fund. If more money goes to funding systems in the short-term, this comes at the expense of those in the following terms unless additional resources are added to the fund.

With regard to program overhead, this model requires that all equipment used within the rebate program be approved and rated by the CEC. The installer or end-user submits a rebate application to reserve funds. This application is reviewed to make sure the equipment is on the CEC list, and that the appropriate efficiency and output ratings were used for all equipment. At the time this article was written, the typical wait time between application submission and rebate approval was about 90 days. Typically, systems will not be installed until funds are guaranteed following this review phase.

The California system also utilizes net-metering, or the practice of allowing homeowners to sell energy back to the utility when PV systems generate more electricity than the home is using. The net effect is that the homeowner receives the same value per kWh as they would pay if they were using this energy from the grid. Most utilities have no provision in place if a homeowner generates more electricity than they use of the course of a full year, meaning they are not compensated for this generation beyond what is consumed. This is seldom an issue since most systems currently installed do not output more electricity than the home uses, and the return rate would be the same as the purchase rate.

2.2 The German Program

By comparison, the German *Erneuerbare Energie Gesetz* program (EEG) does not offer a front-end cash incentive. Instead, it relies upon a feed-in credit, or a buyback price from the utility that exceeds the typical cost per kWh. In Germany for 2004, this production incentive starts at 57.4 €-Cents/kWh for rooftop systems under 30 kW (69.75 US-Cents/kWh at the time of publication). Each successive year for the fist 20 years of a system's life, the initial incentive amount to the end-user is reduced by 5%. As a result, the end-user's near term energy output is more highly rewarded. The government guarantees this rate for all 20 years. Slightly higher feed-in credits are available for building-integrated photovoltaics, while slightly lower rates are given to commercial-sized systems.

The source of funding is a surcharge on conventional electricity consumption (0.001 €-Cents/kWh, or 0.0012 US-Cents/kWh), therefore the government is not paying for this program out of any other program's source of funding – those that use conventional energy systems pay for it. The same rate is charged to all electric customers: residential, commercial, and industrial. The average cost to a homeowner in Germany running conventional electricity resources without PV would typically be under about €20 per year (US$24). The tax rate on conventional resources is recalculated each year based on the amount of kWh expected to be generated for the upcoming year from PV.

Formerly, the German government also operated a program known as the 100,000 Roofs Program that intended to achieve 350 MW of installed PV throughout Germany. The program consisted of a 1.9%-interest, 10-year loan to finance the cost. This program ended in 2003 when the program goal was met. However, to balance this disappearing incentive, the feed-in credit structure was increased for 2004. Meanwhile, the interest rates world-wide are currently quite low, so those that finance systems often receive conventional loans in the 4.5-5.5% range. To receive one of these loans, the homeowner typically requires 10-30% equity for the project cost.

The EEG program does not require any special listings or qualifications for hardware. Instead, it relies on market forces to dictate which equipment is used since higher yields will be achieved by systems with reliable and well-performing equipment. This program format also incentivizes positive system design, site selection, and installation practices, since these factors also lead to the total amount of kWh generated.

2.3 Differences & Analysis

The California model can be considered a success because it has led not just to increased installations in the state, but new business development as a number of PV-related manufacturers and distributors have located in California as a result of these installations. However, there are several program benefits missing from this model as compared to the German program that also led to increased installations and business development.

One such drawback to California's program is the mechanism used to supply funding. The German government, recognizing the industry's current dependency on consistent and predictable incentives, placed a strong emphasis on the sustainability of such funding. By guaranteeing program availability, the market can more aptly plan and build. By contrast, California's CEC funding is under constant threat due to both unexpected burn-rates and changing legislative agendas.

Another difference between the two programs is that performance and reliability are not currently accounted for in the California program. Although a PTC derating factor is used to distinguish between different products and their performance in similar conditions, this model does not incorporate any mechanism to encourage good system design, site selection, and/or installation practices. An installer could push the limits of good design practice or ignore them entirely and would obtain the same rebate funds as a well designed, installed and site-optimized system. Moreover, reliability beyond the minimum warranty period of the products is completely ignored and unrewarded.

By basing the rebate funds on kilowatt-hours of system energy output, the entire industry is held accountable. End-users have quantitative measures of how well an installer or system has worked in previous applications. Installers must strongly consider the ramifications of their site options and limitations, and make efficacious decisions to avoid call-backs and/or negative exposure. Equipment manufacturers must make products that meet the reliability and performance requirements of the industry. A product that is highly efficient but low reliability would not be as attractive in this type of program as one that has optimized both factors because both the installer and the end-user require these. Under the California model, minimum warranties are required. However, once a system is installed there is no requirement on the end-user's part to ensure that the system is ever operational or optimized.

3. DIFFERENCES IN TECHNICAL REQUIREMENTS

As significant as the differences in incentive programs are, the effects of the differing approaches to the PV market are apparent in the technical realm as well. Within the US, individual cities, counties, and states may each have their own ordinances and requirements specific to the installation of PV. By far, the most common set of common rules is the National Fire Protection Association's National Electrical Code (NEC). Section 690 deals specifically with photovoltaics, while numerous other sections are also applicable. The goal of the Code is to prevent fire and other damage resulting from electrical systems. Underwriters Laboratory listing is required for both modules and inverters, as well.

Within the EU, there is modest variability between different countries; for example, Germany requires inverters to check for grid impedance while the Netherlands has no requirements at all. However, very few countries have a specific set of rules and regulations for installers that are PV-specific. The most common requirement is the ENS, which is a grid impedance measurement to help ensure the inverter is outputting to a live grid. This typically adds about US$200 per system. In recent months, this requirement has been removed in Austria and there is currently consideration to remove it in Germany as well.

In Germany the *Deutsche Industrie Norm* (DIN), or German Industry Standards, defines regulations across a broad range of construction (for roads, buildings, etc.). The *Verband Deutscher Energiewerke* (DIN VDE) is the subset of rules that represent the equivalent of the NEC. Specifically, the VDE 0100 represents the electrical codes that apply to building. The VDE does not have any specific language relating to PV, but its scope makes it the closest equivalent of the US's NEC PV-related requirements. The different approach of these frameworks with respect to PV is relatively profound, as can be seen by looking at a few specific examples. It is important to emphasize that the information below is not supporting one method over another, but is meant to highlight the ways each market has addressed safety issues.

3.1 Product Testing/Listing Requirements

One of the primary ways the US market verifies safety of PV-related equipment is to require successful completion of Underwriter's Laboratory (or an equivalent test agency) testing to applicable UL and IEEE protocols. These tests are widely-acknowledged to be quite thorough and are crucial to satisfying utilities and other technically-critical agencies.

First-time completion of UL's tests often takes many months and typically costs over US$50,000 for inverters, and US$40,000 for modules. This does not include the cost for units that are sacrificed for testing. The time and costs are associated with laboratory scheduling and the requisite redesign as a consequence of the technical analysis. These costs are passed on to consumers in the form of slightly higher product prices.

In Germany and other European countries, every consumer product of any kind is required to have a CE marking on it – electrical and otherwise. CE listing provides the equivalent assurance by testing to IEC standards for PV and associated components with respect to electrical safety and EMI emissions. The technical differences of the tests are non-trivial, but minimal. However, each requires anti-islanding and other means of ensuring electrical isolation.

The difference between the UL-type testing and the CE tests is that CE tests are performed by manufacturers themselves and established by manufacturer testing and documentation. The test results must be recorded, but no independent test agency is required to perform these tests. As a result, the associated time and costs are minimized. TÜV, a European third-party test agency, can perform and verify such CE-required testing. This is required for modules, but is optional for inverters and other equipment, and seldom done within the PV industry for anything other than modules.

3.2 Grounding & GFDI Requirements

US authorities determined that the negative leg of PV systems must be connected to ground (as opposed to the floating ground used in Europe). This presents a philosophical difference in terms of safety. On the one hand, some feel it is safer to have possible ground faults isolated through the negative leads and have the positive leg be substantially higher than ground. Alternatively, others (like the Europeans) believe it is safer to have a floating array where there is no chance of the negative lead carrying a ground fault current when the system is theoretically off, and the differential between the positive and ground may be smaller.

As a result of the NEC's approach, the negative lead of all modules and other PV-related equipment must be bonded to the building ground. Furthermore, to prevent the PV system from operating when a ground fault condition exists, the NEC requires a ground fault detection and interruption device (GFDI) on all grid-connected inverters. By making sure there is no current traveling through to ground to a fault condition, users can avoid concern about possibly touching a conductor passing a fault current. This GFDI typically adds approximately $75 to the development and production cost of each inverter. This is less than the expense the German's pay for the ENS feature.

However, the requirement of having a grounded negative lead prevents the use of transformerless inverters. This type of inverter cannot currently be used in the US market since the grounded negative lead prevents it from operating properly. This, in turn, stifles innovation of different inverter technology.

In proposed revisions for 2005 version of the NEC, the grounding requirement has been altered to allow for a floating array. This would effectively allow transformerless inverters to enter the market.

3.3 DC Disconnects

The NEC also requires a DC disconnect to be installed "to disconnect all conductors in a building or other structure from the photovoltaic system conductors." (5) Although it is often advisable to have a DC disconnect in a system, the necessity of one is debatable. When a US system is first installed, conductors must be brought from the array to such a DC disconnect. However, to do so safely, installers typically leave one module in each series string disconnected prior to connecting the array leads to the disconnect. The array's final modules can be connected safely by leaving the disconnect in the open position, but this could also be achieved by covering the array if the disconnect was closed or not present. Conversely, if this disconnect were to ever be removed for any reason, the procedure would involve the same safety issues as if no disconnect were present.

In Germany, the VDE also requires a means for disconnecting DC conductors. However, this disconnect can take multiple forms: it can be a switch-type disconnect like the ones typical in US installations, but multi-contact plugs are also considered acceptably-safe as a disconnect means. As a result, systems in Germany can save the cost of additional hardware without significantly decreasing safety, while those who consider the practice of installing a DC disconnect safer still do so. The DC disconnect typically costs about $125 US and takes about 15 minutes to install.

3.4 AC Disconnects

Utilities may place additional restrictions upon the installer. Depending upon the nature of the utility (investor-owned, municipal, co-op) and the state's relationship with the utility through the Public Service Commission, there may be limitations to these restrictions. The most typical requirement is that of an external, lockable AC disconnect. This disconnect typically costs about $100 US, and requires about 15 extra minutes to install. Many utilities feel that it is safer to have such an AC disconnect so line workers can definitively remove the system from energizing the AC line. It seems unlikely that a utility would have the time nor personnel available to disconnect all PV systems from the grid given significant enough penetration of PV into the residential and commercial markets. Additionally, a case can be made that disconnection from the grid is the intent of the anti-islanding portions IEEE 929 and the testing required for UL 1741 listing – that a PV system will not feed power to the utility when the line's voltage and frequency are not within acceptable limits (among other cases).

Some manufacturers offer integrated disconnects, saving both the labor cost and part of the equipment cost. However, this still represents some additional equipment cost over not having these disconnect requirements.

3.5 Conductor Insulation & Conduit

In the US, only USE-2 wire can be used without conduit. Any other type of wire requires the additional time and expense of installing appropriately-rated conduit such as EMT or PVC.

In this particular case, the German system is not significantly different – it is also concerned with ampacity limits, UV-resistance and wet-ratings of conductors. However, the German market has adapted to provide a product that eliminates the need for such conduit. A special wire made by companies such as Siemens that is rated for high voltage applications, has double-insulation, and is rated for outdoor use without conduit in the EU.

3.6 Installer Qualification

One potential explanation for the lessened regulation in Germany is the experience and quality of installation professionals. In Germany, the norm is for installers to be professional electricians with who have made a foray (or a complete business shift) into PV from more traditional electrical contracting applications. Over the last several years, however, the market has continued to grow and other types of professionals are becoming installers – specifically, HVAC and roofing contractors.

In the US, there is significantly more variability in the backgrounds of installers. Although it is increasingly common for US installers to be electrical professionals, there are many installers that have developed their skills in PV after coming from other disciplines, such as plumbing, roofing, or general contracting. Many of these installers have developed extensive skill and proficiency with PV system design and installation, but others lack the technical competency to guarantee success.

3.7 Technical Analysis

Safety is paramount, and both the German and US code-making bodies intend to create rules that lead to safe electrical installations. To generalize the two approaches, the US code authorities tend to err on the side of caution, while the German officials set a minimum standard and yield a higher level of responsibility to installers to use equipment that is appropriate for their given system. This is a philosophical difference in analyzing the cost/benefit relation. However, when one looks at the results of these differences, these are harder to discern.

Although the Germans may have a less-stringent set of codes, no known safety issues have ever occurred as a result of these differences. (6, 7) Given the number of systems installed in Germany (approximately 500 MW as of the date of publication), this is statistically-relevant. This is not to say there is not sound logic as to why the NEC maintains various requirements – it is to say that the added value of some of these requirements may not outweigh the benefit of allowing qualified installers to decide. This becomes less of an issue as installers become increasingly qualified and other minimum competencies become institutionally required. In the US, larger numbers of electrical contractors are beginning to branch out into the PV installation business thereby raising this qualification level (cf., the State of Oregon's Energy Trust IBEW symposium in April 2004, et al.).

Additionally, no known product failures have ever occurred as a result of equipment that purportedly met the CE standards, but did not. (6, 7) It is, again, a matter of belief as to whether manufacturers can or should be trusted to meet such standards on their own, or whether a third-party verification agency should be required to validate such results. Thus far, the penalty for falsely claiming to meet such CE standards (product removal from the market) is harsh enough to prevent such misrepresentation and satisfy utility officials.

It is currently recognized by manufacturers desiring to sell products in the US that the costs and effort are part of the price of doing business in this market. However, such requirements make it more difficult to introduce new products or alter existing ones, and make it especially difficult for start-up organizations without significant financial backing.

4. CONCLUSIONS

Making summary statements based on the comparison of California and Germany is quite difficult given the complexities involved. Even comparing California to other states represents the introduction of variables such as the number of installers competing for business, average knowledge base of the installers in a state or region, cost of labor, tax rates/incentives, typical roof type and accessibility, among many other issues. Despite this, a few facts can be deduced.

To the financial levels currently encountered, the quantity of installations goes up with increasing incentives regardless of their financial structure. The effectiveness between the different structures appears less to be associated with the quantity than the viability of those systems. Because the dollar-per-Watt model front-loads the rebate, the primary incentives to keep the systems performing well for installers are based in reputation and the desire to not spend non-billable hours on service. When homeowners have a larger vested stake in the continued operation of their system, it holds the entire industry accountable. Furthermore, such production-based systems eliminate the need for state qualification of equipment, saving the bureaucracy of testing and/or analyzing specifications for equipment and avoiding the requirement of manufacturers to pass through additional market hurdles.

The counter-argument often used against such a production-based incentive is that it is difficult to manage, and that utilities would bear the brunt of this management expense. Although it is true that utilities would be tasked with this added bureaucratic and metering expense, this could be completely or largely offset by the same fund that would be used to pay end-users. Given that utilities already meter these sites and have systems in place for billing purposes, it seems technically plausible (and well established by other markets) that a utility can record one additional meter reading from either an additional mechanical-type meter or a solid-state meter that can record both building load and PV output at PV-equipped sites. Utilities and others justify their lack of desire to do so by the expense that it would cause them to bear, and if this objection could be overcome it would promote the adoption for this incentive format.

Another conclusion is that in an area where installers are appropriately-qualified, installation regulations may be loosened to allow the most efficient installation while maintaining safety. In the US, it would be possible to adopt such similarly basic standards. The trade-off would be to increase the qualification requirements for installers such that they are commensurate with those of professional electricians but with enhanced expertise on PV equipment as well.

There is also reason to believe that the structure used to maintain safe products may be hindering competition and adding expense. In the EU, over twenty inverter manufacturers compete within the grid-tied market, compared to less than half that in the US. Most of these companies in the EU market possess less than 5% market share, but are able to enter the market due to the lower overhead involved with their startup costs and the flexibility they possess to adapt their products. It gives each of these smaller manufacturers the opportunity to improve and grow over time, as opposed to requiring a larger amount of market capitalization to overcome additional institutional barriers from the beginning.

Although these technical barriers loom large, they appear to be intentionally set forward for a variety of reasons. However, after nearly a decade of incentive programs using the front-end rebate program model, better alternatives have now proven to help the market reach greater levels of penetration.

In a world dominated by direct and indirect subsidies to other energy forms, financial incentives are currently required to assist the photovoltaic industry compete. Financial programs based on front-end dollar-per-Watt incentives such as those in California, New Jersey, New York, and other states significantly assist in the promotion of PV, as can be evidenced by the rate at which installation numbers are increasing in these places. However, subsidies that take the form of a production-based credit more adequately promote the value of appropriate site selection, good installation practice, high performance component development, and extended system reliability. Several such smaller-scale programs exist including those in Washington State (the Sustainable Natural Alterative Power Program of Schelan County PUD), Pennsylvania (the Energy Cooperative co-op program of Philadelphia), and several Green Tags programs. Additionally, the State of California's CEC has begun a pilot program to test the protocol and feasibility of adopting such a performance-based structure in the future. However, these fledgling programs are currently the exception from the rule within the US.

4.1 Summary

As the photovoltaics industry moves to provide a larger percentage of the country's and world's demand for electricity, it becomes increasingly necessary to highlight ways to increase the cost-effectiveness of our approach to deploying and financing it. Although increased competition, new technology, and economies of scale will all eventually help drive price down, it is critical to use the limited financial resources the industry has been granted as effectively as possible. All aspects of the industry will mature with time, but there are several ways to assist in that process. Providing financial incentives that encourage more knowledgeable installers and superior products is one mechanism to accelerate this. Increased qualification of installers would help promote the safest and most efficient means to reducing the need for less-critical Code requirements and developing new products to expedite installations. Shifting the burden of proof of compliance with required standards from third-party laboratories to the corporations themselves could expedite product development and enhance competition. Although the institutional inertia relating to all of these points to continue on as before is strong and there are valid reasons for maintaining the status quo, it is critical to consider the possibility that each of these changes would support a more streamlined industry and promote the growing market penetration of photovoltaics.

5. ACKNOWLEDGEMENTS

The author would greatly like to acknowledge the tremendous support of the following individuals and their associated organizations in preparing this research: Marco Siller of IBC Solar AG, Michael Pupkes, DI of EWS GmbH & Co., Michael Nelson of the Northwestern Solar Energy Center, Terry Jester of Shell Solar, and Edward Eugeni of Princeton Energy Resources International, LLC. Internal support from Ulrich Winter, Hannes Wendeler, Thomas Mühlburger, Mark Stimson and Timothy Ball was critical to the collection of this information and the completion of this work.

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