Washington Internships for Students of Engineering

Solar Electricity:
Residential Photovoltaic Implementation via National Feed-in Tariff

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Commonly Used Acronyms

ACES2009	American Clean Energy and Security Act of 2009
EIA	Energy Information Administration
EIEA	Energy Improvement and Extension Act of 2008
EPAct2005	Energy Policy Act of 2005
FIT	Feed-in Tariff
ITC	Investment Tax Credit
kWh	kilowatt hour (measure of energy)
PURPA	Public Utility Regulatory Policies Act
PV	Photovoltaic
RPS	Renewable Portfolio Standard

Abstract

For some time it has been a focus of the United States to decrease the consumption of non-renewable energy resources and limit the emission of greenhouse gases by increasing the use of renewable energy. Replacing fossil fuel-generated electricity with electricity produced via solar Photovoltaic (PV) technology will help accomplish these goals. Although some homeowners have installed Photovoltaics on their rooftops, it is the high cost of PV systems which has inhibited more from implementing PV systems at their residences. This paper focuses on the advantages of PV systems in residential America, discusses the reasons why current legislation has not spurred PV implementation in residential areas, and outlines the incentive structure necessary to achieve residential implementation. The paper suggests that in order to stimulate the implementation of PV systems at a residential level, the U.S. must implement a national Feed-in Tariff system to make PV-generated electricity financially attractive to homeowners.

1 Introduction

1.A Fossil Fuel-Generated Electricity

For some time it has been a focus of the United States to replace the use of fossil fuels for electricity generation with renewable resources. Meeting the U.S. electricity demand with renewable resources will conserve a tremendous amount of fossil fuels, chiefly coal and natural gas. According to the Annual Energy Outlook of 2009, published by the Energy Information Administration (EIA), 4,160 billion kilowatt hours (kWh) of electrical energy were produced in the U.S. in the year 2007. Of this total, 2,915 billion kWh, more than 70 percent, were generated using coal or natural gas as a fuel source.

Not only do coal- and natural gas-burning power plants consume a tremendous amount of their non-renewable resources everyday, they also emit greenhouse gases, pollutants, and hazardous material into the environment. In 2007, coal-burning power plants were responsible for 34 percent of the carbon dioxide emissions in the United States.[1] A greenhouse gas, carbon dioxide is suspected of contributing to global warming. In addition, roughly 66 percent of all sulfur dioxide and 25 percent of all nitrous oxide emissions are released from electric power plants that rely on burning fossil fuels, like coal. Sulfur dioxide and nitrous oxides contribute to acid rain.[2] Coal-fired power plants also contribute 48 tons, or one-third, of the total anthropogenic mercury released annually in the U.S.[3] Replacing coal and natural gas with renewable resources will result in fewer greenhouse gases, pollutants, and hazardous material emitted into the atmosphere.

Furthermore, generating electricity by burning coal and natural gas is not a sustainable practice. Coal and natural gas are limited resources. Thus, it is necessary to begin investing in renewable electricity technology today such that the U.S. will eventually become independent of coal and natural gas for electricity generation.

While many forms of renewable electricity will displace the use of coal and natural gas and benefit the environment, this paper will focus solely on the residential generation of solar electricity.

1.B Current State of Solar Electricity

Of the 4,160 billion kWh of electrical energy produced in 2007, 350 billion kWh, less than 8.5 percent, were produced using renewable resources: 6 percent from hydroelectric, 0.9 percent from biomass, and 0.8 percent from wind power.[4] Solar electricity contributed only 0.06 percent, or roughly 2.5 billion kWh, to the total amount of electricity produced.[5]

The EIA forecasts predict that by the year 2030 the total electricity production in the United States will supersede 5,100 billion kWh. During the time span of the next 21 years, it is projected that solar electricity will grow from its current contribution of 0.06 percent to approximately 0.4 percent, or 20 billion kWh, of the total electricity generation in 2030.[4] Although this increase is a step in the right direction, solar radiation is such an abundant resource that even at 20 billion kWh it is largely untapped. To illustrate this point, the State of Arizona receives 20 billion kWh of solar radiation in approximately 17 minutes. Furthermore, the United States receives 5,100 billion kWh (the entire forecasted electricity demand of the U.S. in 2030) of solar radiation in roughly three hours.

1.C Availability of Solar Radiation

Not only is solar radiation an extremely abundant resource, it is reliable and non-depletable. As illustrated in Figure 1, the sun radiates an enormous amount of energy to the U.S. everyday and does so in a largely uniform manner across the States.

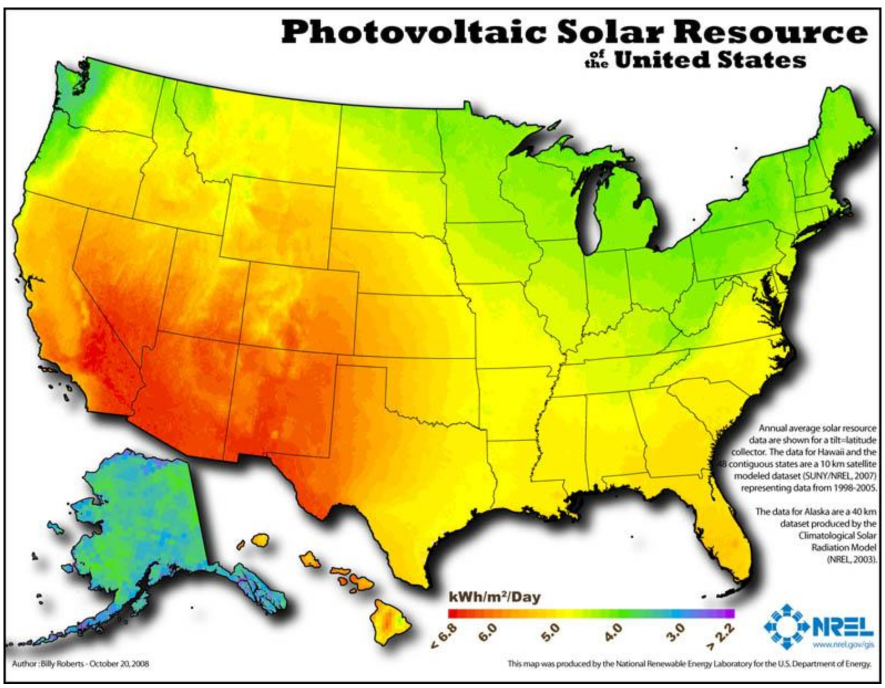

Figure 1: Solar radiation in kilowatt hours per square meter per day striking the United States.[6]

Even though the southwestern States receive the most solar energy, there is a tremendous amount of energy to be captured across all the States.

1.D Conversion of Solar Energy to Electricity

A number of technologies have developed to convert solar energy into electrical energy. This paper, however, will focus solely on Photovoltaic (PV) technology for electricity production because PV is applicable for residential implementation.

The most fundamental unit of PV technology is the solar cell. The solar cell uses semiconductors to convert solar energy directly into electrical energy. Numerous solar cells comprise a PV module, and a number of interconnected PV modules constitute an array. The PV array is ultimately connected to an inverter, which converts the direct-current electricity from the modules into alternating-current electricity and allows the system to be tied to the local grid*. All the components connected together make up a PV system. Figure 2 is a schematic of a PV system.

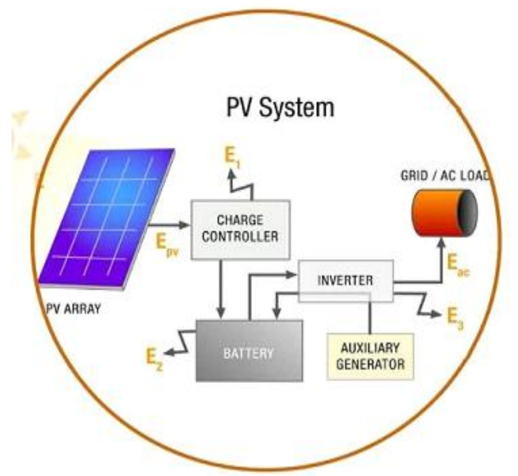

Figure 2: Schematic of PV system.[7]

1.E Definition: Solar Electricity

For the purpose of this paper, it will be beneficial to henceforth define the phrase "solar electricity" as the "electricity produced via PV systems."

1.F Solar Electricity: Advantages and Disadvantages

There are many advantages to solar electricity, yet solar electricity is not all rainbows and sunshine (pun intended). There are many who oppose the use of solar electricity. Consequently, it is important to fully understand the arguments for and against solar electricity.

i) Advantages

First, an inherent advantage to solar electricity is its energy source: solar radiation. Solar radiation is free, reliable, abundant, and non-depletable. It is a domestic energy resource, and the use of domestic resources enhances national energy security.

*The grid refers to the system of electric transmission lines from the power plant to the consumer.

Second, PV systems require no moving parts. Figure 2 subtly illustrates this important attribute about PV systems. Robust manufacturing and a lack of moving parts translates into a highly reliable product that requires minimal maintenance and repair costs after installation.

Third, once installed, PV systems produce electricity with no air pollution or hazardous waste byproduct. This effect is two-fold: PV systems produce zero emissions and prevent harmful emissions from the fossil fuels that would have been burned to generate the same electricity replaced by the PV systems.

Fourth, not only do PV systems displace fossil fuel-generated electricity, they do so when electricity is in highest-demand and most costly; Photovoltaics produce their electricity when electrical consumption is at its peak. During the daylight hours, electricity usage is at its highest state because businesses are open, industry is operating, and people are using electricity at their homes for appliances, lighting, and heating or cooling purposes.[8] It is also during daylight hours that Photovoltaics produce electricity from solar radiation. Thus, Photovoltaics provide electricity "during periods when energy is most constrained and expensive."[9] Furthermore, producing electricity during the most costly hours, solar electricity mitigates the risk of fuel-price volatility, which further enhances national energy security.

Fifth, solar electricity promotes economic growth. An increase in solar electricity production will fund and expand the relatively young and high-tech PV industry, which in turn creates jobs.

ii) Disadvantages

Most installed Photovoltaics currently operate at an efficiency between 10-20 percent. That is, the PV systems only convert 10 to 20 percent of the received solar energy into electrical energy. To compensate for the lack of efficiency, more PV modules are necessary to capture more sunlight. Buying more PV modules, however, means spending more money, and PV modules are expensive to purchase. The high cost of PV modules and systems has deterred individuals from investing money into generating solar electricity at their homes.

Additionally, the high price of PV modules causes the cost of solar electricity to be higher than electricity generated by conventional means. Presently, the cost of solar electricity is roughly 23 cents per kWh in sunny locations,[10] which is significantly higher than the national average cost of residential electricity at 11.3 cents per kWh.[11]

Even when solar electricity is compared to other forms of renewable electricity, solar is generally more costly. In 2008 for example, solar electricity cost between 21-81 cents per kWh. Hydropower, wind, and biomass, on the other hand, were capable of producing electricity between 2-5, 4-7, and 5-12 cents per kWh, respectively.[5]

Finally, one of the main advantages of solar electricity, its energy source (i.e. solar radiation), is also a disadvantage. Solar radiation is only available during daylight hours. Thus, in order to provide uninterrupted flow of electricity to the user, storage technology, such as batteries, or an alternate source of electricity is required.

In summary, solar electricity is derived from a free resource, but one which may only be harnessed during daylight hours. Although solar electricity is costly because of the high price of PV systems, these systems utilize a renewable resource, create no air pollution or hazardous waste, and displace the use of fossil fuels in generating electricity. Additionally, PV systems are highly reliable and have low maintenance costs. Increased demand for PV systems spurs the high-tech PV industry and creates jobs, which can guarantee a more stable energy economy for the future.[12]

With the advantages and disadvantages of solar electricity in mind, it is important to be knowledgeable of past, present, and proposed legislation that had, have, or will have an effect on the use of solar electricity.

2 Legislation Affecting Solar Energy

In 1978, Congress passed The National Energy Act. The National Energy Act consisted of five major pieces of energy legislation, and two of these, the Public Utility Regulatory Policies Act (*PURPA*) and the Energy Tax Act, had significant implications on the development of alternative energy.

2.A National Energy Act of 1978

The oil embargoes of the 1970's created concerns about the security of the nation's electricity supply, which lead to the enactment of *PURPA*.[13] Section 210 of *PURPA* was intended to promote electricity generation from small-scale Qualifying Facilities. The Qualifying Facilities would use alternative sources of energy to produce electricity, which would be purchased by the utility at a determined incremental cost.

Although not intended at the time, this basic concept of utility-purchased electricity is the same concept used in the Feed-in Tariff system (discussed later in Section 4.B) that has recently been used effectively in Germany to spur solar electricity generation.

The Energy Tax Act introduced federal incentives for homeowners who invested in solar energy equipment installed on their principal homes. The Federal government provided an Investment Tax Credit (ITC) of 30 percent for solar energy equipment expenditures that did not exceed $2,000 plus 20 percent of such expenditures which exceeded $2,000 but did not exceed $10,000. Under the Reagan administration, the residential ITCs established by the Energy Tax Act were allowed to expire as scheduled in 1985.

2.B Energy Policy Act of 2005

The Energy Policy Act of 2005 (*EPAct2005*) refocused the push for renewable energy generation. In Section 1335 of the bill, the Federal government provided individuals an ITC of 30 percent of expenditures made for certain residential energy property, including PV property, not to exceed $2,000. This level of tax credit had not been seen since the ITC expiration in 1985. However, the ITC mandated by the *EPAct2005* expired at the end of 2007, which proved to be an insufficient time period to spur solar energy growth.

2.C Energy Improvement and Extension Act

As part of the Emergency Economic Stabilization Act of 2008, the Energy Improvement and Extension Act (*EIEA*) reinstated and extended the ITC originally enacted in *EPAct2005*. For residential PV purchases, the ITC was extended until 2016 and the $2,000 cap was removed. The ITCs made available by the government are intended to act as a stimulus for investment in the PV industry, which funds further research of solar technology. Much of the research focuses on increasing the efficiency and decreasing the cost of PV modules. On May 27, 2009, the Federal government allocated stimulus money from the American Recover and Reinvestment Act of 2009 to further promote research in the field of solar technology.

2.D American Recovery and Reinvestment Act of 2009

To accelerate widespread commercialization of solar technologies across the United States, the American Recovery and Reinvestment Act of 2009 will provide the

Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) with seed money of $51.5 million for PV technology development and $40.5 million for solar energy deployment. The goal of PV technology development is to invest in PV research with the aim of making PV-generated electricity cost-competitive with traditional sources of electricity. Solar energy deployment, on the other hand, is focused on non-technical barriers to PV deployment, such as grid connection, market barriers, and the shortage of trained solar energy installers. These two technologies combined will help pave the way for adoption of solar electricity in residential environments.[14]

2.E American Clean Energy and Security Act of 2009

In the 111th United States Congress, representatives Henry Waxman [D-CA] and Edward Markey [D-MA] proposed the American Clean Energy and Security Act. If passed into law, The American Clean Energy and Security Act of 2009 (*ACES2009*) would, among other things, establish a renewable electricity standard. The renewable electricity standard would require electricity providers to supply an increasing percentage of their electricity generation from renewable sources, including solar, culminating in 20 percent by year 2020. The bill was approved by the House of Representatives on June 26, 2009. The Senate has yet to address this legislation.

All of the abovementioned legislation was or is designed to incentivize homeowners to invest in and install Photovoltaics at their residences. But why is implementation of Photovoltaics in residential areas, specifically, so important? The answer illustrates the potential benefits of residential implementation of PV systems.

3 Why Residential Implementation of PV?

A beneficial characteristic of Photovoltaics is that they are modular, which means they can be constructed in any size to fit specific energy needs. Such modularity allows for various-sized PV systems to be installed on the rooftops of homes. Rooftops are an excellent site for PV installation because they are abundant, provide large areas for PV modules (even in densely crowded cities), are often in direct sunlight, and are unobtrusive to everyday life. This last point is extremely important. Photovoltaics can be installed on rooftops and produce electricity quietly while not interfering with a person's everyday activities. By using rooftop area, there is no need for large, remote plots of land designated for solar electricity production. Additionally, PV systems installed at the residential level produce and integrate solar electricity into the grid, creating distributed generation of electricity throughout the grid.

Distributed generation of solar electricity is beneficial in numerous ways. First, consumption of electricity close to the point of production reduces electrical transmission losses greatly. Second, dispersion of electricity generation can prevent debilitating blackouts because electricity is being produced at numerous sources, rather than at one centralized location.[15]

PV systems in residential areas act as a constant reminder that the world of energy is changing. No longer will people be ignorant of the environmental consequences that are caused by fossil fuel-generated electricity. PV systems will increase public support of solar electricity and of the renewable energy sector as a whole, which will provide support for future actions regarding solar technology.

Now, knowing the benefits and future implications of PV systems in residential areas, it is important to determine the effectiveness of the aforementioned legislation by examining the current state of Photovoltaics in residential America.

3.A Investment Tax Credits

Initiated with the Energy Tax Act of 1978 and reinstated by *EPAct2005* and *EIEA* in 2008, ITCs are available to help defray the cost of PV systems to homeowners. Although ITCs help decrease the initial cost of purchasing and installing PV systems on residential homes, they still require the homeowner to front the majority of the money, and with PV systems this is no small task. For example, purchase and installation of a PV system today costs approximately $8,000/kilowatt, so a 4 kilowatt system comes to $32,000.[7] From 2005 to 2007, Federal ITCs under *EPAct2005* would have provided only $2,000, leaving the investor to cover $30,000! Since 2008, the Federal ITCs under *EIEA* provide the full 30 percent of the cost, or $9,600. This still leaves the investor to cover $22,400![*] While a select few U.S. citizens can afford such a capital-intense investment, the majority is forced to use debt financing to fund the project or completely forego the project because of financial constraints. Thus, ITCs only provide incentive to the portion of the population able to afford the initial costs of a PV system.

[*] Note: Additional Investment Tax Credits are available in some States to help further defray initial costs, but have not been included here.

For those who have installed Photovoltaics at their residence, net metering is an additional incentive available to most electricity consumers.

3.B Net Metering

Net metering programs allow the consumer to offset his or her electricity bill by the amount of electricity generated by the consumer's PV system. In the event the consumer produces more electricity than he or she consumes, a credit is provided to the customer and may be carried over from month to month, depending on the State.

Net metering, unfortunately, is not guaranteed to everyone. States are allowed to set a cap on net metering electricity capacity. Thus, not all financially capable homeowners are able to participate in the net metering system.

To observe the economic effects of net metering, an example of residential Photovoltaics under net metering in Los Angeles, California, is provided. California receives a lot of sunlight and has high electricity prices (14.42 cents per kWh as compared to the national average of 10.65 cents per kWh in 2007).[16] Utilizing the National Renewable Energy Laboratory's PV Watts Version 1 Calculator*, solar electricity production of a 4-kilowatt system in Los Angeles will produce 5,879 kWh of electricity over the course of the year. At 14.42 cents per kWh, this amounts to $848 of savings for the homeowner. According to EIA data collected in 2007, the average amount of electricity purchased in California was $1,003 per household per year.[20] Solar electricity would offset almost 85 percent of the yearly electricity bills!

A 4-kilowatt system, however, is not inexpensive. It will cost the investor $22,400 after the Federal ITC, as calculated earlier. A net metering cash flow analysis with an annual utility inflation rate of 3 percent calculates a payback period of 21 years.† The same analysis was completed for Phoenix, Arizona. Arizona has cheaper electricity prices than the national average (9.66 cents per kWh) and is possibly the sunniest State in the nation. Despite net metering savings of $625 per year, PV systems in Phoenix offer a payback period of 26 years. Photovoltaics do not currently provide the residential producer with a practical return on his or her investment.

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* PV Watts Version 1 Calculator <http://www.pvwatts.org/>

† For the mathematically inclined reader: $\$22{,}400 - \sum_1^{\boldsymbol{n}} [\ \$848\ (1 + 0.03)^{\boldsymbol{n}}\ ] < 0$, where $\boldsymbol{n}$ is the number of years to provide payback.

3.C Renewable Portfolio Standard

The renewable electricity standard proposed in *ACES2009* is frequently called by another name: Renewable Portfolio Standard (RPS).

3.D RPS in the United States

The RPS is already a common form of renewable energy policy in the United States, but has currently been passed only on a State level. Presently, 30 States and the District of Columbia have established a RPS, and five States have set voluntary renewable energy goals for adopting renewable energy instead of portfolio standards with binding targets.[17] Because each State has been allowed to formulate its own RPS, portfolio standards vary widely among the States and there is no standard policy across the nation. *ACES2009* includes a national renewable electricity standard to fix this problem.

Even though 35 States and DC presently have some form of RPS established, neither the renewable electricity standard in *ACES2009* nor a future version of a national RPS, if necessary, will be passed without opposition. There are those who strongly oppose portfolio standards, arguing that they are designed to raise electricity rates. Ben Lieberman, a senior policy analyst at The Heritage Foundation, stated that the standard proposed in *ACES2009* "is nothing more than a mandate for higher electricity bills."[18] Examining how a RPS functions exposes the likelihood of an increase in electricity rates.

A RPS sets a target amount of renewable electricity to be generated, but does not specify how that target must be achieved. Therefore, it is up to electricity suppliers to determine how they will meet the regulations. Typically in the U.S., a competitive solicitation is used to secure renewable electricity supply to meet the RPS mandate. As part of the competitive solicitation, suppliers issue requests for proposals and select the projects that offer the most attractive site, operational expertise, and cost. Due to the cost of developing a bid, the high risk of failing to obtain a contract, and the nature of investor financing at this scale (i.e. competitive solicitation projects tend to be financed by large institutions or corporate investors who provide equity as opposed to debt financing, and equity is more expensive than debt[19]), the required rate of return for competitive solicitations is generally high.[20] High rates of return correspond to high renewable electricity prices for the consumer.

It appears, therefore, that by instituting a national RPS, the government is knowingly increasing electricity rates. And thus, Lieberman is correct in his prediction that a RPS is designed to raise electricity rates. Lieberman overlooks, however, that electricity rates will rise regardless of whether or not we institute a national RPS. As fossil fuels continue to increase in price, increases in electricity rates are inevitable. Thus, the RPS is designed to elevate electricity rates today in order to fund renewable electricity research and promote the advancement of technology such that in the future electricity rates are not dictated by the volatile cost of fossil fuels, but by the steady cost of renewable resources.

It is important to understand that even though the RPS is designed to invest in renewable energy technology, its design does not favor solar electricity. As it is presently written, the renewable electricity standard proposed in *ACES2009* does not require a certain amount of electricity to come from solar. Rather, solar electricity must compete with cheaper forms of renewable energies for project bids, which further inhibits implementation of Photovoltaics. Even if the renewable electricity standard did have a requirement for solar electricity, the competitive solicitation process basically excludes small investors (i.e. homeowners) who are unable to compete against wealthy investors and/or corporations. Something more than the renewable electricity standard stipulated in *ACES2009* or another form of RPS is necessary to incentivize homeowners to install PV systems.

In summary, State RPS regulations do not promote the use of residential solar electricity, let alone solar electricity in general. Federal ITCs do not lessen the capital intensity of PV installation to the point where Photovoltaics is affordable to a large portion of the population, and net metering does not provide the homeowner an adequate return on investment. Thus, lack of sufficient financial incentive has prevented mass implementation of solar electricity at the residential level.

4 Germany

Germany, on the other hand, has recently experienced tremendous growth in the solar industry. Germany is a leader in solar electricity installation, with a large amount of that capacity coming from Photovoltaics installed on residential rooftops.

4.A German Legislation

Germany receives less sunlight than most other countries in Europe. Yet, solar electricity has become a major industry there. The reason for this is that the German government enacted legislation which provides homeowners with great financial incentive to install Photovoltaics.

The Electricity Feed Law (*StrEG*) was federally adopted in 1991. *StrEG* obligated public utilities to purchase electricity generated from renewable resources at a rate based on the utilities' average revenue per kWh. Compensation for wind electricity, for example, was set at 90 percent of the average retail electricity price.[21]

StrEG was replaced in 2000 by the Renewable Energy Law (*EEG*). The *EEG* essentially expanded the earlier law, with a few key differences, and introduced the Feed-in Tariff (FIT) system.

4.B Feed-in Tariff

Even though *StrEG* mandated utilities to purchase renewable electricity, it did not guarantee renewable electricity generators access to the grid. The *EEG*, however, obligates grid operators to connect renewable electricity generators to the grid and purchase the renewable electricity from those generators. The operators and utility companies, however, do not bear the burden of purchasing such renewable electricity. Rather, the costs are distributed equally amongst the grid operators and then distributed amongst all utility consumers.[22] This burden sharing is a fundamental aspect of the German Feed-in Tariff model.

Also, the remuneration system for the FIT is set up much differently than in *StrEG*. The payment rate for renewable electricity is no longer based on the average retail price of electricity, but on a fixed, premium rate differentiated by technology.[*] The differentiation compensates higher-cost renewable electricity with a higher rate than lower-cost renewable electricity. Solar electricity, being an expensive form of electricity generation, receives 43 euro-cents per kWh (for a PV system under 30-kilowatt capacity), whereas onshore wind electricity receives 9 euro-cents per kWh.[23] The tariff rate of PV, however, decreases each year. That is, PV systems installed in 2009 receive the guaranteed rate of 43 euro-cents per kWh for the next twenty years. PV systems installed

[*] Rates are also differentiated by project size, but that aspect will not be discussed in this paper.

in 2010 will receive the guaranteed rate of 39.5 euro-cents per kWh for the next twenty years. This "degression" in tariff rate is meant to incentivize homeowners to invest in PV sooner rather than later, and also to focus research on increasing the efficiency and decreasing the cost of Photovoltaics.

To recap the Feed-in Tariff, a homeowner with an installed PV system produces electricity that is fed onto the grid. The homeowner still purchases electricity from the grid at retail price, but is compensated for all PV-generated electricity at the guaranteed, premium rate by the electric utility provider for the entirety of his or her 20-year contract. The tariffs paid by the utility are then distributed evenly amongst all the consumers, modestly increasing the price of all consumers' utility bills.

4.C FIT Benefits and Concerns

i) Benefits

The FIT provides incentive to consumers to install Photovoltaics without the need for Federal or State subsidies or Investment Tax Credits; assured access to the grid and guaranteed premium tariff rates relieve the necessity of government subsidies. The subsidy-free FIT will provide consistent demand for PV systems, which is much better for PV businesses than the demand fluctuations associated with the intermittency of past Federal ITCs. Steady demand for Photovoltaics will provide reliable funding for research of Photovoltaic technology and development of manufacturing processes. Consistent demand will also allow the U.S. to return to the forefront of Photovoltaic technology and manufacturing, a position currently held by Germany and Japan.

The rate degression built into the FIT is also designed to provide multiple benefits. First, the degression acts as incentive for homeowners to invest in PV technology this year rather than next year. This causes homeowners to invest in PV and begin generating solar electricity as soon as possible, thereby offsetting fossil fuel-generated electricity sooner. Second, the degression motivates researchers to focus on increasing the efficiency of Photovoltaics and innovating less expensive methods of manufacturing solar cells. Increasing the efficiency and decreasing the cost of PV will help solar electricity become cost competitive with conventional electricity in the future.

Additionally, it is beneficial that the FIT greatly incentivizes residential implementation of PV because it provides demand stability in difficult economic times, like today. In the past, when the market was "riding high on mortgage backed securities," big banks funneled billions into renewable energy.[24] When the market collapsed, however, the number of investors dwindled drastically. Because the FIT attracts a great number of potential investors rather than relying on a few wealthy investors and/or large corporations like the RPS does, the FIT provides more economic stability for the PV industry than a RPS.

ii) Concerns

One concern is that the FIT does not help cover the initial cost of the PV system, which the U.S. Federal ITCs do. This makes it such that the investor has to provide the capital to purchase the PV system, and this effectively excludes a portion of the population unable to afford the cost. The guaranteed premium rate, however, assures investors a return on investment, which has incentivized many to take loans or front the capital and install Photovoltaics at their residence.

Another concern with the FIT is that it is designed to raise electricity rates. This is true, but by capping the amount of solar electricity that can be installed per year the regulating body can limit the percentage that electricity rates will rise. For example, in 2006 the Feed-in Tariff system in Germany raised the utility costs of the average household by only 2.20 euros per month for a reference household.[25]

4.D Solar Electricity in Germany

The Feed-in Tariff has led Germany to become the top PV installer in the world. In 2006, Germans installed 850 megawatts of PV-capacity. In 2007, Germany accounted for almost half of the global market with 1,100 megawatts of installed PV-capacity.[26] The United States, in contrast, installed a mere 145 and 250 megawatts of PV-capacity in 2006 and 2007, respectively. The great demand for PV in Germany has been mostly met by domestic production, which has led Germany to become one of the leading manufacturers of Photovoltaics in the world. The German company Q-Cells, for example, produced more Photovoltaics than Japan's Sharp to become the number one manufacturer in the world.[27]

The fact that Germany is a global leader in Photovoltaic installation and manufacturing is a remarkable feat considering Germany on average receives less sunlight than Japan and the United States, two of its main competitors. As illustrated in

Table 1 and Table 2, four major cities across Germany all receive less sunlight than cities across the U.S. Consequently, a PV system in the U.S. will produce more electricity than an equivalently sized PV system in Germany.

Average Sunlight Hours per Day	
Frankfurt, Germany	4.3
Hamburg, Germany	4.5
Berlin, Germany	4.9
Munich, Germany	5.1

Table 1: Average sunlight hours in Germany.[28]

Average Sunlight Hours per Day	
Seattle, USA	5.7
Chicago, USA	7.1
Atlanta, USA	7.3
Boston, USA	7.4
Salt Lake City, USA	8.3
Phoenix, USA	11.1

Table 2: Average sunlight hours in United States.[28]

Despite the fact that Germany has significantly less solar radiation, Germany is besting the U.S. in PV installation and manufacturing because of its Feed-in Tariff system. Because of the United State's greater ability to produce solar electricity, a Feed-in Tariff in the U.S. would perform at least as well as, if not better than, the FIT in Germany. However, PV implementation will remain underdeveloped if the U.S. does not implement a Feed-in Tariff system to promote residential implementation of PV.

5 Feed-in Tariff in the United States

There are currently a few different FIT policies implemented in the United States. It is the design of these Feed-in Tariffs, however, that has prevented the production and use of solar electricity from permeating throughout residential areas and achieving global recognition. For example, some U.S. Feed-in Tariffs do not focus on residential implementation of Photovoltaics. California State's FIT, for example, mandates investor-owned utilities purchase renewable electricity from eligible facilities, such as water and waste-water facilities. Additionally, the payment structure of many U.S. Feed-in Tariffs is not based on the cost of electricity generation. In Germany, the tariff rate is a fixed, premium rate based on the cost of solar electricity production in order to ensure a return on investment. In the United States there are two common tariff payment structures: utility avoided cost and fixed-price incentive. Neither of these payment types ensures a reasonable return on investment because neither is based on the cost of solar electricity production.

Since February 2009, however, one small area in the United States instituted a FIT similar to Germany. Gainesville Regional Utilities enacted a FIT policy in Gainesville, Florida, that is specifically designed to incentivize PV-generated electricity. The Gainesville FIT has many similarities to the German model. First, the tariff rate is based on cost of production. Second, the tariff rate degresses a certain percentage per year. Third, the fixed-price contract is structured over 20 years. Additionally, in order to limit the increase in electricity rates, the FIT includes a cap so that no more than 4 megawatts of new solar capacity may be installed in any one year.

Despite Gainesville's similarity to the successful German model, it cannot have nationwide-reaching benefits because the FIT is only available to consumers of Gainesville Regional Utilities. In order to stimulate PV investment across the U.S., Feed-in Tariffs cannot be left to the utility or State to implement. A nationwide FIT must be set up by the Federal government to encourage homeowners across the U.S. to invest in PV.

5.A National Feed-in Tariff Interaction

Implementing a national FIT policy, however, provokes concerns as to how the FIT will interact with existing policies such as ITCs, net metering, or a RPS.

i) Investment Tax Credits

As stated in Section 2.C, in 2008 the Energy Improvement and Extension Act reinstated and extended the Investment Tax Credits until 2016. If a Feed-in Tariff is enacted before 2016, the combination of the ITC and the FIT could provide a financial stimulus even greater than that offered in Germany. Not only does the FIT ensure remuneration to investors for an extended period of time, but the ITC decreases the initial cost of investment, which allows a greater portion of the population access to Photovoltaics.

With both policies acting together, it would be imperative to take into account the ITCs when calculating the FIT payment rate. Because the ITCs decrease the initial cost of investment, this puts a downward pressure on the required tariff rate necessary to ensure a return on investment. Thus, the tariff rate to the investor would be less with the ITCs than without the ITCs. A lesser tariff rate means that electricity rates would increase less for an equivalent amount of installed PV capacity, thereby benefitting all utility consumers.

ii) Net Metering

Because net metering and the FIT both involve feeding PV electricity back onto the grid, there is possibility for conflict between the policies. In order to decrease the likelihood of conflict, there are options for how the two systems may be treated. For one, net metered systems could switch to the FIT system, which would require an additional meter be installed to monitor the electricity output of the system. However, the question of whether existing net metered systems should be grandfathered into the FIT system could also create problems. If ITCs are no longer available under the FIT regulation, grandfathering could be seen as providing an unfair amount of incentive if the net metered systems had previously received Federal ITCs.

Another approach is to allow net metering and the FIT to coexist. The homeowner would be allowed to choose between net metering and the FIT, basing their decision on the current electricity price, the size of their system, and the rate offered by the FIT system. This is currently the option for residents in Gainesville, Florida. Homeowners with PV systems less than 10 kilowatts have the option between net metering and the Feed-in Tariff.

iii) RPS

If designed properly, the RPS and the FIT would enhance the effect of the other policy. As stated before, the RPS sets a target amount of renewable electricity to be generated, but does not specify how that target must be achieved. The FIT provides the utility company structure in order to meet the RPS target. The FIT would encourage the utility customers to invest in Photovoltaics and sell their electricity back to the utility. All this solar electricity bought by the utility would contribute to the utility's renewable electricity goal set by the RPS.

5.B Barriers to a National Feed-in Tariff for Solar Electricity

Instituting a national FIT system for solar electricity will not be an easy task. There are also a number of natural, technological, and political barriers that oppose the ratification of such a system. For one, certain States naturally receive less sunlight than others. The installation of a 4-kilowatt PV system in Arizona will produce much more electricity than an equivalent-sized PV system in Alaska. Thus, for the same amount of installed PV capacity, States that receive a large amount of solar radiation can produce a greater amount of electricity than States that receive less solar radiation. In order to account for this, tariff rates would need to be differentiated between States in order to provide an accurate payment based on cost of electricity production – the Alaska residents would receive a larger tariff rate than the Arizona residents.

It is not technically sound to feed too much electricity back onto the grid. Only a certain percentage of PV systems in one area would be capable of feeding electricity back onto the grid. This would prevent a number of financially capable homeowners from being eligible to participate in the FIT system. The American Recovery and Reinvestment Act of 2009, remember, appropriated stimulus money to fund solar deployment research. It is possible that this stimulus money and future upgrades to the grid will allow more homeowners to tie onto the grid and participate in the FIT system. Thus, for the short term, limiting the amount of new solar capacity is necessary to prevent the grid from being overloaded. In the long-term, this limit may not be necessary.

Politically, many members of Congress will be opposed to a Feed-in Tariff because it will increase electricity rates. For those members of Congress who represent poorer districts, the FIT could be seen as putting their constituents at a disadvantage. The FIT is available to the portion of the population who has the ability to finance the initial cost of a PV system, yet the rest of the population who cannot afford Photovoltaics are obligated to contribute to the FIT by paying an increased electricity rate.

In this case, it is important to remember that the electricity rate increases are regulated to a small percentage per year. This cap is instituted in order to prevent increased electricity rates from significantly affecting utility consumers and their finances. However, it is the ultimate goal of the Feed-in Tariff that is more important than the implications of increased electricity rates. It is necessary to look past the short-term effects of increased rates to the long-term effects that the increased rates will have: the money garnered from the FIT system will fund research to improve PV technology and decrease PV manufacturing costs, such that one day PV systems will be affordable for everyone. Decreasing the cost of Photovoltaics to the point that PV systems become a staple in residential areas will increase the United State’s production of solar electricity and decrease its reliance on fossil fuels. The FIT system is more than an increase in electricity rates, it is an investment in the future of electricity.

With a correctly designed national Feed-in Tariff system, current barriers can be overcome and solar electricity may become a major part of our electricity portfolio.

6 Recommendations

In order to properly design the national FIT, the following recommendations should be taken into account:

Recommendation 1: Stable National FIT Policy

Ensuring that the national Feed-in Tariff system will be available for a guaranteed number of years will provide incentive to invest in Photovoltaics. As seen with Investment Tax Credits, if the incentive is only available for a few years it will not promote long-term investment in PV. A national FIT guaranteed for an extended period of time gives homeowners time to invest in PV systems and demonstrates commitment to the use of solar electricity.

Recommendation 2: Payment Based on Cost of Generation

A payment rate based on the cost of solar electricity generation provides investors remuneration that will enable them to make a return on investment.

Payment rates should also be differentiated by State. Because some States receive more sunlight than other, the cost of production will vary by State. As a general rule, States that receive more sunlight will receive a payment rate less than States that receive less sunlight.

Recommendation 3: Long-Term Contracts

Long-term contracts guarantee the homeowner will be compensated for solar electricity generation at an invariable, premium rate for an extended number of years. Long-term contracts assure the investor a reasonable rate of return on their investment.

Recommendation 4: Annual Tariff Degression

An annual tariff degression encourages homeowners to invest in Photovoltaics sooner rather than later and motivates PV research to increase the efficiency of Photovoltaics and decrease the cost of manufacturing PV modules.

Recommendation 5: Incorporate the Costs of FIT into Electricity Base Rate

Distributing the cost burden of solar electricity generation amongst all the end users causes electricity rates to increase by only a small percentage.

Recommendation 6: Limit the Installation Capacity of Photovoltaics per Year

By limiting the amount of new PV capacity that may be installed in any one year, the increase in electricity rates can be regulated to a certain percentage.

About the Author

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About WISE

Founded in 1980 through the collaborative efforts of several professional engineering societies, the Washington Internships for Students of Engineering has become one of the premier Washington internship programs. Its goal is to groom future leaders of the engineering profession who are aware of and can contribute to the important intersections of technology and public policy. Please see http://www.wise-intern.org for more information.

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