Grid-Tied Photovoltaic Development and Barriers in Texas

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Executive Summary

This report describes the grid-tied photovoltaic market, the technology, the support policies and the barriers that have impacted the development of this market. This report is organized into five sections. Section 1 is the introduction of the report. Section 2 contains technology aspects of photovoltaic systems; section 3 contains economic aspects of photovoltaic; section 4 contains barriers different than technological and economical. The last sections contain our conclusion.
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1. INTRODUCTION

Texas has been a global energy leader in oil and gas drilling, production, and refining. This allowed Texas to gain expertise in energy research and innovation, which in combination with huge natural resource could be used to develop energy production based on solar energy.

The global PV market has grown by an average of 30 percent annually for the last 2 decades. With this increase, there is significant improvement in economical scale of manufacturers. The consumption of electricity is growing every other day. The average use of electricity varies from state to state so we focused our research on the national level first and then it will be compare with the energy that we use in Texas.

Our project at this time will include available resources, and other benefits for supporting photovoltaic (PV) technology in Texas. The Texas electric market and the impact of the PV dissemination programs at both federal and state level will be discussed, and some of the technological and social barriers that should be overcome in order to make PV viable will be identified.
2. TECHNOLOGY

2.1 History of Photovoltaic Technology

The foundation of solar photovoltaic energy was laid in 1839 by French scientist Edmond Becquerel with the discovery of photovoltaic effect. During early twentieth century some progress was made for the development of solar power. The first application of solar power was made in 1958 when Vanguard-One, a satellite with small solar array, was launched to the space. In 1970, the price of solar power was $20/watt [1] and it has been estimated that by 1977, the global annual photovoltaic installed capacity was 500 kilowatt (kW) [2]. After 1982, full megawatts scale projects started to emerge as well as intense research in this topic, which contributed with advancements in technology. By 1999, the world’s solar cumulative power capacity reached 1 gigawatt (GW) [2], and the application of solar photovoltaic became more diverse and its use was spread worldwide.

Solar photovoltaic (PV) is a semiconductor technology that converts sunlight directly into electricity. The thin semiconductor wafer forms an electric field with positive terminal on one side and negative on the other side. The semiconductor material exhibit a property called photoelectric effect that absorbs photon of light and releases electrons. These electrons in turn constitute the electric current which can be used as electricity. A number of solar cells are electrically connected to each other and are placed on the frame to form a photovoltaic module. In turn multiple modules are wired together to form an array. In fact, modules can be configured in both series and parallel arrangement to get any required voltage and current.

In today’s PV device, single junction/interface is used to create an electric field. Here, the photons with energy above the band gap of the semiconductor device are used while those of lower energy photons are unused. In addition to single junction PV cell, there is a multi-junction device still under research. In multi-junction device, individual single-junction cells are arranged in the descending order of band gap. The top junction (e.g. Gallium indium phosphide) captures the high energy photons while the remaining junctions aid the flow of photons (e.g. copper indium diselenide, Gallium arsenide). Such cell combination is believed to have efficiency of 35% [3].

According to the recent survey done by solarbuzz.com, today’s market shares (78-80) % by crystalline silicon solar cell while thin film solar cell shares only (18-20) %. Crystalline silicon used in solar cell is poor absorber and thus required more thickness. The efficiency of such cell is in between (11-16) %. In fact, there are two types of crystalline silicon used in the today’s industry, namely mono and multi-crystalline silicon. An interface is formed by doping phosphorous on the top of boron. In practice, most efficient production cell have mono-crystalline silicon as the semiconductor in solar cell.

On the other hand, thin film solar cells have amorphous silicon to absorb light. Here, material cost are significantly reduced while the efficiency ranges from (5-8) %. There is a tradeoff between price and efficiency between thin film and crystalline solar cell. The thin film solar cell is more popular in residential uses and is exploring every year due to its economic price.
2.2 Some recent PV innovations in labs

A) Research and development (R&D) is done to improve the efficiency of these thin film technology. For instance, according to the US National Renewable Energy Laboratory (NREL), they have successfully tested thin film solar cell based on copper indium gallium diselenide (CIGS) with efficiency of 19.9% [4] as shown in figure 1. This makes thin film competitive with traditional silicon semiconductor cell.

![Copper indium gallium diselenide (CIGS) thin-film solar cell](image1)

Figure 1  Copper indium gallium diselenide (CIGS) thin-film solar cell (NREL) []

B) On the other hand, SUNRGI a California based PV manufacturing has developed a Xtreme Concentrated Photovoltaic (XCPV) that concentrate sun’s light close to 2000 times. It is believed that the wholesale cost of electricity produced from such PV cell is as low as five cents per kWh [5]. If such cells are commercially used in the market, the price is competitive with the wholesale of producing electricity using fossils fuels. Here, the system tracks the sun from sunrise to sunset. In short, these cells have advantages of more efficient (~37%) as well as less surface area for the same output. Figure 2 shows the comparisons of average outputs of three different PV cell in Daggett, California in the period of one year.

![Energy output comparison for three different PV cell](image2)

Figure 2  Energy output comparison for three different PV cell [4]

According to the research done by State Energy Conservation Office (SECO), the energy from sunshine falling on one acre of west Texas land is capable of producing energy equivalent of 800 barrels of oil each year. While west Texas has a huge potential of solar resources, this technology can be implemented readily.
C) Researchers at McMaster University have developed light absorbing nanowires made from high performance photovoltaic such as gallium arsenide, indium gallium phosphide on carbon nanotube fabric as shown in figure 3. They have a target of achieving 20% efficiency within couple years. This technology can be the best alternatives for current thin film technology of (5-8) % efficiency. The reason behind this fact is that, nanotubes have absorbing nature and we can significantly reduce manufacturing cost.

![Figure 3 - Hairy solar panels made from nanowire](image)

**2.3 Photovoltaic System Analysis**

Now, let us discuss more detail about photovoltaic system. The photovoltaic system is composed of following major components as shown in figure 4:

- a) Modules for Energy conversion
- b) Inverter for energy inversion
- c) Utility meter for energy distribution and
- d) Electric Utility for transmission and distribution

![Figure 4 - Photovoltaic System Composition](image)

**2.3.1 Modules**

Technological details about the solar modules have already been discussed in the previous section. However, in this section we are going to estimate the average cost of PV modules per watt. In general, an installation cost of PV system is determined by the cumulative cost of modules, inverter, regulatory and compliance, and labor cost. More importantly, about 50 % of the installation cost is determined by the price of module as shown in figure 5. Figure 6 and 7 show the survey that was made within United States to calculate the average cost of PV modules and PV inverters.
The installation cost varies widely within United States and overseas. Now, let us calculate the average residential installation cost per watt for in Unites States based on the assumption on the following assumptions:

- Modules=$2.65 (from figure 6)
- Inverter = 0.65 (considering inverters below 10k – residential system, figure7)
- Labor cost = $0.75
- Regulatory, Compliance =$2.35
- Other accessory materials =$0.56
Total sums up to $6.96 ~$7.00

The average PV installation cost per watt decline by an average of $.30 from 1998 to 2008 [5]. This can be illustrated in the figure 8. For residential PV, the average installation cost has reduced from $12.30/watt in 1998 to $8.50/watt in 2008. This reduction in cost is the cumulative effect of improvement in cost structure and efficiency of PV infrastructure and of course the policy.

![Figure 8 Average installation cost/watt historical trends [5]](image)

On the other hand, in 2007 the average installation cost per watt in Japan was $5.9/watt while that of Germany was $6.6/watt. During the same year, the average installation cost in US was $7.9/watt. The reason behind this high cost PV installation in US might be because of the less grid-connected PV capacity (500MW) as compared to Japan (1800MW) and Germany (3800 MW). However, it is important to keep in mind that, market size is not the only determining factor. For instance, Japan had smaller market as compare to Germany but the installation cost/watt was lower. One reason behind this fact was that PV support policies in Japan were oriented to the residential sector. Several other factors that make the difference in installation cost include labor cost, foreign exchange rate, procedure for receiving incentives, and the module cost.

2.3.2 Inverters

Now, let us discuss more on the inverter from the technological prospective. Inverter currently comprises 10% of the system cost. The higher the power rating of the inverter, the less average price/watt we get. This can be seen from the graph above. Technology in the inverter mainly affects CEC efficiency and the warranty period. From the recent survey made in United States, the grid-tied inverters in the market have CEC efficiency of 95%.

Inverters are becoming more sophisticated with the advancing technology. Inverters these days are designed with many features such as data logging and communication capabilities. A configuration called master-slave is introduced to operate inverter at a maximum power levels for higher system efficiency. In addition to that multi-string inverter can be used to connect many strings to a single inverter to have separate maximum power point tracker (MPPT) to each string. This method is beneficial for PV with shading problems. Many inverter models available in US don’t have such features.
On the other hand, it is believed that conventional inverters are responsible for the loss of 2% in peak efficiency. Furthermore, they are weightier. In order to solve such problem, transformerless inverters are introduced and are more popular in Japan and Germany. However, the development of transformerless inverter in US is very slow. In August 2010, SMA has received certificates from Underwriters Laboratory (UL) for its transformerless inverter. Now, SMA can distribute them in the US market. Some of these models include Sunny Boy 8000TL-US, Sunny Boy 9000TL-US, and Sunny Boy 10000TL-US inverters. Before that there was a special requirement imposing designer to use galvanically isolated device because there was concern about having transformerless electrical system feed into the public utility grid (lack of galvanization between AC and DC circuit).

High frequency inverter on the other hand employs multi-step process to convert power into high frequency AC and back to DC, and finally to the AC output voltage. These HF transformers are small, lightweight and provide isolation. These are considered as the compromises between low frequency (traditional transformer) and transformerless design. Regarding the transformerless inverter, manufacturer still expect changes in regulations or in utilities requirements and in the meantime inverter with transformer continue to serve the market.

In addition to efficiency & design, warranty is a part of inverter’s technology. From the recent market survey in US (Assignment #2), the grid-tied PV inverter has an average warranty period of 5-10 years, while off-grid have 1-3 years within the same power rating. Some manufacturers such as KACO, PV Powered, SMA, Xantrex, and Fronius offer their customers a warranty of 10 years. This data supports the rapid expansion of grid-tied PV in US as compare to off-grid.

Thus, technology plays a significant role in solar energy implementation. It is important to keep in mind that the main barrier for the growth of PV industry is high cost. The cost in turn is directly related to the technological achievement we make in these areas. For instance, reducing the module material cost by using effective semiconductor material/technology and increasing efficiency leads us to significantly reduce installation cost. The following is the survey done by international energy agency (IEA), 2002 and 2007 to study the components reliability and system performance. Although these data are pretty old but still represent the same trend in PV industry. Also, there is not vast technological difference between Europe, North America and Asia, it still represent US PV market. The big difference it make is with federal, states, & local policies. More importantly, this is even valid for different states in US. Thus, we have assumed Texas is also represented in the research & survey we made in this photovoltaic technology part.
2.4 PV Performance Analysis

According to the report published by IEA in 2002, inverters have more failure rate than other component in Photovoltaic power system as shown in figure 9.

This is the result published after the survey done 1000 roof in Germany. Although, the failure rates is declining with the innovation and research over time but this significantly impact PV performance, and reliability.

Figure 10 shows the data published in 2007 by IEA PVPS about the performance ratio of Photovoltaic power system.

Figure 10 performance ratio over time in grid connected PV system between 1990 and 2006 [7]

In this survey, 461 grid-tied PV system built in between 1990 and 2006 with a total of 1648 years of operational data were analyzed. The survey was done in PV system below 10k (residential) and the participant countries were from Germany, Japan and Switzerland. The middle green dots represent the mean performance value of the PV system over time. This report shows a trend towards higher inverter efficiency and hence higher performance ratio over time.

This survey reveals that there always exist challenges in improving the reliability of the inverter. Some of the methods that help towards better inverter and overall system reliability are as follows:

- Building block approach for standardization and modularization of the inverters
• Interconnection technologies
• Reduction in inverter heat loss, and better electrolytic capacitor
• Design, installations and standards maintenance can significantly improve this part

2.5 Some other technological Barriers in PV system

Since the main challenge in PV system is the high cost, several ways of managing cost have already been discussed. In addition to cost, solar energy is not highly concentrated and therefore requires significant surface area to collect an appreciable amount of energy. Research and development is underway to introduce high concentration photovoltaic in the market in affordable price. Also, there are lots of protection issues related to PV system. Some of them are:

• Ground fault can harm life and electronic components
• The system is always energized
• In-circuit arc can ignite fire
• Overcurrent protection difficult to provide

Intermittency is another technological problem related at high penetration. Such problem can be solved using Energy storage that decreases base load generation requirement. Storage device such as Batteries (lithium, lead-acid, alkaline), Kinetic flywheel, or hydrogen fuel cell can be used depending on the cost, efficiency and available resources.

In short, from the research done on the Technological reveals that solar photovoltaic energy has great potential to contribute on the renewable energy system. However, there are many technological challenges to overcome every other day. The challenges include but not limited to cell material & module technology, power electronic system (inverter), and electrical network. From the cost prospective, PV modules play a significant role and from the system reliability point of view, inverter plays an important role. Our modern technology should focus on solving this problem in order to have overall system reliability.
3. ECONOMICS

3.1 Energy Market in Texas

Due to its large population and an energy-intensive economy, Texas leads the nation in energy consumption [9], accounting for more than one-tenth of total U.S. energy use and per capita residential use of electricity is significantly higher than the national average, due to high demand for electric air-conditioning during the hot summer months and the widespread use of electricity as the primary energy source for home heating during the typically mild winter months.

Since January 1, 2002, Texas has a deregulated market, which means that people have the power to choose their electricity provider [10]. Deregulation was designed to promote competition among retail electricity providers (REPs), which in turn, spurs competitive pricing. However, deregulation is not present in all the state. For instance, in areas served by cooperatives or municipal utilities, people have the option of choosing an alternate REP only if the cooperatives and municipal utilities opted in to deregulation. To date, only the area served by the Nueces Electric Cooperative has chosen to opt in. Therefore, deregulation has not been opted in by most of the municipal and cooperatives utilities in Texas.

ERCOT is one of nine regional electric reliability councils under North American Electric Reliability Corporation (NERC) authority, which was designated for operating the electric grid and managing the deregulated market for 75 percent of the land area (figure 11) and 85% of the electric consumption in the state [14].

Texas is a state with abundant natural resources, which are used for meeting its energy needs. Texas leads the Nation in fossil fuel reserves. Texas crude oil reserves represent almost one-fourth of the U.S. total, and Texas natural gas reserves account for over three tenths of the U.S. total, making it the nation’s leading natural gas producer [18].

Natural gas-fired power plants typically account for about one-half of the electricity produced in Texas and coal-fired plants account for much of the remaining generation [18]. Texas is a major nuclear power generating State. Two nuclear plants, Comanche Peak and South Texas Project, typically account for about one-tenth of the State’s electric power production.
As an example of the non-renewable energy source dependence in Texas, figure shows the sources of energy for generating electricity in the ERCOT area. According to figure, natural gas is the most important source followed by coal and nuclear. Due to the size and the dependence of the electricity market in fossil fuels, the emissions of carbon dioxide and sulfur dioxide are among the highest the nation.

Texas leads the nation non hydroelectric renewable energy potential, including wind, solar, and biomass resources. Despite this potential, renewable energy sources contribute minimally to the Texas power grid (about 2% in ERCOT area). Most of the electricity from renewable energy sources in Texas is generated with wind.

3.2 Cost of Electricity in Texas

Texas retail electricity prices (price that REPs sell the electricity to the consumers) averaged 11.99 cents per kWh for residential, 10.27 cents per kWh for commercial, and 8.27 cents per kWh for industrial customers in March 2008 [11]. On the other hand, wholesale electricity price (price that power generation companies sell the electricity to REPs) is significantly lower, averaging 5.5 cents per kWh, but ranging from an average monthly low of about 4.5 cents per kWh in October to an average high of about 7.5 cents per kWh in August 2006 [11]. The wholesale price of electricity during peak hours, however, can sometimes rise to over 80 cents per kWh in ERCOT.

3.3 Cost of Photovoltaics

PV system cost, which is measured in dollars per watt ($/W), involves module and non-module cost. The non-module cost may include array mounts, wiring, switches, fuses, connectors, the inverter and possibly metering or other components that may be required for the interconnection. The installation cost, permitting and fees, shipping, and taxes also must be included. Figure 13 shows the trend of global module price from 1998 to 2008. In this period, the average percentage of the module cost was 52% of the system cost, which give us an idea how important is the module price for the total cost of the system.

The price of solar PV panels (or “modules”) is established by national and even global markets. According to figure, from 1998 to 2008, the average sale price of modules reduced from 6 to about 4 $/W, that is, a reduction of 33%. However, this price has fallen from $4 per watt in 2008 to about $1.80 per watt in early 2010 [17], which means a drop of about 50 percent, attributable in part to slow demand during the economic crisis and to a global surplus of silicon. Based on this trend, the module price is expected to continue to drop.
As a consequence of the drop of the module price, the cost of electricity generated from photovoltaics has decreased as shown in figure 14. Currently this ranges from about 20 to 35 cents per kWh [11]. This cost is significantly higher than the average wholesale price of electricity. However, wholesale price of electricity sometimes can rise to over 80 cents per kWh in ERCOT area [11] during peak demand hours, which occur incidentally when solar resource is greatest, particularly in Texas.

The fact that solar energy tends to be synchronous with energy demands, makes solar PV applications suited during peak periods, which would help to offset the need to add expensive electric generating capacity to satisfy peak demand. This also could lead to substantial savings for Texas energy consumers in the form of “avoided generation capacity capital costs, avoided fuel costs, avoided CO\textsubscript{2} emissions, the value of fossil fuel price hedging and avoided distribution costs.

Trends in non-module costs may be particularly relevant in gauging the impact of state and utility PV programs. Non-module costs consist of a variety of cost components that may be more readily affected by local programs – including both deployment programs aimed at increasing demand (and thereby increasing competition and efficiency among installers) as well as more targeted efforts (e.g., training and education programs). Non-module costs have fallen over time, at least until 2005, suggests that state and local PV programs have had some success in driving down the installed cost of PV.

Cost will continue to decrease as experience is gained in installation, as interconnection and installation requirements are standardized and as a fair value for PV electricity is agreed upon. And, of
course, if petroleum becomes scarcer or if global warming is taken seriously, the price of fossil generation may rise to the cost of PV generation.

### 3.4 Economical Barrier

The main motivation for developing PV technology is the desire to reduce dependence on depletable fossil fuels with their adverse effect on the environment. Photovoltaic technology has made huge technological and cost improvement, but except for certain niche markets such as remote power applications, PV technology is still more expensive than traditional energy sources in terms of initial cost. PV has its major cost “upfront”. This means that buying a PV system is like paying years of electric bills up front. Your monthly electric bills will go down, but the initial expense of PV may be significant. Investment in a PV system tends to be problematic for small businesses and individuals who find it hard to raise the initial capital. In order to understand the real cost of a PV system, it is necessary to perform a life-cycle analysis, that is, the total cost of owning and operating the system over its lifetime.

![Figure 15, PV life-cycle analysis [19]](image)

Figure 15 shows an example of the cash flow over the life of a PV system. Negative cash flows, which depict the expenditures, are shown in red; positive cash flows, which depict the incomes, are shown in blue. A major feature of PV systems is that the initial capital cost (A) produces by far the largest negative cash flow. This is followed by many years of positive cash flows representing the value of electricity generated (or savings due to electricity not purchased), and small negative ones to pay for routine system maintenance. Generally, it is also prudent to allow for additional capital expenditure to replace worn out or damaged components such as the inverter. And finally we may hope to obtain an end-of-life scrap value for the system (E). One of the major considerations for a long-term project like a PV system is the time value of money. A proper life analysis refers all future cash flows to their equivalent value in today’s money. A positive value of present worth is generally taken as a good indication of financial viability. One aspect that potential PV owners want to know before investing money is the payback period of the system, that is, the number of years it takes for the total cost to be paid for by the income derived from the system [12]. Due to uncertainties about technical performance, system and component lifetimes, interest rates, and the future price of electricity, it is hard to know how long the system will last, or if additional capital injection will be needed as time goes by.
3.5 Incentives

The products of a new high tech like PV tend to be very expensive at the start, before cumulative production gathers pace. If governments wish to pursue urgent policy objectives such as reduction of carbon emissions, they may decide to stimulate market development with financial incentives. There are markets, typically small scale and remote from the electricity grid in areas, where PVs are economically successful. On the other hand, Grid-Tied PV systems are rarely economic at present, but if incentive programs are available in any of a number of forms, they may significantly affect the life-cycle cost (LCC) or payback of a system making.

In United States, a combination of federal, state, and utility subsidies and policies have been implemented to accelerate market growth with the confidence that it will become cost effective without assistance in the future. Federal incentives used to promote renewable energy sources include investment tax credit. State policies used to promote renewable energy sources include renewable portfolio standard, renewable energy credits (RECs), net metering rules and financial incentives including exemptions from state taxes. In the next sections, it will be analyzed each of these incentives:

3.5.1 Federal Incentives

At the federal level, an important subsidy is the investment tax credit (ITC), which is a reduction in the overall tax liability for individuals or businesses that make investment in solar energy generation technology. The tax credit is for 30 percent of the cost of the system (including equipment and labor), up to $2,000 [11]. The credit originally was set to expire at the end of 2007, but Congress extended it for another year, through December 31, 2008. Then, in October 2008, Congress extended the credit for an additional 8 years and eliminated the $2,000 cap for residential systems [11].

The tax credit amount is simply 30% of the cost basis of the installed system and the tax credit is taken for the year the system is placed in service. Unused credit can be carried forward till at least 2016, the year the ITC expires. Three points can be deduced here:

- For people and businesses having considerable or at least consistent income tax exposure, tax credits are an especially valuable incentive to invest in PV system.
- For people or businesses with little or no income tax liability (due to low income relative to expenses) could not take advantage of the 30% ITC in that short period of time.
- As 2016 is approaching, less people or businesses are going to invest in PV since they could not take advantage of the totality of the credit in a short period of time.
On an industry level, a long-term ITC provides consistent financial support for growth such as building manufacturing plants, developing an installer workforce, and investing in large-scale solar electric plants that require extended planning and construction time. However, since ITC program was created in the 1970’s, ITC’s have come and gone; they’ve been extended, expired, and revived, which has created uncertainty in solar industry markets.

Federal income tax credit for solar energy has expanded markets for solar products; however, it can be inferred that longer ITC periods would help to provide a more stable environment for solar project development.

3.5.2 State incentives

State governments have been important supporters of renewable energy development. State policies used to promote renewable energy sources include renewable portfolio standards, renewable energy credits (RECs), interconnection and net metering rules and financial incentives including exemptions from state taxes. There is a wide difference in the incentives that various states offer for solar power, which means the growth of solar power will vary substantially by state. Penetration of PV will be faster in states with higher electricity retail rates and supportive state legislation, rather than in states with the best solar resources.

3.5.2.1 Renewable Portfolio Standard

Renewable Energy Portfolio (RPS) is a regulation in which a specified percentage of the electricity acquired by REPs comes from renewable energy sources. Each electricity provider is required to acquire renewable energy capacity based on its market share of energy sales times the renewable capacity goal. Currently, about 25 states have adopted RPS, which vary widely in design, percentage requirement, eligibility and time frame.

REPs can meet their RPS individual requirements by acquiring specified percentage of the electricity from renewable energy sources or by presenting the requisite quantity of Renewable Energy Credits (RECs) bought by electricity generators. RECs are issued to generators for each megawatt hour (MWh) of renewable power generated. Additionally, businesses and individuals may voluntarily purchase RECs to offset their carbon footprints and to support the development of clean energy sources.

Texas introduced its first Renewable Portfolio Standard as part of the state's electricity industry restructuring legislation in 1999, in which it was mandatory that electricity providers collectively acquire 2,000 MW of electricity from renewable energy sources generated by both large scale generators and small scale distributed generators by 2009 [8]. Municipally and cooperatives utilities are not required to achieve the renewable energy goals, but those choose that choose to enter in the deregulated market become subject to RPS requirements.

Since its implementation, the Texas RPS has promoted the growth of renewable energy in Texas and demonstrated to be one of the most effective and successful in the nation. However, due to the lower
cost associated with wind energy compared with other sources of renewable energy and the favorable wind resources across Texas, RPS only has had great influence for wind market while it has not proven to be an effective driver for the solar market where high costs of solar outweigh the higher revenues afforded by the ability to create and sell renewable energy credits.

To encourage diversity of renewable resources in the State, in 2005 the Texas Legislature was reformed to include a target of 500 MW of non-wind renewable generation while increasing the state’s original RPS goal from 2,000 to 5,880 MW by 2015 and 10,000 MW by 2025 [8]. Despite this reform, since 2005, just 9 MW of non-wind renewable generating capacity, in the form of a single landfill gas plant, along with several MW of customer-sited solar generation spurred by municipal subsidy programs, has been completed. This means that the current RPS in Texas is not capable by itself of stimulating the growth of the solar generation and hence, additional incentives are needed to spur solar generation in the state.

Texas’ RPS goal is stated as a minimum number of megawatts; other states define their RPS goals as a percentage of total electric production. Reference 8 shows a list of the RPS requirements of the states that have this regulation. By 2015, Texas RPS requirement will be 5880 MW, which will represent 4 to 5 % of the state’s estimated electricity generation [15]. Considering that Texas has the largest solar energy resources among the states and that in terms of annual consumption, Texas is the largest electricity market in the United States, Texas RPS target is low in comparison to the RPS requirements of the other states whose solar resource and consumption are lower than Texas.

In order to increase the total amount of energy that comes from solar, the current RPS could be modified for adding solar specific requirements within the RPS. This addition to the RPS is known as solar “carve-out”, and has been adopted by eleven states.

3.5.2.2 Rebates

Because of the financial crisis, the rebate is a good opportunity for customer to decrease their initial payment for PV system directly. Although rebate program varies significantly by different states and different utilities, we can’t deny that the state or utility rebate programs are the primary driver stimulating PV market.

Right now, there are several interesting rebate in Texas. The first one is the Solar and Wind Energy Device Franchise Tax Deduction [20]; Texas allows a corporation or other entity subject the state franchise tax to deduct the cost of a solar energy device from the franchise tax which is equivalent to a corporate tax. Entities are permitted to deduct 10% of the amortized cost of the system from their apportioned margin. It is difficult for us to tell if 10% of amortized cost the system compared with the apportioned margin is an attractive incentive for the corporation which has purchased a PV system. The second one is Solar and Wind Energy Business Franchise Tax Exemption [21]; Companies in Texas engaged solely in the business of manufacturing, selling, or installing solar energy devices are exempted from the franchise tax. There is no ceiling on this exemption, so it is a substantial incentive for solar manufacturers. The third one is Renewable Energy Systems Property Tax Exemption, The Texas
property tax code allows an exemption of the amount of the appraised property value that arises from the installation or construction of a solar or wind-powered energy device that is primarily for the production and distribution of thermal, mechanical, or electrical energy for on-site use, or devices used to store that energy.

Compared the franchise tax deduction, property tax exemption with the franchise tax exemption, we can notice that Texas gives their local business of manufacturing, selling, or installing solar energy devices more attractive incentive than selling the PV system to the corporations which is interested in or has already purchased a PV system. Perhaps the Texas wants to develop the Texas local PV industries which is not only a driver stimulating local PV market by attracting more investment from other states, but also gets better preparations for future U.S. PV market. Because Texas is a very famous state in United States for the petroleum, In order to increase more industrial investment, solar energy technology is a great opportunity for Texas because of the amazing potential solar energy in Texas.

If we compare the state rebate in Texas with California, we can notice that the rebates in California are much more than Texas. The first two are California Solar Initiative – Single and Multi-Family Affordable Solar Housing (SASH & MASH) Program [22, 23], the California Solar Initiative (CSI) provides financial incentives for installing solar technologies through a variety of smaller sub-programs. Of the total $3.2 billion in total funding for the CSI, $216 million has been set aside for programs to help fund photovoltaic (PV) installations on low-income housing. The third one is California Solar Initiative - PV Incentives [24], the California Public Utilities Commission (CPUC) adopted a program -- the California Solar Initiative (CSI) -- to provide more than $3 billion in incentives for solar-energy projects with the objective of providing 3,000 megawatts (MW) of solar capacity by 2016. The fourth one is CEC - New Solar Homes Partnership [25], the New Solar Homes Partnership (NSHP) is a 10-year, $400 million program to encourage solar in new homes by working with builders and developers to incorporate into the homes high levels of energy efficiency and high-performing solar systems. The NSHP specifically targets the market-rate and affordable housing single-family and multifamily sectors, with the goal of achieving 400 MW of installed solar electric capacity on new homes, and to have solar electric systems on 50% of all new homes built in California by the end of 2016.

We can notice that California has the totally different PV plan with Texas. The main target for PV in California is not only increase the PV market, but also want to increase their electricity generation significantly by PV system. Compared with Texas, California does not have abandon petroleum resource as Texas, the traditional generation in California is less than Texas, and the population in California is 10 million more than Texas, so renewable energies especially solar and wind are so helpful for California to solve the energy demand crisis. That’s why California spend lots of money to encourage people to buy and use the renewable energy as soon as possible even the cost of PV system is a little bit expensive than traditional generation.

Besides the Texas state rebate, there are many utility rebates available in different area in Texas, shown in the following table.
<table>
<thead>
<tr>
<th>Utility name</th>
<th>Rebate program</th>
<th>Amount</th>
<th>Applicable Sectors &amp; Maximum Incentive</th>
</tr>
</thead>
</table>
Residential: $25,000  
Non-residential: $90,000 |
Residential: $25,000  
Non-residential: $180,000 |
Residential: $25,000  
Non-residential: $90,000 |
<p>| Austin | Residential | $2.50 per | Residential, Must be Austin Energy Customer |</p>
<table>
<thead>
<tr>
<th>Energy</th>
<th>Solar PV Rebate Program</th>
<th>watt-AC</th>
<th>$15,000 per home installation and $50,000 per site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryan Texas Utilities</td>
<td>Solar PV Rebate Program</td>
<td>$3 per watt AC</td>
<td>Commercial, Industrial, Residential, Nonprofit, Schools, Local Government, Multi-Family Residential, Institutional, Any BTU Customer Lesser of 80% of invoice cost or $12,000 per site, per fiscal year</td>
</tr>
<tr>
<td>CPS Energy</td>
<td>Solar PV Rebate Program</td>
<td>$3.00/W AC watt standard, may be altered based on inspection results</td>
<td>Commercial, Industrial, Residential, Nonprofit, Institutional, Must be CPS Energy Customer Residential: $30,000 or 50% of cost; Non-residential: $100,000 or 50% of cost</td>
</tr>
<tr>
<td>Denton Municipal Electric</td>
<td>GreenSense Solar Rebate Program</td>
<td>PV: $3.00 per AC watt (based on the calculated expected performance of the system)</td>
<td>Commercial, Residential PV: $15,000 per structure</td>
</tr>
<tr>
<td>Company</td>
<td>Program</td>
<td>DC PV Rate</td>
<td>Eligibility</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>----------------------------------------------</td>
<td>------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Guadalupe Valley Electric Cooperative PV</td>
<td>PV: $2.00/watt</td>
<td></td>
<td>Commercial, Residential, Nonprofit, Schools, Local Government, State Government, Fed. Government, Agricultural, Institutional, Must be a GVEC member</td>
</tr>
</tbody>
</table>
We collected some the utility rebate information in California shown in the following table.

<table>
<thead>
<tr>
<th>Location</th>
<th>Program Details</th>
<th>Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alameda Municipal Power</td>
<td>Solar Photovoltaics Rebate Program</td>
<td>Systems up to 50 kW: $2.42/W&lt;br&gt;Systems larger than 50 kW: $0.27/kWh for first 5 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commercial, Residential&lt;br&gt;Maximum size is 1 MW or 110% of customer's load, whichever is less</td>
</tr>
<tr>
<td>Anaheim Public Utilities</td>
<td>PV Buydown Program</td>
<td>Residential: $2.99/watt AC&lt;br&gt;Commercial under 30 kW: $2.09/watt AC&lt;br&gt;Commercial between 30 kW and 1 MW: $0.31/kWh for first 5 years of production.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commercial, Residential, Low-Income Residential&lt;br&gt;The incentives are based on the customer's most recent 12-month electricity usage.</td>
</tr>
<tr>
<td>Azusa Light &amp; Water</td>
<td>Solar Partnership Program</td>
<td>$3.00 per watt if customer transfers RECs to utility&lt;br&gt;$2.42 per watt if customer retains ownership of RECs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commercial, Residential&lt;br&gt;50% of system cost</td>
</tr>
<tr>
<td>Burbank Water &amp; Power</td>
<td>Residential &amp; Commercial Solar Support Program</td>
<td>Commercial installations:&lt;br&gt;Systems up to 30 kW (upfront payment based on expected performance):&lt;br&gt;$2.09/watt AC if customer keeps RECs&lt;br&gt;$2.33/watt AC if customer grants RECs to utility&lt;br&gt;$2.67/watt for schools, affordable housing, non-profits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commercial, Industrial, Residential, Nonprofit, Schools, State Government, Low-Income Residential&lt;br&gt;Maximum payment of $400,000 per year for performance-based incentives</td>
</tr>
</tbody>
</table>
Systems over 30kW (performance based incentive paid over the first 5 years):
$0.226/kWh if customer keeps RECs
$0.288/kWh if customer grants RECs to utility
$0.311/kWh for schools, affordable housing, non-profits

Residential Installations (customer has the option of the upfront rebate or the production based incentive):

Upfront Incentive:
$2.64/watt AC if customer keeps RECs
$3.14/watt AC if customer grants RECs to utility

Performance-based incentive paid over the first 5 years:
$0.364/kWh if customer keeps RECs
$0.464/kWh if customer grants RECs to utility

<p>| City of Gridley Utilities | PV Buy Down Program | $2.80/W-AC | Commercial, Residential. $5,600 |
| City of Lompoc Utilities | PV Rebate Program | Non-profits: $3.50/W AC; All other customers: $3.00/W AC | Commercial, Residential, Nonprofit 50% the system cost, up |
| City of Palo Alto Utilities | PV Partners | Systems &lt;30kW: Rebate varies depending on customer class; based on CEC AC watts. Systems 30 kW and larger: Performance-based incentive (PBI), based on actual monthly energy produced (kWh) for 60 month term. | to $50,000 |
| City of Shasta Lake Electric Utility | PV Rebate Program | Residential: $2.80/W-AC Commercial: $1.92/W-AC | Commercial, Residential Residential: $14,000 Commercial: $192,000 |
| Colton Public Utilities | PV Rebate Program | Systems under 30 kW: $1.71/W if customer keeps RECs; $2.44/W PTC if utility gets RECs Systems 30 kW or larger, up to 100 kW: $0.18/kWh if customer keeps RECs; $0.26/kWh if utility gets RECs (paid for 5 years) Systems larger than 100 kW: $0.18/kWh (paid for 5 years) | Commercial, Residential Up-front incentives: 50% of project costs |
| Corona Department of Water &amp; Power | Solar Partnership Rebate Program | $2.19 per watt | Commercial, Residential Residential: $6,570 Commercial: $54,750 |
| Glendale Water and Solar Solutions | Less than or equal to 30kW-DC: $3.22/W, or $4.02/W for affordable | Commercial, Industrial, Residential, Nonprofit, |</p>
<table>
<thead>
<tr>
<th>Power Program</th>
<th>Housing Cost</th>
<th>Multi-Family Residential, Low-Income Residential, All Customer Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Greater than 30kW-DC: $0.394/kWh for first 5 years of operation, or $0.554/kWh for affordable housing</td>
<td>50% of the gross installed system cost plus any applicable City of Glendale licenses, permits, and fees</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hercules Municipal Utility PV Rebate Program</th>
<th>Systems up to 10 kW: $2.60/watt AC</th>
<th>Commercial, Residential Systems 10 kW or less: $10,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Systems larger than 10 kW: $0.17/kWh for 5 years</td>
<td></td>
</tr>
</tbody>
</table>

| IID Energy PV Solutions Rebate Program | $2.60/watt AC, rebate level will step down over time as specific capacity targets are met. | Commercial, Industrial, Residential, Nonprofit, Local Government, State Government Residential: $39,000 Commercial/Industrial: $780,000 Government/Nonprofit: $1,040,000 |

| LADWP Solar Incentive Program | Incentives are paid up-front on a per-kWh-basis for the estimated production over 20 years Incentive amount will step down over the life of the program in 10 phases as certain installed MW levels are | Commercial, Residential, Nonprofit, Local Government Up to 75% of project costs for residential installations and up to 50% for commercial |
reached. systems
The maximum system size for incentive payment is 1 MW AC per site, or per government, or per corporate parent per year.
2 MW may be reserved depending on fund availability

<table>
<thead>
<tr>
<th>Lassen Municipal Utility District</th>
<th>PV Rebate Program</th>
<th>Residential: $3.72/W-AC Commercial: $2.61/W-AC</th>
<th>Commercial, Residential Residential: $10,000 or 50% of system cost, whichever is less Commercial: $25,000 or 50% of system cost, whichever is less.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lodi Electric Utility</td>
<td>PV Rebate Program</td>
<td>2010: $2.42/W AC 2011: $2.25/W AC</td>
<td>Commercial, Industrial, Residential, Local Government $375,000 per system, with a cap payment of $75,000 per customer per year until the entire rebate commitment is paid.</td>
</tr>
<tr>
<td>Merced Irrigation</td>
<td>PV Buydown Program</td>
<td>$2.80/W AC</td>
<td>Commercial, Residential, Nonprofit</td>
</tr>
<tr>
<td>District</td>
<td>Photovoltaic Rebate Program</td>
<td>Systems &gt;1 kW to 30 kW: $2.00/W AC. Additional $0.50/W for governmental or non-profit entities. Systems &gt;30 kW to 1 MW: performance-based incentive of $0.133/kWh for 10 years.</td>
<td>Residential: $8,400 Commercial: $70,000</td>
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</tr>
<tr>
<td>Modesto Irrigation District</td>
<td>Solar Power Installation Rebate</td>
<td>Systems up to 30 kW have the option of receiving an expected performance based buydown (EPBB) or a performance based incentive (PBI). Systems larger than 30 kW are only eligible for the PBI. EPBB: Residential: $2.40/watt AC Commercial and all PPAs: $1.40/watt AC Non-profits and Government: $2.15/watt AC Income-qualified residential: $4.00/watt PBI: Residential: $0.363/kWh Commercial and all PPAs: $0.212/kWh</td>
<td>Commercial, Residential, Nonprofit, Local Government, State Government, Agricultural, (All MID Customers) 50% of total project costs.</td>
</tr>
<tr>
<td>Institution</td>
<td>Program Details</td>
<td>Incentives</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
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<td>------------</td>
<td></td>
</tr>
<tr>
<td>Non-profit and Government:</td>
<td>$0.325/kWh</td>
<td>Residential, Construction, Installer/Contractor, Home Builders</td>
<td></td>
</tr>
<tr>
<td>Income-qualified residential:</td>
<td>$0.632/kWh</td>
<td>Design Team Incentive: $5,000</td>
<td></td>
</tr>
<tr>
<td>PBI</td>
<td>is awarded for the first 5 years of the system’s operation.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| PG&E | Advanced Homes New Construction Incentives | Baseline Entry Level Home: $75 /kW; $0.43 /kWh; $1.72 /Therm |
| Home 30% Above Baseline: $225 /kW; $1.29 /kWh; $5.14 /Therm |
| ENERGY STAR® New Homes Program or other Green Home Certification: 10% bonus |
| Compact Home (10% smaller than LEED for Homes threshold): 15% bonus |
| Design Team Incentive: 50% cost for projects that have at least ten units |
| Photovoltaic (PV) Systems Peak kW Reduction: $75 /kW, $0.43 /kWh, $1.72 /Therm |
| Homes 30% Better than 2008 Title 24 with a 30% Reduction in Cooling Load: $1,000/single unit home and $200/multi-family units |

<p>| Plumas-Sierra REC | PV Rebate Program | 2010 rebate level: $2.42/watt (AC) |
| Commercial, Industrial, Residential, Nonprofit, Agricultural |</p>
<table>
<thead>
<tr>
<th>Utility</th>
<th>Program Name</th>
<th>2010 Levels</th>
<th>Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redding Electric</td>
<td>Earth Advantage Rebate Program</td>
<td>2010 Levels</td>
<td>$6,000 for residential; $12,000 for small commercial, agricultural and non-profit applications; $20,000 for large commercial and industrial applications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PV (less than 10 kW): $2.42-$3.07/watt AC;</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>PV (10 kW - 1 MW): $0.35/kWh for first 5 years of actual production</td>
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<td></td>
</tr>
<tr>
<td>Riverside Public Utilities</td>
<td>Residential PV Incentive Program</td>
<td>$4/watt AC</td>
<td>$6,000 or 75% of project cost, whichever is less</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roseville Electric</td>
<td>PV Buy Down Program</td>
<td>Residential: Unavailable</td>
<td>Commercial, Residential, Roseville Electric Customers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commercial systems less than 10 kW: $2.00/watt AC</td>
<td>Residential: $6,000 cap on retrofit projects;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10kW to &lt;25kW: $0.337/kWh 5yr</td>
<td>Commercial: Cannot exceed 100kW (CEC AC watts) of installed PV over the life of the program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25kW to &lt;50kW: $0.241/kWh 7yr</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>50kW to &lt;75kW: $0.223/kWh 7yr</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>75kW to 100kW: $0.156/kWh 10 yr</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>SCE</td>
<td>Advanced Homes New Construction</td>
<td>Baseline entry level home: $75 /kW; $0.43 /kWh; $1.72 /Therm</td>
<td>Residential, Construction, Installer/Contractor,</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>SDG&amp;E</td>
<td>Advanced Homes New Construction Incentives</td>
<td>Residential, Construction, Installer/Contractor, Home Builders</td>
<td>Design Team Incentive: $5,000</td>
</tr>
<tr>
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<td>-------------------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td></td>
<td>Baseline entry level home: $75 /kW; $0.43 /kWh; $1.72 /Therm</td>
<td>30% better than 2008 Title 24 with a 30% reduction in the cooling load: $1000/single unit home and $200/multi family units</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30% above Baseline: $225 /kW; $1.29 /kWh; $5.14 /Therm</td>
<td>California ENERGY STAR® New Homes Program or other Green Home Certification: 10% bonus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>California ENERGY STAR® New Homes Program or other Green Home Certification: 10% bonus</td>
<td>Compact Home - 10% smaller than the LEED for Homes square footage threshold: 15% bonus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design Team Incentive: 50% cost for projects that have at least ten units</td>
<td>Photovoltaic (on site PV) systems peak kW reduction: $75 /kW, $0.43 /kWh, $1.72 /Therm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$1000/single unit home and $200/multi family units</td>
<td>30% better than 2008 Title 24 with a 30% reduction in the cooling load: $1000/single unit home and $200/multi family units</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30% above Baseline: $225 /kW; $1.29 /kWh; $5.14 /Therm</td>
<td>California ENERGY STAR® New Homes Program or other Green Home Certification: 10% bonus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design Team Incentive: 50% cost for projects that have at least ten units</td>
<td>Photovoltaic (on site PV) systems peak kW reduction: $75 /kW, $0.43 /kWh, $1.72 /Therm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30% better than 2008 Title 24 with a 30% reduction in the cooling load: $1000/single unit home and $200/multi family units</td>
<td>California ENERGY STAR® New Homes Program or other Green Home Certification: 10% bonus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Design Team Incentive: 50% cost for projects that have at least ten units</td>
<td>Photovoltaic (on site PV) systems peak kW reduction: $75 /kW, $0.43 /kWh, $1.72 /Therm</td>
<td></td>
</tr>
</tbody>
</table>
projects that have at least ten units Photovoltaic (on site PV) systems peak kW reduction: $75/kW, $0.43/kWh, $1.72/Therm
30% better than 2008 Title 24 with a 30% reduction in the cooling load: $1000/single unit home and $200/multi family units

| Silicon Valley Power Solar Electric Buy Down Program | Rebate levels as of 5/24/10: Commercial, Residential Residential: $3.00/watt AC Commercial (up to 100 kW): $2.25/watt AC Commercial (>100 kW to 1 MW): $0.30/kWh for 5 years Residential: $30,000 | Residential |
| SoCalGas Advanced | Baseline entry level home: $75/kW; Residential | Residential |
| Homes New Construction Incentives | $0.43 /kWh; $1.72 /Therm  
30% above Baseline: $225 /kW; $1.29 /kWh; $5.14 /Therm  
California ENERGY STAR® New Homes Program or other Green Home Certification: 10% bonus  
Compact Home - 10% smaller than the LEED for Homes square footage threshold: 15% bonus  
Design Team Incentive: 50% cost for projects that have at least ten units  
Photovoltaic (on site PV) systems peak kW reduction: $75 /kW, $0.43 /kWh, $1.72 /Therm  
30% better than 2008 Title 24 with a 30% reduction in the cooling load: $1000/single unit home and $200/multi family units |
| --- | --- |
| Construction, Installer/Contractor, Home Builders  
Design Team Incentive: $5,000 |

| Truckee Donner PUD Photovoltaic Buy Down Program | 2010 level: $4.05/W AC, adjusted based on expected performance  
2011 level: $3.65/W AC, adjusted based on expected performance |
| --- | --- |
| Commercial, Industrial, Residential  
2010:  
Residential: $12,150;  
Commercial: $20,250  
2011:  
Residential: $10,950;  
Commercial: $18,250 |

<table>
<thead>
<tr>
<th>Turlock Irrigation PV Rebate</th>
<th>Systems smaller than 30 kW (as of 7/7/2010):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial, Residential, (Turlock</td>
<td></td>
</tr>
<tr>
<td>District</td>
<td>PV Rebate</td>
</tr>
<tr>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Turlock Irrigation District</td>
<td>Systems smaller than 30 kW (as of 7/7/2010): Residential: $1.87 per watt AC; Commercial: $1.47 per watt AC; incentives may be adjusted based on expected performance. Systems 30 kW or larger (as of 7/7/2010): Residential: $0.22/kWh, Commercial: $0.17/kWh; payments are made monthly for 5 years. Incentive amount will step down over the life of the program in 10 phases as certain installed MW levels are reached.</td>
</tr>
</tbody>
</table>

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| Ukiah Utilities | PV Buydown Program | $1.96/watt AC; incentive may be reduced based on expected performance | Commercial, Residential
Residential: $7,000;
Commercial: $20,000 |

According to the two utility rebates tables, we can find that in Texas twelve utility companies have begun to offer PV rebate, three of them offer their custom less than $2.5/W, another three offer $3/W, the six left offer their customer $2.5/W, $2.5/W rebate will easily cover 40%-50% cost of a 1KW PV system. The customer could save their investment. That is a great deal. At the same time the utility will take the renewable energy credit from you. Because the renewable energy credit market is not applicable for most PV customers due to the value of renewable energy credit we have, selling the renewable energy credits to utility to get the rebate is a good choice for both of PV customers and utility company.

In California, we can find that the number of utility rebates is bigger more than Texas. Besides the number we can easily notice another interest things which is included in the rebate, they are Renewable energy credits (RECs) and Net-metering, we have already mentioned the RECs in previous section, and the Net-metering will be discussed in the following part. Considering the combination with PV system rebate, RECs and Net-metering, the whole PV market promotions are more attractive than in Texas. According to this table, there are thirty two kinds of PV rebate from utility companies in California, and five of them are more than $3/W, half of them are between $2-3/W, and about eleven of them offer their customer rebate less than $2/W, but the lower rebate always come with the RECs or/and Net-metering rebate, so compared with Texas utility rebates, California utility company offer their customers more kinds of rebate to attract them to buy and use PV system.

3.5.2.3 Net-metering:

Net metering is a useful electricity policy for consumers who own (generally small) renewable energy facilities (such as wind, solar power or home fuel cells) or V2G electric vehicles. "Net", in this context, is used in the sense of meaning "what remains after deductions" — in this case, the deduction of any energy outflows from metered energy inflows [28]. It is very important because the Net Metering enables customers to use their own generation to offset their consumption over a billing period by allowing their electric meters to turn backwards when they generate and inject the electricity back to the utility. This offset means that customers receive retail prices for the excess electricity they generate.

Net metering is a low-cost, easily administered method of encouraging customer investment in renewable energy technologies. It allows customers to "bank" their energy and use it a different time than it is produced giving customers more flexibility. For example, if you are a residential customer, you may not be home during the day when your system generates electricity. Net Metering allows you to "bank" this excess electricity on the grid, reducing or offsetting the electricity you would otherwise have to purchase. Providers may also benefit from net metering because when customers are producing electricity during peak periods.
However, the rules vary significantly by country and possibly state/province; if net metering is available, if and how long you can keep your banked credits, and how much the credits are worth (retail/wholesale). In 1986, Texas began to implement net metering, which allowed customers (served by investor-owned utilities) with renewable electricity generators of 50 kW or less to have their net energy consumption measured with a single meter capable of spinning forward and backward. Although net metering was not applicable to municipal and cooperatives utilities, they had the option of offering net metering voluntarily to their customers. After deregulated market was introduced in the state and after a few years of debate, a new legislation passed in 2007 changed the rules of net metering, allowing investor-owned utilities within the ERCOT area to offering to their customers net metering voluntarily, and to buy back excess production at a rate negotiated with customers. The net metering rule for investor-owned utilities outside the ERCOT area (such as El Paso Electric Company, Entergy Texas, South Western Electric Power Company and Xcel Energy), unlike ERCOT areas, was not changed and hence instantaneous excess that flows onto the grid will be valued at avoided cost as opposed to a negotiated value. Net metering continue being voluntary for municipal and cooperative utilities as before the deregulation.

Duo to the RPS, more and more utility companies have begun to offer their customers Net-metering. Right now, because of less competition, In order to meet the requirement of RPS, the utility companies attract their customers to not only sell the renewable energy by using rebate, but also sell their RECs, mentioned in previous parts. So in many states the owners who have a Grid-Tied renewable energy system have only one choice, the consequence of that they do not sell the RECs, they get nothing, no the cash rebate and no Net-metering incentive. Most electricity meters accurately record in both directions, allowing a no-cost method of effectively banking excess electricity production for future credit. If government could guarantee that under net metering, a system owner should receive retail credit for at least the electricity they generate. The renewable energy market will be more attractive.

Of course, in order to protect the customers’ right and encourage more people to join the renewable energy market, the Net-metering law has been expanded to allow “time of use (TOU)” agreements that a higher dollar value on electricity during peak times of high demand, which increases the value of the electricity produced by renewable generation more significantly than the original idea about Net-metering [29], such as on weekdays from noon to 6 p.m. during summer months. This could mean savings for you if your excess generation occurs during peak hours, and your electricity use occurs mostly during off-peak or partial off-peak hours. If you generate more than you use during the afternoon, the electricity you put on the grid is valued at a higher price than electricity you consume in the late evening or early morning. This is an amazing incentive to guarantee the renewable energy investors’ benefit, especially solar customers because solar system could generate more during the day peak times of high demand.

The Figure 16 illustrates the variety of net-metering, system-size limitations across the United States. Currently, 43 states and Washington, D.C., have net metering policies in place. Net metering policies differ in several ways, including the eligibility of different technology types, customer classes, system sizes, the use of aggregate caps for DG contribution back to the grid, the treatment of customer net-excess generation, and the types of affected utilities, and the issue of REC ownership.
As we mentioned, it is important to have Net Metering available for any consumer that interconnects their renewable generator to the grid. As with interconnection standards, state governments can authorize or require their state public utilities commissions to develop comprehensive net metering rules, and cities with municipal utilities can have significant influence over net metering rules in their territory, and by offering more good policies for renewable energy, the market will be stimulated, just like California. At the end of 2008, 420 electric industry participants reported net metering customers in every state except Tennessee. From the Fig.2 Total net metering customers were up by 21,180 to 70,009 between 2007 and 2008. California had, by far, the largest number of net metering customers with 45,719 or 65 percent of the U.S. total. California also accounted for just over half of the increase in
2008. Net metering programs included 64,400 residential customers or 92 percent of total U.S. net metering customers. So that is why the renewable energy market in California is the best in U.S.

Actually compared with off-grid renewable energy system, the grid-tied system would be more popular because they have the opportunity to get incentives by connecting to the grid. Without connect to the grid, we cannot enjoy the Net-metering incentives. From the Fig.3 the growth rate of grid-connected PV varied significantly, with large growth in the residential and utility sectors, and no growth in the non-residential sector. Residential and non-residential installations are generally on the customer’s side of the meter and produce electricity used on-site. In contrast, utility installations are on the utility’s side of the meter and produce bulk electricity for the grid. Figure 3 shows the annual PV installation capacity data, Residential capacity installed in 2009 more than doubled compared with capacity installed in 2008 and represented 36% of all new grid-connected PV capacity. This market share is consistent with residential installations in 2005, 2006 and 2007, and is significantly higher than the 27% market share for residential installations in 2008. The Fig.4 over 34,000 grid-connected PV installations were completed in 2009, with 92% of these at residential locations. At the end of 2009, 104,000 PV installations were connected to the U.S. grid, including over 93,000 residential installations. The government needs to make the policies to guarantee that the benefit of more and more Grid-Tied PV system investors will be protected, otherwise that will be a huge barrier for PV even renewable energy market.

![Figure 18 Annual Installed Grid-Connected PV Capacity by Sector (2000-2009)](image)

Figure 18 Annual Installed Grid-Connected PV Capacity by Sector (2000-2009) [32]
3.5.3 Employment

Adopting PV as a renewable energy source has a significant positive impact on employment. As a consequence of the longer-term incentives suggested in the last section, the solar industry to would create more jobs and contribute billions of dollars in investment and income to the Texas economy. PV industry requires a variety of jobs in areas ranging from manufacturing, construction, and installation to ongoing operation and maintenance. Table 3 shows the number of jobs both in solar industry and fossil fuel electric power generation sector.

Table 3 Number of jobs in solar industry and fossil fuel electric power generation sector [13]

<table>
<thead>
<tr>
<th></th>
<th>Solar Industry</th>
<th>Fossil fuel electric power generation sector</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010 Jobs</td>
<td>2011 Jobs</td>
</tr>
<tr>
<td>State Total</td>
<td>3068</td>
<td>3443</td>
</tr>
<tr>
<td>National</td>
<td>57197</td>
<td>67889</td>
</tr>
<tr>
<td></td>
<td>2010 Jobs</td>
<td>2011 Jobs</td>
</tr>
<tr>
<td></td>
<td>4975</td>
<td>5120</td>
</tr>
<tr>
<td></td>
<td>135458</td>
<td>131352</td>
</tr>
</tbody>
</table>

From this table, it can be inferred the following:

- It is expected that there will be 12% increase in solar industry jobs for the year 2011 and 3% in fossil fuel electric power generation sector. The growth rate in jobs creation in solar industry higher than in fossil fuel electric power generation sector.
- Fossil fuel electric power generation supply about 85% of the state electricity needs, whereas solar sector less than 1%. However, the difference between the jobs in both sectors is small and
therefore solar industry has the capacity of creating more jobs per megawatt (MW) of power generated.

- In comparison to similar data in the other states, Texas fall 3rd in the national ranking according.

The following are some of the new projects that support this claim

- The first solar farm has started operating in San Antonio, Texas since the first week of November 2010. The capacity of this farm is 14 MW and CPS Energy has signed a Power Purchase Agreement (PPA) for 30 years.
- CPS Energy also signed a 20-year agreement last June to acquire 27 MW from Tessera Solar’s new project in West Texas [7].
- In February 2009, Austin Energy Council approved 25 year contract of 30MW solar energy to be purchased from Gemini Solar Development Company (farm built near Webberville, Texas) [8]. It is expected that 293 net new jobs will be added when a target of 100 MW by 2020 is accomplish.
- Recently US based Sun Power Corp has announced its expansion into Austin Texas after receiving USD$2.5 million from the Texas Enterprise Fund (TEF). It is believed that this project will add 450 new solar jobs in the state [9].

Clearly, such agreements and announcements from these companies demonstrate the rapid expansion of PV industry in Texas and thus reflect the subsequent increase in solar jobs.

Despite the education and training programs offered in the state for preparing people to work in the solar industry, according to [13], solar employers report difficulty finding qualified workers. This surprising result, given the current unemployment rate, could be due to many factors, such as lagging workforce development. It is clear, however, that solar jobs are growing rapidly and are hard to fill, which typically indicates fertile opportunities for job seekers and the necessity of creating more education and training programs across the state.
4. OTHER BARRIER:

4.1 Regulations and Permitting

With building, zoning, and historic regulations that vary by municipality, builders and architects sometimes find it difficult to become involved in a solar energy market. The challenge of understanding these different regulations can prevent builders from integrating solar technology in their projects or building owners from requesting solar. Getting approvals and permits is sometimes challenging because of a lack of knowledge in building code departments and differences in approval requirements between different departments. [34]

Moreover, some homeowner associations have restrictive covenants limiting visible solar or wind installations. Others require approval to install them, which adds a lack of certainty to the project and can be difficult to receive due to concerns about aesthetics and lack of uniformity across the subdivision or condominium.

Historic district regulations also often limit the ability to install solar. For instance, Ann Arbor is home to about 1,850 properties in 14 historic districts that add additional requirements to the installation of solar energy.

4.2 Sitting and Aesthetic Issues

Early solar installations from the 1970s were often long on enthusiasm and short on aesthetics. Installers often insisted on implementing the ideal angle, to the detriment of the roof form of many homes. It has been shown that using a less than ideal angle such as 10 percent (still on a south facing roof slope) would reduce efficiency by less than 5 percent for a thin-film PV product. Some installers are still focused on the ideal solar gain and do not balance it with aesthetic issues. Other siting issues include building ownership (business and residential rentals utilities are often paid for by tenants instead of landlords) and the fact that some buildings do not have enough solar access to make a solar energy system viable. [34]

4.3 Lack of Solar Knowledge

Another significant barrier to solar energy use is a lack of understanding about how viable solar energy is currently and in the future as costs for other types of energy increase. In Michigan, it is widely believed that we do not get enough sun to be able to effectively employ solar technology. [34]

In addition, many residents and businesses are not aware of current financial incentives, and mistakenly believe solar has a longer payback period than it actually does. Another concern voiced by residents is that solar energy systems might negatively impact property values, or be considered unattractive and not a good fit for the neighborhood.

4.4 Lack of government policy supporting EE/RE.

This includes the lack of policies and regulations supporting development of solar and other EE/RE technologies and the presence of policies and regulations hindering EE/RE development and supporting
conventional energy development. Examples include fossil-fuel subsidies, insufficient consumer-based EE/RE incentives, and government underwriting for nuclear plant accidents and difficult zoning and permitting processes for renewable energy. [35]

4.5 Difficulty overcoming established energy systems.

This includes difficulty introducing innovative energy systems, particularly for distributed generation such as PV, because of technological lock-in, electricity markets designed for centralized power plants and market control by established generators. [36]

4.6 Failure to account for all costs and benefits of energy choices.

This includes failure to internalize all costs of conventional energy (e.g., effects of air pollution, risk of supply disruption) and failure to internalize all benefits of EE/RE (e.g., cleaner air, energy security). [36]

4.7 Inadequate workforce skills and training.

This includes lack in the workforce of adequate scientific, technical, and manufacturing skills required for EE/RE development; lack of reliable installation, maintenance, and inspection services; and failure of the educational system to provide adequate training in new technologies [37].
5. CONCLUSION

In conclusion, research on the solar primer is done based on three components mainly technology, economical/financial viability, and barrier to growth. The research done on the Technological aspect of PV reveals that solar photovoltaic energy has great potential to contribute on the renewable energy system. However, there are many technological challenges to overcome every other day. These challenges include but not limited to cell material & module technology, power electronic system (inverter), and electrical network. From the cost prospective, PV modules play a significant role and from the system reliability point of view, inverter plays an important role. Our modern technology should focus on solving these problems primarily in order to have overall system reliability. Other technological problems can be solved according to their urgency.

The research done on the Economical aspect of PV concludes that the PV market is developing rapidly both globally and domestically. The reason behind this success is that PV markets are continuously supported by governments either in local level or through national policy. What we can learn from the incentives and policies in Texas is the following

- Incentives are implemented to promote national or territorial energy independence, high tech job creation and reduction of carbon dioxide emissions which cause global warming.
- The three main financial incentives are those that (1) lower the upfront cost (e.g., up-front rebates) (2), improve asset-life cash flow (e.g., net metering), (3) and reduce tax liability (i.e., ITC).
- One of the biggest threats to rational decision-making of potential PV owners and steady growth in the PV market is uncertainty about government policy.
- There are policy distortions in favor of other energy sources, subsidies for conventional electricity sources for example, unfairly distort the market away from PVs and hence PVs do not therefore compete on a level playing field.
- Limited accessibility to affordable credit reduces private sector participation in renewable energy development.
- The measures of supporting the PV market should not be changed during their planned lifetimes.
- The conditions for support measures for market introduction should be in force for a long time.
6. REFERENCES


[36] Financing Projects That Use Clean-Energy Technologies: An Overview of Barriers and