SOLAR PRIMER

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for

ECEN 689 - 605

Technical Report:

TR-2010-ECE689fall Group<#4>

December 10, 2010

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EXECUTIVE SUMMARY

Texas has a potential to be the world leader in solar energy development. Texas has the biggest solar potential in the U.S. according to the State Energy Conservation Office; the energy from sunshine falling onto just one acre of land in West Texas is equal to 4000 barrels of oil that equals around 7GWh each year.

Photovoltaics (PV) system is one of the solar technologies. Photovoltaic panels produce electrical energy by absorbing sunlight within little solar cells. A PV system has a lot of components which are electrical and mechanical. Texas is a unique state which can provide most of these components such as solar panels, wires, racks, inverters, or batteries among other states in the U.S. There are also many manufacturers which are developing photovoltaic technology in Texas.

For the last decades, the price of retail electricity was increasing. On the other hand, the PV system price is decreasing. Price trends shows that in the next few years the PV system will cost less than the fossil fuel electricity.

Many countries and sates were successful in promoting photovoltaic (PV) systems by providing financial incentives. Texas offers some incentives but these incentives were not effective in promoting PV systems. Most of these incentives are not statewide but are based on utilities.

By providing incentives, photovoltaics could make many useful impacts on the economy. For instance, these incentives could attract new companies and help existing businesses to expand. Furthermore, implementing photovoltaic projects could create four times more jobs than fossil fuel electricity.

Solar technology has many barriers to growth. This report includes main barriers in this technology by focusing on the United States and Texas. Financial, regulatory and educational aspects of barriers are discussed by giving details. Furthermore, results of a survey which shows the knowledge of Texan-people about renewable and photovoltaic systems will be delivered.

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1 INTRODUCTION

The U.S. needs huge amount of electrical energy as one of the biggest developed country in the world. Most of this energy is generated by fossil fuels as it is shown in Figure 1. The electric generation systems which are using fossil fuels have some advantages, but they threat the environment with their many disadvantages. These fossil fuels give off carbon dioxide to the environment when they burn. Especially coal is the most harmful one because it has more carbon dioxide emission to the environment. Addition to that, coal mining is also very difficult and may endanger the lives of coal miners. We have had many bad experiences during coal mining process and many people lost their lives [1].

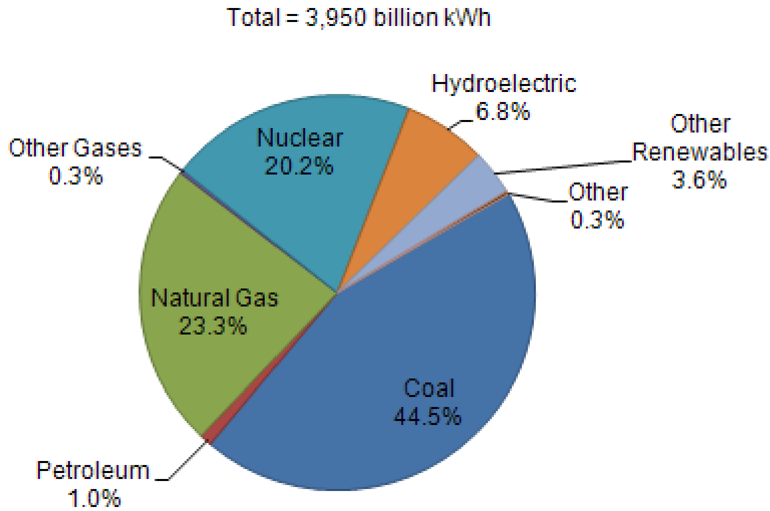

Figure 1: US Electric Power Industry Net Generation 2009
Sources: U.S. Energy Information Administration, Form EIA-923, "Power Plant Operations Report."

Most of the countries have been trying to avoid bad effects of fossil fuels and they have some legislation. There is only one environment for all the countries, so they should think in global wide perspective and take an action to reduce carbon emission together. One of the best ways to decrease the amount of carbon emission and to stop increasing effects of global warming is to generate electrical energy by renewable sources such as wind, solar or hydro. Each country or state can take advantage of one of these renewable sources depending of their resource type. For example, Texas has huge potential of solar and wind power.

The solar energy industry began developing in the U.S. during 1980s as the federal government provided some incentives for solar water heaters. When the fossil fuel costs remained low, the growth of solar industry slowed in the 1990s. However, the U.S. and world solar market has renewed growth since 2000. This new increasing solar activity is due to costs and price volatility of fossil fuels, which concerns about global climate change, decreasing costs and improving technology in the solar industry, and the combined effect of new federal, state and local subsidies [1].

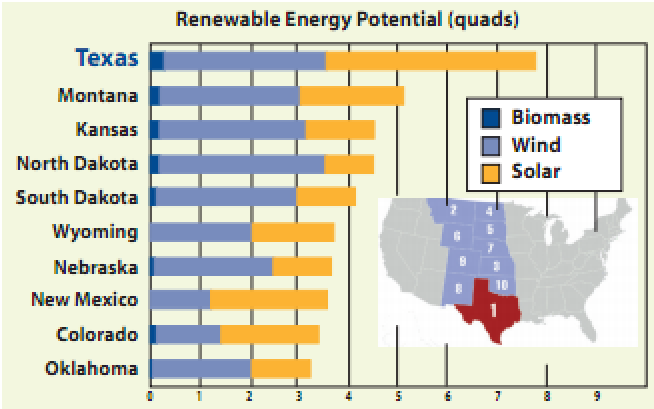

Figure 2: Renewable energy potential for some states [1].

Texas has a great potential for solar energy as shown in Figure 2. According to the State Energy Conservation Office, Texas has the greatest solar radiation in the nation [2]. That potential can support more than 148GW of electric capacity from solar power alone, that amount is more than current capacity in the state [3]. According to the department of energy, solar energy electricity generation more than tripled in the US from 2000 – 2008 [4]. However, Texas could not use its natural advantage in that period, and as a result Texas is not in the top ten states for total solar installed capacity [4].

Texas should compete not only with the states in the U.S. but also with other countries because Texas has many manufacturers which can provide every component in a PV system. Although these companies know what to do to be more successful and to make Texas a leader in solar industry, lack of incentives are forcing those companies to move away from Texas to other states to invest there.

2 Photovoltaic Technology

Photovoltaic (PV) cells are semiconductor devices that convert sunlight into direct current (DC) electricity. Groups of PV cells are electrically configured into modules and arrays, which can be used to supply electricity for many electrical devices and loads. PV systems can produce alternating current (AC) with appropriate conversion devices. This makes the PV systems compatible with any conventional appliances, and can operate in parallel with, and interconnected to, the utility grid [5].

Figure 3 shows the basic components which are used for PV systems. Electrical energy cannot be used directly from output of photovoltaic panels. Electrical output of the solar panels is direct current (DC), but most of the electrical devices, which we are using in our houses and in industry, need alternative current (AC). Inverters are used to convert electrical output from DC to AC. Battery is mostly used for grid off systems. Wires are the fundamental components for all electrical system to make connection between all electrical components.

Texas is a unique state which can provide all these components within the state. Not only suppliers but also many manufacturers are located in Texas. Solar cells and inverters are featured components for a PV system because these components directly affect the system efficiency.

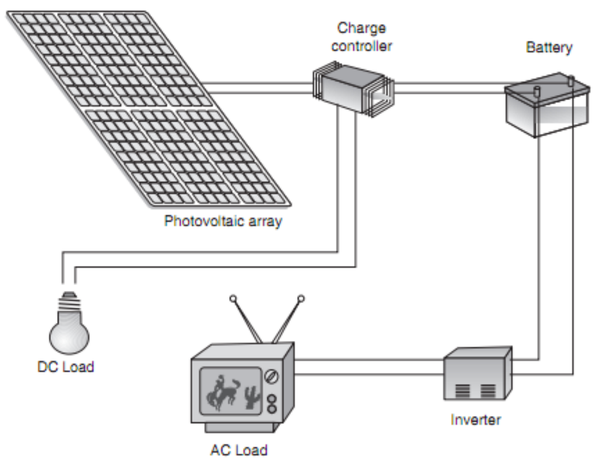

Figure 3: Basic components for a photovoltaic system [5].

2.1 Solar Cells

Solar cells are responsible for producing energy by absorbing sun light. Photovoltaic cells are made of special materials called semi-conductors. These semi-conductors produce electricity when sun light falls onto their surface. Solar electric cells do not require anything but sun light to operate. They are reliable and easy to maintain. Their life time is also longer than 20 years [6].

There are many types of solar cell technologies which are under development, but three of them- are crystalline silicon, thin film and organic cells- are commonly used. Let’s study commonly used photovoltaic cell technologies in detail.

2.1.1 Crystalline silicon solar cells

Crystalline silicon is the oldest solar cell technology which is called as the first generation solar cell. Crystalline silicon (c-Si) has been used as the light-absorbing semiconductor in most solar cells even though it is a relatively poor absorber of light and requires a considerable thickness (several hundred microns) of material. However, it has a good efficiency and uses process technology developed from new improvements in microelectronics industry [7].

Manufacturing silicon cells today costs approximately $3 per watt, but for sure improving technology will reduce the costs. Texas has a few manufacturers which produce crystalline silicon solar cells. Generally silicon solar cell technology has more than 80% of the solar cell market [8][9]. Texas produces 11.5% of the world's processed silicon need, so it is a key way for Texas to improve silicon solar cell technology in order to spread this technology in Texas and to have bigger market in the world [10]. Figure 4 shows 2 main types of crystalline silicon solar cells; monocrystalline and polycrystalline.

Figure 4: a)Monocrystalline silicon solar cell b)Polycrystalline silicon solar cell (© 2010 Sharp)

2.1.2 Thin film solar cells

Thin film solar cell technology- shown in Figure 5- is called the second generation solar cells. Thin film modules are designed by extremely thin layers of photovoltaic materials on a low cost backing such as glass, stainless steel or plastic. Laser technology is used to form individual cells by scribing through the layers. Thin film cells are cheaper because it requires much less semiconductor material, thus material costs are lower. Labor is also reduced because the films are produced large in size and they do not need to be mounted in frames and wired. However, the efficiency is lower than crystalline silicon cells [7].

Figure 5: Thin film solar panel thin film solar panels

According to Heliovolt which is a Texas based company working on thin film solar cell technology, thin film solar cell technology can be more efficient than crystalline silicon technology. The U.S. Department of Energy (DOE) estimates that thin film solar cells produced in the U.S. may exceed crystalline silicon cells in near future [11].

2.1.3 Organic solar cells

Organic solar cells are the third generation solar cells. They are still under development. Organic semiconductor material-based solar cells have less commercial efficiency and are mainly used for much smaller applications. Nevertheless organic solar cells have many advantages; they are flexible, compact, lightweight and cheaper. Figure 6 especially shows its flexibility-its biggest advantage. In market, the main reason to invest money is related to market size. Therefore they are not many companies investing their money in this technology. However some companies have been trying to develop the efficiency of cells and increase their share in the solar market [12].

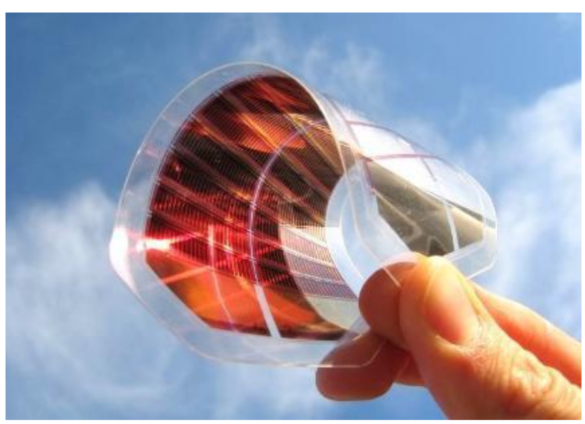

Figure 6: Organic solar cell

Figure 7 shows the current performance and price for different solar cells. If we ignore concentrating solar cells and just analyze photovoltaic solar cells which we mentioned so far, the efficiency is decreasing while price is decreasing. As a conclusion, as it is mentioned before since crystalline silicone solar cells have the biggest share in the solar cell market, we can say that efficiency becomes more important than price.

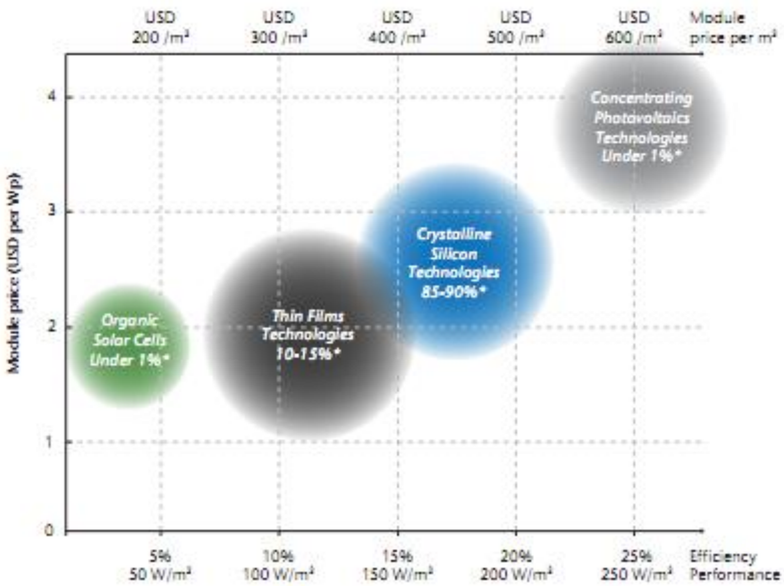

Figure 7: Performance and price for different solar cells [13].

2.2 Solar Inverters

Inverters are used for DC voltage to AC voltage conversion. In conventional PV solar installations, shown in Figure 8, solar modules are designed in a series, creating a PV array then connected to a string inverter. This conventional inverter system converts the high voltage DC output from the PV array to AC for connection to the electricity grid. The inverter will typically be rated at 3kWp or 5kWp for the residential PV applications. The conventional inverters have bigger market than micro-inverters. In figure 6, inverter market is busier and competitive among the solar inverter manufacturers between 2kW and 6kW. It means there are lots of choices for the customers to buy an inverter for their residential PV systems [14][15].

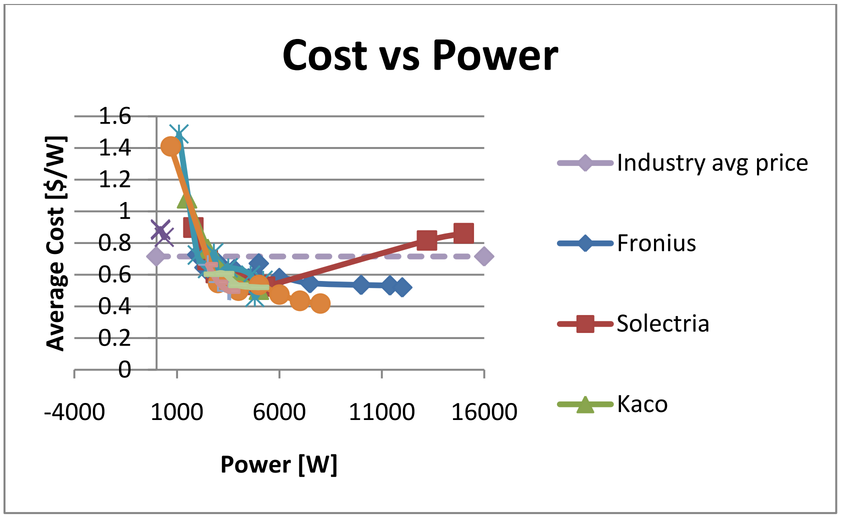

Figure 8: Average cost vs. power based on solar inverter companies

Figure 9 shows both conventional solar inverter system and micro-inverter system. Micro-inverters are connected to each modules and it makes the system more reliable and efficient. When PV system has a problem such as shading or a technical problem on some PV modules, the whole system only performs at the level of the poorest performer in the string for conventional inverter connection. However, in micro-inverter system, only that module which has the problem will perform at a lower level depending on the problem. That is the biggest advantage of the micro-inverter system. Maintenance is also easier and cheaper [14][15]. Especially for the residential scale PV systems, the trend is moving towards micro-inverter technology.

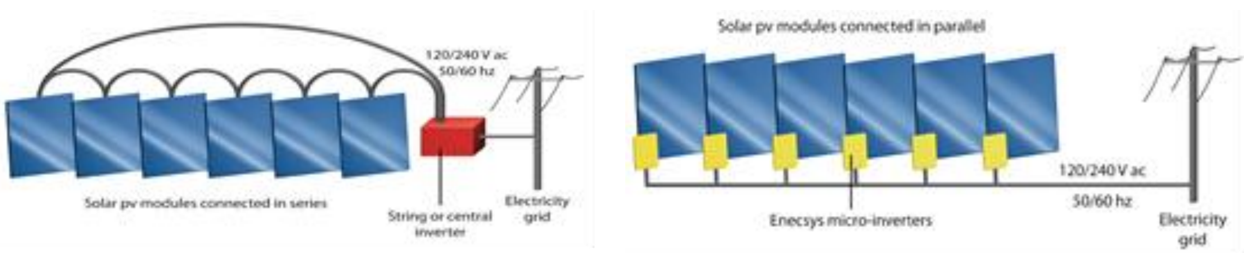

Figure 9: Solar inverter technologies; conventional(left), micro-inverter(right) [11].

Texas has a few solar inverter companies and Exeltech which is a Texas based manufacturer company has a big portion of this market in the world [16].

2.3 Solar Companies in Texas

There are more than 150 solar companies in Texas. As it is mentioned, Texas is a unique state which can supply all the components for a PV system. They are not only product suppliers but also some of them are technology developer manufacturers.

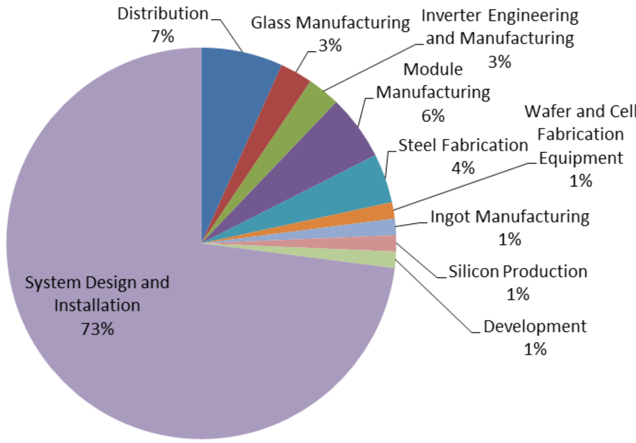

Figure 10: Percentage of Texas based solar companies for different solar market in Texas.

When we have analyzed Texas based solar companies as it is shown in Figure 10, 73% of the companies are just designing and installing the system. Although the number of the manufacturers is less in the figure, Texas has an important place to produce PV technology in the U.S. Powerful PV manufacturers and installers in Texas know what to do in this area. They do not invest their money for the bigger systems in Texas because of lack of incentives; instead they invest in other states such as California and New Jersey. These states offer many more incentives to attract these companies' attention.

3 ECONOMY ASPECT

3.1 Incentives in Texas

3.1.1 Importance of Incentive

In comparison to retail electricity, the costs of photovoltaic (PV) systems are more expensive. These PV systems could not be promoted without the governments or utilities support. Moreover, owners of photovoltaic systems should be compensated for the benefits they create for society. For instance, substituting fossil fuels with solar electricity reduces environment pollution and reduces the necessity for expensive investments in power plants and transmission lines.

Texas Renewable portfolio standard (RPS) states that by 2015, a target of at least 5,880 MW installed renewable capacity should be achieved, where 500 MW of it is coming from a renewable energy technology other than wind energy [17]. Furthermore, by 2020, city of Austin has the goal of producing 30% of all energy needs through the use of renewable energy which include at least 100 MW of solar power. [18] Figure 11 shows the RPS goals and policies in the United States.

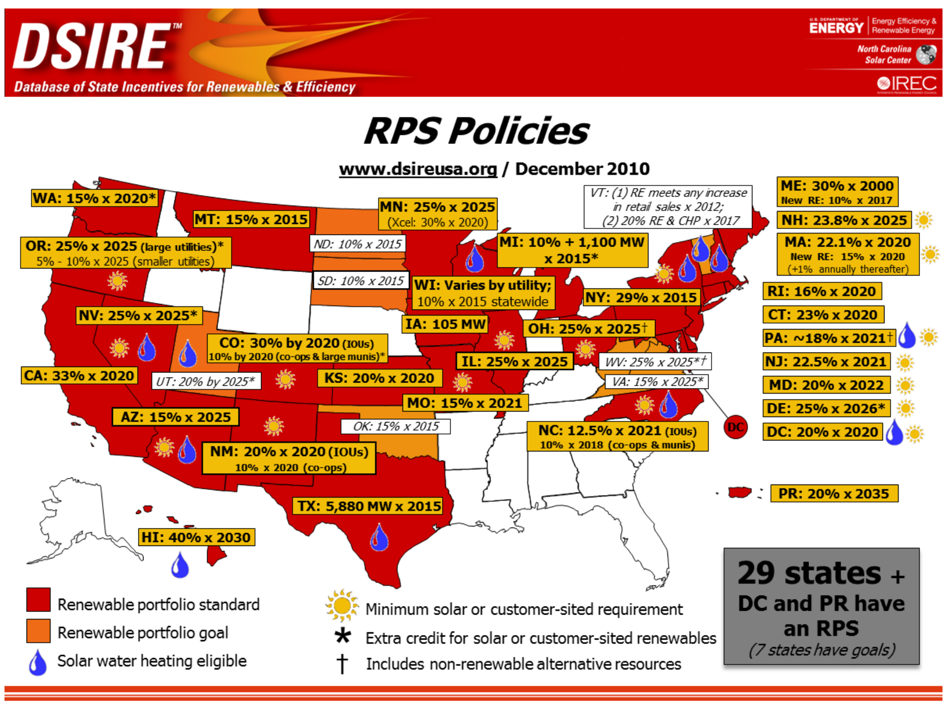

Figure 11: Renewable portfolio standards for all states in USA [13]

3.1.2 Current incentives offered in Texas

Texas offers many incentives to promote renewable energy, but few of these incentives are related with photovoltaics. The main current incentives that Texans could use are [19]:

- **Federal investment tax credit (ITC)**
  This incentive is offered by the federal government. Currently, it covers 30% of the initial cost and it is valid until 2016.
- **Utilities PV rebate programs**
  This is only offered by some utilities in Texas. For example, Austin Energy offers 2.5 $/W [20] and Bryan Texas Utilities offers 3 $/W (AC) with a maximum amount of 9,000$ [21]. This amount covers almost 40 % of total initial cost.
- **Statewide property tax exemption**
  The property tax exemption means that the value of solar systems is not included when calculating property taxes.
- **Net metering**
  This regulation allows owners to sell excess electricity to their utility. This is only offered by few Texas utilities.
- **Renewable Energy Credit (REC) trading**
  Many RPS laws including Texas have a REC trading program where every REC represents 1000 KWh of qualified renewable energy that is generated. This credit can be sold to utilities that have not met their renewable energy obligations.

3.1.3 Comparison of Incentives

To compare Texas incentives with other successful incentive programs worldwide, we can see that they focus on three main areas to reduce the cost of PV systems.

- **Refunds**
  In addition to the federal tax credit, some states offer additional rebate program [19]. Texas does not have a statewide rebate program but -as mentioned- refunds are offered by some utilities.
- **Feed in tariff**
  After the introduction of a feed-in tariff in Germany, the growth of solar industry rose sharply. The market growth is closely related to the introduction of the Renewable Sources of Act (EEG) in 2000 [22]. Although feed in tariff policy is costly, but it can offer great potential for ramping up PV systems.
- **Low interest loans**
  Low-interest loans can reduce the financial bar for individuals. California has recently adopted a new solar loan law that allows cities and counties to provide low interest loans for homeowners and businesses.
  In Texas, the LoanSTAR Program offers low-interest (3% APR) loans. This program is intended for all public entities, but not for homeowners. [19]

3.2 Price Trends

Figure 12 shows the electricity price demand for the last decade. The retail electricity price increase was parallel to the increase in demand [23].

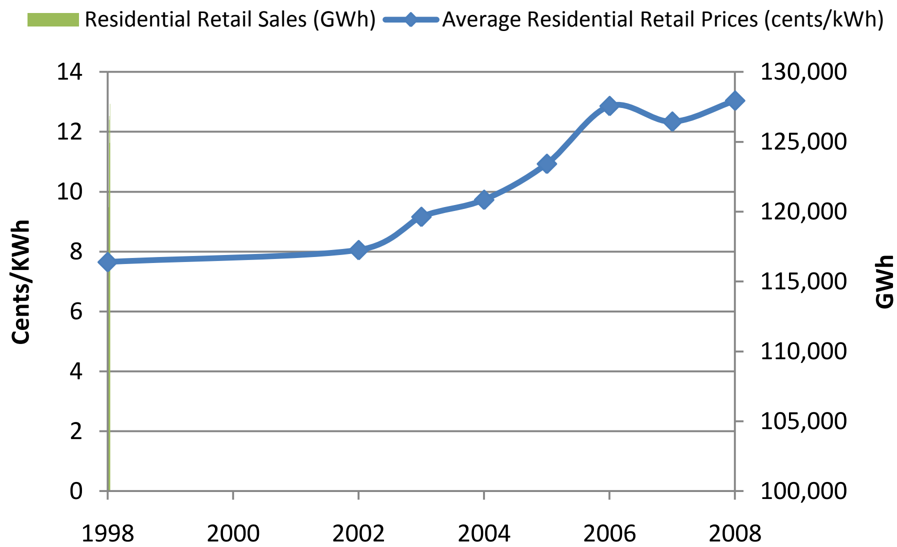

Figure 12: Price and Demand Trends for Residential Retail Electricity in Texas

The total residential retail sale in 2008 was 104,966 MW. On the other hand, the cumulative installed grid connected PV Capacity was 8.6 MWDC [24] which is less than 0.1 %.

3.2.1 PV System Cost

According to [25], the components of the initial cost are shown in Figure 13:

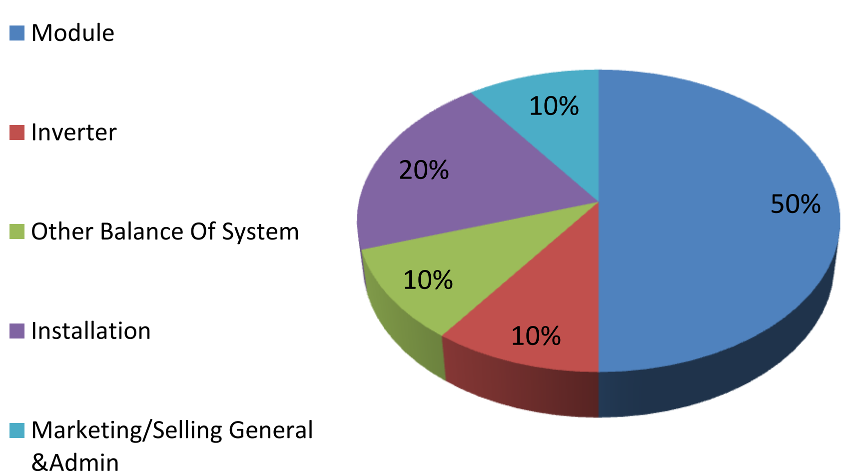

Figure 13: Initial Cost of the PV system

On the next Figure we can see that cost is falling down as a result of the mitigation of the current silicon shortage. In the long term, system cost will reduce further due to the technology developments and efficiency improvements.

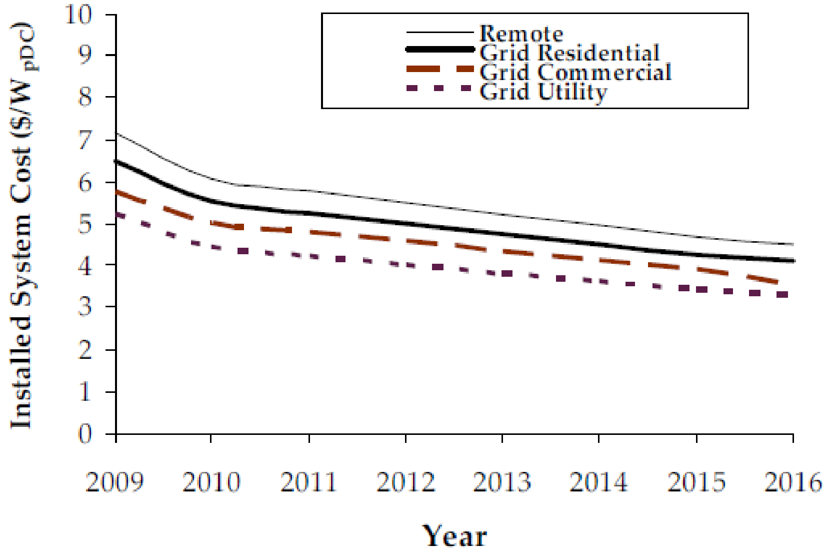

Figure 14: The expected future cost of the PV system [19]

3.2.2 Solar Price Index

Figure 15 shows the cash flow diagram for retail and solar electricity. We can see that the solar system has a high one time initial cost while retail electricity consists of almost constant monthly payments. The current average initial cost of a PV system is 6.5 $/W as shown in Figure 14, and the operation and maintenance cost is 8-9$ /KW-year excluding the inverter replacement cost [25].

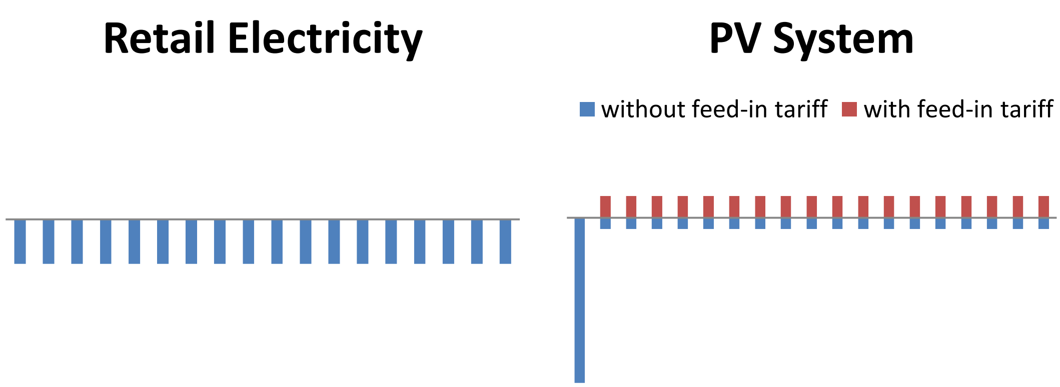

Figure 15: Cash Flow Diagram of Retail electricity and PV system

To compare the solar system cost with retail electricity, the solar initial cost is converted to monthly payments (Solar Price Index). In 2008, the average residential retail price in Texas was 13.04 Cents/KWh [23] where the solar price index is 31.91 Cents/KWh.

For the data given in [23] and [26], Figure 16 compares electricity retail price with solar index price and shows the price trends:

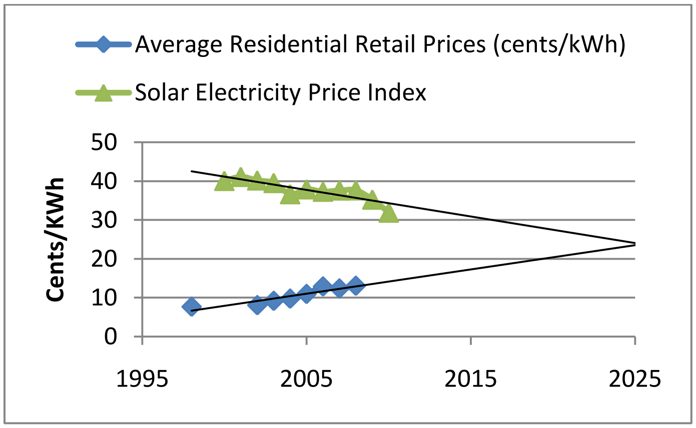

Figure 16: Price Trends for Retail Electricity and Solar Index Price

It is clear that the retail electricity prices are increasing while the solar price index is decreasing. If we look at the price trends we can see that the two prices will be almost equal by 2025. However, this can change depending on different scenarios. For instance, DOE estimated that solar technology will reach the same price by 2015.

In Figure 17 below, it is expected that for a 2000 MW goal by 2020 the prices will drop. Additionally, the figure shows that 20,000 new green jobs could be created by that time.

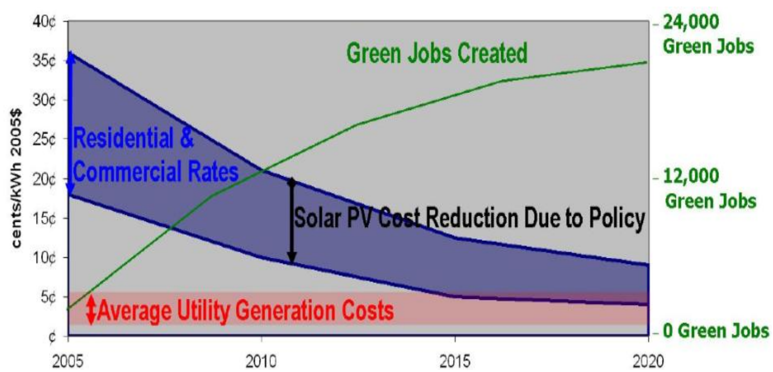

Figure 17: Incentives will drive down overall costs of solar and create jobs with a 2000 MW goal by 2020 [27]

3.3 Job Opportunities

Many studies have shown the potential of renewable energy in job creation. For instance, The Center for American Progress states that an investment in renewable energy can create approximately four times more jobs than an investment in oil resources. [28]. In addition, another analysis done by the Vote Solar project reports that by 2020 and under a 2000 MW program the solar industry would introduce more than 20,000 jobs to Texas [29]. Table 1 shows the distribution of direct and indirect jobs.

Table 1 : Jobs created under a 2000 MW program [23]

Job Type	Direct Jobs	Indirect/Induced	Total
Manufacturing	2,700	9,400	12,100
Installation	2,100	7,200	9,300

3.4 Cost of a residential PV system in Texas

3.4.1 Assumptions

To show the cost of a PV system and the effects of incentives, a 3KW PV system was studied. In this calculation some assumptions were made:

- The average annual electricity consumption for a U.S. residential utility customer in Texas is 1,140 kilowatt-hours (kWh) per month [30].
- Average Retail electricity price in Texas is 13.04 Cents/KWh [23].
- 7 $/W initial cost [25].
- 3 $/W utility rebate [21].
- 5.5 sun hours per day [26].
- All the produced electricity from the PV system is consumed.
- 30% Federal Tax incentive.
- 90% constant efficiency.
- 20 years lifetime for the whole system [26].
- 9 $/KW per year operation and maintenance cost was assumed. This value does not include the inverter replacement cost [25].
- Financing cost is assumed to be 5% fixed annual percentage rate.

3.4.2 Calculations

Calculations were done for the following four cases:

1. Base Case: only the 30% federal incentive was applied
2. Cut costs: an additional 3$/W rebate was added.
3. Better loan: the interest rate was decreased to 1.5%
4. Both: both cut costs case and the better loan case were applied.

Table 2 : Calculations for 3KW system

	Base Case	Better loan	Cut costs	Both	
ELECTRICITY USAGE					
Electricity Retail Price	13.04	13.04	13.04	13.04	Cents/KWh
Usage	1140	1140	1140	1140	KWh/month
monthly bill	148.66	148.66	148.66	148.66	$/month
SOLAR SYSTEM					
system size	3	3	3	3	KW
Efficiency	90	90	90	90	%
sun hours	5.50	5.50	5.50	5.50	hours/day
monthly production	445.5	445.5	445.5	445.5	KWh/month
AFTER INSALLING					
new usage	694.5	694.5	694.5	694.5	KWh/month
new bill	90.56	90.56	90.56	90.56	$/month
SOLAR COST					
cost/W	7	7	7	7	Cents/KW
initial cost	21000	21000	21000	21000	$
after Federal rebate	14700	14700	14700	14700	$
utility Rebate	0	0	3	3	$/WAC
after utility Rebate	14700	14700	6600	6600	$
operation and maintenance	9	9	9	9	$/KW/year
monthly O&M	2.25	2.25	2.25	2.25	$/month
LOAN					
APR	5	1.5	5	1.5	%
monthly interest rate	0.41	0.12	0.41	0.12	%
loan years	20	20	20	20	years
monthly loan payments	96.11	70.87	43.15	31.82	$/month
Total Monthly Payment	188.93	163.68	135.97	124.63	$/month

Figure 18 compares the results with the monthly payment before installing the system. It is clear that reducing the initial cost has greater effect than providing low interest loans. In the case were both incentives were applied, the monthly payment dropped almost by 25 $/month.

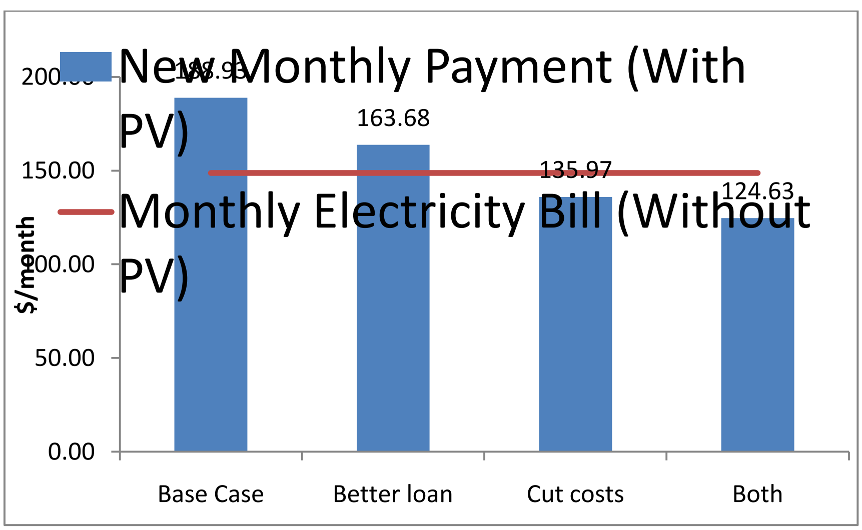

Figure 18: Monthly payments before and after installing the PV solar system

4 BARRIERS TO GROWTH

Solar energy has tremendous advantages over other conventional energy sources. Decreasing prices, availability in everywhere, negligible maintenance after installation, no need for fuel catch attention of people. Particularly for Texas, it is also a great opportunity; however, some barriers keep solar vast usage in Texas. Despite many advantages, solar future cannot be built without promoting it due to these barriers.

4.1 Cost

Majority of society thinks that the biggest barrier to solar energy is cost. It is true until some point that photovoltaic systems have been more expensive than other conventional energy sources. In fact, the cost of the system is becoming less severe due to the high drops in installed system costs and other benefits coming from solar investments.

The installed cost of PV systems declined by 31% during the period 1998 and 2008 without any effect of tax incentives and subsidies [31]. Furthermore, cost of PV modules declined dramatically over the last decades. During 1970 cost of a module was around 100$/W, where it dropped to 4 $/W in 2002, and further lower till 2008. **Error! Reference source not found.**9 shows how module and non-module ost trends changed between 1998 and 2008.

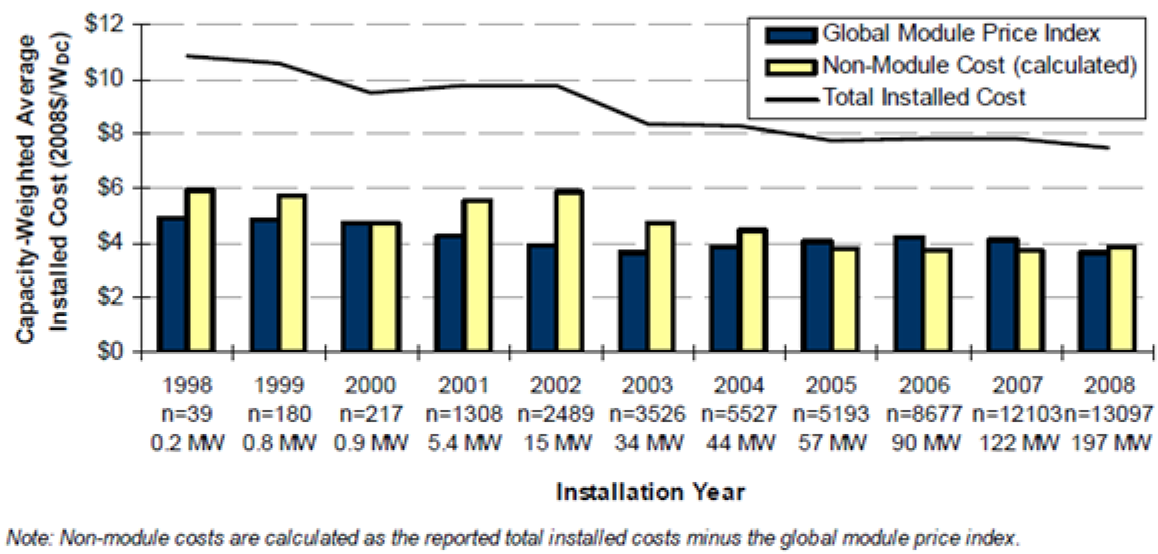

Figure 19: Module and Non-module cost trends over time [31]

Table 3 shows that retrofitting a home with PV system is assumed to decrease from 7.40$/W to 4.80 $/W between 2007 and 2015, and if Department of Energy's Solar America Initiative's targets are met, prices could drop to 3.10 $/W by 2015.

Table 3: System Pricing Assumptions [32]

System Price Scenario	Market Segment	Retrofit Installed System Price ($2007/Wpdc)			New Construction Installed System Price ($2007/Wpdc)		
		2007	2010	2015	2007	2010	2015
Business as Usual (BAU)	Residential	$7.40	$6.20	$4.80	$7.40	$5.90	$4.50
	Commercial	$6.41	$5.80	$4.50	$6.70	$5.50	$4.20
Solar America Initiative (SAI)	Residential	$7.40	$5.11	$3.10	$7.10	$3.86	$2.44
	Commercial	$6.41	$3.75	$2.49	$6.23	$3.60	$2.32

According to DOE, by 2015 PV will reach "grid parity" which is the point of an equivalent cost of grid electricity. High radiation levels, high electricity prices, generous incentives and falling PV system prices bring PV systems faster to grid parity. Indeed, in some states such as Hawaii and then California grid parity has already been reached due to high electricity costs and more incentives. Figure 20 shows grid electricity cost among states.

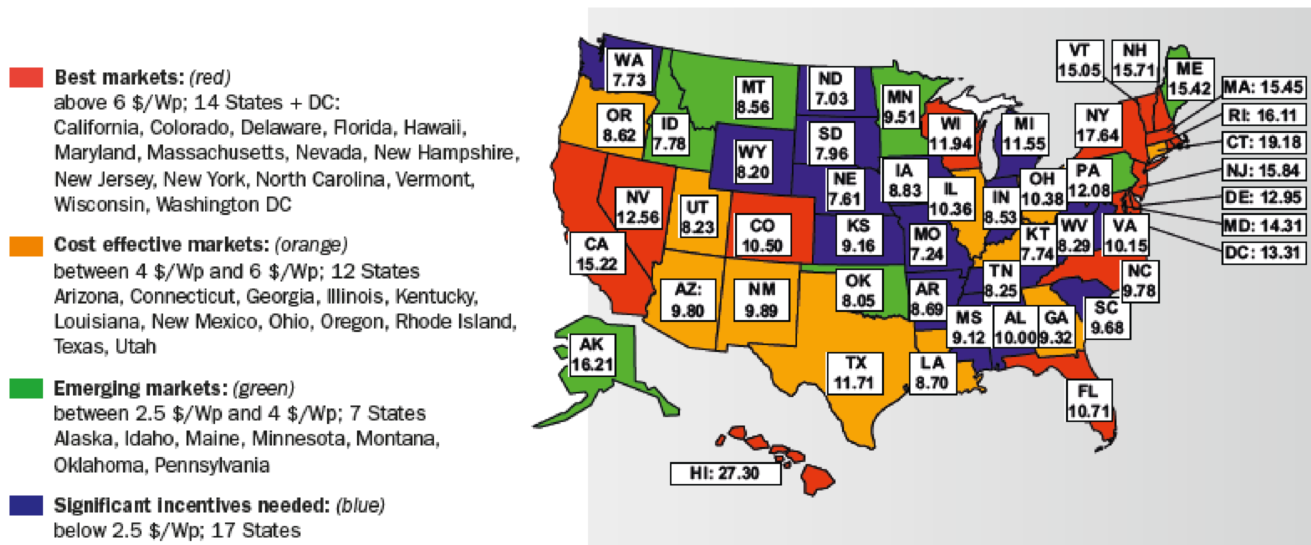

Figure 20 Average residential electricity prices (cent/kWh) for 2009 [Source: EIA2010]

If other benefits such as reducing carbon emissions, free of fuel, lessening pollution, improving national security etc. coming from PV systems are considered, cost of PV systems is becoming less severe problem. However, there are other effects which put barriers to solar energy's path.

4.2 Lack of Adequate Incentives and Payback times

One of the barriers which impede the spread of solar power is long payback times of a PV system. The system pays itself back over a period, however, it is obvious that if payback time is too long, investors will be reluctant to invest in solar. According to DOE, only a small percentage of people invest in those which have more than 5 year payback times [33].For many businesses, payback time should be even shorter, a research tells that for these the required payback time is 3 years or less [34].

Precisely there are more factors into it, but for residential markets simple payback can be shown by the equation below [32];

$$Simple\ Payback = \frac{[Installed\ Cost - Federal\ Incentives - Capacity\ Based\ Incentives + Tax\ Rate * Rebate\ Amount]}{[Annual\ Electric\ Bill\ Savings + Performance\ Based\ Incentives - O\&M\ Costs]}$$

It is obvious that payback time will closely depend on incentives. That brings the issue to the point that the more incentives, the shorter payback times, thus, spreading PV systems among society. That means incentives are closely correlated with PV installations. Figure 21 shows how the effect of some incentives could be on cumulative installations.

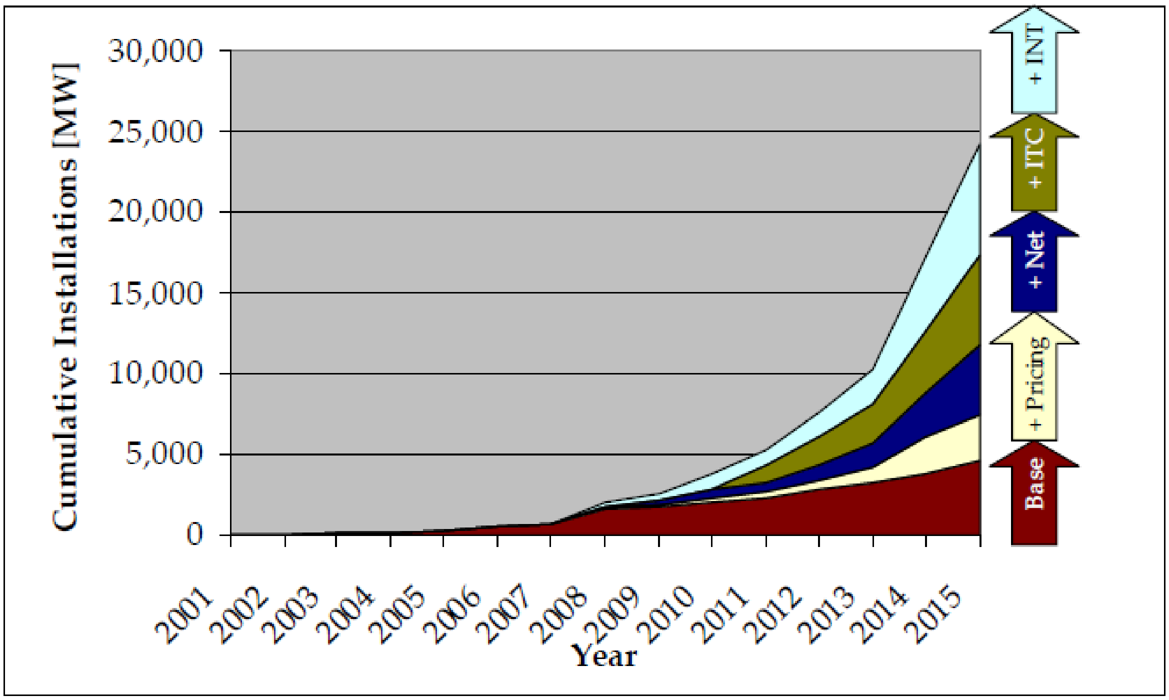

Figure 21: Influence of system pricing, net metering policy, federal tax credits and interconnection policy on cumulative installations [32]

Incentives are the key point of the problem because it is one of the most effective ways to promote PV installations by reducing payback time. However, reducing payback time could not be enough to promote the installations due to other barriers regarding this issue. For example, if the incentives do not support both the owner of the house and the person who pays the electricity bills, then until owner feels his investment will be secure, he may not want to invest his money. Therefore, incentives should be split among people in a fair way.

The other issue about incentives is that investors should be compensated for the benefits they deliver to society. Increased cumulative PV installations save a lot of money by reducing need for peak electric plants and transmission lines as well as environmental benefits- reducing pollution and as a result reducing health care costs. If all these and more benefits were taken into consideration while regulating the incentives, results would be much better.

4.3 Upfront Costs, Capital Availability and Length of Residence

Although overall cost of the electricity during the lifetime of a PV system could be lower, for small businesses and homeowners it could be hard to finance upfront cost in the beginning. For a PV system, costs occur in the beginning of the investment whereas benefit comes during the lifetime of the system. Families and small businesses who cannot afford upfront costs may not be able to obtain necessary credits from banks to finance the upfront costs. Those miss opportunity to install PV system on their households.

Additionally, even if people are able to finance all costs or able to obtain enough credits and accept long payback times, they still may not want to install PV systems on their households having concerns that it is not worth especially if they are planning to stay a few years at their current location. The remaining value of the system may not be received upon sale when people move out of their current location before the whole system pays itself off.

4.4 Risk of Failure

Owners of PV systems take the risk of system failure or being destroyed although the risks can mitigate through insurance companies or warranties, whereas if there is a failure in a conventional system, the cost will split to all customers.

4.5 Regulatory and Utility Barriers

Besides financial and investor based barriers, there are some regulatory and utility barriers prevents solar spread usage. In some states installing PV modules on roofs may be against laws more than just a challenge. For instance, Homeowners' Association rules due to concern that PV installations will harm the appearance of neighborhoods or archaic zone rules may restrict installation of PV system on land or roofs. Texas is also unfortunately faced with this barrier.

The other barrier to PV installations is put by utilities by limiting the size of the PV system eligible for net metering or creating hassles to connecting PV systems to the grid. Additionally, for utilities seeking to invest in solar may have no access to transmission lines or have limited transmission capacity needed to carry their power to the customers.

4.6 System Size Based Barriers

In addition to barriers to solar PV growth, there are some considerations for large scale PV system. While arguments focus on land use, availability of adequate power transmission capacity and backup resources, cost of the system, feedstock availability, energy payback time and etc., the biggest concerns about land and transmissions line issues.

Utility size PV systems require a lot more land than other energy sources due to its low energy density nature. It is not so easy to find huge land sufficient enough to install large scale PV systems. Furthermore, even if the land is found, availability of interconnection to transmission lines becomes a big problem. Power transmission capacity of transmission lines that are installed before and in service may not be enough to carry all power generated from solar farm. Thus, new transmission lines need to be built which adds a lot to the cost of the system results in longer payback times and even unfeasible systems.

However, although all considerations about large scale PV system, it has still less environmental effect compared to other large scale power plants. PV systems do not have neither any gas emissions which causes global warming nor any waste unlike nuclear plants. Therefore, these systems are still in consideration for supplying huge amounts of energy need.

4.6.1 Availability Utility Size PV in Texas

Many companies raise their opinion about large scale PV systems that it is a good opportunity for Texas since there are available sources, and many barriers are no longer exists for Texas. Investors need to develop their projects by evaluating location of the system; picking either best resource with good economic aspects but transmission line constraints or closer lands to the loads having less constraints while transmitting energy produced.

In this frame, companies claim that Texas has many advantages. West Texas has a good source of solar power for large scale PV projects and convenient for land usage. Figure 22 shows where solar is available for large scale projects in Texas. Moreover, west Texas also have huge wind projects- Competitive Renewable Energy Zone (CREZ)- and Public Utility of Texas(PUC) has already ordered LCRA Transmission Services Corporation to construct new transmission lines for this area. In Figure 22, solar potential map of Texas shows that CREZ has a good source of solar power. Combining intermittent resources like solar and wind farms in this zone plays an important role by balancing huge amount of energy produced by wind and increasing the utilization of transmission lines. Since solar generation occurs during day time, whereas wind occurs during night, this zone can provide reliable, consistent and renewable energy for Texas.

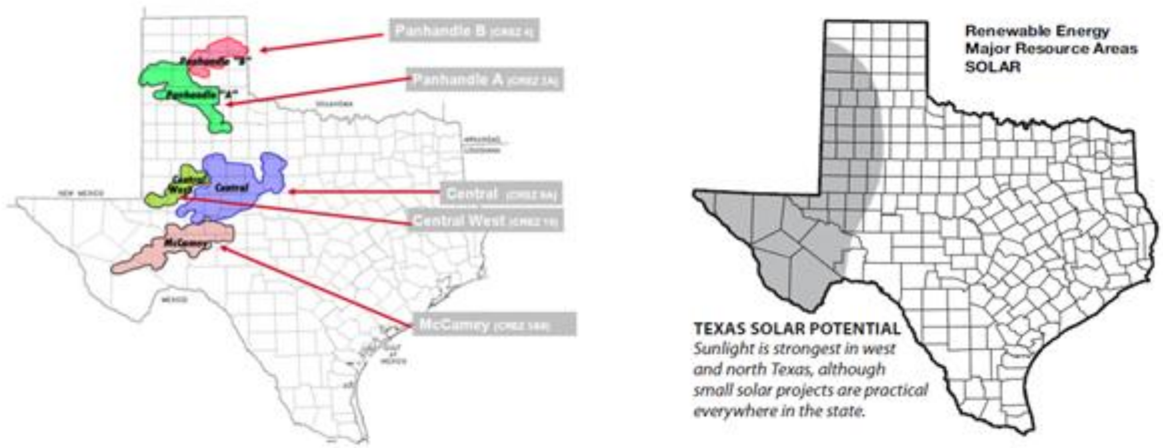

Figure 22: Competitive Energy Zone (CREZ) and Texas Solar potential [35]

In addition to that, peak power demand occurs in summer in Texas. As it is shown in Figure 23, since solar energy output curve and load curves are syncronous(peak output occurs when demand is peak), for Texas investing in solar energy will reduce need for investments peaking energy demand,thus saves a lot of money.

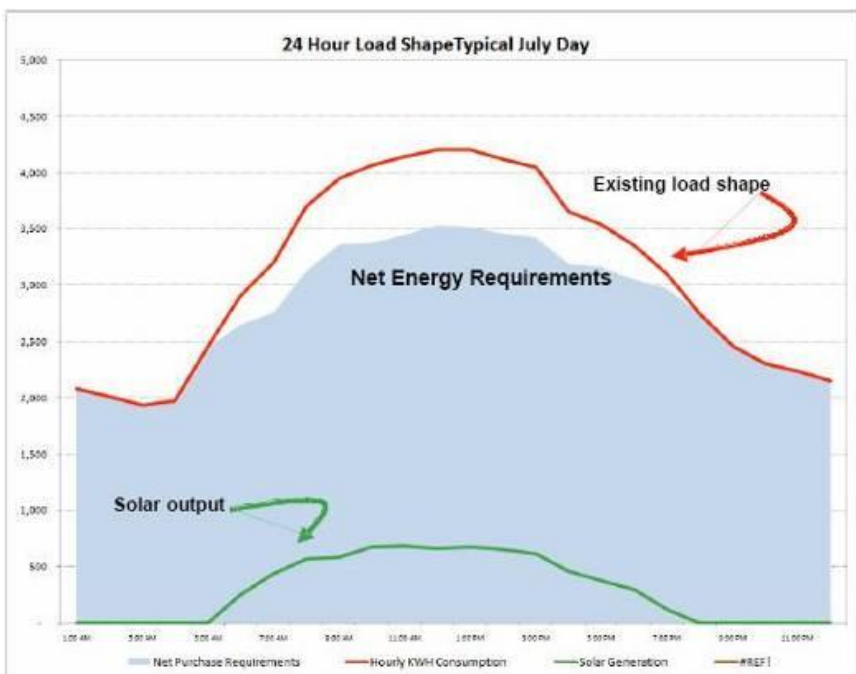

Figure 23: solar power- energy demand curves in Texas [36]

4.7 Lack of Education

Public education has a very important role in expanding the usage of solar energy and thus increasing the cumulative installation of PV systems. It is essential to answer consumers' questions in order to convince them to go solar. "To sell PV directly to the customer, you have to do lots of educational outreach and marketing because the product is both expensive and unfamiliar to most customers" says Jim Torpey, GPU Solar.

A Study show that demonstrations in schools have also big effects on promoting solar technologies, because changes or any upgrades in schools are easier to realize in the community and people are following schools closely, students educate their families about new technologies, and today's students will become tomorrow's energy users.[37]

In order to have an idea about the level of the public awareness in renewable energies and PV systems, we conducted a survey among more than 100 Texan people, 45% of those are college students or graduates with an average age of 22 and the rest is homeowners with an average age of 50. The results regarding the survey are shown in the Table 4.

Table 4: Survey results

☺	??	☹☹☹
80%	Wind in Texas?	10%
56%	Solar is renewable?	10%
	Cost of a system	97.5%
	Incentives	92%
	PV?	80%
90%	Donation	10%

We can summarize important observations as below;

- Although Texas has one of the biggest wind installation capacity among the world, 10% of people who have been living in Texas their entire lives do not have any idea if Texas has electricity production from wind energy.
- 10% of these people do not know that if solar is a renewable energy type. Additionally, according to responses, it is observed that people have limited knowledge about "renewable energy" concept.
- 80% have no idea or not sure what "photovoltaic" means. People think of hot water heating systems when they are asked "solar energy".
- Only a few of them have heard about incentives and have an approximate number in their mind for cost of a possible PV system for their houses.

- They rather install hot water heating system than a PV system when they are asked to choose a type of solar technology.

- They are positive to support new technology programs to deliver benefit to their society.

Although the results do not show 100% accurate results, there are still important points needed to be focused on. For example, we can say that people do not have enough knowledge about renewable particularly solar and PV systems. Another point is that most of the college students do not know enough about renewable energies and some of them even haven't heard about photovoltaic systems. However, these people accept paying average $ 3 per month as an extra to their electricity bill in order to promote research in PV technologies when they are told that it will contribute to the state's economy.

We believe like Jim Torpey that education has enormous impact on promoting a new technology and our results show us that Texas has a barrier regarding to education. Even if there is no other barrier, unless people become aware of the opportunities, it is not easy to reach targets for PV put by governments.

5 CONCLUSIONS

Introducing a competitive market development program could ensure that Texas will have a great expansion in PV capacity in near future. This program shall include financial incentives, regulations and policies. Texas utilities should offer various incentives and rebates to reduce the initial cost of the system. Many researches and studies suggested particular recommendations to minimize the barriers that prevent PV systems from growth in Texas.

1. Set specific targets for PV systems and add specific PV requirements to the RPS.
2. Require all utilities in Texas to provide net metering for customers.
3. Exempt the PV system and the installation from sale tax.
4. Provide more funding for research and development centers in Texas to help in technology development.
5. Improve the current regulations and prohibit Home Owner Associations from rejecting customers' right to install PV system.
6. Introduce new Public Utilities Commission (PUC) to offer more incentives.
7. Allow third parties to own the PV system.
8. Promote educational programs and make PV systems demonstration in schools.

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