SOLAR SUPPLY CHAIN AND MARKET DRIVER ANALYSIS

A Senior Scholars Thesis

by

NICHOLAS T. MARTINEZ

Submitted to Honors and Undergraduate Research
Texas A&M University
in partial fulfillment of the requirements for the designation as

UNDERGRADUATE RESEARCH SCHOLAR

May 2012

Major: Industrial Distribution

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Approved by:

Research Advisor: Barry Lawrence
Associate Director, Honors and Undergraduate Research: Duncan MacKenzie

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ABSTRACT

Solar Supply Chain and Market Driver Analysis. (May 2012)

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This study aims to explore the evolution of the photovoltaic supply chain in the United States and the drivers which foster growth of the solar market. The study will gather knowledge on the growth of the solar market and roles of different firms in the supply chain as the solar market moves toward maturity. Based on different drivers including, but not limited to, government incentives, electricity prices, and component prices, the study will build a methodology to conduct a solar market potential analysis for each state. During this process, the study aims to interpret the trends in the supply chain and assess the impact of these trends on the solar market

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CHAPTER I

INTRODUCTION

The photovoltaic (PV) market in the United States has shown substantial growth in recent years. The United States has risen to the top four in cumulative installed megawatt (MW) capacity of the world behind Germany, Italy, and Japan (Despotou, Fontaine & Latour, 2010) . During the economic recession, the installation base for solar grew from 508 MW in 2007 to more than 2200 MW in 2010 (Shah, 2009). Recent projections foresee the market more than doubling by 2014 (Shah, 2009). Multiple start-up firms emerged due to the increased availability of funding to entrepreneurs and small to medium sized enterprises (Causey, 2011). This growth opportunity coupled with the economic downturn spawned companies that were not entirely familiar with solar energy to enter the market (Jubinsky, 2009). The unfamiliarity of the market has caused a non-traditional supply chain as firms are not following a channel discipline in an effort to increase their market share.

Firms are attempting to integrate the supply chain in order to sustain in the solar market (Maslin, 2008). The study aims to dive deeper and analyze the to-go market strategies and business models that companies are undertaking in order to keep up with the projected growth and analyze their validity with the foreseen trends.

This thesis follows the style of *Industrial Marketing Management*.

Solar energy is indisputably a sustainable energy form for the United States in the future and its success correlates with its cost to the customer. Recent developments in states such as Arizona and California have ingrained the thought of solar installations in many home owners and industrial firms. Many drivers have resulted in strengthening this confidence amongst consumers. Some of these are government incentives, overseas demand, technological advances which increase the efficiency of panels, and more streamlined installation processes (Porter, 1980).Some intangible drivers are the increased concern for greener technologies amongst potential consumers.

Regardless of the fluff, from an economic stand point, it boils down to the total cost of ownership of the clean technology and its return on investment in comparison to traditional sources of energy (Molavi, 2011). A combination of the cost of solar components, conventional electricity prices, installation costs and purchasing schemes impact the buying decision. Government regulations, both federal and state, influence each of these costs directly or indirectly. Some factors such as electricity costs can be related to personal disposable income that corresponds to the wellness of the economy, which again is an innate government agenda.

CHAPTER II

MARKET ENVIRONMENT

This research was compiled using various literature resources as well as interviews with professionals in the industry. This information was then used to gather preliminary data and a background of the photovoltaic market as it pertains to the United States.

Market snapshot

The photovoltaic market in the United States is expected to more than double by 2014 and become one of the leaders in global market share (Stevens, 2009). Multiple market drivers include, but are not limited to, government incentives or regulations, the decreasing price of system components, increasing electricity rates, and the availability of innovative financing methods that increase the return on investment (Molavi, 2011). These drivers are depicted in Figure 1.

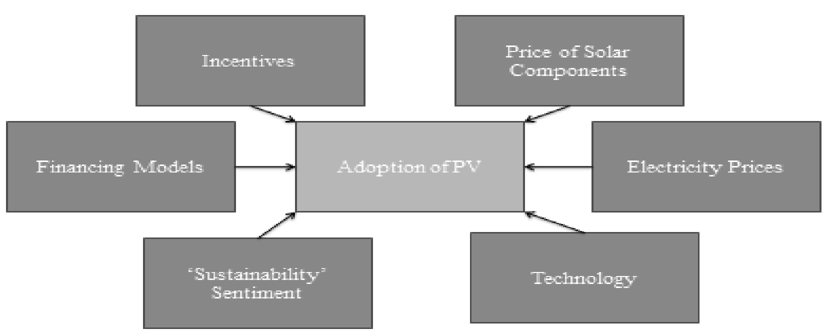

Fig 1: Market Drivers

The solar market is fundamentally divided into 3 segments (Shaio, 2010). The stand-alone generation installations are defined as utility-scale projects while the installations that use distributed generation from the grid can be broken up into residential and industrial or commercial segments as shown in Figure 2.

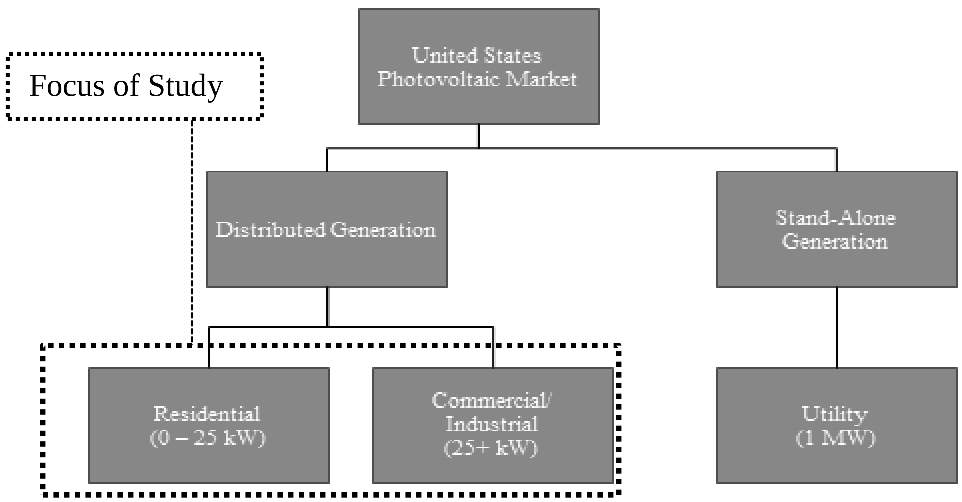

Fig 2: Market Segmentation

As Figure 3 illustrates, the photovoltaic market in the United States has shown exponential growth in the recent years. The residential market segment is currently 32% of the market share (Shiao, 2010). This segment is projected to maintain a steady growth rate in the coming years due to decreasing panel prices and growing ‘green’ sentiment. The commercial or non-residential market represents 52% of the market and is projected to grow substantially in the coming years mainly due to financing methods and the initiative to remain sustainable into the future (Shiao, 2010). Utility currently has 16% of the market, however, it is projected to grow the most in the next 5 years and possibly overtake the commercial market due in part to state renewable portfolio standards (Shiao, 2010)

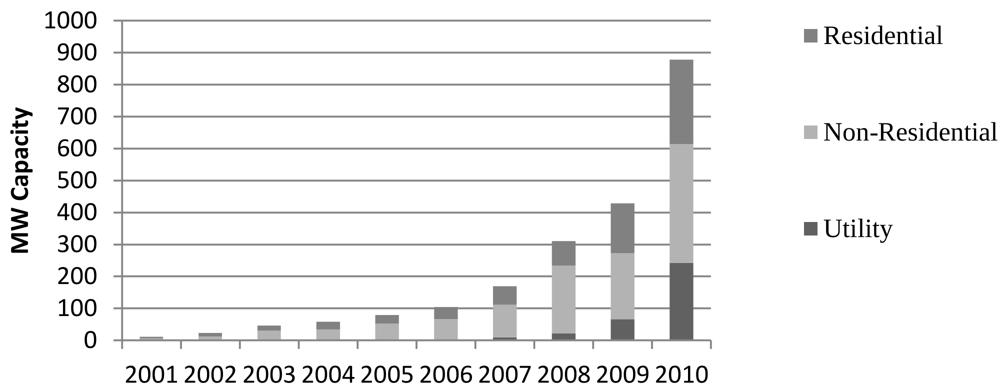

Fig 3: Historical Installed Capacity

This adoption has only occurred in a select region of states. These states, such as California and New Jersey, have been at the forefront of fostering solar energy adoption. They have enacted aggressive renewable portfolio standards and multiple financial incentives such as rebates and tax credits to lower the upfront cost on the solar components required for the installation. These regulations and financial incentives have benefited the market due to the increase in investment return for customers. The top 10 states in installed capacity make up the vast majority of installations in the current market as depicted in Figure 4 (Shiao, 2010).

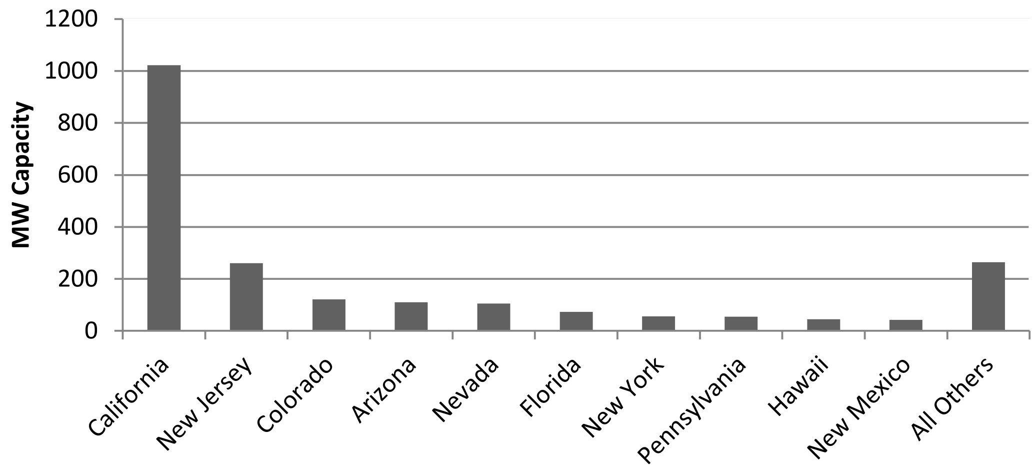

Fig 4: Top 10 States Cumulative Capacity

Photovoltaic value chain

As the market continues to grow and reach its stage of maturity, a multitude of companies have emerged to address this growth opportunity. The photovoltaic industry is functionally divided into two different segments: Upstream and Downstream. The upstream segment is comprised of raw material procurement and developing wafers and cells. It also includes designing, testing, and manufacturing photovoltaic modules. The downstream segment consists of project development, distribution, and installation to the end customer. The number of new and specialized participants, and the immaturity of the industry results in supply chain complexity. The supply chain includes module manufacturers, engineering, procurement and construction (EPC) firms, distributors, contractors, and integrators. The integrators are firms that provide their own products and install directly to the end user without using a channel of distribution. The study focuses on the downstream segment and how these firms get to market. The value chain is illustrated in Figure 5.

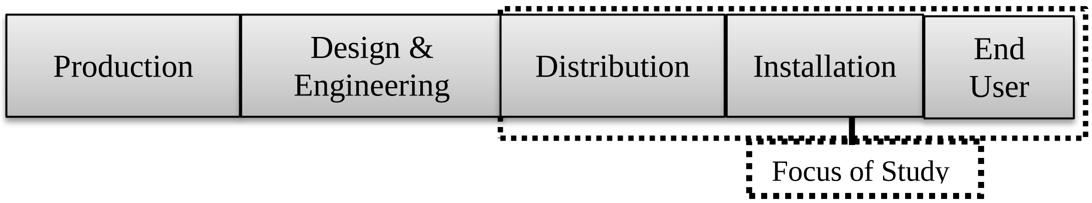

Fig 5: Photovoltaic Value Chain

Product life cycle and diffusions of innovation theory

The product life cycle is a normative and descriptive model for the life of products in general. Individual products will experience their own variations and may have longer segment in the curve or a longer curve overall (Rogers, 1995). The product life cycle's importance to marketing decision makers helps identify strategies for presenting the product (Rogers, 1995). The stages of the product life cycle are Development, Introduction, Growth, Maturity, and Decline. Table 1 describes the basic characteristics of the product in each stage.

Table 1: Product Life Cycle Characteristics

Characteristics	Development	Introduction	Growth	Maturity	Decline
Product	Prototype	Unknown to many	Capabilities being recognized	Competing with alternatives	Reduced competition
Price	Research & Development	Generally high	Decline with volume	Lowest point	Rise as volume declines
Placement	None	Selective	More wide spread	Intense	Selective
Promotion	None	Personalized and informative	Need and satisfying properties	Competition and repeat purchasing	Reminding

As these stages pass over time, customers can be classified into categories by the diffusion of innovations theory (Rogers, 1995).This theory proposes that as a new product reaches market and matures over time that the customer's perceptions change and strategies must be put in place to reach these different customers (Rogers, 1995). The classifications include innovators, early adopters, early majority, late majority, and laggards. In parallel to the product life cycle, the theory's classifications can be addressed at certain phases of the product life cycle (Rogers, 1995). This is shown in Figure 6.

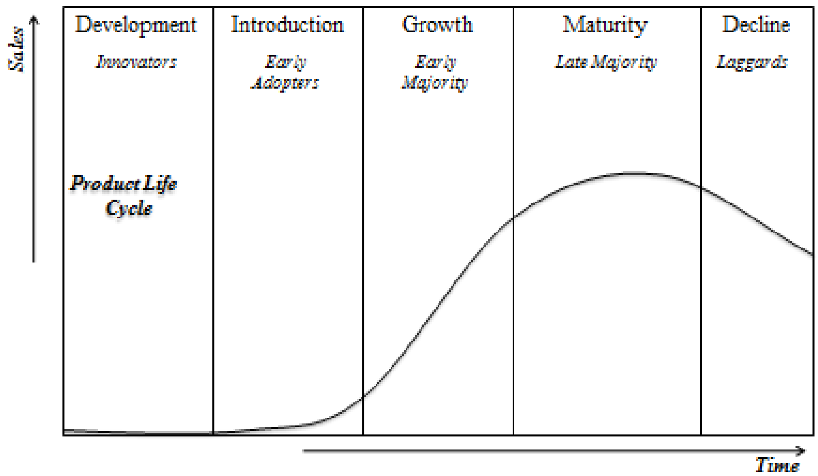

Fig 6: Product Life Cycle

The product development phase begins when a company finds and develops a new product idea (Golder & Tellis, 2003). A product is usually undergoing several changes involving a lot of money and time. The companies involved in this stage will use a lot of its resources on research and development. During this phase, the company's sales are zero and revenues are negative (Golder & Tellis, 2003). It is the time of spending with no absolute return. Innovators and technology enthusiasts will be targeted in this stage of the product life cycle to aide in design and preliminary marketing approaches.

The introduction phase is when the product is launched. This phase can be described as high expenditures with little revenue recognition to the company. These expenditures include aspects such as targeted advertising and increasing product availability (Golder & Tellis, 2003). The number of companies in the industry is small but growing fast and the market is still relatively small. A company must target the early adopters who want the new technology to be seen as leaders by their peers. The early adopters are estimated as 13.5% of the population (Golder & Tellis, 2003). These people tend to be younger in age and risk-takers who want to be seen as trend setters to peers.

Once the product has passed the introduction phase it enters the growth phase. More people are apt to purchase and knowledge is starting to spread about the product. This phase is characterized by increasing profits and a large amount of firms in the industry (Rogers, 1995). The investment is still high but the company is starting to see a growth in margins. During this phase, the early majority should be the target segment for most companies. According to the diffusion of innovations, the early majority makes up roughly 34% of the population (Rogers, 1995). This segment is characterized by the group of people who follow the lead of the early adopters and the first to utilize mass advertising as a major information source (Rogers, 1995).

After the product has experienced growth, it then enters the maturity phase of the product life cycle. At this time the late majority of customers will begin to purchase the new technology or product. The late majority is estimated to be roughly 34% of the population according to the diffusion of innovations. In the growth phase, the product's prices are stable and the companies that remain are experiencing higher profits than the previous phases. The transition from the growth phase to maturity elicits a multitude of challenges to the industry. Consolidation will occur to a certain degree as companies cannot adapt to the changing market environment (Golder & Tellis, 2003).

Once the market is saturated the decline phase begins. At this time the laggards will consider purchasing the product but are more conservative and resistant to change. The advertising will be limited and most efforts in the industry will be towards reducing costs and increasing technical support on previously sold products. Companies will have to decide on outsourcing in the industry or leave the market entirely.

CHAPTER III

PHOTOVOLTAIC SUPPLY CHAIN EVOLUTION

As the market continues to grow across the United States, market players are positioning themselves to manage the pace of growth and expand into the market. Using the product life cycle and diffusions of innovation theory, this study will outline the evolution of the photovoltaic downstream supply chain and its changes as the market progresses into the future. The supply chain's evolution can be defined into First, Second, and Third Generation. These generations depict different times for the solar industry and the strategies that companies put forth to reach the market. As the industry goes through its life cycle, the nature of the competition will shift (Porter, 1980). The photovoltaic supply chain evolution can be characterized with the product life cycle as in Figure 7.

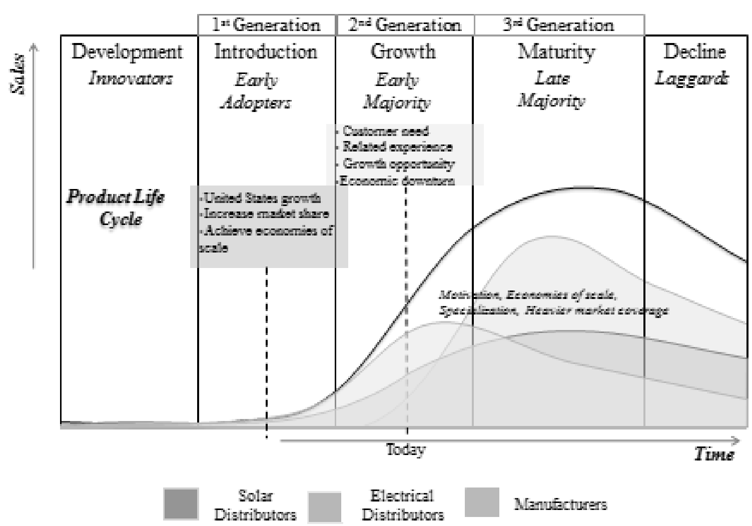

Fig 7: Photovoltaic Product Life Cycle and Distribution Channels

First generation supply chain

The PV market when it first began to emerge in the United States was unorganized, and the few players worked mostly regional and off the grid. PV was not held high in public sentiment because of the high product and installation cost, and there were only a few states where there was any growth (Shah, 2009). This time period up to the early part of the millennium is defined as the ‘First Generation’.

The players included manufacturers, local EPC firms, and solar niche contractors. In the first generation, manufacturers were new to the market and as a result had to go direct to the end customer using an internal project development arm to increase market share (Frantzis, Graham, Katofsky, & Sawyer, 2008). This gave the manufacturers the proximity to understand the needs of the customer. Regional and local EPC firms were prominent but still very few were prepared for the new specialization. They would procure products from the manufacturer and reach a very small installed base in the residential and commercial segments. As the market began to expand, solar specific contractors emerged to address the growing installations and reach an array of customer segments due to the extension of federal incentives and decrease of component pricing (Blakely & Smith, 1981). They partnered with EPC firms and manufacturers in reaching the end customer who couldn’t undertake the growing task themselves. Figure 8 illustrates the First Generation supply chain.

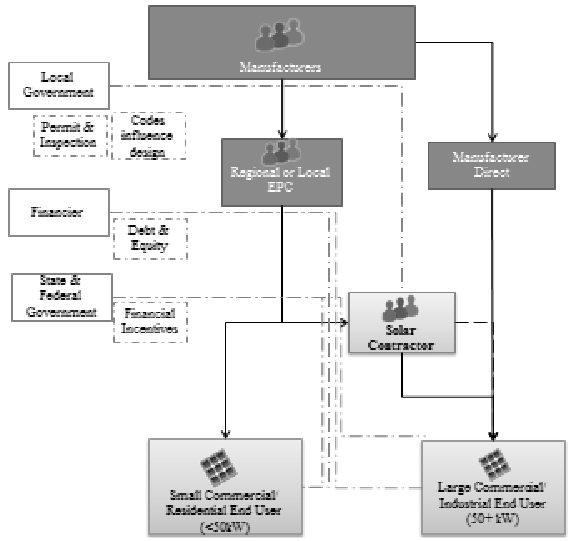

Fig 8: First Generation Supply Chain

Second generation supply chain

The market has become an emerging industry with characteristics such as strategic uncertainty, high initial costs but steep cost reduction, first-time buyers, as well as being subsidy driven (Porter, 1980). As the contractor base and market expanded, there arose a need for structured distribution. Many contractors were electricians who were familiar with distributors and wanted the support that distribution had to offer. Regional solar distributors began to emerge and supply these contractors with product inventory and competitive pricing. This period is referred to as the ‘Second Generation’. Regional specialized solar distributors began to grow and merge with one another and, in parallel, the local EPC firms began to merge with contractors and become regional integrators. This first stage of the Second Generation is modeled below in Figure 9.

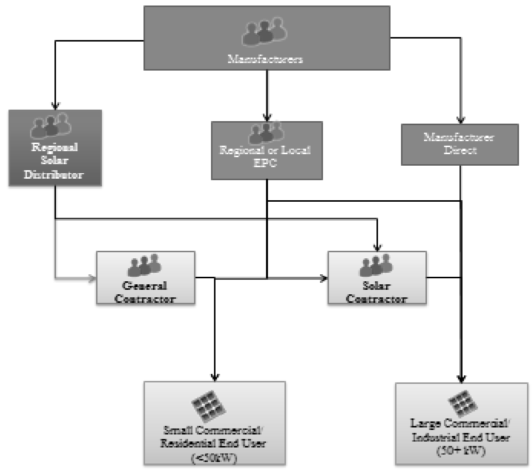

Fig 9: First Stage of Second Generation Supply Chain

Due to the expansion of general and electrical contractors in the market, and a few motivated by the slow-down of the economy, large electrical distributors began to move into the solar market during the later phase of the second generation. The electrical distributor has synergy with the electrical market and also has the financial strength to compete with solar niche distributors.

Presently, the solar market is considered by many to be ‘the wild west’. Manufacturers, integrators, and contractors are all competing to reach the end customer segments with very little channel discipline. Electrical distributors, the new-comers in the industry with little limited expertise in the solar market have grabbed a sizable share of the market in competition with the niche distributors. This fragmentation as it pertains to the supply chain includes low overall entry barriers, erratic sales fluctuations, little to no advantages of size in dealing with suppliers, diverse market needs, and newness. In addition, given the abundance of off-shore players seeking a part of the growing market and the high degree of price fluctuation, an industry wide shake-up is imminent. We have already seen instances of this with the closure of multiple manufacturing facilities across the United States. These closures may build a negative perception of photovoltaic energy. However, these incidents may be mainly due to the growing pains of any new and emerging industry and will eventually benefit the market in the long run. We see this market as a prime opportunity for electrical distributors to play a prominent role in growing the industry. A model illustrating the current supply chain is presented below in Figure 10.

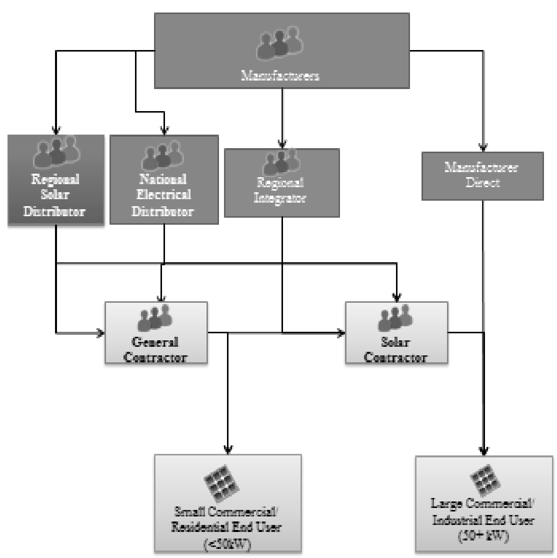

Fig 10: Second Generation Supply Chain (Current)

Discontinuation of Feed-in-Tariff (FIT) programs in Europe and large subsidies to promote PV production in China has created an oversupply of panels in the market. It is currently estimated that about 450 worldwide PV manufacturers exist; 400 of which are from China. With this oversupply of off-shore panels, prices have been driven to record lows, which in turn, have put pressure on manufacturer and distributor margins. Consolidation of the players has begun to occur as the market inches towards maturity. This has put a degree of doubt into many companies pertaining to the success of the industry as a whole. However, the electrical distributors are positioned to help manufacturers achieve economies of scale and also provide some insight into forecasting the market through their partnership.

If a tariff is imposed on Chinese PV manufacturers to protect the American module manufacturers as indicated in recent news events, it would bring dramatic changes once again. This tariff has the potential to stabilize the market price and allow for competition based on value added services as opposed to price alone. On the other hand, raising the price of an already higher cost product may turn away some potential consumers. In a turbulent economy, consumers are constantly hunting for lower prices in order to decrease total spend but this approach may not be sustainable for the longevity of the PV industry. The idea of waiting on the sidelines for the next wave of cheaper panels may have hurt some of the businesses operating in this concept, but distributors can use their value service offerings to offset this impact in the long run.

The incentives and regulations, which help drive the industry, deviate from state to state at municipal and local levels making it hard to calculate the return on investment for consumers (Barbose, Dargouth, & Wiser, 2011). There is a large degree of uncertainty as to which state markets will flourish, especially if the funding is weakened at various levels. On the other hand, a government incentive such as the federal investment tax credit of 30% has proven beneficial to the PV market and isn't set to expire until 2016. However, the Treasury Grant 1603 program in lieu of the tax credit is set to expire at the end of this year. The possible discontinuance of these incentives boasts new challenges to the market that many will have to face. Installers and distributors will have to acquire or form new types of financing and offer various forms of credit terms to foster growth in certain areas.

Third generation supply chain

As the market reaches a level of maturity, consolidation of the players will likely begin to occur due to high mobility barriers (Porter, 1980). Firms that saw early growth but are unable to adapt to market conditions will collapse or be acquired by larger firms. The installation base will have grown so vast that manufacturers going direct to the end customer will not be able to keep up with changing logistical and other distribution needs. The manufacturer will be forced to follow a more traditional approach and partner with distributors to increase volume and manage logistics across the United States. As this occurs, the price levels will begin to stabilize as the supply of modules begin to equal the demand. Vendor selection begins to emerge as a major issue for the distributors due to the thinning of the market place. Firms will have to have a qualified and long-lasting relationship to be able to stay in the market. This transition to a consolidated market forms the emergence of the ‘Third Generation’. This supply chain is depicted below in Figure 11.

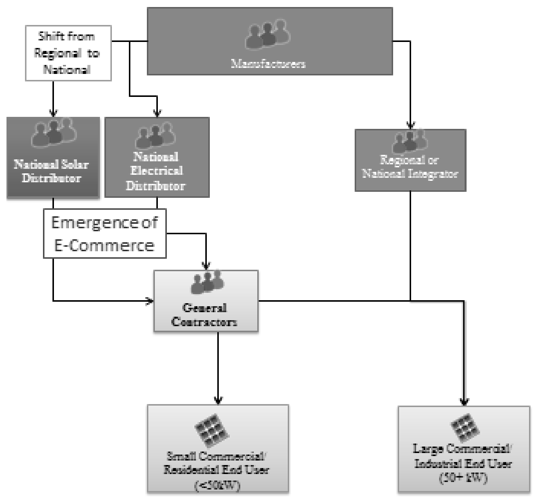

Fig 11: Third Generation Supply Chain

When the market reaches full maturity, there will only be a few players left to reap the benefits. Rather than the market being driven by incentives and tax credits, it will be driven by service offerings and financing models that firms put forth (Porter, 1980). The local contractors with the most expertise and intimate services will be prominent in the residential and small commercial segments while the integrators will pursue the larger scale projects such as utility and industrial scale applications. The solar niche distributors will be acquired by one another or by traditional electrical distributors to form national distribution networks that will better serve the customer base. EPC firms or integrators may still handle utility scale projects (depending on the location and many other externalities).

Since the state markets are so diverse and fragmented, it will take longer for some states to mature than others. The states that adopted solar the earliest, such as California and New Jersey, will reach maturity far sooner than states lacking the incentive and regulatory base. The state's market potential analysis will be discussed further in the study.

Market strategies as supply chain evolves

Almost every player in the supply chain is going to face a multitude of obstacles to stay in the market and must be able to best position themselves for longevity in the supply chain. Formulation of the strategy in emerging industries must be able to deal with the uncertainty and risk during this period of the industry's development. Companies in the photovoltaic supply chain have taken on many forms of integration to increase their market share (Maslin, 2008). The industry will have to standardize diverse market needs. This approach will succeed in the short term. However, in the long term this strategy will probably have to be refined. Some ways to cope with the industry fragmentation as discussed below include increasing the value added and specializing by customer types or by geographic areas (Porter, 1980). Porter also suggests such strategies as shaping the industry structure, changing the role of suppliers and channels, and shifting the mobility barrier to compete in an emerging industry.

Manufacturers should focus on achieving economies of scale with the best design practices and a establishing a known brand name. Many of these manufacturers are of European or Chinese origin and will need to be able to account for the industry structure and variability of the market from state to state and region to region. As the market matures, manufacturers should consider utilizing electrical distribution channels to reach the residential and commercial customer segments. Electrical distributors have synergy in these customer segments and already have relationships with electricians needed to sustain growth of the niche business. This method has been utilized through recent partnerships by multiple companies seen in industry headlines. This approach can increase volume for the manufacturer while also allowing the firm to better logistically serve the market from coast to coast. The industry partnerships that follow could also foster marketing opportunities that can further push solar energy into the mainstream.

National distributors with a local presence and expertise will have to choose between either forming partnerships with niche players or expanding their service offering internally. Distributors should seek a more intimate design approach and offer training courses in an attempt to become the installer’s knowledge source in the solar field. Many forms of innovative financing will come from the distributors in order to expand their customer base. Electrical distributors will need to be able to make complex proposals that bundle energy efficient products with solar products to offer a holistic energy service solution (Yudelson, 2009). This approach will help the installer provide the end customer with the greatest energy reduction. The largest distributors may be able to take on an integrator role for the large scale projects and oversee the process from design and procurement to financing then installation.

Regional distributors are feasibly positioned to serve markets that have not matured. They can offer the pricing and credit terms that contractors seek from distributors in order to foster growth. The norm for the regional distributors will reasonably remain in the smaller scale installs. If the incentive or regulatory base gives for an expansion in these markets, these distributors will probably be required to form alliances with national players or even pushed out by the financially stronger firms with better pricing.

Solar contractors will most likely have to move out of the niche and attempt to offer a total sustainability package for the end customer. Contractors with a vast portfolio of projects and valuable partnerships will be able to prosper in almost any market, regardless of its maturity. Integrators may only be prominent in niche areas across the United States. These firms may be required only on the largest scale projects in a mature market. They will most likely have to compete directly with the integrated distributors or be forced to form a partnership to keep their market share.

There is going to be an extent of difficulty in managing the change within the industry as different state markets begin to emerge and mature over time in the United States. Firms need to be agile in positioning themselves acquire a niche and competitive advantage in the industry. Though the market appears to go direct, it seems to be moving towards a traditional distribution focused supply chain.

CHAPTER IV

STATE MARKET ANALYSIS

As mentioned earlier, the adoption of solar energy hinges on many key drivers. Some of these drivers drive down the cost of solar electricity which in turn increases the return on investment for potential customers. Many state and local governments have enacted regulations and monetary incentives to spur the solar market in their respective region (Rogers, 1995). The federal government has enacted an investment tax credit of thirty percent towards photovoltaic energy as well as grant program in lieu of the tax credit which helps customers by giving them the capital up front (Bernier & Hunt, 2011). This has helped spur the market in the United States but would not be as successful if not for the help of state regulations. Several such technological products have relied on government support for its success.

The drivers that are assessed in this study include both monetary incentives and state regulations for each area. The monetary incentives include dollar per watt rebates, tax credits, and loan programs. These incentives can either be through a state funded program or through a regional utility that supports PV energy. The regulations that states put forth to adopt solar energy include renewable portfolio standards (RPS), the availability of net metering, and the availability of unique financing options such as a power purchase agreement (PPA) or property assessed clean energy (PACE).

The installed cost of a photovoltaic system has declined dramatically in the recent years (Barbose, Darghouth, & Wiser, 2011). Components of the PV system include the solar panel (module), inverter, mounting, and the wires or balance of system components. Recently the module prices have experienced a dramatic decline due to an oversupply in the U.S. industry and decreased demand due to decreased incentives from European countries such as Spain and Germany (Kim & Hari, 2011).

This study will attempt to quantify the key drivers that states have enacted and assess their potential as these drivers are presented to market. The rankings will be presented on a one to four scale. A grade of four indicates the highest potential for a solar market while a grade of one indicates the worst potential for a solar market. Through this process, it will become clearer which states are pursuing photovoltaic energy as the early adopters, early majority, late majority or laggards. The ranking and relative criteria are illustrated below in Table 2.

Table 2: State Ranking Description

Score	Relative Ranking of Applicable States	Description	Current Status
4	Top 30%	Early Adopters	Leading Market
3	41-70%	Early Majority	Emerging Market
2	21-40%	Late Majority	Lagging Market
1	Bottom 20%	Laggards	Little to No Market

Monetary incentives

Monetary incentives include rebates, performance-based payments, tax credits, and loan programs. Some of these incentives are available through a state program but the vast majority is available through utility and local programs. The electricity rate that customers are already paying has also been identified as a key driver to the adoption of photovoltaic energy. This study will quantify the incentive amounts and average them against the average installation cost and size for each type of system in order to identify the actual savings towards each type of system. The average and size and cost are defined below in Table 3.

Table 3: Average Installation Size and Cost by Customer Segment (Shiao, 2010)

Customer Segment	Average Size	Average Cost
Residential	5 kW	$33,000
Lite Commercial	25 kW	$142,500
Large Commercial or Industrial	75 kW	$427,500

A rebate, as it pertains to the photovoltaic industry, is an up-front payment administered by the state or a utility in a dollar per watt installed scale (Barbose, Darghouth, & Wiser, 2011). In order to quantify the rebates in a holistic approach, the study attempts to identify the source of the rebate, the applicable customer segments, the dollar amount, the amount of funding required, and the expiration date. Table 4 is a sample table used for an Arizona rebate program. Please note that not all of the rebates are depicted in this table.

Table 4: Sample State Rebate Table

State	Level	Name	Sectors	Size	Amount ($/W)	Max	Expires
AZ	Utility	APS Incentive Program	Residential (On-Grid)		$1/W	50% of cost or $75,0000	Yearly allocation
			Residential (Off-Grid)		$2/W		
			Commercial (On-Grid)	<30kW	$1.75/W	50% of cost or $75,0000	
				>30kW			
			Commercial (Off-Grid)		$1.35/W		

The savings from each rebate program are then averaged together to give the state a final dollar amount which are used to give the state a grade to be used for further analysis. There is a degree of error in the state calculations due to the differing number of utilities offering the rebates as well as the amount of funding used in each rebate program. Table 5 below depicts the states with the top 10 rebate programs as they pertain to each customer segment.

Table 5: Top 10 Rebate Packages by Customer Segment

Residential	Small Commercial	Large Commercial	Residential	Small Commercial	Large Commercial
Michigan	Nevada	Nevada	Minnesota	New York	Florida
Florida	Florida	New York	New York	Illinois	Texas
Nevada	Minnesota	Arizona	Arizona	Arizona	Oregon
California	Mississippi	California	Mississippi	Texas	Mississippi
Texas	California	New Hampshire	Delaware	New Hampshire	Illinois

A tax credit can be given in various forms. The most common credits given to the photovoltaic market pertain to either the overall cost of the installation, the sales tax, or the property tax (Vanega, 2011). These credits are usually peaked at certain percentage of cost and help foster the adoption to the most tax savvy of customers who use the tax break (Molavi, 2011). Table 6 depicts the rankings of each state as it pertains to the type of credit and the customer segment is shown below.

Table 6: Top 10 State Tax Credit Programs

Residential Tax Credit	Commercial Tax Credit	Sales Tax Credit	Property Tax Credit
Louisiana	Oregon	Arizona	Colorado
Idaho	Montana	Colorado	New York
Georgia	Hawaii	Idaho	Massachusetts
Hawaii	North Carolina	Florida	Minnesota
North Carolina	Vermont	New York	Maryland
West Virginia	South Carolina	Massachusetts	Connecticut
New York	Arizona	Minnesota	Iowa
South Carolina	Utah	Kentucky	Nevada
Arizona	New Mexico	Maryland	Michigan
Utah	Texas	Connecticut	Oregon

The loan programs that states offer vary in a multitude of ways. A loan is based on the amount applicable towards each customer segment, the amount of funding the program requires, interest rates charged and time it takes to pay back the loan. Table 7 depicts the states with the largest amount of funding and the most efficient payback times that help increase the return on investment for various customers.

Table 7: Top 10 State Loan Programs

Residential Loan	Commercial Loan	Residential Loan	Commercial Loan
Hawaii	Illinois	South Carolina	Arkansas
Nebraska	Texas	Washington	Hawaii
Oregon	Pennsylvania	California	Delaware
Ohio	Tennessee	Texas	Iowa
Connecticut	Michigan	Kansas	Missouri

A performance-based incentive (PBI) is a dollar per kilowatt-hour (kWh) payment based on the amount of energy the photovoltaic system generates in a given time period (Hunter, 2011). These are usually administered by a utility and help the consumer directly save on their energy bill. Table 8 depicts the top ten PBI amounts below.

Table 8: Top 10 Performance Based Incentives

Performance Based Incentive	
New Jersey	Michigan
Iowa	California
DC	Maryland
Oregon	Delaware
Ohio	Alaska

Regulatory incentives

Regulatory incentives include mandates and standards that states enact to ensure the adoption of photovoltaic energy. These include renewable portfolio standards, renewable energy credit markets, the availability of finance programs, and the availability of net metering.

A PPA is a hybrid form of finance that has emerged recently for the solar industry. What a PPA allows the customer to do is achieve immediate savings on their electricity bill by paying for the solar energy produced as opposed to the solar products themselves (Frantzis, Graham, Katofsky, & Sawyer, 2008). The installer, in turn, will own the photovoltaic system which allows them to receive the incentives and act as a solar energy provider to the customer. These agreements will vary in length but have still proven to be a key component in reducing the up-front cost of photovoltaic energy. PACE is a form of financing that is enacted through local and municipal levels. The customer will not have to pay for the solar components themselves but instead will have to pay an increase in property taxes for the home (Hunter, 2011). Currently, 19 states allow a form of PPA while 25 states have allowed PACE financing (Vanega, 2011).

RPS standard is a goal that a state puts forth to ensure a certain amount of energy to be produced by renewable sources (Maslin, 2008). Some states have also carved a solar niche out of the RPS and have required of percentage to be used specifically from photovoltaic energy (Hunter, 2011). A fraction of these states have enacted a Renewable Energy Credit (REC) market (Hunter, 2011). These states use renewable energy credits to symbolize ownership of energy being produced by renewable sources and are used to count towards a state's renewable portfolio standard. These RECs are traded and sold in an open market to further incentivize the adoption of solar energy. Currently, 36 states have enacted a renewable portfolio standard (Vanega, 2011). The most aggressive of these include California and Hawaii with 33% and 40% requirements for renewable energy. There are 21 states which have solar specific renewable portfolio standards, of these 21, only 13 states have available REC markets (Vanega, 2011). Table 9 depicts these states.

Table 9: States with REC Markets

	REC Market	
Pennsylvania	New Jersey	Kentucky
DC	West Virginia	Massachusetts
Delaware	Michigan	Indiana
Maryland	Illinois	
Ohio	Virginia	

Final ranking

Using the quantified monetary incentives as well as the regulations that each state has put forth, this study uses a grading scale in order to depict which states are the early adopters of photovoltaic energy and which states are the laggards in the market.

Criteria used to calculate the market analysis that was not a driver discussed earlier include the historical installation data for each state. The purpose of this is to take into the account the historical market of the state and the adoption of renewable energy. Table 10 depicts the amount of weight given to each driver as they are applied to score.

Table 10: State Market Ranking Methodology

Criteria	**Weight**	**Driver**	**Score**
MW Capacity	23	2010	10
		Cumulative	13
Federal Funding	2		
State Regulations	20	RPS	4
		Solar RPS	5
		MW 2015	2
		Net Meter	4
		PACE	1
		PPA	4
State Incentives	50	Electricity Price (cents/kWh)	5
		Rebate: Residential (5 kW)	5
		Rebate: Small Commercial (25 kW)	5
		Rebate: Large Commercial (75 kW)	5
		Performance - Based Payment (cents/kWh)	5
		Tax Credit Residential	3
		Tax Credit Commercial	4
		Loan: Residential	3
		Loan: Commercial	4
		SREC Market	5
		Sales Tax Exemption	3
		Property Tax Exemption	3

As discussed earlier, the states receive a grade of 1-4 depending on their relative effectiveness and incentive amount as compared to other states. The final rankings for the states' current markets are shown below in Table 11.

Table 11: Final State Market Classification

Leading	Emerging	Lagging	Little Market
New York	Florida	Iowa	West Virginia
Arizona	Connecticut	Maine	Missouri
Massachusetts	Michigan	Tennessee	Kentucky
California	Hawaii	Georgia	Arkansas
Nevada	North Carolina	Rhode Island	Nebraska
Oregon	Minnesota	Alaska	South Dakota
Texas	Utah	Indiana	Wyoming
Delaware	Ohio	Idaho	Oklahoma
Illinois	New Hampshire	Kansas	North Dakota
Maryland	New Mexico	Montana	Alabama
Pennsylvania	Washington	Louisiana	
New Jersey	Mississippi		
Colorado	Wisconsin		
DC	Virginia		
Vermont	South Carolina		

CHAPTER V

SUMMARY AND CONCLUSIONS

In recent years, the photovoltaic industry has shown substantial growth in comparison to other sectors in the United States. This growth opportunity has spawned a multitude of firms to enter the market searching a new stream of revenue. These firms have various to-go market strategies that as discussed in the study. The current supply chain is defined as the Second Generation of growth as it pertains to the product life cycle. Once the market matures and solar has become a commodity, the industry will then move into the Third Generation supply chain. Since the state markets are so fragmented and diverse, this supply chain will emerge in the leading markets first and spread as the remaining states reach maturity. An understanding of the demands as driven by the end user and its impact to the roles of the downstream members is important.

The solar market is driven by many key drivers such as monetary and regulatory incentives, electricity prices, and the availability of innovative finance methods. This study quantified these drivers to determine which states have the most mature and thriving markets. Such calculations enhance decision making for businesses to estimate growth in a market driven by incentives and subside as the product matures.

The growth of solar as well as other renewable technologies has been positive in the United States as a whole. The issues that the industry faces today are uncertainty of key incentives and the dwindling amount of capital available to invest in photovoltaic components. These problems give an uncertain long-term outlook on the photovoltaic market, but for the short term this industry has been proven as a growth engine. Downstream members have to be equipped during this uncertainty.

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