The International Photovoltaics Industry: An Analysis of Multinational Firm Marketing Strategies.

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ABSTRACT

The photovoltaic energy markets around the world have progressed unevenly, primarily as a result of industry-specific externalities regarding political, environmental, and economic market factors. Photovoltaic technologies present solutions that address the concerns about pollution and long-term energy security attributed to contemporary electrical generation methods. To date, photovoltaic technologies have not met the levels of anticipated electricity contribution on an international basis, even though awareness of global warming and demand for electricity both continue to rise.

The purpose of this study was to identify, prioritize and ultimately present potential market factors multinational firms may utilize as part of a focused marketing strategy to increase implementation of photovoltaic technologies. Most marketing strategies of photovoltaic technologies predominantly emphasize the benefits that impact large groups or a nation but often do not clearly provide motivations for the individual as a consumer. Current technology within the photovoltaic industry provides a wide variety of potential benefits such as the reduction of carbon dioxide emissions; however, emphasizing these benefits may not be the most successful marketing strategy. Appealing to group benefits may have been appropriate for early adopters. However, to penetrate larger, second generation consumers, a different marketing strategy is suggested. This research suggests that the most effective market stimuli for the photovoltaic industry are the various forms of financial incentives that most directly benefit the individual consumer. It is concluded that marketing strategies need to focus more on the benefits to the individual rather than the broader national or societal

benefits. While benefits that focus on public good are important, this research finds that marketing strategies should focus more private good benefits such as financial incentives.

The modern consumers of the 21st century live in an age of competing choices. Marketing is the mechanism used to "keep the means of production-our products and services-in touch with our evolving social and personal conditions" (Moore, p27. 2002). Few current issues of the global economy are as dynamic as that of energy. Currently, one of the most emotionally charged perspectives of energy is renewable energy, with all its potential implications for the global economy and environment. The potentials of renewable energy are both exciting and intimidating at the same time. This research sought to evaluate one of the most promising segments of renewable energy, photovoltaics, and evaluated some political, financial and environmental factors in order to better shape multinational marketing strategies.

Energy markets around the world have begun to re-examine the costs and benefits attributed to conventional electrical energy production methods by broadening considerations that reflect both environmental and security issues. As demand for electricity soars, so do levels of pollution and the perceived supply volatility associated with conventional fuels. The subsequent ripple effects on the conventional electrical generation markets have influenced the growth of photovoltaics as a viable substitute in many major markets around the world (Bradford 2006). Solar energy has been identified as a renewable energy alternative that may be able to contribute up to 30% of the world's electrical demands by the year 2030 (IEA 2005). Unfortunately, after more than two decades of technical progress and increased investments that have reduced the cost to produce solar modules, the adoption of photovoltaic technologies remains highly scattered, with only a few international markets realizing significant installed capacity.

Renewable energy in general, and photovoltaics in particular, provide a unique set of benefits such as scalability, a stable technology platform, and the ability to provide a fixed cost to a major energy source. Consumers seeking to invest in alternative sources of energy will each have individual reasons for adopting solar as an energy source. Multinational manufacturing firms in this sector have attempted to identify what factors most significantly influence potential customers considering investing in solar energy. The challenge occurs when the unique set of benefits solar energy provides are compared with the established benefits of conventional electrical energy products. Too often, photovoltaic manufacturers appeal to benefits that are not focused upon the individual consumer but rather on broader national benefits such as the reduction of pollution levels. This study examined a group of market factors and concluded that current marketing strategies are not well focused to maximize increased future photovoltaic sales. Of the factors measured, financial incentives resulted as the most consistent factor for increasing installed capacity of photovoltaic services within the analyzed countries. The factor of price for commercial electricity did have notable exceptions when analyzed by country. Levels of carbon dioxide were determined to be secondary to financial incentives as a potential marketing factor, concluding that incentives should play a prominent role in the marketing strategies of multinational photovoltaic manufacturing firms.

Introduction of the Problem

Fossil fuel energies such as petroleum derivatives, natural gas and coal have propelled the global economy to new heights, changing how the world produces and moves goods and services for the past two hundred years (Black 2006). However, these traditional forms of energy face growing concerns regarding the availability of long term supplies, potential impacts on national security, and the impact of environmental pollution. These concerns combined have contributed to the accelerated interest in developing alternative forms of renewable energy such as wind, solar and hydro power. From these alternatives, solar energy, created by the use of photovoltaics, has been positioned as an alternative for producing electricity that represents a solution that directly addresses the concerns related to conventional electrical generation techniques. To date, however, the international levels of adoption for photovoltaic technologies have been inconsistent, with only a few key nations demonstrating a high level of commitment to the technology (Bradford 2006, Bubenezar 2003).

Multinational firms competing in the photovoltaic industry currently rely upon a broad set of messages in their marketing campaigns. The potential benefits presented include (the reduction of carbon dioxide, stability of the price of electricity as a hedging tool, reduced burning of carbon based fuels, energy security, unlimited access to the sun, utilization of a safe technology) and the potential of financial incentives. The blending of such diverse potential benefits may leave a potential consumer confused about why to purchase photovoltaics and therefore diminish the number of installations.

After considering the list of presented product benefits, the marketing message of the photovoltaics industry can be separated into two different marketing categories, public investment benefits and private investment benefits. The discussion of public and private goods is well established (Samuelson, 1954, et al) and is relevant to the marketing of renewable energy technologies as existing literature frequently focus upon benefits beyond traditional individual marketing strategies. Global warming, and the related topic of reduction of greenhouse gases, is a classic example of marketing initiatives that address a public good. This research classifies a public investment benefit as one that is equally shared by all members of a given community equally regardless of choice to participate in a specific behavior. A private benefit is one that is only enjoyed by those that actively choose a specific behavior and the benefits are not shared with others in the community. As the marketing of photovoltaics equipment often attempts to combine the two perspectives, it may be suggested that the decision process for prospective customers is unnecessarily complex and can be more focused to promote future growth of the industry.

Photovoltaic equipment manufacturers often focus marketing messages that identify environmental benefits such as the reduction of carbon dioxide levels (Farhar, Houston 2000, Day 2002). There may be additional market factors photovoltaic equipment manufacturers need to consider as potential barriers of future adoption of photovoltaic technologies. Travis Bradford, of the Prometheus Institute in Boston Massachusetts, suggests that the largest challenge to the photovoltaic industry is the high upfront investment cost of photovoltaic equipment, which can often be in the tens of thousands of dollars even for residential customers (Bradford, NOREL et al.). While many potential investors do value being environmentally conscious (Farhar, Houston 2000), the financial commitment necessary to implement a photovoltaic system cannot often currently be justified economically. This leaves the photovoltaic manufacturing firms in an unconventional position of representing a product that benefits those that purchase the equipment and those who do not with equal levels of the same benefit. Many of the multinational manufacturing firms in the photovoltaic industry focus on the public good benefits (Cowen, Tyler & Littlefield 2007) but do little to individually justify the personal investment in this form of technology.

The majority of firms competing in the photovoltaic industry have experienced constrictions of raw material used in manufacturing processes (Bradford, 2006). Silicon and other silicon derivatives are currently the primary raw materials used in manufacturing solar panels. This has resulted in an increase in competition for raw materials with the electronics industry that also source significant quantities of silicon for manufacturing (Bradford 2006). The technology used in photovoltaic electrical generation is stable and reliable and has not been considered a barrier to increased adoption of the technology. However, adequate levels of production of photovoltaic modules have been an issue for the industry because current manufacturing capacities have not been able to keep pace with demand throughout the past five years. In addition, production levels have yet to achieve full potential economies of scale, which will further contribute to a more competitive price per kilowatt of generated kilowatt in relation to current conventional generation methods. Even with this limitation, the price per kilowatt generated using photovoltaic technologies for residential, commercial and industrial applications has consistently fallen over the last ten years (Bradford 2006). Lower prices have also allowed photovoltaic energy to become more competitive as an alternative to commercial electricity in some markets when combined with other market factors. Increased competition with the electronics industry for raw silicon has resulted in rising costs of silicon that has slowed the continued price reductions and delayed shipments of photovoltaic modules. This strain on the supply chain has impacted most of the major manufacturers of photovoltaic modules, reducing their competitive ability. The pending increase in the supply of raw materials is projected to reduce costs of photovoltaic panels and the subsequent cost per kilowatt of energy produced even further (Bradford 2006). At that point in time, marketing strategies will need to play a larger role in educating consumers about the individual benefits of solar energy that will simultaneously benefit all by providing a public good. A reshaping of the marketing strategies of international firms may present both public and private benefits more effectively to better position photovoltaics as a viable, mainstream energy alternative.

The installation of photovoltaic equipment in the major solar energy markets around the world is critical to the success of the photovoltaic market. The installation of photovoltaic equipment is a local function, requiring an understanding of regional environmental, zoning or other regulatory guidelines for installation compliances. To date, no manufacturer of photovoltaic equipment has the consistent, local installation capabilities necessary to support even the major markets around the world. This service element has been addressed by hundreds of independent, local installers in each nation to assist the customer in the installation or modification of their existing electrical infrastructure. The independent installers are positioned to have significant influence on a prospective customer of solar equipment; however, the manufacturing firms currently have little or no permanent relationships with these firms, which instead serve as independent agents for a variety of solar equipment manufacturers.

Background of Study

In the discipline of international marketing, scholars have presented a myriad of perspectives as to how to approach the introduction of a new product or service into varied international markets. It can be argued that no two markets are exactly the same and that each nation possesses a matrix of unique considerations, suggesting that each product requires a tailored marketing strategy for each nation. In addition, each market may not be defined by established national boundary lines (Ohmae 1989), but grouped by other cultural, political or industrial similarities. Energy is one of only a few broadly common threads all nations share in economic activities around the world (See Appendix A: Figure 13). Electricity as an energy form is a vital component in the production of goods or services in nations, ranging from the most fully developed to nations still classified as emerging markets (Chart 1 in Appendix A depicts historical and projected net electrical consumption by region.) Electricity is present in almost every nation around the world; however, the forms of generation and levels of demand are different and changing all the time. Electrical energy can no longer be classified as a single isolated industry, but instead as many industries tied to the many facets of a nation's political, cultural and industrial activities (IEA 2005). The combination of these external influences has contributed to the renewed international dialog as to how nations view electrical energy generation alternatives. To date, each nation has responded to the varied dynamics of the renewable energy marketplace differently as a result of varied cultural, political, and financial priorities.

One aspect of the renewable energy industry that has not received significant debate relates to the classification of renewable energy as either a public or private good. Some scholars have debated whether energy in general should be considered a public good or a private good. A private good is defined as a good that is both "rivalrous and excludable regardless of price" (Rowman & Littlefied, 2007). Pure public goods are the opposite and by nature are not exclusive; an example would be clean air or water. The 20th Century suggests that energy may have attributes of both as supported by the parameters developed in The Rural Electrification Act of 1936. In the years following the Rural Electrification Act, the role of energy became the subject of a debate among economists. Mancur Olsen, 1965) saw energy as possessing characteristics of both definitions. Political leadership in the United States and Europe discussed the role of government as it pertains to monitoring or controlling pollution levels, suggesting that the energy industry is a public good. If increased government environmental regulation materializes, it will be difficult for governments to implement corrective legislation, because as doing so might alter expectations of existing investors who own the sunk cost investment of incumbent suppliers. If the energy industry is classified as a public good rather than a private good, financial expectations of investors within the energy sector will potentially be altered. While pollution is an obvious bi-product of energy consumption, it may be necessary at some point for governments to pursue increased authority to regulate pollution levels within a given nation to maintain group benefits for the entire country. The United States Supreme Court in May of 2007 decided that in fact the

Environmental Protection Agency, as a department of the US government, is responsible for providing clean air and water as part of its charter to the citizens of the United States.

The strongest examples of entities that have moved the debate from theoretical to actual application include Germany, Japan and the states of California and New Jersey in the United States (Chart 2 in Appendix A depicts cumulative installed photovoltaic capacity over the last ten years). Germany is the largest photovoltaic market in the world primarily due to a significant governmental effort to encourage customers to take an active role in their own energy production (Appendix A: Figure). Political and be economic policies have resulted in financial commitments to renewable energies that have achieved measurable benefits to all citizens of Germany (IEA 2006). The success of renewable energy is often predicated upon a more active involvement of individuals, corporations or institutions than current forms of energy. Renewable energy consumers take on the added responsibility of sizing, installing and maintaining location level equipment that is not required in traditional commercial power alternatives. Renewable energy can therefore be interpreted as a reversal of the dependency upon a central or commercial energy source reverting back to a more location level solution to specific energy demands. This behavioral change is the crux of the problems of marketing photovoltaic technologies, and is the primary focus of this research.

Statement of the Problem

For the international photovoltaic industry to evolve from isolated geographic areas of economic success to a more mainstream energy alternative, a comprehensive understanding of the market must be developed. Solar energy can be classified as a lower-end disruptive technology (Christensen 2000) that requires substantial awareness on the part of both the potential individual investors and the political leaders within a given market. While there are examples of nation-specific case studies, there is little research that looks at the entire international photovoltaic market to determine what has been successful, and what has not, that can then be incorporated into the marketing strategies of photovoltaic manufacturers.

Purpose of the Study

The purpose of this study was to incorporate data from multiple nations, ranging from developed to developing nations, in an attempt to measure and prioritize actual market drivers as measured by installed photovoltaic capacities. It is the opinion of the researcher that current marketing strategies of the major photovoltaic manufacturing firms are too broad and lack focus on the motivations of the individual investor. The most frequently used benefits used in promoting solar energy are difficult to measure at the individual investor level. While it is not suggested in this research that stated public good benefits are not important, this study will show they need to be repositioned. The potential to identify and develop a new set of marketing strategies from the perspective of the individual may be beneficial as the industry attempts to attract new commercial and residential users. The possibility that two distinct markets for photovoltaic products may exist, one with financial incentives to invest and a second market where there are no financial incentives. The results of the study are intended to assist firms in assessing what factors are to be emphasized in varied market environments.

Research Questions

Hypotheses (Group One):

How does price of utility-provided electricity influence potential photovoltaic customers?

It is hypothesized that, in comparison to nations with low prices of utility-provided electricity, nations with high prices of utility-provided electricity would be less resistant to photovoltaic technologies, resulting in higher levels of installed capacity for photovoltaic technologies.

There are numerous potential factors that influence the final cost of a delivered kilowatt of commercial electricity. This hypothesis attempts to measure photovoltaics as a possible substitute in those markets where commercial electric rates are comparatively high. If price of commercial electricity was identified as a potential market factor, firms may adjust their marketing strategies accordingly to position the relevant photovoltaic advantages. Many nations such as Sweden and portions of the US have offered electricity that is branded "green" as it is generated by renewable energy production methods. Green alternatives are not widespread and are not available in all countries or in all markets. Where these programs have been introduced, electricity is often sold at a premium price ranging from 10% to as high as 33% above the price for a "brown" kilowatt of electricity. Clearly, the premium price of green electricity has a potential impact on a given market as the success of these programs is mixed. These conclusions suggest additional future research is necessary to identify how the pricing of solar energy output can be designed most effectively. In some regions of the United States during the 1990's, marketing of green energy programs failed altogether because demand was not adequate to justify continued investments by the regional utility firm. During this same period of time, other nations were able to invest in photovoltaic technologies and produce great quantities of electricity, suggesting that there are still market factors within the photovoltaic industry that are not fully understood. The key research questions still remain: why have some nations been able to embrace the sacrifices, capital investment requirements and learning curve demands of photovoltaics while other nations have not been as successful? What does the role of price, as measured in per kilowatt of commercial electricity contribute as a potential factor in evaluating photovoltaics as an alternative electricity source?

Hypotheses (Group Two):

Does the concern for pollution levels such as carbon dioxide influence adoption rates of solar energy?

This set of hypotheses was studied to compare nations with high levels of carbon dioxide emissions with nations with low levels of carbon dioxide as a possible market factor of adopting photovoltaic technologies. Global warming is currently one of the most debated public health issues around the world. This issue presents an almost unprecedented challenge to the global economy, in that as one nation's policy regarding carbon emissions is determined it will immediately and directly impact neighboring nation environmental conditions. As the debate over global warming has expanded, renewable energies of all forms have benefitted from the rising tide of awareness. This set of hypotheses seeks to determine if the factor of carbon dioxide as a proxy for a nation's overall level of pollution may be identified as a contributing factor to the growth of photovoltaics in a given market. Currently, reduction of carbon dioxide is one of the more prominent elements in the marketing of photovoltaics; however, it is unclear if this factor is actually a sellable benefit in marketing of photovoltaic products.

Hypotheses (Group Three):

Are financial incentives such as rebates or feed-in tariffs effective market stimuli for increasing installed photovoltaic capacity within a given marketplace?

The researcher was able to compare nations that offer any form of financial incentive (rebates, feed-in tariffs, tax incentives, etc), with those nations that do not have financial incentives, and then measure them as a factor in promoting photovoltaic technologies. The existing levels of installed photovoltaic generation capacities measured in kilowatts generated are highly varied internationally. Some nations such as Germany, Japan and portions of the United States enjoy substantial quantities of installed capacity while other nations with seemingly similar political, economic or institutional infrastructure have not embraced the technology.

Nature of Study

Because no rich comparison of potential photovoltaic market factors exist, a quantitative exploratory study will be useful to research the presented sets of market hypotheses. In this study, twenty- nine different nations were classified into three economic categories and then compared by the set of stated potential market factors. The dependent variable, current installed generation capacity of photovoltaics measured in kilowatts, was used to measure progress of photovoltaic technologies in each country. An empirical analysis was used to identify which factor(s) directly correlated with the actual increase in photovoltaic capacity in the given nation. Existing research does exist that analyses individual nations, but this research attempted to incorporate multiple factors over a twelve year period to identify more comprehensive market stimuli factors. This research attempts to develop results that can be immediately incorporated into international marketing strategies of firms competing in the international solar energy marketplace.

Research Scope Assumptions & Limitations

The researcher made several assumptions regarding the study by limiting the number of incorporated independent variables to three. Price of incumbent electricity as provided commercially, levels of carbon dioxide per capita, and a dichotomous variable representing financial incentives were the only variables incorporated in the statistical model. It can be argued that other variables may exist; however, lack of reliable data for some nations was often a barrier to the researcher. Additional variables, such as the quantity of electricity imported by a nation or statistics measuring energy intensity of a given nation in terms of per capita usages, was also considered but not ultimately selected for this research.

The nations selected in this research are nations that have measurable levels of installed photovoltaic capacities. The resulting sample of nations is imbalanced primarily because of the larger number of developed nations as an economic category, which accurately reflects the current imbalance in international photovoltaic installed capacity.

Organization of the Remainder of the Study

The remainder of the study contains four additional chapters. In Chapter 2, classical international business theories are presented as a theoretical umbrella relevant to marketing of photovoltaic technologies. Additional current literature in the areas of marketing of innovative technologies and photovoltaics is also introduced. Chapter 3 describes the methodology used in the study and model selection. Chapter 4 presents the three primary groups of hypotheses as well as the original data collected and applied. Chapter 5 provides conclusions and a prescriptive summary of the research as well as recommendations for future extensions of research.

Introduction

The research questions presented in this study examine the impact of three potential market variables: price of electricity, concern for pollution, and financial investment subsidies as potential market stimuli supporting growth of photovoltaic energy products. There is no single study that directly addresses the research questions posed here; however, there are many studies that identify and explore elements of this topic as it pertains to the international marketplace for solar energy. Each variable being considered in this study is currently positioned in marketing campaigns of the leading photovoltaic manufacturing firms as a perceived benefit of photovoltaic technologies. The literature introduced to this study will relate specific streams of research pertaining to identified variable or marketing theories that identify how these factors relate to behaviors of consumers of renewable energies.

International Marketing Strategies

To begin assessing the photovoltaic energy sector from an international perspective, it is necessary to review two competing international marketing strategies that are relevant to multinational firms seeking to expand beyond domestic markets. The first stream of literature focuses upon Theodore Levitt's work in *The Globalization of Markets* of (1983). Levitt introduces the idea of standardized products that are adaptable universally to all the major markets of the world. The benefits of standardized products will promote enormous economies of scale, leading to cost and knowledge efficiencies and establishing a substantial competitive advantage. Levitt also argues that marketers of standardized products will utilize standardized marketing approaches establishing a single, common message for all potential consumers. Levitt uses the example of battery-powered products which are all part of what Levitt describes as the "Japanese game". Consumer electronics ranging from cameras to pocket calculators will be dominated by Japanese manufacturers due to the common design element of using batteries as a power source. This stream of literature is interesting to this study in that, just as Levitt used batteries as the common element as to why the Japanese will dominate the electronics industry, the sun as an energy source can be extended as a common element in the photovoltaics industry. The sun does shine on all nations of the earth and therefore an implied standardization of solar modules can be applied to manufacturing of solar modules because there is no need to customize solar panels for any single market. A standardized solar module can be sold around the world with no technical modifications, potentially applying Levitt's proposed advantages. The second element of Levitt's theory, the potential for a common marketing strategy for all markets, is not as obvious a conclusion as will be discussed later in this research.

A contrary set of marketing strategy literature is presented by Kenichi Ohmae in his research *Managing in a Borderless World* (1989). In this article, Ohmae discusses the benefits of local management adjusting the "headquarters" nearsightedness by applying local perspectives to marketing strategies to incorporate cultural differences. A home market manager of a multinational firm cannot have the same equidistant perspective of all markets, potentially diminishing marketing effectiveness. Ohmae (1989) suggests that there will always be the tendency to have a home market perspective that may not be appropriate for certain overseas markets. Local market conditions often require adjustments to the product or service to accommodate local regulations or market conditions. Conclusions suggested in this research demonstrate the importance of local solar equipment installers as representation for manufacturers of photovoltaic equipment. To date, the photovoltaic industry is too small in scope and scale to provide adequate direct representation of major manufacturers through branded local agents. Local expertise within a given market is most frequently represented by local, non-branded installers of equipment. These local installers also possess knowledge of electrical codes or other regional information that is beneficial to the education of potential consumers. The local installers of photovoltaic equipment are often the last and strongest contacts the manufacturers have to consumers. These local installers do possess the unique market knowledge of a given state or region, providing consumers with local expertise in a given geographic market. Ohmae's conclusions are well suited for the solar equipment industry because there is a wide variety of local market factors to be considered when assessing solar energy. Regional installers are not usually under the direct supervision of any manufacturer, creating a competitive vulnerability for the manufacturer.

Niche Market Status

The photovoltaics industry in 2007 can most accurately be described as a "niche" market based upon total installed capacity data. For many new technologies, different stages of development have been developed to describe characteristics of the firm, the market and the levels of penetration a new product realizes at given points in time of development. This life-cycle model, from invention to market saturation, has been analyzed in numerous studies to provide additional clarity used to react to the market at that given stage. Generally, these models represent an S-shaped diffusion curve showing slow initial growth then leading into accelerated growth then concluding with slower growth during saturation phases. The time frame of these different stages can range from a year to many decades (Grubler, 1998) and often have periods of phase overlap (Turkenburg, 2002).

Grubler's Stylized Stages of Innovation (1999)

Stage	Mechanisms	Firm Costs	Market Share
Invention	R&D breakthroughs, applied research,	Highest and often un-focused.	0%
Focused R&D	Identification of applications. Applied research for specific projects.	Highest but increasing in focus.	0%
Niche Market / Early Commercialization	Identification of specific applications. Close relationship between developers and end users.	High but declining due to standardization of processes.	0-5%
Initial Diffusion	Standardization of product and mass production. Economies of scale. Network effects	Rapidly declining	Rapidly Rising. 5-50%
Saturation	Limited incremental improvement. More efficient competition.	Low, perhaps declining	Up to 100%
Senescence	Dominance of superior competition.	Low, perhaps declining	Declining

Grubler et al. (1999)

In relation to all energy consumed by all current means, on average, PV technology only represents 0.01% of all energy consumed internationally (IEA, 2006). A significant disconnect is apparent, however, when current levels of installed photovoltaic capacity are compared with literature projecting the role solar energy will play in future energy contributions. The 2006 International Energy Association published report frequently do not isolate photovoltaic contributions as a portion of total electricity generated but rather as part of a portfolio of future levels of all renewable energy alternatives (IEA, 2006). One might ask why then pursue growth strategies of a technology that is currently so insignificant to global energy consumption?

The answer lies in the long-term benefits of solar energy that are often under-valued or poorly explained to potential consumers. Currently, customers of photovoltaic technologies are predominantly self-educated as to the benefits of solar energy. These early adopters often approached the adoption of photovoltaics with prior convictions with their priority being to utilize an environmentally-friendly alternative. These early adopters place less emphasis on the financial drawbacks favoring more altruistic benefits (see the section on Pro-Environmental Attitudes later in this chapter,(Wiser & Fowle, 2001). The primary focus of this research is to identify market factors within the photovoltaic marketing strategies that will look beyond the motivations of these early adopters in an attempt to attract potential consumers with alternative criteria for of product evaluation. Currently, photovoltaics are an established technology but are a form of energy production that is not understood by many potential consumers outside of early adopters. It is argued in this research that motivations for early adopters of photovoltaic products are different than for potential second generation adopters of photovoltaic technologies. For this niche market to expand beyond current levels of installed capacity, a different blend of product benefits must be communicated to potential customers that identify and address mainstream consumer purchasing criteria. It is also suggested that each international market represents unique attributes, a fact that may preclude the ability to develop broad or standardized marketing solutions.

Size and Scope

The sheer size of the photovoltaic industry is an issue that has not received significant analysis in the current literature. Studies investigating regional behaviors of consumers, while interesting, are limited in scope to either one nation or few potential consumer variables. Wiser & Fowle, (2001) wrote an interesting paper titled "Public Goods and Private Investors". In this study, five variables were measured in a US-based survey of both residential (52%) and small to medium commercial installations of some form of renewable energy technology. The five variables presented in this study were employee morale, public image, efficiency gains, regulatory risk reduction, and altruism. The conclusions of this study identify two key results relevant to this research pertaining to how utilizing renewable energy can impact the perceptions of employees when renewable energy applications are used within a firm. The first result showed that efficiency gains are not the primary reason why consumers adopt renewable energies. This is a logical conclusion, as currently most forms of renewable energy are more expensive than conventional energy sources. Consumers seeking efficiencies would not be interested in a product alternative that is priced at a premium over other alternatives. The second relevant discovery of this research is the two primary motivations consumers stated as to why they support green energy. The top three responses were altruistic (organizational values and civic responsibility) and employee or family morale. Altruism is the primary motivator of green energy support in the United States (Wiser & Fowle, 2001). This conclusion is logical when considering the value commercial firms place on public relations. Being able to identify a firm as pro-environment is a potentially important market differentiation characteristic and competitive advantage. Firms electing to participate in green energy programs or to purchase green products directly assisted all forms of renewable energy by serving as an example to their industry and community. Renewable energy alternatives are still small in proportion to conventional energy generation means. However, consistent progress is being realized as a result of green marketing initiatives that expand awareness of these energy alternatives.

Location of Markets

The majority (64% in 2007) of installed photovoltaic capacity is located in three countries, Japan, Germany and the United States (Prometheus Institute, 2006). Michael Porter's theory of economic clusters has significant relevance to the photovoltaic industry. Manufacturing of solar modules occurs all around the world; however, manufacturers depend upon a variety of local, complementary firms to support and install their products after the sale. The major markets within the international photovoltaic market can also be related to the theories of economic clustering. Porter discusses how physical concentration of firms, both primary and secondary partners, within developed industries can establish a combined benefit for all firms (Porter, 1998). The International Energy Association has published renewable energy data on over one hundred nations identifying the major markets by usage for photovoltaic technologies. The results of this market analysis identify Japan, Germany and portions of the United States as the largest photovoltaic markets in the world today in terms of installed PV capacity. With these geographic areas of industry concentration, Porter's economic clustering observations can be applied supporting the accelerated growth within these specific markets. Integration of knowledge, facilities, and infrastructure offer numerous efficiencies resulting in unusually high levels of success for members the supply chain, both upstream and downstream. Foreign direct investment (FDI) in the photovoltaic industry has been fruitful because it has given companies such as BP, Kyocera, and Sharp access to trained installers and peripheral equipment manufacturers that have in turn spawned additional demand for PV products.

Region	Country	Installed Capacity in MW
Europe	Germany	1100
	Spain	75
	Italy	35
Asia	Japan	1320
	South East Asia	20
	China	4
North America	US	460
	Canada	25
ROW	Australia	40
	Middle East	25
	Latin America	21
	Other	20
Total		**3,145**

Figure 1: Approximate Current Installed Capacity by International Region 2007. Prometheus Institute (2007)

Japanese firms such as Kyocera, Sanyo, Mitsubishi, and industry-leading Sharp all have facilities in all three key markets. Complementary industries such as manufacturing facilities for polysilicon raw material have become critical to the decision of foreign direct investment.

To date, only Mitsubishi has developed an internal silicon supply source. However, the pursuit of larger quantities of raw materials is a major market focal point for the years 2007 and 2008. Additional manufacturing of silicon raw materials is expected to have a major impact on the industry starting in 2008 from both a price and capacity dimension. The balance of all other global photovoltaic manufacturers relies upon only eight major international manufacturers of photovoltaic-grade polysilicon. The physical demands of production and the transportation of raw materials may lend itself to Porter's theory in that clusters will continue to form around the major manufacturers and these eventual sources of key raw material suppliers.

Pro-Environmental Attitudes

From a socio-political perspective, the "green" movement has seen marked progress over the previous decade, with increased environmental concern across a wide range of nations (Frazen 2003). Surveys conducted by the Health of the Planet (HOP) have resulted in conflicting reasons for the increased concern for the environment. Evidence of heightened concern can be seen in the increased the number of environmental treaties signed and the number of international, nongovernmental organizations focusing on a wide range of environmental challenges (Frank, Hironaka, and Schofer 2000; Frank 2000.) Currently, 48 nations, (14 developed nations, and 34 developing), have renewable energy policies. All 25 European Union nations have very specific energy targets in terms of reducing CO_2 emissions as well as installing renewable energy technologies (IEA 2006).

One set of literature argues that concern for the environment increases in a country as economic stability increases (Inglehart 1995, 1997). Richer countries have the luxury of not worrying about fundamental economic conditions and therefore can focus on other values such as the environment. Established economic stability allows a regional population to incorporate broader and more diverse considerations into their financial and social policies. Poorer nations react differently as a result of obvious social or economic deficiencies. When pollution issues such as unhealthy air or water occur, these are viewed as local issues with a direct impact upon the citizens of that community. Local issues often result in more immediate resolution efforts by richer nations. This is supported by results provided by the World Values Survey where high per capita GDP nations of Sweden, Denmark and Scandinavia showed the greatest levels of support environmental protections while low GDP per capita nations Russia, Turkey and the Czech Republic rated the lowest in concern. Poorer nations often have extensive social and economic issues that may be perceived as more significant than environmental concerns. Inglehart's post materialism index has become the foundation of additional studies by Miguel Basánez, Jaime Díez-Medrano, Loek Halmann and Ruud Luijkx (2004). These studies did not focus on environmental behavior patterns but on more conventional demographic data such as race, religion or political perspectives. This research does provide a hierarchy of how societies migrate from basic needs to more complex values. This research extends those conclusions to potentially include environmental issues as a new form of a non-material good and as a market factor for solar energy.

Contrary literature by Dunlap and Gallup (1993) and Dunlap and Mertig (1997) argue that per capita GDP has no correlation to environmental support. However, their findings have been challenged by Diekmann and Frezen (1999), who stated that Dunlap and Mertig's findings were one-dimensional and not fully reflective of the issue. Diekmann and Frezen go on to provide analysis of how the environment versus the economy cannot be dismissed. Frazen concluded in a study, which analyzed both the 1993 and 2000 International Social Survey Program (ISSP), that higher proportions of citizens in wealthier nations support environmental protections over economic growth than do citizens in poorer nations. Poorer nations support environmental protections as a result of environmental challenges that are local issues that impact the public good of those regions.

Two additional areas of literature exist that attempt to understand pro-environmental attitudes of large, national groups. The first set of literature focuses upon sociodemographic variables such as age and levels of education (Dietz, Stern & Guagnano 1998). This line of theory has only resulted in a nominal level of explanation in measuring environmental concerns. A second group of literature focusing upon social-psychological studies has been more successful in predicting pro-environmental behaviors. Works by Boldero (1995) and Taylor and Todd (1995) studied how people act in supporting pro-environmental behaviors. Boldero's research examined how recycling programs were developed and then measured success rates during the 1990's for small to medium sized companies. Boldero attempted to identify the incentives and barriers to recycling programs as they relate to the perceived importance of environmental concerns. Conclusions of this study introduce the barrier to what is defined as a "free rider" where a non-participant enjoys the same benefits as a committed participant. This specific observation can be extended to solar energy as a potential barrier of implementation. These studies, while not intended to support marketing efforts, can provide a basic framework for predicting pro-environmental behavior. The measurement of a consumer's willingness to sacrifice by paying higher prices in an effort to protect the environment is an interesting marketing factor.

Firms within competitive markets seeking to utilize environmental concern as a marketing strategy need to identify how those concerns can be applied. As stated, many forms of renewable energy, and photovoltaic technologies in particular, all have a higher cost per unit of generated electricity than conventional generation methods. Several studies attempted to measure consumers' "willingness to pay" for green products. Houston and Farhar (1996) presented a variety of survey questions that attempt to determine how much of a premium price consumers would be willing to pay to support renewable energy alternatives. Results show that up to 70% of the survey respondents would be willing to pay a premium in support of an environmental protection initiative or a renewable energy alternative. The willingness to pay (WTP), however, is greatly impacted by the number of alternatives a consumer may have in a given market. Farhar and Houston's research identified that many utility markets do not have adequate competition, resulting in the diminished likelihood of having a "green" alternative available to consumers. The results of the willingness to pay lines of research also reveal a key potential outcome that should be considered by all renewable energy firms. Research identified a gap between what people say and what they actually did in supporting alternative energy programs that were environmentally supportive. Actual participation levels of these green programs were often significantly lower than the total number of those indicating support in favor of environmentally friendly electrical generation alternatives. Houston and Farhar concluded their research by suggesting that each market requires individual market area research before implementing future green marketing programs.

A final study conducted by Hokby and Soderqvist measured the elasticity of demand and willingness to pay for environmental services in Sweden (2001). This study combined the environmental curve of Kuznets but added the viewpoint that environmental services may be considered luxuries. A survey looked at the demand for public goods such as clean air and clean water in relation to the price of the good and its related protection costs. This research showed that income levels and willingness to pay were positively correlated. Hokby and Soderqvist also concluded that environmental improvements tended to benefit low-income nations more so than rich nations. The results of this group of behavioral studies may identify some additional market factors relating a country's economic environment as it pertains to support for photovoltaic energy. Nations with high per capita income or high levels of education may be stronger candidate markets for photovoltaic technologies than nations without these attributes.

Paradigm Shift: A Need for Cultural Commitment

If photovoltaic technologies are expected to continue beyond current niche market levels, a major paradigm shift will need to change how people view purchasing electrical energy. The potential migration away from conventional fossil-fuel energy sources would represent epochal changes to both global industrialization processes and the international energy markets. Large centralized generation facilities and grid distribution networks have molded nations of the world to expect commercial electricity to supply all commercial and residential market needs. To leave this combination of entrenched expectations may require not just technological breakthroughs, but cultural modifications as well. Leading research in the classification of the impacts of epochal innovation can be found in Simon Kuznets's book, "Modern Economic Growth". The term "epochal innovation" was first coined by Kuznets in 1966 when he described a "major addition to the stock of human knowledge which provides a potential for sustained economic growth and utilization absorbs the energies of human societies and dominates their growth for a period long enough to constitute an epoch in economic history" (Kuznets 1973. p247-258). As the debate over future energy reforms evolves and various alternative energy strategies are explored, leadership within industry, academic and political institutions suggest that renewable energies must play an increasing role in economic sustainability for all classifications of nations. Similar to other preceding technological innovations such as the introduction of the automobile or the personal computer, Kuznets suggests that the adoption of the new technology will require institutional and societal changes in order to provide value. Many global markets are deeply entrenched in fossil fuel energy (Stobaugh, Yergin et.al); to leave these established energy sources, a massive re-education process must take place to increase awareness of the potential benefits of any new viable energy alternative. Kuznets cited an example of the steam engine and the role it played regarding the issue of black slaves in the southern-states of the US. He stated that the timing and technology of the steam engine were right for epochal change in relation to how mechanical labor had previously been perceived within those cultural conditions. Mechanical labor contradicted the idea of using unpaid human labor to accomplish the manual work. However, social complications regarding the evolving perceptions of slave labor leant credence to learning about the benefits of new, mechanical labor devices. This contradiction opened the discussion of why slaves were used in this capacity, and whether it was really necessary to treat some people in this manner in order to provide services to others. These discussions led to epochal innovations such as the steam engine that supported changes in both institutions and society well beyond the single issue of slavery and affected the broad societal norms outside of the slaves and owners themselves. This transformation was far more than just an economic phenomenon, but a cultural one as well. It could be argued then that during the 1970s, when photovoltaic technologies were first introduced, the timing was just wrong, and therefore solar technology was not embraced. Change was not possible at that particular time and with that set of societal factors. It may also be suggested that current energy dynamics and current technologies are different as a result of increased concern for global warming.

Once a potential cultural change has been identified it is then in the hands of the individuals within a given market to determine how to proceed. The book "The Logic of Collective Action" by Mancur Olson (1965) addresses both the challenges of group behavior and the influence of supporting a public good. Olson stated that the reason an individual joins a group or a movement is to further that individual's personal gains by efforts of other members in the group. If a group shares a common bond, then the group will perform better as a unit in attaining the desired outcome than as a set of individuals pursuing a similar objective. The member enjoys the benefits of the group but, if left to his own, would rather not pay individually for the benefit provided by the group; therefore, groups often reduce investment costs. A collective good in this example can be represented by one of the potentially largest marketing factors supporting photovoltaic energy, the reduction of green house gasses. Solar energy reduces carbon dioxide, a major form of pollution in nations with substantial carbon-based energy sources. The challenge for photovoltaics is that the air is a common good and the adoption by one, two or even a hundred individuals will have a limited benefit on them as a group. The cleaner air as a bi-product of the group's photovoltaic investments benefits all, not just the group. What the group does depends upon the group but the common good remains public. Each member of the group will also likely have a different value upon the collective good, resulting in varied levels and forms of support. Currently, electric power generation can be classified as a non-collective good and is often supplied or supported by the government. Participation is not compulsory and the group decides how it will behave in a given situation or environment. Currently, pollution is not equally shared upon members of a nation. Olson concluded that a collective good will be provided when the group's collective good is growing faster than the cost or value of the good. There is currently a disconnect in the impact that photovoltaic or other forms of renewable energy will actually have upon a given nation because the world's weather patterns are so integrated. Pollution does not stop at a nation's border any more than it does at a firm's property boundary. Today the collective good is not cost justified according to Olson's model because the individual (or firm), does not gain by participating directly in a group that adopts photovoltaics. The level of critical mass to a group's size in a given market must be significant to overcome that level of benefit in relation to those providing no benefit. In addition, those with a higher degree of commitment run the risk of being exploited by those who have not contributed to providing the collective good. The marginal cost of the collective good must be equally shared and be proportional to the benefit but today that is not the case. Olson's work is relevant to the marketing of photovoltaics because some nations appear to be much closer to substantial levels of commitment to the collective good than other nations. Determining how to identify what nations (markets) are committed to the collective benefits of photovoltaics will be a major accomplishment for the manufacturing firm(s) that is able to incorporate this information. Competitive electric markets offering electricity that is produced by environmentally friendly generation methods and marketed as pro-environmental have seen marginal success in markets within the United States (Farhar & Houston, 1999). While the development of green or pro-environmental marketing is clearly group related and public benefit oriented, success rates have not been proven adequate in many examples. Green marketing represents complications to conventional marketing strategies because the ability to market a product with public benefits is not adequately researched. Farhar and Houston also state that not all markets offer green product alternatives, therefore, there is no option for some consumers to participate in green marketing efforts.

Environmental Literature

McVeigh, Burtraw, Dalmstater and Palmer (1999) presented research that identified the initial cost of the equipment as the primary barrier to the growth photovoltaics in the United States. This paper reviewed the progress of the industry from a variety of external factors such as the deregulation of both the electrical and natural gas industry, and the progress in the reduction of production costs for photovoltaic equipment. The general impact for consumers has been positive because cost per kilowatt of electricity produced by photovoltaic technology has consistently fallen, benefitting both commercial and residential markets around the world. Additional factors that have benefitted solar energy are concerns for the environment, regional and national energy policies, and monopolistic control structures of certain energy markets. The general conclusion of McVeigh, Burtaw, Dalmstate and Palmer is that renewable energies have not failed to become a viable consumer alternative; however, they have failed to meet projection in terms of overall energy contribution levels. These conclusions were also offered in research by Robert L. Bradley (1998) in his book titled *Not Cheap and Not Green.* Bradley presents a variety of observations ranging from raw material cost increases to the impacts of subsidies that, when combined, reduce the actual realized benefits of some forms of renewable energy alternatives. Bradley concludes that the combination of these negative factors often result in many forms of green energy are actually not competitive when compared with conventional, commercial energy sources. Many modern photovoltaic marketing strategies do not focus on the cost of the equipment or the benefit of overall cost savings. This total cost of ownership approach is a complication of almost all energy forms, conventional and renewable, as R&D costs, disposal costs and subsidies or tax benefits are difficult to incorporate into an actual end user rate per unit. Automobile companies like Toyota or Honda manufacture automobiles that focus on the total cost of ownership, and provide savings as a result of greater fuel economy or reduced repair and insurance costs. These companies present a cumulative ownership experience that is less expensive when all factors are considered and compared to their competition. Renewable energy companies cannot make those claims because some the benefits presented by these firms are intangible or are considered a collective public good. The costs of the equipment remain tangible individual considerations, and as noted are often more expensive than conventional energy alternatives.

When a consumer evaluates renewable energy technologies, the costs are easy to assess; however, the proposed intangible benefits lack a valuation method that consumers can apply to an individual decision process. Firms offering green products need to expand consumer understandings of these considerations as part of an educational process to determine the value of their products and services. While installed capacity of photovoltaics has grown substantially, costs have remained high compared to conventional electricity primarily because there is no initial investment by a consumer for commercial power. Bradley (1998) suggested that it is difficult to separate the total cost to produce from the potential benefit of green energy production because the comparison is not really comparing two similar alternatives. Bradley concludes that renewable energy technologies are also dependent upon conventional fuels and petroleum products to produce, suggesting that green energy is not green at all. The amount of petroleum products used in the full production cycle of a renewable energy product is considerable and significantly reduces the overall "green" benefit proposed by the manufacturers in this market.

Of all the potential benefits of photovoltaics, reduction of pollution is by far the most prominent of the potential advantages over carbon based fuels. Pollution is a result of industrialized processes. The harvesting of a given raw material (oil, coal, natural gas) used for electricity production by some mechanical process, has been analyzed in a variety of studies and is the identified source of health and environmental issues. There are two general classifications of production of electricity, primary and secondary. Secondary electricity is produced by the combustion of fossil fuels such as coal, oil and natural gas. Primary forms of electrical generation include nuclear power, hydroelectric, wind and photovoltaics because the energy does not go through a generation process fueled by another substance. A very large share of the international demand for coal (90% in the United States) and other primary forms of energy such as oil and natural gas that have been used for decades around the world for electrical generation (WTO Council in Trade 1998) are all secondary forms of generation. Pollution, a bi-product of secondary electrical generation, has become an increasing concern of all developed nations and has led to the introduction of a variety of political and regulatory policies intended to reduce these levels of pollution. Historically, corrective measures to this problem have been viewed as an additional overhead expense rather than a potential new market opportunity. Harvard author and international strategic expert Michael Porter (1995) offered a unique perspective on how many types of bi-products of energy that were previously only seen as an overhead expense may now become a potential competitive advantage to a firm if the proper perspectives are applied. Michael Porter offers the resource-productivity model as a second potential viewpoint that can be adapted to the issue of renewable energy. Porter framed his position in a paper "Green and Competitive, Ending the Stalemate" where he discussed the increasing role of environmental regulatory policies and their effects upon global competition. He stated that current environmental policies erode competition and stifle innovation, leading to harsher regulatory actions because the problem is never fully resolved; it is just identified and then penalized by way of fines or taxation. Current resolutions to pollution are addressed either by preventative measures or clean up costs. Each of these alternatives is an overhead cost with no advantage, and firms are forced to grudgingly comply. Porter's key premise is that this is not a necessary conclusion to this process, and that properly designed environmental standards can trigger innovations and lower the production cost of a product while also creating value.

If Porter's argument is extended, revised regulation should allow companies to experiment more with key factors such as energy costs. This resource productivity model potentially could establish a new realm of competitive advantage to assist companies to become more competitive. According to Porter, pollution is simply a "flaw in the product design or production process" (Porter, p. 355), and efforts to address this flaw can lead to innovation and even competitive advantage. Pollution prevention has proven to be more cost effective than pollution cleanup. However, the change in the mindset of international firms has seen inconsistent rates of adoption. In the paper, Porter detailed the Dutch floral industry and Dow Chemical, where the root problems were related to better resource productivity research rather than simply resolving a problem without addressing the cause. Porter suggested that a variety of potential benefits ranging from reduction of materials, conversion of previous wastes to other valuable forms, lower energy consumption, and reduced handling costs have been realized by firms who change their thinking as to how to approach the problem of pollution. Porter concluded with the case of Germany, which was one of the first in the world to adopt strict recycling standards many years ahead of other European nations. German companies did not resist the regulatory policies but instead developed innovative programs to address the new standards. As a result German products had far less packaging, thus reducing end use pollution and packing material cost for the firm. By viewing pollution from the perspective of the life span of the product, a series of innovations were created which justified the expense and changes needed to accomplish the objective of reducing pollution.

Pollution is an issue for the nation and not just the firm. The firm is merely the steward of the product and process representing a larger group of participants. The embedded costs of regional and national services relating to pollution control, and their regulation, are represented in the form of taxes and fees. These costs are borne by all, including the firm; therefore, all the costs were factored into the financial assessment of the innovative processes. Porter concluded with a key statement: "We are now in a transitional phase of industrial history in which companies are still inexperienced in handling environmental issues creatively" (Porter p. 362).

Customers, too, are not fully aware how resource issues affect pollution and ultimately consumer costs. Energy is a central and often significant cost to any firm or institution. If energy can be viewed from the perspective of a total cost of utilization, then solar energy takes a significant lead forward in terms of total cost of ownership. Other industries have been able to accomplish this; examples include the German and Japanese auto manufacturers. Germany and Japan started to produce lighter, more fuel efficient cars as a result of tightened fuel consumption standards. The US manufacturers initially fought the standards only to later accept them but at the cost of losing first mover advantages. The world economy is in transition between competition and the environment. Historically, the lowest cost per unit of labor, capital, or natural resources reinforced the comparative advantage theories utilized by many multinational firms. Globalization is making competitive advantage obsolete as products can be sourced from almost anywhere in the world. Industries that respond to environmental problems have an opportunity to innovate and it may lead to a competitive advantage.

Historically, power that could be classified as environmentally friendly or "green" was seen as commanding a premium price and was reduced to only a small niche player in the broader energy markets. This "niche market" was defined by affluent, highly educated customers with environmental convictions that distorted conventional energy market strategies that were often technologically based, (Day, 2005), (Bird, Wustenhagen, Aabakken, 2002). The willingness to support "green" products or to purchase renewable energies at a premium has been discussed in a variety of papers with varied conclusions. In a 1996 paper produced by the National Renewable Energy Laboratories (NREL) customers in markets where electric reform and deregulation were being sought, results showed that 70% of their customers would be willing to pay a premium of some degree for a renewable energy alternative. The research developed a "willingness to pay" index (WTP) that can be applied to other market conditions and market estimation models (Farhar and Huston 1996). WTP, combined with other environmental marketing tools such as regulatory policies intended to protect the environment, were variables used in the research as a means to determine if green pricing alternatives would be a viable in future markets. The results were clearly favorable for establishing green pricing options for customers whose electrical markets were entering restructuring or other reforms, and subsequently new competition. The willingness to pay index (WTP) was then tied to the development of incentive programs that would allow a potential client to view utilization of electricity produced by a renewable generation means, such as PV, to be considered an investment in the community offering long-term benefits. Purchasing PV equipment was then positioned more as an investment, rather than a substitution of a conventional fuel. The premium price was then more tolerable to the market participants. The WTP index also offers a key observation that separates the buying decision of renewable energy equipment in general when compared to purchasing conventional energy. Renewable energy "investments" incur substantial up-front costs for those who invest, with the long-term benefit of on-going electrical costs of near zero after the payback period. Conventional energy is positioned as having lower initial investment costs but with infinite future costs of fuel and environmental impacts.

Government Incentives and Policies

A third set of literature focuses on the role of governmental policies that support both existing energy producers and alternative energy producers. As financial incentives to promote photovoltaic technology installations were developed, the process of switching becomes a value assessment process that is different for each country and even each potential client considering PV technology (Starrs 2004, Ingersoll, Gallagher, and Vysatova 2005). A variety of funding alternatives have been used to stimulate growth in the photovoltaic industry for both on-grid and off-grid applications. The most common incentive in many international markets is an upfront rebate provided at time of sale for installed equipment. Financial incentives are used as a form of market stimulation to reduce the high initial investment in photovoltaic systems. Rebates are often structured differently for residential and commercial applications, offering different payouts. A key challenge to up-front rebate is that the there is no guarantee that the equipment will ever generate electricity because the incentive is not tied to electrical output of the equipment purchased. This strategy lacked commitment on the part of the landowner because once the incentive was received there was no guarantee that the equipment would be maintained or would continue to produce power. Strict financial incentives have proven to be short sighted, (Starrs, 2004) as they may or may not actually produce the intended contribution of the quantity of electricity projected because equipment is not monitored for actual production, only installation. Incentives that simply reduce the cost per installed kilowatt of power do not guarantee that the installed location will ever come on-line.

Starrs suggested a production-based incentive system such as the feed-in-tariff structure established in Germany, which has proven to be more effective. This form of incentive compensates the location owner but also effectively shifts the demarcation point back towards the customer premise equipment and away from the centralized utility. This approach increases ownership rewards and participation over the life of the equipment because when a site is not producing electricity, it is not earning the incentive. This system represents a key point to the overall renewable energy experience in that ownership of energy generation now resides with the customer and not with the utility. Marketing campaigns often suggest this via quotes such as “energy independence” or “take control of energy costs”. Citizens of developed nations have long forgotten what it is like to be self sufficient when it comes to energy, expecting the economy to provide adequate supply of electricity like any other public service. The marketing of a product that requires participation represents a major cultural shirt and perhaps the largest hurdle to the future of PV technology. The marketing of a product that actually increases the level of responsibility may be an issue for multinational firms, because traditional approaches require less work from the home or business owner, not more work.

The design of the delivery systems for electricity and the consumer's perception of their relationship with an electricity supplier were the foci of research done by Lund and Munster (2004). This research showed that nations that have functioning, distributed electrical grid systems are well suited for photovoltaic systems to back-feed excess power that can be utilized by commercial providers. Supplemental power provided by hundreds or thousands of small, independently managed photovoltaic locations can provide a tremendous potential benefit to large commercial generation facilities, especially during peak load periods. Grid-tied systems are the largest category of photovoltaics and well established in all the major markets for photovoltaics around the world. However, the nation of Denmark saw a different benefit of a grid delivery system for electricity. The increased potential flexibility of a grid system could invite regional electricity producers to reverse-feed the system rather than utilize large, centrally planned generation facilities. By integrating the energy markets within Denmark, local markets can now be developed to take advantage of alternative electrical sources that can accumulate to become significant contributors (Lund, Munster, 2004). This de-centralization strategy essentially reverses the conventional larger, centralized generation points into a series of smaller, less dominant contributors. It should be noted that Denmark has one of the world's most expensive commercial electrical rates, averaging $0.1685 per kWh when converted to US dollars and adjusted for purchasing power parity (PPP) (IEA Annual Report 2006). Solar energy is best used during mid-day when the sun is at its most productive in terms of available sunlight. This peak of availability is exactly the same time of day as when commercial generators face their highest demands for commercially provided power. The demand curve matches almost perfectly the supply curve offered by photovoltaics, allowing solar energy to provide a potentially key strategic growth path for any commercial electrical generation facility. Today, 83.2%. (PV News Vol. 25, March 2006) of the world's installed capacity of grid-tied photovoltaics are in three countries, Japan, Germany and the United States. Each of these three key markets currently offers financial incentives to support the growth of photovoltaic systems as a form of market stimulation.

Price of Electricity

A final aspect of the literature review focuses on the element of price per generated watt of electricity. The variable of price within the photovoltaic industry can be interpreted in multiple ways, ranging from the price of the equipment to the price of a delivered kilowatt of electricity. The field of literature analyzing the cost of photovoltaics in comparison to utility-supplied electricity or as a cost per unit is limited, with only a few regional studies. The price-volume relationship was the topic of a research paper, "Industry Development Strategy for the PV Sector" presented by Eric Ingersoll, Daniel Gallagher and Romana Vysatova (1996). They argued that the price per installed watt generated needs to approach $1.00 to become a viable alternative to commercial energy alternatives from a strictly pricing basis. Ingersoll, Gallagher and Vysatova also classify photovoltaics as a disruptive technology and discuss how photovoltaics suffer from the perception of being a "developing technology". Ingersoll, Gallagher and Vysatova argued that photovoltaic technologies will not make a significant impact upon global carbon emissions and that demand for PV technologies will be limited until the next century. They position PV technology at such a price disadvantage to conventional power that the green market alone will ensure industry viability. The paper suggested that a market-based strategy and not a financial incentives strategy is needed to grow the photovoltaics market. By identifying and focusing on specific applications in both grid-tied and off-grid applications, photovoltaics will develop by traditional market-based processes rather than the artificial stimulus of financial incentives. This research suggests that the challenges of the photovoltaic industry are purely based on price per kilowatt. Once the price per generated kilowatt approaches $1.00, PV will be competitive enough to displace conventional generation methods.

The National Renewable Energy Laboratory in Boulder Colorado has also identified factors that may become more prominent within the photovoltaic market as the industry matures. In a 2006 report, "The Framework for Evaluating the Total Value Proposition of Clean Energy Technologies", (2006) Peters identifies how many valuation techniques may fail to fully capture the value of clean energy alternatives. Peters argued that simple financial decision criteria that fail to include long-term benefits are inadequate to assess renewable energy technologies. He described a broader perspective he presented in a "total value proposition" model. Using this perspective, Peters suggests that including all the benefits of solar energy significantly increases the competitive viability of photovoltaic technology. While these benefits can be grouped in different general categories, the benefits to the "end user" are not limited to financial valuations, but extend to social and environmental benefits. Peters' model can be incorporated into valuation processes and the frameworks of marketing strategies. However, the conventional benefit / cost analysis used in evaluating marketing campaigns may struggle to identify the complexities of this extended value model put forth by Peters and the National Renewable Energy Laboratories.

Summary

The topic of solar energy represents a dynamic set of potential value points for prospective customers. Electric energy is a regulated commodity that is created by a wide variety of generation techniques but delivered primarily via a standardized grid-tied connection system prevalent in many nations of the world. It is suggested that photovoltaic energy requires a wider evaluation criteria than per-kilowatt costs alone. Scholars have identified independent investment aspects of solar energy but few have attempted to tie key potential market factors into a broad international analysis. Cultural, economic and political advances are currently proceeding at individual rates in each of the nations examined in this study. This represented a fascinating contradiction because few products are as well suited technically for global implementation as photovoltaic modules due to their relative uniformity in design. This research develops a matrix approach to evaluate market potential for each nation based upon three identified market factors. From the perspective of the multinational firm seeking to compete in a foreign market the question remains: what drives adoption rates of photovoltaic technologies? In particular, should firms strive to appeal to public benefits or private benefits when marketing solar energy products to increase market share? Should firms position this as a social issue or as a simple economic consideration?

This research examined a total of twenty nine different countries over a span of thirteen years, from 1992 to 2005 inclusively. Nations were divided by the classification guidelines of the World Bank in terms of economic production into categories of developed nations, newly industrialized nations and emerging markets. Note that a majority of the countries in the sample were developed nations (55%) while a minority of nations was classified as emerging markets (17%).

Major multinational manufacturers (See Appendix A: Table 14) such as BP, Kyocera, Sharp and Schott, are in the difficult position of competing in highly varied markets around the world, often against other fuel types that have significantly entrenched infrastructure and facilities. These entrenched energy firms logically have long-term relationships with their markets in developed countries, establishing a confident in the service and brand they represent. In the major PV markets around the world, no manufacturer approaches the levels of market penetration of entrenched energy providers. This observation is considered significant for this research because it is important to identify what market factor, or factors, will be successful as a market stimulus. Energy consumers investigating renewable energy alternatives such as photovoltaics will be considering a significant shift in their individual level of participation in a given location's electrical supply. As discussed, early adopters may use one set of decision criteria where second generation consumers may apply more pragmatic decision criteria. The three factors being evaluated were selected to begin the process of better understanding how these second generation consumers may evaluate photovoltaic technologies.

Of the three major markets for photovoltaic equipment, installation levels of PV systems are most fragmented in the United States, where each state offers different combinations of incentives, ranging from personal income tax reductions, corporate tax reductions, sales tax exemption, property tax reductions, rebates, grants, loans or production incentives. Each of these alternative financial incentives can potentially affect the installed cost per module by as much as 50% within that given state. These incentives do not include the flat 30% national renewable energy tax credit that is currently capped at 30% or $2,000 for residential and a flat, un-capped 30% for most commercial installations. Within the United States, federal and regional incentives can be combined to provide aggregate financial incentives in many markets. To date, states with more generous incentive options, such as California and New Jersey, have significantly higher installed PV capacity when compared to states with no incentives (NREL 2006).

Presently, most developed countries access electricity by means of large grid systems where the sourcing of electricity can vary by generation method. Often, each country incorporates a blend of nuclear, hydropower, natural gas and petroleum-based fuels to supply necessary electrical demands. The convenience of using a grid system tied into regional generation capabilities has removed the ownership factor from the end user. Most major economic markets are predicated upon dependable, reasonably priced electrical services. Few firms and even fewer residential customers ever consider what it takes to generate enough electricity to supply a given location to the expectations of a modern electric consumer. It is these expectations of end users that are a major hurdle for multinational firms producing PV technologies. The degree of ownership and necessary involvement levels are significantly different than with commercial electric utilities. Large, grid-based distribution systems have been developing for the last one hundred years and are fully integrated into the economies of all developed nations. This entrenched position also may prevent consumers from thinking about competitive alternatives for electricity or to investigate the actual price per kilowatt generated by commercial means.

The PV industry, as with most other forms of renewable energy, is predicated upon the end user taking a more direct role in the production of a location-based energy source. From design to monitoring, most PV systems are not "set and forget" as is with a conventional electricity utility connection. To increase market share of PV systems, multinational firms must facilitate a paradigm shift in which end users assume some degree of energy independence and awareness. The variety of potential motivations to leave an established utility may range from volatility of utility pricing, reliability of service, environmental consciousness, security concerns, or independence from a local monopolistic utility. All major power companies with their integrated delivery systems have had, at some point, a disruption to their end users to some degree. In the United States, California has experienced rolling brown-out or blackouts that unexpectedly disrupt power to both commercial and residential areas. Multinational firms that produce PV products and systems must develop a method of educating prospective end users that will overcome the perceived risk of leaving these established electrical utilities. The migration path for a potential customer, either residential or commercial, is a critical consideration of the multinational manufacturers of PV systems if deeper market penetrations are to be experienced.

The combination result of varied market conditions, delivery methods, role of government and the other variables discussed lead to the following question. How can multinational manufacturers of photovoltaic equipment achieve higher levels of adoption for their technologies? This research intends to determine what marketing strategies will maximizing growth of photovoltaic capacity in three current market environments in developed, newly industrialized and developing nations.

Hypothesis Statements

The first group of hypotheses deals with the issue of price of utility provided electricity as a potential factor of adoption for photovoltaic technologies.

Predicted Results: Price of Commercial Electricity

Nations that have higher priced utility supplied electricity are ***more receptive*** to adopting alternative electrical generating technologies such as photovoltaics as measured by installed capacity as measured in total kilowatts of photovoltaics. (Refer to Table 1.)

\+ Positive effect predicted (more receptive to PV as an alternative)

\- Negative effect predicted (less receptive to PV as an alternative)

0 No effect predicted

Table 1: Predicted results of price as a factor of installed capacity of photovoltaics

	Developed Industrial Nations	**Newly Industrialized Nations**	**Developing Nations**
High Price of utility supplied electricity	+	+	+
Low Price of utility supplied electricity	-	-	-

$H_{1a:}$ Developed industrialized nations with high prices of utility provided electricity are more receptive to the adopting photovoltaic technologies than nations with low prices of utility supplied electricity.

$H_{oa:}$ Developed industrialized nations with high prices of utility supplied electricity have similar adoption rates as all other developed nations.

H_{1b} : Newly industrialized nations with high prices of utility provided electricity are more receptive to the adopting photovoltaic technologies than nations with low prices of utility supplied electricity.

H_{ob} : Newly industrialized nations with high prices of utility supplied electricity have similar adoption rates as all other newly industrialized nations.

H_{1c} : Developing industrialized nations with high prices of utility provided electricity are more receptive to the adopting photovoltaic technologies than nations with low prices of utility supplied electricity.

H_{oc} : Developing industrialized nations with high prices of utility supplied electricity have similar adoption rates as all other developing nations.

The second group of hypotheses deals with the potential market factor of carbon dioxide as a proxy for pollution of a given nation. It is hypothesized that nations with concerns for pollution most commonly stemming from carbon based fuels may seek photovoltaics as an alternative energy source based upon the feature benefits that photovoltaics provide. If pollution is the underlying market driver for renewable energies, then marketing campaigns can tailor their communications accordingly.

Predicted Results: Carbon Dioxide Emissions

Nations that have high levels of carbon dioxide emissions (CO2) per capita are ***more receptive*** to adopting new technologies such as photovoltaics as measured by installed kilowatts of capacity within a given nation. (Refer to Table 2)

\+ Positive effect predicted (more receptive to PV as an alternative)

\- Negative effect predicted (less receptive to PV as an alternative)

0 No effect predicted

Table 2: Predicted results of CO2 as a factor of installed capacity of photovoltaics

	Developed Industrial Nations	**Newly Industrialized Nations**	**Developing Nations**
High levels of CO_2	+	+	-
Low levels of CO_2	-	-	-

H_{2a} : Developed nations with high levels of carbon dioxide are more receptive to the adopting photovoltaic technologies than nations with low levels of CO_2 .

H_{2o} : Developed nations with high levels of carbon dioxide have similar adoption rates as all other developing nations.

H_{2b} : Newly nations with high levels of carbon dioxide are more receptive to the adopting photovoltaic technologies than nations with low levels of CO_2

H_{2o} : Newly industrialized nations with high levels of carbon dioxide have similar adoption rates as all other developing nations.

H_{3a} : Developing nations with high levels of carbon dioxide are more receptive to the adopting photovoltaic technologies than nations with low levels of CO_2.

H_{20} : Developing nations with high levels of carbon dioxide have similar adoption rates as all other developing nations.

The third group of hypotheses focuses on the role of financial incentives in the purchase of photovoltaic equipment. Around the world, there are a variety of financial incentives including rebates, feed-in-tariffs or other monetary programs that are designed to diminish the initial investment in equipment or provide a supplemental income stream based upon electricity generated in a grid-tied system. A feed-in tariff is a regulated amount per unit of electricity generated paid back to a location owner that generates electricity by means of photovoltaic technology. Feed-in tariffs are most common in Germany and have been identified as providing benefits that may promote initial investment as well as long term commitment to photovoltaic installations. Financial incentives can be offered by a national government or a regional government such as an individual state in the United States. This group of hypotheses was introduced as a dichotomous variable allowing a general grouping of all the variations for financial incentives into a simple determination for each given nation. Either a country offers incentives or they do not and level or type is not considered. It should be noted that not all nations offer incentives that qualified for this study or that not all forms of incentives were present during all years of the sample.

The hypotheses for financial incentives are as follows:

Predicted Results: Governmental Incentives for Environmental Protection

Nations with financial incentives for environmental investment are ***more receptive*** to adopting photovoltaics technologies as measured by installed kilowatts.

+ Positive effect predicted (more receptive to PV as an alternative)

- Negative effect predicted (less receptive to PV as an alternative)

0 Varied effect predicted

Table 3: Predicted results of incentives as a factor of installed capacity of photovoltaics

	Developed Industrial Nations (A)	**Newly Industrialized Nations (B)**	**Developing Nations (A)**
Presence of financial incentives.	+	+	+
No financial incentives.	0	-	-

H_{3a} : Developed nations with any form of financial incentives are more receptive to the adopting photovoltaic technologies than nations without government financial incentives.

H_{3o} : Developed nations with financial incentives have similar adoption rates of photovoltaic technologies as all other developed nations.

H_{3b} : Newly industrialized nations with any form of financial incentives are more receptive to the adopting photovoltaic technologies than nations without government financial incentives.

H_{3o} : Newly industrialized nations with financial incentives have similar adoption rates as all other newly industrialized nations.

H_{3c} : Developing nations with any form of financial incentives are more receptive to the adopting photovoltaic technologies than nations without government financial incentives.

H_{30} : Developing nations with financial incentives have similar adoption rates as all other developing nations.

Methodology

A set of mixed ANOVA models were used for this research to best measure each proposed dependent variable (price, CO2 and financial incentives) separately.

Hypothesis H1 (Price) representing hypotheses 1-3, had a 2 x 3 mixed ANOVA with the first factor (between subjects), price of electricity having 2 levels. The second factor, (between subjects), nation type, having 3 levels, and the third factor (within subjects). For H2 (CO2 levels), a 2 x 3 matrix ANOVA was used with the first factor (between subjects), CO2 emissions had two levels and the second factor time (within subjects) had five levels.

For H3 (financial incentives) a 2 x 3 matrix ANOVA was used with the first factor (between subjects), financial incentives, had two levels while the second factor time (within subjects) had two levels.

As stated, the primary objective of this research was to investigate the relationship among utility-supplied electricity prices, levels of carbon emissions as a proxy for environmental concerns, government or financial incentives, and the dependent variable, installed photovoltaic capacity in the selected list of countries. To this end, a repeated-measures analysis of variance was conducted to identify the relationship of one or more of the factors as a method to identify potential strategies to grow photovoltaic technologies. Identified factors can be featured in future marketing strategies, potentially increasing the impact and effectiveness of varied marketing media. In the following section, the descriptive statistics of the study's variables are presented. Following that, the results vis-à-vis the hypotheses will be discussed.

Descriptive Statistics

A description of the study sample is provided in Table 4 below. Note that a majority of the countries in the sample were developed nations (55%) while a minority was developing countries (17%). Measurable installed photovoltaic capacity for many newly industrialized and developing countries is difficult to obtain and establishing the integrity of the data was also challenging. Category of nation is derived based upon classification criteria defined by the World Bank in terms of GDP per capita and other economic criteria. The three levels of nations are designed to represent a variety of economic and institutional developments that affect the overall photovoltaic market.

Table 4: Descriptive Statistics

Description of Study Sample

Variable	Frequency	Percentage
Categories of Countries		
Developed	16	55.17
Newly Industrialized	8	27.59
Developing	5	17.24
Electricity Price		
Low	12	41.38
High	16	55.17
Missing	1	3.44
Level CO2 Emissions		
Low	14	48.28
High	15	51.72

The mean, standard deviation, and skewness for the study's dependent variable, installed photovoltaic capacity, is presented in Table 5. The measures were highly skewed; therefore, the measures were transformed using a square root transformation.

Table 5:

Descriptive Statistics for Photovoltaic Growth Across Time in Years

Variable	N	Range	Mean	SD
1995	29	0 to 115	5.95	21.825
1996	29	-12 to 110	5.99	21.112
1997	29	0 to 66	6.10	16.392
1998	29	-12 to 172	10.73	34.469
1999	29	0 to 189	12.74	36.996
2000	29	0 to 207	18.37	46.079
2001	29	-6 to 117	14.00	30.073
2002	29	0 to 161	20.44	43.771
2003	29	-8 to 512	49.53	137.276
2004	29	0 to 578	48.34	148.338

Upon completion of the square root transformation, skewness improved by a point or two (skewness values of the transformed variables ranged from 1 to 3); the transformed variables were used in all succeeding analyses.

Table 6 describes the ten year period and the range of fundamental statistical results for each period as it pertains to price of commercial electricity and the changes in installed photovoltaic capacity when segregated by nation type. To date, monthly or other more detailed data does not exist on a consistent basis for all but a few of the largest, most developed nations.

Hypotheses 1A-1C

The following sections summarize the results and analysis of the study as it relates to the research propositions addressed in Chapter 1. The initial hypotheses focus on the influence of price of commercially, available electricity in relation to the changes of installed capacity within the categories of nations:

It was hypothesized that, in comparison to nations with low prices of utility supplied electricity, nations with high prices of electricity would be less resistant to adopt photovoltaic technologies, regardless of nation type. As can be gleaned from Tables 4, 5, 6 and 7, this hypothesis was not confirmed. The main effect for electricity price was not statistically significant ($F = .080$, $p = .288$) when analyzed by groups of nations or level or price (high or low). First, on average, the increase of photovoltaic capacity in developing nations was about the same as the increase of photovoltaic capacity in both newly-industrialized countries and developed countries ($F = 1.193$, $p = .288$). In addition, there was no significant difference in photovoltaic capacity between developed countries and newly-industrialized countries ($F = .075$, $p = .786$).

Table 6

Photovoltaic Installed Capacity as a Function of Nation Type and Electricity Prices

	Low Prices			High Prices		
Time Period (Year)	Developed N = 6	NIC N = 3	Developing N = 4	Developed N = 10	NIC N = 5	Developing N = 1
1996						
Mean	2.02	2.49	.00	3.68	23.26	.00
SD	4.95	4.32	.00	9.44	51.29	
1997						
Mean	1.03	6.12	.00	3.86	22.10	.00
SD	8.37	10.60	.00	8.00	49.14	
1998						
Mean	12.00	6.04	.03	1.55	14.26	.00
SD	24.00	10.46	.05	3.73	29.01	
1999						
Mean	3.06	6.57	.00	9.59	35.46	.00
SD	14.20	11.39	.00	22.67	76.36	
2000						
Mean	10.22	7.56	.05	9.27	38.49	.00
SD	21.25	13.09	.10	18.02	84.32	
2001						
Mean	17.66	8.95	.00	18.91	42.17	.00
SD	32.00	15.51	.00	40.88	92.22	
2002						
Mean	21.89	12.09	.00	22.08	3.53	.00
SD	47.60	20.94	.00	34.04	5.60	
2003						
Mean	25.28	11.52	.01	34.37	12.56	.00
SD	59.03	19.95	.02	56.11	24.40	
2004						
Mean	85.33	10.67	.30	81.82	14.57	.00
SD	206.10	18.48	.60	173.08	31.95	
2005						
Mean	7.00	14.52	.48	72.95	116.96	.00
SD	17.15	25.15	.56	180.55	257.50	

Units: Installed Photovoltaic Capacity in Mw.

Table 7

ANOVA Results for PV Installed Capacity as a Function of Nation Type and Electricity

Prices

Variable	SS	df	MS	F	Sig.
Between Groups					
Electricity	10.405	1	10.405	.080	.780
DING vs. D, NIC (N1)	155.163	1	155.163	1.193	.288
D vs. NIC (N2)	9.751	1	9.751	.075	.786
E x N1	5.462	1	5.462	.042	.839
E x N2	3.77	1	3.77	.029	.866
Error	2471.167	19	130.061		
Within Groups					
Linear trend	43.133	1	43.133	1.847	.190
E x linear trend	4.063	1	4.063	.174	.681
N1 x linear trend	12.657	1	12.657	.542	.470
N2 x linear trend	27.954	1	27.954	1.197	.288
E x linear x N1	2.662	1	2.662	.114	.739
E x linear x N2	11.653	1	11.653	.499	.488
Error	420.354	18	23.353		

Exceptions to these conclusions were discovered however when analysis was performed removing price levels (high and low) but retaining nation classification to determine the predictive accuracy of the linear equations. Results of this analysis yielded interesting exceptions to the analysis of variance procedure. It is concluded that price of commercial electricity is a factor in the increased adoption of photovoltaics when level of price is removed and all nations grouped by nation classification only. These results conclude that price of commercial utility electricity is a significant factor. Therefore, price should be included in future marketing strategies of solar equipment products as well as the assessment of future potential market evaluation techniques.

Table 8

Nation Classification: Price of Commercial Electricity

	Developed	Newly Industrialized	Developing
Price of Commercial Electricity in US $	R^2 = .881	R^2 = .240	R^2 = .899

Dependent Variable: Total Installed Photovoltaic Capacity in Mw.

Regression results conclude that price is a market factor in both developed (H_{1a}) and developing nations (H_{1c}) but not so in newly industrialized nations. Predicted results stated that all nations with high priced utility supplied electricity would be less resistant to adopting photovoltaic technologies. It is unclear as to why newly industrialized nations did not demonstrate predicted results where both developed and developing nations did perform as predicted. It is also unclear as to why regression results would vary from analysis of variance results so significantly for this independent variable.

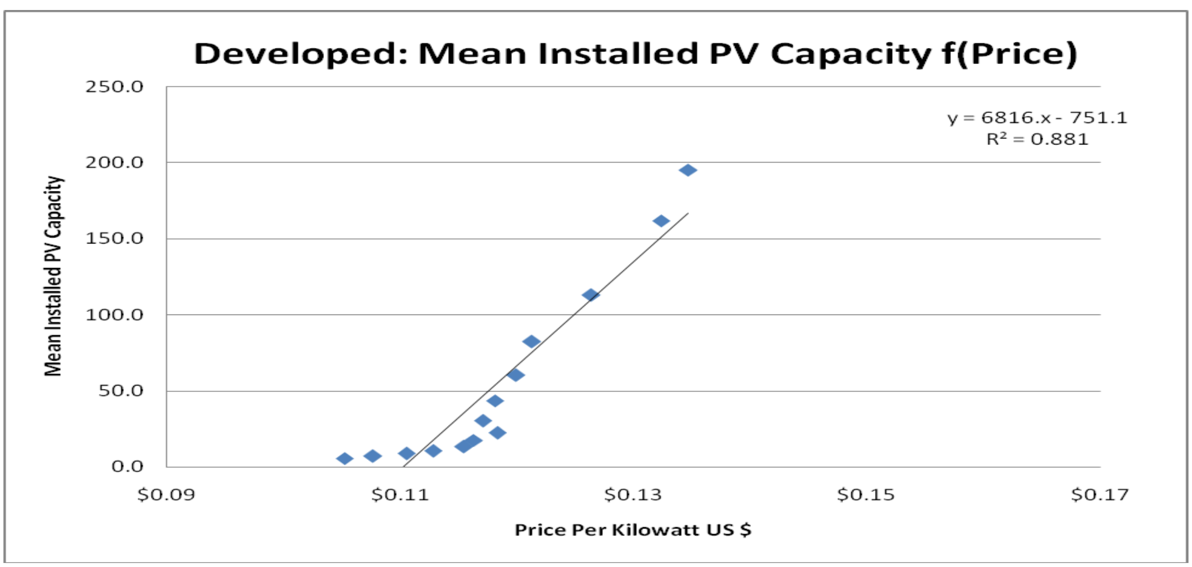


Figure 2: Developed nations mean installed photovoltaic capacity as a function of price

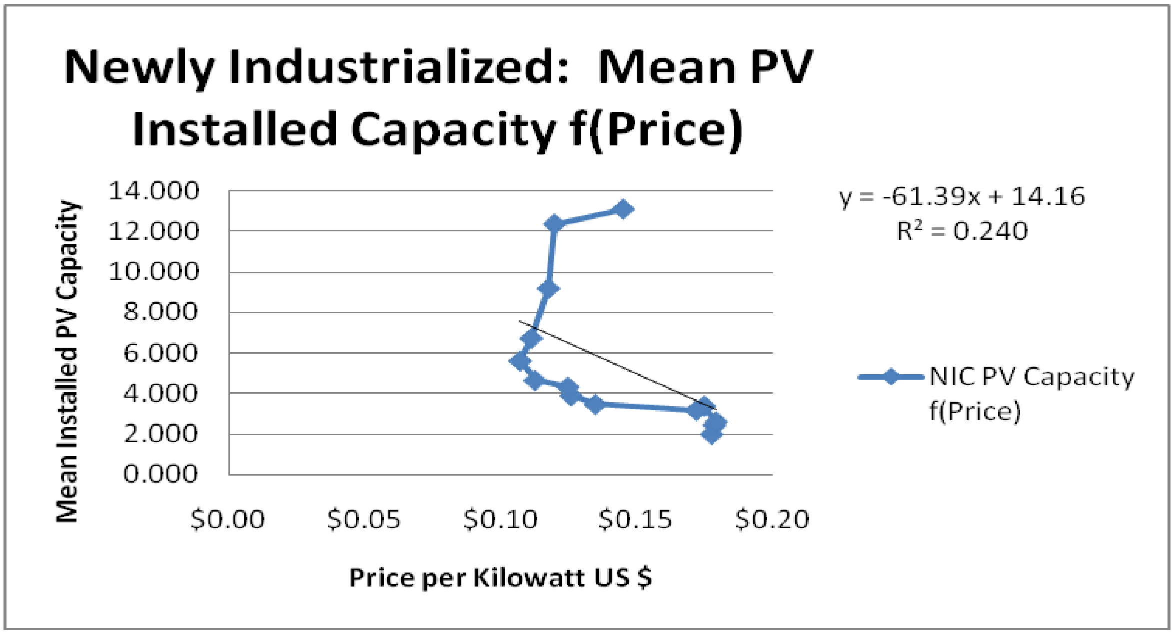


Figure 3: Newly industrialized nations mean installed photovoltaic capacity as a function of price

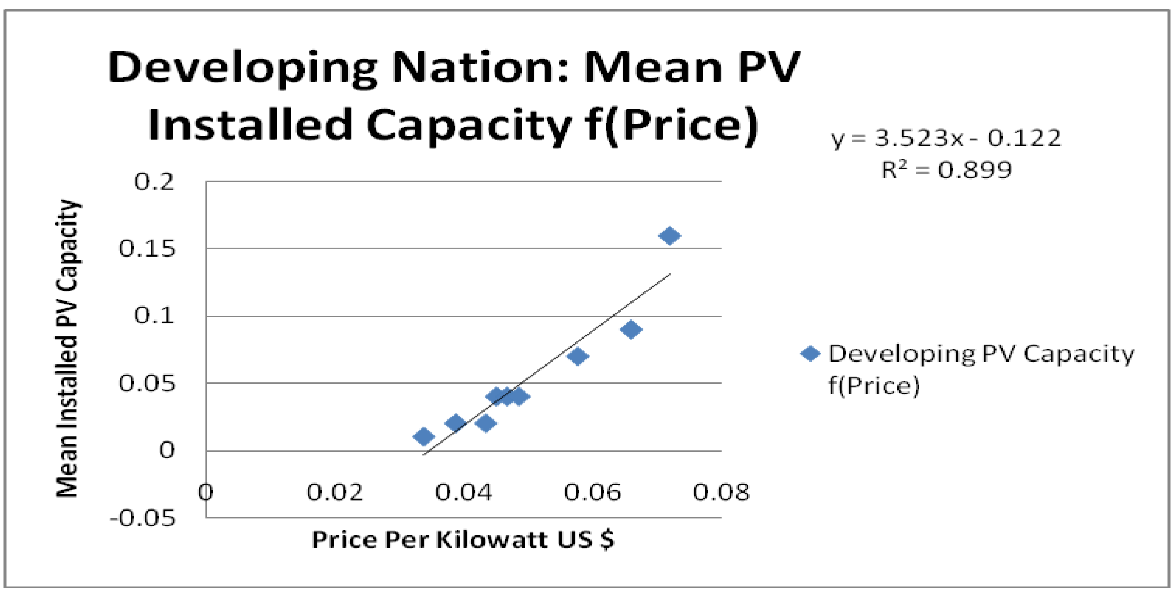


Figure 4: Developed nations mean installed photovoltaic capacity as afunction of price

Additional individual nation analysis demonstrates additional exceptions to the initial analysis of variance results. Secondary analysis was performed by using linear regression to measure the impact of the single independent variable of price of commercial electricity as a function of identifying changes in installed capacity of photovoltaic modules within a given nation. Results show significant variation within each nation supporting the conclusion that price may be a relevant marketing factor in some nations while not in other nations.

Table 9: Country Capacity Comparison Developed Nations

Country	**R^2**	**Mean Installed Photovoltaic Capacity (Kw)**
Germany	.842	217.282
Japan	.570	94.64
United States	.834	28.357
France	.258	10.92
Canada	.540	10.832
Switzerland	.518	9.64
Norway	.115	5.00
Austria	.164	4.01
Australia	.606	2.071
Finland	.823	1.857
United Kingdom	.089	1.42
Denmark	.828	.714
Belgium	0	.142

Results of individual nation by nation regression analysis demonstrate a wide range of results suggesting significant potential exceptions to the factor of price as it relates to increased installed photovoltaic capacity. These results suggest additional factors contribute to the lack of a general linear trend within similar nation classification as it pertains to the factor of price.

Hypotheses 4-6

The following sections summarize the results and analysis of the study as it relates to the research propositions addressed in Chapter 1. The second set of hypotheses focus on the influence of carbon dioxide levels as a proxy for concern for pollution in relation to the changes of installed capacity within a the categories of nations. It was hypothesized that, in comparisons to nations with high levels of carbon dioxide emissions, nations with low levels of carbon dioxide emissions would be more resistant to adopting photovoltaic technology. As presented in Tables 11 and 12, this hypothesis was not confirmed. The main effect for carbon dioxide emissions was not statistically significant ($F = .101$, $p = .753$). The only statistically significant effect was a linear photovoltaic trend; that is, photovoltaic growth increased linearly across time, regardless of carbon dioxide emissions level ($F = 6.352$, $p = .019$).

Table 11

Photovoltaic Installed Capacity as a Function of Level of Carbon Dioxide Emissions

Time Period	Low (N = 14)	High (N = 15)
1995		
Mean	10.44	1.77
SD	31.13	3.71
1996		
Mean	9.60	2.61
SD	29.59	7.27
1997		
Mean	5.27	6.89
SD	17.54	15.83
1998		
Mean	17.80	4.14
SD	48.33	10.54
1999		
Mean	17.87	7.94
SD	51.04	16.36
2000		
Mean	25.76	11.47
SD	62.77	21.96
2001		
Mean	8.25	19.37
SD	22.75	35.56
2002		
Mean	14.14	26.31
SD	31.93	52.99
2003		
Mean	26.36	71.15
SD	73.35	177.92
2004		
Mean	49.76	47.01
SD	154.68	147.60

Table 12

ANOVA Results for PV Installed Capacity as a Function of Level of Carbon Dioxide Emissions

Variable	SS	df	MS	F	Sig.
Between Groups					
CO2	12.096	1	12.096	.101	.753
Error	2750.111	23	119.570		
Within Groups					
Linear trend	145.601	1	145.601	6.352	.019
CO2 x linear trend	18.200	1	18.200	.794	.382
Error	504.284	22	22.922		

A second analysis was performed removing level as was done with the previous independent variable of price. Nation classification was retained. When linear regression analysis was performed, levels (high and low) of carbon dioxide were removed and groups of nation type were analyzed with the following results. No nation classification group was statistically significant as the result of this analysis. These results conclude that concern for pollution as represented by proxy of levels of carbon dioxide per capita is not a significant factor resulting in increased photovoltaic capacity with these nation classifications.

Table 13

Nation Classification: Carbon Dioxide

	Developed	Newly Industrialized	Developing
Tones of Carbon Dioxide Per Capita	R^2 = .331	R^2 = .023	R^2 = .052

- Dependent Variable: Total Installed Photovoltaic Capacity in Mw

A limited number of individual nations were removed from the categories of developed, newly industrialized and developing nations and individually analyzed to see if country results were similar. Individual country regression analysis was performed to provide additional clarity of analysis and to attempt to identify any exceptions nation group conclusions. Regression results identify that some nations, Austria (R^2 .801) and Australia (R^2 .810) did have high correlation in the direction in opposition to the overall trend. Hence, there are exceptions that support the conclusion of a multi-domestic approach. Other developed nations such as Germany (R^2 .313) and the United States (R^2 .260) did not demonstrate significant statistical results for the factor of carbon dioxide. For the purpose of this research, the factor of carbon dioxide has been positioned as a proxy for global warming. Over the past ten years, the topic of global warming has migrated from being a predominantly scientific issue to a more mainstream topic presented in a variety of contemporary literature. During the 1997 negotiations of the Kyoto Treaty, levels of carbon dioxide were positioned globally as a measurement of the overall environmental health of the plant when comparing nations. Carbon dioxide levels are a major greenhouse gas contributing factor, therefore, monitoring the levels of carbon dioxide has become an important statistic. While clearly not the only measurement of environmental concern, it is necessary to develop a method comparing multiple nations and the bi-products of conventional industrial energy generation technologies. The findings in this research are significant in that the independent factor of levels of carbon dioxide is not statistically significant for explaining adoption of photovoltaics. Results of this research conclude that consumers do not appear to be reacting directly to the reduction of carbon dioxide as a reason to purchase photovoltaic systems. Firms in the photovoltaic industry may decide to adjust the emphasis placed upon the focus on the reduction of carbon dioxide, as a benefit of solar energy. The results of this research bring into question the effectiveness of presenting pollution reduction as a primary marketing strategy to promote the implementation of photovoltaic technologies. Future research may seek to discover with more clarity the role of this factor plays as a marketing strategy or with combination of other environmental measurement criteria.

High and low levels of carbon dioxide as defined by range of values of all studied nations.

Figure 7: Developed nations installed capacity as a function of carbon dioxide

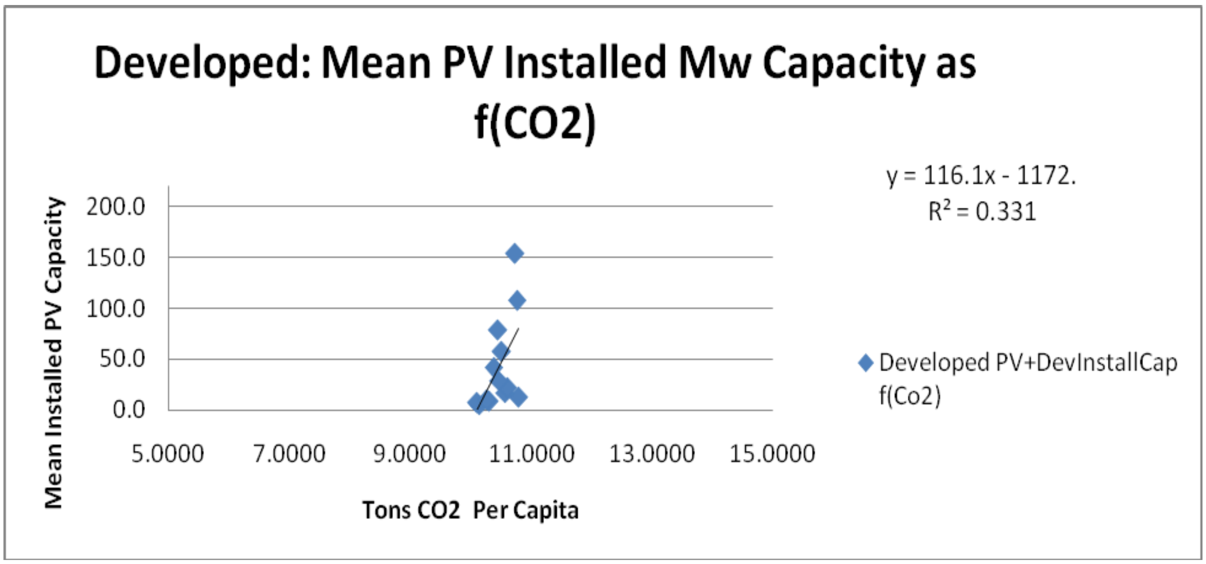


Figure 8: Newly industrialized nations installed capacity as a function of carbon dioxide

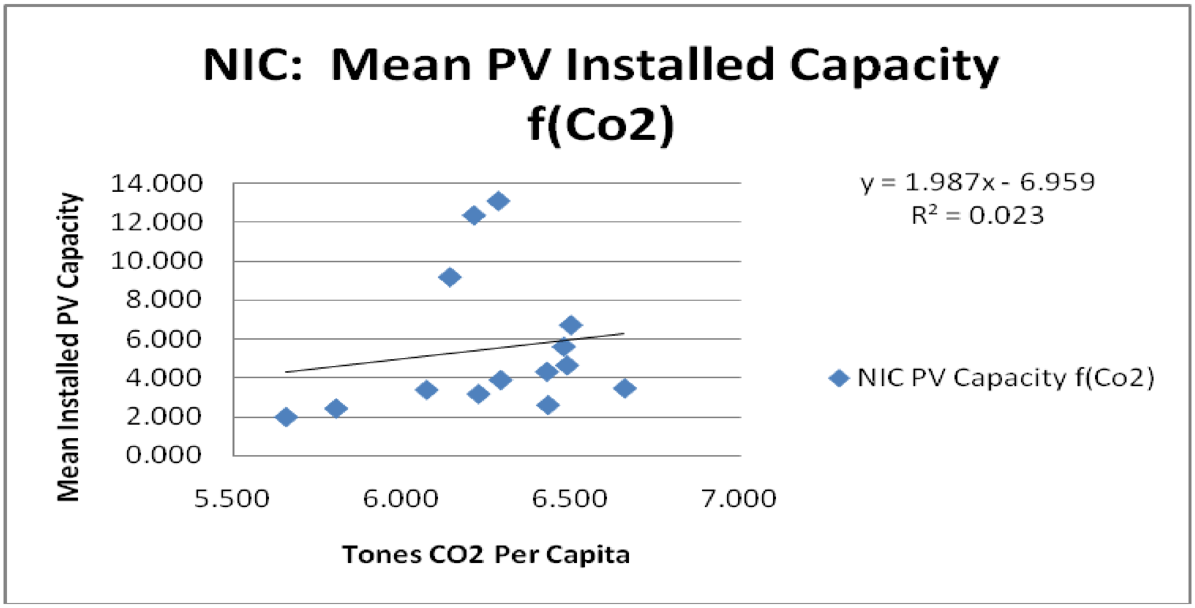
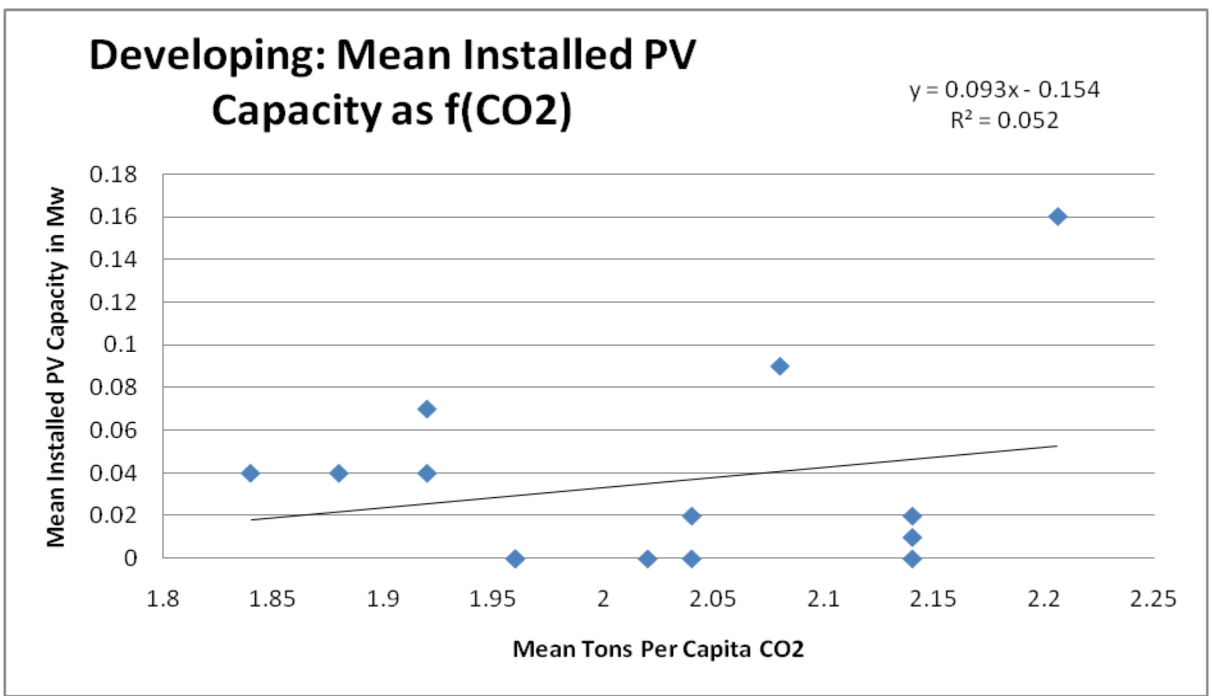


Figure 9: Developing nations installed capacity as a function of carbon dioxide



Hypotheses 7-9

The following section summarizes the results and analysis of the study as it relates to the research proposition in Chapter 1 and the potential role of financial incentives.

It was hypothesized that, in comparison to nations that have governmental financial incentives for environmental protection, those nations that do not have governmental financial incentives will be more resistant to adopting photovoltaic technology. As can be gleaned from Tables 13 and 14, this hypothesis was supported. In particular, there was a significant interaction effect between the linear trend and government or financial incentives ($F = 4.826$, $p = .038$). Thus, photovoltaic growth increased across time and this linear trend was moderated by government incentives. Nation type is also significant as none of the nations in the sample classification developing nations offered government or financial incentives. As Figure 10 illustrates, there was an increase in photovoltaic capacity in developed nations whose governments provided financial incentives. There was no growth (i.e., no linear trend) in increased photovoltaic capacity in nations whose governments did not provide financial incentives (Figure 12). This is a critical finding to support the claim that financial incentives are a necessary component in the development of the solar energy industry. Financial incentives benefit the industry by providing financial assistance to overcome the significant initial investments therefore increasing the number of installations within that country. When financial incentives are offered, the barrier to entry is reduced.

Table 13: Photovoltaic Installed Capacity as a Function of Government Financial Incentives

As Measured in Installed Megawatts of Installed Capacity

Time Period	Nations With No Financial Incentives (N = 16)	Nations With Financial Incentives (N = 13)
1995		
Mean	7.72	3.78
SD	28.67	8.65
1996		
Mean	8.31	3.13
SD	27.51	8.84
1997		
Mean	5.59	6.74
SD	16.76	16.59
1998		
Mean	12.30	8.80
SD	42.88	21.60
1999		
Mean	13.58	11.70
SD	47.20	20.17
2000		
Mean	15.69	21.67
SD	51.49	40..24
2001		
Mean	3.23	27.26
SD	9.62	40.61
2002		
Mean	7.69	36.13
SD	36.13	60.55
2003		
Mean	6.14	102.93
SD	19.36	194.69
2004		
Mean	40.14	158.43
SD	143.73	159.12

Table 14: ANOVA Results for PV Growth as a Function of Financial Incentives

Variable	SS	df	MS	F	Sig.
Between Groups					
Financial Incentives	166.167	1	166.167	1.472	.237
Error	2596.041	23	112.871		
Within Groups					
Linear trend	168.647	1	168.647	8.604	.007
FI x linear trend	94.594	1	94.594	4.826	.038
Error	431.222	22	19.601		
Quadratic trend	.095	1	.095	.011	.918
FI x quadratic trend	2.320	1	2.320	.270	.608
Error	189.024	22	8.592		

FI= Financial Incentives

While not measured in this study, it can be implied that when a state or government provides financial incentives, there is an implied stability to the photovoltaic industry that can serve as an additional benefit of providing legitimacy to solar energy as an alternative to commercial electricity. This may also encourage the growth of complimentary products and service firms providing installation, monitoring and educational capabilities. These complimentary firms increase competition and consumer choice within the industry potentially accelerating both the awareness of the incentives and subsequently the technology itself. If in fact, the cycle of adoption of photovoltaics begins with financial incentives, then marketing strategies need to emphasis this factor above all others when developing a marketing strategy. Manufacturing firms in this sector must plant a “golden seed” that may ultimately germinate the entire industry.

Figure 10|

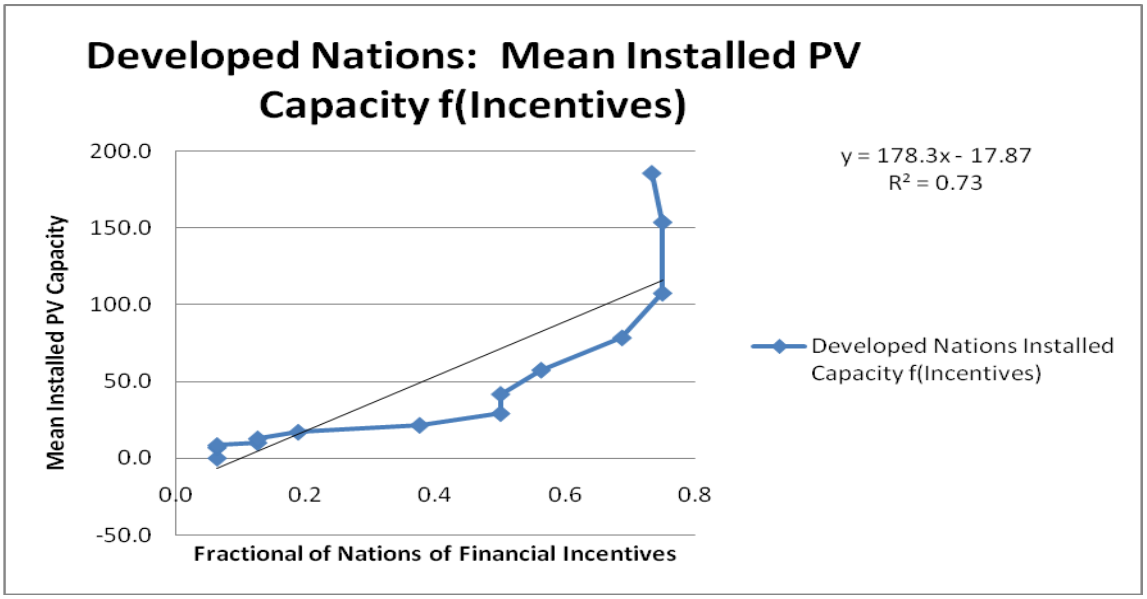


Figure 11

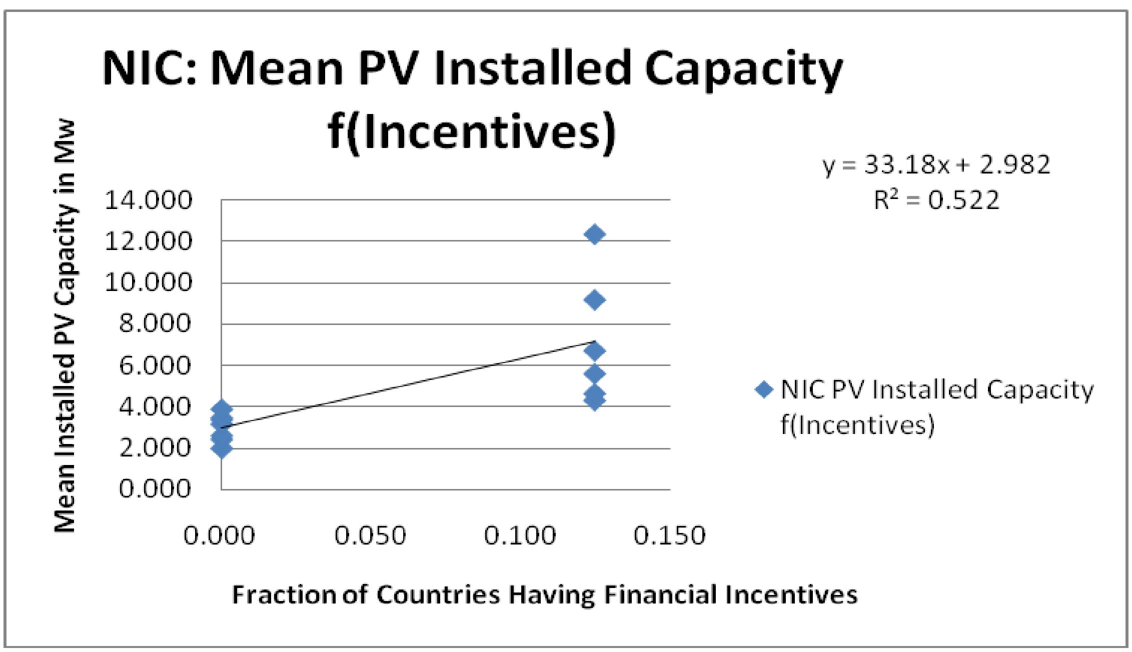
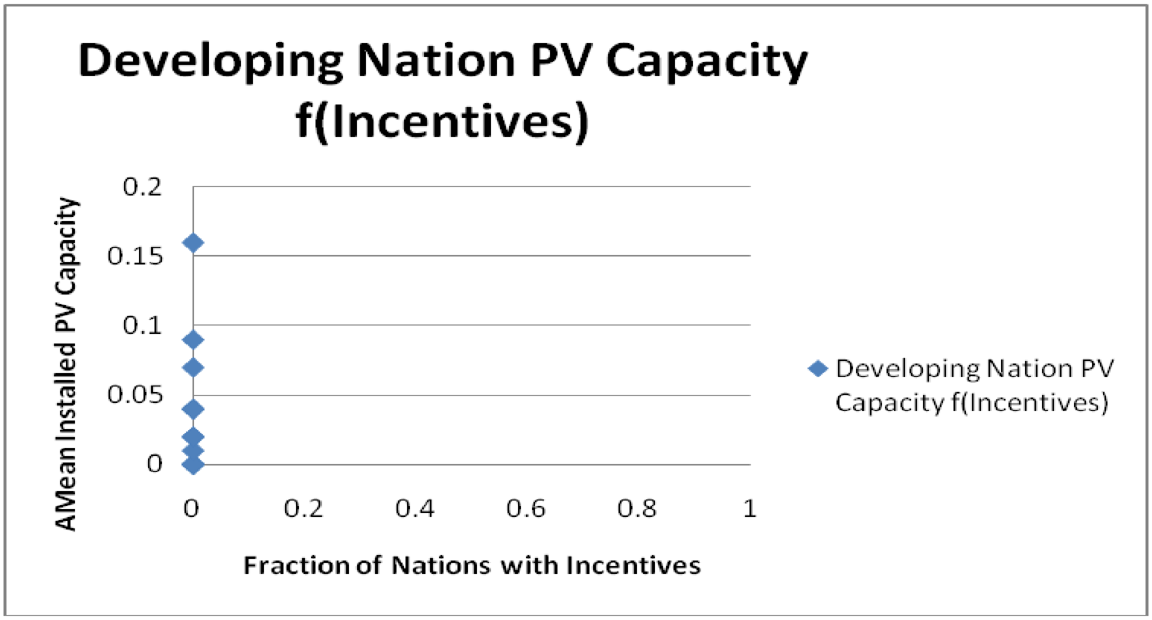


Figure 12



Case Study 1: Germany and the United States Case Study Results

A survey was administered in a case study format to measure end-users of installed photovoltaic customers within the two major markets of Germany and the United States to identify actual purchasing criteria. Surveys were administered in Germany and the United States to gather data on the perceived benefits of photovoltaics and how these consumers valued the factors during individual decision processes. The three key factors of interest in the survey were the same as conducted in the twenty nine nation research. Measurements of both qualitative and quantitative responses were applied to this case study approach to help determine the causal factors relating to the varied rates of growth in these key markets. Ten survey questions were developed to represent how the three identified factors influenced the decision to switch away from centrally distributed utility-based electricity to a photovoltaic, independent generation of electricity alternative. The survey was completed by a total of fifty one customers in these markets and the results were tabulated to identify priorities of decision criteria. The process of leaving established, utility-provides electrical services, to initiate location-based renewable energy such as photovoltaics, includes multiple potential influential factors. The results of the survey provide insight into consumer behaviors that can be incorporated into subsequent marketing strategies of photovoltaic equipment.

Dissertation Survey Questions

Sample Responses: Germany N= 22 United States N=29

1. What was the primary motivating factor for the purchase of a photovoltaic system for your home or business?

a. To reduce dependency upon other types of fuel to generate electricity.
b. To establish a fixed, predictable cost of electricity for the future.
c. To be environmentally friendly and limit pollution.
d. To utilize the tax incentives or rebates available in our country.
e. Independence from my current electric utility.

	Germany		United States	
a	1	4.5%	1	3.4%
b	2	9.1%	4	13.8%
c	3	13.6%	5	17.2%
d	16	72.7%	18	62.1%
e	0	0.0%	0	0.0%
a	1	4.5%	1	3.4%

2. Was this your first renewable energy purchase for your home or business?
a. Yes
b. No

	Germany		United States	
Yes	19	86.4%	23	79.3%
No	3	13.6%	6	20.7%

3. When considering this purchase, was the decision based upon a traditional pay back calculation in terms of justification for the financial investment? (Payback, ROI, etc)

a. Yes
b. No

	Germany		United States	
Yes	15	68.2%	20	69.0%
No	7	31.8%	9	31.0%

4. From whom did you purchase your photovoltaic system?

a. The manufacturer
b. A distributor
c. An installer
d. As sales organization
e. Online
f. Other.

	Germany		United States	
a	2	9.1%	2	6.9%
b	1	4.5%	3	10.3%
c	11	50.0%	16	55.2%
d	4	18.2%	1	3.4%
e	4	18.2%	5	17.2%
a	0	0.0%	2	6.9%

5. Approximately how long was the time between your first consideration of installing a photovoltaic energy system to the date the system was purchase?

a. 1 day to one week
b. One week to one month
c. One month to three months
d. Three to six months
e. Six months to one year.
f. More than one year.

	Germany		United States	
a	0	0.0%	3	10.3%
b	7	31.8%	3	10.3%
c	8	36.4%	9	31.0%
d	4	18.2%	9	31.0%
e	2	9.1%	3	10.3%
f	1	4.5%	1	3.4%

6. Did the total amount of federal and or state and regional tax incentives combined with other rebates contribute more than 50% of the total system investment cost?

A. Yes
B. No

	Germany		United States	
Yes	12	54.5%	20	69.0%
No	10	45.5%	9	31.0%

7. Please estimate how much of your total electrical demand did the photovoltaic system is supplying?

a. 5% -10% of annual electricity needed for the location
b. 11-25% of annual electricity needed for the location
c. 26-50% of annual electricity needed for the location
d. 51-75% of annual electricity needed for the location
e. 75%- 100%
f. Greater than 100% it is intended to generate a surplus and is used for income generation for the site.

	Germany		United States	
a	0	0.0%	2	6.9%
b	3	13.6%	4	13.8%
c	3	13.6%	9	31.0%
d	6	27.3%	5	17.2%
e	8	36.4%	8	27.6%
f	2	9.1%	1	3.4%

8 In my location, my residence or company has access to a utility that offers commercial electricity that is generated by means of a form of renewable energy?

a. Yes
b. No
c. Not Sure

	Germany		United States	
Yes	6	27.3%	4	13.8%
No	8	36.4%	13	44.8%
Not Sure	7	31.8%	12	41.4%

9. Please rank the following purchase decision factors in order of significance to the decision to install a photovoltaic system at your location: (Rank 1-6 with 1 being the most significant decision criteria to 6 being the least significant.)

   a. Photovoltaic electricity does not generate any CO2 or other pollutions.
   b. Cost stabilization of electricity for long term.
   c. Cost of photovoltaic equipment and installation as an investment.
   d. Cost comparison of commercially available megawatt or electricity in relation to cost per megawatt of location based photovoltaic system.
   e. To contribute to the overall environmental benefits of our country.
   f. To make an effort to reduce consumption of traditional fuels such as oil or natural gas.

10. Please rank the following criteria as they applied to your decision to install a PV system? (1 being most important and 6 being lease important)

1) The brand name of the equipment and their reputation.
2) The suggestion of the local installer.
3) The product was made in my home country and I support the purchase of domestically produced products.
4) The lowest net price of the system combined with the available tax and rebate incentives.
5) A clear technological advantage of one manufacturer over the competition.
6) Other ____

	Germany		United States	
a	3	13.6%	3	10.3%
b	8	36.4%	13	44.8%
c	4	18.2%	3	10.3%
d	6	27.3%	6	20.7%
e	2	9.1%	4	13.8%
f	0	0.0%	0	0.0%

Survey Interpretation

The survey results yielded additional support for two key conclusions of this dissertation.

The first conclusion drawn from the survey responses is that financial incentives in the United States and Germany are a significant market stimuli positively impacting photovoltaic sales. In the United States, 62% of the respondents cited that financial incentives were the primary factor they chose to purchase photovoltaic technologies at that time. In Germany, the results were even higher, 73% indicated financial incentives (feed-in tariffs), as the primary motivating factor. The factor for the reduction of dependency upon other fuel types was only 3.4% for the US and 4.5% in Germany suggesting limited concern for the public good as presented in chapter three. Being environmentally friendly scored, 17% for the US and 14% in Germany further demonstrating an overall lack of concern for the public environmental issues.

A second key discovery of this research supports the claim that most photovoltaic systems are purchased from an installer and not the manufacturing firm directly. In the United States, 52% of the systems were purchased from a local installer, in Germany, the results show 50% of the respondents worked with a local installer. This represents a key opportunity for the manufacturing firms within this industry to develop stronger relationships with the local installers as a means to better position a specific manufacturer's brand. Results show that the majority of purchase decisions take between one to three months to complete indicating that this is not a long sales cycle. The potential influence of a local installer that can serve as a branded marketing agent represents the largest area of opportunity identified in this study.

The overall conclusion of this survey suggests that incentives and local installers are the two key factors that influence consumer behaviors during the purchase cycle of photovoltaics. Additional research and the expansion of the sample size would greatly improve upon these results however, fundamental conclusions can be drawn from this survey that support similar conclusions of the broader dissertation research.

CHAPTER FIVE: CONCLUSIONS

Implications for Multinational Firms

The results of this research are intended to provide multinational firms, in the international photovoltaics industry, a better understanding of how to communicate the benefits of solar energy in markets around the world. It is the opinion of this researcher that current marketing strategies are often too broad in that they attempt to address multiple potential benefits simultaneously, often resulting in un-focused marketing strategies. The resulting marketing message is not as effective is it could be and is not adjusted appropriately to any given market. It is the conclusion of this research that the benefits of solar power must be tailored to each potential market to maximize installed capacity rates. This research suggests that the primary factor that directly influences the adoption of photovoltaic technology is financial incentives. Rebates, tax credits or feed-in tariff programs were proven to be the most successful market stimuli across the twenty nine nations researched in this study. However, there are individual country exceptions that argue for a multi-domestic marketing strategy.

One of the biggest challenges facing the international photovoltaic industry stems from core consumer expectation about the service aspects of commercial electricity. Electrical consumers, in most developed and newly industrialized nations, expect dependable electrical services with little or no active involvement on their part. The convenience that commercial utilities have provided is a major barrier for all forms of renewable energy including photovoltaics. Large scale, entrenched electrical utility providers have set the expectations of the consumers to believe that electricity is not an active involvement service. For decades, consumers have outsourced their energy production and have abandoned the notion that each consumer will internalize energy generation in commercial or residential applications. The expectation of consumers is that markets will provide a product or service that addresses this need and that it is scalable such that consumers need not plan for increased or decreased energy demands. The markets have provided the solutions demanded and have been perceived as infinitely more convenient and practical than utilizing any form of internal electrical generation technologies. Photovoltaics (and many other forms of renewable energy) need to reverse this mind-set and encourage the benefits and values of consumer participation in the production of electrical energy. In previous years consumers grew their own vegetables; today a garden is a hobby not to be taken as a serious form of self sufficiency. The marketing strategy for solar energy must identify and address the core *individual* motivations that will initiate participation and begin to reverse the utility mentality of most consumers. This is why a marketing strategy that promotes a group or nation-based benefit has not been successful in growing photovoltaic adoption rates. Consumers of photovoltaics are aware and often motivated to benefit the community in which they live, however, the factors that appear to drive actual installations are more economic than environmental.

Summary of Study: Individual Factor Results & Interpretations

Factor One: Price of Electricity

The purpose of this study was to analyze the identified market factors and their relationship to installed capacity of photovoltaic products within the sample group of nations. The first factor considered, price of commercially supplied electricity, was shown not to have a significant impact on the rate of growth of installed photovoltaics capacity in any segment of this study. Commercial prices of electricity were gathered in each country and then measured against levels of installed photovoltaic capacity in each nation. This analysis was used to discover whether if price of commercial electricity rose, photovoltaic technology became a more attractive substitute? Research findings did not support this conclusion. This represents a minor disconnect in current marketing strategies in that there are solar energy manufacturing firms that promote stability electricity as a benefit of photovoltaic technologies. These results suggest that price of electricity is not always a motivating factor of firms assessing photovoltaics as an alternative energy source but it was in some cases. The hedging effect of a renewable energy source may reduce the risk of future price increases, but this alternative was not statistically supported as being related to nations increasing installed capacity of photovoltaic technologies. Many of the world's largest photovoltaic manufacturers tout energy independence as a form of security in terms of both supply and price security. While there is ample literature discussing this position, it is suggested that this benefit should not be included as a primary marketing strategy.

Factor Two: Levels of Carbon Dioxide

The second factor considered, carbon dioxide as a proxy for environmental concerns such as global warming, also did not yield a substantial result that can be used to promote the installed capacity of photovoltaics. As presented, carbon dioxide is a common proxy for levels of pollution within a given nation. The marketing of many forms of renewable energy including photovoltaics, often refers to the reduction or elimination of levels of carbon dioxide produced by that given technology as a key benefit. Results of this research do not support levels of carbon dioxide as a factor in the increase in installed capacity within a given nation. Based upon that conclusion, firms seeking to market photovoltaic equipment or services should not use the reduction of carbon dioxide as a benefit for their products or services. This research acknowledges that the reduction of any form of pollution is an admirable attribute, however, for the purposes as to what is an effective market stimulus for this industry; research suggests it is not a consistent marketing factor. Carbon dioxide levels are what have been classified in this research as a public good. The benefits of better air quality as a result of lowered levels of carbon dioxide with a given nation's territory becomes a very complex topic to address as no one person or no one firm has significant control. Firms within the photovoltaic industry are individual competition with firms providing both conventional and renewable forms of electrical generation. Marketing of photovoltaics when positioning this benefit as a private good for the consumer is not accurate, it is a public benefit.

Factor Three: Financial Incentives

The final factor examined was the impact of any form of a financial incentive provided to end-users that adopt photovoltaic technologies. The results of this research do support the claim that financial incentives most frequently result in the increased adoption of photovoltaic technologies. Financial incentives were proven to provide market stimulus by addressing one of the most substantial barriers to all renewable energies, the initial investment. Financial incentives included any form of financial assistance to the investor and included alternatives such as up-front rebates and feed-in-tariffs. Applying these conclusions to analysis of sample countries that have robust photovoltaic growth this conclusion is supported. Germany, Japan and portions of the United States do all currently offer forms of financial incentives to stimulate growth of photovoltaic technologies. The inverse is true as well as no nation without financial incentives has seen any substantial, prolonged photovoltaic growth within that country. The provision of financial incentives is not the responsibility of any manufacturing firm. However firms may seek to target nations that do provide these resources to accelerate growth in those countries.

Marketplace Conclusions: Two Different Markets

Multinational firms that participate in the photovoltaic industry need to develop location based marketing strategies that reflect pan-regional values regarding photovoltaic technologies. The conclusions of this research suggest that there are two primary market types within the photovoltaic industry, markets with financial incentives and markets with no financial incentives. In nations with financial incentives, the marketing strategy may focus on the following factors:

- Photovoltaics can benefit the ***individual*** investor. Incentives can significantly alleviate many financial barriers that may inhibit the investment decision for or both commercial and residential photovoltaic systems.
- Present traditional return on investment calculations demonstrating the long term benefit of photovoltaic technologies.
- Consumers that value financial incentives will likely perceive that photovoltaic technologies can be used as a hedging tool against future energy price volatility.

- Establish a direct sales force to bring stronger brand recognition to the individual manufacturing firm and assist curious solar energy prospects on how to participate in utilizing available of financial incentives. Local equipment installers offer a potentially significant educational and sales influence upon potential photovoltaic customers. There may be a disconnect between the manufacturer and potential consumers under the current product distribution system.

Proposed Market Segmentation Model

In assessing any nation by the identified factors used in this research, firms competing in a given market (nation), may utilize the following model to focus what factors to emphasize in a given country. A multi-national marketing approach is suggested to promote flexibility in suggesting a successful marketing strategy for each potential photovoltaic market. The conclusions of this research suggest that individual economic factors are more influential than public environmental factors as market stimuli for this industry. Firms seeking to grow market share should present their product benefits with the following market segmentation strategy.

Bi-Level Marketing Strategy

	With Incentives Focus: Economic	**Without Incentives** Focus: Environmental
Public Good	Group Membership, “We”	Altruistic, Early Adoptors, Green Marketing
Private Good	Behavior Modification, Education	Conventional Marketing,

In many markets, local installers represent a variety of solar manufacturers often with little allegiance to any one brand of solar equipment. This relegates the manufacturing firm to a secondary role in the sales process and in markets like Japan has made it difficult for some firms to penetrate new market opportunities without the benefits of local representation. It is suggested in this research that marketing strategies for the next phase of market growth must focus on end users as individual investors while also clearly communicating differentiated brand value for the selection of a given manufacture's technology. Few products on the market today represent the complexities in regards to both short term and long term considerations as do photovoltaic technologies. The challenge for multinational firms is to resist the "spray and pray" marketing strategy and to adopt a set of clear ***consumer*** benefits that are well supported financially, technologically and environmentally for this industry to realize the full potential of solar energy. In markets or regions with financial incentives, some suggested marketing objectives may seek to utilize the following initiatives.

- Educate local real estate brokers as to the increased financial value of a property that incorporates photovoltaic technology.
- Educate prospective clients to the availability of financial incentives and assist in the taxation implications.

- Attempt to bundle both internal firm benefits (product features, warranty, support, installation etc) and external market benefits (reduced Co2 emissions, energy independence, and consulting services on financial incentives) as part of a branded service to increase national market share.

In markets with no financial incentives the marketing strategy will be significantly different. In these markets, marketing strategies could focus upon the following factors to stimulate adoption rates:

- Seek to increase awareness of individual benefits as well as group or national benefits of solar energy.
- Have a dedicated direct sales force that will focus on selling to high visibility institutional or industry locations. This will begin the education process as to the benefits of photovoltaics and also provide credible local references within a community.
- Sell to regional utility companies offering supplemental power during peak loads as an alternative to expensive facility expansions.
- Seek to partner with national or local retail banking sources. Markets without financial incentives provide end-users with a way to the initial investment costs of solar technologies. Providing consumers with an alternative method of diffusing the initial investment via a loan or financing alternative will provide a similar benefit to the end users in these markets.
- Lobby local governments to institute incentive programs.

Catherine Day of the European Commission in Belgium published a handbook in 2004 that targeted purchasing agents of government procurement agencies advocating the use of green energy. Day did research between 2001 and 2003 on the purchasing procedures of the various state and local governments within the European Union in an attempt to increase the awareness of key governmental purchasing staff. The handbook discussed how buying green energy contributes to saving the national environment and can be cost effective and instructed government procurement officials how to actually purchase green products. In Day's report, she indicated that 16% of the European Union's GDP is government spending and therefore the benefits of investing in green products and services were consistent with the benefits of the common good that government should pursue. An unintended bi-product of this handbook was to increase public awareness because when a local government invested in a renewable energy source, it indirectly provided exposure and an implied viability of the product to those in the community that may have never considered renewable energy. As awareness of the benefits of a renewable energy technology grew, the legitimacy of proposing and funding of financial incentives also increased. Multinational firms seeking entrance to a market that does not offer financial incentives should implement marketing strategies that can maximize awareness of individual benefits. If successful, the result will be environmentally friendly behavior of public authorities which can then be positioned as part of a long-range sustainable development strategy.

The Role of Local Installers

The telecommunications industry enjoyed a period of tremendous growth during the 1980's and 1990's not because digital services were invented but more that they were developed to accommodate consumer level applications. The information super highway was in place for many years before individual local connectivity, commonly referred to as the digital driveway, via cable television or DSL services. The last mile digital access services gave rise to new products and services that are today in almost every household. The photovoltaics industry is lacking the digital driveway that will fill in the gaps of awareness and acceptance within most major markets around the world. The availability of increased local installation services would offer consumers integrated products and services that could be branded by a major manufacturer. This would significantly increase consumer awareness and help minimize anxieties of potential customers concerned with photovoltaic technologies. If manufactures were able to expand their own installation services, they would find additional cost efficiencies that could be passed on to the consumers reducing return on investment timeframes. In addition, firms would be able to provide better support and receive better consumer feedback for future product and service development. Currently, early adopters that championed photovoltaic technologies have often needed to commit to higher levels of direct participation in the implementation of this energy alternative. Second generation consumers will seek less direct involvement with the implementation of the technology and far fewer financial concerns as to the viability of this alternative. Local installation services can address this issue providing multiple potential benefits to future photovoltaic consumers.

Final Observations

It would be naïve to think that changes to the conventional generation methods and delivery of electricity would come without significant resistance. The international electricity energy industry is very complex and also one of the most politically charged economic sectors in the world. While it has become fashionable to publically support renewable energies, it could be argued that this has been merely lip service and that actual progress of renewable energy technologies has not kept pace with the increased international demand for electricity.

The findings of this research state that not all of the identified benefits of photovoltaic technologies translate well into marketing strategies. The results of this study show that public, environmentally focused benefits of solar energy are not statistically proven to increase installed capacity of photovoltaic technologies. These findings represent both a key disconnect in the marketing strategies of many multinational firms and an opportunity to reshape marketing communications in the future to increase future sales. The broad set of benefits presented by photovoltaic technologies is still valid. However, increased focus on the individual investor as viewed as a private benefit of photovoltaic technologies appears to hold more promise than strategies that focus on public, environmental benefits. Multinational firms competing within the photovoltaics industry may seek to modify their publically communicated marketing strategies to incorporate these conclusions.

The findings of this research also suggest that a multinational marketing strategy is more appropriate for promoting photovoltaic technologies due to the variety of key market distinctions. The conclusions of this research did identify some exceptions especially as it pertained to the role of price of commercial electricity supporting the conclusion that no two markets are similar within this industry. This dissertation provides new market conclusions that may be extended in future research to educate consumers of the benefits of photovoltaic technologies.

Figure 13: Current and projected electrical consumption by both OECD and Non-OECD Nations.

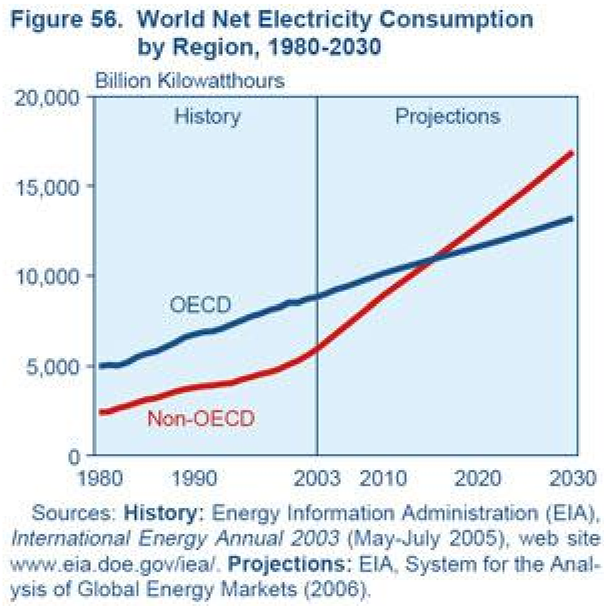


TABLE: Cumulative installed PV Power in IEA-PVPS countries 1992-2003 (MW)

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AUS	7,3	8,9	10,7	12,7	15,7	18,7	22,5	25,3	29,2	33,6	39,1
AUT	0,6	0,8	1,1	1,4	1,7	2,2	2,9	3,7	4,9	6,6	9
CAN	1	1,2	1,5	1,9	2,6	3,4	4,5	5,8	7,2	8,8	10
CHE	4,7	5,8	6,7	7,5	8,4	9,7	11,5	13,4	15,3	17,6	19,5
DNK	0	0,1	0,1	0,1	0,2	0,4	0,5	1,1	1,5	1,5	1,6
DEU	5,6	8,9	12,4	17,8	27,9	41,9	53,9	69,5	113,8	194,7	277,31
ESP	4	4,6	5,7	6,5	6,9	7,1	8	9,1	9,12	16,03	16,04
FIN	0,9	1	1,2	1,3	1,5	2	2,2	2,3	2,6	2,7	3,1
FRA	1,8	2,1	2,4	2,9	4,4	6,1	7,6	9,1	11,3	13,9	17,2
GBR	0,2	0,3	0,3	0,4	0,4	0,6	0,7	1,1	1,9	2,7	4,1
ISR	0,1	0,1	0,2	0,2	0,2	0,3	0,3	0,4	0,4	0,5	0,5
ITA	8,5	12,1	14,1	15,8	16	16,7	17,7	18,5	19	20	22
JPN	19	24,3	31,2	43,4	59,6	91,3	133,4	208,6	330,2	452,8	636,8
KOR	1,5	1,6	1,7	1,8	2,1	2,5	3	3,5	4	4,8	5,4
MEX	5,4	7,1	8,8	9,2	10	11	12	12,9	13,9	15	16,2
NLD	1,3	1,6	2	2,4	3,3	4	6,5	9,2	12,8	20,5	26,3
NOR	3,8	4,1	4,4	4,7	4,9	5,2	5,4	5,7	6	6,2	6,4
PRT	0,2	0,2	0,3	0,3	0,4	0,5	0,6	0,9	1,1	1,2	1,7
SWE	0,8	1	1,3	1,6	1,8	2,1	2,4	2,6	2,8	3	3,3
USA	43,5	50,3	57,8	66,8	76,5	88,2	100,1	117,3	138,8	167,8	212,2
Total[1]	**109,9**	**136,2**	**163,9**	**198,6**	**244,7**	**314**	**395,7**	**520**	**725,8**	**990**	**1 327,7**

*Source: **IEA** Photovoltaic Power Systems Programme*

Figure 14: Cumulative Installed Photovoltaic Capacity Largest Global PV Markets.

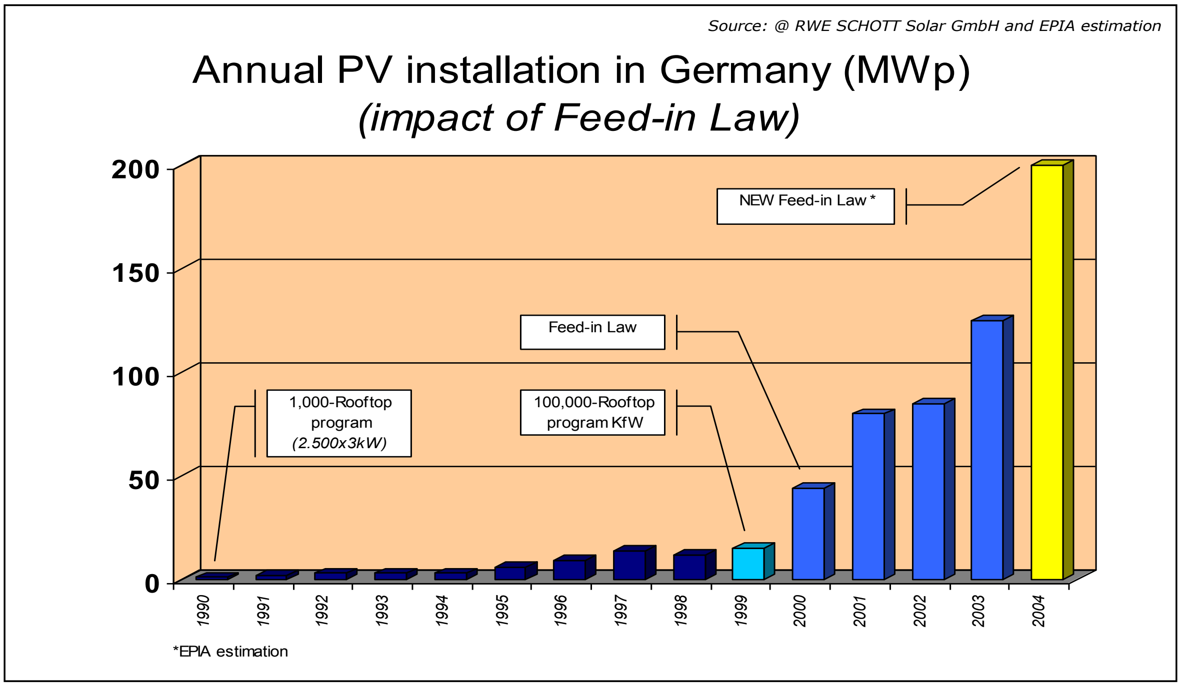


FIGURE 15:. HISTORICAL TIMELINE OF GERMAN PHOTOVOLTAIC INDUSTRY. (2005)

Table 14: Top Fourteen Photovoltaic Module Manufacturers as Measured in Produced Megawatts

Company	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Sharp	50	75	123	198	324	428
Q-Cells				28	75	160
Kyocera	42	54	60	72	105	142
Sanyo	17	19	35	35	65	125
Mitsubishi	12	14	24	40	75	100
Schott Solar	14	23	30	42	63	95
BP Solar	42	54	74	70	85	90
Suntech CN					28	80
Motech TW					35	60
Shell Solar	28	39	58	73	72	59
Isofoton	10	18	27	35	53	53
Deutsche				17	28	38
Photowatt	14	14	17	20	22	24
USSC	3	4	4	7	14	22
Total World	232 **288**	314 **399**	451 **560**	637 **759**	1044 **1195**	1476 **1727**

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ACRONYMS & ABBREVIATIONS

BIC	BONN INTERNATIONAL CONFERENCE
IEO	INTERNATIONAL ENERGY OUTLOOK
OECD	ORGANIZATION FOR THE CO-OPERTATION AND DEVELOPMENT.
WB	WORLD BANK
WTO	WORLD TRADE ORGANIZATION
PV	PHOTOVOLTAICS
DC	DIRECT CURRENT
WH	KILOWATT HOUR
OPEC	ORGANIZATION OF THE PETROLEUM EXPORTING COUNTRIES
PURPA	PUBLIC UTILITY REGULATORY POLICY ACT
EIA	US ENERGY INFORMATION ADMINISTRATION
ASES	AMERICAN SOLAR ENERGY AGENCY
IEA	INTERNATIONAL ENERGY AGENCY
EPA	ENVIRONMENTAL PROTECTION AGENCY
C02	CARBON DIOXIDE
PPP	PURCHASING POWER PARITY
GDP	GROSS DOMESTIC PRODUCT
GHG	GREEN HOUSE GASES
BIPV	BUILTING INTEGRATED PHOTOVOLTAICS
MITI	MINISTERY OF INTERNATIONAL TRADE & INDUSTRY
WWEA	WORLD WIND ENERGY ASSOCIATION
AC	ALTERNATE CURRENT
BP	BEYOUND PETROLUEM, FORMERLY BRITISH PETROLEUM
ROW	REST OF WORLD
FEED-IN-LAW	SPECIFIC GERMAN LAW THAT GUARANTEES A SPECIAL RATE FOR THE SUPPLY OF ELECTRICITY PROVIDED TO THE PUBLIC UTILITY GRID