ASSESSING THE POWER OF SUNSHINE:
A MULTICASE QUALITATIVE STUDY OF SOLAR ENERGY

By

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Dedicated to my sister, mother and grandmother - three generations of contrary advice.

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LIST OF ABBREVIATIONS

EPA	US Environmental Protection Agency, federal agency responsible for the protection of human health and the environment by writing and enforcing regulations on laws passed by Congress
FIT	Feed-In-Tariff, a policy mechanism designed to accelerate investment in renewable energy technologies through offering long-term contracts to renewable energy producers, typically based on the cost of generation of each technology
GRU	Gainesville Regional Utilities, a power and utility company serving Gainesville, Florida
HIA	Health Impact Assessment, a means of assessing the health impacts of policies, plans and projects in diverse economic sectors using quantitative, qualitative and participatory techniques
HUD	U.S. Department of Housing and Urban Development, Cabinet department of the Federal Government responsible for the development and execution of policies on housing and metropolises
kW	Kilowatt, the typical measurement of energy used to express output power of engines and the power consumption of electric devices, equal to one thousand watts of electricity
kWh	Kilowatt hour, the most common billing unit for energy delivered to energy consumers by an electric utility, equal to 1000 watt hours
LLC	Limited Liability Company, a business enterprise blending partnership and corporate structures to provide limited liability to its owners in the majority of United State jurisdictions
NBER	National Bureau of Economic Research, an American private nonprofit research organization dedicated to promoting a greater understanding of how the economy works
PV	Photovoltaic, refers to a cell or panel capable of converting light into electricity at an atomic level
VSL	Value of a Statistical Life, the value that an individual places on a marginal change in the likelihood of death, not the price someone would pay to avoid certain death NBER
WHO	World Health Organization, a specialized agency of the United Nations that is concerned with public health

Abstract of Thesis Presented to the Graduate School
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This paper seeks to understand the complex nature of the advantages and disadvantages of solar feed-in-tariffs (FIT) as they relate to utilities, investors, communities and environments. Primary objectives include the determination of which stakeholders stand to benefit most from such policies; whether solar energy production is truly sustainable; if FIT policies are the best way to encourage investment in such technologies; whether there is potential for expansion of these programs in the U.S. and abroad; and why such policies and technologies have not been more widely adopted. Utilizing an integrative qualitative comparison of policy and stakeholder interests, this analysis uses data and research literature from documented project outcomes and reports to examine the overall impacts incurred through solar FIT policies in Germany, China and the United States – particularly in Gainesville, Florida. This information is elucidated through the definition of costs and benefits, the difference between quantitative and qualitative cost benefit analyses; the need to examine the advantages and disadvantages of both individual projects and the overall strategy; and the potential weaknesses of these analyses. Upon examination, it becomes clear that solar FIT

programs offer more advantages than disadvantages to all stakeholders, that broad employment of current solar technologies can only be sustained through government subsidization, FIT policies are currently the best means to do so, many nations show potential for solar adoption, and unfavorable political and financial barriers are the main inhibitor of such implementations.

CHAPTER 1
INTRODUCTION

Policy Overview

Historically, America has utilized policies such as federal tax incentives, utility quota obligations, net metering, favorable rate structures and easy grid access (Cruger, 2011). Yet the sum of these approaches has been insufficient motivation of large-scale investment in photovoltaic (PV) installations and other forms of renewable energy (Farrell, 2009). Therefore, governments in the U.S., China and elsewhere have looked at mass implementation of solar programs in Germany for guidance toward successful solar policies and have found that their success is tied to FIT policies. Unlike widely used models of net metering, in which a property owner produces electricity to offset domestic use and sells the excess at a wholesale rate, Feed-in-Tariffs allow investors to sell power to the grid at a fixed premium price for the duration of a twenty year contract, while purchasing their electricity from the utility at the retail rate (Farrell, 2009).

From a desire to reduce greenhouse gas emissions and stimulate local economies, Gainesville Regional Utilities began such a FIT program in September of 2009, becoming the nation’s first municipality to establish a solar Feed-in-Tariff program (Clean Coalition, 2011). In the two years since, the city has experienced the emergence is a localized solar economy with approximately 260 new private sector jobs and a 2,000% increase in citywide solar capacity (Clean Coalition, 2011). These and a variety of other factors are weighed in Chapter 4 (Results) as relates to utilities, investors, communities, and the environment. Additionally, the full effects of solar FIT policies are assessed in terms of influence on land use, housing markets, commercial property, municipal entities, and land scarcity. Based on this analysis, one may understand the qualitative advantages and disadvantages of solar FIT policies, enabling a series of conclusions and recommendations within Chapter 5 (Discussion of Results).

Rationale

Based on this qualitative analysis of solar Feed-In-Tariffs in Germany, China and the United States, utilities and governments benefit from reduced investment costs, reduced reliance on volatile fuel prices and favorable rates that may be adjusted through degression (Farrell, 2009). These FIT programs also offer a reliable investment to a range of participants. Provided they are able to pay the initial cost of PV system investment, stakeholders receive a reliable return of 5%-10% over the course of their 20-year contracts (gru.com, 2008). Additionally, communities and ecosystems are altered through the establishment of localized solar economies, offsetting of pollution loads and reduction of negative health effects associated with conventional energy production. Still, such programs can only be sustained through the continued support of governments through prioritization, funding and collaboration with private sector participants, continuous system evaluation and international cooperation (Cruger, 2011).

Purpose

Given growing interest in such programs both domestically and internationally, this paper will explore, in broad qualitative terms, the costs and benefits of such programs as they relate to utilities, investors, the public and the environment. Externalities of implementation range from energy security gained from reduced reliance on foreign oil, reduced pollution levels, slowed of global warming, and mitigation of the health effects of pollution generated in conventional power production (Cruger, 2011). While the program has shown success as a stimulus for economic growth and long-term change, the full qualitative advantages and disadvantages of solar FIT programs are assessed in this report as determined through the literature review.

Objectives

The primary objectives and questions to be answered in this report relate to the variety of stakeholders and scales of the solar FIT policies and their related elements. Within Chapters 4 and 5 the answers to these questions are addressed in an exploration of barriers and drivers based on relevant economical, social and environmental data. Also within the results, a series of tables map the costs and benefits (direct and external) of solar FIT programs as observed through the reports, observations and case studies examined in the literature review. The objectives and questions of this report are summarized as follows:

Objective: Determine which stakeholders stand to benefit most from such policies.

- What resources are required of a utility for such implementations?
- Who pays for installation and maintenance and what are their costs and benefits?
- How do such initiatives alter local economies?
- What effect do such programs have on local environments?

Objective: Determine whether solar energy production is truly sustainable on economic and ecological levels.

- What is the greatest percentage of a community's energy consumption that could come from solar given existing technologies and market factors?
- How do solar and other electricity production methods affect communities and environments?
- Can the world meet 100% of energy need through current renewable energy technologies?

Objective: See if FIT policies are the best way to encourage investment in such technologies and whether new technologies might accelerate this process.

- What existing or future policies of technologies might ease implementation and increase efficiency?

Objective: Examine possible potential for expansion of these programs in the U.S. and abroad.

- How did the photovoltaic market develop internationally and domestically?

- Is a given policy or technology transferability to other markets?
- What are the barriers to implementation and how might they be overcome?
- Are there market mechanisms implemented to drive sustainable development?
- What is the position of a given utility or government in relation to photovoltaic technologies and policies?

Objective: Examine the reasons for which such policies and technologies not been more widely implemented.

- How did the photovoltaic market develop internationally and domestically?
- What government policies or market forces are supporting or hindering the solar market?
- What is the level of social, economic and environmental awareness in terms of solar and other renewables?

Objective: Gain a fuller understanding of the present solar energy situation in Gainesville, Florida through the analysis of solar programs in Germany, China and the United States.

- What percentage of GRU's power comes from solar?
- How has Gainesville's biomass plant affected future solar implementation given current renewable energy targets?
- Has GRU passed the cost of their solar FIT policy to consumers?
- What factors are contributing to the termination of new FIT contracts in Gainesville in 2016?

Methods

The parameters outlined within Chapter 2 will establish the different elements and definitions used in the analysis of various data sources. This is followed by the methodology, which gives a more thorough examination of the research methods used for the obtainment of the data informing this study. From secondary and primary research on solar production, policy and technology a greater understanding of the qualitative advantages and disadvantages of solar initiatives is gained. Based on research studies, interviews, and observations, case studies were compiled on the solar policies of Germany, China and the United States. From this literature review, a series of results and recommendations are outlined to better elucidate the means by which such policies can be adopted and expanded in the future.

Limitations

Of the studies limitations, the greatest is the limited availability of economic information on new programs and technologies, as well as within smaller programs such as that of Gainesville, Florida. Due to this fact, an interpretive theoretical approach was necessary in order to relate the broad implications of national and statewide policies to the smaller scale.

CHAPTER 2
CONCEPTUAL FRAMEWORK

Parameters

In defining costs, they may include resources expended by stakeholders and negative outcomes that may or may not be caused by difficulties in implementation. Benefits are understood as the achievement of positive outcomes and the avoidance of negative outcomes. In comparing quantitative and qualitative cost benefits, the three central components include: the identification and description of costs and benefits; factors hindering the achievement of outcomes; and the summarization of the ratio between benefits and costs. Such qualitative analysis differs from quantitative in that it defines non-monetary parameters for advantages and disadvantages with values not fully converted to monetary values, thereby producing a non-numeric ratio of costs to benefits.

A variety of challenges are presented when undertaking a quantitative cost benefit analysis of solar FITs and the external factors effecting their implementation. Of particular concern is the under-estimation of costs in terms of resources expended; miscalculation of positive outcomes achieved (particularly given the long-term nature of many of these outcomes); under-estimating negative outcomes; overestimating the contribution of solar FITs in achievement of outcomes; and miscalculating of the distributional of costs and benefits to different participants.

Of the distinguishing features, the main difference between solar FITs and other policies is the focus on providing incentive to establish a community-scaled solar capacity rather than offsetting an individual’s power consumption. Consequently this analysis is not able to make direct comparisons of costs and benefits with similar independent programs and factors such as net metering, tax breaks or government subsidies. However, reference is made to similar interventions when assessing the advantages and disadvantages of particular types of projects. Unfortunately, a thorough literature review of comparable programs in Germany, China and the United States failed to identify a program of scale comparably to that of Gainesville's solar FIT. Regardless, advantages and disadvantages may be interpreted and related to GRU's solar FIT and can be applied to the understanding of how such implementations might effect the U.S. as a whole.

Methodology

Information has been generated via both secondary and primary market research related to various aspects of solar power production, policy, technologies and external forces supporting or hindering these processes. Secondary research was extracted from pre-existing materials of research studies performed by government agencies, chambers of commerce, non-government organizations, etc. In cases when new or nonexistent data was needed, information was collected though the primary research means of interview or observations. From the result of these data sources, theoretical questions were analyzed to develop clearer ideas and understanding of the subject matter.

Allowing for comprehensive analysis of opinions, trends and processes, as well as the resulting behaviors, a qualitative approach was also useful for the collection and understanding of market reactions, attitudes and mechanisms. Based on such qualitative data, long-term relationships can be observed, aiding in the analysis of future activities of governments and investors.

CHAPTER 3
LITERATURE REVIEW

The German Model

On a train ride through the German landscape, one may pass forests or snow-capped mountains, pastures, villages and cities and, if one looks close enough at the rooftops of their structures, the white light of the sky might be seen reflected from the surface of a photovoltaic solar panel. With Germany's designation as world leader in total installed photovoltaic solar panels, this is a likely sight (Torrens, 2008). Given the nation's leadership in solar power production, the past thirty years of German energy policy serve as a model for others seeking to understand how the choices and policies enacted in Germany may affect the economies, citizenry and environmental quality of a given municipality.

Policy Context

Most critical to the success of German solar energy production has been the broad scale adoption of feed-in tariffs which, in the words of John Farrell, "seek to create electricity price competition [and] require utilities to purchase power from renewable energy generators at a fixed price [and] interconnect all eligible renewable generation, thereby guaranteeing that renewable electricity can "feed in" to the grid." (Farrell, 2009). As seen in Germany, Japan, much of Europe and parts of the U.S., it is this basic principle that has proved to be the most effective means of successful solar power proliferation.

Policy History

With the energy crises of the 1970s, Germany began to question the reliability of foreign fuel sources. A decade later, the incident at Chernobyl's nuclear facility sparked furthered debate as they questioned the safety and long-term consequences of nuclear proliferation (Jacobsson and Lauber, 2004). Climate change and the desire to develop local industry further propelled the search for an answer to these concerns (Farrell, 2009). So Germany turned to renewable energy as a possible environmental solution and means to foster local industry (Jacobsson and Lauber, 2004). The result was investment in solar cells, film and inverters. The government offered investment funds to eighteen universities, thirty-nine private firms and twelve research institutions to advance solar technology (Jacobsson and Lauber, 2004). While these initial investments were minimal, the final result was a position of industrial leadership, innovation, and success through the agglomeration of solar research and energy production (gru.com, 2008).

This decades-long process was also the result of a series of policy ratifications that included tax incentives, obligations that utilities produce a given amount of power via renewables, zero interest loans for start-up costs and guaranteed access to the electrical grid (Farrell, 2009). But the greatest incentive was the nation's Renewable Energy Act, which provided "priority access for renewable energy systems," and twenty-year FIT payments based on production costs rather than retail electricity rates (Farrell, 2009). Unlike traditional methods such as net metering, FIT policies assured a steady source of long-term income for all renewable energy producers, as costs were, "spread among all high-voltage grid operators and end customers." (Farrell, 2009). So successful were these policies that by 2007, 14 percent of German electricity came from renewables (Farrell, 2009).

Major Issues in Implementation

As with most large-scale initiatives, the system did not develop seamlessly. When the national renewable energy program began in 1989, market stimulation occurred but was limited by the lack of grid connection provided to small energy producers (Farrell, 2009). Later legislation led to the Electricity Feed In law of 1991, which obligated utilities to purchase up to 5 percent of their marketable electricity from qualified renewable energy producers at 80 percent of the retail price (Farrell, 2009). Nearly ten years of modest growth passed before the government introduced the 100,000 Roofs Program. Under this policy, the government provided companies and individuals with, “zero interest loans and a grant worth 12.5 percent of the system cost.” (Farrell, 2009). But perhaps the greatest solar incentive offered to the German people was the Renewable Energy Act. Under it’s guidance, the current FIT system came into full conception as grid connection was guaranteed along with priority access for renewable energy systems, and twenty-year payments based on production costs rather than retail electricity rates (Farrell, 2009). Thus was assured a steady source of long-term income for all renewable energy producers. So successful were these policies that by 2007, 15% of German electricity was derived from renewables (Farrell, 2009).

When looking at the success of the German feed-in-tariff program compared to the stalled programs of other nations, one ultimately encounters the fundamental debate over ‘best’ energy policies as occurs between proponents of various economic controls or governance (Jacobsson and Lauber, 2004). Assuming that renewable energy is desired, the argument is made that, “visions and values, the relative strengths of various pressure groups,” regulates political and economic policy as, “beliefs of ‘how things work,” may often carry more weight than the reality of what in fact does work

(Jacobsson and Lauber, 2004). When such trappings are met, complaints become common and as people such as Minnesota wind developer Dan Juhl voice them, "We need to get something on the table that allows community projects to get financed, move ahead, and not get bogged down in all the B.S. that's involved in large power generation." (Farrell, 2009).

In analyzing the causes of such frustrations, one need only understand that the typical U.S. power purchase contracts established between investors and utilities is an 85-page document, whereas the typical Germany contract is 2-4 pages (Rickerson and Grace, 2007). By simplifying the processes, a producer is more apt to develop a system in which they may benefit from a reasonable rate of return. Furthermore, unlike federal tax credits, feed-in-tariffs free utilities, investors and political entities from repeated negotiations as a guaranteed return is already established. This means of stability is a key factor in explaining how, "Germany generate[s] more than 15 percent of their electricity from renewable energy, while the U.S. achieved only 3 percent in 2007." (Rickerson and Grace, 2007).

Another factor in the successful implementation of feed-in tariff policy is the need to make a system fair and easily accessed by a number of participants. While the majority of U.S. solar tax credits are only accessible to individuals or businesses with a large tax base, a feed-in-tariff allows those with little tax liability or non-taxable municipal and non-profit entities to view renewable energy as a profitable source of income, rather than a tax shield (Rickerson and Grace, 2007). Thereby, renewable energy becomes an investment option that may be pursued by a broader range of participants, rather than only those wealthy enough to need the tax credit.

More complicated policy elements include tariff degression, or reductions in payments based on innovation rates as well as reduced output associated with the natural aging of PV systems, and 'stepped tariffs' that vary by the size and quality of the system (Farrell, 2009). Accordingly, utility prices may go through fluctuations due to input prices or technological innovations. Therefore, feed-in-tariffs must be, "revised regularly in order to check if the tariffs are still on an appropriate level to reach the energy policy goals." (Klein et al. 2008). Based on this principal, Germany has raised degression rates from 5% per annum in 2008, to 10% in 2010 and 9% from 2011 onwards." (Klein et al. 2008). While the argument is made that rates paid to investors are reduced in sequence with the rate of innovation, concerns have been raised that they may ultimately lower returns on photovoltaic systems to such a level that it halts further investment.

Advantages and Disadvantages

Germany's Renewable Energy Act integrated a cost-sharing program by which the costs of renewable energy incentives and payments are, "spread among all high-voltage grid operators and end customers." (Farrell, 2009). While these measures are made fully transparent to providers and customers, some critics argue that they result in higher retail electric prices. Admittedly, German electricity is more expensive at $0.65/kWh compared to the U.S. average of $0.09/kWh (Torrens, 2008). But, there are a variety of factors contributing to this and proponents of solar argue that the benefits of such systems far outweigh the costs incurred through renewable power generation, such as the renewable energy tax breaks and rebates (Farrell, 2009). Such practices have seen limited success in the U.S., while Germany's prioritization of renewables and employment of FITs has resulted in the proliferation of solar and other renewable power supplies and the displacement of non-renewables. Based on the principal of merit order, renewable energy production lowers the average price per unit of electricity as it counteracts the effects of peak demand experienced by conventional power plants that are typically powered by fossil fuels subject to foreign and domestic fluctuations in price and availability (Farrell, 2009).

Indicators of successful policy abound in the Germany system. But, in spite of 2007 estimates of 249,000 jobs in the field of renewable energy industries and total earnings of nearly $15 billion in revenue, with the largest share (44%) derived from solar, (Farrell, 2009), criticism remains that Germany is an anomaly in solar production. And regardless of market controls on taxation or tariff levels, investment costs remain the greatest barrier to PV deployment. Given that the power source is still underutilized and that 2007's three leading solar producing nations produced 88 percent of the global supply, it may be inferred that acceptance and knowledge is still limited. This is due, in part, to the fact that the cost of photovoltaic installations is still too high for most of the world's nations to offset via tax breaks or rebates, along with constraints on administrative controls and grid capacity (Torrens, 2008).

Analysis and Resolution

Eventually, the analysis of solar feed-in-tariffs or any other renewable energy policy needs to address the fact that energy security and climate change warrant an aggressive shift to these alternatives (Torrens, 2008). The first step necessary for solar power to be considered a viable option is the removal of the economic barriers of photovoltaic system costs. As a natural part of the research and development initiatives taken by Germany thirty years ago, the cost of these technologies is reduced through continuous innovation and advancement of the business sectors that support these systems. Through investment in such sectors, the German ministry estimates that the resulting environmental and economic benefits have "exceeded the costs by a factor of three," as indicated in Figure 3-1 (Farrell, 2009). Whether nations can currently afford these initial development and administrative costs, PV system prices are becoming more economical. Still, the most effective means of increasing their competitive costs would be the equal pricing of green house gases and other externalities (Torrens, 2008).

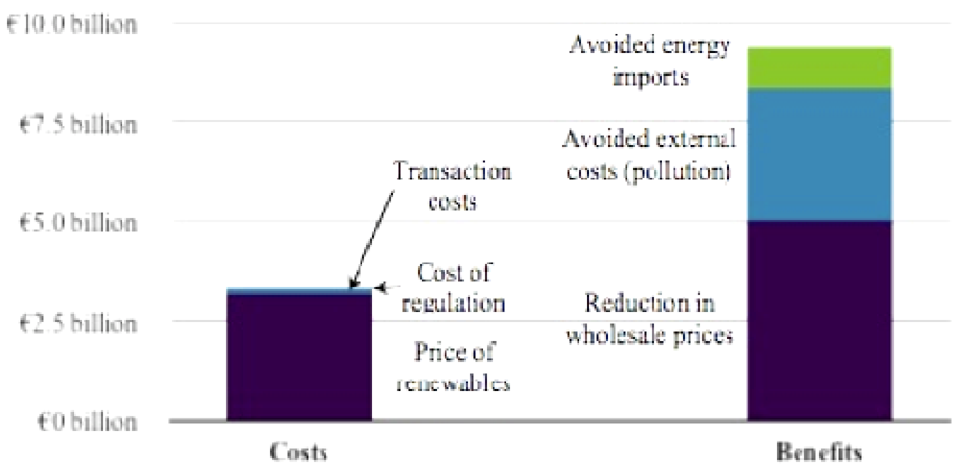


Figure 3-1. Benefits of German feed-in-tariff are three times greater than costs (Source: http://www.boell.de/downloads/ecology/FIT_in_America_web.pdf. Last accessed June 2003).

If governments see potential in solar FIT policies and systems, Germany serves as the model by which they may do so efficiency. In looking at popular U.S. policies such as: federal tax incentives for solar investors; quotas obligating utilities to produce a given percentage of their power through renewable energy; net metering wherein a producer sells only their excess power; favorable rate structures for solar investors: and easy grid access, these have proven to be insufficient stimuli for wide scale construction of photovoltaic installations (Torrens, 2008). So, until governments implement FiT policies, or some variation of their structured rate of guaranteed return on an investment, Germany's feed-in-tariff system will await a rival as the world's leading producer of solar energy.

China's Rising Sun

As solar installations have become more common through FITs and other incentives, production has accelerated, with an increasing number of firms outsourcing contracts to China (The Rise of Big Solar, 2011). As a result, knowledge of these technologies has increased and production costs have gone down. Further aiding these economies of scale, "the Chinese government spent a total of USD 126 million on R&D in the renewables sector," between 2001 and 2006. Of these funds, photovoltaic technology received 39%, or $49,140,000 (gru.com, 2008).

China's scale of growth in the sector is underscored by the fact that in 2007, only 2% of California purchased solar devises came from China, but market shares rose to 46% by the end of 2009 (The Rise of Big Solar, 2011). The truth is that, like many things, China can produce PV panels cheaply and, "Cheaper panels have led to a renewed interest in power-plant-sized installations." In China, panels can be made and distributed quickly, aiding global PV systems (The Rise of Big Solar, 2011).

Policy Context

In recent years, the combined effects of rising energy costs, accelerated energy consumption, regional electrical shortages, environmental degradation and adverse health impacts have lead the People's Republic of China to seek energy alternatives to fossil fuels (Cherni and Kentish, 2007). Additionally, the nuclear disaster at Japan's Fukushima Daiichi nuclear power plant has halted the approval any new nuclear plants within China (Liu, 2011). Much like Germany's reaction to the Chernobyl incident, China is turning to solar energy production as a future means of sustainable energy independence. Therefore, in a wave of reform measures the nation has enacted a string of policies, laws and regulations to make large-scale renewable energy production feasible (Liu, 2011).

Policy History

Considering limited Chinese historical knowledge or participation in renewable electrical energy production, the nation has undertaken a huge transition in less than a decade. Beginning with the enactment of the Renewable Energy Law of January 2006, the government provided a working legal definition of renewable energy sources and offered direct financial incentives, including discounted lending and tax breaks, to stimulate development. The following year, Article 181 of the revised PRC Property Law introduced legal and regulatory standards for secured lending through security rights on present and future assets – a new concept to the long-time communist nation (Liu, Yi, and Wang, 2009). On the first day of 2008, the Enterprise Income Tax Law provided a additional incentive to investors by giving a three year tax exemption on all projects involving renewable energy installations, and three years of taxation at half the full tax rate to enterprises involving renewable energy power stations (Liu, Yi, and Wang, 2009). In an effort to focus investment on solar power production, the announcement of a national rooftop solar subsidy in March of 2009 helped launch a rapid rise (Seeking Alpha, 2012). Additional investment has been generated through 2011's Five Year Plan (the effects of this are indicated in Figure 2-2), which called for total solar capacity to increase by 1000% in the next five years (Seeking Alpha, 2012). Furthering the likelihood of achieving this goal, a nationwide Feed-In-Tariff has been enacted as a means for investors to sell power directly to the governments, which in turn guarantees a return on installation costs within a matter of seven years and cash yields for another twenty (Liu, 2011). Such a rapid and intensive series of implementations helps to emphasize the world's biggest energy consumer's desire to embrace renewable energy (Hook, 2011).

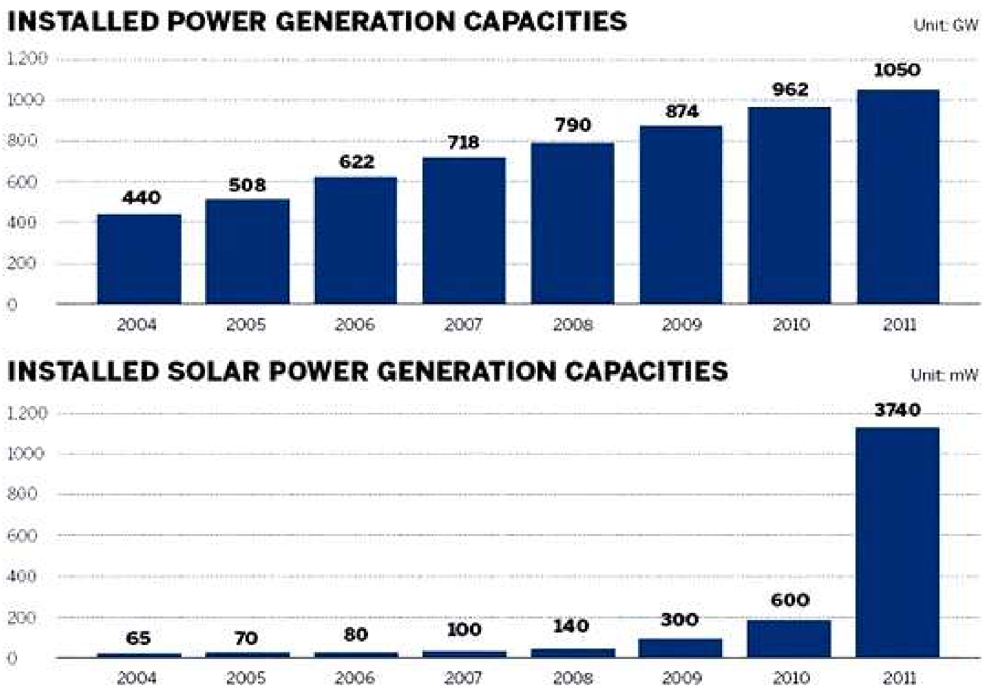


Figure 3-2. Solar's influence on China's shifting power paradigm (Source: http://www.ongreen.com/image/installed-solar-capacity-china-growing-rapidly. Last accessed June 2003).

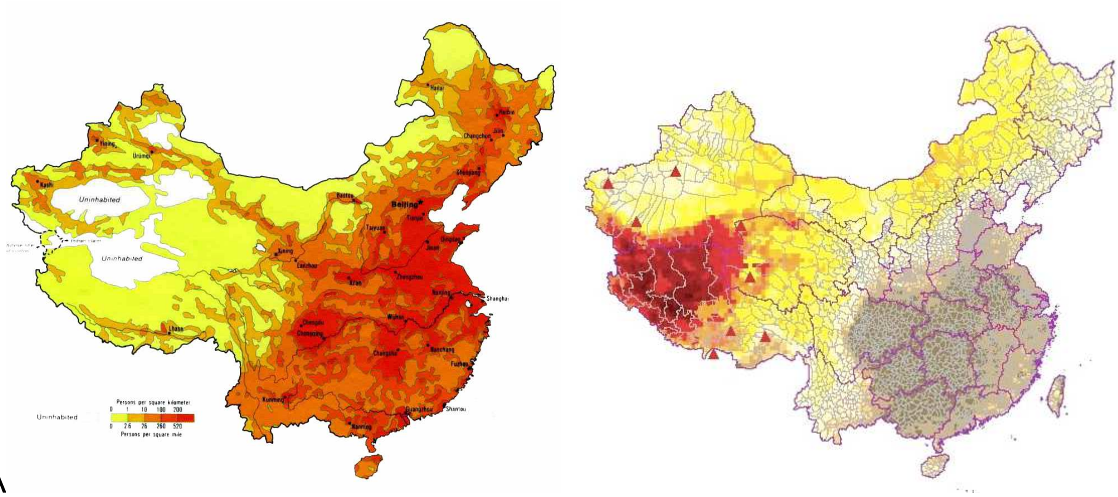
Public Review Process

Given such a rapid series of policy adoptions, one must ask what role the public sector had in the process. But, when considering that Chinese policy implementation occurs in a top-down manner, with no elective process and little to no public involvement, the speed of enactment should be of little surprise. Indeed, the only input garnered from those outside of bureaucratic agencies was input gained from various corporations. For example, in working toward a nationwide Feed In Tariff, requests for proposals on given photovoltaic projects gave the government a better sense of competitive tariff rates based on the bids of private solar investment corporations (Seeking Alpha, 2012).

Major Issues in Implementation

Matters of complication in China’s solar power policies are many, ranging from issues of management and corruption, to logistics and simple geography. As growth in production of photovoltaic cells has accelerated in China, the effect has been two fold. First, as the Chinese are so well known for doing, their cheaper production costs has lead to strong reductions of equipment prices. Second, solar equipment production has far outstripped demand in recent years and producers. Responsible for over half the world’s annual supply, producers have called upon the government to encourage domestic consumption (Hook, 2011).

This need has been met through the policy and stimulus methods outlined, along with dual administrative and ownership systems that may further complicate the process as state and privately owned industries are forced to collaborate in the establishment and administration of solar installations (Cherni and Kentish, 2007). In addition, electric grid connections and cable capacity is limited and has repeatedly proved insufficient when linked to localized wind turbines (Liu, 2011). Concern over inadequate grid capacity is only exacerbated when one considers the fact that most of China’s solar potential lies in the largely uninhabited West, far from the mega cities, ports and production centers of the east and southeast coasts, as shown in Figure 2-3. Attempts to reconcile this disconnect have been obstructed by mountains, rivers, poor roadways, inhibitive cable costs, power loss through transmission, and a shortage of manpower following enactment of the feed-in-tariff (Liu, 2011).



A B

Figure 3-3. Comparison of Chinese population versus sunlight levels. A) Map of China's population density. B) Map of national UV exposure levels (Source: http://www.china-mike.com/chinese-culture/society/china-population-growth-crisis/.http://www.geni.org/globalenergy/library/renewable-energy-resources/world/asia/solar-asia/solar-china.shtml. Last accessed June 2003).

Advantages and Disadvantages

Currently, the costs of solar installations in China and the rest of the globe are prohibitively high for most investors. Given these high initial costs of investment, longer maturity rates are subsidized by the Chinese government via tax breaks and discounted loans (Liu, Yi, and Wang, 2009). Nationally, these subsidies amount to millions of dollars per year and the burden of financing the solar feed-in-tariff is further exacerbated by the need for regional and national governments to install and maintain additional grid connections and high voltage power lines. While the nation strains to increase production, health and safety are sometimes compromised. In one case large quantities of silicon tetrachloride, a by-product of solar cell production that may cause burns and damage to eyes and the respiratory system, were dumped near a Chinese plant (Oregon Dept. of Transportation, 2012). While these costs may be rationalized as the necessary means through which a technology becomes acceptably feasible through innovation and mass production, questions remain as to whether increased domestic and foreign demand for PV cells may strain supply and raise costs in domestic and international markets.

Given the range of costs associated with China's solar policies, one must determine if the benefits outweigh these factors. Of the positive aspects of the program, the most immediate seems to be the guaranteed return offered to enterprises involved in renewable energy power stations (Liu, Yi, and Wang, 2009). In response to the concerns of solar equipment producers, the demand created for solar cell, inverter, steel, and cable production has risen dramatically, with cost of units still falling (Hook, 2011). Additionally, a variety of job markets have experienced growth, as solar installations require the skills of construction workers, technicians, electricians, engineers, and planners.

Though difficult to quantify in monetary terms, there are a wide variety external and intangible benefits related to the program, including: reduced dependence on fossil fuels and nuclear power; improved public health and environmental quality as an estimated 656,000 deaths result from air pollution each year (Segal, 2012). Also, the slowing of climate change and risk of sea level rise are of great concern along China's hugely populated coastline (Liu, 2011). Additionally, increased solar production provides access to reliable power, which is especially important for people residing in isolated areas with historically low levels of electrical access and the associated benefits to health, education, employment and communications.

Legitimacy in View of Public Interest

Although public involvement in the policy process has been extremely limited and a large project contracts may go to companies closely tied to government officials, the public benefits of solar implementation are clear. Economic benefits are greatest for those involved in production and installation of solar projects, but the economy as a whole may grow through increased demand for the skilled and manual laborers required for installment, maintenance and operation of systems. Broader benefits are also seen as environmental quality and public health are improved through curtailment of carbon emissions from the conventional use of fossil fuels for power generation. Indeed, the lifetime of coal and oil creates a variety of hazards, especially in developing nations with limited safety standards. According to the Chinese State Administration of Work Safety, coal production in 2009 resulted in the death of 2,631 coal miners due to gas leaks, explosions, or flooded tunnels (Epstein et al. 2011). And, as previously stated, the ability to produce one's own power (and the external benefits of the fact) is beneficial to a broad contingency of Chinese citizens.

Analysis and Resolution

With falling prices for photovoltaic cells, increased efficiency, their position as the world's leading manufacturer, and a seemingly endless stream of government funds, China's solar production will likely continue to grow. As Beijing officials may be attempting to satisfy domestic solar manufacturers by countering the decline in international demand for solar panels (Hook, 2011), the industry is expected to receive continued financial stimulus for as long as incentives are needed to offset the costs (Liu, Yi, and Wang, 2009). This fact is one that can be looked at favorably by the Chinese public given increased jobs, health and environmental quality. And, when seen in light of the nation's Foreign Investment Guidance Catalogue of 2007, a favorable business model is established for foreign investment in the construction and management of solar power stations (Liu, Yi, and Wang, 2009). Thereby, China has left the option open for their citizens, along with corporations from around the globe, to benefit from their ambitious renewable energy policies.

Photovoltaics in America

In recent years America has seen resurgence in solar investment as the nation that originated the idea of Feed-In-Tariffs (under the Carter administration) is once again adopting such policies (Shahan, 2012). While New Jersey has the highest concentration of solar panels in relation to landmass, California is the leading U.S. state in terms of total solar utilization with nearly 80% of the total U.S. market share of grid-connected installations and FIT programs in place in both Sacramento and Palo Alto (Torrens, 2008). Additionally, the Los Angeles Department of Water and Power has allocated 10-megawatts of grid capacity for solar FIT contracts under their CLEAN LA Solar program. By 2016, the city expects to have a 150-megawatt FIT program in place – enough to power 34,000 homes, making Los Angeles largest city in the nation to adopt such a program (Luskin Center, 2012).

Solar in California Housing

With Los Angeles' approval of the largest solar Feed-In-Tariff in the U.S., officials have cited Gainesville as a case model for policy adoption (Cruger, 2011). Provided the system is put into place at the projected rate, Federal tax credits for solar could provide

Los Angeles property owners with $300 million worth of solar investment costs by the time they expire in 2016 (Cruger, 2011).

In a study conducted by the National Bureau of Economic Research (NBER), experts used data related to homes and residents in San Diego and Sacramento, California to evaluate the effect of solar on residential real estate values (Dastrup et al. 2011). Analysis of demographics and property rates indicated that areas where PV is most common are, “richer, whiter, more educated, have more registered Democrats, and have larger homes.” (Dastrup et al. 2011). Additionally, the NBER looked at age and education, finding that solar homeowners were likely born after 1950 and those with bachelors or masters degrees are 27 to 55% more likely to live in a solar home than is a person without a degree (Dastrup et al. 2011).

Recognizing that home solar investment costs are prohibitive, with installations costing 80 percent more than their lifetime energy output, researchers found that external value was added through pride in producing one’s power and community approval of “green” technology (Dastrup et al. 2011). Looking at comparisons of similar home sales, data indicated that, “after controlling for observable characteristics and flexible neighborhood price trends,” solar panels added 3.6% to home resale value (Dastrup et al. 2011). And, while the 2009 average for household PV systems was $35,967, subsidies and tax incentives reduced the price to $20,892, and predicted average resale value was increased by $22,554 (Dastrup et al. 2011). Additionally, data indicated that two or more homes with solar installations adjacent to one another resulted in an average capitalization value of 7 percent (Dastrup et al. 2011).

In addition to providing opportunity to property owners, the city is also focused on providing rooftop solar to non-profits, senior living centers and low-income housing. Indeed, the U.S. Department of Housing and Urban Development (HUD) has committed to “greening” 2,500 low-income housing units in Los Angeles and 157,000 units nationwide (Cruger, 2011). This will result in benefits for municipalities and low-income residents.

New Jersey’s Solar Land Use

Through the enactment of various financial incentives, New Jersey now boasts 9,000 solar projects, with a capacity of over 320 megawatts (Sturm, 2011). In 2010, the state’s Solar Advancement Act called for 4,000 additional megawatts of solar output by 2026 – thirteen times current capacity (Sturm, 2011). As a densely populated state with little land for ground installations, New Jersey has focused on developing adequate regulations, incentives and policy to guide the size and siting of solar facilities (Sturm, 2011).

Seeking to preserve their remaining agricultural and ecological lands, New Jersey is attempting to establish priority incentives for rooftop installations with increased benefits for rooftop installations, rather than ground (Torrens, 2008). Recognizing the potential value of municipal sites and industrial facilities with plentiful land and extensive energy needs, the state has also considered using limited-use lands, such as brown-fields and capped landfills, as possible sites for solar development (Sturm, 2011).

The Influence of Solar Investment Firms

Since the solar Feed-In-Tariff program began, GRU has seen a surge of investment from firms local, national and international (Clark, 2010). In Gainesville, where 260 local jobs have been created through solar installations, dozens of regional, national and international firms have acquired contracts on land held by them, as well as on the rooftops of local commercial and municipal buildings. These solar investment companies offer a variety of services such as consultation, feasibility studies, project design and engineering, financing, rebate and incentive assessment, implementation through sourcing of equipment, installation, construction, operations, maintenance and system monitoring (Borrego Solar Systems, 2012). With such a complete range of services, it is possible for property owners to profit by simply renting their roof space to such companies. One such California-based company took advantage of Gainesville's solar FIT by renting the rooftop space of a large retail strip called Butler Plaza, installing the largest rooftop solar installation in the Southeastern United States (Clark, 2012).

In the Gainesville region of north central Florida, the largest such company is Solar Impact (Solar Impact, 2012). In facilitating most of the services listed above, the company has established the greatest presence of any solar investor in Gainesville, profiting from expert knowledge and the ability to buy large quantities of equipment at wholesale rates (Solar Impact, 2012). Recently, Solar Impact submitted multiple applications for the same contracts via a number of LLCs, beating out a majority of competitors through odds alone. This incident raised a level of debate as many community members and other investment firms claimed that Solar Impact operated outside of the established guidelines. While there have been no steps made to prevent such incidences from happening again, GRU officials argue that no wrong committed as all LLCs are able to submit applications and submittal was reopen for those contracts as loopholes are recognized and accepted given that everyone has the same opportunity to exploit them (Meek, 2012).

In another case, a German subsidiary called Sybac is building the largest privately owned solar array in the state, covering 7 acres of open land in northwest Gainesville (Clark, 2010). Capable of producing enough electricity to power 200 to 300 homes, the project will cost $8 million to construct, employing dozens of people to assist in site preparation, surveying, construction, security and accounting (Clark, 2010). As the city's largest single-site provider of solar electricity, power from the installation will be sold directly to GRU as part of the FIT system. Clearly, the project is a boon to the local economy, but it remains unclear how large-scale ground installations may alter local land use and property rates. And, while such investments benefit landowners and companies, it is unclear how such installations can be assured if property is sold or the investment strategies of companies fail, possibly creating greater volatility in energy and property markets.

CHAPTER 4
RESULTS

Ultimately the assessment of solar FITs in Germany and China, as well as solar policies in the United States, gives a better understanding of the qualitative advantages and disadvantages incurred upon utilities, solar FIT investors, the environment and the community. Additionally, by considering how solar FIT policies affect land use, housing markets, commercial property, municipal entities, and land scarcity, one may understand how the policies and economics relate. As outlined in the methodology, the following sections delineate the various aspects of the framework established for the analysis of Gainesville's solar FIT program.

Gainesville Regional Utilities

Through a simple FIT program based on the German model, GRU is able to simplify America's, "byzantine mix of tax incentives, rebates, state mandates, and utility programs,"(Farrell, 2009) as it's established that, "GRU will purchase the energy produced for $X per kilowatt hour." (gru.com, 2008) This system allows the utility to reduce their maintenance and personnel costs as investors install and maintain equipment, while reducing reliance on unstable foreign fuel prices (gru.com, 2008). The latter of these is essential as experts estimate that by 2030, worldwide electricity demand will be twice that of 2005 (Epstein et al. 2011). Given FIT metering policy, the utility's established rate may provide savings as twenty year contracts are based on current fuel prices that will likely rise (Clean Coalition, 2011). With regular reviewed the rate paid to producers may be lowered or raised in correspondence with market prices for technology, as well as when too much investment is occurring or when investment is found insufficient. With another set of controls that may be manipulated in the utility's favor, degression makes solar power more affordable as producers are given incentive to reduce system prices (Farrell, 2009).

Among the program's costs to GRU are increased transmission lines, administration fees, and increased grid connections (Farrell, 2009). Thus far, these processes in Gainesville have been simple and straightforward, with little alteration to the existing grid needed. Of greater concern has been the simple fact that sunlight levels are unpredictable and limitations of current storage technologies inhibit solar power from being used as a primary power source as voltage drops occur in times of sustained cloud cover and normal evening darkness (Meek, 2012). Based on such fluctuations in production, there are limitations on the level of dependence a utility can place on solar power alone. This is one factor cited as reason for the limitation of GRU's solar capacity to less than one percent of the utility's total electrical capacity (Meek, 2012). Even in Germany, the world's leading producer of solar power, only 3% of the nations total electric power comes from PV. And, though there are projections for 25% of German power to be supplied via solar by 2050, this is unlikely without great improvements in battery capacities that might enable solar energy to be stored for times of darkness, or with the use of a smart grid system capable of feeding all solar energy to the grid in hours of sunlight, while adjusting for weather conditions (Reuters, 2011).

Table 4-1. Utilities

Financial Benefit	Financial Cost	Externality
Program is simple and easy to administer	Increased need for grid connections	Hedges against future greenhouse gas regulation
Reduced Maintenance/ personnel costs	Maintenance must be coordinated and administered	Serves as a model for other communities
Metering may be altered/ manipulated	Risk of theft and vandalism of installations	

Table 4-1. Continued

Financial Benefit	Financial Cost	Externality
Less commitment of capital	Production is intermittent/ dependent on light levels	
Satisfies renewable energy credits		
Lower overhead may reduce water and power costs		
Able to construct advanced equipment with engineers who can install and maintain it		
May use unused roofs, land, or parking lots for installations		

Investors

Through the use of more flexible ownership models, investors of various backgrounds are able to make a low-risk business investment that was unlikely via older models that inhibited small projects and offered no guarantee of grid access or purchase at a fixed price (Rickerson and Grace, 2007). With these amenities, investors benefit from state and federal tax incentives as the state of Florida currently offers investors $4.00 per installed watt of solar PV (gru.com, 2008). This further reduces the cost of installation and maintenance, which can be considerable. Indeed, of the costs PV system installation are substantial for commercial investors who, on top of equipment costs, must also pay GRU a non-refundable application fee of $500 to $1,200, depending on system size (Clean Coalition, 2011). Fortunately, residential investors are exempt from this fee (Meek, 2012). But, all investors are required to pay a deposit of $30 per kilowatt to be produced, plus an insurance policy of $100,000 in liability (Clean Coalition, 2011). But, most general insurance polices cover these insurance costs as only 2% of investors require additional coverage on top of their existing policies (Meek, 2012).

Clearly, investor costs are greater than those for GRU, but they are reduced when installation prices fall through technological innovation as, “The lower the price of a module, the more attractive a feed-in tariff looks,” (The Rise of Big Solar, 2011). And, as with most commodities, bulk purchases of solar cells, in excess of 100 Kilowatts, results in the relatively cheap cost of $1.50 per watt (Meek, 2012). Solar investment firms have made full use of this fact.

As it stands, fossil fuels are more cost effective when not adjusted for indirect costs. But installation costs for solar are falling quickly thanks in part to accelerated production of equipment (as shown in 4-1) as well as other factors associated with government subsidies and tax breaks, innovation and localized economies of scale (Zhao et al. 2011).

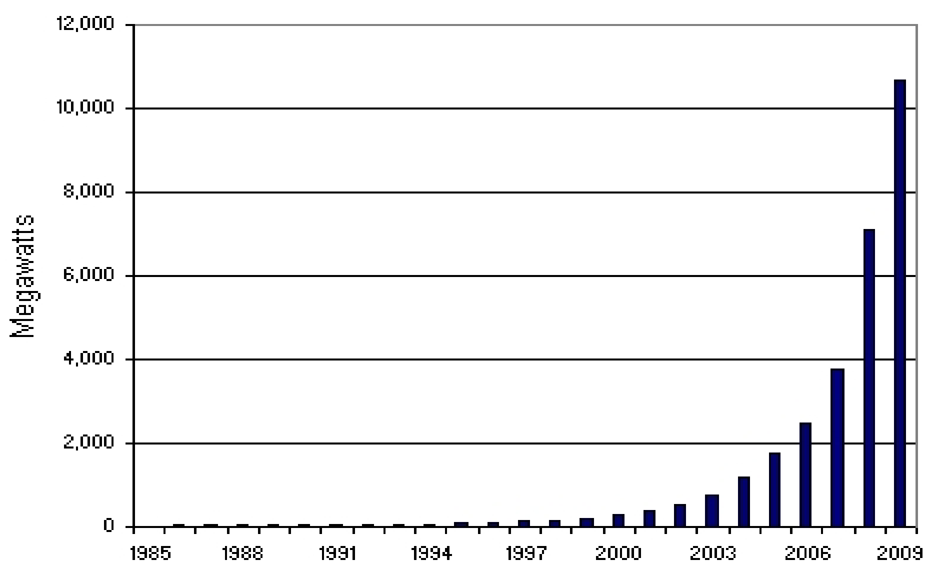


Figure 4-1. World annual solar photovoltaic production from 1985 to 2009 (Source: http://www.renewableenergyworld.com/assets/images/story/2010/9/24/1-1332-solar-cell-production-climbs-to-another-record-in-2009.jpg. Last accessed June, 2012).

The rate of innovation in PV technology, known as the learning ratio, is the percentage that costs decrease each time the grid capacity doubles. In the case of GRU, costs will decrease by 18% with each doubling of installed capacity (Meek, 2012). Regardless of system scale, costs to investors include part replacement and cleaning (Clean Energy in California, 2011) and degression policies, which are said to create, “incentives to reduce costs and, hence, move down the learning curve,” but may also make an investment unappealing as value of PV a system falls each year (gru.com, 2008). In Gainesville this has occurred as the payment scale is adjusted each year on the equipment cost basis assessed through the mandatory provision of a total costs invoice to GRU given by all investors. While this policy is intended to provide a five percent return on investment costs over the course of each twenty-year contract, some investors are accruing earnings up to 10% as costs continually fall. Indeed, since 2009 investors have seen a 50% drop in initial investment costs as one kW of production capacity has gone from $8.50 to $5.00 (Meek, 2012).

4-2. Investors

Financial Benefit	Financial Cost	Externality
Flexible ownership models	Initial cost of installation	
Predictable investment	Maintenance	
Guaranteed grid access	Metering may be altered through degression	
Possible reduced cost of PV systems in future		
Freedom from negotiation with utility or municipality		

Solar's Influence on Land Values

Given the relatively new policies implemented through FITs and other investment stimuli, many of the effect of the wide-scale implementation of solar power production have yet to be documented in a long-term U.S. context. But, in looking at existing in Gainesville, along with results of the literature on both domestic and international cases, one may come to a series of speculative conclusions on how FIT will influence commercial property, along with single, multifamily and low-income housing.

Commercial property owners

Gainesville's solar FIT program provides commercial property owners with incentive for investment via rebates and tax credits that lower upfront costs, reduced utility rates through improved rooftop insulation, and fixed-rate contracts assuring a profitable return on investment costs (Dastrup et al. 2011). Similar to housing markets, the affect that these factors may have had on long-term commercial property values is unclear, but the benefits of owning and operating such installations are evident (Meek, 2012). While both economically and environmental beneficial, incentives to build are also acting as public subsidies for landowners accruing substantial benefits from Federal and local governments (Zhao et al. 2011). Additionally, the leasing, development and monitoring of large commercial roof space by solar investment companies may benefit those immediately involved, but there remain risks of discontinued production through resale of property, uncertain property values and the potential solvency of individual solar investment firms (Dastrup et al. 2011).

Table 4-3. Commercial property

Financial Benefit	External Cost
Rooftops may be leased to solar investment companies that pay investment and operating costs	Risk of theft and vandalism of installations
Rebates and tax credits reduce up-front costs	
Improved roof-top insulation reduces operating costs	
Additional income from power generation	

Single and multifamily housing

Based on research findings, it can be assumed that solar investment provides a return to homeowners before accounting for profits garnered from power generation within the Feed-In-Tariff system (Dastrup et al. 2011). Though the causality of increased home values in the California cities of San Diego and Sacramento is clear, Gainesville's rapid development of solar installations has been too brief for complete assessment of the degree to which solar installations have altered resale values. Based on Figure 4-2, one might assume that solar installations may increase home prices, but the literature dictates that PV systems are typically installed in neighborhoods that are home to wealthy, well-educated people who already live in larger, more valuable homes (Dastrup et al. 2011).

The simple matter of installation costs that are prohibitively high for the average property owner is likely the primary factor in the positive relationship between Gainesville PV installations and property rates. On top of this, residential installations have been difficult to establish given that smaller installations cost property owners contractors and investment firms more in installation costs with lower overall productive value. Due to this, GRU has allotted a relatively small 200 KW capacity to residential projects (Meek, 2012).

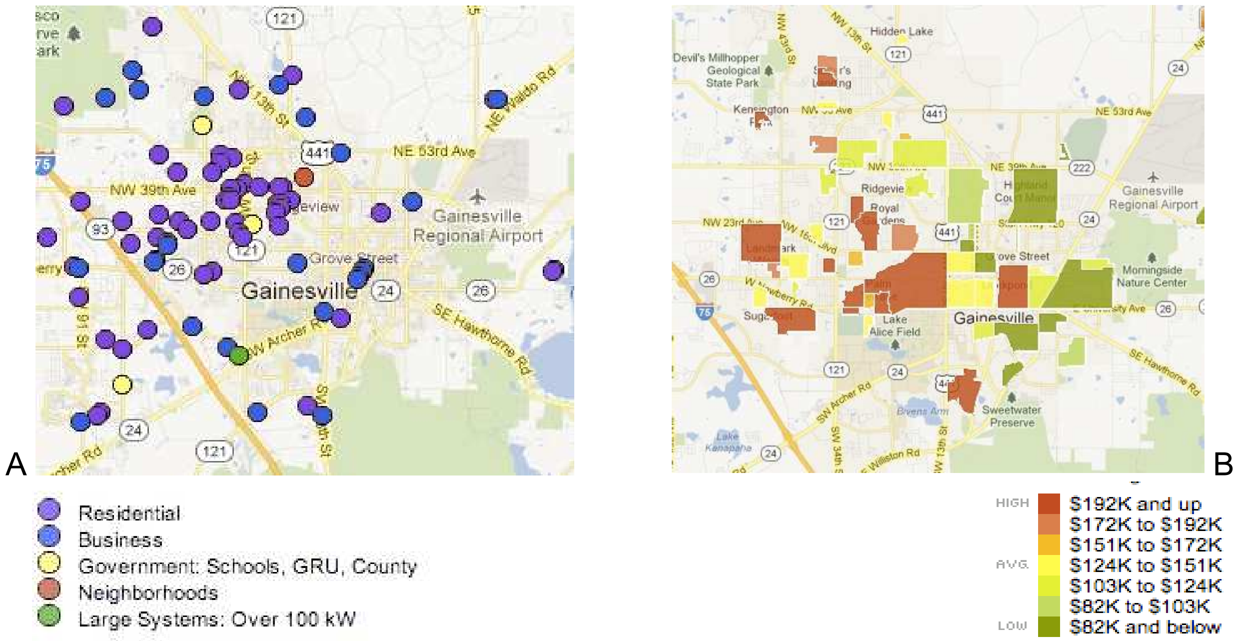


Figure 4-2. Correlation between Gainesville solar PV installations and average property rates. A) Gainesville solar PV installations. B) Gainesville property rates (Sources: https://www.gru.com/YourHome/Conservation/Energy/solarMaps/. http://www.trulia.com/home_prices/Florida/Gainesville-heat_map/. Last accessed June, 2012).

Table 4-4. Single and multifamily housing

Financial Benefit	Financial Cost
Subsidies lower the effective price to about $20,892	Average total system cost: $35,967
Revenue generated from unused roof space	Cells last 25 years while GRU contracts expire after 20
Quick renovation with return of 5-10%	Installation and Maintenance
Increased property value – average of $22,554	Subsidies for PV/ FITs may be an unfair homeownership subsidy
Reduced heat absorption lowers utility bills	

Table 4-5. Externalities in single and multifamily housing

External Benefit	External Cost
Existence value in generating one's own electricity	Some communities don't allow PV installations
Observability value	Considered by some to be an eyesore
Increased tenant attraction, satisfaction, and retention	UV access not guaranteed, as when neighbors build in proximity
Slowed global warming	

Low-income housing

That said, Gainesville's solar FIT has been successful in providing a reliable rate of return for landowning investors, but renters and low-income homeowners have gained no monetary benefit. Given investment costs and the need for land ownership, there are concerns that solar FITs, as well as Federal and state subsidies, are a new form of mortgage subsidy on top of those for which U.S. homeowners are already eligible (Meek, 2012). As of yet, no community members have raised public concern that the tax incentives, rebates, and tariffs are rewarding those with the means and desire to purchase property and solar panels (Dastrup et al. 2011).

Table 4-6. Low-income housing

Financial Benefit	Financial Cost
Investment companies may pay initial & operating costs	Maintenance requirements must be coordinated and administered
Reduces operation expenses	Risk of theft and vandalism of installations
Counteract and equalizes homeownership subsidies	
HUD plans to "green" 157,000 units	
Combines low-income housing tax credits, solar tax credits, cash rebates and affordable housing subsidies	

Community

Gainesville benefits from a spectrum of externalities such as serving as a model to other municipalities, achievement of renewable energy goals and reduced emissions of greenhouse gases and pollutants (gru.com, 2008). This reduction in fossil fuel demand is also a direct financial benefit to the community as citizens feel less of the affects of volatility, and as less demand results in lower long-term prices (Rickerson and Grace, 2007). Such volatility costs communities through the resulting damages to jobs and economic growth, which is further exacerbated if high oil prices coincide with economic depression, as seen in recent years. Indeed, the oil crisis of 1973 was estimated to have cost the U.S. economy $350 billion in lost productivity (Awerbuch, 2012). Of the costs incurred on the community through these policies, all consumers of electricity are made to share the burden of offsetting the higher price paid to producers of solar energy. Funding is therefore not a budget item for the government or utility, but something utilities pass on to consumers more or less immediately (gru.com, 2008).

Economic Growth

Additional financial benefits include flexible models of ownership that open the market to smaller investors, increasing the community's share in a locally owned power source (gru.com, 2008). From these cooperative ownership models, market power is diffused, creating, "a more distributed and democratic energy infrastructure." (Rickerson and Grace, 2007) Perhaps the greatest social benefit of a FIT is the potential for direct and external job growth as needs rise with installation, maintenance and research and development (Torrens, 2008). In theory, the result is an agglomerate community that propels idea exchange, innovation, policy, entry of new firms requiring additional goods and services, formation of specialized niche markets and the possible establishment of regional solar advocacy groups that, "provide an enlarged opportunity to influence the institutional set-up." (Jacobsson and Lauber, 2004). While this opportunity has proved beneficial, it should be noted that only 30% of the awarded FIT contracts have gone to local investors given that regional, national and international firms have recognized the profitability of participating in the program (Meek, 2012).

With growth and foreign investment comes increased potential for collaboration with national and international experts, allowing for the benefits of shared research and knowledge, specialization and comparative advantages (Torrens, 2008) From this, an accelerated rate of innovation allows for increased efficiency and reduced costs of PV technology as short-term development can result in long-term benefits, as shown in Figure 4-3 (Rickerson and Grace, 2007)

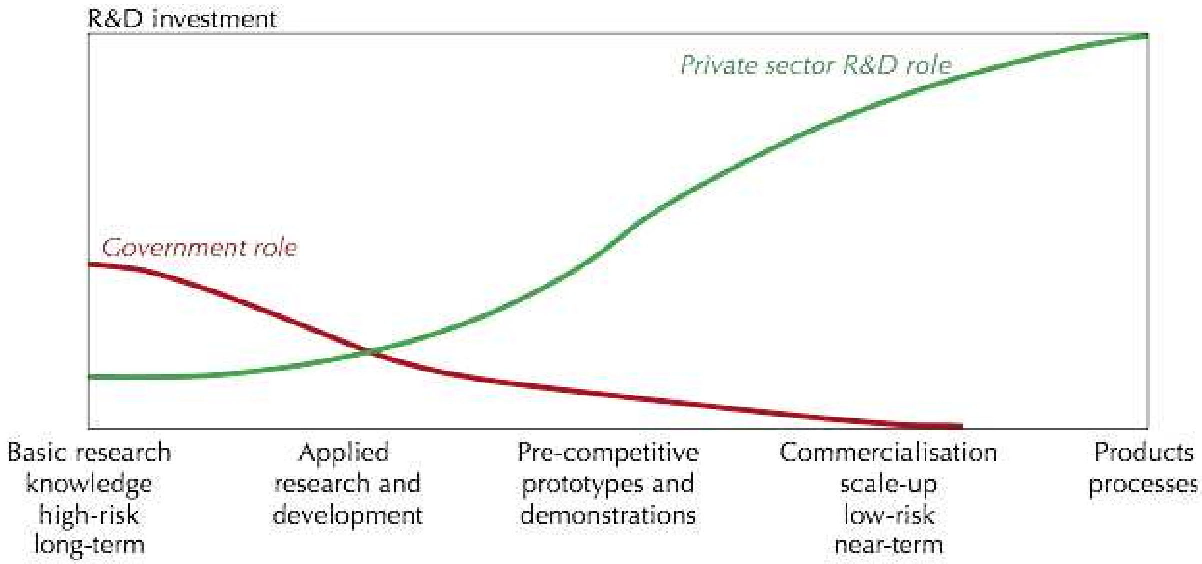


Figure 4-3. Negative correlation between government investment versus private sector research in the development of solar PV technology (Source: http://www.iea.org/textbase/nppdf/free/2008/DeployingRenewables2008.pdf. Last accessed June, 2012).

In order for these benefits to be felt, the community must commit itself to a policy of education, stressing the reality of success within the FIT system, rather than allowing for the perpetuation of conventional energy production (Jacobsson and Lauber, 2004) Some argue that a fixed price for solar power is contradictory to the free market economy as it shifts market competition and results in higher costs. But supporters argue that, unlike rebates and tax incentives, FITs focus on price to stimulate competition and reduce technology costs (Farrell, 2009). Central to the argument against FITs is the idea that they lead to benefits for the investors, but also to a higher burden on society (e.g. electricity consumers). Contrary to this belief, the program is only costing the average GRU customer $0.23 for every 1000 KWH consumed, resulting in an average monthly increase of slightly more than a quarter of a dollar per household (Meek, 2012). And, one should remember that, “In calculating social costs, we need to consider both subsidies and external costs.” (Jacobsson and Lauber, 2004). And, while the cost of the feed-in-tariffs are obviously paid for by the consumers and taxpayers, current U.S. standards disguise the true price of fossil fuels from consumers and utilities through the long-term employment of heavy subsidies (Jacobsson and Lauber, 2004).

The Role of Fuel Subsidies

While the external costs and benefits of fossil fuel are often seen as intangible, thorough examination gives light to the influence of these mechanisms. In one study of a seven-year period (2002-2008), researchers examined the levels of federal subsidies dispersed to the energy sector and found that there was a substantially higher level of funds given to fossil fuels than to renewables. In that time, approximately $72 billion in tax dollars was given to the long-standing and highly profitable fossil fuel industry (Environmental Law Institute, 2009).

Given that many of these subsidies are written into the U.S. Tax Code, the very standard by which the government is funded, the unquestionable permanence and of these standards are often overlooked. Through just a handful of provisions – such as the Foreign Tax Credit, in which energy companies can claim tax credits for payments on the international production of oil – investors in fossil fuels insidiously receive beneficial tax treatment (Environmental Law Institute, 2009). On top of this, companies are able to plan and propose investments using “discount rates,” or nominal interest rates that disregard inflation and allow present currency rates to be compared with future money, a speculative practice that further compromises the stability of these industries (Awerbuch, 2012).

Not only are fossil fuel subsidies used to support activities that create high levels of pollution, resulting in a variety of health and environmental costs, but in the same seven years the fledgling renewable energy industries received less than half of the $72 billion allocated to fossil fuels. Though $29 million dollars is a substantial sum of money, the mechanisms through which these funds were distributed were mostly limited-time programs with expiration dates, as with the American Reinvestment and Recovery Act of 2009 (Environmental Law Institute, 2009). The result is an atmosphere of speculative hesitation that leads many investors to question the financial sustainability of the sustainability movement (Wan, 2011). And, with nearly half of these renewables subsidies going to corn-based ethanol production, a technology that is often said to use more fuel than it produces, the legitimacy of these subsidies comes under greater debate (Environmental Law Institute, 2009).

Assessment of Fossil Fuel Externalities

Further examination leads one to wonder what the total external costs of supporting the fossil fuel industry may be in terms human health and environmental quality. In one study the life cycle of coal, America’s leading source of electric energy, the external damages of the fuel were analyzed and quantified. While the study was forced to omit certain intangibles such as the affects of heavy metals and toxic chemicals on ecological systems, damage to fresh and coastal waters, the impacts of acid rain, and the full danger posed by an increasingly unstable climate, researchers still found substantial costs incurred (Epstein et al. 2011).

With a thorough health impact assessment (HIA), researchers quantified best and worst case scenarios in accounting for the health impacts of water and air pollution, including: skin irritation, headaches, fatigue, cardiovascular disease, digestive and respiratory illness, and increased cancer risk (Segal, 2012). In addition to this, mortality from coal health impacts were valued using the value of statistical life (VSL), the U.S. Environmental Protection Agency (EPA) standard by which the preservation of a human life was estimated to be worth $7.5 million in 2008. Combining these health and environmental statistics with the costs of subsidies and tax breaks, the monetized estimates of the total cost of coal to the U.S. economy in 2008 ranged from $175,193,683,964 to $523,303,948,403. Given minimum costs of $175 trillion per year, the real price of coal would be an additional 17.8¢ to 26.89¢ per kWh on top of 2008 prices. If markets were to account for this discrepancy, the price of coal would make wind, solar, other forms of renewables, efficiency, and conservation far more cost competitive in the U.S. and abroad (Epstein et al. 2011).

Debating Biomass

Even among renewables there is a great deal of debate over which production methods are most beneficial to communities overall. In Gainesville, the need to increase future power production capacity led to the consideration of twenty-eight generation options, including wind and solar. In the end it was decided that, in lieu of a 220-MW extension on GRU's existing 250-MW coal facility, a biomass plant would be constructed. With construction currently underway on a privately owned, 100-megawatt plant to be fueled by wood waste when it comes online in 2013, it's estimated that the three-year building project will employ 350 temporary workers with half of the construction workers and specialists employed locally (Wan, 2011). Once the plant is finished, the contracted operator American Renewables claims that the facility will employ 45 people over the next 40 years, with 160 additional jobs created indirectly through forestry, logging, and trucking within a 75 mile radius of the facility (Wan, 2011).

In explaining why biomass was chosen as the city's best option for sustainable power generation, officials claimed that it is the most cost-effective renewable energy available. But, power bills may rise under this initiative as the Gainesville residents are made to pay for: labor; ash transport and disposal; purchased biomass, transport and storage; facility maintenance; road maintenance; insurance and general costs (Caputo et al. 2005). On top of this, one must address external costs as several organizations, including the Florida Medical Association, the American Lung Association, and Physicians for Social Responsibility cite air pollution associated with biomass energy as a strong concern (Wan, 2011). Indeed, estimates of GRU's biomass facility indicate that it will emit 30 percent more carbon emissions than a coal facility generating the same amount of electricity, while creating additional pollution, health risks and traffic congestion via the claimed benefits of added forestry, logging and trucking (Wan, 2011). And, while American Renewables may be backing the facility's $450 million construction costs, one third of this is to be reimbursed through the American Reinvestment and Recovery Act of 2009, creating a direct cost to federal taxpayers (Wan, 2011).

Community Effects of Photovoltaics

Given the clear costs incurred by communities through the production of electricity via fossil fuels and biomass, the risks of solar production are relatively minimal. In the beginning stage of production, the greatest dangers are incurred by factory workers through the inhalation of vapors or dusts and exposure to hazardous chemicals through accidents. Of the risks to neighboring communities, the greatest is the accidental release of hazardous gasses through facility spillage or fire. In efforts to mitigate these risks, regulations provide for accident prevention and planning programs, extensive ventilation systems, and emergency confinement and absorption methods (Oregon Dept. of Transportation, 2012).

Beyond the PV production phase, the greatest risk posed by a solar installation is fire, through which noxious fumes may be released and inhaled with the possibility of causing negative effects to health and the environment. Unlike other fuel sources however, incidence of fire is rare and brief, with extremely high temperatures needed to melt and release the hazardous materials present in solar equipment (Oregon Dept. of Transportation, 2012).

With strict environmental, health and safety regulations on PV production enforced in the developed world, the technology poses far fewer risks than conventional sources of power production. Indeed, the U.S. Department of Energy asserts that, “few power-generating technologies have as little environmental impact as photovoltaic solar panels,” given that PV systems mitigate the emission of greenhouse gases associated with conventional fossil fuels (Union of Concerned Scientists, 2002). So, even while production capacity has grown substantially and with little regulation in developing nations such as India and China, the external health costs of these energy technologies are minimal when compared to standard production methods (Oregon Dept. of Transportation, 2012).

Table 4-7. Community

Financial Benefit	Financial Cost	Externality
More flexible ownership models allowing for more diversity of investors	Higher energy prices	Accelerated achievement of renewable energy goals
Locally owned and operated power generation	Education and acceptance of systems is necessary	Hedges against greenhouse gas regulations
More jobs		Reduced pollution levels
Economies of scale (agglomeration)		Slowing of global warming
Accelerated rate of innovation		Serve as a Model
Decreases Fossil Fuel Demand		Energy security through less reliance on foreign oil
Increased collaboration with domestic and international firms		Improved air and water quality
Possible reduced cost of PV systems in future		

Schools

Recognizing the potential for a steady income stream provided by investment in GRU's solar FIT program, schools and solar investors have looked to their rooftops as locations on which installations may benefit both parties (Millionsolarrooftops.com, 2011). With no costs directly incurred by Alachua County School District, solar investment firms have installed PV systems on the vacant roof space of eight local schools (gru.com, 2008). Under this arrangement, each investment group pays the costs of investment, receiving $0.29 for each kWh produced while maintaining the installations and proving the School District with $0.10 per watt for the length of the 20 year contract. Though this may seem a paltry sum, the total system capacity of 2,750 kilowatts will provide $275,000 per watt of production for two decades

(Millionsolarrooftops.com, 2011). Given the current finances of schools in Florida and most other states, the economic benefits of GRU'S solar FIT are tremendous. As an added incentive, buildings become more efficient as PV cells absorption of heat of the sun, which would have fallen on empty roofs. And, even once the contracts have expired at the end of the twenty-year period, Alachua County School District will gain ownership of the solar installations. Though they will no longer feed into the grid, the panels will continue to produce power for the schools for five to ten years, saving the School District money on operation costs in a future where electricity prices will be higher (Millionsolarrooftops.com, 2011).

While school involvement in the FIT has been beneficial, administrative challenges have arisen as each school may deal with multiple investors given that each building's rooftop is contracted as a different system (Meek, 2012). Still, benefits far outweigh the costs as schools receive: additional revenue from leased roof space; increased insulation and efficiency; as well as the ability to teach students, faculty and community members about the merits and possibility of solar power generation (Borrego Solar Systems, 2012).

Table 4-8. Schools

Financial Benefit	External Cost
Additional revenue for struggling school budgets	Risk of theft and vandalism of installations
School districts/ colleges may deploy large, multi-site \ installations, reducing total installation costs	
Investment companies may pay initial & operating costs	
Increased insulation reduces energy bills	
'Solar curriculum' offers lessons in sustainability for students, faculty, and the community	

Environment

Major arguments in support of solar and other renewable energy may be made when considering broad and intangible issues of environmental damage caused by conventional fuel sources, health and ecological issues associated with air and water quality, and sea level rise as the result of global warming. Given that fossil fuels account for 80% of global energy supply and 64% of electricity production, the environmental factors are difficult to quantify with full accuracy. And, although these environmental advantages and disadvantages of the solar FIT model are external, they are no less significant.

Major benefits of solar and other renewables include cleaner air and water, achievement of renewable energy goals and reduced imports of fossil fuels – which further reduces fuel consumption given that required in the transportation and maintenance of transportation systems (gru.com, 2008). With 70% of all U.S. rail traffic dedicated to the shipment of coal, the latter is considerable (Epstein et al. 2011). If the cost of fossil fuels truly correlated with real costs to health, community and ecosystems, renewables would be far closer to parity (Jacobsson and Lauber, 2004)

Effects of Fossil Fuels

In analyzing the costs of fossil fuel as compared to solar, one may look at methods of extraction, transportation, processing, and combustion to see a continuous process of waste generating several environmental risks. As previously stated, the accounting of these damages conservatively triples the price of coal-generated energy (Epstein et al. 2011). In the case of oil, the second leading source of U.S. energy production, similar environmental risks are posed, along with the additional hazards of liquid toxin dispersion as seen in the case of oil spills such as the disasters of Exxon Valdez and

Deepwater Horizon. In these cases, the extraction, transportation and processing of oil has resulted in severe ecological damage and subsequent costs incurred upon fisheries and tourism, and through their remediation, litigation, and long-lasting health consequences (Fontinelle, 2010).

If the costs of fossil fuels were fully recognized, renewable energy might seem like a better option and government policies could promote their adoption and development in the future (Jacobsson and Lauber, 2004). With coal said to be the cause of one-third of annual greenhouse gas emissions, climate change is central to current concerns over fossil fuels as the real and observed phenomenon is causing the collapse of eco-systems, increased storm incidence, widespread forest and crop losses, and uncertainty over long-term water resources. In the U.S. alone, economic losses from these events was estimated at between 5 and 20% of GDP ($1.75 - $7 trillion) in 2005 (Epstein et al. 2011). In addition to this, concern is growing over sea level rise and its direct impacts on land use given that, "40% of the world's population lives within 100 km of a coast." (Rickerson and Grace, 2007). Given these environmental factors, it's essential that solar and other renewable energy sources be recognized as a means to slow global warming and stabilize rising water levels.

Issues with Biomass

As previously stated, renewable energy technology is varied, offering different environmental advantages and disadvantages. In the case of Gainesville's future biomass facility, the effects begin in local forests as GRU's Stewardship Incentive Program will allow local landowners to sell the wood and detritus from invasive, unhealthy or undesirable trees (Wan, 2011). Huge amounts of biomass will be needed to power the facility, as 1.2 million tons of organic material (80% forest products, 20%

urban wood waste) consumed annually (Wan, 2011). Concerns have been raised that clear-cuts will be needed, harming local ecosystems and competing with regional lumber and paper mills.

So skewed is this debate that proponents of biomass power production claim that the burning of organic matter may even offset emissions that would otherwise have gone back into the atmosphere due to wood decomposition that would release both carbon dioxide and methane (Wan, 2011). The argument is countered by the simple fact that while burning biomass immediately releases large quantities of carbon dioxide, wood takes years to decompose as natural methane-consuming bacteria in the soil minimize it’s release. Indeed, biomass facilities may release even greater levels of carbon into the atmosphere than coal combustion (Walker, 2010). And, the combustion of biomass materials has been shown to result in the emission of dioxin, carbon monoxide, sulfur dioxide, nitrogen oxides, formaldehyde, chlorine, heavy metals and particulate matter (Wan, 2011).

In addition to environmental concerns over air quality, Gainesville’s biomass plant is expected to use an estimated 1.4 million gallons of water per day (Wan, 2011). Given the continuing debate over water resources in the region as Florida, Georgia and Alabama contend with an extended drought, the plant will be using large quantities of the city's wastewater which will be pumped to the plant, filtered, combined with well water and sent to the cooling towers. While concerns remain, officials claim that waterways will be unharmed by the project (Gainesville.com, 2011).

Environmental Effects of Solar

Of the environmental costs of solar PV systems, toxic materials used in cell production and disposals are the leading concern (Union of Concerned Scientists, 2002). From a substantial body of research investigating the life cycle of photovoltaics, from raw material production, manufacture, use and disposal, the full environmental costs of these systems may be assessed. With the mining of crystalline silica, health safety and environmental concerns are raised as the material may cause respiratory damage to workers. Aside from this, the end life disposal of solar cells presents an environmental concern as the lead solders contained therein may leach into landfills, eventually reaching the water table. Though, it merits noting that lead solder accounts for only 0.5% of annual U.S. lead use (Oregon Dept. of Transportation, 2012).

In spite of any risk posed by PV systems, researchers at the Brookhaven National Laboratory, have stated that, "regardless of the specific technology, photovoltaics generate significantly fewer harmful air emissions (at least 89%) per kilowatthour (KWh) than conventional fossil fuel fired technologies." (Oregon Dept. of Transportation, 2012). Still, the U.S. PV industry actively promotes recycling programs that make use of the glass, aluminum, solar cells and minute quantities of copper and steel contained within each panel (Oregon Dept. of Transportation, 2012).

Table 4-9. Environment

Financial Benefit	External Cost
Accelerated achievement of renewable energy goals	Hedges against greenhouse gas regulations
Curtailment of Global Warming	May cause habitat destruction
Reduced import and transport of fuels	Toxic materials are used in PV production
Improved health of people and ecosystems	

Land Scarcity

Of environmental concern in solar production is the development of land, as installations may displace ecosystems and interfere with threatened species such as Florida's gopher tortoise (Clean Energy in California, 2011). But, given that 100% of annual U.S. power consumption could be generated through either 100 square meters of horizontal installations or 200 square meters of tracking arrays per person, land requirements for solar power are comparatively modest; see figure 4-4 (Denholm and Margolis, 2008). This is especially true when considering unused roof space. With 18% of residential and 65%of commercial roofs (65 sq. total meters per capita) suitable for utilization, 32% to 64% of total domestic energy needs could be generated on America's rooftops (Denholm and Margolis, 2008).

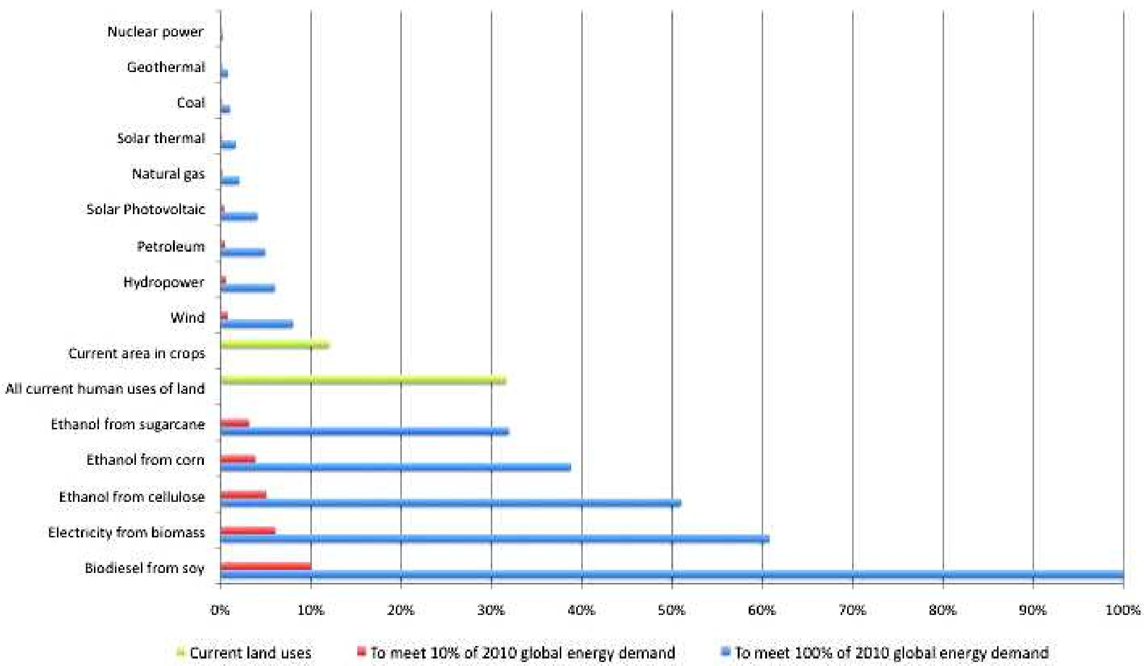


Figure 4-4. Percent of Earth's land area used for energy production (Source: http://12degreesoffreedom.blogspot.com/2010_05_01_archive.html. Last accessed June, 2012).

Still, PV systems can create external costs through conversion of ecosystems and farms into ground installations (Dale, Efroymson, and Kline, 2011). Accounting for this, GRU has priced the tariff for ground mountings at a lower rate than rooftop installations in an effort to steer investors away from ground mounted installations (Meek, 2012).

And, concerns over land conversion from farmland to PV may be partially eased through the grazing of animals and the growth of shade tolerant crops on land between and below ground mountings (Denholm and Margolis, 2008). Overall, land used in solar production is minimal when considering the fact that golf courses and airports currently occupy 35 square meters of land per capita, while land for corn ethanol production currently exceeds 200 sq. meters per capita – more than that needed to enable complete U.S. dependence on solar (Denholm and Margolis, 2008).

Table 4-10. Land scarcity

External Benefit	External Cost
Solar land requirements are relatively modest	Farmland and ecosystems may be cleared for ground installations
Per capita, 200 sq. meters of land could supply 100% of U.S. electric needs	Orientation/ low light / vegetation may reduce output
Land between arrays may support grazing and shade crops	
Zero impact “land” on rooftops	

Limited-use lands

Given the successful conversion of limited-use lands into viable sources of revenue in California and elsewhere, it would be logical that Investors in Gainesville might try to mimic such initiatives (Sturm, 2011). Although there has been discussion of developing local limited-use lands – like the heavily polluted 140-acre superfund site of a defunct lumber mill in North Gainesville called Cabot Koppers – such projects have yet to occur (Meek, 2012). It may be assumed that the Utility’s premium rate on rooftop installations and an aversion to the associated environmental and safety risks has prevented implementation of such plans.

Table 4-11. Limited-use lands

Financial Benefit	External Cost
Additional revenue for unused land with low demand	Environmental and safety concerns may arise
Typically unsuitable for residential or commercial	Permit approval may be difficult
Most limited-use sites are close to grid connections	Risk of theft and vandalism of installations
Shorter distances to lines reduces line costs and transmission losses	

CHAPTER 5
DISCUSSION OF RESULTS

Conclusions

As U.S. cities and states search for ways to provide such benefits, it’s logical that they look to FITs. Indeed, “As many as 11 U.S. state legislatures are seriously considering adopting the system as a complement to their renewable electricity mandates.” (Farrell, 2009). Simple and easy to administer, Gainesville’s FIT program arrives at a time when, “The costs of solar are dropping; in some sunny places it may, in a few years, be possible to get solar electricity as cheaply from a set of panels as from the grid, and later on for solar to compete with conventional ways of putting electricity into the grid.” (The Rise of Big Solar, 2011) As one of those sunny places, Florida could lead the nation in solar production. If this happens, the city of Gainesville will have a greater part in the energy future of the region.

While there are some major drawbacks to Gainesville Regional Utility’s solar Feed-In-Tariff program, the program’s benefits outweigh the costs. Among these costs, the greatest seems to be that of the disproportionate benefits accrued by property owners and investment firms in profits from power generation and increased property values gained through publicly financed subsidies and tax incentives (Dastrup et al. 2011). Though this is a direct financial benefit for those involved, it creates costs for all taxpayers and consumers, and may increase levels of disparity between people of different income and education levels – a growing trend throughout the nation. Additional concerns over the possibility for increased crime via theft and vandalism has not yet been realized in the area but, with growing awareness of system value, this may yet occur (Avro, 2009). Still, land scarcity and environmental damage caused by solar power is minimal when compared to many methods of energy production and land use types.

Recommendations

Given assertions from energy experts that 100% of the world's energy consumption could be supplied through wind, water and solar power by 2030, it's essential for citizens and legislators to consider this option, and the reasons for which it remains a lesser-known reality (Jacobson and Delucchi, 2009). Even in Gainesville, where legislators and community members have seen the benefits of solar FIT outweigh the costs, the program will expire in 2016. While all investors will have their contracts honored, no future projects are planned (Meek, 2012). Given the disproportionality of energy subsidies and the high cost of initial investment in solar power, the presence of installations will likely diminish without future innovation, tax breaks, rebates and policies (Zweibel, Mason, and Fthenakis, 2008).

Low-Income Housing

If the city of Gainesville were to place greater emphasis on development of PV systems for non-profits, senior living centers and low-income housing, the standards of living for the cities most needy would be improved, while likely saving the city money on program operation costs. Through coordinated efforts to convert units to green standards through HUD, as well as by offering incentives for solar investment companies to capitalize on low-income housing rooftops, the city would make the many benefits of the GRU's solar FIT program more obvious to the average resident. Also, by further emphasizing the priority of rooftop installations over ground mountings, the city would be able to ease some of the negative effects that solar Feed-In-Tariffs may have on property rates through volatility and increased scarcity.

Limited-Use Lands

The conversion of unused landfills, brownfields, and superfund sites into viable solar PV ground installations is a very real possibility given that the Environmental Protection Agency and the National Renewable Energy Laboratory has already identified, “over 11,000 sites (hundreds of thousands of acres) suitable for solar installations.” (Denholm and Margolis, 2008). In Gainesville and elsewhere, the use of defunct landfills and brownfields could make economic use of unwanted land, while furthering the social and environmental benefits of solar energy production.

General Policies

While the GRU FIT system is a logical means of stimulating investment and diffusing costs amongst a variety of participants, more productive solar technologies are in existence and under development. Given that PV technology is still in its infancy, “a one-gigawatt coal plant running at 70% of capacity,” is capable of replacing the output of half of all solar panels installed worldwide in 2011. Therefore, the improvement of existing policies and the development of new technologies are critical issues that must be addressed through a variety of integrated solutions (The Rise of Big Solar, 2011).

Looking at the potentials of solar power, a nationwide transition from coal, oil, natural gas and nuclear power production to solar generation could provide the U.S. with 69% of it’s electricity and 35% of total energy by 2050 (Zweibel, Mason, and Fthenakis, 2008). While critics argue that this would require an estimated $420 billion in infrastructure and subsidization for cost-competitiveness, the argument in rendered null by the fact that the U.S. government spent $72 billion on coal subsidies between 2002 and 2008 (Zweibel, Mason, and Fthenakis, 2008). Therefore, if legislators and citizens called for such actions, a nationwide solar plan could be established by redirecting the annual tax revenue spent on annual coal subsidies alone (Environmental Law Institute, 2009).

Reason for the extraordinary low employment of solar and renewable energy sources in the U.S. and abroad is largely based on unfavorable political and financial barriers. Due to these political, regulatory and the market factors, the barrier of perceived risk for investors is high. Furthermore, renewable energy projects often fail because of inconsistent government interventions (as may happen with GRUs termination of their solar FIT program in 2016), poor technology, as well as missing planning and maintenance capacities. Based on these factors, the main barriers to solar implementations are summarized as:

- Inadequate policies and strategies
- Lack of finance for investments
- Poor capacity of governments and utilities
- Little awareness, knowledge or confidence

Potential Technologies

With a wide disbursement of major U.S. cities within close proximity to the nation's highest solar concentrations, solar technologies should be embraced and refined as viable alternatives to destructive and expensive power sources such as coal, oil, natural gas and nuclear power. Beyond photovoltaic solar cell technologies, concentrated solar thermal power generation can be used to produce clean, efficient energy. Benefits of these systems include a wider range of system types, higher efficiencies, greater production levels and the ability to store the sun's energy for consumption at night and in times of obstructed sunlight (Solarpaces.org, 2012). If these and PV systems were to be integrated into a direct-current power transmission grid, these technologies could power the nation day and night (Zweibel, Mason, and Fthenakis, 2008).

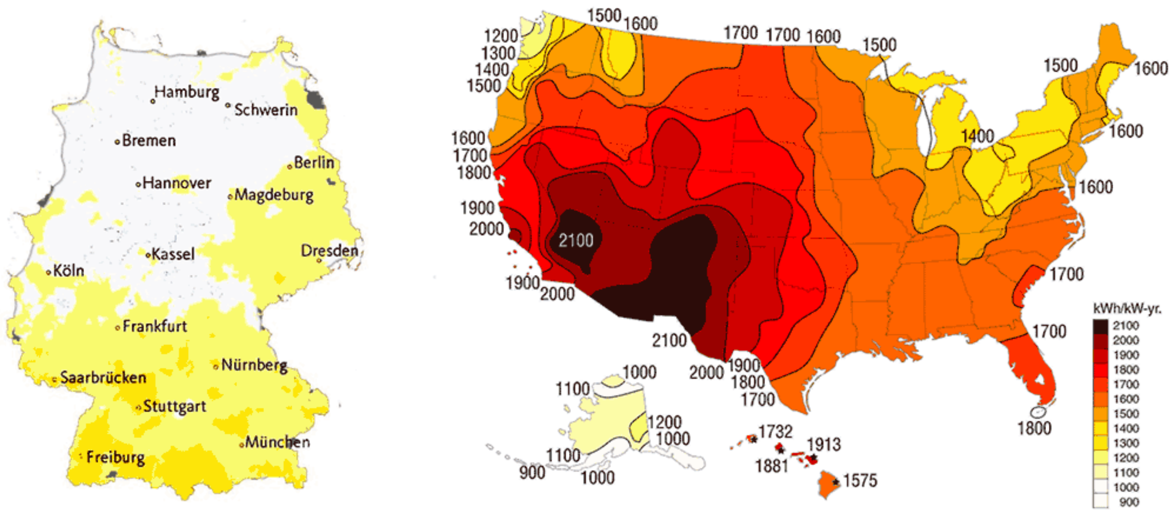


Figure 5-2. Maps (not to scale) depicting the kilowatt-hour solar potential per year in Germany versus the United States (Source: http://www.seia.org/cs/news_detail?pressrelease.id=342. Last accessed June, 2012).

Concentrated solar thermal's primary limitation lies in economics as the large scale of most such plants are, "harder to finance than small photovoltaic installations, and require more planning permissions and infrastructure, such as transmission lines." (The Rise of Big Solar, 2011). Assuming that polices and subsidies were implemented, multiple systems types would be available for exploitation.

Using a variety of mountings, mirror systems, and heat transfer fluids; concentrated solar thermal power produces electricity by concentrating sunlight to heat fluids to high-temperature. This heat is then channeled through conventional generators, producing clean electric energy (Solarpaces.org, 2012). Systems vary in size, appearance and production capacity, making them suitable for a range of needs and locations (Solarpaces.org, 2012). Examples of these configurations include: parabolic dish systems that rotate with the sun's movement, concentrating solar radiation at a receiver mounted above a reflective bowl resembling a satellite dish; stationary parabolic troughs with curved reflectors that concentrate heat on a receiver pipe; and power tower systems featuring massive arrays of sun-tracking mirrors concentrating the sun's heat at a point atop a tower (Solarpaces.org, 2012). With various designs, heat is concentrated on different liquids, depending on the purposes. These fluids then heat steam, which is carried to electricity generating turbines. Some systems use air, others steam, and some employ molten nitrate salts, which offer superior heat transfer and energy storage capabilities.

All forms of concentrated solar thermal are adaptable for use with thermal storage systems, which capture and compress heat within underground chambers, storing large quantities of the sun's energy for hours they offer a clear advantage to solar photovoltaics (Solarpaces.org, 2012). Through the adoption and refinement of such technologies, one of solar power's most limiting constraints may be overcome. Until then, systems can be integrated with existing coal-fired plants, creating hybrid systems that run with continuous reliability (Solarpaces.org, 2012).

In addition to technological innovations, scientists are finding unconventional ways to maximize solar productivity. In one case, researchers have discovered that a Fermat spiral, a naturally occurring pattern seen in the sunflower crowns, may be mimicked to maximize space by nearly 16% (Flower Power, 2012). With each mirror placed 137° from to the previous one, they're now able to save space and prevent solar thermal mirrors from shading each other (Flower Power, 2012). This arrangement may to be used for ground mounted photovoltaics, as well as solar thermal mirrors, reducing land requirements for either technology by one sixth (Flower Power, 2012).

Summation

Assuming that it is technologically feasible to power the world sustainably, the discontinued use of nuclear power plants, ecologically harmful hydroelectric dams, inefficient biomass and biofuels, and dangers of diminishing supplies of fossil fuels, wide-spread solar implementation would greatly improve global stability on a variety of social, political, economic, medical and environmental levels (Wan, 2011). Though such a shift would take years, along with billions of dollars, ignoring the issue will only perpetuate the inefficiencies and externalities of conventional power production. And, sunlight is a free and perpetual energy source with far fewer costs in terms of acquisition, transport, storage and externalities incurred by communities and the environment (Zweibel, Mason, and Fthenakis, 2008).

Based on the rapid actions of German and Chinese governments, it seems that the greatest hindrance to the broad U.S. implementation of solar and other renewables is the dual causality of need for a citizen referendum and a lack of political will (Wan, 2011). Until one of these entities demands that such actions take place, U.S. energy businesses will continue to operate as usual.

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BIOGRAPHICAL SKETCH

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