Solar Energy Incentives: Gauging the Investment Climate and Chasing Grid Parity

Emanuel John Borg, Emily Kalish, and Thomas Meyer[1]
University of Notre Dame

Abstract

Existing research on solar energy has focused on the technical requirements or economic effects of attaining grid parity. In this paper we gauge the current investment climate and determine if current risk adjusted returns are attractive enough to carry the solar market to 2014 when The Union Bank of Switzerland (UBS), Deutsche Bank, and Macquarie Group predict that grid parity demand will take over from government incentives as the driving force behind the panel manufacture market. We explore the attractiveness of solar energy investments by taking on the role of an infrastructure private equity investor and comparatively modeling all worldwide, 10 megawatt (MW), 20 year, solar energy investment opportunities. We draw conclusions on market attractiveness by comparing return outputs to risks in each region and determining a potential for attractive risk adjusted returns. Our findings show that: all predicted national and state level investment return outliers can be explained by abnormal risks and by strict contractual obligations. The market for solar energy infrastructure investments is competitive, but remains attractive for investment. Finally, this attractive investment climate will continue to drive global energy markets towards the ultimate goal of these incentive schemes – grid parity.

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I. Introduction

When French physicist Antoine-Cessar Becquerel first conducted his breakthrough solar energy research in 1839, and McLean Industries conducted the first corporate leveraged buyout (LBO) in 1955 no one could have predicted that the marriage of these two seemingly unrelated innovations would launch a clean energy revolution decades later. With mounting scientific evidence for a link between greenhouse gasses and climate change, nations around the world have set binding renewable energy targets. The European Union has taken the lead mandating that 20% of energy production comes from renewable sources by the year 2020. In the United States, 29 states have set targets with varying degrees of ambition and accountability. Globally, these renewable energy targets have been met through the deployment of renewable wind or renewable solar energy infrastructure assets. While immediate clean energy generation is certainly a goal of these renewable energy targets, the greater aspiration is that these investments will improve renewable energy technologies and make grid parity feasible. BusinessGreen, a leading wind energy trade publication, reports that general grid parity was attained for wind generating assets on continental Europe in 2010 and that grid parity for wind assets in the United States has been hindered due to significant electricity transmission costs. Within the solar industry, some very specific regions of India and Southern Italy have attained grid parity, however falling solar costs and a surge in recent solar investment has put many regions of the world on the cusp of Grid Parity (UBS 2013).

Existing research on solar energy incentives has documented the rise of renewable energy incentives with two common components – a feed in tariff (FiT) and an investment tax credit (ITC). The world's leading investment banks in this space – UBS, Deutsche Bank, and Macquarie Group – have also documented and researched the impacts that these incentives have had on reducing solar costs, making them more competitive with fossil fuels, and making a panel manufacture industry supported by grid parity a reality in 2014. In this paper we research whether recent debt inspired incentive cuts and a flood of investment capital have reduced the attractiveness of this investment market enough to significantly reduce risk adjusted returns, and thus postpone the panel manufacture transition to grid parity beyond 2014.

Our group utilizes two experiments to gauge risk adjusted returns: First, we explain how these deals are initiated and replicate this deal process through the use of an LBO investment model. Our group has chosen to simulate the acquisition of a 10 MW (utility scale), ground mounted photovoltaic (PV) plant, backed by a 20 year FiT because data provided by PV Magazine, a leading solar industry trade magazine, indicates that this investment scenario is the most commonly incentivized investment scenario worldwide , and thus has the greatest predictive power.

Solar energy infrastructure investments, excluding areas that have already attained grid parity, commence with the public sector. This initiative must come from the public sector because the government must mandate an economic inefficiency through a financial incentive. Governments most commonly initiate the incentives through their national energy agency, and these incentives often include a FiT and an ITC. A second and less common method of government initiative is a mandate from a state or national government that requires utility companies to produce a certain percentage of their electricity from renewable sources. This utility will then initiate a similar FiT program that may be combined with government or state backed tax incentives.

The most significant private sector actors in these investments are private equity firms. Private equity firms are created to invest capital contributed by limited partners (investors) to their funds in private investment opportunities. These firms originally followed a basic recipe and focused on corporate transactions – raise money from investors, find an undervalued business to buy, take on as much debt as possible and use equity to make up the remainder in the purchase price, then cut costs, grow revenues, and try to sell the business after five to seven years. These private equity style transactions have been labeled as leveraged buyouts (LBOs) because they use extreme financial leverage to buyout equity holders in a private entity. Corporate LBOs became popular in the 1980s as prominent private equity players (KKR, Blackstone, Carlyle) conducted a number of mega-LBOs with great financial success. As the corporate private equity niche became more crowded and competition increased, the complexity of these buyouts grew as well with the most successful private equity firms branching out and raising funds from limited partners to pursue similar LBO style transactions in real estate, infrastructure, and other unconventional asset classes.

These renewable energy infrastructure investments conducted by private equity firms are structured in two primary ways – engineering, procurement, and construction (EPC) or secondary market transactions. Beginning with EPC style transactions, an investor will decide to take on a maximum amount of risk and enter into an investment by physically creating the power generating assets. The investor will hire engineers and a multitude of advisors to construct these assets, secure an incentive contract, and then manage these assets during the holding period. While private equity firms have developed methods of limiting these risks, these risk limitations are heavily dependent upon negotiations with other parties involved in the deal and are often approximated by an advisor with extensive knowledge and experience in that region.

Our group has chosen to focus our analysis on the second type of transaction (the secondary market transaction) because risks can be quantified more easily and these values are less dependent on individual negotiations. Additionally, these types of transactions will be more relevant in the future as investors seek to acquire existing renewable assets in LBO style transactions because new construction has been limited by global economic uncertainty (Photon 2013). In these secondary market transactions, a plant that has already been constructed and has secured an incentive contract is acquired by an international investor. By acquiring these assets after construction, the international investor is able to offset negotiation and construction risk and approach the investment as if they are simply acquiring a set of government or utility supported cash flows – leading to low revenue uncertainty and even lower risk uncertainty. These secondary market acquisitions are also important to attaining grid parity because they create liquidity for specialized EPC investors who prefer to exit their investments immediately after construction.

Second, we compare the unlevered return outputs of these investments to the risks that they carry and compute risk adjusted returns for a sample investment in each global region. While the group has calculated both levered and unlevered internal rates of return (IRRs) the group compares unlevered IRRs (yearly compounded returns) with ratings based default spreads (% risk measure based upon sovereign credit ratings) to calculate risk adjusted returns . The unlevered IRR value is used because levered IRRs take advantage of a perfectly efficient risk-return exchange, whereby higher returns are achieved by taking on risk through leverage. Thus, comparing unlevered IRRs with Moody's ratings based default spreads yields a risk adjusted return. Based upon this analysis our group finds the current investment climate to be attractive, and predicts that investment will continue in this sector.

II. Literature Review

In response to the mounting evidence that humans contribute to climate change, governments around the world have instituted financial incentive programs to encourage the adoption of and development of clean energy technologies. Through the implementation of FiTs (Feed in Tariffs) and ITCs (Investment Tax Credits), the sector has grown tremendously and has attracted the research attention of academics, think tanks, and specialized investment banks alike. Engineers have pioneered methods of making solar more efficient (Green et al. 1999), economists have addressed the effects of the implementation of such technologies (Breyer & Gerlach 2012) and have hypothesized about the validity of these incentives in the current economic climate (Lorenz et al. 2008), and think tanks have verified the link between these financial incentives and decreasing costs of solar (Bazilian et al. 2013). Recently, UBS, Deutsche Bank, and Macquarie Group have published research predicting a solar panel manufacture market that is fueled by grid parity based demand as opposed to incentive based demand in 2014.

2.1 FiTs of Renewable Energy

The FiT is the dominant form of renewable energy incentive worldwide. First pioneered in the United States under President Carter, and popularized by the German Law on Feeding Electricity into the Grid and subsequent European adoption, the FiT incentive mechanism has spread as far as Africa, the Middle East, and Asia. The effects of this incentive mechanism have been well documented, with most nations pointing to Germany as the most effective solar energy market in history (EPIA 2010).

Germany's first renewable energy law, passed in 1991, provided small renewable power generators with a market for their electricity. Germany created this market by requiring utility companies to connect all solar power producers to the national grid and buy the power that they produced at a fixed, above-market rate. These higher prices accounted for the externalities of pollution, and represent a true social cost of electricity (Curry 2013).

Following the widespread adoption of the FiT scheme and the emergence of other competing schemes, the National Renewable Energy Laboratory conducted a study that aimed to identify which qualitative factors made a FiT scheme most successful in an effort to more effectively shape U.S. energy policy (Gouchoe 2002). Gouchoe identified seven qualitative factors that policy makers must take into account when designing renewable energy incentives and FiTs: Funding duration and stability, incentive amount, infrastructure quality assurance, application procedures, end consumer awareness, bureaucratic efficiency, and coupled incentives.

In an effort to provide a quantitative complement to Gouchoe's qualitative research, Christos Makridis published a study in the Michigan Journal of Business in 2011 titled "A Multi-Criterion Model for Evaluating the Efficiency of Solar Energy Incentives." In this paper Makridis developed a mathematical model to value incentives and their expected success from the viewpoint of the governments that initiate them. Our team's work builds upon Makridis' work in that it values incentives and predicts their success from the viewpoint of the infrastructure investors who take advantage of them.

2.2 The Effect of Recent Technological Improvements on Efficiency and Cost

Another area of scientific and economic research has centered on the most recent technological improvements that have been made to PV technologies. These technological improvements either increase the efficiency of PV panels or allow them to be produced more cost effectively. Thus, these technological improvements either increase energy outputs or reduce costs of panels.

The 1999 article by Green et. al documents the evolution of solar panel technology before the 21st century. In this article Green researches the drastic improvements realized in silicon solar efficiency. Recent investment in the solar market has triggered significant improvements in panel efficiency. Research that builds upon Green's findings indicate that commercial panels have reached a 17-18% efficiency level – a level that was previously thought unattainable (Lorenz, Pinner, and Seitz, 2008)

During the bottom of the financial collapse in 2009, the revenues for those in the PV industry fell by approximately 40% from the previous year. In 2008, solar-panel manufacturers produced 66% more product than they could sell, resulting in a massive disparity between supply and demand and significantly lower prices (Halper 2010). Most recently, incentive backed demand has caused panel manufacture competition to increase. As a result, PV prices have decreased so significantly, that many Chinese manufacturers have been forced out of the market (Bazilian et. al 2013). Research on these now bankrupt Chinese manufacturers has shown that the supply of PV panels was more than double what the demand for PV panels was in 2011 and 2012 (Coggeshall, 2013). As the panel manufacture market fell out of equilibrium, large economies of scale were being realized simultaneously as in the United States alone nearly 70% more PV panels were installed in 2012 than in 2011 (Coggeshall 2013). This supply-demand disparity coupled with large economies of scale caused the price of panels to drop significantly: The U.S. average price dropped approximately 50% from an installed price of $11.00/W in 1998 to $5.50/W in late 2011 (Burbose 2011).

2.3 The Causal Link between Subsidies and Costs

While a clear relationship can be seen between the literature highlighted in sections 2.1 and 2.2, researchers have set out to scientifically prove this relationship between renewable energy subsidies (including the FiT) and more efficient output or lower costs. Clarke, Weyant, and Edmonds (2008) were able to mathematically model the effects that renewable energy subsidies have on technological change, and found that when coupled with other, R&D specific, incentives, a FiT has extraordinary capacity to drive intra-industry innovation. Building upon Clarke, Weyant, and Edmond's research the Breakthrough Institute (2012), an ecological think tank, found that direct government investment in technology provides a strong free-market signal for clean technology investment, and this relationship can be seen in the rise of popularity of the FiT during the 21st century and the influx of firms in the Bloomberg Index of large solar panel manufacture companies over that similar time frame.

2.4 The Year of Grid Parity

The most current literature discusses the future of solar investments, and the approaching grid parity. Specialized investment banks (Deutsche Bank 2013; UBS 2013; Macquarie Group 2013), agree that grid parity in the solar market will be achieved in select markets by 2014, and that at that time the market demand in the solar panel manufacture market will switch from incentive backed demand to grid parity backed demand. These findings are significant because they indicate a panel manufacture market that, beginning in 2014, will continue to function regardless of incentive backed infrastructure investments. In a financial analysis of the current solar market, UBS (2013) reported that grid parity will be reached in parts of Europe in 2014 due to a sharp decrease in solar panel costs. Analysts from UBS write that households and commercial energy users are installing their own small scale PV systems without government or utility backed subsidies (G. Parkinson, 2013). The Deutsche Bank Solar Update report (2013) states that grid parity has already been achieved in India and regions of Italy are on schedule to reach grid parity in 2014. The conclusions of Macquarie Group mirror those of UBS and Deutsche Bank.

These predictions of a solar panel manufacture market that is driven by grid parity based demand in 2014 assume a consistent source of investment from the present moment until 2014. Thus, our paper seeks to evaluate the current set of incentive backed solar energy infrastructure investments and determine if this opportunity set is attractive enough to carry the panel manufacture market to 2014 when grid parity demand, and the investment bank predictions will take hold. Our results show that while the market for solar energy infrastructure investments is competitive, it remains attractive for investment. Our prediction of an attractive investment climate will continue to drive infrastructure investments in these markets, ultimately satisfying the goal of these incentive schemes – grid parity.

III. Data

3.1 General Information

In order to take on the role of an infrastructure private equity investor we have constructed an LBO model similar to what such an investor would use to evaluate an array of investment opportunities. The premise of this model, and common industry practice, is to purchase solar energy assets using a combination of debt and equity and compute an IRR that our firm and its investors will receive on their contributed capital to our fund. The team identified a number of noncritical inputs (inputs that do not significantly affect IRR output) and obtained reasonable input ranges from GE Capital and Foresight Group LLP. These sector specific experts also provided the team with average input values that represent industry standard practice. For information regarding noncritical inputs please see appendix B. Below we outline, in detail, critical inputs of this model and their sources.

Through research and discussions with GE Capital and Foresight Group LLP, the team identified six critical inputs: FiT Rate, Irradiance, Investment Tax Credit (ITC), Federal Tax Rate, State Tax Rate, and Risk data.

The FiT rate represents the primary form of incentive given to investors, as it is the investment's source of revenue. The FiT is a legally binding purchasing contract between the government or utility and the investor, whereby the government or utility purchases units of power from the power generating assets in contractually guaranteed quantities at a contractually guaranteed price. Our model utilizes FiT data supplied by PV magazine, a leading renewable energy trade publication. The FiT is entered into the model in $/kilowatt hour (kWh) units.

An investment's irradiance score measures the average amount of solar energy potential at a specific global latitude and longitude. In instances when the FiT did not specify a specific town or city, a state-wide average value was used for an irradiance score. Irradiance data was provided by Sealite, an Australian marine technology firm that aggregates solar irradiance data from energy agencies and observatories around the world. All solar irradiance scores are entered into the model in kWh per meter squared per day units.

The ITC represents a secondary incentive that goes to equity holders. The ITC is similar to a "tax break" given to investors and is unique to the United States. This ITC can make financial models much more complex through the inclusion of a tax-equity flip. We have simplified these complexities by assuming that the investor directly reaps the effects of the ITC. This assumption results in an overstatement of returns in U.S markets by approximately 3%. This model utilizes ITC data supplied by PV magazine, a leading renewable energy trade publication.

The federal and state tax rates are the relevant tax rates that an investor would expect to pay in the jurisdiction in which it invests. This model utilizes tax rates supplied by KPMG.

Finally, the model utilizes sovereign and domestic credit ratings provided by Moody's that have been converted into risk premiums by Professor Aswath Damodaran of New York University.

3.2 Constructing the Dataset

After compiling our dataset, we were missing one final critical input – private auction prices. Given the private nature of these auctions, these prices are not publicly available and must be approximated. In order to circumvent this problem our group used a benchmark price to determine other auction prices in a process listed below. We feel that it is important to outline this approximation process since this input does not use exact auction data, and because this process can be used by future researchers to approximate blind auction pricing.

From the technical experts with whom we consulted at GE Capital and Foresight Group LLP, our group obtained a reasonable winning auction bid approximation for a 26MW solar asset in southern California of $72,000,000. This auction price was calculated based on the noncritical, average input values listed in appendix B, and the critical input values obtained from the sources listed above. Using this data point the group scaled the 26MW project to the 10MW cross-geographical opportunity set that we are exploring by calculating a price per megawatt figure of $2.81/kWh. Given that solar irradiance was the critical input with the greatest variance, and that our technical advisors identified this variable as having the highest correlation with auction price, the team calculated two sets of price per kWh datasets: one by allowing the price to solar irradiance relationship to float (decoupled analysis), and the other by maintaining this link (coupled analysis). The decoupled analysis rests on the premise that global auction markets are not perfectly efficient. The coupled analysis rests on the premise that global auction markets are equally efficient as the southern California base case.

IV. Methodology

Using the data detailed above, our model runs through three sets of transactions: accounting, amortization, and risk. The accounting and amortization sections of the model follow a typical financial model structure to calculate levered and unlevered free cash flows. The only critical difference between this model and a typical LBO model is that infrastructure investments assume an exit at the end of the contractual agreement, as opposed to the five to seven year exit targeted by most corporate private equity investors..

Given the unique and almost perfectly quantifiable nature of the risks in this secondary market style transaction, we have explained our group's process of calculating risk adjusted returns below. In order to best quantify investment risks, we focused on the contractual risks behind these investments and we treat these power purchase agreements (PPAs) as having the full backing of the government agency or utility company that originates them. Therefore, by analyzing government-specific default risks and bond ratings for utility companies, we can assume an equivalent risk for these incentive contracts and can use a rating-based default spread as a numerical approximation of this risk. By using Moody's ratings and the spread between this % risk and the projected returns of the investment this model computes the risk adjusted returns that the investor receives by entering the market.

As stated previously, this model computes two rates of return: one with leverage (levered IRR) and the other without leverage (unlevered IRR). While it was crucial to build a model that calculated both of these outputs, we utilize the unlevered IRR output to compute risk adjusted returns because the assumption behind financing is that an investor takes on additional risk by "levering up," and this risk is efficiently balanced by increased returns after leverage. It is important to use the unlevered IRR because of this efficiency between risk and return, and therefore it is impossible to, through a risk-return framework, make an investment more attractive through leverage. Regions are thus classified as being attractive for investment if the unlevered project IRR, after making adjustments for the credit based risk premium is still comfortably higher than the risk free rate. This risk adjusted return figure must be "comfortably higher" than the risk free rate because the risk free fixed income investment is a less complex investment and can be liquidated in a fixed income market. This complexity and illiquidity premium must be compensated for by increased returns. This relationship is illustrated by the below table which contains our coupled analysis of Germany's investment opportunity set.

Risk Example				
Nation	Unlevered IRR	Risk Premium	Adjust. Return	RF Rate
Germany (coupled)	11%	0%	11%	2.5%

Figure 1

Following the Germany example from left to right the unlevered IRR is forecast at 11% while Germany's risk premium is 0%. As a result, Germany offers its investors a risk adjusted return of 11% which is comfortably higher than the risk-free asset offered by the U.S. Government at a rate of 2.5%. The investor in this scenario would select the Germany investment because they are compensated fairly for the added complexity and illiquidity of taking on a 20 year PPA agreement in the form of a risk adjusted return that is 4x higher than the equivalent risk free bond yield over that period.

V. Discussion of Results

5.1 Decoupled Case

As mentioned above, we first ran the price data through the model that allowed the price to irradiance relationship to float. Based on this assumption we hypothesized that locations with irradiance levels higher than the southern California base case would have abnormally high returns, while locations with irradiance levels less than the southern California base case would have abnormally low returns. We also expected that this analysis would be less accurate than our coupled analysis because it rests on the assumption that auction markets are inefficient. The results of this decoupled analysis are summarized in the table below.

Country	FiT Rate	National Corp. Tax	State Tax	Irradiance %	ITC	IRR	Risk	Premium Return	Risk Type
Armenia	0.05	20%	-	96%	-	1%	4.13%	-3.13%	National
Belgium	0.15	34%	-	50%	-	6%	1.05%	4.95%	National
Bulgaria	0.11	10%	-	81%	-	9%	2.63%	6.37%	National
Canada	0.34	26%	11.30%	74%	-	21%	0.00%	21.00%	National
Czech Republic	0.14	19%	-	59%	-	3%	1.28%	1.72%	National
France	0.11	34.43%	-	71%	-	2%	0.38%	1.62%	National
Germany	0.15	29.50%	-	54%	-	2%	0.00%	2.00%	National
India	0.16	32.50%	-	116%	-	12%	3.00%	9.00%	National
Israel	0.25	25%	-	114%	-	26%	1.28%	24.72%	National
Italy	0.15	31.40%	-	75%	-	12%	2.63%	9.37%	National
South Africa	0.42	34.60%	-	108%	-	37%	2.25%	34.75%	National
Ukraine	0.07	0%	-	65%	-	0%	9.00%	-9.00%	National
California -Palo Alto	0.17	35%	8.84%	94.00%	30%	18%	0%	18.00%	City
Florida	0.05	35%	5.50%	104.00%	30%	2%	0.75%	1.25%	Utility
Illinois	0.2	35%	9.50%	74.00%	30%	17%	1.50%	15.50%	State
Nevada	0.13	35%	0%	105%	30%	16%	0.75%	15.25%	State
New York	0.22	35%	7.10%	70.00%	30%	18%	1.73%	16.27%	Utility

Figure 2

The above table summarizing the decoupled model analysis highlights all six critical inputs as well as the risk adjusted return enjoyed by investors. The team's intuition was validated by the high return levels in Israel where irradiance levels are higher than southern California base case and the low return levels in Germany where irradiance levels are lower than the southern California base case. Our intuition regarding market efficiency was also validated as investors report unofficial and nonpublic risk adjusted return figures that are significantly higher in Germany than in Israel, significantly contrasting the 2.00% risk adjusted returns in Germany and 24.72% risk adjusted returns in Israel predicted by the decoupled analysis.

5.2 Coupled Case

Second, the team ran the price data through the model in a coupled form, preserving the relationship between price and irradiance. We hypothesized that this model could overstate returns in markets with competitive auction markets and understate returns in markets with noncompetitive auction markets. The team also hypothesized that this model would yield risk adjusted returns closer to unofficial returns reported by investors because it operates on the as-

Country	FiT Rate	National Corp. Tax	State Tax	Irradiance %	ITC	IRR	Risk	Premium Return	Risk Type
Armenia	0.05	20%	-	100%	-	0%	4.13%	-4.13%	National
Belgium	0.15	34%	-	100%	-	10%	1.05%	8.95%	National
Bulgaria	0.11	10%	-	100%	-	7%	2.63%	4.37%	National
Canada	0.34	26%	11.30%	100%	-	29%	0.00%	29.00%	National
Czech Republic	0.14	19%	-	100%	-	11%	1.28%	9.72%	National
France	0.11	34.43%	-	100%	-	6%	0.38%	5.62%	National
Germany	0.15	29.50%	-	100%	-	11%	0.00%	11.00%	National
India	0.16	32.50%	-	100%	-	12%	3.00%	9.00%	National
Israel	0.25	25%	-	100%	-	22%	1.28%	20.72%	National
Italy	0.146	31.40%	-	100%	-	10%	2.63%	7.37%	National
South Africa	0.42	34.60%	-	100%	-	38%	2.25%	35.75%	National
Ukraine	0.07	0%	-	100%	-	2%	9.00%	-7.00%	National
California -Palo Alto	0.165	35%	8.84%	100%	30%	19%	0%	19.00%	City
Florida	0.05	35%	5.50%	100%	30%	1%	0.75%	0.25%	Utility
Illinois	0.2	35%	9.50%	100%	30%	24%	1.50%	22.50%	State
Nevada	0.132	35%	0%	100%	30%	15%	0.75%	14.25%	State
New York	0.22	35%	7.10%	100%	30%	28%	1.73%	26.27%	Utility

Figure 3

The results shown in the above table validate our team's intuition that these coupled risk adjusted returns are more closely related to current, unofficial return figures. Under this coupled analysis Germany and Italy, two of the most developed solar markets in the world have unlevered risk adjusted returns of 11.00% and 7.37% respectively.

5.3 Coupled vs. Decoupled

By utilizing decoupled market return outputs as representing a severe auction market inefficiency, and coupled market return outputs as representing a market that is at least as efficient as southern California auction markets we establish a range of acceptable return premiums for these solar investments in various geographic locations. This range of risk adjusted returns is summarized in the table below, which facilitates a side by side comparison of the model's decoupled and coupled risk adjusted returns.

Country	**Decoupled Risk Adjusted Returns**	**Coupled Risk Adjusted Returns**
Armenia	-3.13%	-4.13%
Belgium	4.95%	8.95%
Bulgaria	6.37%	4.37%
Canada	21.00%	29.00%
Czech Republic	1.72%	9.72%
France	1.62%	5.62%
Germany	2.00%	11.00%
India	11.00%	9.00%
Israel	24.72%	20.72%
Italy	9.37%	7.37%
South Africa	34.75%	35.75%
Ukraine	-9.00%	-7.00%
California - Palo Alto	18.00%	19.00%
Florida	1.25%	0.25%
Illinois	15.50%	22.50%
Nevada	15.25%	14.25%
New York	16.27%	26.27%

Figure 4

While current, unofficial risk adjusted returns reported by investors mirror the coupled returns much more closely than the decoupled returns, it is worth noting that under certain market assumptions actual investment returns will fall closer to one bound than another. The most significant such assumption is auction market efficiency. Greater auction market efficiency (competitiveness) will yield results that most closely mirror coupled returns. Returns will fall closer to this bound because the model's coupled analysis rests on an assumption of an auction market that accounts for a price vs. irradiance relationship as efficiently as the southern California base case. Likewise, lower levels of market efficiency (competitiveness) will yield results that most closely mirror uncoupled results.

This relationship between market efficiency and the coupled bound does have limits, as efficiency must not be confused with overcrowding of the auction space. By way of example, in a reasonably competitive market (equivalent auction competitiveness of the southern California market) risk adjusted returns will closely mirror coupled analysis outputs. This statement makes intuitive sense because the price to irradiance link in the model was established through the use of this location's data point, and thus any auction market with equivalent competitiveness would yield similarly scaled results. Conversely, a market that is overcrowded, or more competitive than southern California could experience results that significantly deviate from the coupled values. In most scenarios, overcrowding in the market will drive returns towards decoupled values, however in all cases, overcrowding in the market will drive risk adjusted returns down. In fact, this overcrowding effect is employed to explain outliers in the United States in the following section.

5.4 Explaining Outliers

There are three clear explanations for the categorically overstated risk adjusted returns in the United States markets. Through discussions with GE Capital and Foresight Group LLP, the U.S. market is agreed upon as the most competitive Private Public Partnership (PPP) market in the world with the most sophisticated investors and efficient auction markets. In the United States large private equity players (Blackstone), colossal investment groups (Macquarie Group), and multinational corporations (GE) have developed the most precise investment models in the world and as a result have the most precise understanding of how high they can bid at auction before they fall below their target IRR. As a result, there are minimal inefficiencies in the infrastructure auction markets in the United States, and these auctions auction markets, if more competitive than the southern California base case, can exhibit the overcrowding effect discussed above. The second, and weaker explanation for a categorical overstatement of U.S. IRRs is that U.S. based incentives are backed by utility companies and their bond ratings categorically understate their risk. This explanation would mean that investors are paying lower prices for high performing assets because they want a "cushion" in their IRR in the instance that a utility company defaults on its obligations. There is some historical evidence to back this theory, as U.S. bankruptcy laws are unique in that they amount to a legally acceptable means of shedding contracts. PG&E is an oft sited example of a utility company going bankrupt and shedding its contracts (SF Gate, 2001). While the utility company's bond ratings may indicate outstanding financial health, investors may have a significant risk premium built into their bids because they know, for example, that the consequences of the Long Island Power Authority defaulting on its FiT contract are much lower than if the equivalently rated government of Malaysia were to default. Finally, U.S. returns are categorically overstated because the model is programmed to return the ITC to the private equity holder. In reality, the private equity investor would reap the rewards of such an incentive through a tax equity flip, and would sacrifice a portion of its returns to do so. Our group expects that because the model does not account for the tax equity flip, investment returns in the U.S. are overstated by 3%.

As for the non-U.S. anomalies they can be explained by contractual provisions or misevaluation of market risk. While Ontario, Canada seems like an attractive region for investment with an astronomical 29% risk adjusted return, there are a litany of stipulations attached to investments in Ontario requiring, for example, that a certain percentage of panels and inverters to be made in Ontario, and a certain percentage of maintenance and construction labor be Canadian as well. These regulations significantly raise installation costs, minimum auction prices, and O&M costs which reduce cash flows over time. A similar non-U.S. example of an investment with overstated returns is Israel, with a risk adjusted premium of 20.72% explained by regulatory impediments and high geopolitical risk levels. On the regulatory front, Israel has developed a reputation as being a "slow" market, and therefore prices reflect this. Researchers cite a story of a PV plant that was supposed to take 3 months to construct and wasn't finished until 14 months after construction began (Siderer 2012). On the economic front, large quantities of shale gas have recently been discovered in Israel, lowering the domestic price of fuel and increasing the spread between the FiT rate and the market cost of electricity, and therefore making the FiTs relatively more expensive. There is a risk premium that investors subtract from their auction bids to cover the probability that the price of electricity will drop enough for the Israeli government to impose cuts to their FiT. Finally, Israel's geopolitical status poses the most extreme risks, with dangerous threats being exchanged between the states of Israel and Iran. Beyond the physical damage that a war could do to PV assets in Israel, the economic consequences of such a conflict could lead the government backed public utility to cut the FiT and abandon incentive programs.

5.5 Grid Parity

By analyzing the nuances between the decoupled and coupled risk adjusted return values, the auction market efficiencies that can cause real values to float between these bounds, and the contractual and risk-based factors that can explain outliers, we have found no evidence to suggest that solar investment returns have dropped below their fair market values. We can therefore predict that trends in solar installations will continue barring any massive reductions to the current FiTs or large nationwide defaults similar to Spain. Because the current climate for investment is attractive, we therefore expect that demand for solar panels will remain constant, and that the solar panel manufacture market will transition from incentive based demand to grid parity based demand in 2014 as predicted by Deutsche Bank, UBS, and Macquarie Group.

VI. Conclusion

Our analysis has shown that despite debt-driven reductions to FiT rates and increased competition, the current investment opportunity set remains attractive, offering superior risk adjusted returns. Our analysis has also produced a new method of benchmarking private auction data through irradiance based approximations, and an innovative way of framing projected risk adjusted returns between decoupled and coupled bounds. Moreover, the model that this paper utilized will continue to serve as a predictor of investment attractiveness, as a transition to grid parity would simply require inputting the market price of electricity in the place of the FiT rate. In this sense, this paper's research design could be rerun by an international investor with access to technical advisors and private pricing data in order to more accurately predict risk adjusted returns in different regions of the world.

On a final note, a future paper could take our group's risk adjusted return findings and argue that these numerical findings for risk adjusted returns could actually equate to a quantified complexity and illiquidity premium discussed earlier. Recall that when discussing risks we stated that investors require a risk adjusted return figure that is comfortably higher than the equivalent 20 year risk free investment. We stated that this risk adjusted return figure must be significantly greater than this risk free investment because these infrastructure investments are more complex than a risk free fixed income investment (complexity premium) and less liquid than a risk free fixed income investment (liquidity premium). Thus, if markets are perfectly globally efficient and our model is accurate there would not actually be any difference in risk adjusted returns between international jurisdictions, and when accounting for these complexity and liquidity premiums no investment produces positive risk adjusted returns. Any such positive risk adjusted return would signify international market segmentation, acquisition market inefficiency, or financial model error.

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Appendix A: Useful Acronyms

DSCR	Debt Service Coverage Ratio
EPC	Engineering Procurement and Construction
FiT	Feed in Tariff
IRR	Internal Rate of Return
ITC	Investment Tax Credit
kWh	Kilowatt Hour
LBO	Leveraged Buyout
MW	Megawatt
O&M	Operation and Maintenance
PV	Photovoltaic

Appendix B: Non-critical inputs

Input Name	Units	Value	Scaled (Y/N)	Description/Notes
Deal Initiation				
Cost Per Megawatt	$/MW	$2.81	Yes	Based on data for 25.61 MW solar energy assets in southern California. Must assume this value because auction price data is not available. Analysis includes "decoupled" and "coupled" investment cases.
Transaction Expense	%	1%	No	Covers expenses related to intermediaries in the acquisition process.
Miscellaneous Expense	%	2%	No	Covers expenses related to accounting, legal, and technical advisors who assist the private equity firm in evaluating the project's predicted returns and potential risks.
Land Purchase	$	$585,708.71	Yes	Because this price reflects California land prices which are among the highest in the world, this figure is a more conservative figure and is appropriate for our analysis.

Input Name	Units	Value	Scaled (Y/N)	Description/Notes
Sales Tax	%	0% No		0% assumed value because most regions in which these investments are acquired treat these LBO transactions as a corporate acquisition between two special purpose vehicles (SPVs) which are legal entities. These acquisitions are therefore taxed according to corporate acquisition guidelines.
Fees				
Insurance Fee	$	$39,047.25	Yes	Assuming global insurance markets are competitive, and that locations in different countries do not have significantly different natural disaster risks, this is a fair value.
Management Fee	$/MWp	$8,000		$8,000/MWp assumed value is an industry common value as a part of the operation and maintenance of these energy producing assets by third party contractors.
Property Taxes	$	$10,000	No	Property tax values vary widely across different nations, but this value was assumed because it is a fair representation of a yearly tax liability for investments within the U.S., and provides an additional element of conservatism for nations or states that do not have property taxes.

Input Name	Units	Value	Scaled (Y/N)	Description/Notes
Land Lease	$	0	No	$0 assumed value for land lease because we have assumed a purchase price of the land and therefore have chosen to buy land as opposed to lease it.
Inverter Fee	$	$40,000	Yes	$40,000 assumed value that has been scaled down from data for a 25.61 MW solar power plant in southern California. This expense is taken as a yearly expense to allow for failed inverters between years 5 and 15 on the solar assets. This is a fair assumption to make because it assumes (factored into assumed purchase price) the industry leading inverter fail rate, which is independent of geographic installation locations.
Accelerators				
Panel Degradation	%	0.50%	No	0.5% assumed value based off of current solar Photovoltaic (PV) technologies. This value would be provided by a technical advisor, and would fluctuate minimally based upon which panels the PE firm decides to use and the hours of sunlight that they are subjected to, however this is a minor input and a conservative value to use as California has higher sunlight levels than most regions of the world.

Input Name	Units	Value	Scaled (Y/N)	Description/Notes
O&M	%	2.50%	No	2.5% assumed value that Operations and Maintenance (O&M) expenses will increase year over year. This value would be open to negotiation as part of the sale process, however all values would be close to 2.5% as it would likely be pegged against inflation.
Insurance Fee	%	-1%	No	-1% assumed decelerator value. This value could vary based on geography or risk of the project; however this is a conservative value to plug in and is a minor input into the model.
Land Lease	%	2%	No	2% assumed value that is an average, although negotiated, accelerator that mirrors global historical rent increases. Note, however that while this functionality is built into the model it is not used in our simulation as we are purchasing land as opposed to leasing it.
Property Taxes	%	2%	Yes	2% assumed accelerator of property taxes represents a conservative plug-in value consistent with California tax code. This value is conservative because property taxes would be indexed against inflation to allow for consistent taxation power over time.

Input Name	Units	Value	Scaled (Y/N)	Description/Notes
Power Purchase Agreement	%	3%	No	3% assumed accelerator of the power purchase agreement (PPA) which is the source of revenue in the investment. This is a conservative accelerator and is the equivalent of tying future cash flows to an inflation accelerator or long term GDP growth. Technically, this is best likened to a Gordon growth method of modeling cash flows in a discounted cash flow analysis (DCF).
Debt Service Coverage Ratio (DSCR)	Multiplier	1.3x	No	1.3x assumed multiplier, which allows for a 70/30 debt/equity split. This value is the amount of cash flow available to meet annual interest payments and is modeled in accounting terms as Net Operating Income/Total Debt Service. This value would be established in negotiations between the investor and the investment bank that provides the loan, however values between 1.2 and 1.4 are typical.

Input Name	Units	Value	Scaled (Y/N)	Description/Notes
Leverage Term	Years	20 years	No	Assumed value of 20 years because project risks remain consistent throughout the duration of the project. As a result, investors will minimize debt payments yearly and collect cash flows. Prepayment penalties can be negotiated between the investor and the bank, and adjustments could be made on a case by case basis to the model.
Interest Rate (borrowing)	%	6%	No	Assumed value of 6% which is a conservative interest rate as these investments are generally low risk investments and would be rewarded for that low risk in the form of a low interest rate. The conservative rate of 6% is fair, however, because it serves as an average across low risk and moderate risk host nations. Please note also, that the model is based on the fair assumption that all debt is taken in the form of bank debt (no bond offerings, high yield, mezzanine debt, etc.), as a 10 MW investment is a mid-sized investment, and would not need multiple tranches of debt.
Debt Placement Fee	%	2%	No	Assumed value of 2% which is a standard commercial banking fee.

Appendix C: Irradiance Data for Decoupled Analysis
The irradiance data utilized in the decoupled analysis is summarized below.

Country/State	**Irradiance Score**	**% of Base Case**	**Average or Specific Source**
Base Case – So. Calif.	**5.043**	**100%**	**Specific**
Armenia	4.83	96%	Average
Belgium	2.53	50%	Brussels
Bulgaria	4.07	81%	Average
California - Palo Alto	4.76	94%	Palo Alto Specific
Canada - Ontario	3.75	74%	Average
Czech	2.97	59%	Average
Florida	5.26	104%	Miami Specific
France	3.57	71%	Average
Germany	2.73	54%	Average
Illinois	3.72	74%	Chicago Specific
India	5.86	116%	Average
Israel	5.76	114%	Average
Italy	3.8	75%	Average
Nevada	5.3	105%	Las Vegas Specific
New York	3.53	70%	NYC Specific
South Africa	5.47	108%	Average
Ukraine	3.29	65%	Average

Appendix D: FiTs Ignored, Reasons, and Default Risks

Country	Reason Not Considered	Default Risk
Algeria	Political Instability	N/A
Argentina	15 yr FiT	9.00%
Australia	Discontinued	0.00%
Austria	Size	0.00%
Bosnia and Herzegovina (gov, .11, 10)	Instability	9.00%
China	FiT Reduc. Risk	1.05%
Croatia	Size	3.00%
Cyprus	Financial Risk	9.00%
Ecuador	15 yr	10.50%
Estonia	12 yr	1.28%
Greece	Financial Risk	10.50%
Hungary	FiT Reduc. Risk	3.60%
Iran	Political Instability	N/A
Ireland	Expired	3.60%
Japan	Size	1.05%
Kenya	Size	6.00%
Latvia	10 yr	3.00%
Lithuania	12 yr	2.25%
Luxembourg	Rooftop Only FiT	0.00%
Macedonia	Size	N/A
Malaysia	8% Degression (Large)	1.73%
Malta	FiT by negotiation	1.73%
Mauritius	Expired	2.25%
Mongolia	10 year	6.00%
Montenegro	Rooftop Only FiT	4.88%
Morocco	Expired	3.60%
Netherlands	Size	0.00%
Netherlands Antilles	Expired	0.00%
Philippines	40% foreign equit. Limit	3.60%
Portugal	FiT Reduc. Risk	4.88%
Romania	6 yr	3.00%

Serbia	Size	N/A
Slovakia	Abolished	1.50%
Slovenia	Size	2.63%
South Korea	Rooftop Only FiT	1.05%
Spain	Defaulted	3.00%
Switzerland	25 yr	0.00%
Taiwan	Size	1.05%
Thailand	Size	2.25%
Turkey	10 yr	3.60%
Uganda	Size	N/A
United Kingdom	25 yr	0.00%
United States of America		0.00%
Alabama	Size	
Alaska	Size	
Arizona	No FiT	
Arkansas	Size	
California	Size	
California - Los Angeles	No FiT	
California - San Marin County	Size	
Colorado	Size	
Connecticut	Size	
Delaware	Size	
Florida - Gainesville	Size	
Georgia	Size	
Hawaii	Size	
Hawaii - Lanai & Molokai	Size	
Hawaii - Main island & Maui	Size	
Hawaii - Oahu	Size	
Idaho	Size	
Indiana	10yr	
Iowa	Size	
Kansas	Size	
Kentucky	Size	
Louisiana	Size	
Maine	Auction Process	

Maryland	SREC	
Massachusetts	SREC	
Michigan	Size	
Minnesota	Size	
Mississippi	Size	
Missouri	Size	
Montana	Size	
Nebraska	Size	
New Hampshire	Size	
New Jersey	15 year	
New Mexico	Size	
North Carolina	Size	
North Dakota	Size	
Ohio	Size	
Oklahoma	Size	
Oregon	Size	
Pennsylvania	Size	
Rhode Island	Size	
South Carolina	Size	
South Dakota	Size	
Tennessee	Size	
Texas	Size	
Utah	Size	
Vermont	Size	
Virginia	Size	
Washington	Size	
West Virginia	Size	
Wisconsin	Size	
Wyoming	Size	