Why Resource Matters:

Impacts of Preconstruction Resource Data on Long-Term Production Estimates and Project Finance

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Abstract

Accurate resource and energy production assessments are needed to establish project revenues with confidence thereby sizing debt appropriately. However, when plant performance exceeds the pre-construction energy estimate, what are the financial implications?

This presentation will review the impacts of overproduction on tax equity and debt financing models, while evaluating the major variables that contribute to plants outperforming the pre-construction energy estimates, such as: solar resource input data, plant loss assumptions, and uncertainty.

Some developers are still relying on higher uncertainty or non-site specific solar resource data for inputs into energy simulation models. These datasets typically have a larger uncertainty band and are less accurate, either under-estimating or over-estimating the resource at the project location. When used in an energy simulation there are direct impacts on the forecasted energy production. Additionally accurate plant loss considerations are crucial to best represent the long-term production of the solar plant. When poor plant loss assumptions are made in conjunction with inaccurate and high uncertainty solar resource datasets, actual plant production may vary considerably from the pre-construction estimate.

Plant production and the associated revenue are key inputs into financial models used to size debt or tax equity contributions. Therefore, relying on a poor quality resource and energy estimate can lead to less than optimal debt sizing which can result in lower returns on investment for equity partners.

Objectives

- Determine how various sources of solar and meteorological data impact production estimates
- Determine how uncertainty of data sets inhibit the ability to leverage the project
- Determine how plant overproduction can lead to lost revenue
- Determine how plant overproduction can result in lower rate of returns for debt, tax equity, and cash equity finance partners

Investor Interests:

- Cash Equity Investors: Long-Term energy production estimates (Reliant on P50 analysis)
- Tax Equity Investors: Interests are greatest in the beginning of the project life-cycle (Reliant on P50 analysis)
- Debt Lenders: Interested in only the minimum ability to pay back loan (Reliant on P90/P99 analysis)

Financial Model Key Performance Metrics:

- Debt Ratio: Ratio of acquired debt to cash equity
- Tax Equity Contribution: Amount financed through tax equity investor
- Projected Internal Rate of Return (IRR): Estimated IRR for the cash equity investor when financing with each resource dataset
- Actual IRR: Realized IRR for the cash equity investor when running the actual ground measured resource data file through the financial model for the Satellite TMY and NSRDB TMY3

Methodology

Resource Inputs:

- To test the impacts of potential over-production AWST evaluated three geographically diverse sites across the United States , studying the impacts of how various resource inputs predict long-term resource versus a high quality ground reference. The sources of data included Typical Meteorological Year (TMY) from:
  - Satellite derived dataset
  - National Solar Radiation Database (NSRDB) TMY3 [1]
  - Ground measured data from the United States Climate Reference Network (USCRN) [2]
- The ground measurements from the USCRN sites were used as the baseline for all results and assumed to be representative of the actual irradiance on site.
- The three project sites selected were in:
  - Merced, California
  - Tuscon, Arizona
  - Millbrook, New York
- Uncertainty for each dataset were assessed utilizing AWST's standard approach.

Energy Analysis:

- Energy was simulated for each of the studied resource files using the PVSyst Software.
- All three sites were simulated using AWS Truepower standard loss assumptions.
- Basic plant designs are as follows:
  - 12.5 MW_{DC} / 10.0 MW_{AC} (DC/AC Ratio: 1.25)
  - Generic 300 W polycrystalline module
  - Generic 500 kW inverter
  - Row tilt optimized for each project location using PVsyst
  - Modeled without near shading
  - Plant loss assumptions were applied consistently for each project location and resource analysis

Uncertainty Analysis:

- Uncertainty around resource data, as a percentage of the resource data, is highly variable and dependent on the source of data, type of campaign, and accuracy of the sensors utilized.
  - Measurements: 1% - 5%, depending on the measurement campaign
  - Satellite Modeled: 5% - 10%, depending on the resolution of the model and the project location
  - NSRDB TMY3: 10% or greater, depending on the proximity of the dataset to the project location

Projected Revenue:

- Power Purchase Agreement (PPA) pricing for each project location was developed using Locational Marginal Pricing (LMP)[3]:
  - The Base Price was assumed to be 1.5 x the average LMP
  - Time of Day and Seasonal (TOD) multipliers were developed from the raw LMP prices
- Potential project revenue was estimated from the hourly net energy and the TOD PPA price
- Production thresholds were assumed within the PPA structure.
  - Guaranteed Energy was assumed to be the annual P50 estimate
  - Overproduction limitations began at 110% of the Guaranteed Energy and paid 75% of the TOD PPA price.
  - Default was assumed to occur at 70% of the annual P50

Financial Model:

- Traditional Debt financing and Tax Equity Financing structures were evaluated:
  - CAPEX: \$2.2/W_{AC} Installed Capacity
  - OPEX: \$25/kW_{AC}/year Installed Capacity
- Debt Sizing: sized using a DSCR of 1.0 and P99 production estimates
- Tax Equity Investment sized assuming an 8.0% IRR

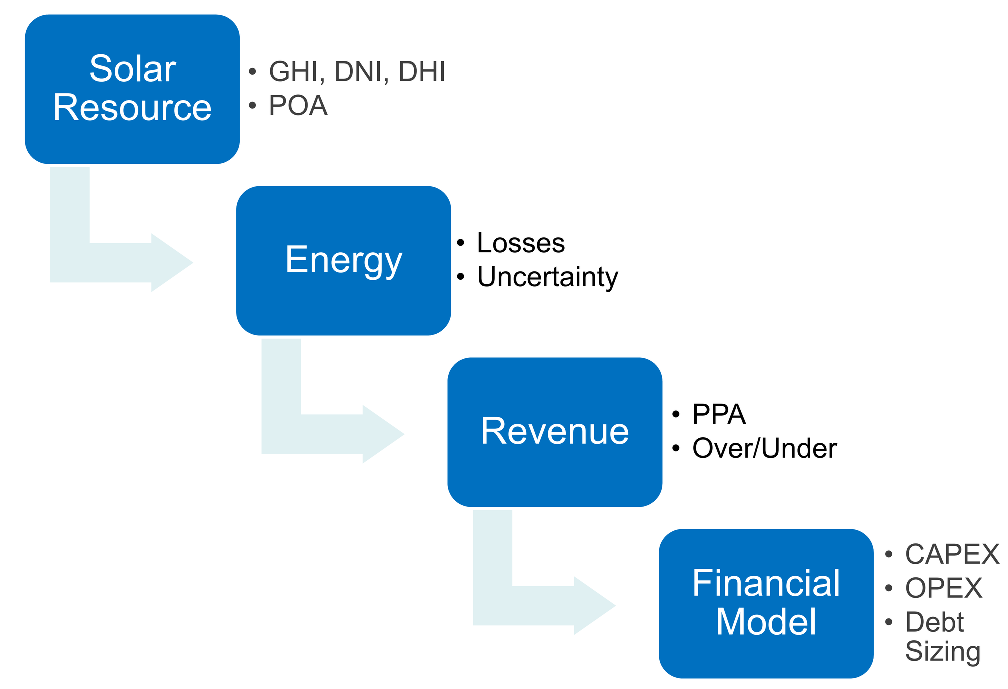

Figure 1. Flow Chart of Case Study Methodology

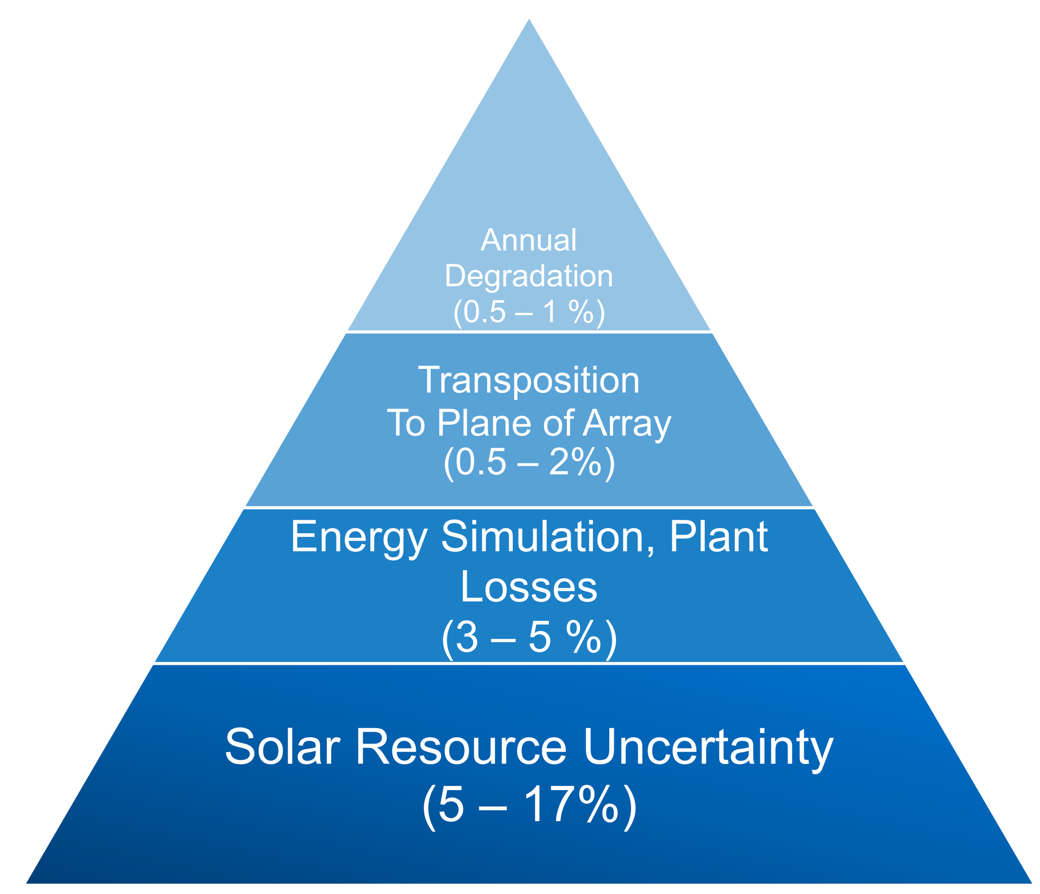

Figure 2. Sources of Energy Uncertainty

Results

- Figure 3 presents the gross energy yield and long-term net energy yield for the NSRDB TMY3 and Satellite modeled TMY for each case study location.
  - From this graph the most notable trend is that the NSRDB TMY3 under-predicts the energy yield when compared to the ground measured data at all three locations.
  - The Satellite Modeled TMY is more variable across each region.
- Figure 4 presents the projected revenue for the Satellite Model and the NSRDB TMY3 at the Merced, CA location where both estimates under-predicted the resource and energy
  - In both cases the projected revenue is lower than what the plant would actually produce.
  - For the NSRDB TMY3 the estimate is low enough that over the long-term the PPA overproduction threshold would be met, resulting in lost revenue of approximately 0.5%.

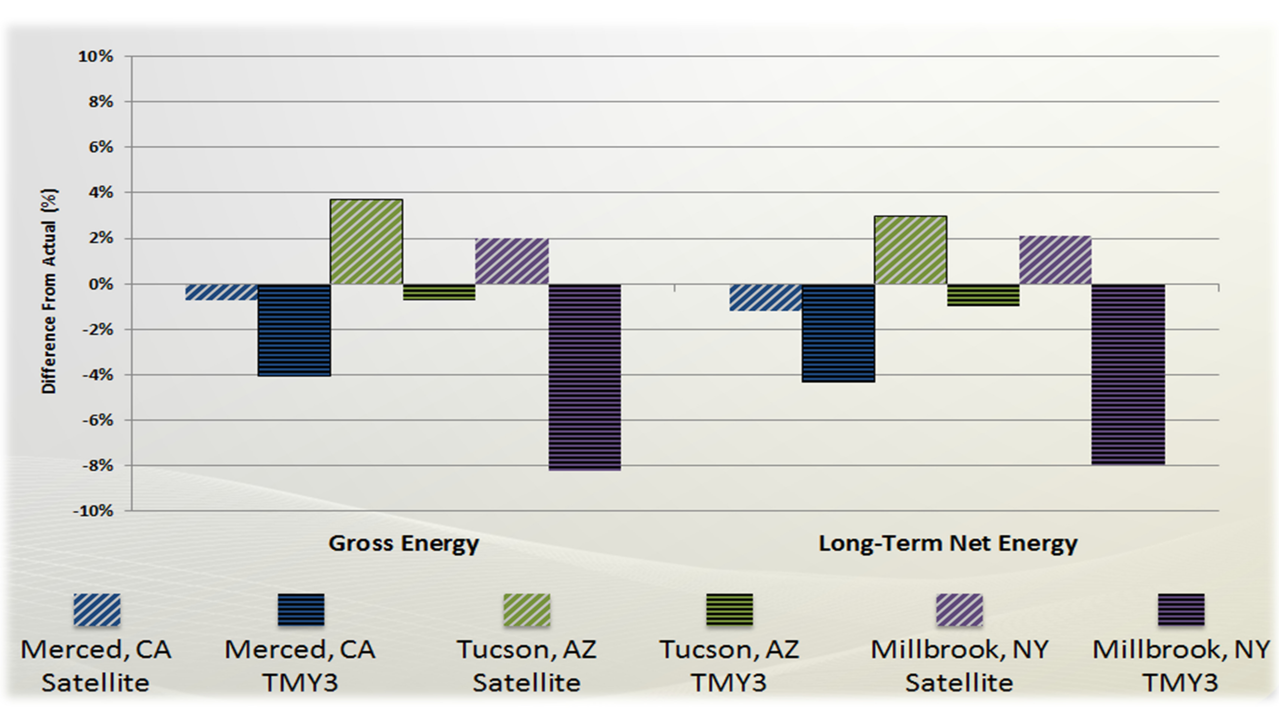

Figure 3 Project Energy Yield for all three case studies

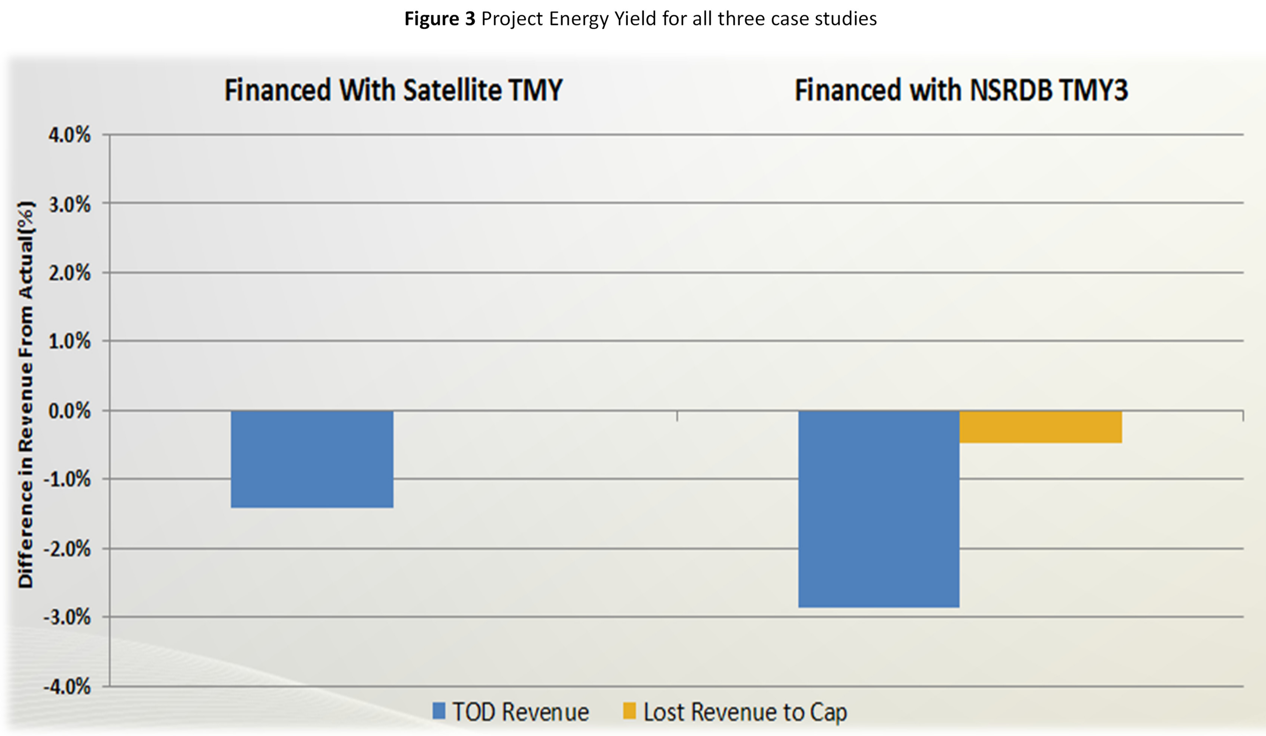

Figure 4 Project Revenue for the Merced, CA case study

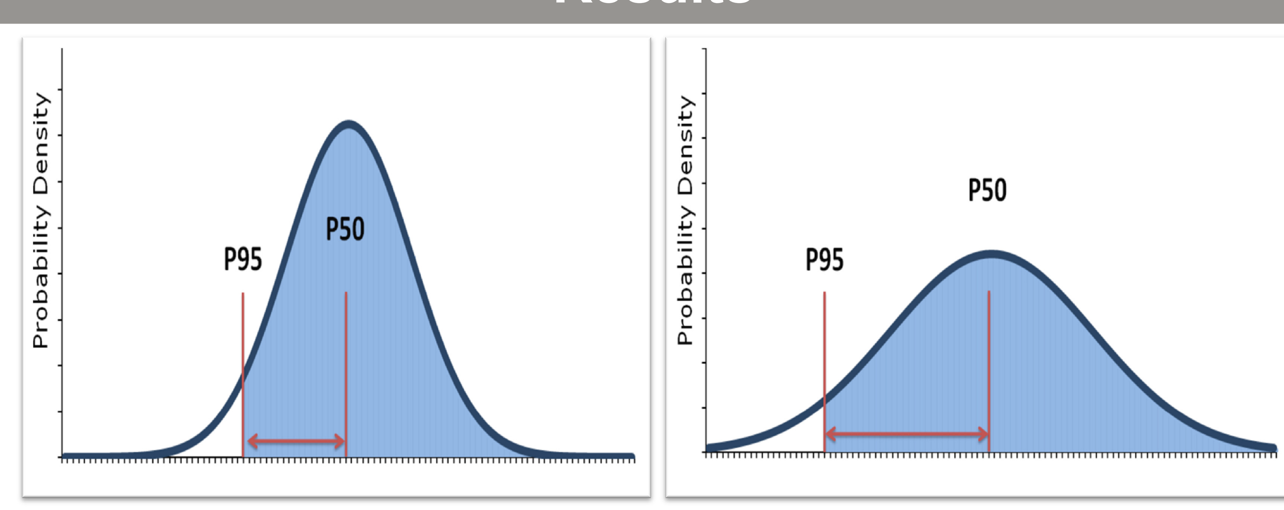

Figure 5 Example of low uncertainty (left) and high uncertainty (right)

- Figure 5 illustrates how energy estimates with larger uncertainty bands can impact the P90/P99.
  - When financing with debt, use of higher uncertainty resource datasets will limit the risk lenders are willing to take on.
- Figure 6 presents the Debt Ratio, Projected IRR, and Actual IRR for a traditional debt financing structure.
  - The results of financing with the Satellite Modeled TMY for the Merced, CA case study shows that the cash equity investor would have yielded an Actual IRR of 0.5% lower than if a higher quality resource dataset was used for financing. If we assume a \$10M cash equity investment over a 25-year project lifetime, the 0.5% IRR differential would have a cash equivalent of roughly \$1.3M of unrealized revenue potential.
  - The results from the NSRDB TMY3 analysis yield actual IRR losses of nearly double those of the satellite model, which is due to the larger uncertainty band around the resource data. This point Illustrates the importance of high quality resource input data to reduce the spread between P50 to P90/P99 estimates.
- Figure 7 presents the Tax Equity Contribution, Projected IRR, and Actual IRR for a tax equity financing structure.
  - The results of financing with the Satellite Modeled TMY for the Merced, CA case study shows that the cash equity investor would have yielded an Actual IRR of 0.5% lower than if a higher quality resource dataset was used for financing. As in the scenario above, for a \$10M cash equity investment over a 25-year project lifetime the cash equivalent is roughly \$1.3M left on the table.

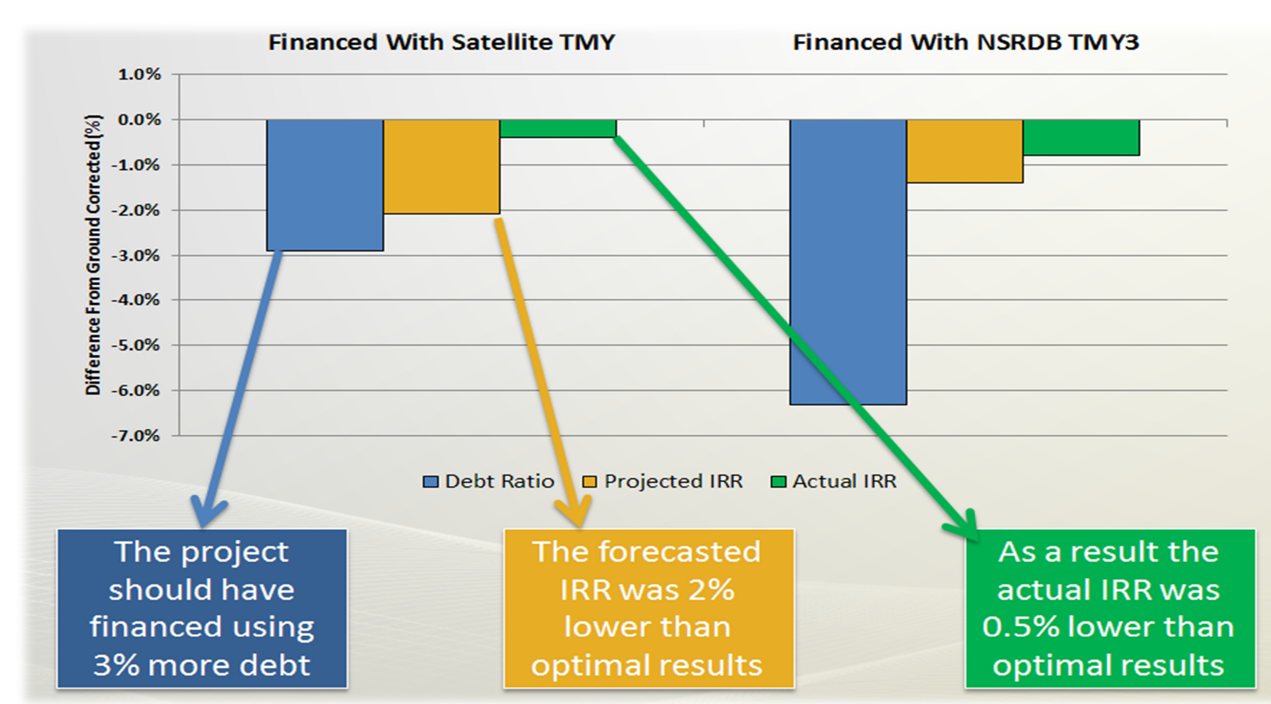

Figure 6 Debt Financing Structure Project Yields

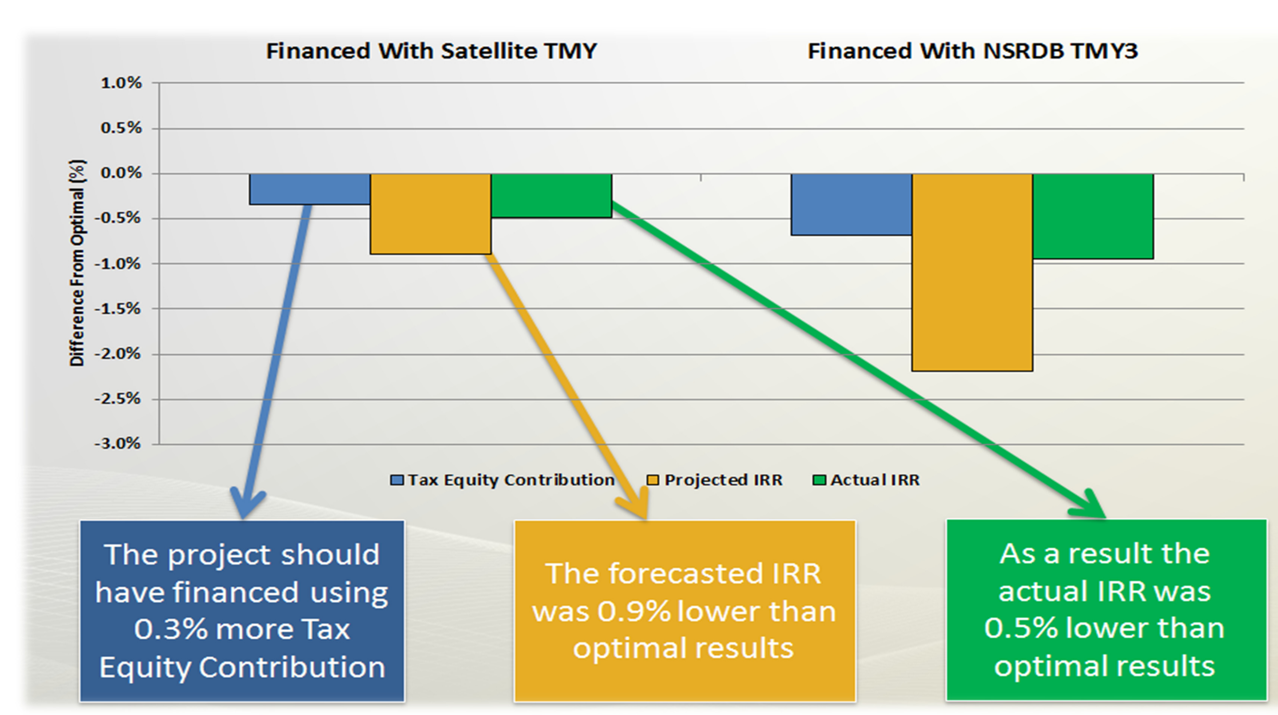

Figure 7 Tax Equity Debt Structure Project Yields

Conclusions

- Choosing an accurate and reliable source of solar resource data is critical for project financing
- Under-estimating solar resource can lead to plant overproduction and lost revenue to PPA caps
- Plant over-production can result in lower returns for lenders, tax equity, and cash equity finance partners

References

[1] National Solar Radiation Data Base "1991 – 2010 Update" http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2010/

[2] United States Climate Reference Network "Hourly Data" http://www1.ncdc.noaa.gov/pub/data/uscrn/products/hourly02/

[3] California ISO "Open Access Same-time Information System" http://oasis.caiso.com/

[4] Paul Thienpont, AWS Truepower "Is Solar Overproduction Costing You?" 18 November 2014 Webinar, https://www.awstruepower.com/knowledge-center/webinars/

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