Best Practices for Solar Risk Management

A practical guide for financiers of solar projects and portfolios

2017 Edition

As part of its ongoing effort to codify industry best practices, SEIA invited kWh Analytics and other members of the SEIA Solar Energy Finance Advisory Council to jointly author this document. Additional support provided by the U.S. Department of Energy's Orange Button Program.

Introduction

Tax equity and debt investment in solar energy projects require complex due diligence and oversight by investors. Fortunately, the industry has matured greatly over the past decade, and industry stakeholders have developed highly effective risk management techniques to improve the quality of project cash flows and reduce the risk of technological and credit-related risk factors.

This analysis was written for bank risk managers, credit officers, and senior business leaders who recognize a wide range of potential risk factors pertaining to solar investments and seek a systematic distillation of the industry's best practices. Since the risk management function begins at origination, the audience also includes those within the sales or origination function at banks or within project finance groups at solar companies. This report assumes that a reader has a basic competence in project finance and tax equity structures. This guide is designed to provide an authoritative perspective on solar risk management, as this document reflects experiences and learnings drawn from investors representing more than 50% of the U.S. market.

In this report, we contrast "risk management," which is the responsibility of a financial investor, to "asset management," which is typically the domain of a solar company to maintain the physical asset and the associated contractual arrangements. For our purposes, asset management also includes the administration of an operations and maintenance program. Risk management covers the investor's responsibility to satisfy the internal business and compliance requirements of senior business leaders, credit committees, internal and external auditors, and regulators. The responsibility of the risk manager is to identify items that may lead to the financial deterioration of an investment, and proactively work to resolve these situations. Although much of the data is derived by the asset manager, a key role of the risk manager is to "trust, but verify" the results being presented to them.

While solar investments are sometimes called "passive investments" due to the nature of the structured vehicles, this is in practice a misnomer: Nearly every major investor in the renewable energy markets have staff dedicated to risk management. Fortunately, there are a number of practices and platforms in the market for financial investors to monitor, measure, and manage their risk. These best practices are common between various segments of the solar industry, ranging from distributed residential portfolios to utility-scale assets, and are the topic of this report.

Executive Summary of Best Practices

Risk Measurement

Operational Risk

One of the most fundamental risk management practices calls for ongoing monitoring of the actual electricity generation against projected electricity generation. This is often a leading indicator of cash flow risk to an investor and acts as an early warning detection system. It's also important to separate underlying failures from short-term temporal impacts due to weather. Investors need to know if the system is working to an acceptable standard (often 90-95% of original projections), and if not, ensure that a plan is in place to remedy the situation or impair the asset.

Regulatory and Counterparty Risk

Unfortunately, nearly every large portfolio to date has seen the insolvency of a key vendor or sponsor. In this context, it is important for investors to know their exposure and any potential liabilities that may exist. Reviewing investment allocations and historic operating history may inform a warranty claim, a spare parts strategy, or a modification to O&M practices.

Offtaker Risk

Measuring and normalizing delinquency and default metrics allow investors to rely upon historic performance to manage their risk and inform new investment opportunities. For distributed portfolios, it is critical to define a materiality threshold of non-payment beyond which an investor would define the individual asset to be non-performing.

Repayment Risk

Ensuring that cash flows meet an investment vehicle's obligations, including loan payments and tax equity's preferred return (after expenses and taxes have been paid), is a core requirement for any asset-backed investment vehicle. Tracking cash flows and coverage ratios are an essential requirement to satisfy credit and compliance obligations in all investments, including solar.

Tax Risk

Investors at all levels of the capital stack typically have some sort of exposure to tax credits – whether in the form of indemnities, insurance, cash sweeps, or extended flip dates. Tax equity investors typically track this exposure closely, and it is best practice for lenders to watch it closely as well.

Regular Reporting

Compliance management requires consistent communication with credit teams and senior management, generally under a monthly-quarterly-annual review cadence: monthly production look-backs, quarterly portfolio summaries, and annual portfolio reviews. These reports incorporate production results, cash management tracking, exposure analysis, offtaker credit updates, and other pertinent information about the health of their portfolio.

Industry Standards and Benchmarks

Use industry-standard protocols

Industry trade groups have established "generally accepted compliance practices" to further the growth of the industry. These include: The United States Department of Energy's Orange Button data standard; model contracts; installation and O&M best practices; and consumer protection best practices.

Origination Standards

Risk management starts at origination, and risk managers work with originations teams to define the data and reports that should be provided over the lifetime of the investment. API access should be negotiated into agreements at this stage to ensure automated access to ongoing asset performance data. The originations and risk management teams should also agree on final project budgets.

Performance Benchmarking

"Industry comps" can be effective when evaluating the quality of an investment. Large solar developers use it to compare the health of projects within their own portfolios. An emerging trend is for investors to utilize industry data to benchmark their portfolios' operating health and payment performance against anonymized, aggregated data sets compiling data from other operating portfolios.

Component Benchmarking

Risk managers can identify latent risks that may exist within portfolios by reviewing industry benchmarking data on equipment underperformance or regional performance trends.

Compliant Infrastructure

Asset-level system of record

Banks need a system of record. However, solar transactions typically don't readily conform to pre-existing system of record formats, either due to the structure of the deals to support tax motivated investors, or due to its dual nature as both an energy and financial asset. While a few investors have overhauled internal databases to manage their fleet, most are relying on risk management software designed specifically to satisfy the particulars of the renewable energy industry.

Independent verification

Third-party validation of reported results, run through data quality tests, can unearth surprising conclusions about the health of distributed solar fleets. Independent experts can provide an element of compliance support to ensure the data being used to manage risk is reliable for decision-making.

Risk Management Checklist

Risk Measurement	Industry Standards and Benchmarks	Compliance
1. Operational Risk 2. Regulatory and Counterparty Risk 3. Offtaker Credit Risk 4. Repayment Risk 5. Tax Risk 6. Regular Reporting	7. Industry Standards 8. Origination Standards 9. Performance Benchmarking 10. Component Benchmarking	11. System of Record 12. Independent Verification

- □ 1. Tracking of Performance Index
  - □ 1.1 Tracking of Weather-Adjusted Performance Index
- □ 2. Tracking Allocations
  - □ 2.1 Vendors
  - □ 2.2 Geographies
  - □ 2.3 Utilities
  - □ 2.4 Offtaker Credit Quality
  - □ 2.5 Service Providers
  - □ 2.6 Sponsors
- □ 3. Tracking Delinquencies and Defaults
  - □ 3.1 Standardized Definitions
- □ 4. Tracking Cash Flows
  - □ 4.1 Tracking of Coverage Ratios
  - □ 4.2 Standardized Labeling of Transactions in Ledger of Record
- □ 5. Tax Risk Tracking
- □ 6. Risk Reporting
- □ 7. Industry Standard Protocols
  - □ 7.1 Orange Button
  - □ 7.2 Model Contracts
  - □ 7.3 Installation and O&M Best Practices
  - □ 7.4 Consumer Protection Best Practices
- □ 8. Negotiated Data Sets during Origination
  - □ 8.1 API Access for Monitoring Platforms
  - □ 8.2 Agreement on Project Budget
- □ 9. Use of Relative Metrics for Industry Context
- □ 10. Component Benchmarking
- □ 11. Use of System of Record
  - □ 11.1 Asset-Level Tracking
  - □ 11.2 Adequate Security Controls
- □ 12. Independent Data Verification

Section 1: Measurement is the first step to Managing Risk

Arguably the most important role of a risk management professional is to measure and communicate risk factors to others within their organization. There are areas that risk managers are measuring to track the financial health of solar investment portfolios:

1. Operational Risk

Projections of future energy production drive the financial model and, in most circumstances, the size of the investor's financial exposure. Performance Guarantees may be granted to an offtaker or an investor based on these projections, and production insurance policies are underwritten to these projections.

After an investment has been made, the actual energy production can be viewed as one of the most important indicators of risk to an investor. The ratio of the actual electricity generated to the initial projection is called its "Production Index." Investors need to know if the system is working to an acceptable standard, which is often 90-95% of original projections, and if not, ensure that a plan is in place to remedy the situation.

From a risk management standpoint, the Performance Index is important for the following reasons:

- Under-production presents cash flow risk in situations where there is a Power Purchase Agreement (PPA) in place with the offtaker, since the cash flows are a direct function of electricity production. However, even when the offtaker has signed a lease or a loan, production guarantees may still be in place that must be paid out if performance dips below certain thresholds.
- In situations where a direct lease or loan is provided to the energy consumer, the production is an important driver of credit risk, since it is commonly believed that end users are less likely to make timely lease or loan payments if the asset is malfunctioning or materially underperforming. This is relevant in the residential and commercial segments of the market.
- Production informs the underlying asset's value, on which investors are reliant for myriad reasons. For example, a lender may look to the collateral as a secondary source of repayment, a mini-perm lender is reliant on an operating asset to support a future refinancing, and a tax-equity investor may need a quality asset to justify booked residual values. The production also drives the resale value for an equity investor in the asset.
- In projects with production insurance, actual production values are necessary to support the claims process.

Investors also calculate and track a Weather-Adjusted Performance Index, which adjusts the Performance Index to reflect how the project or portfolio performed, independent of the impact of weather. This is important for assets of all sizes, including residential portfolios, in order to separate short-term, non-controllable variances from longer-term, systemic failures that need to be proactively resolved by the solar asset manager. Third party service providers can calculate and/or insure against these risks for investors. This has the dual benefit of enabling investors to quickly access this information for risk management purposes, as well as improving relationships with investment customers by identifying underperforming assets from poor weather without continually asking for explanations from their asset management counterparts.

2. Regulatory and Counterparty Credit Risk

Unfortunately, solar is a volatile market– nearly every large portfolio to date has seen the insolvency of a key vendor or sponsor. The regulatory environment also continues to evolve, with examples of retroactive changes in net-metering policy and changes to renewable energy credit incentive structures. In this context, it is important for investors to get ahead of potential disruptions by, at a minimum, proactively measuring their exposure to potential liabilities. Reviewing investment allocations and historic operating history may inform a warranty claim, a spare parts strategy, or a modification to O&M practices. But without knowing the risk, investors cannot act.

Many investors track their exposures both at an individual investment level (e.g., a project or a fund), as well as at the entire portfolio level. Common allocation measurements include equipment type (modules, inverters, and tracker manufacturers), state or geographic region, utility, offtaker credit quality, service providers, and sponsor. While some investors may choose to proactively manage their allocations for new investments to achieve portfolio diversification, others may use this information to assess their risk exposure due to a specific negative portfolio event.

Proactively managing allocations--and quantifying the resultant risk--then informs various mitigation strategies that investors may elect to pursue. For example, significant exposure to a solar developer may inform a modification to the approach of asset management, such as outsourcing asset management to third parties or procuring back-up services from independent parties. Large exposure to volatile geographies or equipment types may inform the investor's approach to production insurance procurement. Similar credit risks that reside in many different investments (for example, funds with credit exposure to the same corporate entity offtakers) may need to be aggregated for reporting and tracking at an institutional level.

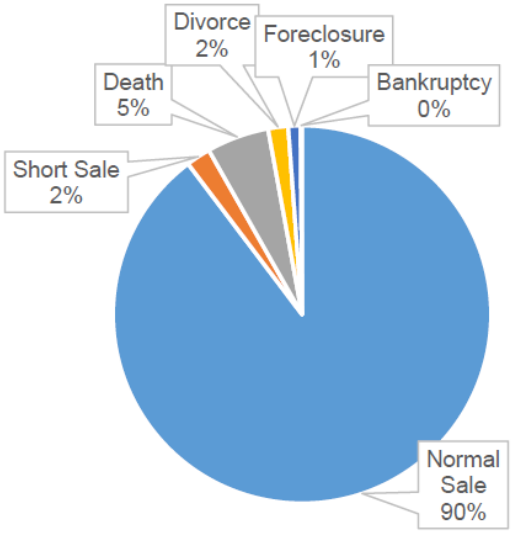
3. Offtaker Credit Risk

A key component of measuring credit risk is the financial health of those obligated to pay the bills. This is approached differently in residential vs. non-residential portfolios, but the end goal is the same.

In non-residential portfolios, traditional measures of credit health are typically used to monitor credit risk. This includes traditional financial analysis or, when available, independent credit ratings from a rating agency such as Standard & Poor's or Moody's. This task may be managed by specialized credit groups or within a risk management team directly, and is frequently complemented with monitoring of public news releases. If a solar plant is located atop a facility that is closing, for example, the investor can proactively work with the asset manager to devise a mitigation approach or scope the potential impact on the cash flows from the portfolio. A real property analysis is sometimes performed to scope potential recoveries if a facility were to be vacated.

For residential portfolios, metrics of financial health are only now beginning to emerge. Whereas in other asset classes a 'default' is clearly defined as 90+ or 120+ days of nonpayment, the solar industry is only now identifying the relevant metrics for residential portfolios. Many investors are tracking contracts with 90+ days of nonpayment as materially delinquent, even if an official

contractual default has not been called. However, historically, there is a higher probability of consumers becoming current on their payments after material non-payment occurs, which is much less common in other industries. As such, investors are separately measuring contract reassignments, renegotiations or write-offs, as well as resolution statistics, to determine the impact on cash flow. A big challenge facing investors is normalizing these metrics across portfolios, and many are turning to specialized technology solutions to support this process.



Transfer Reason	Transfers	NPV Recovery[1]
Normal Sale	6,116	100.2%
Death	363	99.5%
Short Sale	143	95.35%
Divorce	117	99.9%
Foreclosure	72	84.5%
Bankruptcy	8	63.6%
Total	**6,819**	**99.8%**

Fig. 1: Sample reassignment statistics from a residential developer's earnings call.

4. Repayment Risk

Ensuring that cash flows meet an investment vehicle's obligations is a core requirement for any asset-backed investment vehicle. Tracking actual cash flows against projected cash flows, as well as the resultant coverage ratios, is critical to satisfying credit and compliance obligations in all investments, including solar.

There may be differences between pure credit risk, as defined above, and the ability for an investment vehicle to fulfill its payment obligations. These contributing factors include increased expenses, operational issues, and poor servicing quality (such as the inability to send a timely invoice). Tracking cash flows enables a risk manager to measure the extent of the various risk factors within a transaction.

This is often more difficult than tracking a Performance Index. Depending on the financing structure, there may be upwards of five bank accounts per project (such as revenue accounts, reserve accounts, and sweep accounts). For investors that are tracking cash flows closely, and receiving copies of the bank or servicing reports, it's important to work with the solar asset managers to label transactions consistently within the ledger so that the transactions can be audited at a later date. Cash flows may be categorized in the following types and subtypes:

Transaction Type	**Transaction Subtype**
Revenue	Electricity Revenue Lease Revenue SREC Revenue Prepayments Rebates Fees Contract buyouts Reimbursements
Contra-revenue (Negative cash flows that are not expenses)	Refunds Performance Guarantee Payments Referral credits
Expenses	Operations and Maintenance Expense Asset Management Expense Insurance Expense Property Tax Site Lease Other Expense
Other	Transfer to another account Transfer from another account

For transactions that include debt, or for sale leaseback transactions, cash flows and debt service coverage ratios are critical to determining covenant compliance. In these transactions, there are often compliance obligations whereby a portfolio that generates fewer cash flows than expected must deposit cash into a new reserve account for the benefit of the lenders until the cash flows recover. Independently reviewing the financials ensures satisfactory compliance with these obligations.

Some structures, particularly in the debt market, are structured to have a balloon payment at a date certain in the future. In order for their debt to be repaid, they are typically relying on a developer to refinance their loan. To evaluate this risk, some lenders also look at how successful solar companies are at recycling or accessing capital in the market, and running sensitivities based on projected interest rates.

5. Tax Risk

Investors at all levels of the capital stack typically have some sort of exposure to tax credits – whether in the form of basis indemnities, tax recapture insurance, cash sweeps, or extended flip dates. Tax equity investors typically track this exposure closely, and it is best practice for lenders and others involved in the transaction to watch it closely as well. In highly structured, tax-motivated investments, if cash is king, then tax equity may be considered the queen - they form a partnership wherein both have to work together in order for everything to function properly.

Risk managers should be knowledgeable of the tax equity structure and how changes in the realized tax benefits impact return or flow through the project finance model. Typically both need to work in unison for all investors to achieve their target return. The key tax metrics to track are the projected and realized tax benefits, which are themselves a function of the fair market value of the assets, any tax recapture, and the prevailing tax rate.

6. Regular Risk Reporting

Investors who are most focused on compliance management and keeping senior management and credit teams up-to-date on their portfolio generally have a Monthly-Quarterly-Annual review cadence: monthly production look-backs, quarterly portfolio summaries, and annual portfolio reviews.

Monthly look-backs are often focused on production metrics and the Performance Index of a portfolio, with a particular emphasis on identifying underperforming assets and working with asset managers to resolve any problems in the field. Best practice is to report results for both a Performance Index and Weather Adjusted Performance Index.

Quarterly reports may include additional data points such as cash distributions to the investor, a refreshed allocations analysis, or a discussion of material credit events within the portfolio.

Annual reports are often more fulsome in nature and include a refreshed credit underwriting of the important stakeholders, discussion of collateral or residual value, updates of the relationship with each of the third parties, any changes in the broader market, a discussion of third parties supporting the risk management function, and other topics as may be pertinent to the portfolio.

Senior credit managers don't like surprises, so keeping them informed as issues arise is critical to the success of any portfolio manager.

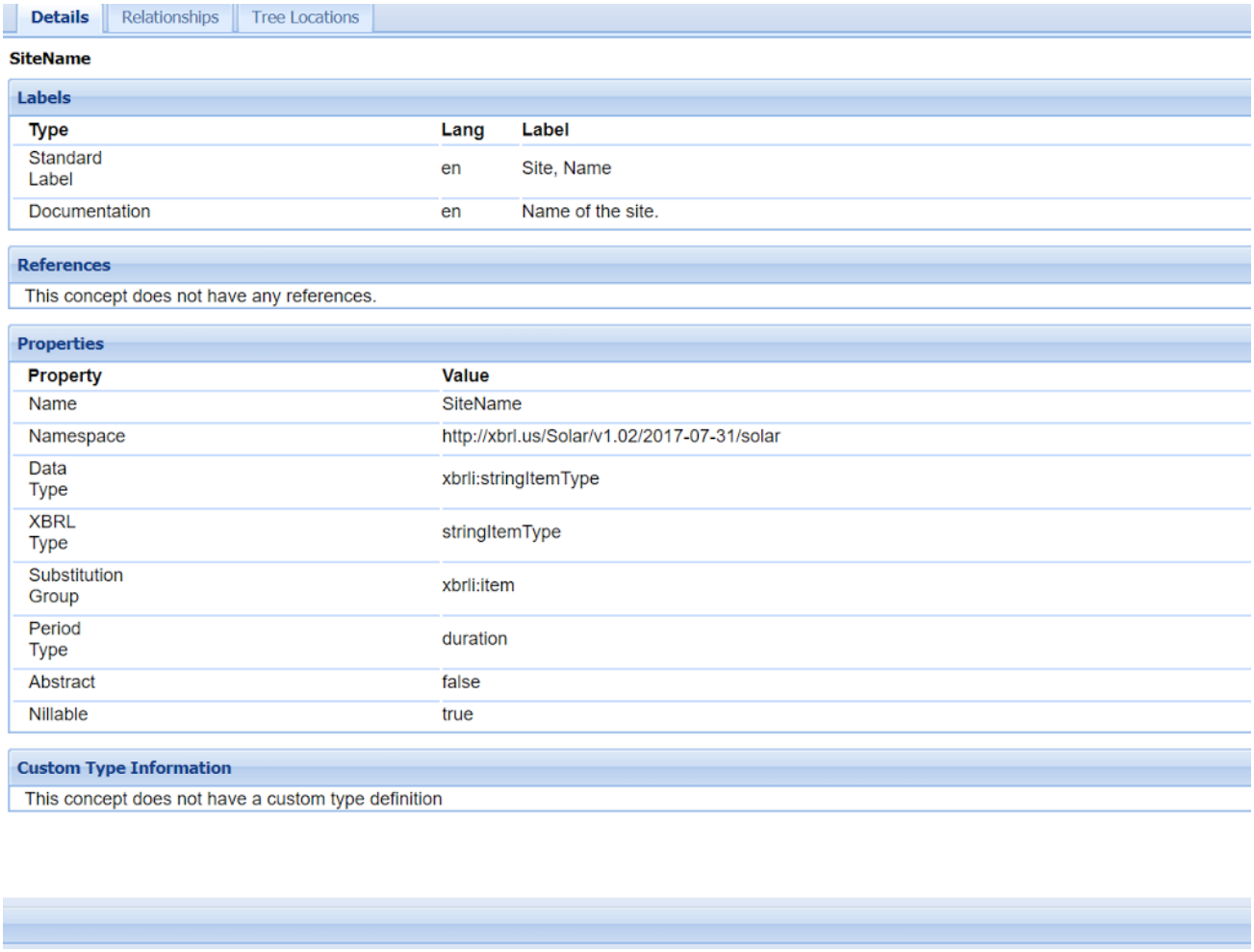
Section 2: Leverage Industry Standards and Benchmarks

Collaboration with asset owners, other investors, and independent third parties can enhance one's risk management practices.

7. Use industry-standard protocols

Industry groups have invested significant time and financial investment into the development of standards to be leveraged by the solar industry. A number of these can be leveraged by risk managers as a way to adopt "generally accepted compliance practices" that have already been vetted and agreed upon by the industry

Orange Button, a program of the U.S. Department of Energy SunShot Initiative, has organized the creation and adoption of industry-led open data standards. The Orange Button Data Standard is a taxonomy for solar data transfer and reporting. The final specifications for this standard are expected to be available by late 2017 / early 2018, and Orange Button-compliant applications are being developed to support the use of this standard.



Details | Relationships | Tree Locations

SiteName

Labels

Type	Lang	Label
Standard Label	en	Site, Name
Documentation	en	Name of the site.

References

This concept does not have any references.

Properties

Property	Value
Name	SiteName
Namespace	http://xbrl.us/Solar/v1.02/2017-07-31/solar
Data Type	xbrli:stringItemType
XBRL Type	stringItemType
Substitution Group	xbrli:item
Period Type	duration
Abstract	false
Nillable	true

Custom Type Information

This concept does not have a custom type definition

Fig. 2: A sample data field from the draft Orange Button taxonomy.

Model Contracts – SEIA and a former working group led by National Renewable Energy Lab (NREL) developed a suite of model commercial and residential solar contracts (including both PPAs and leases). These documents were developed by dozens of leading solar companies, law firms, financiers, and other stakeholders to create legal consistency throughout the market and in turn eliminating transactional burden and allowing the cash flows to be pooled into larger, tradable securities. The model contracts are available here: https://www.seia.org/research-resources/model-leases-and-ppas

Installation and O&M Best Practices – SEIA and NREL continue to refine installation and operation and maintenance best practices in order to drive high quality and consistent development and management practices and protocols. The best practices are available here:

https://www.seia.org/research-resources/industry-backed-best-practices-guides-aim-lower-financing-costs-solar-energy

Consumer Protection Best Practices – Accurate salesmanship and marketing of solar to residential customers has become a critical issue in the asset class. SEIA has led the industry with critical resources and guidelines for its members, available here: https://www.seia.org/initiatives/consumer-protection

8. Risk Management Begins at Origination

Risk management is a process that starts well before the investment is made, and there should be collaboration between the origination team and the risk management team at a financial institution. As discussed earlier in this report, there are some key metrics and data points that should be monitored on a regular basis by risk managers, and the provision of data is often negotiated as part of the financing package. Unfortunately, it is common for each investor to negotiate different reporting packages on each transaction, leading to an unwieldy process of data preparation by the solar asset manager and data collection by the risk management team. Risk Management Software vendors provide software packages to investors that consolidate and aggregate the pertinent portfolio data, easing the burden of report generation on sponsors. Additionally, use of the Orange Button standard could streamline the way data is transmitted between the parties.

Risk managers should work with their origination team to agree on the set of reports and data fields. Whereas in the past some banks had individuals logging into different monitoring platforms simply to collect data, it is becoming common practice for investors to require automated access to the data. Many are negotiating access to an Application Programming Interface (API) from which the bank or a third-party can access the solar project's production data, free of charge. Most data acquisition systems offer this functionality, and the use of an API enables a portfolio to scale more easily.

The origination team is also responsible for setting and validating a project budget within a closing pro forma. This includes estimating revenues (and therefore production estimates, degradation rates, and default rates), as well as expenses. For the pro forma, the estimated O&M cost should equal the cost of full replacement of those services by another provider. These estimates should include scheduled and unscheduled outages, major maintenance, and inverter replacements. Other expenses may need to be budgeted as well, such as property taxes, asset management fees, accounting fees, filing fees, LLC fees, bank fees, trustee fees, and collateral agency fees. Many banks also like to structure deals to ensure the owner of the facility is incentivized to keep their projects a priority for any operational issues that may arise, such as by requiring a minimum rate of return for the project sponsor. Risk managers should work with the origination team to agree on a project budget prior to the close of financing.

9. Performance Benchmarking Puts Operations in Context

Absolute metrics of performance against projected values achieve specific goals related to portfolio performance, but the reality is that the pro forma projections are the results of a 'best guess' at the time the solar project was built. With over a million operating solar power plants in the United States, there is additional value in utilizing *relative metrics* to compare how a given

project or portfolio is performing relative to others in the industry. This exercise can help determine if an asset is underperforming due to poor technical quality, or simply due to overly aggressive underwriting estimates.

For example, much can be learned by comparing the operational performance of an asset against others operating in a similar region. A risk manager can begin to answer questions such as:

- Is the facility performing in-line with others in the industry?
- Is the facility being maintained adequately?
- Are the pyranometers calibrated appropriately?
- Is the asset manager utilizing best practices in clearing snow from the facility?

To identify the quality and operational health of an asset, it's critical to put it within the context of an ecosystem of other operating solar projects.

When it comes to underwriting the credit quality of a portfolio, data products have recently come to the market that shed light on the historical payment quality of various portfolios. In the residential market, proxy asset classes (such as mortgages or home improvement loans) could be used to estimate defaults, but increasingly investors are looking to historical payment trends of solar portfolios themselves as a superior input to project annual default rates. Similarly, in the non-residential market, many investors underwrite a solar project's offtaker as they would a commercial loan and take a binary bet on credit quality for up to 25 years--an audaciously long time--when industry data could be used to better understand the frequency of contract restructurings or defaults, and the causes. This is particularly true for non-investment-grade entities and for emerging segments of the solar market, such as community solar.

Benchmarking investments against each other can take multiple forms. At the simplest, an investor can compare each of their investments against one another. However, single investor portfolios are often limited in scope, and many investors subscribe to services that enable them to gain access to performance indices, which provide insight into performance characteristics of the entire solar industry. These indices are aggregated from historical data and anonymized in such a way as to conceal the performance characteristics of each individual asset. The solar industry is still early in the use of industry data for decision making, but it is becoming clear that this information will be used to stratify and value assets based on their relative quality against industry indices.

10. Component Benchmarking to Identify Latent Risks

In addition to comparing asset portfolios against one another, a key responsibility of a risk manager is to project if there are any anticipated risks to the investment until such time as the loan is repaid or the investor is otherwise out of the transaction. This necessitates risk managers to "see around corners," or identify potentially latent defects within a portfolio that could have negative impacts on the investment portfolio.

Similar to asset indices, performance data from elsewhere in the industry is being utilized for component benchmarks. These are used to identify performance issues experienced by other, anonymized assets in the pursuit of drawing out risk factors. By using this approach, analytics firms can draw key insights, such as whether certain pieces of equipment are experiencing

increased failures at a certain point in the asset life cycle, what system degradation rates are being realized in the field for different pieces of equipment, or if equipment failures are more closely associated with different climate zones.

Risk managers can utilize these component benchmarks to identify latent risks that may reside within their investment portfolios and proactively develop strategies to mitigate any potential risks that may exist.

Section 3: Robust Compliance Infrastructure

A centralized system of record for solar investments is an essential piece to supporting compliance requirements from regulators and auditors.

11. Systems of Record: Asset level information, institutional-grade IT security

It is best practice to keep a centralized system of record for the data associated with renewable energy portfolios. This achieves dual goals of a centralized database as a compliance mechanism to ensure the data is maintained with adequate controls, in addition to a shared source of truth among team members.

Tracking data at the asset level is now common within the industry and is performed by more than half of the tax equity suppliers, even for residential portfolios with a large quantity of systems. This level of detail enables a deeper view into how changes in the composition of a portfolio will impact the cash flows, such as when customers renegotiate or default on contracts, or how regulatory changes may impact cash flows. Additionally, asset-level detail enables benchmarking against industry indices, as discussed elsewhere in this report.

Some investors have internal systems of record that they modify for their renewable energy transactions, which store a history of the key metrics for solar portfolios and, in some cases, generate reports which feed into corporate accounting platforms. In practice, there are many aspects of renewable energy that make modification of existing databases challenging, such as:

- There are many specific data fields specific to solar, both regarding the systems as installed and the ongoing types of data being generated by the solar projects. This results in significant modification to existing databases that may already exist within a financial institution.
- Due to lack of standardized data and lack of data science expertise within renewable energy teams, high-value employees are doing data entry tasks. This is using high-cost personnel for low-value work, and on a task that erodes job satisfaction for top-level employees.
- Solar transactions may cover a large volume of solar assets, particularly for those made within the residential and small commercial segments. Many databases are not designed to store tens of thousands of systems in a scalable manner.

Due to the challenges above, many investors turn to third-party vendors designed to address the specific challenges listed above to manage their systems of record. Qualified vendors will have functionality designed to meet the specific needs of the risk manager and a product that can meet the rigorous security requirements of regulated institutions. This includes adequate internal controls, external validations (such as penetration tests), and adequate business insurance. For

investors considering working with independent third parties on this service, a reference list of other regulated institutions who are already customers is an important vetting mechanism.

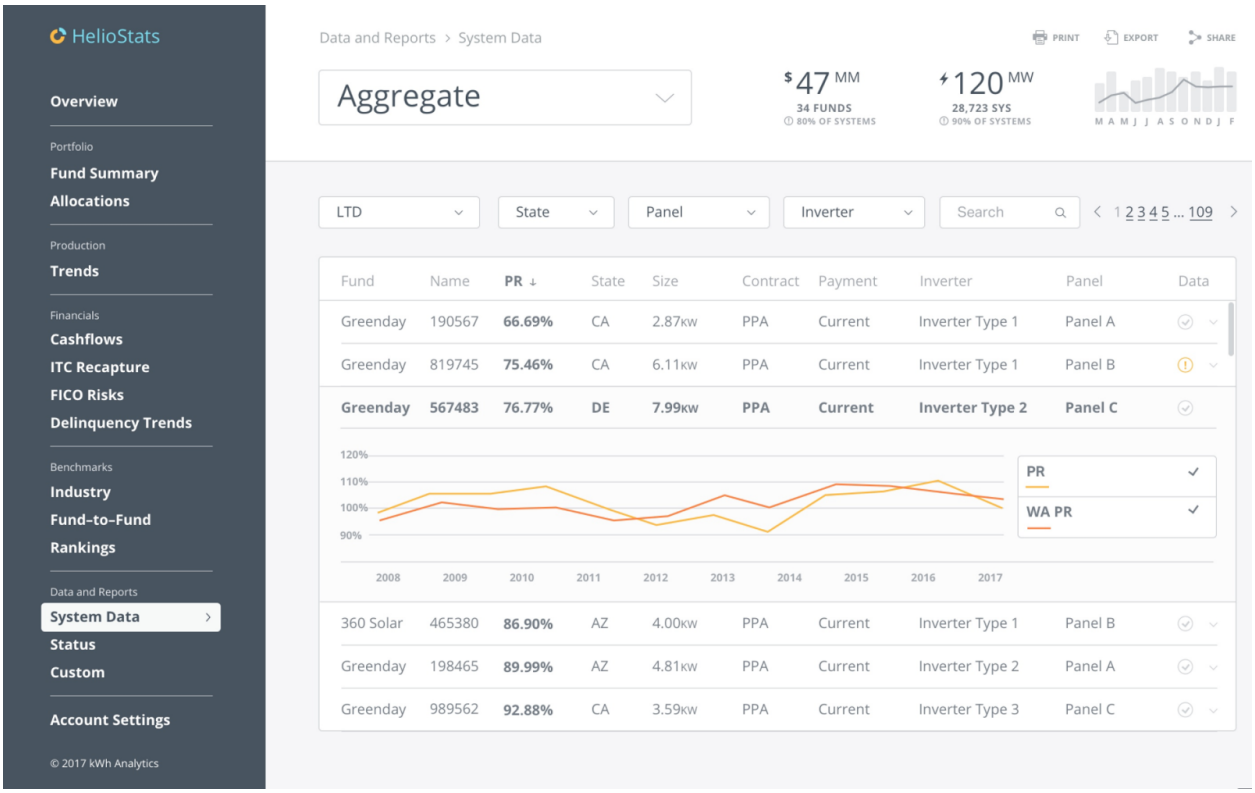


Fig. 3: An example of an asset-level database is the HelioStats Risk Management software by kWh Analytics, Inc.

An additional benefit of working with independent third parties is an independent verification of the data being delivered from the solar asset manager.

Systems of record exist in other industries, such as institutional products for equipment lease groups or for banks financing commercial loans. These systems of record are typically tailored to satisfy the particular needs of the chosen financial product. Some of these may be applied to solar – such as leasing software to manage a sale-leaseback transaction – but when applied to solar, they may be necessary but not sufficient. For example financial investors may still run lease accounting off of a leasing software, but complement these applications with solar-specific systems of record to manage fund-level cashflows and manage the particular risks of the solar asset class.

12. Independent Verification of Reported Results

All the data in the world won't adequately support the risk management function if the data is of questionable quality. The risk manager is almost always reliant on the solar asset manager to provide reliable and timely data and reports in order to fulfill their own compliance obligations. Because solar is a growth industry, it is important for investors to recognize that there will be challenges working with the data, at least until better data standards such as Orange Button are

widely adopted. However, there are mitigation strategies that can be employed to ensure that quality data is being used for decision making.

Examples of frequently identified challenges with the data include:

- Reported system production that is outside of an acceptable range, e.g., a negative Performance Index or one exceeding 200%.
- Reported system production that does not include a Weather Adjusted Performance Index.
- Missing data fields, including situations where the asset manager does not provide key data points due to imprecise negotiations during the origination process.
- For reported data fields, systems reporting null data for extended periods of time.
- Allocations tracked inconsistently, e.g., tracking exposure to Yingli and Yingli Solar as two different module vendors.

In most instances, automated checks can be run on reported data to quickly identify data quality issues. Some investors prefer working with third-parties to perform this service, as it is rooted in data science and falls outside their core expertise as a financial institution, and provides an independent source of validation to satisfy internal compliance requirements. There are dozens of data quality checks that should be performed to ensure reliable data is used for reporting and decision making purposes.

Conclusion

Although solar is still a relatively new industry for financial investors, the industry has developed standards and practices on how to measure and manage the risk for investors who have exposure to solar portfolios. The authors hope this guide provides a comprehensive overview of the pertinent risks and management techniques used in the industry today by investors who have exposure to the asset class.

Solar Energy Industries Association
600 14th Street, NW
Washington, DC 20005
www.seia.org

kWh Analytics, Inc.
230 California Street, Suite 303
San Francisco, CA 94111
www.kwhanalytics.com