

RISK MATRIX

Solar PV projects

Risk = severity*probability (Haimes)

Risk = severity*relative frequency (Bahill)

Residual risk = risk - mitigation

Risk-tier	Description
Utility company or grid	Risks related to operations: not meeting demand, brownouts, blackouts, etc.
Project Management/Development	Risks that may be encountered throughout the development of the PV project: changes in costs, design issues, permit issues, etc.
Hardware	Risks related to the hardware components of the system: reliability
Environmental and Social	Risks related to the location and surrounding environment of the project: effect on local habitats, weather, environmental opposition, etc
Government	Risks related to changes in governmental policies and priorities

Risk Severity and Frequency numerical values

Description	Metric
Extreme	Purple
Very High	Light purple
High	Red
Medium	Light red
Low	Yellow
Very Low	Light Yellow
Negligible	Green

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Risk Control Strategies*

Avoid	Change the project plan to eliminate the risk or to protect the project objectives (time, cost, scope, quality) from its impact. This can be achieved by modifying scope, adding contingency to the project plan either as additional time for critical path activities, or adding resources. Some threats that arise early in the project can be avoided by clarifying requirements, obtaining information, improving communication, or acquiring expertise.
Mitigate	Reduce the probability and/or impact of an adverse risk event to an acceptable threshold. Taking early action to reduce the probability and/or impact of a risk is often more effective than trying to repair the damage after the risk has occurred. Risk mitigation may take resources or time and hence may represent a trade off. However, the overall result may reduce risk to the overall project objectives
Transfer/Share	Shift the negative impact of a threat to a third party through: insurance, performance bonds, warranties, guarantees, incentive/disincentive clauses, cost+time contracts, provided the price for the risk transfer can be supported by project cash flow. Transference reduces the risk only if the person to whom the risk is transferred (such as the contractor) is better able to take steps to reduce the risk and does so. Risk transference nearly always involves payment of a risk premium to the party taking on the risk.
Acceptance	Adopted if is either not possible to eliminate that risk from a project or the cost in time or money of the response is not warranted by the potential impact of the risk. The most common active acceptance strategy is to establish a contingency reserve, including amounts of time, money, or resources to handle the threat or opportunity.

*source: Arthur D Little

Events	Potential effect	Frequency (event/year)	Severity	Estimated risk	Mitigation/Strategy	Risk Control Strategy	Risk taker	Notes
1. Technical								
Performance of technology	Lower yield = lower revenues Losses = lost MWh x tariff	Continued	High	Low	Proven technology Quality components Correctly dimensioned Manufacturer warranties and performance guarantees and terms	Transfer	Manufacturer, EPC Contractor	Technology to be provided by Manufacturer – a company 60% owned by Project Sponsor. Full performance guarantees by the manufacturer and EPC.
Technical Availability	Lower yield = lower revenues Losses = lost MWh x tariff	Low	High	Low	Proven technology Quality components Correctly dimensioned Manufacturer warranties and performance guarantees and terms O&M guarantees	Transfer	Manufacturer, O&M Contractor	Technology to be provided by Manufacturer – a company 60% owned by Project Sponsor. Full performance guarantees by the manufacturer and O&M contractor.
Technical Lifetime	Reduced return from the project	Low	Medium	Low	Proven technology Quality components Correctly dimensioned Manufacturer warranties and performance guarantees and terms O&M guarantees	Transfer	Manufacturer, O&M Contractor	Would reduce the return to the equity holders. Lifetime guarantee by Manufacturer and O&M contractor
Equipment defect / decreasing yield (degradation)	Lower yield = lower revenues Losses = lost MWh x tariff	Low	Medium	Low	Manufacturer warranties and performance guarantees and terms O&M guarantees	Transfer	Manufacturer, O&M Contractor	Degradation rate guaranteed by the manufacturer
Reduced yield due to dusty panels	Lower yield = lower revenues Losses = lost MWh x tariff	High	High	Medium	O&M guarantees	Transfer	O&M Contractor	Would reduce the yield severely, guaranteed by O&M contractor
Connection	Power cannot	High	High	High	Substation constructed with the	Transfer,	Utility	Power cannot be evacuated,

to the grid fails	be evacuated				project Take-and-pay PPA	Accept		needs provision in the PPA (take-and-pay)
Financial strength manufacturer (low risk of default = capability to fulfil guarantees)	Inability to fulfil warranties and guarantees	Low	High	Low	Track record, financial strength of mother company	Transfer	Manufacturer	Technology to be provided by Manufacturer – a company 64% owned by Project Sponsor.
Technological change	Panels get much cheaper. Panels get much more efficient	High	High	Low - in medium term	Distrust of project cost, resentment by the utility and users of electricity	Accept	sponsor/utility	The technology supplied conforms to the best practice of the day Manufacturer performance guarantees on the modules
2. Energy Resource								
Variability of irradiation data	Uncertain yield	Medium	High	Low	Use of different data bases, on-site irradiation measurements	Mitigate	Developer/Consultants	A number of irradiation data and models to be used by the developer, using reputable consultants to perform the feasibility studies. Theoretical data to be combined with on site measurements.
Quality of irradiation data	Overestimation of yield	Medium	High	Low	Use of proven databases with well correlated theoretical and empirical data. Use of on-site measurements.	Mitigate	Developer/Consultants	A number of irradiation data and models to be used by the developer, using reputable consultants to perform the feasibility studies. Theoretical data to be combined with on site measurements.
Simulation Model	Overestimation of yield	Medium	High	Low	Use of proven models. Use of conservative P90 values.	Mitigate	Developer/Consultants	A number of irradiation data and models to be used by the developer, using reputable

								consultants to perform the feasibility studies. Theoretical data to be combined with on site measurements.
3. Severe Weather Event								
Lightning Strike	Damage of installation	High	High	Low	Use of technical protection measures	Transfer, Mitigate, Accept	Designer/E PC contractor	Appropriate measures to be incorporated in the installation's design, Insurance
Extreme wind conditions	Damage of installation	High	High	Medium	Use of technical protection measures	Transfer, Mitigate, Accept	Designer/E PC contractor	Appropriate measures to be incorporated in the installation's design, Insurance
Extreme temperatures	Low performance/damage	High	High	Medium	Use of technical protection measures	Transfer, Mitigate, Accept	Designer/E PC contractor	Appropriate measures to be incorporated in the installation's design, Insurance, good resistance of Manufacturer module performance to high temperature
Flood	Damage of installation	Low	Medium	Medium	Site selection	Transfer, Mitigate, Accept	Designer/E PC contractor	Appropriate measures to be incorporated in the installation's design, Insurance
Sand storm	Damage of installation/low performance	High	High	High	Use of technical protection measures	Transfer, Mitigate, Accept	Designer/E PC contractor	Appropriate measures to be incorporated in the installation's design, Insurance
Dune movement	Damage of installation	High	High	Medium	Site selection	Transfer, Mitigate, Accept	Designer/E PC contractor	Appropriate measures to be incorporated in the installation's design, Insurance
Earthquake	Damage of installation	Low	High	Low	Site selection	Mitigate, Accept	Designer/E PC contractor	Appropriate measures to be incorporated in the installation's design, Insurance
4. Costs Forecast								
CAPEX	Underestimates	Medium	High	Low	The cost estimates to be based on	Transfer	Sponsor/EP	The budget will be based on

	can lead to lack of funds to complete the project	um			recent quotes from the manufacturer/suppliers. Fixed price EPC.		C contractor	fixed price EPC contract
Fixed OPEX	Underestimates can lead to reduced cashflow	Medium	High	Low	The cost estimates to be based on recent quotes from the O&M contractor. Fixed price O&M with escalation built-in into the financial model.	Transfer	Sponsor/O&M contractor	The budget will be based on fixed price O&M contract
Variable OPEX	Underestimates can lead to reduced cashflow	Medium	High	Low	The cost estimates to be based on the on-site conditions (dust, wind rain etc.).	Transfer	Sponsor/O&M contractor	The model will consider the severity of the weather / environmental conditions
Maintenance Reserve Account (inverter replacement)	Underestimates can lead to reduced cashflow	Medium	High	Low	The cost of replacement to be build-in in to the financial model, sufficient MRA to be envisaged in the budget	Transfer	Sponsor	The model will consider the replacement needs based on the technical characteristics provided by the manufacturer. Strong performance guarantees to be requested.
5. Construction Risks								
Cost overrun / adjustments	Can lead to lack of funds to complete the project	Medium	Medium	Low	Fixed time and budget turnkey contract (Engineering Procurement and Construction Contract (EPC)) Completion Guarantees Monitoring reports Performance reports Penalty clauses Project's budgeted costs will include cost contingency funds	Avoid, Transfer, Mitigate	Manufacturer, EPC Contractor	Installation to be provided by Manufacturer – a company 60% owned by Project Sponsor.
Equipment Delivery Delays	Delay in completion, loss of	Medium	Medium	Low	Fixed time and budget turnkey contract (Engineering Procurement and Construction Contract (EPC))	Avoid, Transfer, Mitigate	Manufacturer, EPC Contractor	Installation to be provided by Manufacturer – a company 60% owned by Project

	revenue, penalty for late completion under PPA				Completion Guarantees Monitoring reports Performance reports Penalty clauses			Sponsor.
Transportation Price	Cost overrun	Medium	Medium	Low	Fixed time and budget turnkey contract (Engineering Procurement and Construction Contract (EPC)) Completion Guarantees Monitoring reports Performance reports Penalty clauses	Transfer, Mitigate	Manufacturer, EPC Contractor	Transportation rate to be included in EPC contract.
Completion delay / Non-completion	Delay in completion, loss of revenue, penalty for late completion under PPA	Medium	High	Medium	Fixed time and budget turnkey contract (Engineering Procurement and Construction Contract (EPC)) Completion Guarantees Monitoring reports Performance reports Penalty clauses	Transfer, Mitigate	Manufacturer, EPC Contractor	Appropriate measures to be incorporated in the completion guarantees, Insurance
Sub-contractors	Sub-standard work	High	Low	Low	Fixed time and budget turnkey contract (Engineering Procurement and Construction Contract (EPC)) Completion Guarantees Monitoring reports Performance reports Penalty clauses	Transfer, Mitigate	Sponsor/EPC contractor	To be included in the EPC contract guarantee and completion bond.
Meeting Project specification	Reduced performance	High	Low	Low	Fixed time and budget turnkey contract (Engineering Procurement and Construction Contract (EPC)) Completion Guarantees Performance guarantee Monitoring reports Performance reports Penalty clauses	Transfer, Mitigate	Manufacturer, EPC Contractor	To be included in the EPC contract guarantee and completion bond.
Land availability	Inability to construct the	Medium	High	Low	Exclusive land lease agreements with the Local Government.	Avoid, Mitigate	Sponsor/EPC	Full support of the state government.

	project						contractor	The Sponsor will make its best endeavours to select land for the projects that shows no agricultural use and also where minimum or no resettlement is required.
6. Off-take risk								
Demand / Price and Quantity	Can lead to decreased project income Lower yield = lower revenues Losses = lost MWh x tariff	High	Medium	Medium	Long-term Off-Take- Agreement (PPA) take-and-pay	Transfer, Mitigate	Sponsor/Off-taker/Federal Government	Full price and quantity guaranteed by the off-taker. Typical forms of credit enhancement to be provided.
Tenor	Reduced return from the project	Low	Medium	Low	Long term PPA – 20 years Signing a long term PPA and Project Support Agreement with the relevant State and Federal authorities to counter the risk of arbitrary changes of tariff, accelerated taxes, regulations etc	Mitigate	Sponsor/Off-taker	Negotiated PPA, including: sale and purchase of energy on take-and-pay basis, defaults and remedies, liquidated damages, warranties, control and operation, metering, tariff, billing and payment, insurance, liability and indemnification, termination, taxes and law.
Financial strength of purchaser	Can lead to lack of funds to continually purchase the product	Low	Medium	Low	Credit enhancement, Commercial and political insurance, undertaking from the Government.	Mitigate, Transfer	Sponsor/Off-taker /Federal Government	Strong political and institutional support from the State Government
7. Financing risks								

Interest Rate volatility	Increased interest payments, lowering the DSCR	Medium	Medium	Medium	Fixed rate Hedging Financial Covenants	Transfer	Borrower, Lender	The interest rate increases can be contained by fixing the rate, capping it and hedging it. To be considered at Term Sheet negotiations.
Currency	Devaluation of currency in a foreign currency loan will result in reduction of the ability to repay the loan	High	High	High	Hedging Financial Covenants Market Flex PPA	Transfer	Borrower, Lender	A hedging must be arranged to protect from currency devaluation. If the currency value changes between term sheet and loan agreement, the loan terms can be changed (market flex). A provision in the PPA can stipulate a tariff correlated to the currency of the loan.
Inflation	High inflation can result in increase to increase of the O&M costs	High	Medium	Low	Fixed O&M Hedging	Transfer	O&M contractor	The O&M contract can be fixed with a fixed % indexation/year and the risk of inflation hedged.
Refinancing Risk	Should the project returns worsen, the refinancing on better rates and conditions would become less attractive	Medium	Medium	Low	Financial Covenants	Accept	Borrower	Increased perception of risks and worsening market would make finding cheaper refinancing difficult.
Violation of Terms	Would result in default	Medium	Very high	Medium	Financial Covenants Insurance	Mitigate, Transfer	Borrower, Insurer	Such risks, particularly related to political and commercial will need to be insured in the interest of Borrower, or accepted and managed by the lender (if DFI).
Syndication	Risk of unsuccessful	Medium	High	medium	Overall risk mitigation Attractive terms	Mitigate, Avoid	Sponsor, MLA	The risks, terms and conditions are attractive to other lenders.

	syndication would lead to not sufficient funds to finance the project				Financial Covenants Market Flex			The MLA approaches financial institutions, which accept the terms.
8. Permitting issues								
Land License/Lease agreement	Inability to construct the project	Medium	Medium	Low	Exclusive land lease agreements with the Local Government.	Avoid, Mitigate	Developer/Consultants	300 ha land has been identified for the project in Location. The State Government of Location, as a partner to the project
Connection approval	Inability to distribute the electricity	Medium	High	Low	Exclusive Off-Take agreements with the Bulk Trader () and connection agreement with GRID OPERATOR.	Avoid, Mitigate	Sponsor/Off-taker	The projects are sited in a proximity of the grid.
Environmental Approval	The project has high environmental impact	Medium	High	Medium	Use of environmental protection measures	Avoid, Mitigate	Sponsor	The State Government of Location, as a partner to the project Appropriate measures to be incorporated in the installation's design, Insurance
Safety Regulations	The project not able to meet the environmental/safety regulations	Medium	High	Medium	Use of stringent safety protection measures	Avoid, Mitigate	Sponsor/O & M contractor	Appropriate measures to be incorporated in the installation's design, Insurance
9. Political Risks / other								
Region Stability	Delay in completion, loss of	High	High	High	Political guarantee	Accept, Mitigate	Sponsor/Insurer	Political insurance to be arranged with MIGA or other agencies. Involvement of DFIs

	revenue.							
Terrorism, unrest, war	Delay or stop of completion, loss of revenue or project	Medium	Extreme	Medium	Use of stringent security protection measures, political guarantee	Accept, Mitigate	Sponsor/Insurer	Political insurance to be arranged with MIGA or other agencies.
Theft, vandalism	Delay in completion, loss of revenue.	Medium	Low	Low	Use of stringent security protection measures. Contribution to local economy.	Mitigate	Sponsor/Security contractor	The project will contribute to a local Social Programme. Local people will have vested interest in the project success.
Expropriation, nationalisation	Loss of project	Low	Extreme	Low	Project support agreement with the Government, political guarantee. Contribution to local economy.	Mitigate	Sponsor/Insurer	Political insurance to be arranged with MIGA or other agencies. Involvement of DFIs
Change of law	Delay or stop of completion or operation, loss of revenue or project	High	High	Medium	Strong political and institutional support from the State Government and from the State energy company	Mitigate	Sponsor	Political support agreement with the Government.
Amendment of terms	Loss of revenue.	Medium	High	Medium	Strong political and institutional support from the State Government and from the State energy company	Mitigate	Sponsor	Political support agreement with the Government.
Enforceability of contracts	Loss of contracts, warranties and guarantees	Medium	Medium	Medium	Use of appropriate legal jurisdiction Contribution to local economy.	Mitigate	Sponsor	Political support agreement with the Government.
10. Environmental and Social								
Unacceptable environmental impacts	Protected territory, endangered species, pollution etc.	Medium	Low	Low	Full Environmental and Social Impact Assessment ("ESIA") will be performed as a part of the FS&D process. Use of stringent safety protection	Avoid, Mitigate	Developer, Designer/EPC contractor	Stringent environmental procedures to be followed at construction and operations in accordance to agreed Environmental Action Plan

					measures. Environmental Action Plan agreed and prepared.			
Environmental impact during construction	Pollution to the construction area and surroundings. Destruction of local habitat.	Medium	Low	Low	Full Environmental and Social Impact Assessment ("ESIA") will be performed as a part of the FS&D process. Use of stringent safety protection measures. Environmental Action Plan agreed and prepared.	Avoid, Mitigate	Developer, Designer/EPC contractor	Sponsor will make its best endeavours to select land for the projects that shows no agricultural use and also where no resettlement is required. In the event that the selected land displays such impacts, appropriate mitigation measures will be established.
Environmental impact of transmission lines construction	Visual impact. Disruption of local habitat.	Low	Low	Low	Full Environmental and Social Impact Assessment ("ESIA") will be performed as a part of the FS&D process.	Avoid, Mitigate	Developer, Designer/EPC contractor	The design will follow the best international practice.
Opposition by the local community	Delay in completion, loss of revenue.	High	High	Medium	Social Programme contribution from each project estimated at [] million/yr (/yr) which will be further defined in the FS&D.	Avoid, Mitigate	Project Sponsor	The Sponsor will make its best endeavours to select land for the projects that shows no agricultural use and also where little, or no resettlement is required and land owners/users are fairly compensated. Social Programme contribution from each project estimated at [] million/yr (USD /yr) which will be further defined in the FS&D.
11. Sponsor Risk								
Equity and Leverage	Not sufficient equity, high leverage would worsen the	Low	Very high	Low	The Sponsor commitment to provide sufficient equity and contingent equity	Avoid	Sponsor	Project Sponsor is committed to provide sufficient equity

	DSCR and make the project not attractive to lenders							
Shareholders structure	Disputes amongst shareholders will make the project not attractive to other financiers	High	High	Low	The Sponsor envisages a simple shareholder structure, where initially 100% of the shares are with the Sponsor, with option of other investors to buy in after financial closure.	Avoid	Sponsor	Clear shareholders structure
Willingness to support	Risk of abandonment	High	Very high	Low	The Sponsor is committed to the project and invests development capital and equity	Avoid	Sponsor	Commitment letter issued by Project Sponsor
Corporate governance	Results in inefficient management, PR and compliance issues	High	High	Low	The Sponsor and the operating company are guided by Project Sponsor's corporate governance principles	Avoid	Sponsor	Corporate structure and governance to be presented and approved by the lenders
Project management	Inefficient management, delays and losses	High	High	Low	The project will be managed by professional managers with proven track record and under best management practices	Mitigate	Sponsor, O&M contractor	Management procedures, O&M guarantees