

Overview of Solar Guidebook and Knowledge Management Project

Sustainable Business Advisory

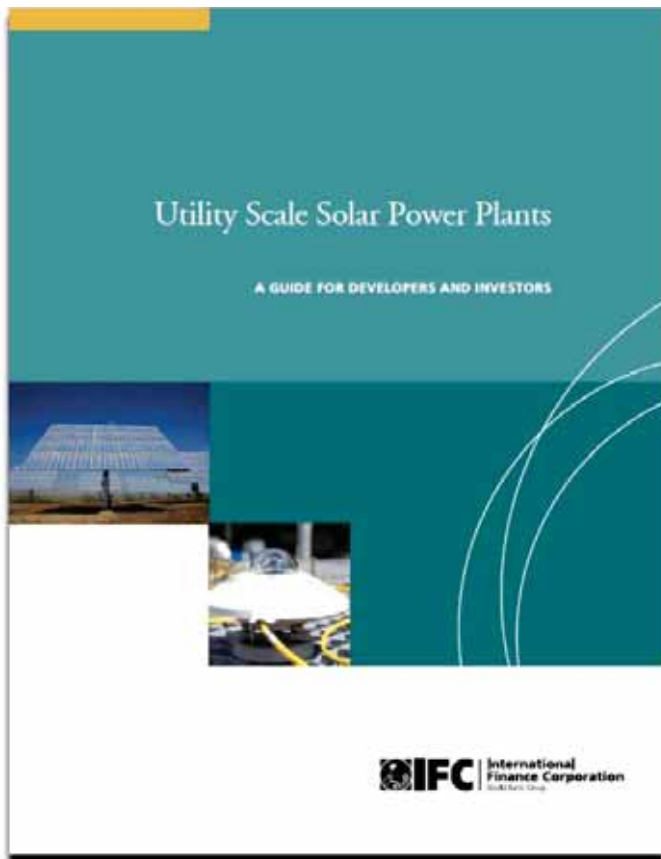
April 2012



Knowledge Management Project - the Aim

“to build capacity, capture lessons learned and disseminate and share knowledge on the Indian PV market with the aim of supporting future solar PV projects by IFC and other market players”

Utility Scale Solar Power Plants



- The guidebook can help!
- For example:
 - Interface risks? See:
 - Section 9.2 Interface Management
 - Appendix C - EPC heads of terms
- www.ifc.org/publications/



Outline

- **Presentation 1: Introduction and project overview**
- **Presentation 2: Completion / Technology Risks and Mitigation**
- **Presentation 3: Operating Risks and Mitigation**



Utility Scale Solar Power Plants - a guide for developers and investors

- Solar PV technology
- The solar resource
- Project development
- Site selection
- Energy yield prediction
- Plant design
- Permits and licensing
- Construction
- Commissioning
- Operation and maintenance
- Economics and financial modelling
- Financing PV projects
- CSP annex
- EPC contract heads of terms
- O&M contract heads of terms



Technology Risk, Completion Risk and Related Risk Mitigation

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Risk Identification, Mitigation & Removal

Site Risks

- Ground, weather, access and resource
- How does resource vary monthly and annually? What is the confidence level?

Completion Risks

- Issues that could affect construction milestones, particularly energisation

Technology Risk

- Is the technology proven? Is it suitable for the site?

Operating Risks

- Issues that could affect project revenue over the project life
- Are there contractual or physical mitigants?

Financial Risk

- Assess the volatility of cashflow
- Are mitigants in place?

Completion risks



- Participant capabilities
 - One of the most critical aspects
 - Sponsors/Contractors
 - Expertise
 - Experience
 - Managerial support
 - Technical support
 - Financial strength
 - Team or single person
- Site Investigations (remove unwanted surprises)
 - Foundation requirements
 - Soil type and consistency
 - Seismic zones
 - Former use of land

Former use of land



Completion risks



- Permitting
 - All required licences
 - Compliance with permit conditions for all phases of the project's life
 - Environmental restrictions
 - No build periods
 - Buffer zones & screening
- Grid Connection
 - Timing of connection
 - Capacity and strength of grid
 - Is it contestable - who's doing it?
 - Interfaces
 - Access routes to grid connection point (permits/way-leaves/road opening licences)

Completion risks



- Contract strategy (EPC or Multi-contract)
 - Both have benefits & drawbacks
- Interfaces
 - Design
 - Construction
 - Who handles them?
- Programme
 - Realistic
 - Lead times
 - Critical path
 - Weather delays
- Adequate liquidated damages
 - Supply contracts
 - EPC contract

Supply chain



Module	Inverter
Module supply eased since 2008, but quality tightening	Talk of quality inverters become issue
Range of quality	Range to types & quality/suitability
Bankability	Bankability

Supply chain problems lead to:

- Technology risks
- High prices / poor contract terms
- Extended project schedules

Completion

- Trial Operation (10 days - 4 weeks)
 - Reliability of:
 - Inverters
 - Tracking
 - Whole System
 - Performance Ratio Tests
- Acceptance
 - Provisional Acceptance
 - Final Acceptance (12-24 months later?)



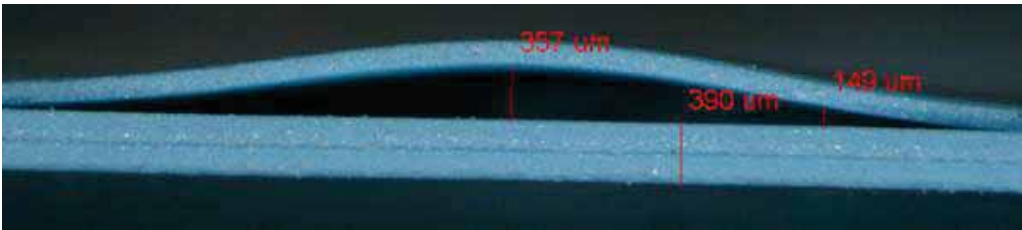
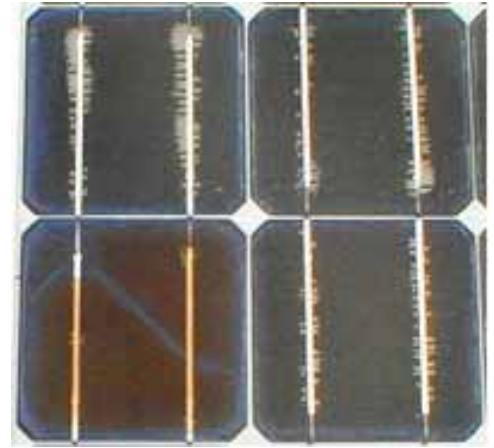
Sapphire - construction / completion issues



Technology Risks - Modules

Reliability Issues

- Quick connector reliability
 - Corrosion
 - Improper insulation
 - Delamination
 - Glass discolouration
 - Moisture ingress
 - Bypass diode failure
- loss of grounding
- Physical degradation



IEC Certification?

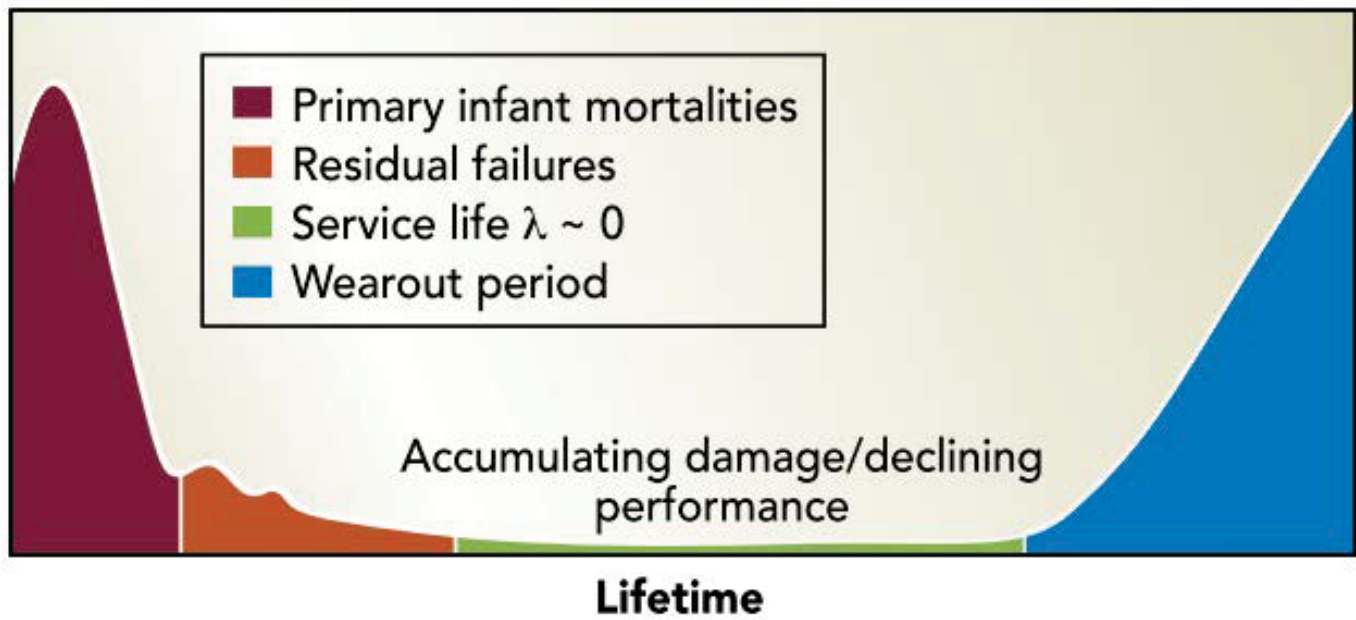
Is IEC 61215 or 61646 proof that a product is durable and reliable?

- No
- Not intended, or capable of showing long term performance
- Some Accelerated Life Testing
But not representative of real field conditions

IEC Proves that the module meets certain standards.



IEC Certification



Suitable for location

- Salt mist corrosion testing
 - Within 3km of the shore
 - IEC 61701
- Snow loading
 - Testing to the higher load 5400Pa



Inverters - very important component!

Quality counts
Reliability
Suitability
Maintenance response



Inverters

- Temperature factors
 - Derating
 - Shutdown
- Enclosure ratings
 - Indoor / outdoor
- Cooling
 - Forced or natural
 - Fans - dusty environments
- Matched to the modules and strings
- Efficiency (Eu $\eta\%$)
- Lifetime
 - Mid term replacements



Mounting systems

- Security of foundations



- Security of modules

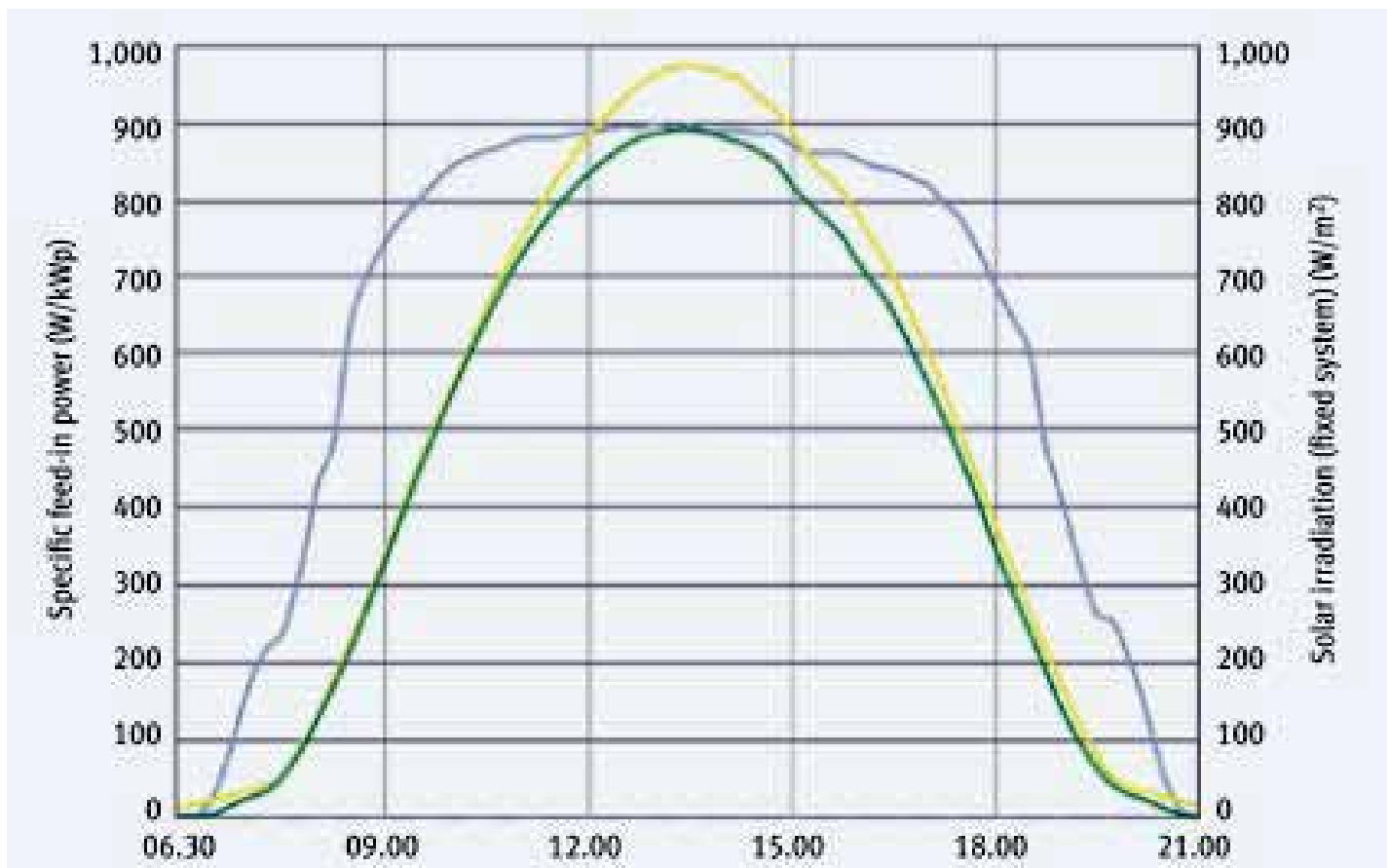


Mounting systems

- Soil Consistency and Stability
- Domino effect
- Module bending stress



Tracking systems



Tracking systems

- Storm mode
 - Loss of tracking bonus
- Increased module temperature
- Tracking error (mismatch)
- Faults in moving parts
- Regional differences
- Operability in harsh climates





Key Messages



Risk Identification, Mitigation & Removal

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Post Construction Risk and Related Risk Mitigation

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Energy Yield Prediction Accuracy

- Document Control (design version)
- Site characterisation
 - Tilt and orientation
 - Shading
 - Horizon
 - Near shading
 - Inter-row
- Solar Resource
 - Source of data
 - Period of data
 - Uncertainty in data



Energy Yield Prediction Accuracy

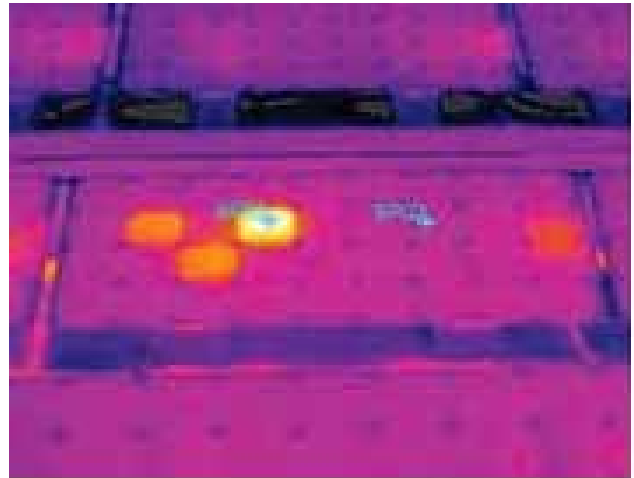
- Losses
 - Mismatch
 - Soiling
 - AC/DC cable
 - Temperature
 - Inverter
 - MPP Tracking
 - Transformer
 - Downtime
- Module degradation
- Total prediction uncertainty



Operating Risk

An experienced O&M contractor required to carry out maintenance tasks (both preventative and unscheduled)

- Regular inspections
- Module cleaning
- Hot spot detection
- Repairs
- Data collection and reporting
- Site security
- Maintaining a stock of spares



Inefficiencies in the operation and management of the project may reduce the cash-flow

Mounting Structures

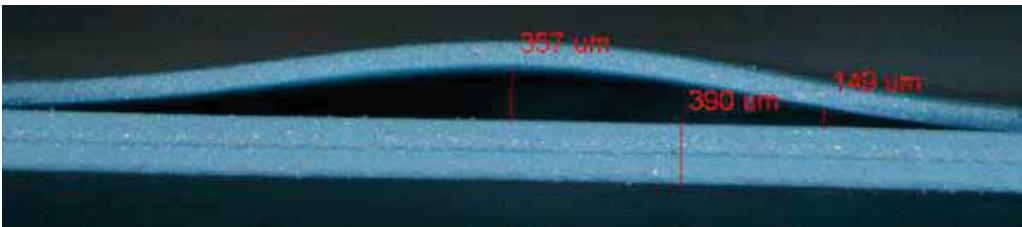
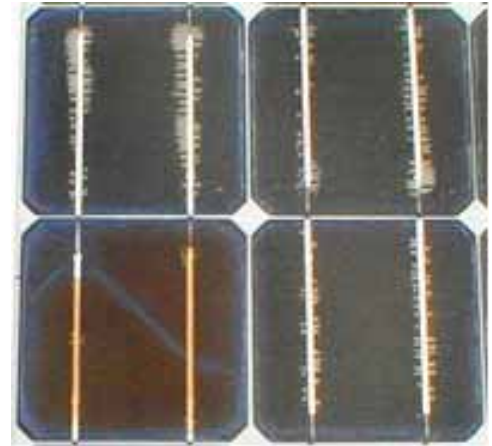
Expensive remedial work can be avoided by checking for:

- Erosion of foundations
- Tightness of bolts (torque wrench)
- Changes in geometry
- Signs of corrosion
- Defects in galvanisation



Modules

- Check for:
 - Delamination
 - Glass fracture
 - Moisture ingress
- Clean modules
- Tighten bolts
- Check cable connectors



Inverters

- Cleaning
 - Air intake
 - Heat sink
 - Fans
- Tighten cable connections
- Check for:
 - unusual noise
 - Discoloration
- Fuses
- Refurbish/replace
 - Mid term replacements?
 - Depends on site temperature factors
 - Mechanical ventilation? natural? aircon?



O&M contract

Operational risk mitigated by a robust O&M contract

- Clauses to mitigate plant underperformance
- Availability guarantee?
- Performance Ratio guarantee?
- Penalties for not achieving targets?
- Liquidated damages capped at 100% of contract price?
- Bonuses for exceeding targets?



Financial Risk

- Can the project generate sufficient revenue to cover annual debt payments and operating costs?
- To assess the financial risk carry out a “sensitivity analysis” i.e. modify financial model input parameters according to stress test scenarios



Financial Risk

- Stress test scenarios:
 - Annual module degradation 0.3% - 0.5% - 0.8%
 - O&M costs $\pm 10\%$
 - Inverter replacement- once over project life?
 - Module soiling losses: 2% , 3%, 4% (O&M dependent)
 - Unavailability: 99%, 98% and 97% (dependent on grid strength)
- Reduce the likelihood or impact of the risk
 - Module cleaning linked to performance monitoring
 - Include a maintenance reserve account
- Yield is often skewed to the summer months
 - Include additional financial reserves to ease financial strain

Sapphire Industrial Infrastructures 5 MW PV Project, Tamil Nadu, India

- Energy yield prediction
 - Only one resource database considered
 - Uncertainty and confidence in prediction not considered (P90)
- Operation and Maintenance
 - Site found to suffer from extreme soiling - cleaned continuously
 - String level performance monitoring not undertaken



Key Messages

Resource risk:

Uncertainty in energy yield prediction is dominated by resource uncertainty

Use several resource datasets

Understand the uncertainty and probability of exceedance in energy yield prediction (P90)

Operating risk

Use experienced O&M contractors

Have a well defined O&M contract with performance targets

Financial risk

Carry out appropriate stress tests

Reduce the likelihood or impact of stress scenarios

SgurrEnergy

- **Leading independent engineering consultancy**

- **International**

- Glasgow (UK Head Office)
- Portland , Maine (America)
- Paris (France)
- Beijing (China)
- Pune (India)
- Wexford (Ireland)
- Vancouver (Canada)

- **Experienced**

- Over 100 responsive engineers and consultants

- **Professional**

- Triple accreditation to British quality standards



FS 85385



EMS 85386



OHS 538996

Leading position by experience

We have consulted on over 65,000 MW of renewable energy in over 30 countries covering both project development and due diligence

Europe

- Belgium
- Bulgaria
- Estonia
- France
- Germany
- Greece
- Ireland
- Italy
- Malta
- The Netherlands
- Poland
- Portugal
- Russia
- Romania
- Slovakia
- Spain
- Sweden
- UK

Asia

- China
- India
- Korea
- Pakistan
- Sri Lanka
- The Philippines
- Turkey
- Vietnam

North America

- Canada
- USA

South America

- Brazil
- Chile
- Galapagos Islands (Ecuador)

Africa

- Angola
- Kenya
- South Africa

Oceania

- Australia
- New Zealand



Any questions?

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IFC Advisory engagement in India to support new markets and business models in Solar energy

Ongoing Activities

Projects	Focus
Sivaganga Project- 5MW Solar Project: <i>Project operational (Advisory Services and Concessional Financing)</i>	Trial of Thin Film technology under Indian conditions, Power performance validation, Resource Validation, Replication in Market
Green Telecoms - India: <i>Expansion of new and existing business models for 'greening telecom towers' and 'community power'</i>	Regulation, Technology development, Business model development Replication in Market
Solar Manufacturing Project : <i>Support to current Investment Climate efforts in Rajasthan (3GW+)</i>	Business model, Economic model, Manufacturing , Technology
Solar Rooftop - Gujarat: <i>PPP transaction being supported</i>	Business model, Commercial model, Standards/guidelines, PPP Transaction, Replication in Market

Activities under development

Projects	Focus
<i>Concentrated Photo Voltaics</i>	<i>Facilitate pilot trials to validate financial and technical feasibility of business models <u>Status</u> - Help create business model for Solar CPV to have the technology adopted in India</i>
<i>Lighting Asia</i>	<i>Expand the usage of Solar Lanterns and the concept of micro grids through supporting business models and industry standards <u>Status</u> - Evaluating the market and the business models</i>
<i>Rooftop Solar expansion</i>	<i>Scale-up PPP business model Expansion into creating business models for private home owners to own and operate rooftop solar projects <u>Status</u> - Evaluating the different potential PPP transactions</i>

Case Study - Thin Film 5 MW Solar Plant in India

• Client Need

- ✓ Financing support and advisory services for the largest grid connected solar thin film plant in India (at the time of completion). Supported replication of similar projects in the Indian market following construction of the power plant in Tamil Nadu, India, and managed QA for project management.

• Support provided

- ✓ Advisory support on project management, ESS and quality management and documented lessons learnt for dissemination
- ✓ Funds provided under IFC /GEF PVMTI program to support PV in India - IFC \$4 million loan to Sapphire Industrial Infrastructures Limited, to support the build, completion, operation and connection of the plant to the Tamil Nadu grid; loan converted into a grant at the completion and grid interconnection of the plant

• Status/Expected Impact

- ✓ The project is the first large scale, thin film solar plant of its kind in India
- ✓ Help scale development of the solar power sector and the thin film technology on a utility scale in India
- ✓ Lessons learnt and knowledge shared from this project to support the sector as a whole

