

## **EPIA 2<sup>nd</sup> International Workshop on Solar PV Investments**

### **Contractual Structures for the Financing of Solar PV**

---

Fabrizio Donini Ferretti  
Dexia Crédit Local

Frankfurt, 19-20 February 2007

## Summary



- 1. Key risks**
- 2. Market practices**
- 3. In search of « good practice »**

# I - Key risks

## 1 – The issue

**PV is unforgiving :  
initial mistakes or poor  
quality cannot be  
mended...**

- From a risk perspective, PV is a specific generation asset :
  - Fuel cost is zero, and more than 80% of the components (except inverters, transformers, and tracking systems) cannot be repaired if they fail, but only replaced;
  - Debt tenors are very long (> 18 years) and coverage ratios low (in Spain,  $x1.20 < DSCR < x1.30$ ), which leaves little room to recover from poor performance;
  - Therefore, any system failure or under performance (other than electronics) will damage ROE and potentially cause a payment default on indebtedness which cannot be reversed ;
  - As a result, it is imperative to be highly confident from the outset that the plant performance will be in line with expectations
- Risk is fairly complex to assess :
  - The capacity of the transformers, the choice of inverters, the number of strings and the type of modules are related to each other. Any change of one of these elements will strongly impact the overall performance of the plant
  - Performance ratio of a plant is rather stable: if the performance ratio is low at commissioning it will remain at this level for the next 20 years or so

# I - Key risks

## 2 – Evaluating the Performance Ratio

**Performance ratio is difficult to predict with accuracy**

- It is difficult to accurately predict the performance ratio at reception. Losses may occur in each segment of the system. Detailed understanding of PV and electrical engineering is required to invest.
- Uncertainties are many :
  - For irradiance, difference between sources can be as high as 10%
  - Assessment of temperature, depending on methodology,
  - The exact installed capacity is often poorly known. Capacity is certified by suppliers through flash tests. Depending on test methods, differences of up to 10% can be observed (degraded reference module, issue with light prism adjustment).
  - Electrical design which did not take into account shading may impact both performance (up to 30% of the output of one string) and module production life span.
- For financing a PR guarantee should be in the range of +/- 3%, whilst a range of +/- 8% is quite plausible from a scientific perspective, when including measurement uncertainties.

**The understanding of modules outdoor performance is no yet fully satisfactory**

## I - Key risks

### 3 – A focus on module performance

- Precise data for module outdoor performance, degradation and optimal electrical design under site conditions are not well known.
- The suppliers' performance guarantees are of only partial help to lenders: apart from suppliers long term credit risk, banks may face difficulties to evaluate a project's maximum probable loss.
  - For a same module, annual degradation can be estimated between 0.3% and 0.5%,
  - If modules are all of low quality – despite certification - (weak junction box, bad encapsulation...), and if spare parts only cover normal degradation (1 module to be changed out of every 4000), a performance guarantee will hardly mitigate the full underlying financial risks.
  - It is not yet fully clear whether several small inverters or few big ones is the most efficient design over the long term.
  - A-Si, CIS, CdTe...: there is little reliable experience regarding degradation (between 0.5% and 1% for the same technology depending on the source), durability and overall performance.
- For all the above reasons, banks are uncomfortable with “small” or inexperienced contractors.

# I – Key Risks

## 4 – Modules failures

- Modules failures are particularly worrying because there is no repair, which means a loss of capital:
  - From a 2005 study it was observed that the module failures with the highest percentages were corrosion and cell/interconnect break;
  - Many failures are related to process control and workmanship;
  - Some failures may result from the way modules are mounted and connected (poor system design).
- Qualification tests are used to qualify modules for purchase, such as IEC 61215 for c-Si and 61646 for thin films. These tests have limitations, for instance with respect to failures which appear after longer term exposure outdoors, failures caused by combinations of stresses, failures which occur with new technologies for which field data does not exist;
- Reliability tests (damp heat testing, thermal cycle testing...) which cause degradation so as to learn from failure need to be expanded. They will improve modules reliability.

# I – Key Risks

## 5 – Output degradation

- Output power reduction over the years varies according to the studies and modules manufacturers. A study performed in Japan at the Japan Quality Assurance Organisation observes a 5.2% reduction rate over 10 years and concludes that this percentage is an improved value but « still not sufficient to achieve 30 year module lifetime »;
- Degradation and its causes vary considerably according to manufacturers as can be observed by comparing modules from 2 manufacturers in the same test :

# I - Key risks

## 6 - Construction risks

**Construction risks: an aggregate of factors that can drastically lower the performance at reception**

- Construction risks are lower comparing to other technologies : civil works, grid connection and module installation are relatively simple.
- Construction risks stem from the plant engineering, the adequacy of equipment with the site, the interface between all parties involved.
- This apparent simplicity has attracted to the business developers, system integrators, lenders, etc. which do not master the full range of required skills or expertise. Modules quality has sometimes been low, due to scarcity. We anticipate some degree of disappointment in the medium term which may harm the industry if it occurs too soon.
- BIPV is a complex market with an additional set of risks:
  - Legal uncertainties;
  - Selection of relevant technology (issues of a-Si...)
  - Interface with the building and leakage / structural issues;
  - Building integrity / availability until final maturity of the debt: acceptable “hosts” should be identified;
  - Complex insurance issues (plant / building insurance);
  - Unexpected shading : no control over urban development
  - Complexity of financing many small size installations; proper monitoring (including visual checks) may be too costly, risk of robbery, decommissioning costs... Rely on stochastic risk ?

# I - Key risks

## 7 – Three adverse scenarios

### Scenarios assumptions:

**Location : France**

**Poly-Si**

**Ground based system**

**Capacity : 10MWp**

**Radiation : 1800kWh/m<sup>2</sup>/y**

**PR : 0,78**

**Debt according to market standards**

**System price : 3.9EUR/Wp**

**FIT : 30 EURc/kWh**

- Based on typical project assumptions, we have evaluated three adverse scenarios in order to estimate the impact on Lenders and Investors ratios:
  - (i) Delay in module supply
  - (ii) “rebuilding” of the plant – the plant design is inadequate
  - (iii) Poor performance ratio and uncertainties on measurements (capacity installed and radiation)
  
- Scenarios (i) and (ii) only impact project economics if there are several construction contracts (there is no full EPC contract). They correspond to the materialization of interface risks.

# I - Key risks

## 8 – Impact on Shareholders' IRR

### Scenarios assumptions:

Location : France

Poly-Si

Ground based system

Capacity : 10MWp

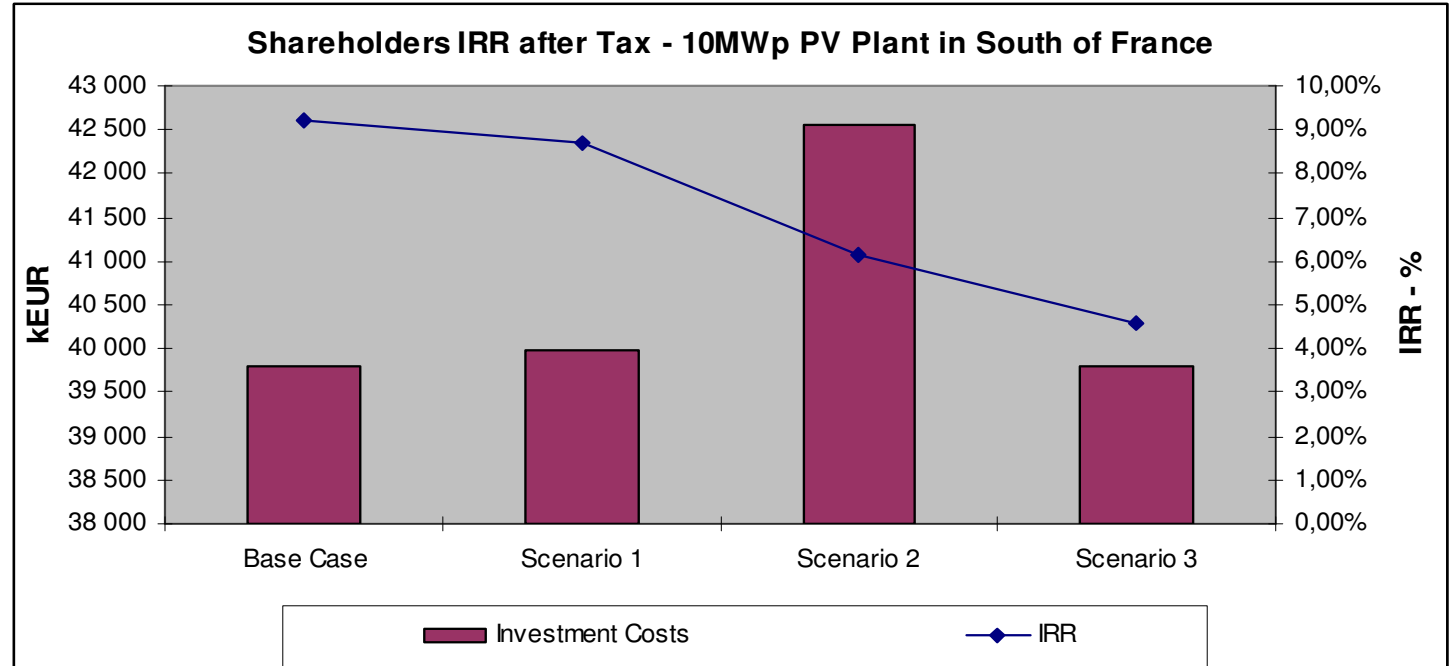
Radiation : 1800kWh/m<sup>2</sup>/y

PR : 0,78

Debt according to market standards

System price : 3.9EUR/Wp

FIT : 30 EURc/kWh



- **Scenario 1** : 2 months delay in module supply
- **Scenario 2** : Poor design / construction leads to an increase of the BoP costs of 32% and 2 months construction delay
- **Scenario 3** : Over-estimation of the PR of 7% (3% accounting for technical loss, 2% for radiation projection estimate, 2% for an error in the estimated initial capacity)

# I - Key risks

## 9 – Equity requirement

### Scenarios assumptions:

Location : France

Poly-Si

Ground based system

Capacity : 10MWp

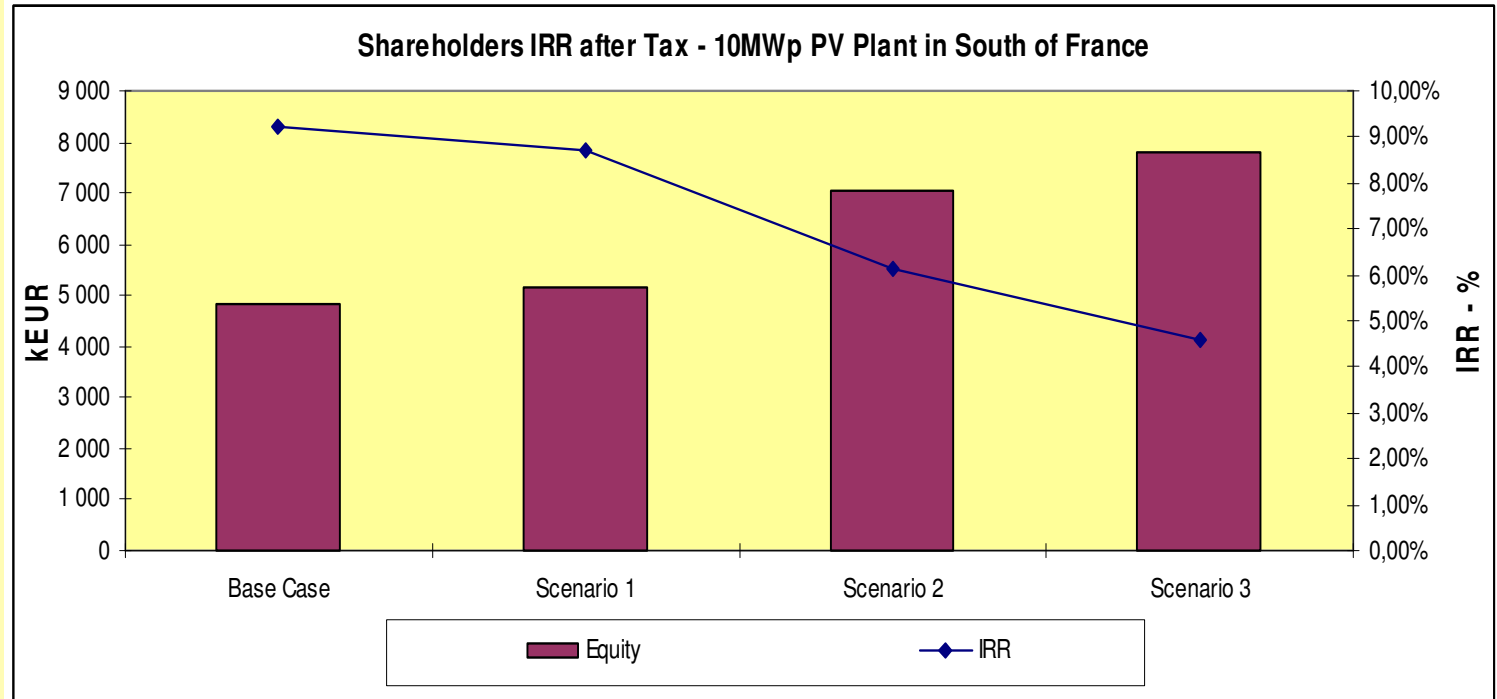
Radiation : 1800kWh/m<sup>2</sup>/y

PR : 0,78

Debt according to market standards

System price : 3.9EUR/Wp

FIT : 30 EURc/kWh



- Scenario 1 : 2 months delay in module supply (IRR – 50bp)
- Scenario 2 : Poor design / construction leads to an increase of the BoP costs of 32% and 2 months construction delay (IRR – 300bp)
- Scenario 3 : Over-estimation of the PR of 7% (3% accounting for technical loss, 2% for radiation projection estimate, 2% for an error in the estimated initial capacity (IRR – 460bp)

# I - Key risks

## 10 - Impact of key operating risks (1/2)

### Scenarios assumptions:

Location : France

Poly-Si

Ground based system

Capacity : 10MWp

Radiation : 1800kWh/m<sup>2</sup>/y

PR : 0,78

Debt according to market standards

System price : 3.9EUR/Wp

FIT : 30 EURc/kWh

- Based on typical project assumptions, we have assumed three adverse scenarios in order to estimate the impact on Lenders and Investors of:
  - (i) Low overall performance of the system
  - (ii) Increase in insurance and security costs
  - (iii) Grid availability is poor / inverters are badly dimensioned / availability of the plant is low
- A lower than expected system performance may be due to a change in shading (BiPV...), a wrong estimate of solar radiation, or a lower performance of the inverter due to a poor quality of the design of the plant
- Robbery may be a critical issue. In case an indemnity is paid out, there is uncertainty about premium, or even to insurance availability. Insurance companies may ask for a redesign of the security system, leading to an increase of both operating and investment costs.
- Grid availability, curtailment, and lower performance of the inverters (especially the MPPT) can lower the global performance of the plant.

# I - Key risks

## 10 - Impact of key operating risks (2/2)

### Scenarios assumptions:

Location : France

Poly-Si

Ground based system

Capacity : 10MWp

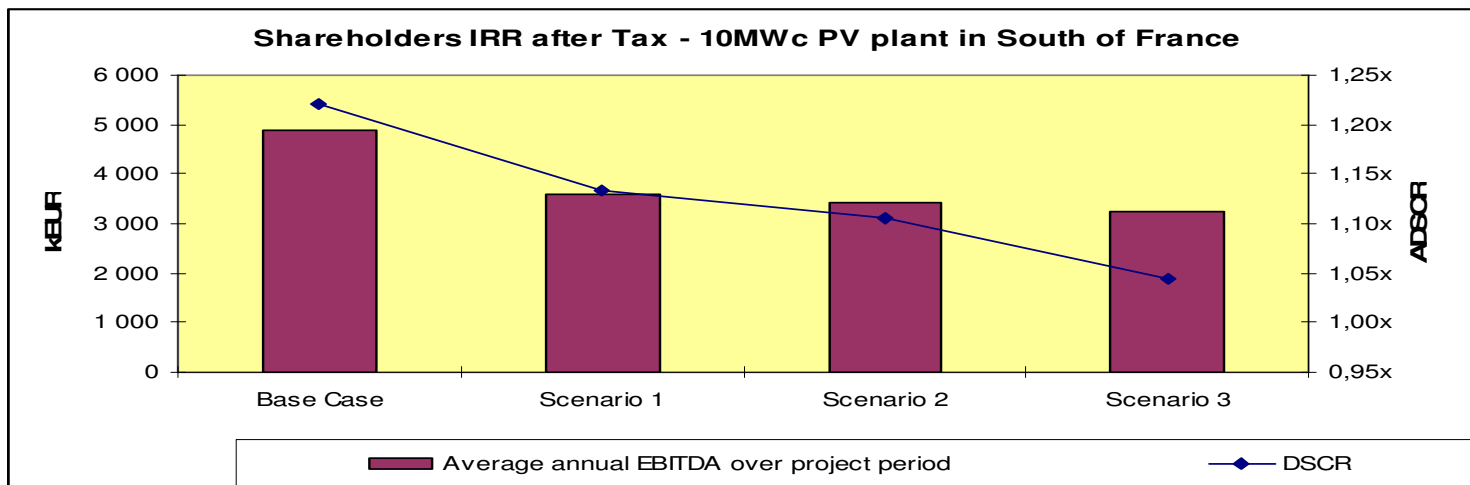
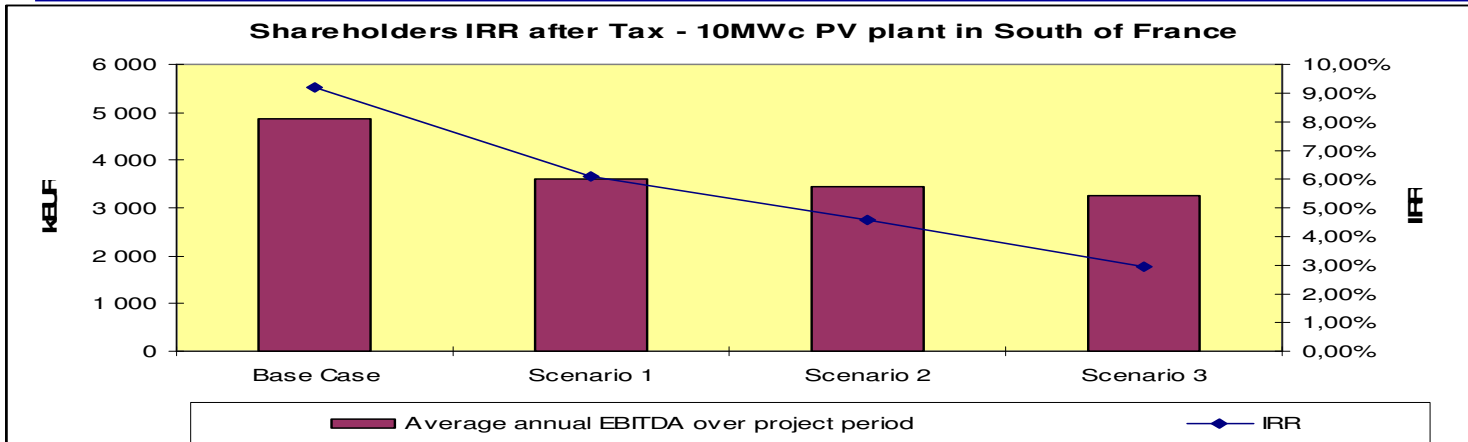
Radiation : 1800kWh/m2/y

PR : 0,78

Debt according to market standards

System price : 3.9EUR/Wp

FIT : 30 EURc/kWh



- Scenario 1 : 10% reduction of PR after ten years (IRR – 300bp)
- Scenario 2 : Insurance premiums & security costs increase by 50%
- Scenario 3 : PR reduced by 5%, availability 90% (98% Base Case).

## II - Case Studies

### Some terms in Spanish EPC Contracts

- Delay L/Ds are payable if the project does not reach COD prior to a date certain. L/Ds typically 0.5%/week, capped to 10% of contract price;
- Tests by contractor and grid connection, followed by power and performance test (120 hours), punch list, and Provisional Acceptance Certificate. PAC tests include a PR, an annual degradation %, a maximum power ( $P_{max}$ ) as measured by an independent institute. If  $P_{max}$  not reached, contractor to replace equipment at own cost to reach it.
- Guarantee of modules by EPC contractor in same terms as modules are guaranteed by manufacturers.
- If the provisional acceptance tests are not met, and after a cure period, the owner may contract with another party at the expense of the contractor. 10 to 25% of contract price paid upon PAC.
- At the end of the warranty period (usually 24 months), and of final acceptance tests, Final Acceptance if guaranteed performance criteria are met. Includes a minimum PR. If not met, contractor to reinstate debt coverage ratios.
- Maximum L/Ds : 15% usually, in some cases 35% until delivery to the grid, 20% until final acceptance certificate, 15% until end of warranty period if longer.

## III – In search of « good practice »

### 1 - Introduction

---

- **Most of the risks need to be avoided upfront, via 3 main « mitigants » :**
  - **Tests and certifications required from the developer prior to any equipment having been delivered on site, or upon delivery, in order to ensure that design, equipment quality and delivered power are satisfactory;**
  - **Tests and penalties to be applied after substantial completion in order to ensure that power and performance are satisfactory, or to mitigate shortcomings;**
  - **definition of measurement equipment and methodologies which ensure that tests are meaningful, and monitoring is optimal.**
- **Most of these mitigants will depend on the drafting of the construction agreements, the terms of reference of the technical advisor, and choice of the EPC contractor or system integrator.**
- **Single EPC contract is preferred, multi contracting possible with adequate coordination**

### III – In search of « good practice »

#### 2 – Prior to / upon site delivery

- **Equipment / modules need to be certified**
- **Quality assurance process of the module manufacturer to be transparent, audited on a regular basis, communicated to the lenders Technical Adviser (TA)**
- **Flash tests at the factory should be made with properly calibrated equipment. Ideally to be performed by, or with equipment belonging to, or supervised by, an independent laboratory**
- **Contractor to carry out acceptance tests of plant components at its own costs and according to a procedure referred to in EPC contract. Lenders TA may witness tests**
- **Installed capacity must be at a minimum that which was ordered to the contractor. Procedure to be define as an annex to the EPC contract. Tests to be performed by an independent laboratory flashing a sample of modules. If it did so at the plant, this is deemed to be sufficient. Lenders bear the risk of the laboratory's measurement uncertainty**
- **Sample destructive tests to be carried out for some technologies (mono-cristalline...) to detect impurities which could affect long term performance**

### III – In search of « good practice »

#### 4 – Completion guarantee (1/2)

##### Existence of an EPC Contract

##### Completion Guarantee (1) :

- The project should reach Commercial Operation prior to the Guaranteed Operation Date defined in the construction contract. After Commercial Operation Date, a 3 to 4 weeks testing period starts (Provisional Acceptance Tests) to reach provisional acceptance
- If the Provisional Acceptance is not reached by the Guaranteed Operation Date : the contractor starts paying delay penalties to the owner which cover operating expenses and debt service.

## Existence of an EPC Contract

### III – In search of « good practice »

#### 5 – Completion guarantee (2/2)

##### Completion Guarantee (2) :

- If the project does not reach Provisional Acceptance prior to a Long Stop Date (say, 6 months after Guaranteed Operation Date), the owner has a rejection right : the contractor reimburses all amounts paid by the owner, plus any amount required to reinstate the site to its previous condition. The contract may determine that the owner and the contractor settle for a price defined by an independent expert, provided that (i) the TA approves and (ii) the contract price difference is used to repay the debt at least pro rata.
- After a period of at least 1 , preferably 2 years of operation after Provisional Acceptance (depending on TA advice/ technology), the project should satisfy Final Acceptance tests.
- If the Project fails to reach Final Acceptance, which implies achieving a minimum performance ratio, the contractor restores Base Case financial ratios on the basis of the observed PR and Base Case degradation or observed degradation if higher.

## Existence of an EPC Contract

### III – In search of « good practice »

#### 6 – Production Guarantee

##### Minimum Production Guarantee :

- At Financial Close, the owner and the contractor agreed on a Target Performance Ratio upon which the Base Case is built.
- In order to satisfy the Provisional Acceptance Tests, the Plant will have reach the Target Performance Ratio [+/- 3%]
- If minimum PR not met, the contractor is given a cure period.
- At Final Completion, the Plant will have reached the Target Performance Ratio

**NB : for BiPV, PR uncertainties may be greater. Higher debt coverage ratios, acceptance involving building controllers, additional certifications for building materials / fixtures. For a-Si, scheduling of tests and performance range different, due to steeper initial degradation and wider range of uncertainty**

### III – In search of « good practice »

#### 7 – Multi - contracting

- Many contract structures are possible; most common is separate modules supply contract / BoS;
- Multi-contracting without a « wrap » puts more pressure on quality issues and role of TA;
- Simple solution is a full completion guarantee by owner, if he is creditworthy;
- If owner in charge of modules delivery, same tests / quality control as above + owner liability for delays in site delivery. Should be a modules delivery milestone triggering L/Ds;
- Module supply contract to include stringent tests on modules because there is no source to compensate for low performance;
- Comfort with long term inverter maintenance contract essential
- Careful crafting of dispute resolution clause to minimise interface issues;
- Debt coverage ratios should be slightly higher because there is no source to rebalance the Base Case;

8 – Monitoring Issues

Modules failures

Types of Failures	% of Total Failures
Corrosion	45.3
Cell or Interconnect Break	40.7
Output Lead Problem	3.9
Junction Box Problem	3.6
Delamination	3.4
Overheated wires, diodes or terminal strip	1.5
Mechanical Damage	1.4
Defective Bypass Diodes	0.2

System outages

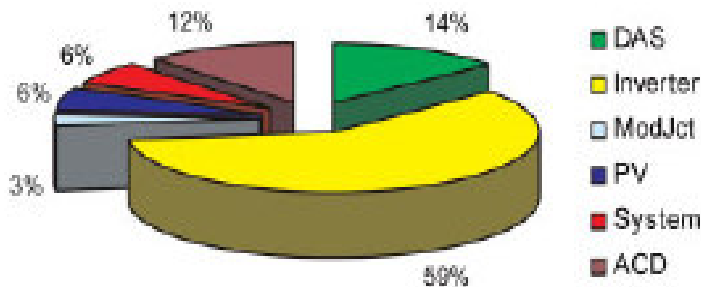


Figure 8. Unscheduled maintenance costs by category

- PV sites are usually unmanned; it is essential for lenders to have sufficient and relevant points of information, with near real-time performance available for TA to be able to check / monitor;
- Test equipment must be available; wind speed, wind direction, air temperature, solar insolation measurements should be monitored and recorded for accurate determination of PR;
- System performance as per a standard such as IEC 61724 which allows to compare performance with other systems and with expectations is required;
- Adequate spare parts accessible upon short notice;
- Vigilance arrangements key in many regions.

## Contacts



### Dexia Crédit Local

Structured Finance Department

Fabrizio Donini-Ferretti, Head of Energy

[Fabrizio.donini-ferretti@clf-dexia.com](mailto:Fabrizio.donini-ferretti@clf-dexia.com)

Tel : +33 1 58 58 70 89

Karim Megherbi,

Renewable energy project manager

[Karim.megherbi@clf-dexia.com](mailto:Karim.megherbi@clf-dexia.com)

Tel : +33 1 58 58 75 81