Solar Bankability

Energy Efficiency Finance Market Place, Brussels, 19 January 2017

Improving the Financeability and Attractiveness of Sustainable Energy Investments in Photovoltaics

David Moser, EURAC

Funded by the Horizon 2020
Framework Programme of the
European Union

www.solarbankability.eu

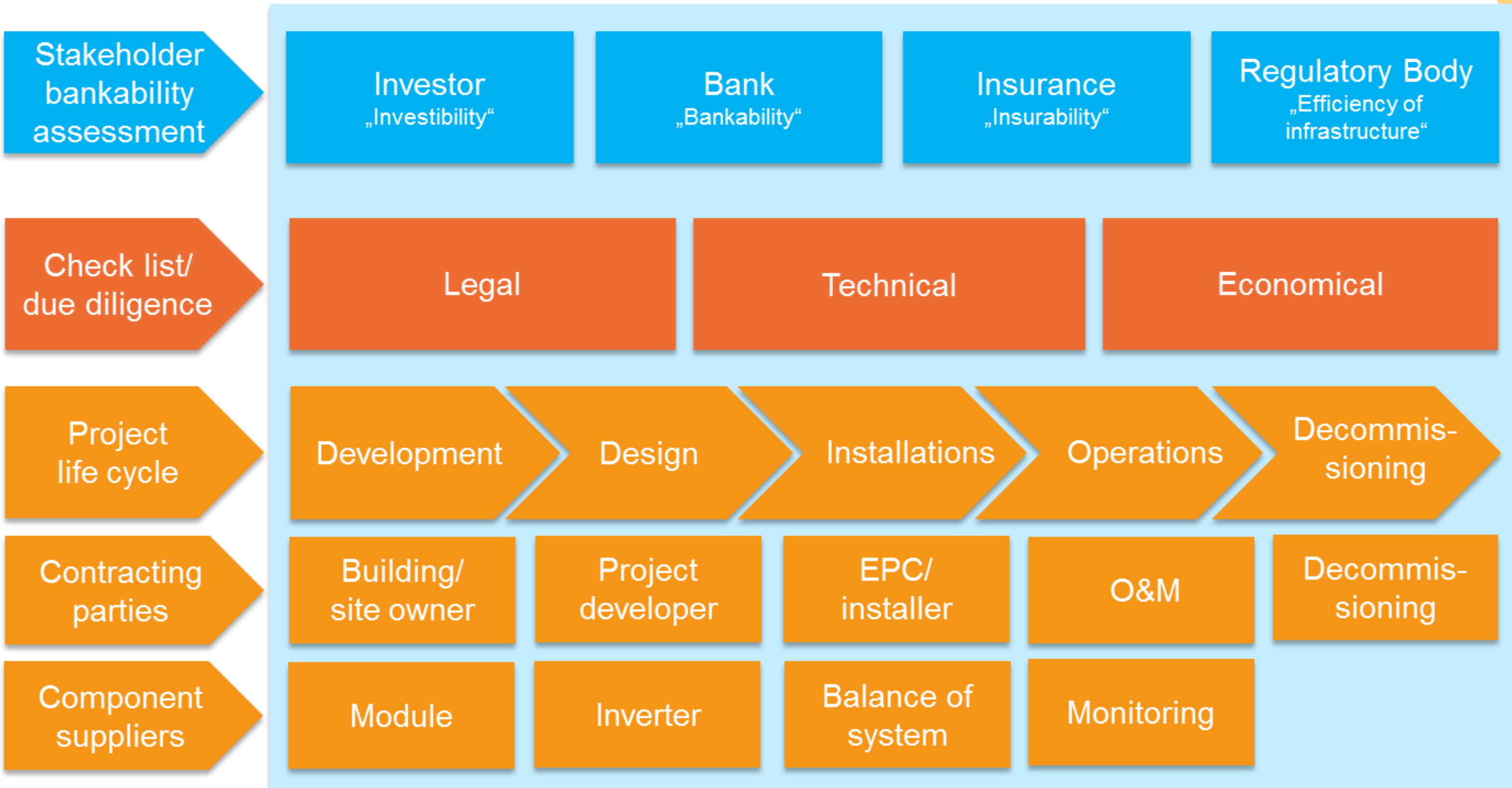
Project Overview

- European Union Horizon 2020 Work Programme
- 24 months (March 2015 – February 2017)
- 5 consortium partners:

Main Objective: Develop and establish a common practice for professional risk assessment which will serve to reduce the technical risks associated with investments in PV projects.

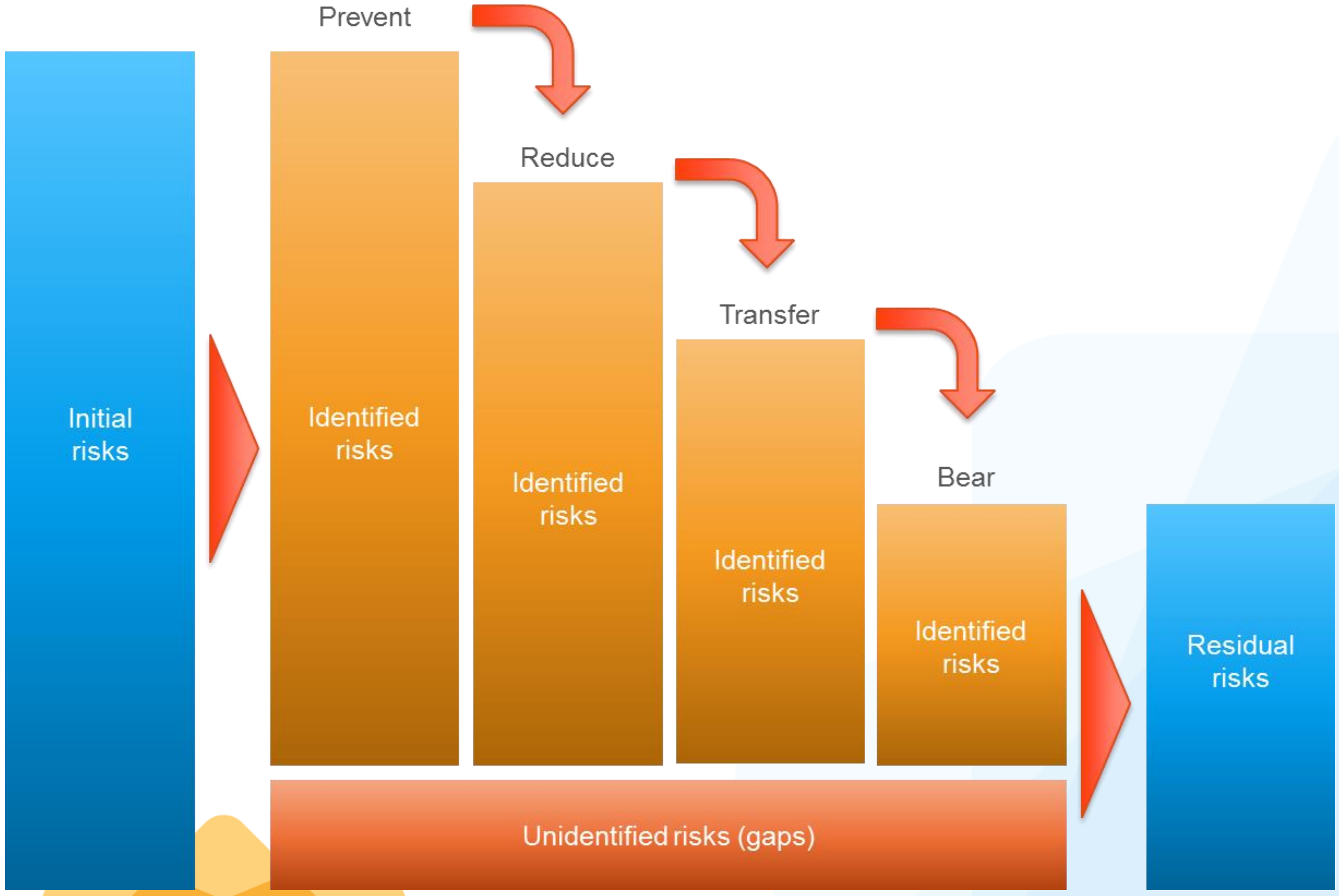
www.solarbankability.eu

Bankability in PV projects



Solar bankability is an active quality management process, where all stakeholders in the approval process of a PV project attempt to identify potential legal, technical and economical risks throughout the entire project life cycle. These risks need to be quantitatively and qualitatively assessed, managed and controlled. Despite a wide overlap in this quality management process, the focus and the assessment criteria will vary whether the stakeholder represents an investor, a bank, an insurance or a regulatory body.

Risk assessment



Gap analysis

20 Identified technical gaps in different project phases

Risk	Phase/field	Identified critical technical gaps
Year-0	Procurement/ product selection and testing	1. Insufficient EPC technical specifications to ensure that selected components are suitable for use in the specific PV plant environment of application. 2. Inadequate component testing to check for product manufacturing deviations. 3. Absence of adequate independent product delivery acceptance test and criteria.
	Planning/ lifetime energy yield estimation	4. The effect of long-term trends in the solar resource is not fully accounted for. 5. Exceedance probabilities (e.g. P90) are often calculated for risk assessment assuming a normal distribution for all elements contributing to the overall uncertainty. 6. Incorrect degradation rate and behavior over time assumed in the yield estimation. 7. Incorrect availability assumption to calculate the initial yield for project investment financial model (vs O&M plant availability guarantee).
	Transportation	8. Absence of standardized transportation and handling protocol.
	Installation/ construction	9. Inadequate quality procedures in component un-packaging and handling during construction by workers. 10. Missing intermediate construction monitoring.
	Installation/ provisional and final acceptance	11. Inadequate protocol or equipment for plant acceptance visual inspection. 12. Missing short-term performance (e.g. PR) check at provisional acceptance test, including proper correction for temperature and other losses. 13. Missing final performance check and guaranteed performance. 14. Incorrect or missing specification for collecting data for PR or availability evaluations: incorrect measurement sensor specification, incorrect irradiance threshold to define time window of PV operation for PR/availability calculation.
Risks during operation	Operation	15. Selected monitoring system is not capable of advanced fault detection and identification. 16. Inadequate or absence of devices for visual inspection to catch invisible defects/faults. 17. Missing guaranteed key performance indicators (PR, availability or energy yield). 18. Incorrect or missing specification for collecting data for PR or availability evaluations: incorrect measurement sensor specification, incorrect irradiance threshold to define time window of PV operation for PR/availability calculation.
	Maintenance	19. Missing or inadequate maintenance of the monitoring system. 20. Module cleaning missing or frequency too low.

Impact on quality of installation

SOLAR BANKABILITY

Impact on cash flow model

Impact on quality of installation

Impact on risk/cost ownership

Impact on risk/cost ownership and on O&M stratgy

Technical risk framework

A	Risk identification
B	Risk assessment
C	Risk management
D	Risk controlling

www.solarbankability.eu

Technical Risks Matrix

	Product Development			Assessment of PV Plants	
	Product testing	Planning	Transportation / installation	O&M	Decommissioning
Modules	….	….	….	….	….
	• Insulation test • Incorrect cell soldering • Undersized bypass diode • Junction box adhesion • Delamination at the edges • Arcing spots on the module • Visually detectable hot spots • Incorrect power rating (flash test issue) • Uncertified components or production line	• Soiling • Shadow diagram • Modules mismatch • Modules not certified • Flash report not available or incorrect • Special climatic conditions not considered (salt corrosion, ammonia, …) • Incorrect assumptions of module degradation, light induced degradation unclear • Module quality unclear (lamination, soldering) • Simulation parameters (low irradiance, temperature….) unclear, missing PAN files	• Module mishandling (glass breakage) • Module mishandling (cell breakage) • Module mishandling (defective backsheet) • Incorrect connection of modules • Bad wiring without fasteners	• Hotspot • Delamination • Glass breakage • Soiling • Shading • Snail tracks • Cell cracks • PID • Failure bypass diode and junction box • Corrosion in the junction box • Theft of modules • Module degradation • Slow reaction time for warranty claims, vague or inappropriate definition of procedure for warranty claims • Spare modules no longer available, costly string reconfiguration	• Undefined product recycling procedure

Technical risk framework

A	Risk identification
B	Risk assessment
C	Risk management
D	Risk controlling

www.solarbankability.eu

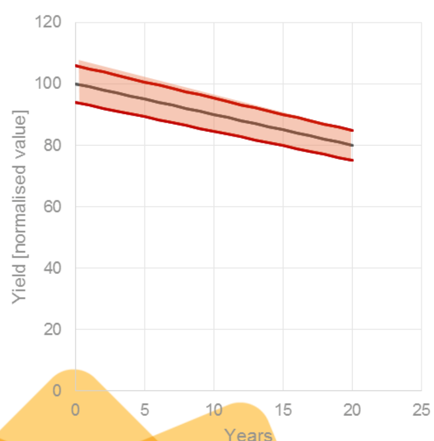
Quantification of the economic impact of technical risks

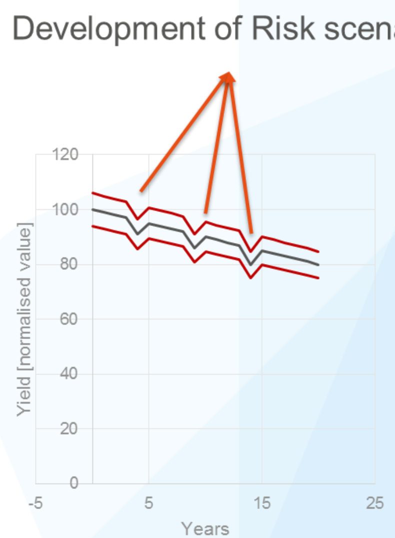
Planning

- **Risks to which we can assign an uncertainty (e.g. irradiance)**
→ Impact on financial exceedance probability parameters

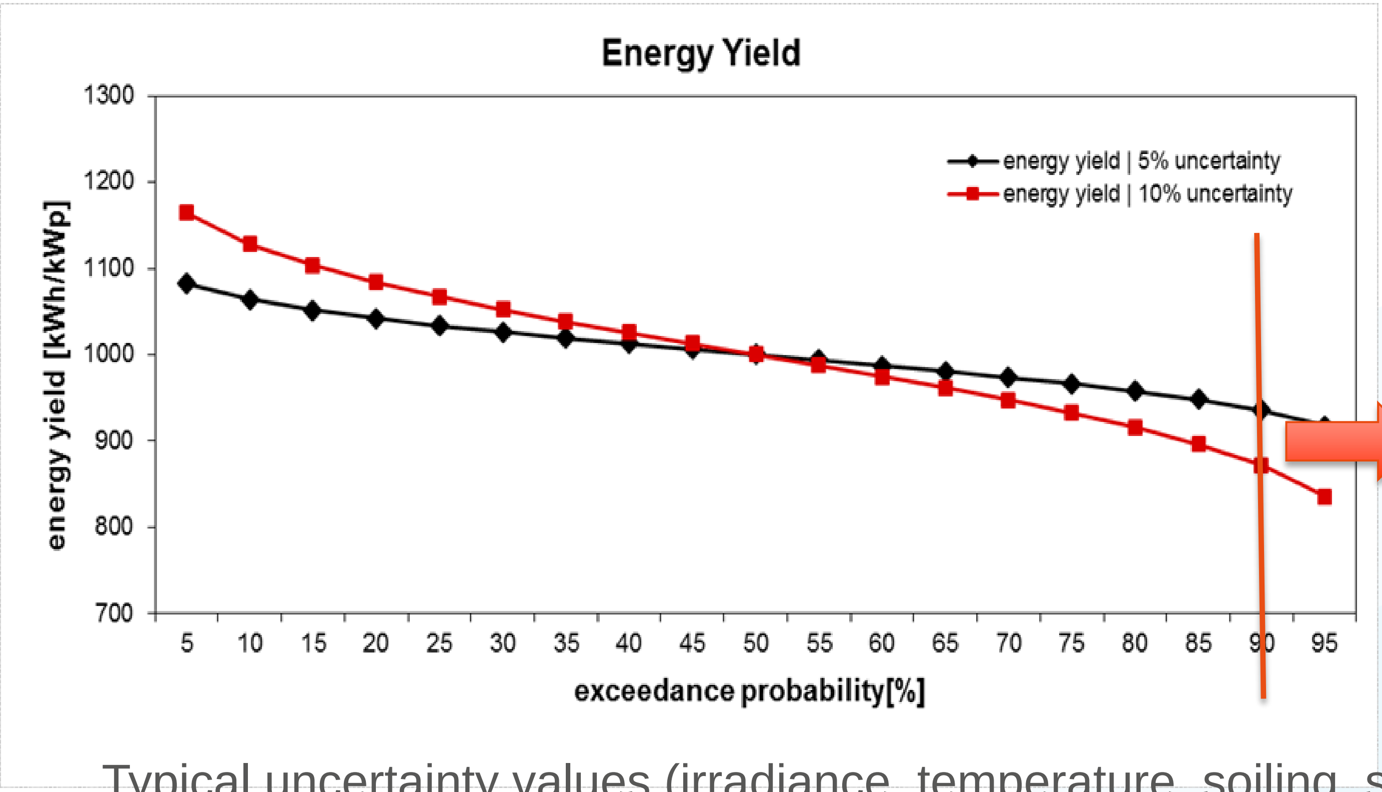
O&M

- **Risks to which we can assign a Cost Priority Number CPN (e.g. module and inverter failure) given in Euros/kWp/year**
→ Impact on cash flow





Quantification of the economic impact of technical risks



Utilisation rate @P90 positively affected by reduction in uncertainty

Link with business models and LCOE calculation

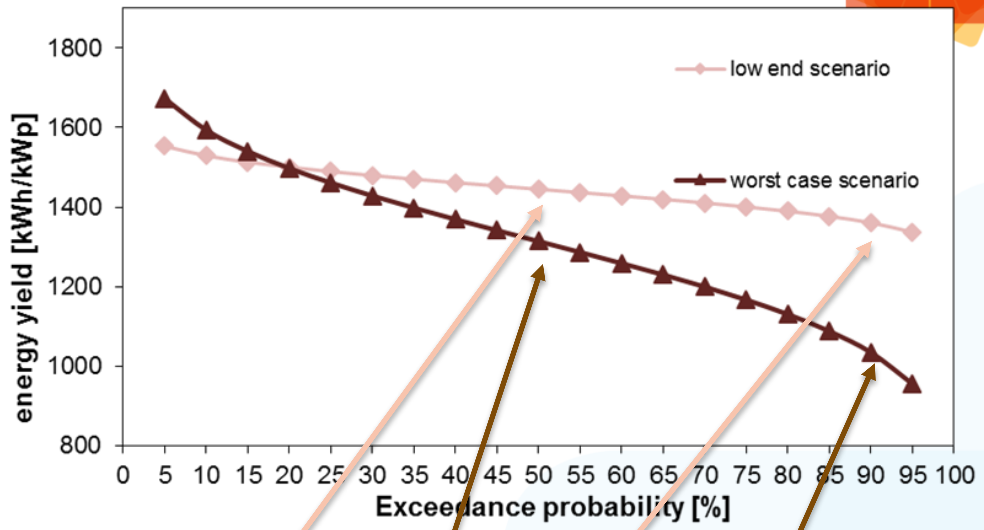
Typical uncertainty values (irradiance, temperature, soiling, shading, etc): 5-10%

Quantification of the economic impact of technical risks

Planning

Objectives:

- More precise estimation of uncertainty in yield estimation
- Reduction of uncertainty



	σ (k=1)	P50 (kWh/kWp)	P90 (kWh/kWp)	P90/P50 (P50 reference case)
Reference case (PVSYST, not all contributions included)	4.3%	1440	1360	94%
Ref. case (sum of squares)	**8.7%**	**1445**	**1283**	**89%**
Low end scenario	4.6%	1445	1365	94%
High end scenario	9.3%	1445	1273	88%
Worst case scenario	16.6%	1445	1138	79%
Worst case scenario (different mean value)	16.6%	1314	1034	72%

22% difference in terms of yield used in the business model

Procedure for the calculation of a Cost Priority Number (CPN)

a) Economic impact due to downtime and/or power loss (kWh to Euros)
- Failures might cause downtime or % in power loss
- Time is from failure to repair/substitution and should include: time to detection, response time, repair/substitution time
- Failures at component level might affect other components (e.g. module failure might bring down the whole string)

→ Income reduction
Savings reduction

+

b) Economic impact due to repair/substitution costs (Euros)
- Cost of detection (field inspection, indoor measurements, etc)
- Cost of transportation of component
- Cost of labour (linked to downtime)
- Cost of repair/substitution

→ Increase in maintenance costs
Reduction of reserves

Technical Risks collection

$CPN = C_{down} + C_{fix}$

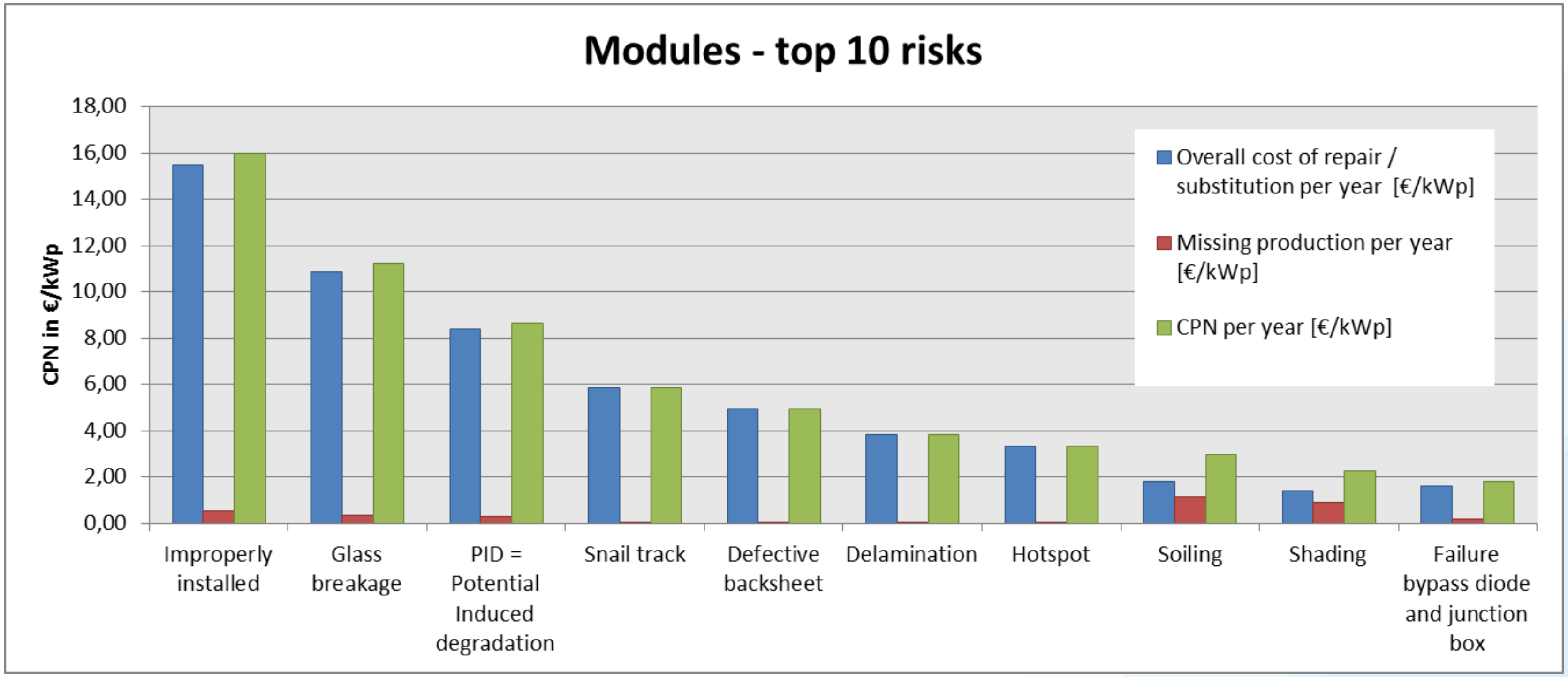
CPN is given in Euros/kW/year
It gives an indication of the economic impact of a failure due to downtime and investment cost

	Total number of plants	Total Power [kWp]	Average number of years
TOTAL	772	441676	2.7
Components	**No. tickets**	**No. Cases**	**No. Components**
Modules	473	678801	2058721
Inverters	476	2548	11967
Mounting structures	420	15809	43057
Connection & Distribution boxes	221	12343	20372
Cabling	614	367724	238546
Transformer station & MV/HV	53	220	558
Total	2257	1077445	2373222

- Tickets from O&M operators from preventive and corrective maintenance
- Visual and detailed PV plant inspections

CPN Results - Components and Market Segments

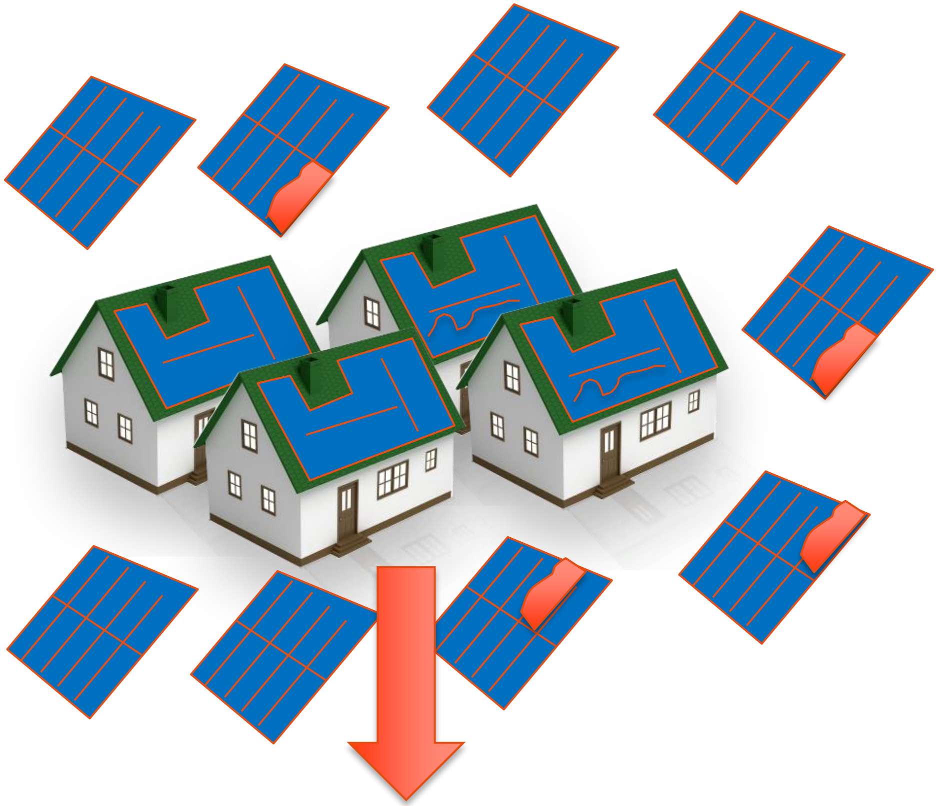
- PV modules - Utility scale



- Highest risk consists of a group of installation failures (mishandling, connection failures, missing fixation, etc.)
- Variety of failures detected by different techniques (VI, IR, EL, IV-Curves)

CPN results - Comparison studies

- Affected components vs total components: CPN ratio

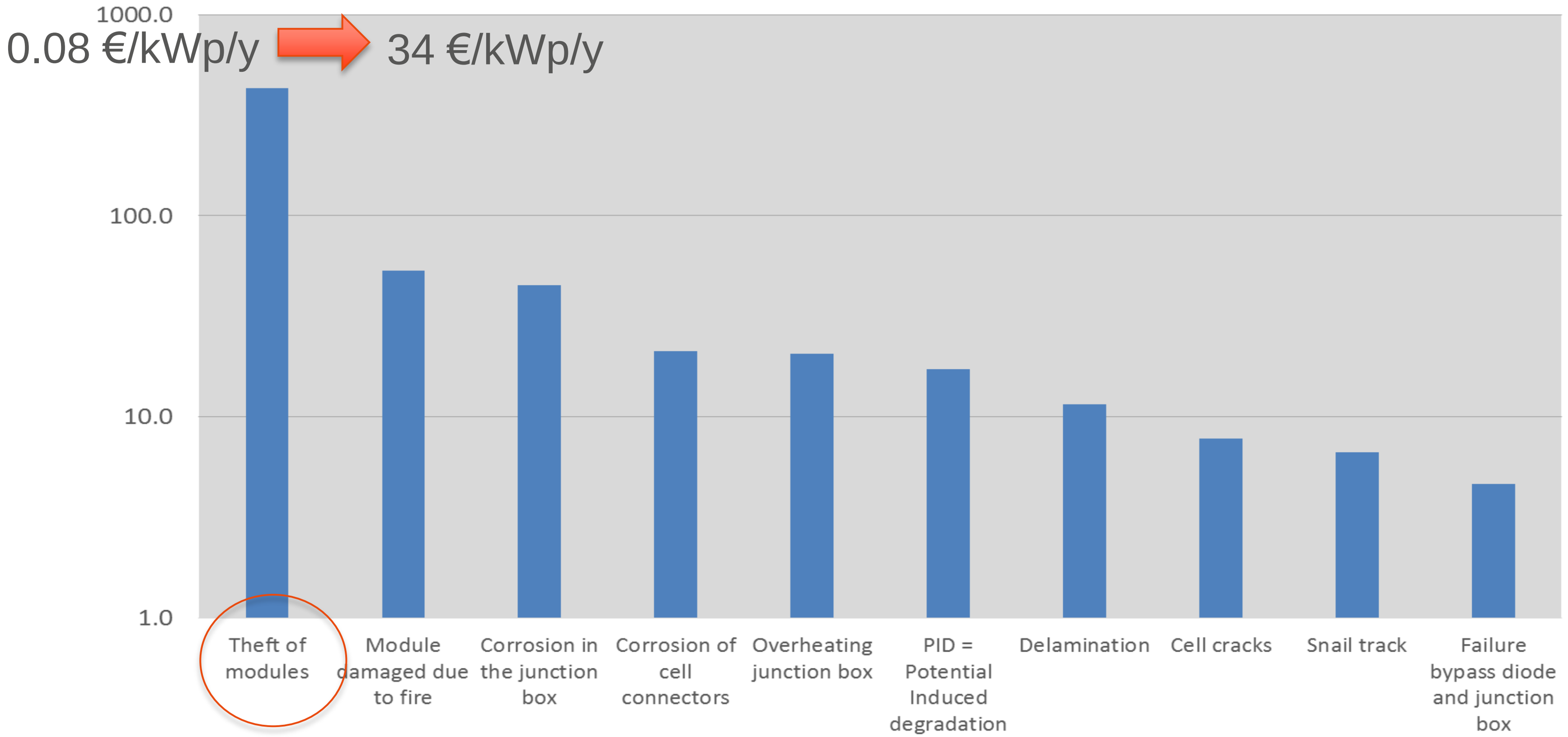


Failures calculated over the whole database

Failures calculated over the affected plants

CPN results - Comparison studies

- Some failures do not occur very often and are not equally spread over the portfolio but when they do, the economic impact is very high



- High CPN ratio for product failures or non technical factors (e.g. safety)

Technical risk framework

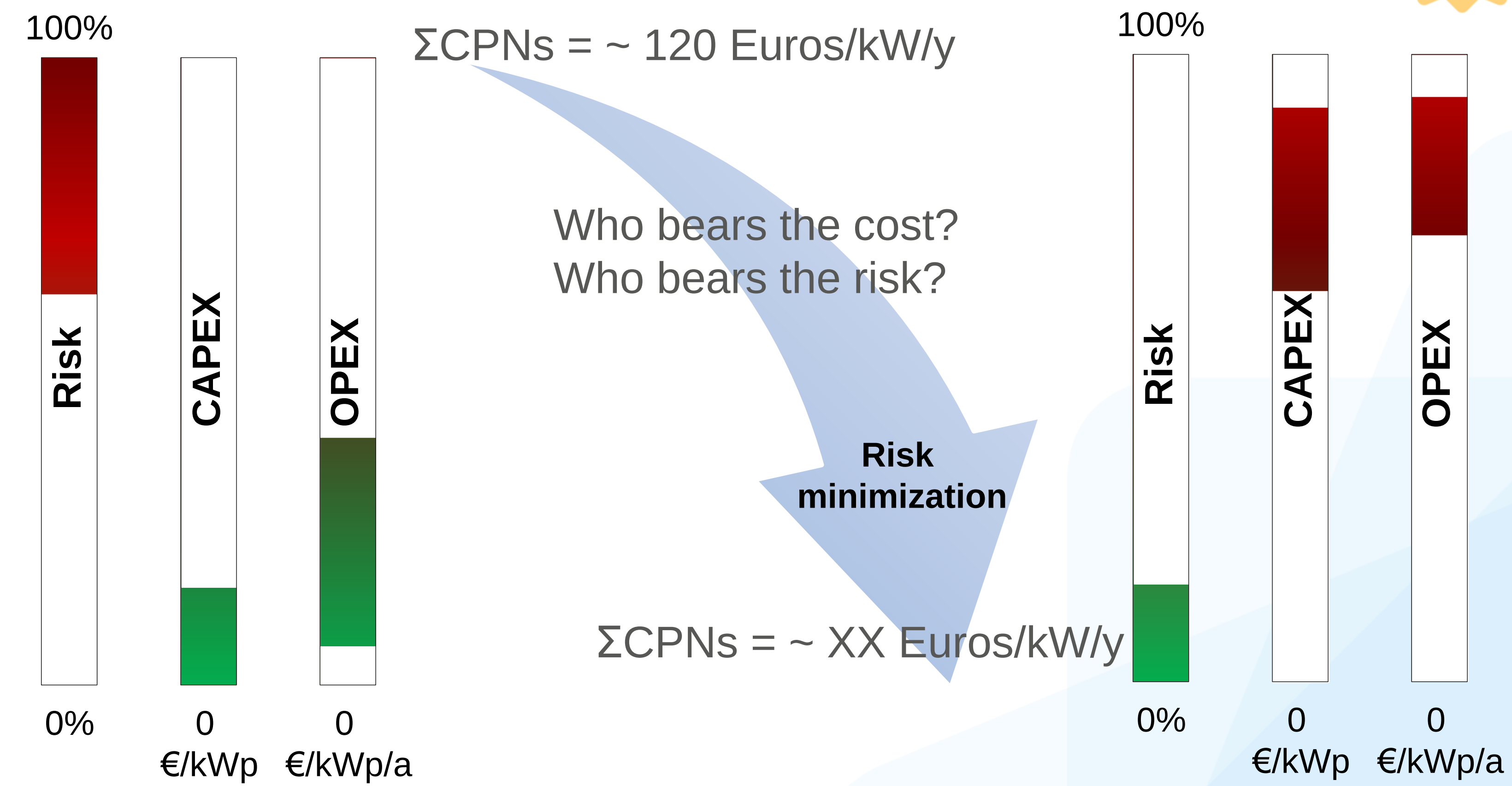
A	Risk identification
B	Risk assessment
C	Risk management
D	Risk controlling

Risk Mitigation

Risk Transfer

www.solarbankability.eu

Risk mitigation



CAPEX & OPEX depending on mitigation measures

CAPEX & OPEX depending on mitigation measures

Mitigation Measure Approach

List of 8 defined MMs, their mitigation factors and affected parameters

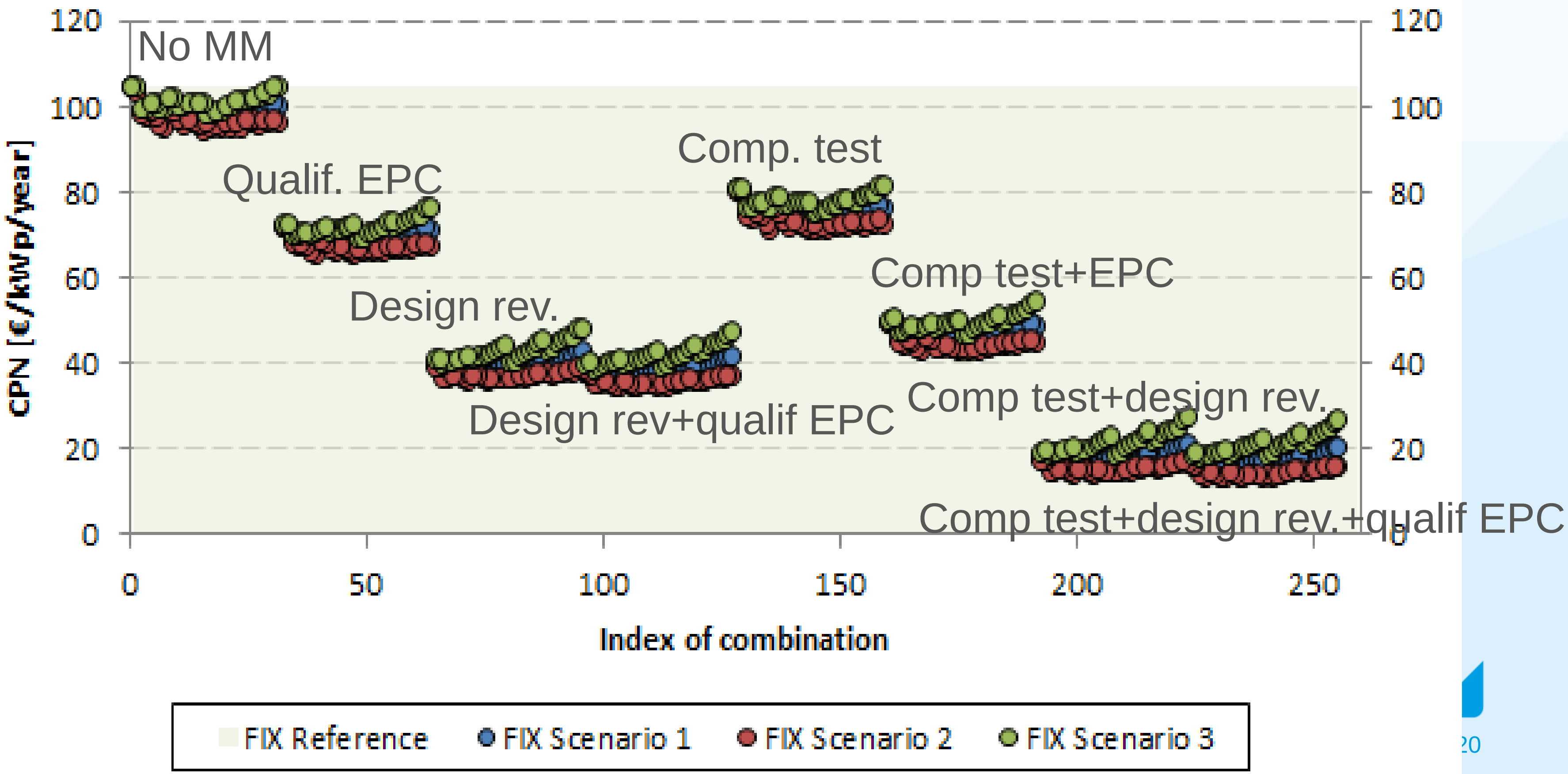
- **Preventive measures**
- **Corrective measures**

Component testing – PV modules	number of failures
Design review + construction monitoring	number of failures
Qualification of EPC	number of failures
Advanced monitoring system	time to detection
Basic monitoring system	time to detection
Advanced inspection	time to detection
Visual inspection	time to detection
Spare part management	time to repair/substitution

Impact of Applied Mitigation Measures

New CPN results of mitigation measure combinations for different cost scenarios compared to CPN without mitigation measures

Preventive measures have higher impact



Impact on LCOE

Germany Italy UK

Input parameter	Low scenario	Medium scenario	High scenario
CAPEX [€/kWp]			
Ground-mounted utility (≥ 1 MWp)	€ 900	€ 1000	€ 1200
Commercial rooftop (< 1 MWp)	€ 1000	€ 1200	€ 1400
Residential (up to 5 kWp) (VAT excluded)	€ 1300	€ 1400	€ 1600
OPEX [€/kWp/year]			
Ground-mounted utility (≥ 1 MWp)	€ 13	€ 15	€ 20
Commercial rooftop (< 1 MWp)	€ 10	€ 10	€ 18
Residential (up to 5 kWp) (VAT excluded)	€ 5	€ 5	€ 9
Performance Ratio 'PR' [%]			
Ground-mounted utility (≥ 1 MWp)	86%	84%	86%
Commercial rooftop (< 1 MWp)	84%	82%	84%
Residential (up to 5 kWp)	82%	80%	82%
Plane-of-array (POA) irradiation [kWh/m^2]	1331	1821	1168
Discount rate [%]	4%	8%	6.5%
Degradation rate [%]		0.5% linear	
Lifetime [years]		25 years	

Market segment	Low scenario	Medium scenario	High scenario
LCOE without any mitigation	*[€cents/kWh]*	*[€cents/kWh]*	*[€cents/kWh]*
Ground-mounted utility (≥ 1 MWp)	5.4 – 8.1	6.2 – 9.3	10.3 – 15.5
Commercial rooftop (< 1 MWp)	5.8 – 8.7	7.0 – 10.7	11.8 – 17.8
Residential (up to 5 kWp)	6.9 – 10.6	7.9 – 12.2	12.5 – 19.2

Impact of Applied Mitigation Measures on the cost of PV electricity

Market segment	Low scenario	Medium scenario	High scenario
% maximum LCOE reduction			
Ground-mounted utility (≥ 1 MWp)	3.6%	3.8%	4.2%
Commercial rooftop (< 1 MWp)	4.6%	4.8%	5.0%
Residential (up to 5 kWp)	4.8%	5.0%	5.1%
LCOE after best mitigation combination	*[€cents/kWh]*	*[€cents/kWh]*	*[€cents/kWh]*
Ground-mounted utility (≥ 1 MWp)	5.2 – 7.8	5.9 – 8.9	9.9 – 14.8
Commercial rooftop (< 1 MWp)	5.5 – 8.4	6.7 – 10.3	11.2 – 17.0
Residential (up to 5 kWp)	6.6 – 10.1	7.5 – 11.6	11.9 – 18.2

Mitigation measures increases CAPEX and OPEX but also the utilisation rate

The most effective mitigation measures are those implemented at the *early stage of project lifecycle*. Those implemented in the operation phase still show some positive impact on LCOE but less gain is found.

Although the implementation of mitigation measures increase either CAPEX or OPEX or both, the overall LCOE decreases as the gain in yield surpasses the extra cost incurred.

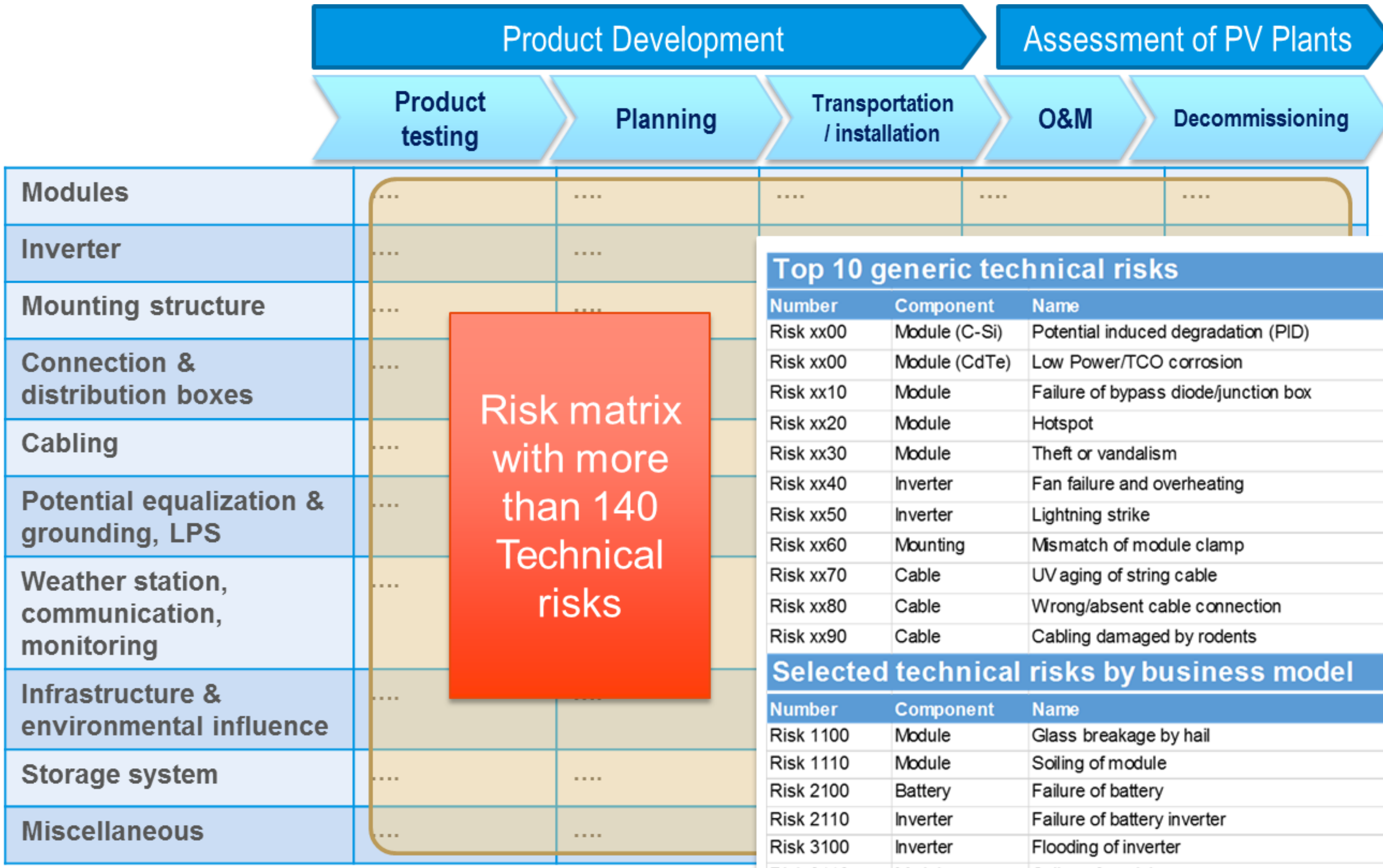
Mitigation measures most effective in lowering PV LCOE are:

1. Qualification of EPC;
2. Component testing prior to installation; and
3. Advanced monitoring system for early fault detection.

Impact on Business Models

	Description
Business model 1	Residential rooftop PV system with crystalline modules located in central Europe (5,6 kW, c-Si, Germany)
Business model 2	Residential rooftop PV system with crystalline modules and battery storage located in central Europe (5,2 kW c-Si + storage, Germany)
Business model 3	Utility scale ground mounted PV system with crystalline modules, central inverters, located in northern Europe (7,6 MW, c-Si, UK)
Business model 4	Utility scale ground mounted PV system with CdTe modules, string inverters, located in southern Europe (0,6 MW, CdTe, Italy)

Technical Risks selection for business models



Top 10 generic technical risks

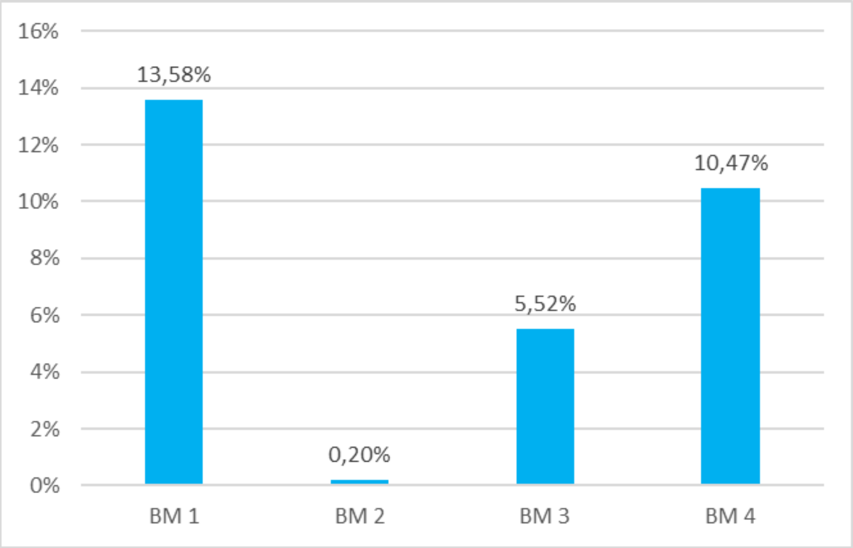
Number	Component	Name	BM1	BM2	BM3	BM4
Risk xx00	Module (C-Si)	Potential induced degradation (PID)	x	x	x	1)
Risk xx00	Module (CdTe)	Low Power/TCO corrosion				x
Risk xx10	Module	Failure of bypass diode/junction box	x	x	x	x
Risk xx20	Module	Hotspot	x	x	x	2)
Risk xx30	Module	Theft or vandalism	x	x	x	x
Risk xx40	Inverter	Fan failure and overheating	x	x	x	x
Risk xx50	Inverter	Lightning strike	x	x	x	x
Risk xx60	Mounting	Mismatch of module clamp	x	x	x	x
Risk xx70	Cable	UV aging of string cable	x	x	x	x
Risk xx80	Cable	Wrong/absent cable connection	x	x	x	x
Risk xx90	Cable	Cabling damaged by rodents	x	x	x	x

Selected technical risks by business model

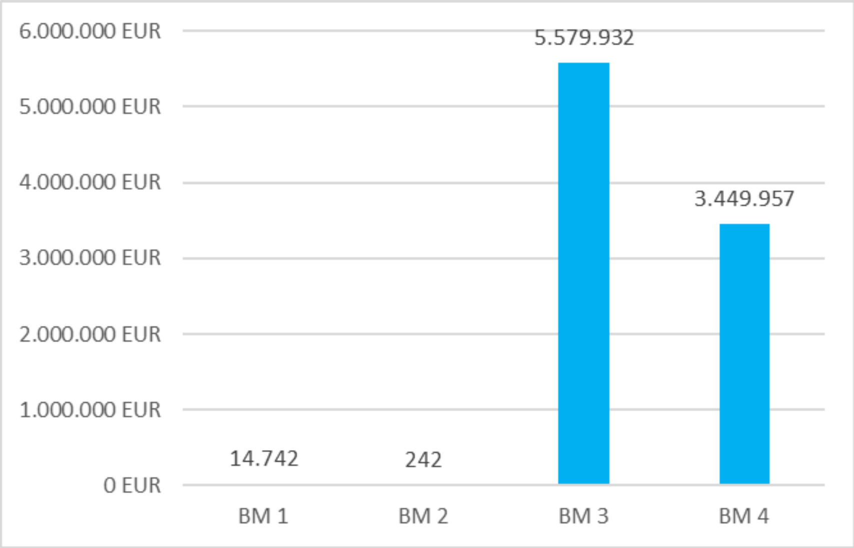
Number	Component	Name	BM1	BM2	BM3	BM4
Risk 1100	Module	Glass breakage by hail	x			
Risk 1110	Module	Soiling of module	x			
Risk 2100	Battery	Failure of battery		x		
Risk 2110	Inverter	Failure of battery inverter		x		
Risk 3100	Inverter	Flooding of inverter			x	
Risk 3110	Module	Soling of module			x	
Risk 4100	Module	Glass breakage, frameless module				x

Financial Performance of Business Models

IRR (Base case)

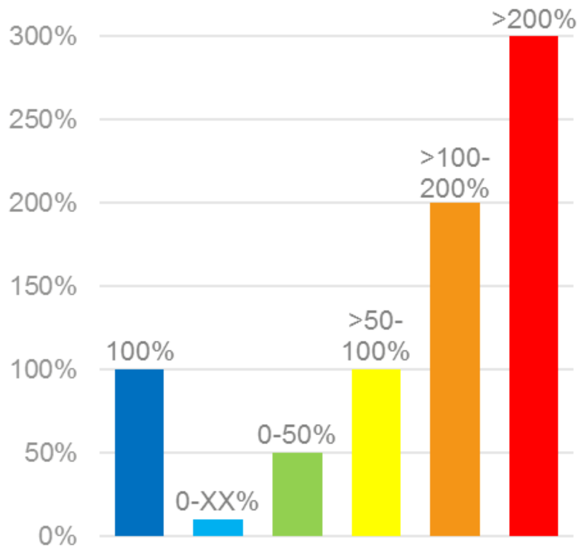


Cumulative cash flow (Base case)



Failure Categories

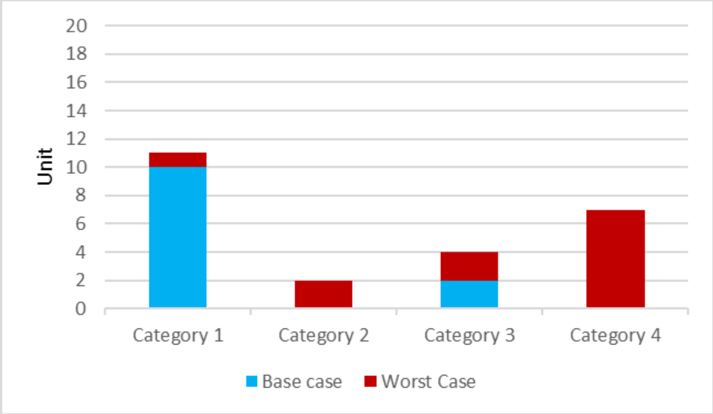
The impact of risks is measured by failure categories based on a 12 month revenue reserve account (as demanded by banks)



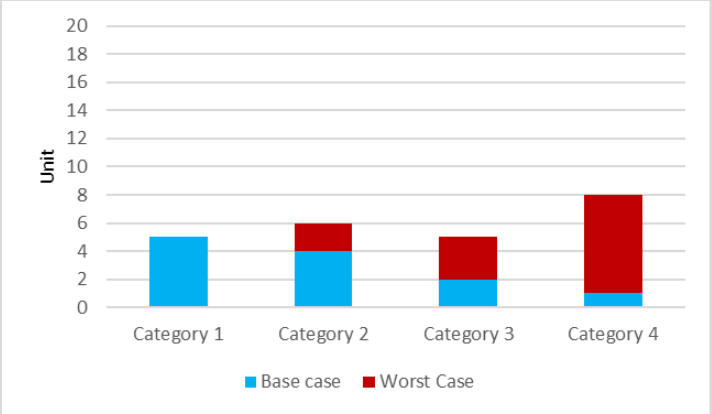
- **Reference base (100%):** 12 months revenues from first calender year of full operations
- **Failure category 0 - (0-xx%):** Regular operations and maintenance provisions
- **Failure category 1- (0-50%):** Covered by 6 months reserve accounts
- **Failure category 2 - (>50-100%):** Covered by 12 months reserve account
- **Failure category 3 - (>100-200%):** Not covered by reserve account, potential need for additional equity
- **Failure category 4 - (>200%):** Not covered by reserve account, potential need for additional equity capital

Failure Category Overview

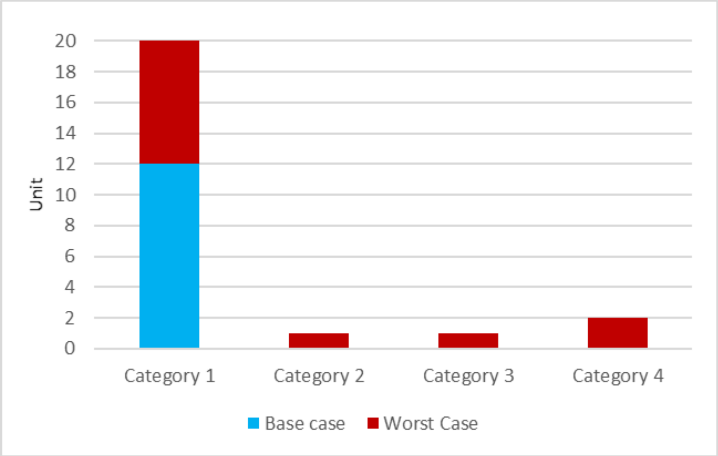
Business Model 1



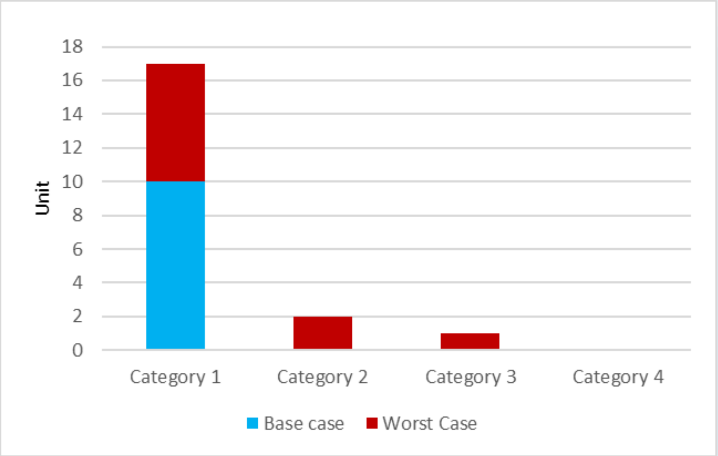
Business Model 2



Business Model 3



Business Model 4



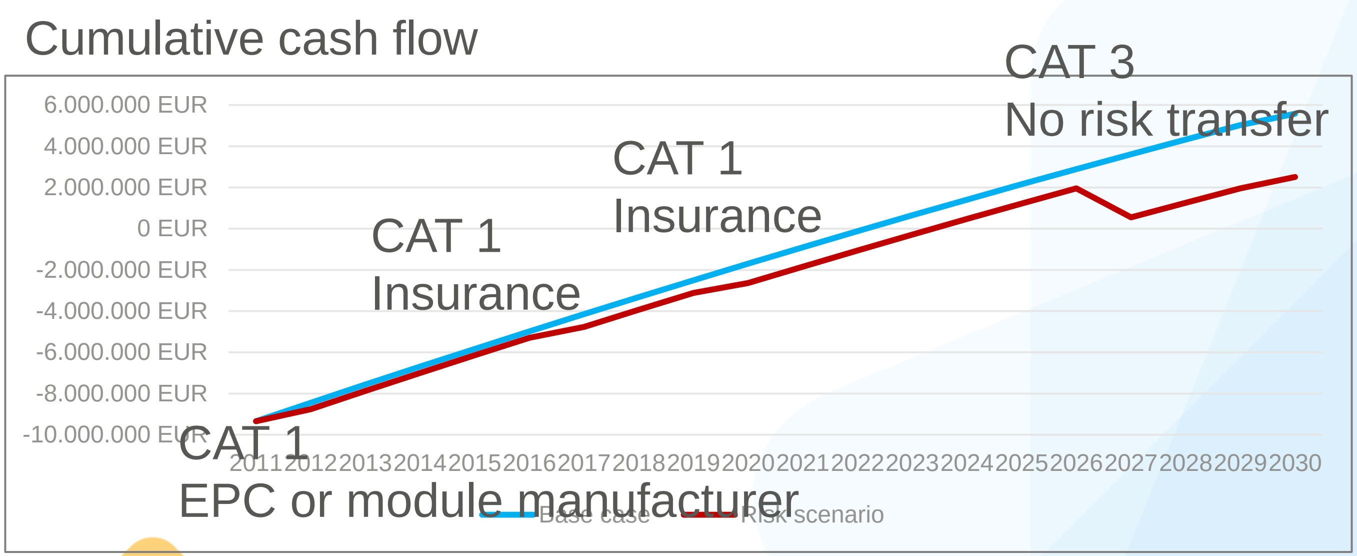
Risk Scenario – Business Model 3 (Example)

Risk scenario - businss model 3					
Risk	**Risk number**	**Risk name**	**Start Date**	**Case**	**Phase**
Risk 1	3020	Hotspot of modules	01.01.2012	Best	Infant
Risk 2[2)]	3101	Flooding of inverter	01.08.2017	Worst	Mid-life
Risk 3[1)]	3051	Lightning strike of inverter	01.06.2020	Worst	Mid-life
Risk 4	3011	Failure of bypass diode and juction box	01.10.2026	Worst	Wear-out

Comments

1) External cause independent from project phase

2) Business model specific risk, i.e. due to system design/technology, geographic/climatic conditions



Risk transfer

Transfer of technical risks

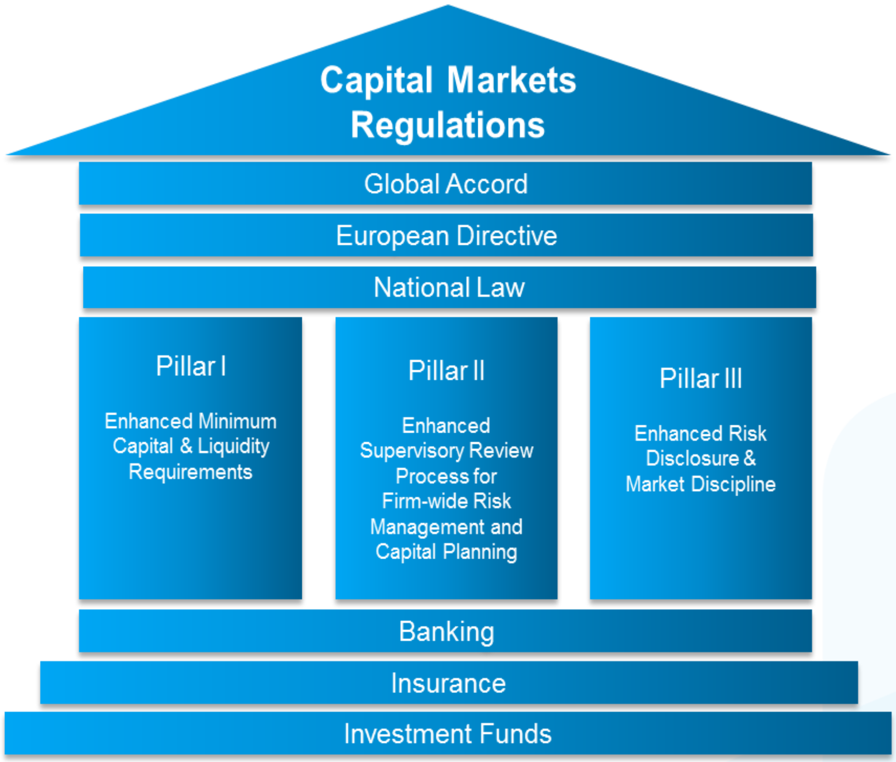
	Engineering Procurement Contruction	Operations	Decommissioning
	Year 0	Year 1-N	Year > N
EPC/ Installer	Service warranty (material & workmanship)		
O&M		Service warranty (material & workmanship)	
Component manufacturer	Product warranty (material & workmanship)	Performance guarantee	Product return and disposal guarantee
Insurance	General liability insurance Construction risk insurance	General liability insurance Property damage insurance Business interruption insurance Performance guarantee insurance	
Investor (Owner/Operator)	Residual risks	Residual risks	Residual risks
Bank	Creditor default risk (Pre-financing)	Creditor default risk (Financing)	

Technical risk framework

A	Risk identification
B	Risk assessment
C	Risk management
D	Risk controlling

www.solarbankability.eu

Capital market regulation



In a harmonized effort, financial regulatory bodies on a global, European and national level have developed a set of regulations for each capital market sector:

- Banking (Basel III),
- Insurance (Solvency II),
- Investment Funds (UCITS V / AIFM).

Best Practice Guidelines

www.solarbankability.eu

☑/☒	Technical aspect & what to look for in the LTYA
A	**Solar resource assessment**
☐	1. Only reliable solar irradiation data sources should be used and the name(s) and version(s) must be clearly stated. Data source(s) used must be able to provide uncertainty estimations and ideally have been extensively validated
☐	2. The period covered by the solar irradiation data source(s) used must be reported. Only data sources with more than 10-year recent data should be used for LTYA calculations
	3. The effect of long-term trends in the solar resource should be analyzed. In the presence of such trends, the long-term solar resource estimation should be adjusted to account for this effect
☐	4. The use of site adaptation techniques is recommended to reduce the uncertainty. A measurement campaign of at least 8 months and ideally one full year is recommended
B	**PV yield modeling**
☐	5. The PV modeling software and the specific version used must be clearly stated in the report
☐	6. If in-house software is used, the name(s) and version(s) must also be stated
☐	7. All assumptions (e.g. soiling losses, availability, etc.) and sub-models used (e.g. transposition model) must be clearly stated
C	**Degradation rate and behavior**
☐	8. The degradation rate(s) used for the calculations must be clearly stated in the report. It is recommended to differentiate between first year effects and yearly behavior over project lifetime
☐	9. Degradation behavior assumption (e.g. linear, stepwise, etc.) over time should be clearly stated and ideally backed up with manufacturer warranties
☐	10. If specific manufacturer warranties are available (e.g. module warranty document or sales agreement), these can be used to fine tune the lifetime degradation calculation
D	**Uncertainty calculation**
☐	11. All steps in the long-term yield calculation are subject to uncertainties. All uncertainties should be clearly stated and references must be provided in the report
☐	12. Special attention must be paid to the solar resource related uncertainties as these are among the most important elements in the contribution to the overall uncertainty
☐	13. If special methods are used to reduce some uncertainties e.g. site adaptation techniques, these should be clearly documented and ideally backed up with scientific validation
☐	14. Special care must be taken when classifying each uncertainty as either systematic or variable (stochastic) since these are treated differently in overall lifetime uncertainty calculations
☐	15. When possible, exceedance probabilities (e.g. P90) for each uncertainty must be calculated using empirical methods based on available data instead of assuming normal distribution for all elements

Best practice in long term Yield Assessment (LTYA)

Area/phase	Recommendations
EPC/procurement and product testing phase	1. The EPC technical specifications should include requirements that the selected components are suitable for use in the specific PV plant environment of application. 2. The EPC should list tests to be performed by the component supplier while manufacturing the components. The test data should be submitted to the EPC contractor for verification. 3. The EPC should specify that the components must pass independent testing before acceptance. The tests and acceptance criteria should be included.
EPC/ system design phase - lifetime energy yield estimation	4. The effect of long-term trends in the solar resource should be taken into account. 5. When possible, exceedance probabilities (e.g. P90) must be calculated using empirical method based on available data instead of assuming normal distribution. 6. Correct degradation rate and behaviour (linear/stepwise) over time should be used in the yield estimation. 7. Overall availability assumption (not O&M guaranteed availability) must be used to calculate the initial yield for project investment financial model.
EPC/transportation	8. The EPC should specify requirement of transportation and handling protocol.
EPC/construction	9. The EPC should include comprehensive protocol and training to its field workers on how to un-package and handle components properly. 10. The EPC should include intermediate construction monitoring site visits.
EPC/plant commissioning and acceptance	11. The EPC should include IR imaging as part of plant acceptance visual inspection. 12. The EPC should include short-term performance (e.g. PR) check at provisional acceptance test, including proper correction for temperature and other losses. 13. The EPC should include correct final performance check and guaranteed performance. 14. The EPC should include correct measurement sensor calibrations and set a correct irradiation threshold to define time window of PV operation for PR/availability calculation.
O&M	15. The O&M should use smart monitoring system for plant fault detection and identification. 16. The maintenance should use IR or EL imaging analysis as regular plant inspection. 17. The O&M should include guaranteed PR, availability and/or energy yield. 18. The O&M should include correct measurement sensor calibrations and set a correct irradiation threshold to define time window of PV operation for PR/availability calculation. 19. The maintenance should specifically include the monitoring system. 20. Module cleaning should be at minimum once a year.

Solar Bankability technical best practice (EPC and O&M)

Solar Bankability financial best practice

1. PV investments are considered as qualified infrastructure investment. Compared with other asset classes PV projects offers a favorable risk profile. Under Solvency II the corresponding equity stress factor has been lowered accordingly.
2. New capital market regulations require a thorough due diligence and ongoing risk management procedures. Banks and insurances are requested to either implement a qualified inhouse risk rating or to take advantage of external professional rating services.
3. Technical risks represent only one out of up several risk categories. In most rating schemes the impact of technical risks is limited up to 20%.
4. The impact of technical failures cannot be generalized. It depends on the individual framework conditions of the underlying PV business model , i.e. system size and design, geographic location, climate, technology, financing, taxation, jurisdiction and national policies.
5. The financial impact of technical failures can be classified in four failure categories. Only categories one and two are covered by regular operations and maintenance provisions and reserve accounts. Failures in category three and four are more common in smaller than in larger PV systems. The financial impact of failures often depends to a large extend on high spare parts costs for modules and inverters and high downtime costs due to long detection times and high yield losses especially during the summer season.

Solar Bankability financial best practice

6. Changing market factors require an enhanced risk awareness. Since the financial crisis in 2008 the profitability of PV systems has decreased along the decline of overall financial market returns. Increasing competition and cost pressure in the PV industry are threatening quality standards. Manufacturer and EPC insolvencies have made product warranties and performance guarantees become void.

7. A professional risk management plan should become integral part for each PV investment. The budget for risk assessment and mitigation measures should be adjusted to size and investment volume of the PV project. Mitigation measures should reflect the bathtub like curve of risk occurance and important milestones of system design, commisioning, end of warranty and guarantee periods. Ongoing monitoring and maintenance checks will help to minimize the occurance of failures.

8 Manufacturers and EPC should incorporate lessons learnt from technical failures into their component and system design. Rather than exchanging entire components, smart repair should become market standard i.e. to exchange defective module junction box diodes or inverter circuit boards. A system design based on i.e. micro or string inverters might be less downtime prone than on central inverters.

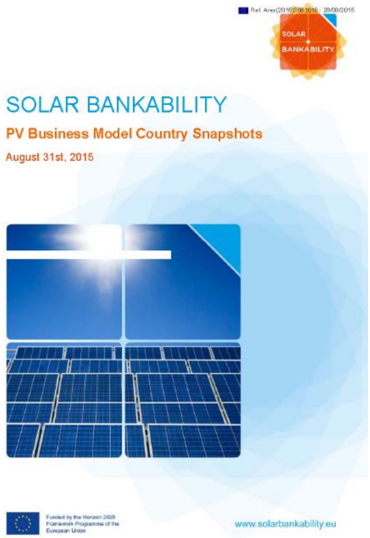
9 The risks assessement methodology developed under the Solar Bankability Project including technical risk catalogue, cost priority numbers, failure categories, failure cost distribution and mitigation measures can be used by banks and insurers to optimize i.e. required debt service reserve accounts or to adjust insurance premiums.

10 To enhance the effectiveness of government tender schemes for large PV projects regulators should consider to also include non-monetary qualification requirements beyond the price-only criteria. A professional risk management plan to ensure the financial viability and technical reliability of the PV system should be incorporated. A monitoring program should accompany the tendering process: It should cover the project realization rate and a technical quality and performance check before the end of the PV system warranty period.

Why not replicating the concept for Energy Efficiency?

A	Risk identification	Risk matrix
B	Risk assessment	Missing savings Increase in operational costs (Euros/m2/year)
C	Risk management	Mitigation measures Risk Transfer
D	Risk controlling	Energy Performance Contracts, role of ESCO

Project Reports: www.solarbankability.eu



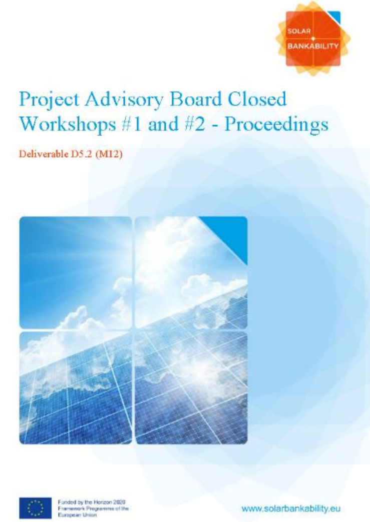
SOLAR BANKABILITY

PV Business Model Country Snapshots

August 31st, 2015

Funded by the Horizon 2020 Framework Programme of the European Union

www.solarbankability.eu

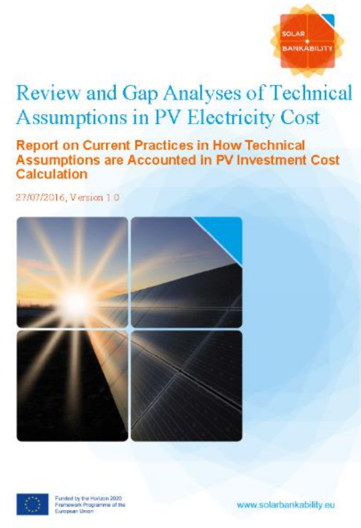


Project Advisory Board Closed Workshops #1 and #2 - Proceedings

Deliverable D5.2 (M12)

Funded by the Horizon 2020 Framework Programme of the European Union

www.solarbankability.eu



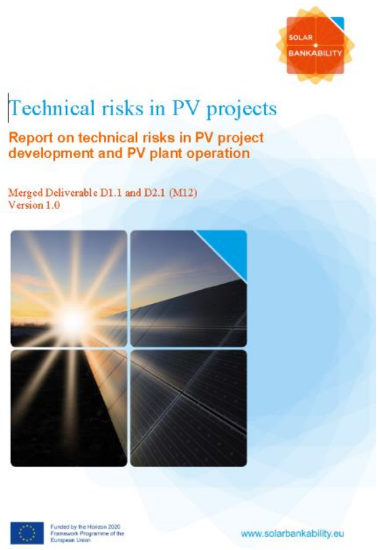
Review and Gap Analyses of Technical Assumptions in PV Electricity Cost

Report on Current Practices in How Technical Assumptions are Accounted in PV Investment Cost Calculation

27/07/2016, Version 1.0

Funded by the Horizon 2020 Framework Programme of the European Union

www.solarbankability.eu



Technical risks in PV projects

Report on technical risks in PV project development and PV plant operation

Merged Deliverable D1.1 and D2.1 (M12)
Version 1.0

Funded by the Horizon 2020 Framework Programme of the European Union

www.solarbankability.eu

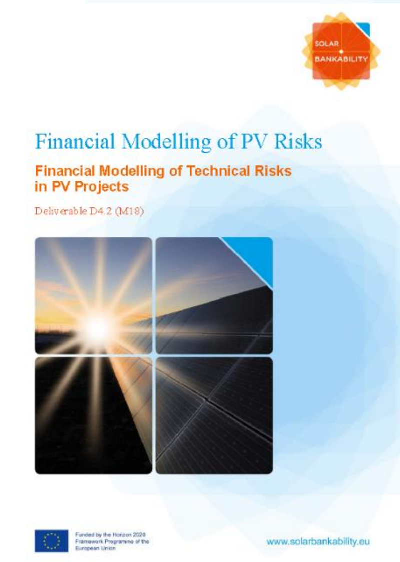
Minimizing Technical Risks in Photovoltaic Projects

Recommendations for Minimizing Technical Risks of PV Project Development and PV Plant Operation

Merged Deliverable D1.2 and D2.2 (M16)

Funded by the Horizon 2020 Framework Programme of the European Union

www.solarbankability.eu



Financial Modelling of PV Risks

Financial Modelling of Technical Risks in PV Projects

Deliverable D4.2 (M18)

Funded by the Horizon 2020 Framework Programme of the European Union

www.solarbankability.eu

Final Public Workshop 7th-8th February 2017
Brussels, Belgium

Enhancement of PV Investment Attractiveness

Concept:

Target groups: Finance sector, insurance, EPCs, service providers, decision makers / broader attendance

1.5-day-Workshop including networking dinner

Fully paid workshop for max. 120 participants

Registration available: End of Oct 2016

Save the date: 7-8 Feb 2017!

Thank you!

- David Moser (Eurac),

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 649997.
The content of this report reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains

Funded by the Horizon 2020 Framework Programme of the European Union

www.solarbankability.eu

Impact of Applied Mitigation Measures on the cost of PV electricity

PV LCOE calculation

$$LCOE = \frac{I + \sum_{n=1}^{N} \frac{C - RV}{(1+r)^n}}{\sum_{n=1}^{N} \frac{Y_o \ x \ (1-D)^n}{(1+r)^n}}$$

N = PV system life (years)

I = total initial investment (CAPEX) (€/kWp)

C = annual operation and maintenance expenditures (OPEX) (€/kWp)

RV = residual value (€/kWp)

r = discount rate (%)

Y_0 = initial yield (kWh)

D = system degradation rate (%)