SAFETY OF A PV PLANT

SMA Solar Technology AG

DISCLAIMER

IMPORTANT LEGAL NOTICE

This presentation does not constitute or form part of, and should not be construed as, an offer or invitation to subscribe for, underwrite or otherwise acquire, any securities of SMA Solar Technology AG (the "Company") or any present or future subsidiary of the Company (together with the Company, the "SMA Group") nor should it or any part of it form the basis of, or be relied upon in connection with, any contract to purchase or subscribe for any securities in the Company or any member of the SMA Group or commitment whatsoever.

All information contained herein has been carefully prepared. Nevertheless, we do not guarantee its accuracy or completeness and nothing herein shall be construed to be a representation of such guarantee. The Company shall assume no liability for errors contained in this document, unless damages are caused intentionally or through gross negligence by the Company. Furthermore, the Company shall assume no liability for effects of activities that evolve from the basis of data and information provided by this presentation.

The information contained in this presentation is subject to amendment, revision and updating, which does not underlie any prior announcement by the Company. Certain statements contained in this presentation may be statements of future expectations and other forward-looking statements that are based on the management's current views and assumptions and involve known and unknown risks and uncertainties. Actual results, performance or events may differ materially from those in such statements as a result of, among others, factors, changing business or other market conditions and the prospects for growth anticipated by the management of the Company. These and other factors could adversely affect the outcome and financial effects of the plans and events described herein. The Company does not undertake any obligation to update or revise any forward-looking statements, whether as a result of new information, future events or otherwise. You should not place undue reliance on forward-looking statements which speak only as of the date of this presentation.

This presentation is for information purposes only and may not be further distributed or passed on to any party which is not the addressee of this presentation solely after prior consent of the Company. No part of this presentation must be copied, reproduced or cited by the addressees hereof other than for the purpose for which it has been provided to the addressee. The content of this presentation, meaning all texts, pictures and sounds, are protected by copyright. The contained information of the presentation is property of the Company.

This document is not an offer of securities for sale in the United States of America. Securities may not be offered or sold in the United States of America absent registration or an exemption from registration under the U.S. Securities Act of 1933 as amended.

THE ENERGY SECTOR IS CHANGING RAPIDLY

MEGATRENDS ARE TRANSFORMING THE ELECTRICITY ECOSYSTEM

1

Decarbonization

is leading to an expansion of PV capacity, which in turn fosters decentralization and the demand for storage systems.

2

Sector Convergence

is providing new means of flexibility – Managing the resulting complexity is creating demand for new energy solutions.

3

The structural transformation of the energy system

will require solutions to control and manage the increasingly decentralized grid enabled by digitalization.

> **SMA will leverage its existing experience to expand into digital solutions.**

SMA IS A LEADING PLAYER FOR PV INVERTERS, STORAGE AND O&M

Investment Highlights

Uniquely positioned in the solar market / best brand

- A leading global specialist for photovoltaics system technology with 65 GW installed base
- Complete portfolio to serve all PV segments
- 20 subsidiaries with strong service capabilities and access to all channels
- Award-winning 20 GW production to achieve scale

Leverage PV expertise to enter into high margin business

- Strong partnerships to create a new ecosystem
- Know-how & products to benefit from strong growth in the field of battery storage
- With the energy management platform ennexOS, SMA has set the basis to manage the complexity of integrated solutions
- Infrastructure to expand into data-driven business models and services

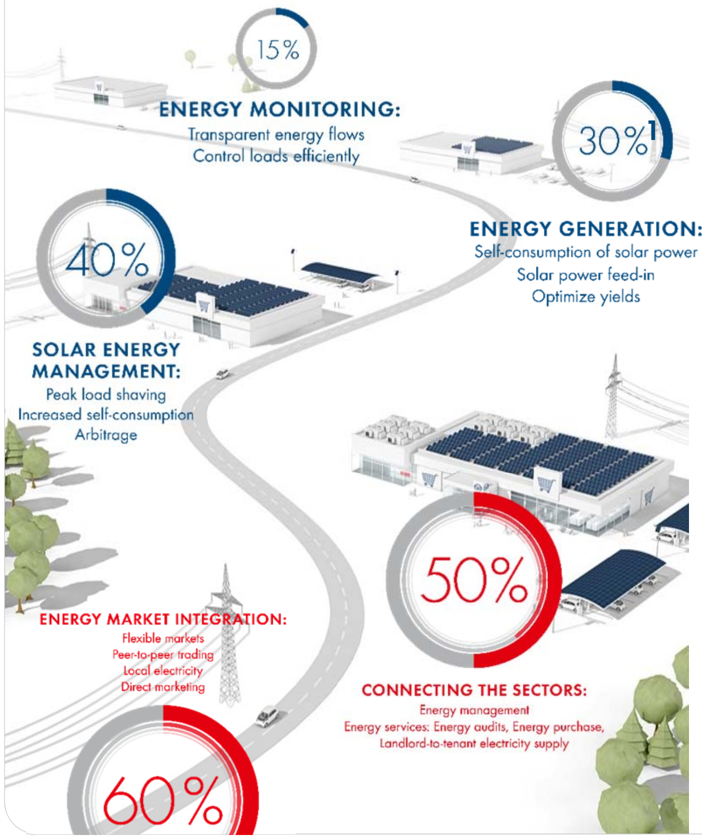
Key Figures

Sales 2017:	891 Mio. Euro
EBITDA 2017:	97,3 Mio. Euro
Inverter output sold 2017:	8,5 GW
Employees:	> 3.000
O&M portfolio:	2,6 GW
Patents and utility models	: >1.000

Product Innovations

INTELLIGENT ENERGY MANAGEMENT SUBSTANTIALLY REDUCES ENERGY COSTS OF HOUSEHOLDS AND COMPANIES

SMA's Commercial and Residential Solutions



STP 6.0 with integrated MLPE-communication


CORE1, 50 kW

Sunny Boy Storage 6.0

ennexOS energy management platform

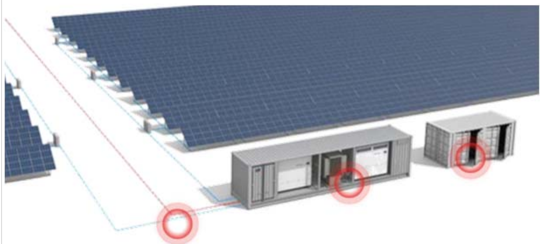
Success Factors

- Reduce number of platforms to improve cost competitiveness
- Improve yield with module optimization
- Storage integration for greater flexibility
- Energy managament platform to couple sectors

> SMA forms strategic alliances to approach new customer groups.

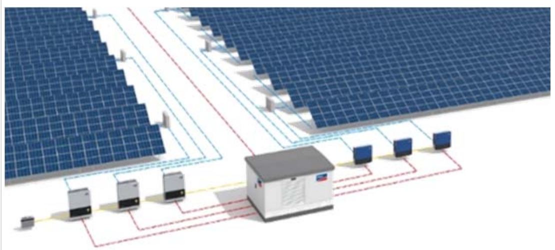
SMA OFFERS THE BEST TECHNICAL SOULTIONS FOR UTILITY-SCALE PV POWER PLANTS WITH COMPLEX SYSTEM DESIGN

SMA's Solution for Central Power Plant Design



SMA Medium Voltage Power Station, up to 6 MW, 1,500 V (2018)

SMA's Solution for Decentral Power Plant Design



SMA Solid-Q (2018)

Sunny Highpower PEAK1 (2018)

SMA Focus

- Increase power sizes to reduce specific costs
- Additional features that reduce total system costs
- Profit+ is a new business model to reduce life-time-cost
- Grid simulation to accelerate comissioning

> Through technical innovations and new business fields, SMA is able to reduce costs.

SMA HAS A SOUND STRATEGY TO BENEFIT FROM THE FUTURE ENERGY MARKET DESIGN

Our Vision and Mission	Our Strategic Goals 2020
Our **VISION** is to make people completely independent in their energy supply using decentralized renewable energy in a connected world. Our **MISSION** is to integrate and network photovoltaics, storage systems and mobility with intelligent energy management. With our superior solutions, we will shape the energy supply of the future.	SMA is the **global market leader** in all segments. SMA is a **provider of systems and solutions**. SMA is characterized by **sustainable profitability** and **low capital intensity**. SMA is continuously evolving by means of **disruptive approaches**. SMA is an **attractive company.**

> **SMA will become an integral part of the new energy market.**

SAFETY OF PV PLANTS

> More than 400GW installed PV systems world wide are already safe

SAFETY OF PV PLANTS

Safety of PV Plant means

- Fire prevention
- Fire fighting

SAFETY OF PV PLANTS: STATUS QUO

Two German institutes (TÜV Rheinland and Fraunhofer ISE) analysed the status quo of the safety of PV plant:

- A Fraunhofer ISE study[1] provided statistics relating to PV-related fires and the number of fatalities in Germany over the last 20 years:
  - Only 0.006 % of all PV plants have caused a fire resulting in serious damage
  - To date, no firefighter has been injured by PV power while putting out a fire
  - Note: In Germany not even a string level rapid shutdown is common practice

- The consequent use of best practice while extinguishing a fire allows safe work of first responders
  - Minimum distance between fire hose and a 1500 Vdc electrical system[2]:
    - Spray water jet: 1 m
    - Full water jet: 5 m

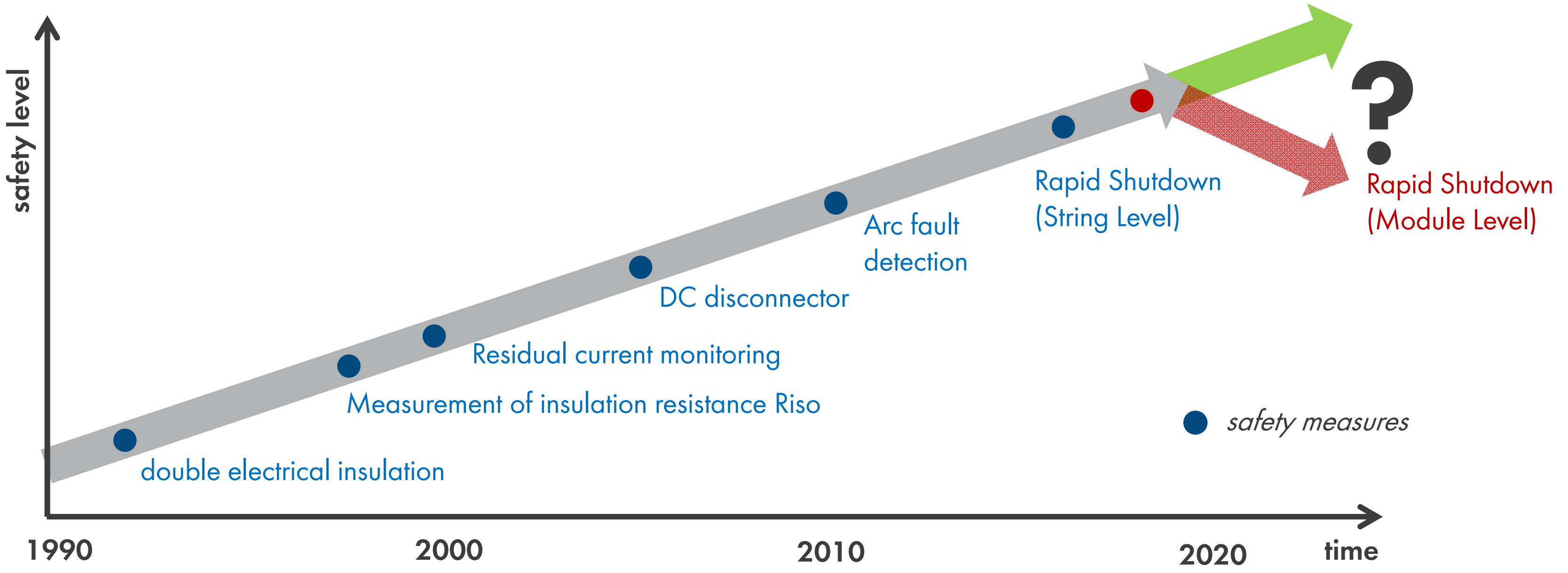
> Experience shows, that conventional PV systems with string technology are safe and can be managed in an emergency

[1] Recent Facts about Photovoltaics in Germany, Fraunhofer ISE, 2015
[2] Assessment of the Fire Risk in Photovoltaic Systems and Elaboration of Safety Concepts for Minimization of Risks TÜV Rheinland, Fraunhofer ISE, 2015

SAFETY OF PV SYSTEMS: SAFETY MEASURES

> Throughout the history of rooftop PV systems a variety of safety measures have been established with a focus on plant and personal safety

> These measures led to a high safety level



> **Will PLE increase, or potentially even decrease, the safety of future PV plants? Will it prevent fires?**

SAFETY OF PV SYSTEMS: RECENT APPROACHES TO INCREASE SAFETY

> Requirements for shutdown of DC power lines led to the market entry of a large number of DC disconnectors from a variety of vendors

Picture: Matthew Smithwick

> Some of these DC disconnectors were **causing** a fire instead of making the PV array safer
>
> > Three types of DC isolators were recalled in Australia in February, March and May 2014 [3]

> Compared to the conventional string technology, a rapid shutdown at module level using PLE will automatically lead to a higher number of components in the PV system

> Shouldn't a PV system with Panel Level Electronics at least reach the same safety level as conventional PV systems with string technology?

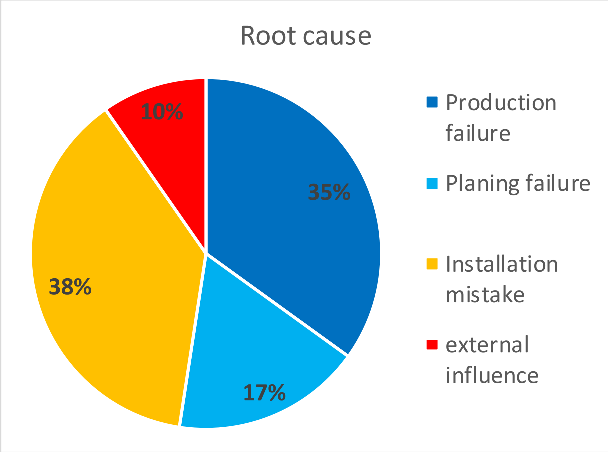
[3] http://www.recalls.gov.au (Australian Competition and Consumer Commission)

SAFETY OF PV SYSTEMS: FIRE PREVENTION

Analysis of the TÜV Rheinland about the root cause of fires in PV plants *[1]

> Root causes:
  > The distribution of root causes
    > **Product failure:** relate to failures of the modules and inverters
    > **Planing failure**: wrong mechanical and electrical installation
    > **Installation mistakes**: bad connection of DC connectors, bad not crimped connector, missing strain relief etc.
    > **External influence**: animal bite, lightnings etc

> DC connector and crimping are the major reason for a failure on the DC side of the PV plant after the module itself



> The root causes are mainly contact failures and product failures

SMA internal; Confidential

1. Bewertung des Brandrisikos in Photovoltaik-Anlagen und Erstellung von Sicherheitskonzepten zur Risikominimierung, TÜV Rheinland, Fraunhofer ISE , 2015

SUMMARY OF THE ANALYSIS BY TÜV RHEINLAND*[1]

Fire prevention:

- **TÜV recommends to check in any individual case if measures like fuses or switches are really needed or if the goal can be reached with alternative measures eg cable conduits *[1]**
  - Operational maintenance and regular checks are needed in any case to avoid hazards eg parallel arc faults against ground can be detected by residual current measurements or measuring the isolation against ground via Riso
  - Additional module level electronic doubles the amount of connectors and increases products in a system

Fire fighting:

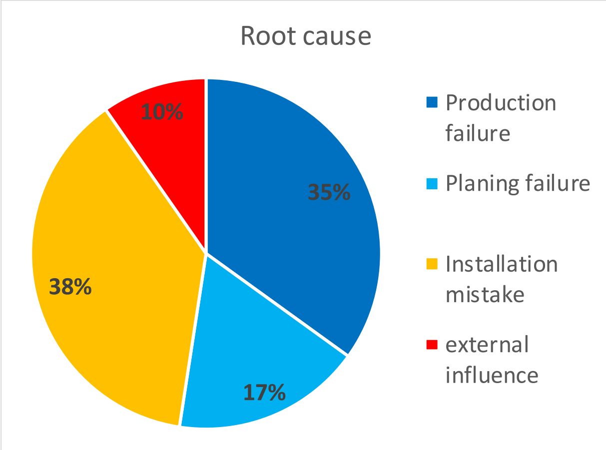
- **TÜV revokes the requirement for shut-down with the reasoning that any shut-down equipement can potentially fail *[1]**
  - In case of fire TÜV relies on proven rules, to approach the fire with a distance of 1m to energized parts and keep a distance during extinguishing of 1m in case of spray jet and 5 m in case of full jet

„In compliance with the recommended fire fighting distances according to DIN VDE 0132, hazardous currents for the fire fighter do not occur“ (page 128)

1. Bewertung des Brandrisikos in Photovoltaik-Anlagen und Erstellung von Sicherheitskonzepten zur Risikominimierung, TÜV Rheinland, Fraunhofer ISE , 2015

SAFETY OF PV SYSTEMS: FIRE PREVENTION

However Safety stays a concern of the PV industry



Recommended next steps to increase safety level

Installation mistakes:

> Define a common interface standard for DC connectors and develop a testing document to test DC connectors from different manufacturers for long-term reliability

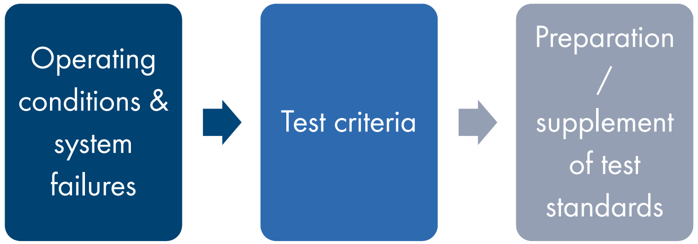
Product failures:

> Test criteria for Panel Level Electronics are necessary and have to be fixed in test standards

  > There are manifold operating conditions and system failures that are specific to PV

  > Test criteria have been developed in the public funded project „PV-Firebreaker“

  > Existing test standards are lacking those PV specific test criteria and have to be improved



SUMMARY

> Experience shows, that conventional PV systems with string technology are safe and can be managed in an emergency

> Panel Level Electronics has to withstand and manage a variety of harsh operating conditions and system failures which particularly apply to PV

> Test criteria for Panel Level Electronics are necessary and have to be fixed in test standards

> Define a common interface standard for DC connectors and develop a testing document to test DC connectors from different manufacturers for long-term reliability

> Without these measures panel level electronic potentially increases the risk of fire

SAFETY OF PV PLANTS

> **Focus on fire prevention instead of fire fighting**

1. Assessment of the Fire Risk in Photovoltaic Systems and Elaboration of Safety Concepts for Minimization of Risks; TÜV Rheinland, Fraunhofer ISE, 2015

BACKUP

DETAILS FROM THE TÜV REPORT

FIRE SAFTEY OF PV SYSTEMS: ANALYSIS TÜV RHEINLAND*[1]

Analysis of the TÜV Rheinland about root cause of fire in PV plants *[1]

- Situation when statistic was raised:
  - Installation base: 1.3 Mio PV plant
  - Total installed power: 30 GW

- Failure Statistic: (page 51)
  - 430 reported incidents of damage in PV plants due to fire / overheating
    - a. In 220 of these cases the root cause was outside the PV plant
    - b. In 210 the root cause of the fire was inside the PV plant

- Example: Walldorf (page 52)
  - The PV plant caught fire due to a technical defekt on the roof
  - The fire could not be extinguished in time

Foto: PR Video

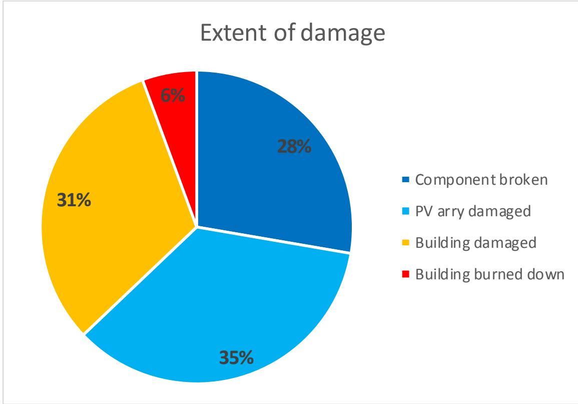
1. Bewertung des Brandrisikos in Photovoltaik-Anlagen und Erstellung von Sicherheitskonzepten zur Risikominimierung, TÜV Rheinland, Fraunhofer ISE , 2015

FIRE SAFTEY OF PV SYSTEMS: ANALYSIS TÜV RHEINLAND*[1]

Analysis of the TÜV Rheinland about root cause of fire in PV plants *[1]

> Extent of damage (page 53):

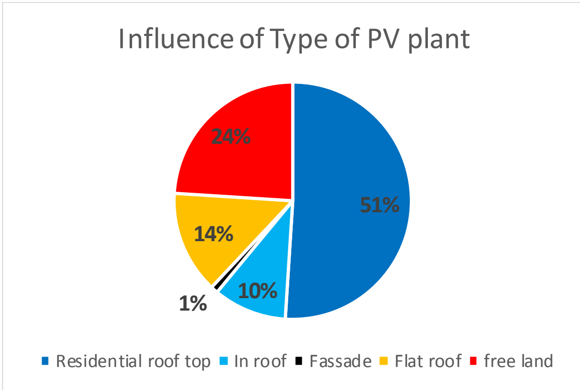
> Of the 210 incidents with root cause within the PV array



> Influence of the type of PV plant: (page 54)

> This distribution corresponds with the estimated marketshare according to Bundesverband Solarwirtschaft BSW which predicts that 70% of the installed base is on roof and 30% is on free land

> According to BSW less than 1% of the installation base is in in-roof applications however they contribute with 10% of the failures



SMA internal; Confidential

1. Bewertung des Brandrisikos in Photovoltaik-Anlagen und Erstellung von Sicherheitskonzepten zur Risikominimierung, TÜV Rheinland, Fraunhofer ISE , 2015

FIRE SAFTEY OF PV SYSTEMS: ANALYSIS TÜV RHEINLAND*[1]

Analysis of the TÜV Rheinland about root cause of fire in PV plants *[1]

> Root cause (page 55):

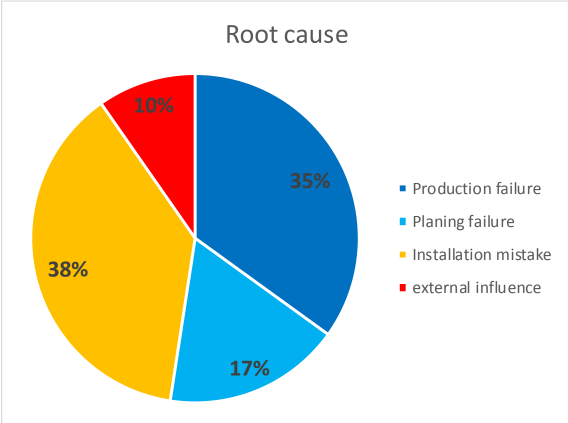
  > The distribution of root causes of 103 PV incidents

    > **Product failure** relate to failures of the modules and inverters

    > **Planing failure**: wrong mechanical and electrical installation

    > **Installation mistakes**: bad connection of DC connectors, bad not crimped connector, missing strain relief etc.

    > **External influence**: animal bite, lightnings etc



> DC connector and crimping are the major reason for a failure on the DC side of the PV plant after the module itself (page 59)

  > Example (page 63):

    > left contact has been damaged by an arc fault, the right one

    > The assessor came to the conclusion that the root cause was a broken conncetor and not correct installation

> All connectivity devices are potentially critical (Page 62)
> The root causes are mainly contact failures

1. Bewertung des Brandrisikos in Photovoltaik-Anlagen und Erstellung von Sicherheitskonzepten zur Risikominimierung, TÜV Rheinland, Fraunhofer ISE , 2015

FIRE SAFTEY OF PV SYSTEMS: ANALYSIS TÜV RHEINLAND*[1]

> Conclusion TÜV Analysis (Page 206 & 211)
  > Every additional device increases the risk of additional contacts
  > Therefore it should be checked in any individual case if measures like fuses or switches are really needed or if the goal can be reached with alternative measures eg cable conduits
  > Operational maintenance and regular checks are needed in any case to avoid hazards eg parallel arc faults against ground can be detected by residual current measurements or measuring the isolation against ground via Riso

> TÜV revokes the requirement for shut-down with the reasoning that any shut-down equipement can potentially fail (page 240)

> In case of fire TÜV relies on the proven rules, to approach the fire with a distance of 1m to energized parts and keep a distance during extinguishing of 1m in case of spray jet and 5 m in case of full jet (tests described in chapter 4.5.1; Conclusion page 132)

„In compliance with the recommended extinguishing distances according to DIN VDE 0132 of 5 m at Full jet and 1 m with spray hazardous leakage currents for the emergency service do not occur“

1. Bewertung des Brandrisikos in Photovoltaik-Anlagen und Erstellung von Sicherheitskonzepten zur Risikominimierung, TÜV Rheinland, Fraunhofer ISE , 2015

OPERATING CONDITIONS & SYSTEM FAILURES