Small components. Big impact.

Cabling of PV installations – Key factors for a successful long-time reliability

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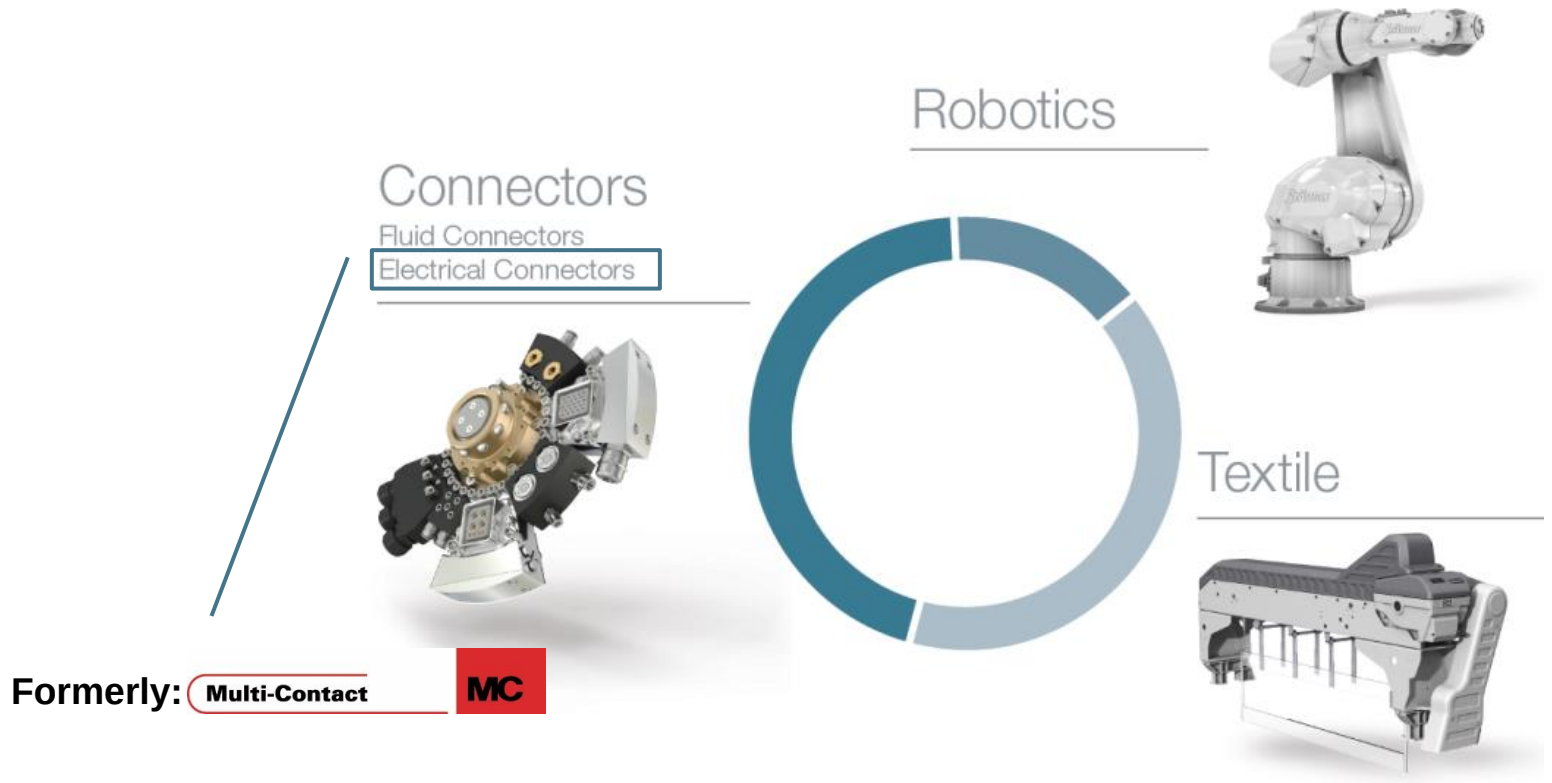
Stäubli Group – three activities, four divisions

> 125 years experience

> 5500 employees in 29 countries

> 300 GW PV connected



Cabling of PV systems – You can’t manage the unknown

Lack of knowledge about eBoS components (cabling/ connectors) …

- Component → technology, norms, materials, production processes
- Installation → norms, tools, assembly instructions

… and their relevance for the long-term success of a PV system

- Technical issues and their root cause
- Consequences/ risk on safety, efficiency (LCOE), profitability (ROI)

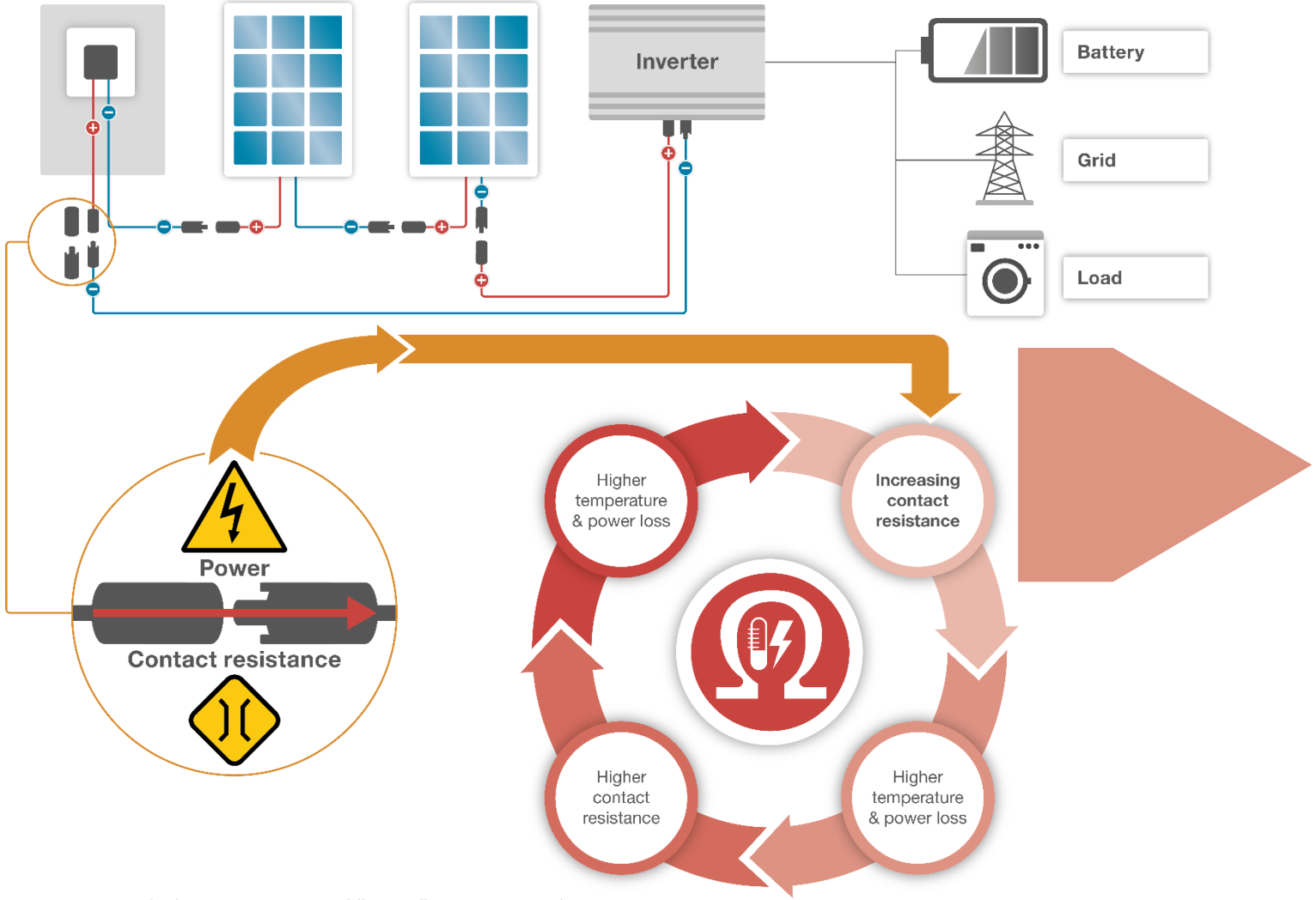
Resulting in eBoS components failures

Higher costs and losses

(Credit: Walmart lawsuit)

Why connectors (eBoS) can have this big impact

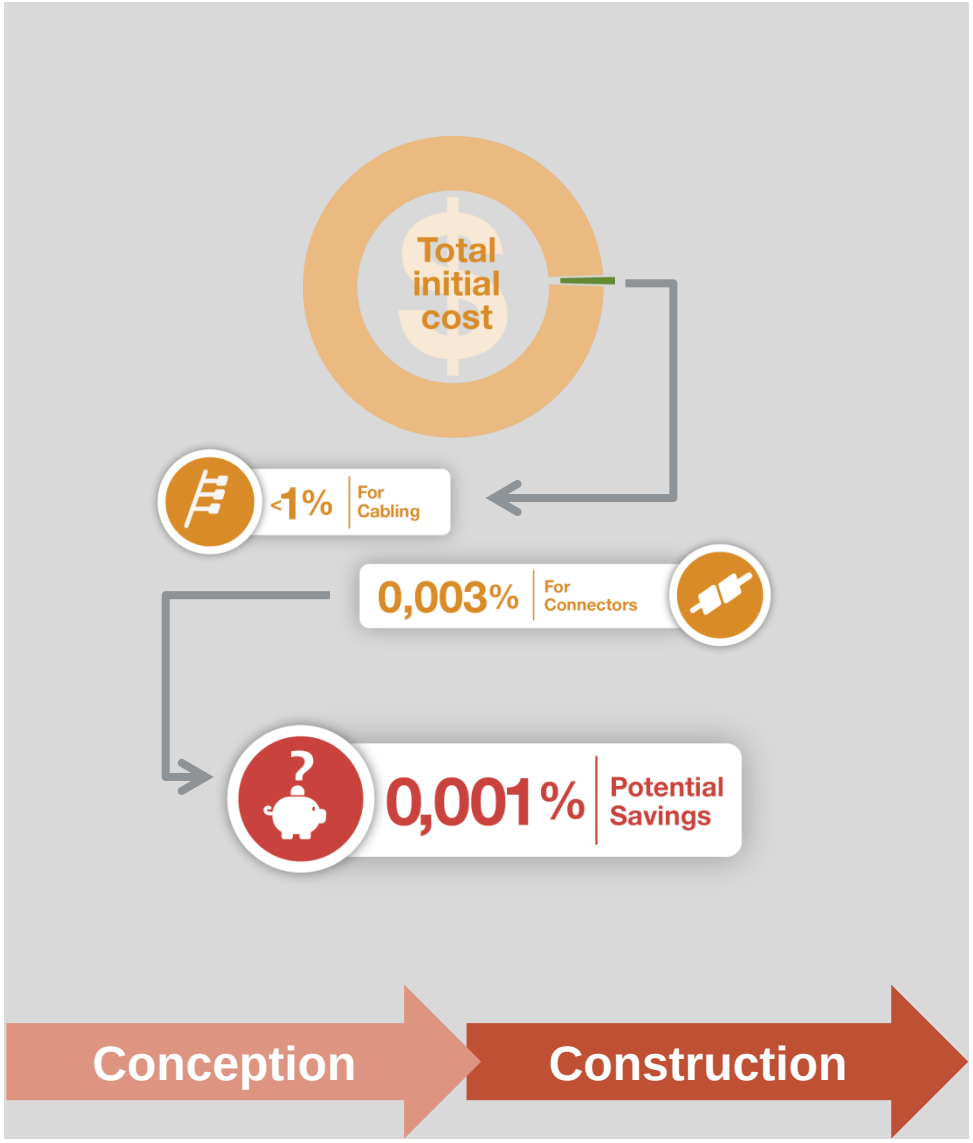
Constant low contact resistance = Long-term reliability and efficiency

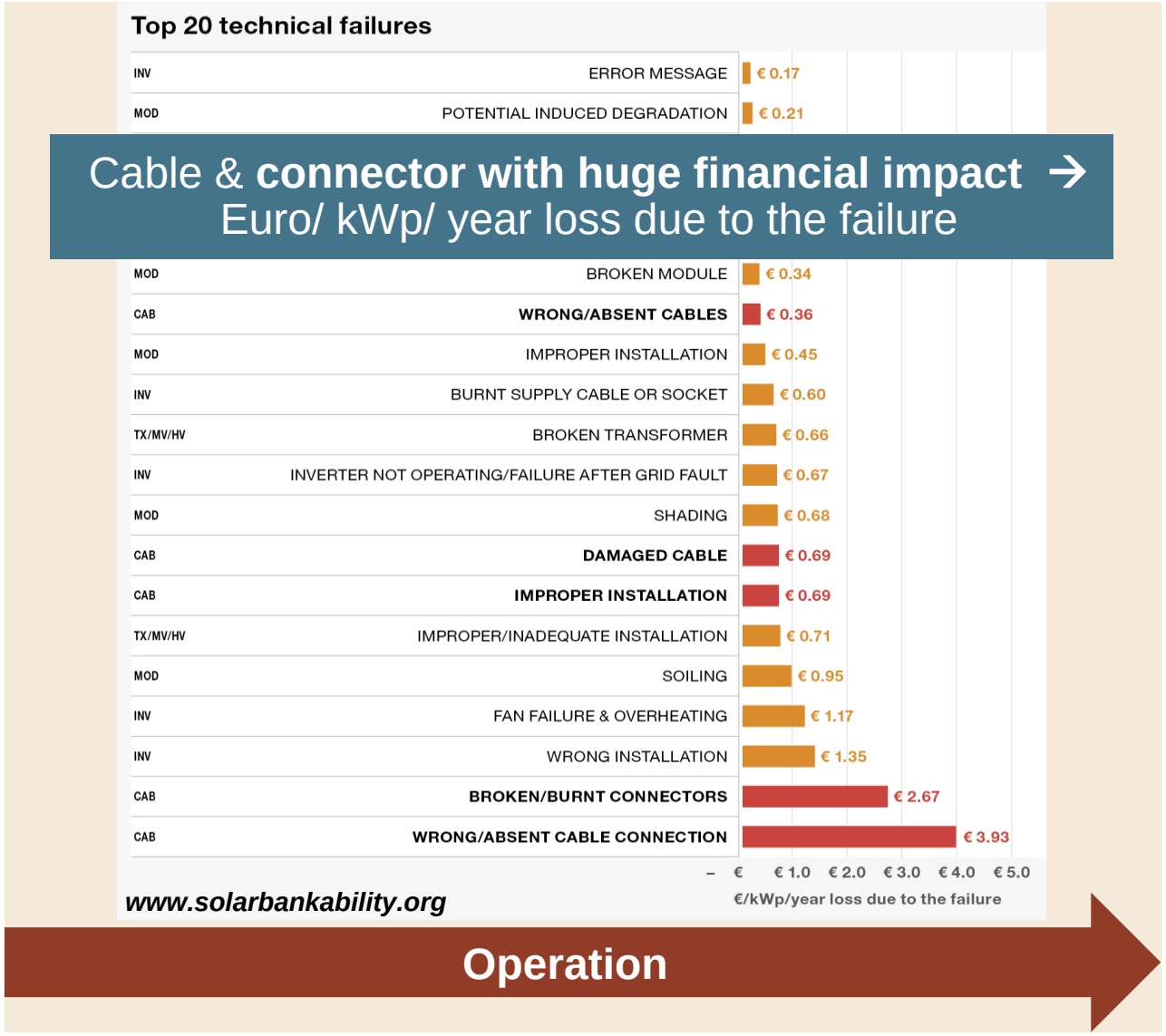


Consequences

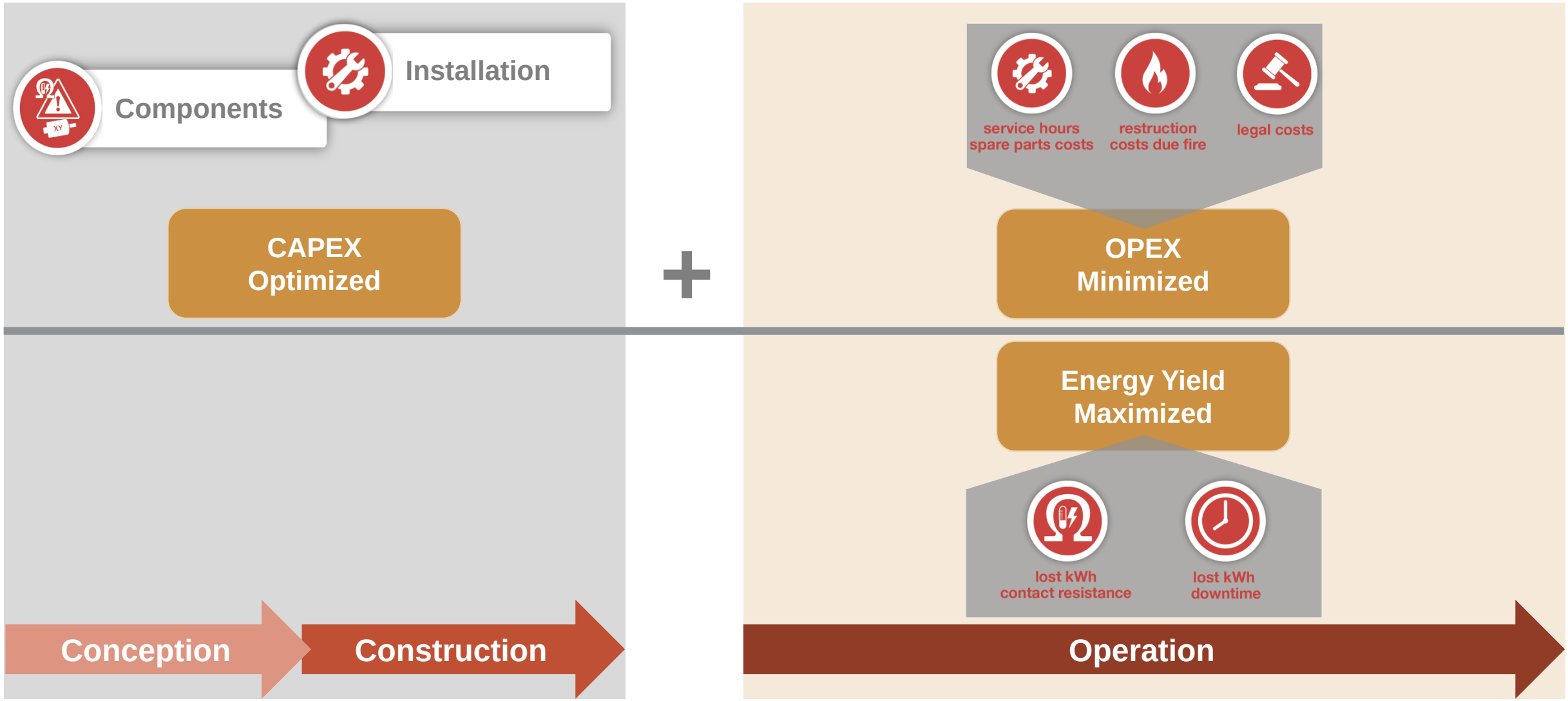
- High risk for (partial) connector failures
- Performance losses, higher PPM-rates and downtimes of modules, strings or plants
- High service/maintenance and spare part costs for repairing
- Hotspots and fire in PV system and reconstruction costs
- High costs for legal disputes due to undefined liabilities

Small components. Big impact.





Leverage on LCOE (Levelized Cost of Energy)

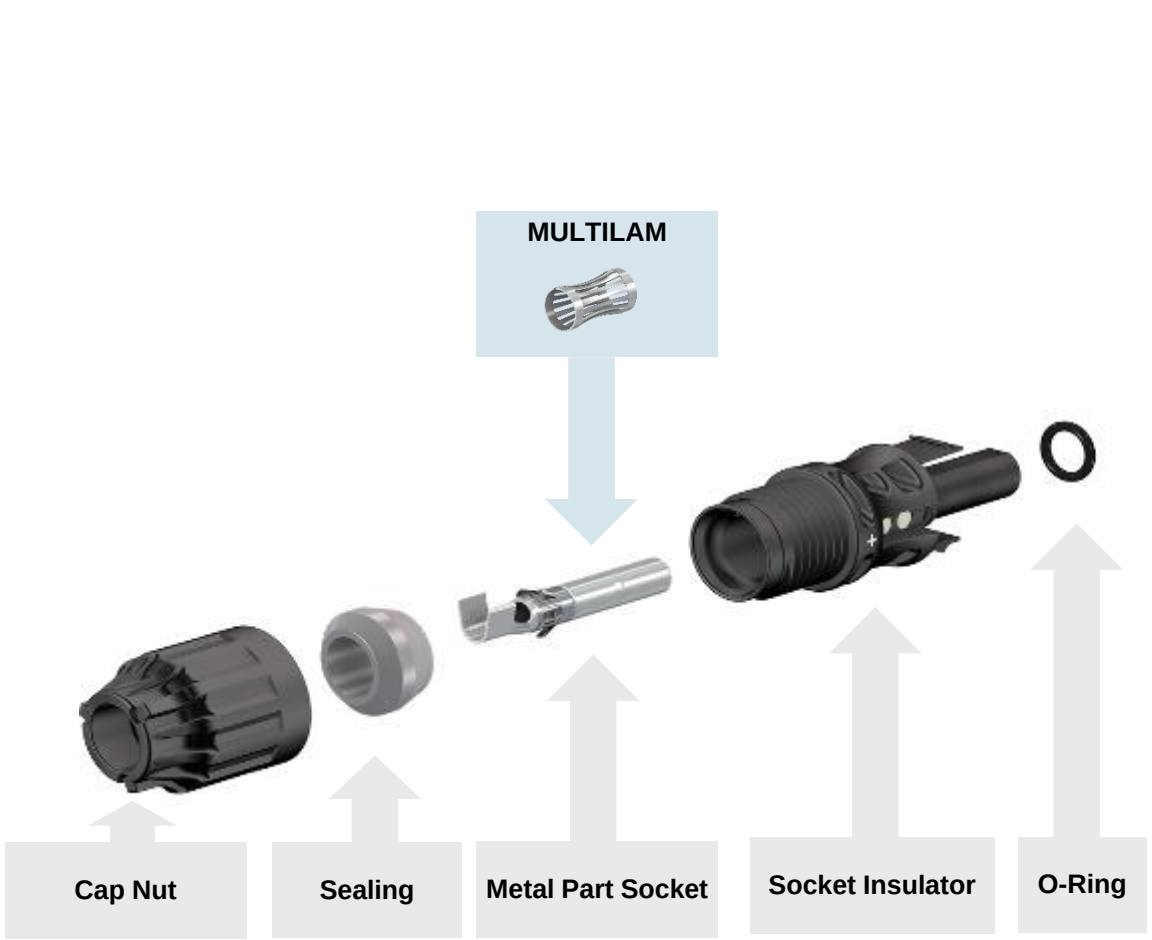


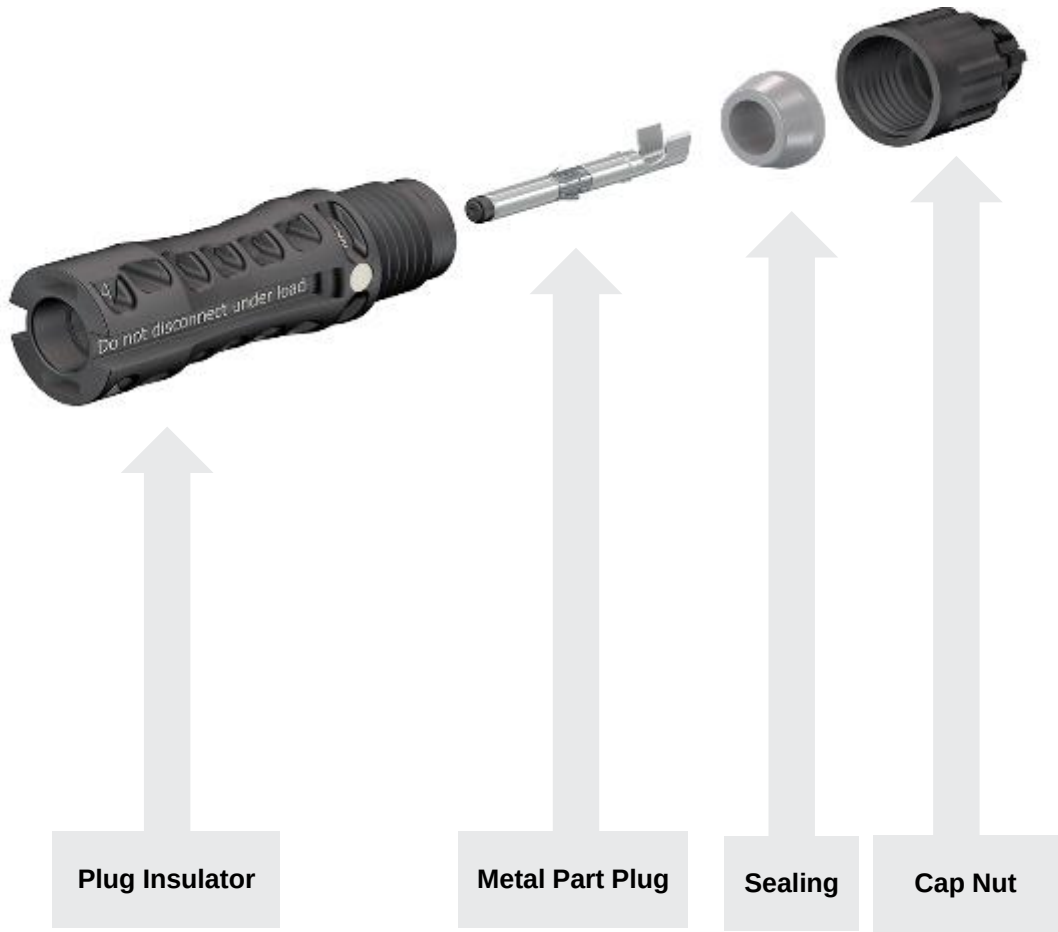
1) Component Quality – PV DC Connector

PV DC Connector

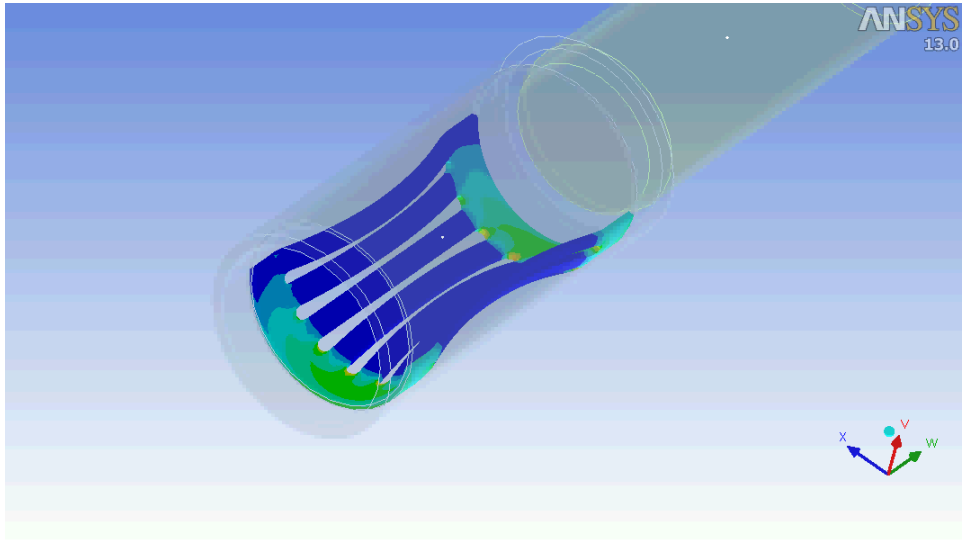
Socket
(marked «+» / female)

Plug
(marked «-» / male)

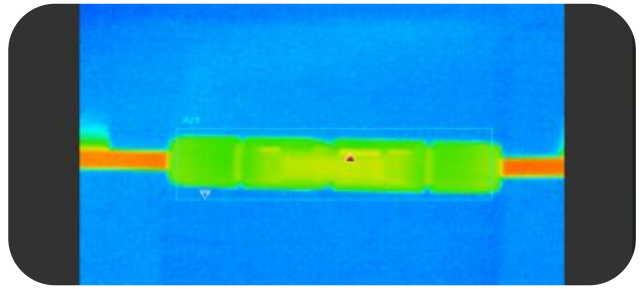




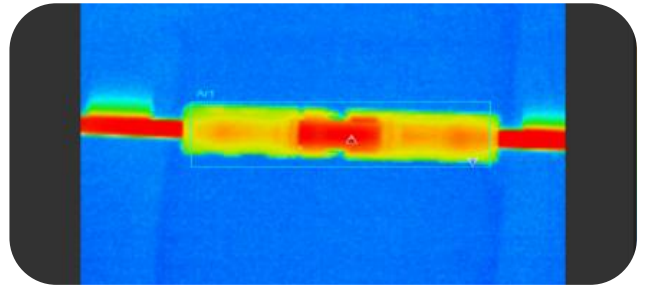
1) Component Quality – Stäubli Technology: MULTILAM



MC4 (MULTILAM Technology)



Competitor Product (no MUTLILAM)

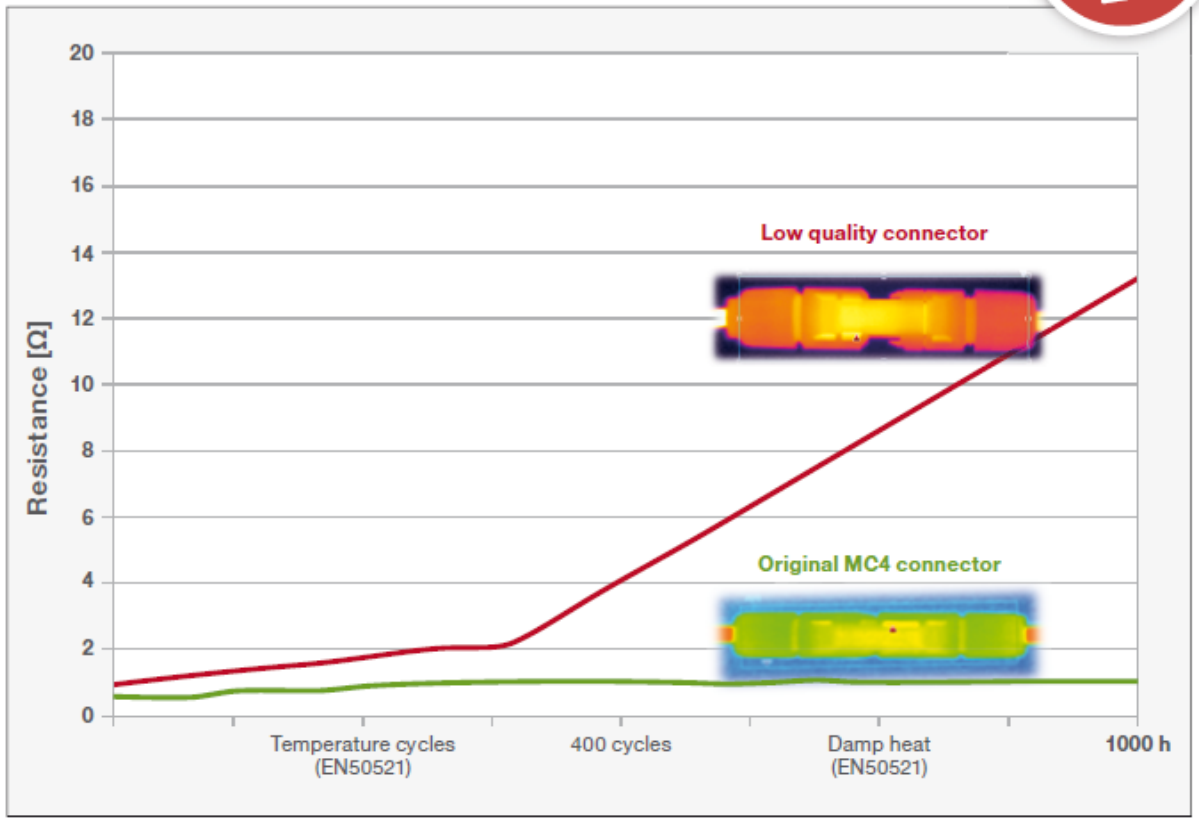


Scale
T_{Min} = 25°C
T_{Max} = 45°C

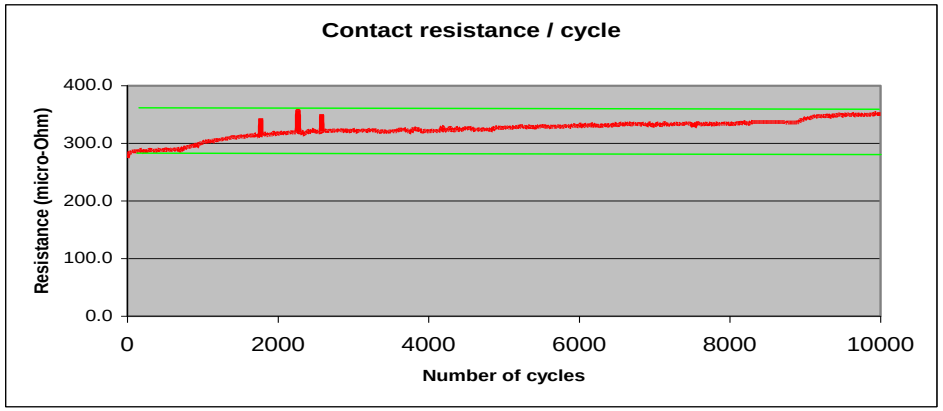
Measurements acc. to IEC60512-5-1

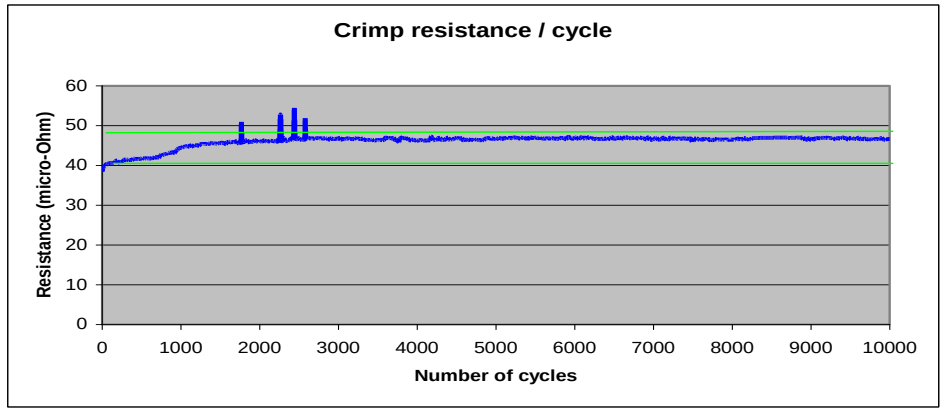
1) Component Quality – Contact Resistance

Initial measurements and after TCT/DHT



Stable low contact resistance

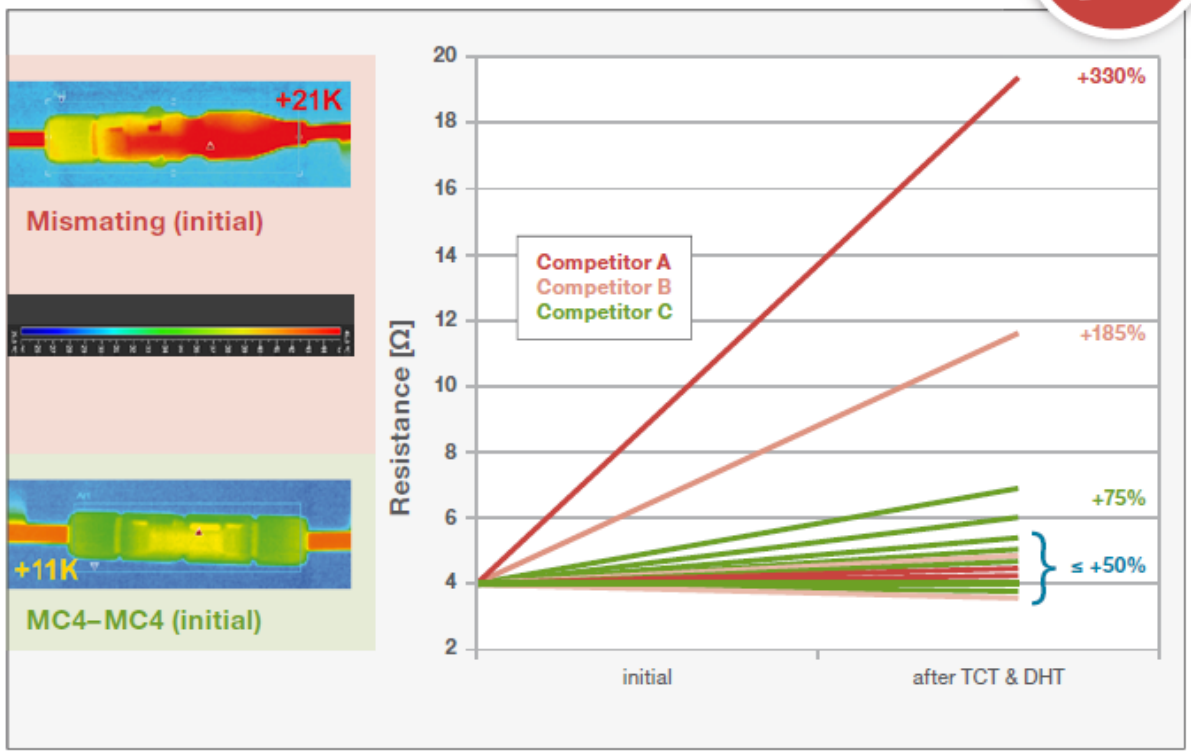




10’000 cycles representing ~ 20 years!

2) Installation – Cross-Connection

Initial Measurements and after TCT/DHT



Consequences

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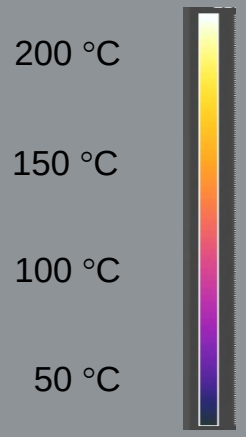
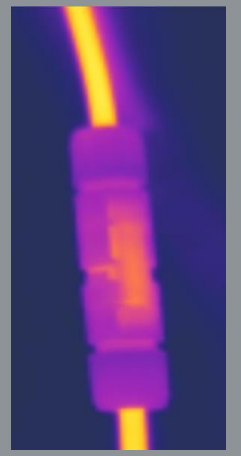
2) Installation – Cross-Connection

After 5min: heavily smoking
Power loss: 800W
Temperature: >200 °C

100A



After 5min: no defects
Power loss: 73W
Temperature: 135 °C



100A

Technical risk

- **Caused by:** Different technology, dimensions, product-material, production-process, -capacity, etc.

Legal risk

- **NO certification:** IEC 62852 (EN50521) and UL 6703 product norm resp. UL 1703 module norm
- **NO compatibility:** IEC 62548 installation norm, Statement TUV Rheinland
- **Liability? → NO warranty/guarantee!**

Statement of TUV Rheinland concerning interoperability of Photovoltaic (PV) connectors of different types and/or manufacturers

In many PV power plants PV modules are installed which are (mostly) from same type but fitted with PV connectors of different types, sometimes even produced by different manufacturers.
This circumstance brings with it that it is likely that such dissimilar connectors will be mated.

Why is it possible to mate connectors of different types?

In contrast to a few types of plugs and socket-outlets for use in household or industry systems, for which dimensions including their permissible tolerances are defined in product standards, such are not fixed for many other connectors, in particular not for PV connectors.

Some of the manufacturers for PV connectors have adapted the dimensions of connectors of a leading producer to their own connector types.
As a result it is possible to mate those connectors. Sometimes this is advertised by the producers as "compatibility".

Is it permitted to mate PV connectors of different types?

Several countries, e.g. France, already require the installation of connectors in PV arrays explicit from the same manufacturer in PV arrays. Australia changed their grid codes to ban the wording "compatible with" in reference to PV connectors. Currently standards for PV systems and PV arrays are under development, which also prohibit the engagement of connectors of different manufacturers.

How does TÜV Rheinland assess the mating of connectors of different types?

Under consideration of existing standards as well as under consideration of the field experience TUV Rheinland recommends to install and to mate connectors explicitly from same type and manufacturer. Aside from the insurability aspects ("who is responsible in case of an incident caused by dissimilar but mated connectors") several safety aspects are relevant for this recommendation:
Substantial problems can occur, e.g. if one of the manufacturers modifies the dimensions or tolerances of his connector. The water and vapor tightness may be affected by slight differences in the dimensions.
Problems may also occur due to incompatibilities of the materials of gaskets or sealings. The materials may be changed or destroyed completely.
This is also true for other materials, e.g. materials for insulation.

The current carrying metal parts also play a role. It is seldom the case that different manufacturers use the same materials or alloys.
This can, e.g. due to the different electrochemical potential, cause corrosion and subsequently high contact resistances. The consequence of the high contact resistances is loss of energy yield in the best case, in the worst case high temperatures which cause

2) Installation – Cross-Connection: Normative References

Global Installation Norm: IEC 62548 – PV Arrays

9.3.9 Plugs, sockets and connectors

Plugs and socket connectors mated together in a PV system shall be of the same type from the same manufacturer. I.e. a **plug from one manufacturer and a socket from another manufacturer or vice versa shall not be used to make a connection.**

UL Standard 6703 – PV Connectors

Conditions of acceptance

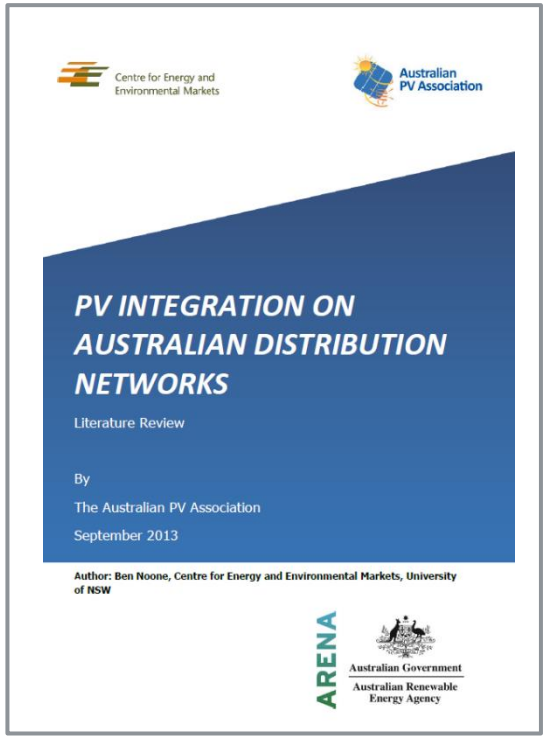
"…have been investigated as acceptable for assembly in the field by qualified electricians with factory provided tooling.

"These devices have only been assessed for UL Recognition with specific types of **mated connectors within their product family.**

They have not been assessed to operate with any other similar devices from any other manufacturer."

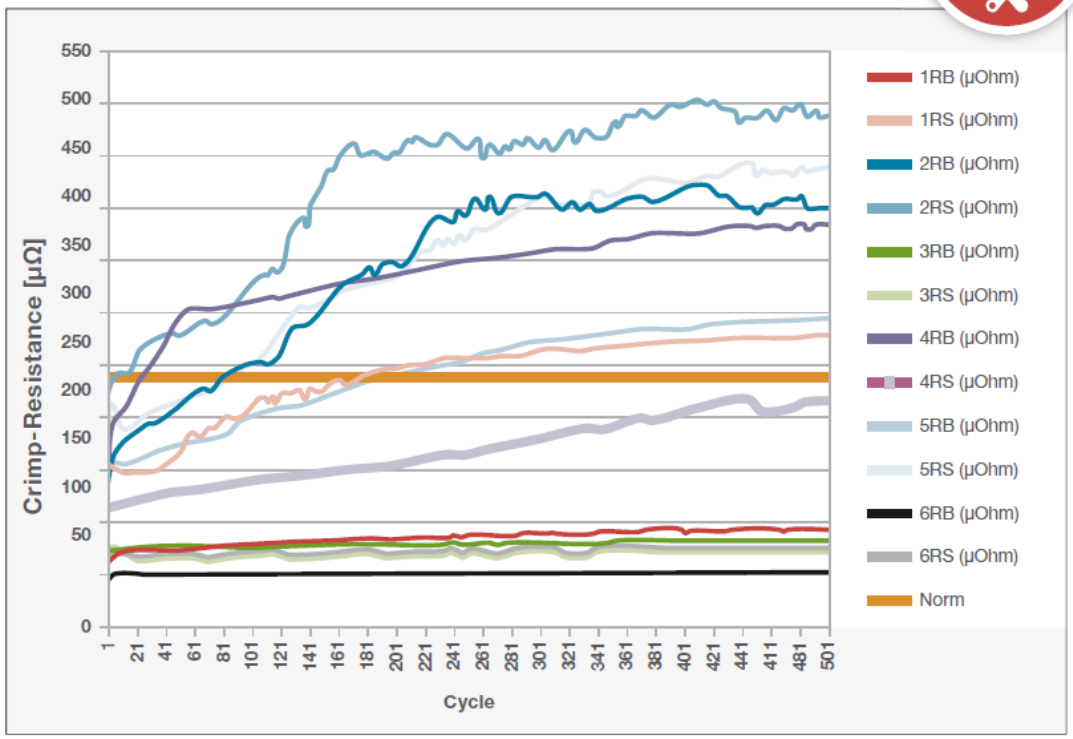
National Guidelines

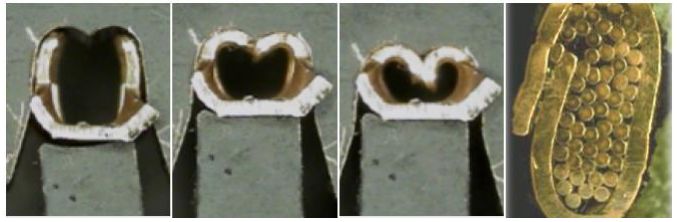
- Australia, France, Brazil & Turkey



2) Installation – Defective Cable Management (Crimping)

Initial Measurements and after TCT





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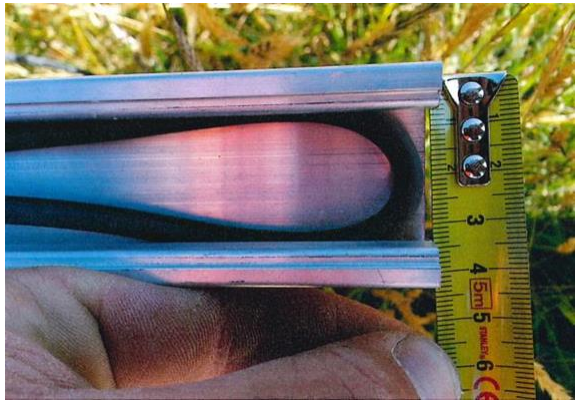
2) Installation – Common mistakes (Examples)

Connectors/ cables directly placed on roof or ground surface

Cable permanently exposed to water

Excessive tension and sharp bending radius



Error in product selection and configuration

Financial and safety risk

Laboratory testing:

Connections 5 years after commissioning

Insulation Resistance

R > 400 MΩ

Original x Original Ø	1660,00 MΩ
Cross-Connection Ø	0,06 MΩ

Contact Resistance

R Ø 530 µΩ

Original x Original Ø	532 µΩ
Cross-Connection Ø	6841 µΩ

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