Why Lean System Design Increases PV System Safety

All of Germany's nuclear power stations are to be decommissioned by the end of 2022. The last coal-fired power stations are likewise to be decommissioned by 2038 at the latest. Renewable energies need to be massively expanded in order for energy needs to continue to be covered. And photovoltaic systems (PV systems) have an important part to play in this.

PV already makes a relevant contribution to our power supply. At the end of 2020, there were two million PV systems installed in Germany with nominal capacity of 54 gigawatts (GW).[1] Together, these systems generated around 50.6 terawatt-hours (TWh) of solar electricity. In absolute terms, this equates to 9.2 percent of Germany's gross electricity consumption.[2]

In this white paper, we have compiled the most important facts and figures for you as well as the latest findings regarding PV system safety. You will also learn how additional devices on the roof affect PV system safety and about the various advantages of lean system design.

[1] "Recent Facts about Photovoltaics in Germany," Harry Wirth, Fraunhofer ISE, download from www.pv-fakten.de, last updated August 6, 2021, page 6
[2] Ibid.

PV systems are safe

PV systems are a generally reliable and safe source of energy. This is supported by numerous studies. But wherever electrical energy flows, there is also a degree of fire risk. Approximately 30 percent of all fires in Germany are caused by electricity. So just how dangerous are PV systems?

The independent institute Fraunhofer ISE determined that to date, less than 0.006 percent of all PV systems in Germany have caused a fire.[3] As such, PV systems are among the safest electrical systems.

Similar data for other EU countries, North America, and Japan[4] illustrate just how rare PV system fires are. Electrical appliances such as tumble dryers represent a far greater fire risk, followed by refrigerators, dishwashers, and power strips.[5]

SMA in figures

In fiscal year 2020, SMA sold PV inverters globally with a cumulative capacity of around **14.4 GW**.

Since being founded, SMA has sold PV inverters globally with a total capacity of more than **100 GW**. In absolute terms, this equates to the capacity of some 100 nuclear power stations.[6]

In theory, 25 million average four-person households – in other words, more than **100 million people** – could be supplied with clean solar electricity by all the SMA inverters installed up to 2020.[7]

[3] "Recent Facts about Photovoltaics in Germany," Harry Wirth, Fraunhofer ISE, https://www.ise.fraunhofer.de/en/publications/studies/recent-facts-about-pv-in-germany.html, last updated August 6, 2021, page 84

[4] Consumer safety release issued by Japan's Consumer Affairs Agency, 2018

[5] This is illustrated by a 2018 statistic compiled by Germany's Institute of Damage Prevention and Research (IFS): https://www.ifs-ev.org/waeschetrockner-brennen am-haeufigsten/. This was based on the fire cause investigations conducted by the institute on behalf of German insurance companies. In the USA, too, electrical home appliances count among the most frequent causes of fire, cf.: "Fire in the United States 2008–2017," 20th Edition, November 2019, U.S. Fire Administration, and "Home Electrical Fires," Richard Campbell, NFPA Research, March 2019

[6] Based on the assumption of average nominal capacity of 1 GW per nuclear power station

[7] Based on the assumption of average annual consumption of 4,000 kWh per four-person household and assuming that all the inverters installed since 1981 were still generating energy

Safety level continues to improve

The safety measures for PV systems are continuously being advanced as photovoltaics are expanded and further developed. For example, residual current monitoring, isolation resistance measurement, and reverse current protection are integral features of an SMA PV inverter.

In addition, intelligent technologies such as SMA's ArcFix electric arc protection and the service and monitoring feature SMA Smart Connected boost a PV system's safety. All the relevant safety components are therefore right there in the SMA inverter. Our aim is to have as few additional devices as possible needing to be installed when a PV system is constructed.

Other manufacturers promote additional hardware that supposedly enhances PV system safety. They claim that module-level power electronic (MLPE) technologies with rapid shutdown functionality will make the job of the fire departments easier, or even that they protect against fires. Since these are additional devices which have to be installed, we closely examine how they really influence PV system safety in the following pages.

SMA ArcFix

Effective electric arc prevention

This Arc Fault Circuit Interrupter (AFCI) efficiently identifies potential electric arcs in the PV system and interrupts the electric circuit before a fire can break out. SMA was a pioneer in the introduction of AFCIs in the USA and has systematically further developed this solution over the past decade. We will henceforth equip all of our string inverters around the world with our AFCI solution SMA ArcFix, thereby systematically further increasing the already high PV system safety standards.

SMA Smart Connected

Automatic monitoring for greater safety

SMA Smart Connected is another component that offers greater PV system safety. This integrated inverter monitor reports errors and error analyses to you directly, allowing you to service the device promptly and precisely. The advantage – the sooner an error is identified, the less likely it is that it will lead to a potentially dangerous situation. You will also save precious working time and will eliminate the cost of lengthy error analyses and unnecessary repeated service calls.

The MLPE myth

1. Deceptive safety

The additional MLPE devices (also promoted as "optimizers" with a rapid shutdown function) are designed to protect firefighters from an electric shock in the event of a fire or even prevent the fire from breaking out in the first place. The idea is that the individual PV modules within the system are separated from one another (module-level rapid shutdown), thereby reducing the voltage to a maximum of 80 volts. But does this function actually work reliably in the event of a fire? Firefighters or electricians who simply rely on the rapid shutdown function in an emergency might assume that the system is fully de-energized, leading to a potential misjudgment of the situation. Therefore, without exception, firefighters should always observe the recommended extinguishing distances which are generally applicable to all electrical systems.[8]

2. The more devices, the greater the fire risk

MLPE devices generally need to be plugged to each individual PV module. The number of DC connectors in the PV system is therefore increased by a factor of three in comparison to SMA's string technology (cf. table and diagram below). This increases the likelihood of connections being faulty, for example due to what's known as "cross-mating" of the DC connectors.[9] In a 2015 study, Fraunhofer ISE and TÜV Rheinland examined PV fires in Germany in the previous 20 years.[10] This determined that installation defects were the most common cause of the fires examined. These include faulty DC connections and connectors which were either poorly or not at all crimped. Not usually being noticeable during installation, this can lead to extremely hot electric arcs at the connectors during ongoing system operations, thus causing a PV system fire. This suddenly puts a different complexion on MLPE technology with its significantly increased number of connectors and the particular danger of cross-mating. Rather than resulting in greater safety in the event of a fire, this may even increase the risk of a PV system fire.

"Several countries report that problems with DC connectors are a major cause of failure such as fire hazards in PV systems."
IEC Technical Report[11]

What is cross-mating?

Cross-mating is when the DC connectors of different manufacturers are used together. In particular when installing PV systems with MLPE, an electrician must ensure that the connectors on the PV modules as well as those on the MLPE devices do indeed come from the same manufacturer. The manufacturers often claim their connectors are compatible, but the reliability of the combination in question has never been tested and evaluated by an independent testing institute.

[8] The DIN VDE 0132 standard recommends extinguishing distances of 5 m (solid jet) and 1 m (spray jet) and water as the extinguishing agent. Scientific measurements confirm that if these specifications are observed, there is no risk for the emergency services when extinguishing PV systems, cf. Sepanski et al., "Assessing Fire Risks in Photovoltaic Systems and Developing Safety Concepts for Risk Minimization," TÜV Rheinland Energie und Umwelt GmbH, 2018, page 131

[9] A risk which, according to a report by the International Electrotechnical Commission (IEC), is one of the most common causes of PV system fires

[10] Sepanski et al., "Assessing Fire Risks in Photovoltaic Systems and Developing Safety Concepts for Risk Minimization," TÜV Rheinland Energie und Umwelt GmbH, 2018, page 56 ff.

[11] "IEC TR 63225:2019: Incompatibility of connectors for DC-application in photovoltaic systems," International Electrotechnical Commission (IEC), 2019-6

String inverters vs. MLPE

	String Inverter	MLPE
(Additional) electrical devices on the roof	0	200
No. of DC connectors in the PV system	200	600 (=3×)
Total no. of electronic components in the PV system	Approx. 2,000	Approx. 60,000 (= 30×)

Table: Example calculation for a commercial PV system with Sunny Tripower CORE1 (50 kW_{AC}/60 kW_P – 200 PV modules, each 300 W_P)

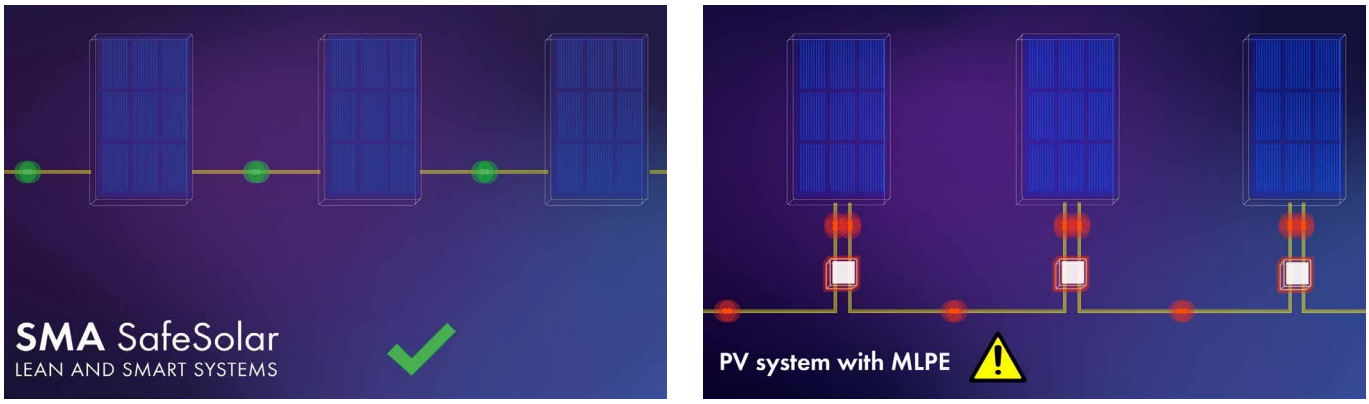


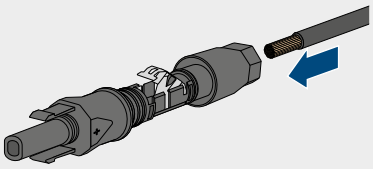
Diagram: The likelihood of cross-mating increases as the number of connectors in a PV system with MLPE increases. This can lead to dangerous electric arcs and can cause a PV system fire.

SUNCLIX

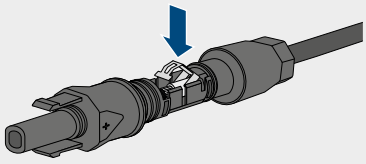
For safe connections

SMA has been successfully solving the problem of cross-mating for years with its proven SUNCLIX DC connector system. SUNCLIX allows the PV module string and the PV inverter to be connected safely and reliably irrespective of the PV modules' DC connector system. SUNCLIX connectors are delivered free of charge with all SMA inverters. In just a few steps, you can replace any kind of DC connector with a SUNCLIX connector. No special tools are needed.

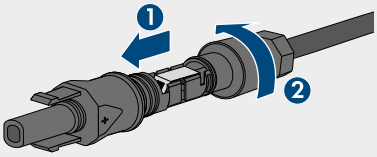
1. Insert stripped PV conductor



2. Push down spring and click into place



3. Screw gland tight – done!



No special tools necessary.

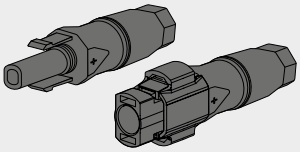
Lean systems: less is more

Lean system design clearly plays a key part in PV system safety. PV systems with SMA string inverters do not require any additional MLPE devices or any other additional hardware to be safe. They avoid any unnecessary wiring and reduce the risk of cross-mating. With SMA's lean system design, you will save precious working time already at the PV system planning stage as well as cost for the system's operation and maintenance. All work involved with installing, servicing, and replacing of MLPE devices on the roof, as well as the associated risk of accidents, are therefore eliminated.

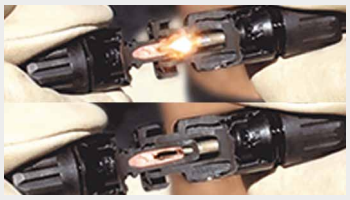
"Often safety components like fuses and switches are integrated in the DC part of PV systems. In the individual case it must then always be checked whether this measure is really necessary. Each additional component poses the risk of additional contact points and other sources of faults. A 'sleek' system with as few components as possible has the advantage of having fewer points where damage could occur to the system."
TÜV Rheinland[12]

Lean system design for greater safety

1. Risk of accidents significantly reduced for electricians
The fewer devices you have to install or possibly repair, the less time you have to spend on the roof. This significantly reduces the risk of potential accidents such as falls. Thanks to the SMA service and monitoring feature Smart Connected, many service calls for PV systems with SMA string inverters can be handled safely and swiftly directly on the inverter, for example in the basement.



2. Avoidance of cross-mating
You can avoid the likelihood of cross-mating by having a smaller number of DC connectors and by using uniform SMA SUNCLIX connectors – a risk which, according to a report by the International Electrotechnical Commission (IEC),[13] is one of the most common causes of PV system fires.



3. Electric arcs interrupted
The Arc Fault Circuit Interrupter (AFCI) efficiently recognizes electric arcs in the PV system and then interrupts the electric circuit, thereby reliably preventing possible overheating or even a PV system fire. SMA's ArcFix is incorporated directly into the inverter, making the installation of additional AFCI devices superfluous. SMA allows for a lean system design in this respect, too.

[12] Sepanski et al., "Assessing Fire Risks in Photovoltaic Systems and Developing Safety Concepts for Risk Minimization," TÜV Rheinland Energie und Umwelt GmbH, 2018, page 204
[13] "IEC TR 63225:2019: Incompatibility of connectors for DC-application in photovoltaic systems," International Electrotechnical Commission (IEC), 2019-6

Summary and conclusion

PV systems on the roofs of houses and apartment buildings and on commercial and industrial operations are one of the keys to a secure and decentralized supply of energy from renewable sources. With your expertise as an electrician, you play a key part in making the transition to a sustainable energy future a success, be it in terms of professional customer advice or on-site system planning and installation. SMA can support you here with high-quality string inverters equipped with intelligent software features that make lean system design possible and do not require additional MLPE devices. Thereby, they lay the foundations for reliable PV system operation.

Developing and installing lean systems

With our SMA Solar Academy, we additionally offer a variety of installation training courses and qualification courses that will help you to optimally install our products for the maximum benefit of your customers.

Find a course

SMA SafeSolar

SMA has been developing perfectly coordinated system components for PV systems for approximately 40 years. We intentionally keep PV systems lean and minimize their susceptibility to errors by incorporating innovative safety technologies directly into our inverters. We call this holistic approach SMA SafeSolar.

Learn more
SMA.de/safety

SMA ENERGY THAT CHANGES

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