TEMPERATURE MONITORING PHOTOVOLTAIC SYSTEMS

Isen, June 2024

Early warning with the d-LIST system.

This white paper describes the use of the d-LIST sensor cable system from LISTEC GmbH for the early detection of overheating and fire hazards in solar and photovoltaic systems. It explains typical thermal risks, highlights technical and organisational solutions, and provides recommendations for installation, integration, and maintenance within existing fire alarm and monitoring systems.

Table of contents

1. Introduction & press reports

Defective photovoltaic systems can trigger large-scale, devastating fires. The damage is immense.
The **d-LIST system** protects human lives and production losses.

Fires caused by photovoltaic systems.
Examples from press reports:

March 04, 2024, Leipzig
Cable in the photovoltaic system burns through:
Farmer sounds the alarm

https://www.agrarheute.com/energie/leitung-photovoltaikanlage-schmort-landwirt-schlaegt-alarm-617257

May 30, 2024, Erding
Fire on the roof of a children's home:
quick rescue

https://www.merkur.de/lokales/erding/erding-ort28651/brand-auf-kinderhaus-dach-schnelle-rettung-kinderhaus-erding-93100656.html

2. Fire risks & triggers

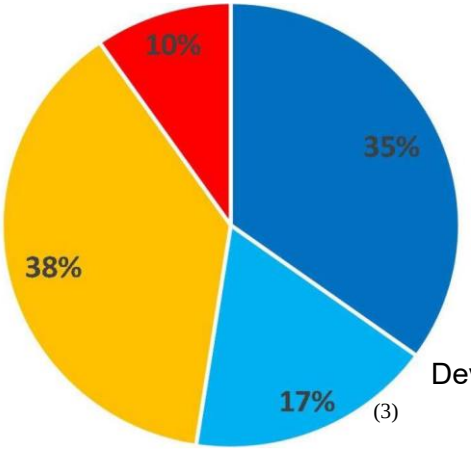
In principle, photovoltaic systems do not pose a greater fire risk than other electrical systems.
Various studies have shown this:

- 0,029 fires per installed MW.
- Share of less than 0.061 % of the total number of fires

However, the number and installed capacity will increase in the future, while at the same time, already installed systems will become older and the risk of faults due to ageing, contact resistance, moisture, etc., will increase. (1)
For outdoor installations, the risk of forest and meadow fires must be categorised as very high (in the millions).

Main causes of fires:

- 38% - due to installation errors (plug and terminal contacts, ...)
- 35% - due to faulty panels
- 17% - due to planning errors (voltages / currents, ...)
- 10% - due to external factors



(3)

Devastating consequences:

There are two ways to categorise how a photovoltaic fire can start: a failure within the components themselves or by adverse external influences.

Internal causes:
- Inferior products (frost cracks in the glass, etc.)
- Poor assembly technology
- Inadequate maintenance

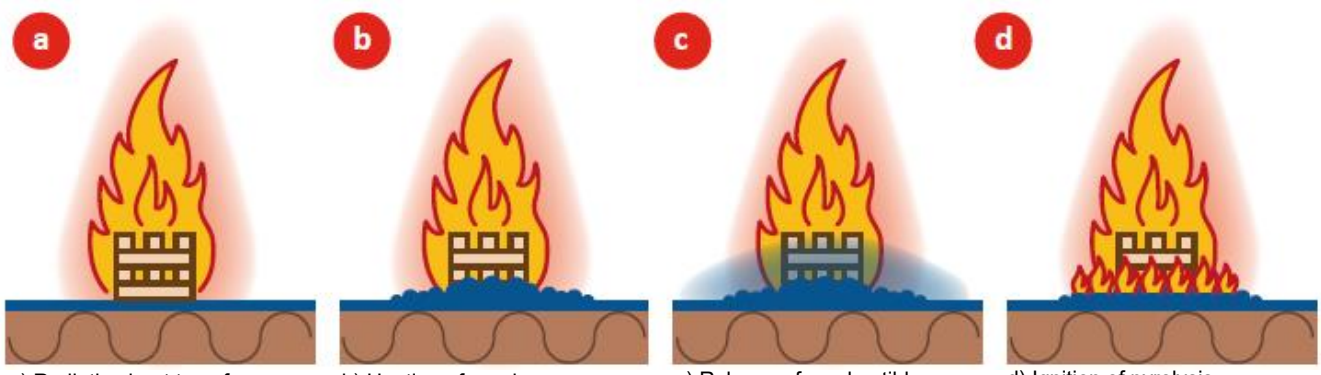
External causes:
- Contamination
- Shading
- Movement (e.g. due to wind)
- Impacts (birds, hail, ...)
- Ignition by flares from forest fires

(2) Source: TÜV (Deutschland 2018) BRE (UK 2017)
(3) Source: A Review on Safety Practices for Firefighters During Photovoltaic (PV) Fire

Fire spread

There are numerous aspects that determine the fire dynamics of a roof with a PV system. Research has shown that assessing the fire risk of a PV system based solely on the evaluation of individual materials and components of the individual products can lead to incorrect conclusions. Instead, it has been found that it is necessary to consider the PV system as a system consisting of several parts, namely the modules, the mounting equipment, and the roof structure, in order to correctly assess the fire risk. For this purpose, system approvals are being developed by the insurance industry. The addition of a PV system changes the situation in the event of a fire. A flame can be deflected under the panels, causing a considerable amount of heat to be reflected back onto the roof surface. This can cause the flames to spread to areas where there would otherwise be virtually no flames (provided that the roofing membrane used has the appropriate fire rating). The following illustrations (according to Kristensen, 2022) schematically show the scenarios with and without a built-in panel (this also applies to flat-mounted modules).

Fire without overlying panels: No (or negligible) flame spread beyond the ignition source (here a wooden scaffold used in the tests, which confirms this fire development).



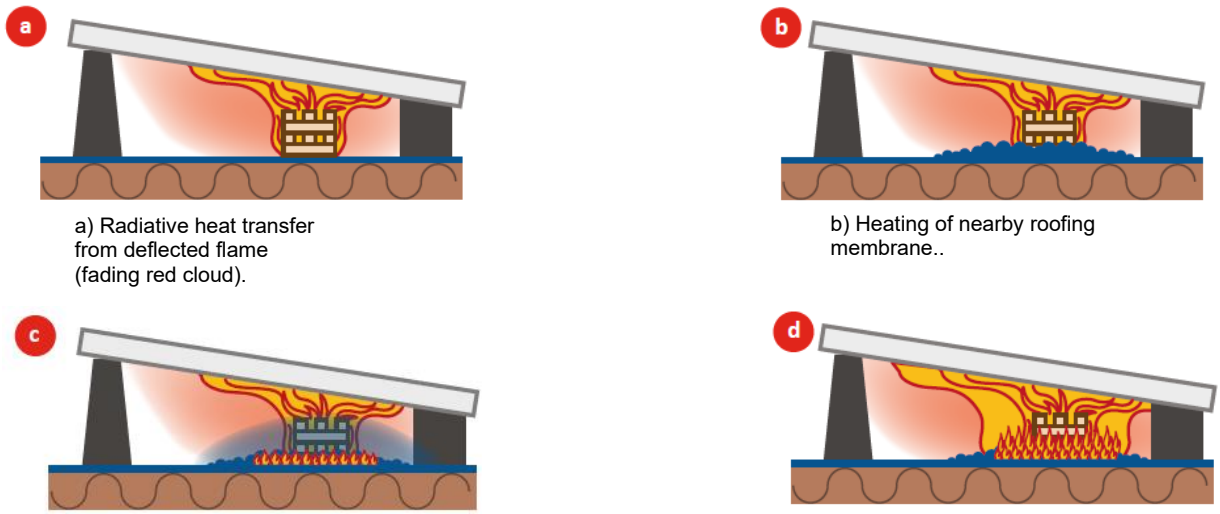
a) Radiative heat transfer from ignited wood crib (fading red cloud).

b) Heating of nearby roofing membrane..

c) Release of combustible pyrolysis gases (fading blue cloud).

d) Ignition of pyrolysis gases, additional radiative heat transfer, but no self-sustained flame spread.

Illustration of the ignition and flame propagation process of a wooden scaffolding on a roof structure (blue roofing membrane, brown insulation). With a PV module above (slanted grey rectangle): Significant flame spread below the PV panel. Note that the roof covering, roofing membrane and the insulation material underneath were identical in both cases.



a) Radiative heat transfer from deflected flame (fading red cloud).

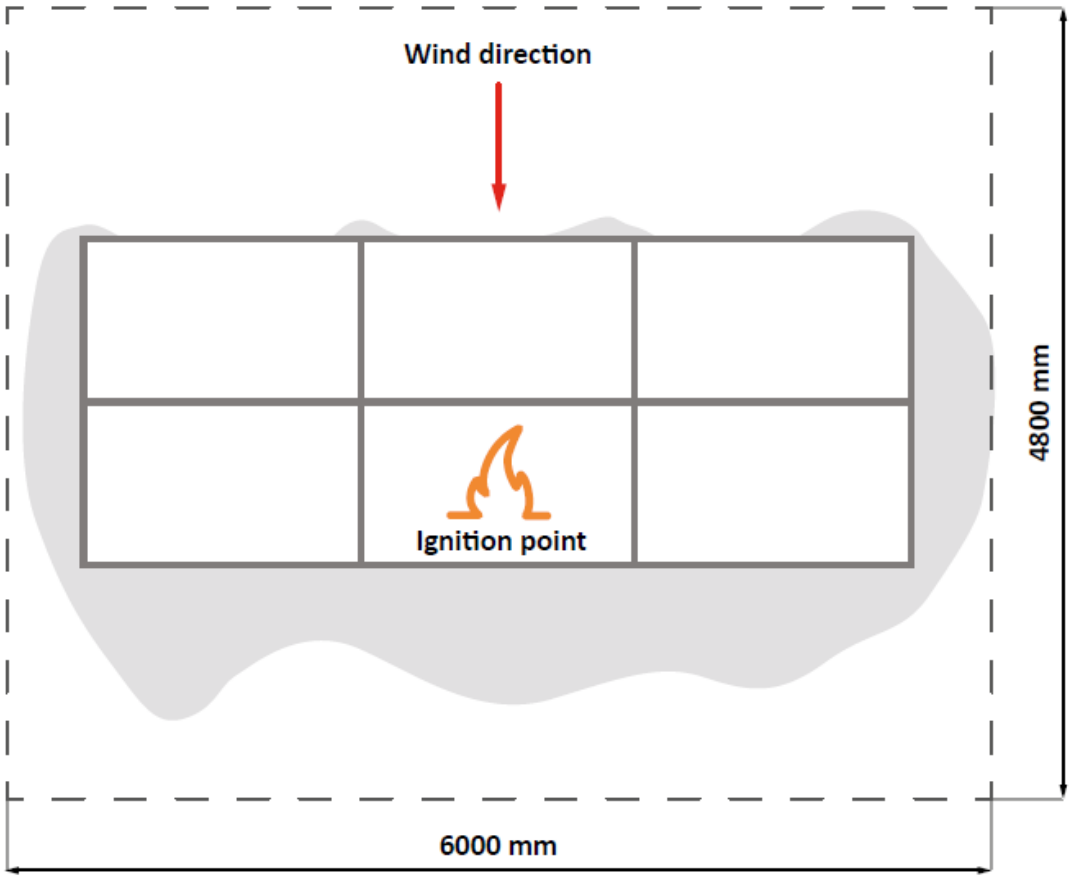
b) Heating of nearby roofing membrane..

c) Release of combustible pyrolysis gases and initial ignition (fading blue cloud).

d) Increased heat release rate due to higher mass flux of pyrolysis gases, heating of nearby materials and self-sustained flame spread.

All configurations have demonstrated that a PV system exceeds the extent of fire spread beyond what would be expected on an otherwise similar roof. This has been observed in both real fires and experiments. Outside the area covered by the panels, fire spread typically comes to a halt after a relatively short distance. The figure below (adapted from Kristensen and Jomaas, 2018) shows the results of experiments conducted outdoors under real conditions. The grey area in the figure shows the extent of the fire spread.

Fire tests on roofs with PV systems have shown that fires do not usually spread far beyond the area of the PV system (adapted from Kristensen and Jomaas, 2018). These findings are generally supported by actual fires on roofs. [4]



[4] Source: https://www.frissbe.eu/news/publication-of-building-applied-photovoltaics-bapv-fire-safety-guideline

3. Solutions LISTEC

LISTEC GmbH has been developing, manufacturing, and distributing a sensor cable system for early fire detection and temperature measurement for over 30 years. The company is located near Munich, from where we distribute our products all over the world – **"Made in Germany."** The robust, enclosed design of our cable makes it ideal for the most adverse conditions, such as dust, dirt, sun, and rain. Our focus is on decades of use in tunnel systems, PV systems, and conveyor belt systems.

Our sensor cable has individual temperature sensors installed at defined intervals, which allow us to pinpoint the location of temperature increases. In the case of **PV systems**, we use this not only for early fire detection, but also for temperature monitoring of the solar cells.

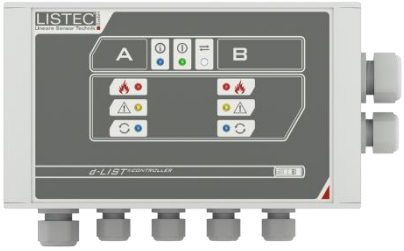
Temperature monitoring of photovoltaic and solar systems

For early fire detection and efficiency monitoring, seamless temperature monitoring of the systems is essential. This is where the **d-LIST / SEC 15 system** can make significant improvements possible.

- Protection of human life in private and public buildings with solar systems on the roof
- Comprehensive early fire detection and warning systems
- Temperature monitoring of solar cells to increase efficiency
- Control of cooling and extinguishing systems
  (see existing VdS protection concept S619004 PV-Protect)
- Control of systems and disconnection from the grid

Advantages of the d-LIST system:

- Differential and maximum temperature evaluation
- Resistant to dust/dirt/gases/vibrations
- Can be installed in single-branch mode or with multiple branches
- Measurement resolution (always 0.1 °C, internally 0.0625 °C for d-LIST)
- Repeatability (always ± 0.1 K along the entire cable length)
- Freely selectable sensor spacing, individual identification possible at any time via cable markings
- Systems are generally maintenance-free, resulting in long-term cost savings
- Low commissioning and maintenance costs
- Calibration-free and location-specific resolution in the event of a fire over the entire service life
- Use of external sensors for specific object monitoring can be integrated into
  sensor cable installations



MADE IN GERMANY

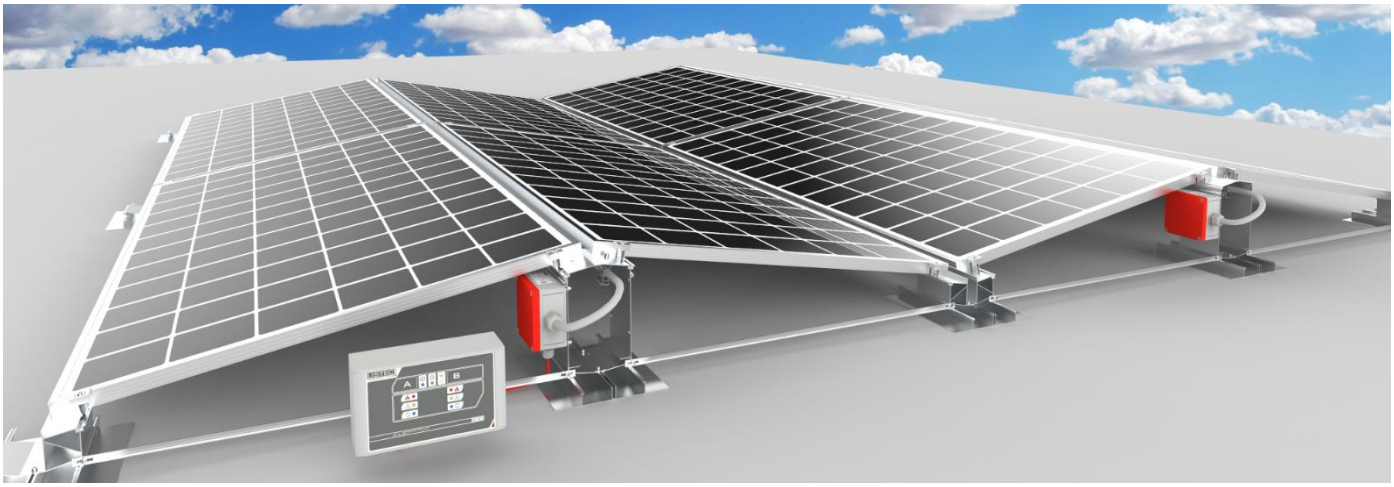
4. Application/mounting/monitoring

Application on industrial units

- To avoid production stoppages and high investment losses
- Risk of overheating, e.g. due to faulty/defective installation/overloading

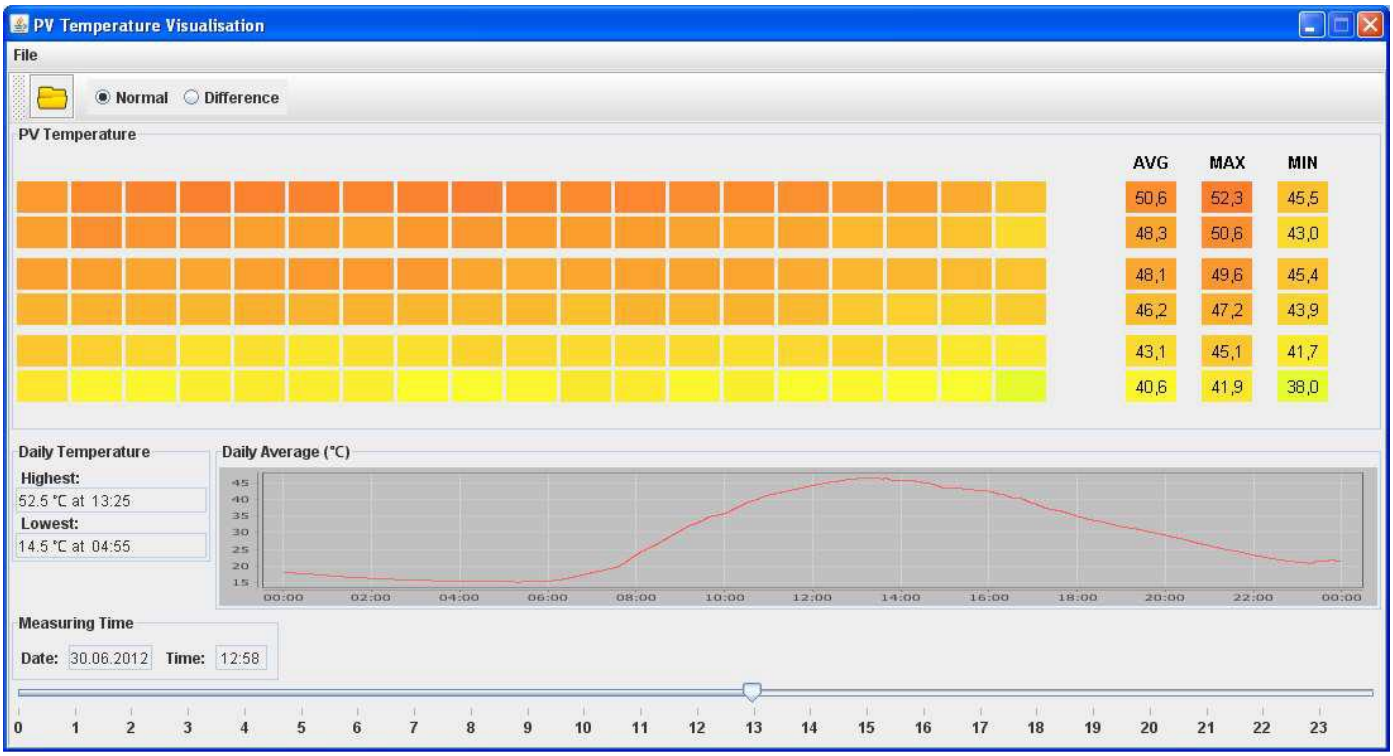
Attachments

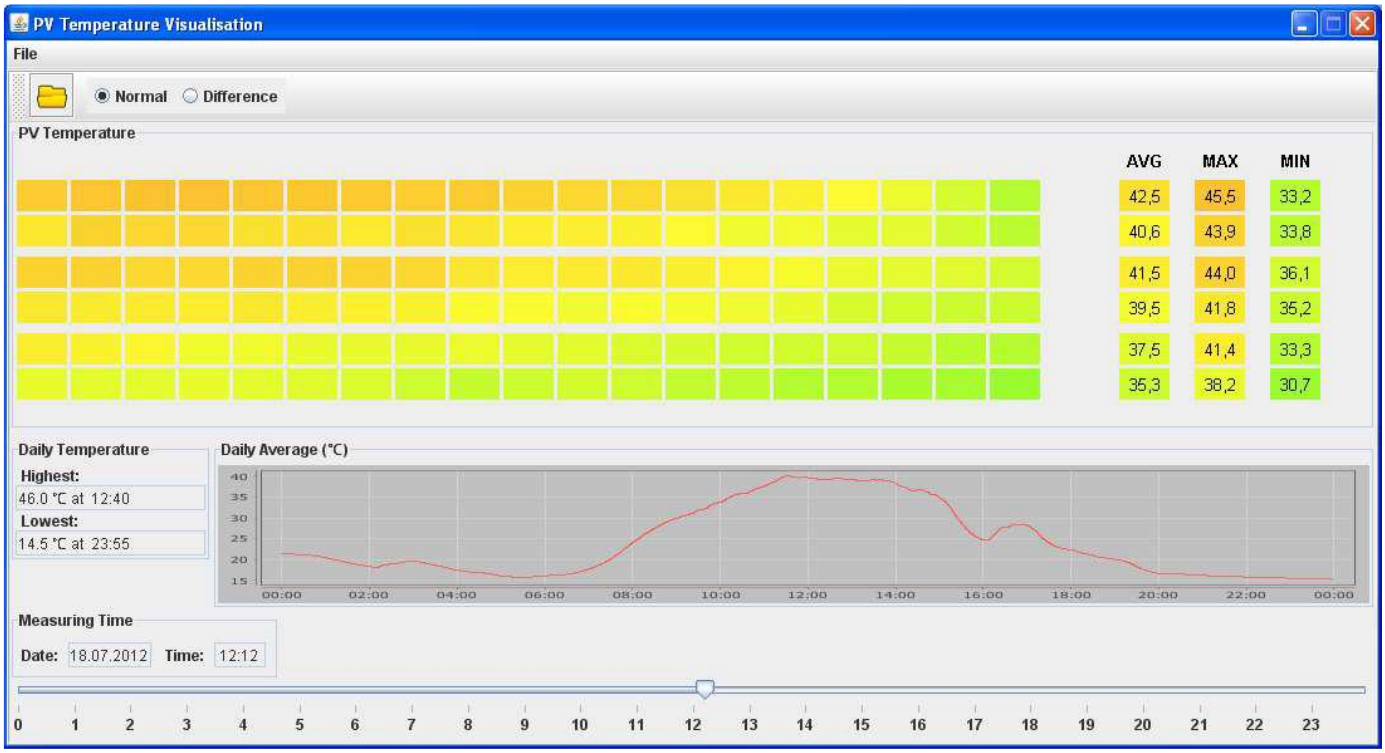
Fastening the sensor cable to mounting profiles with polyamide or stainless steel clamps



Visualisation

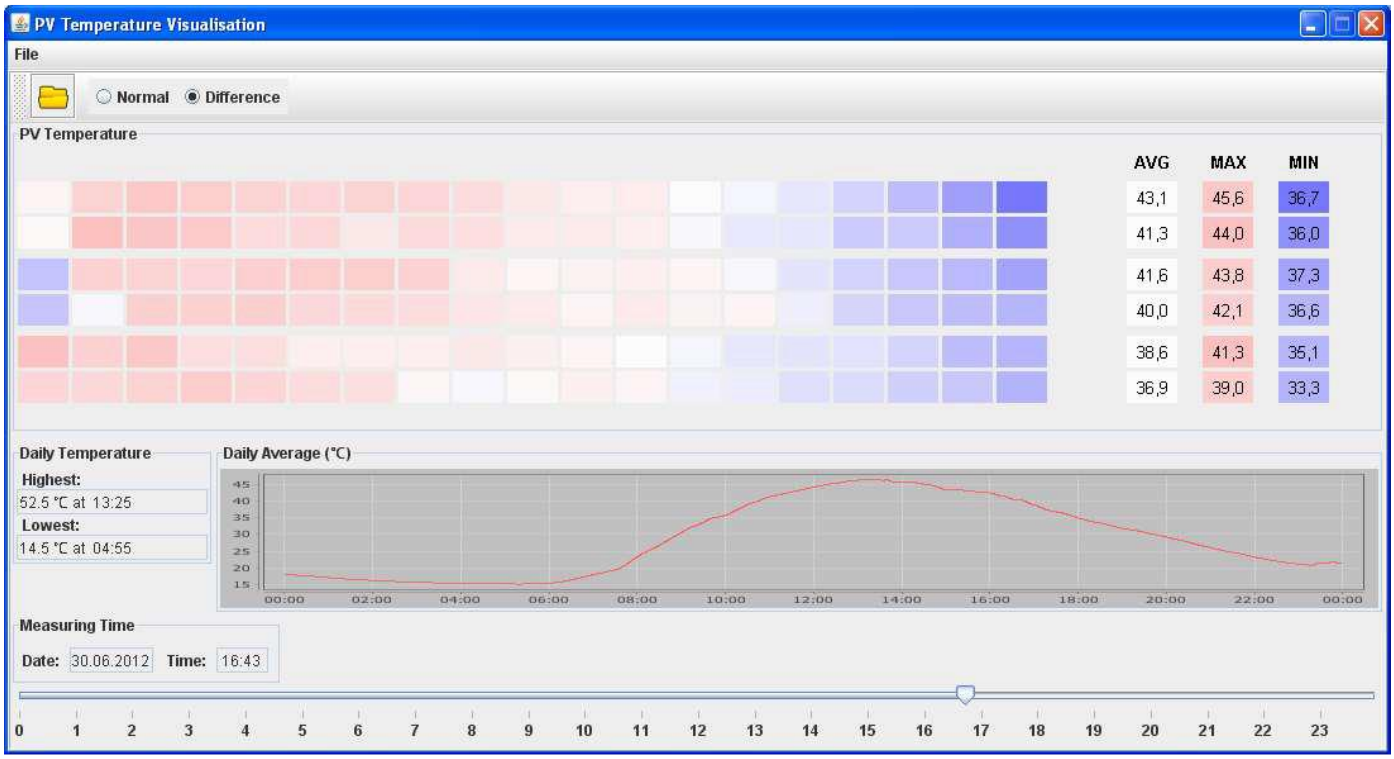
Temperature distribution over solar panels, over the course of 24 h.





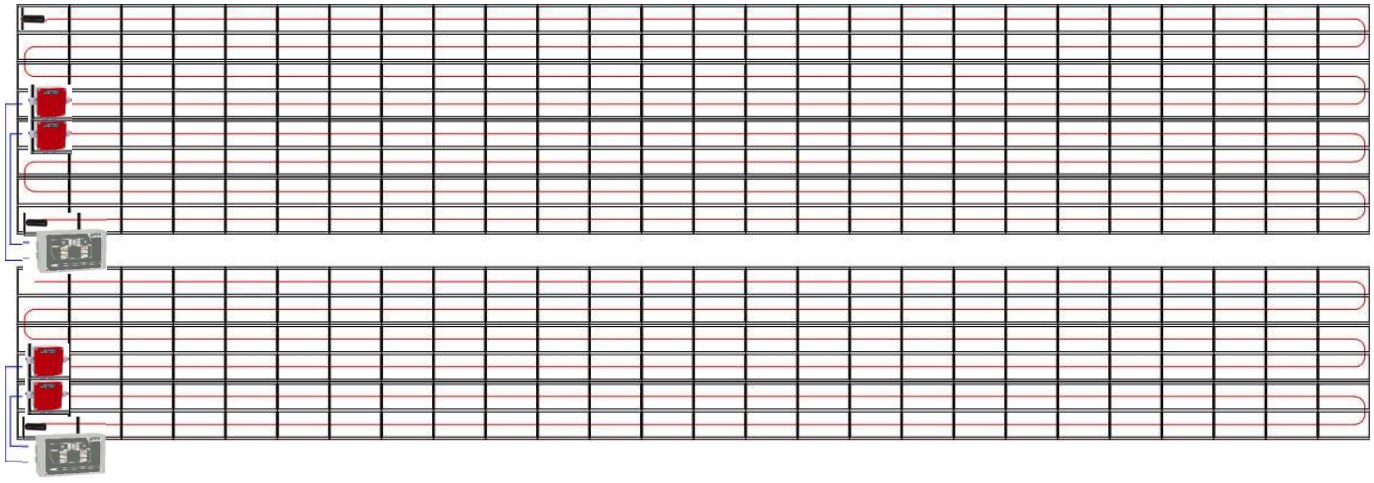
Visualisation

Temperature distribution with detection of shading and cooling by wind.



Installation

- Recommended sensor distance: 3 m or 4 m
  - Sensor cable **SEC 15**
  - Connection cable **CC 15**



5. Extract from certificates

The d-LIST / SEC 15 system is, among other things, a VdS-approved system in accordance with EN 54-22:2015+A1:2020:

Anerkennung
Approval

VdS

von Bauteilen und Systemen
of Components and Systems

Inhaber der Anerkennung / Holder of the Approval

LISTEC GmbH
Am Sandberg 34
DE-84424 Isen

Anerkennungs-Nr. / Approval No.	Anzahl der Seiten / No. of pages	gültig vom (TT.MM.JJJJ) / valid from (dd.mm.yyyy)	gültig bis (TT.MM.JJJJ) / valid until (dd.mm.yyyy)
G 221004	14	26.06.2023	25.06.2027

Gegenstand der Anerkennung / Subject of the Approval

Rücksetzbarer linienförmiger Wärmemelder /
Resettable line-type heat detector
d-LIST

Verwendung / Use

in automatischen Brandmeldeanlagen /
in automatic fire detection and fire alarm systems

Anerkennungsgrundlagen / Basis of the Approval

VdS 2344:2014-07
VdS 2543:2021-03
EN 54-17:2005 + AC:2007
EN 54-22:2015 + A1:2020

Die Anerkennung umfasst nur das angegebene Bauteil/System in der zur Prüfung eingereichten Ausführung

- mit den Bestandteilen nach Anlage 1,
- dokumentiert in den technischen Unterlagen nach Anlage 2,
- zur Verwendung in den angegebenen Einrichtungen der Brandschutz- und Sicherungstechnik.

Bei der Anwendung des Gegenstandes der Anerkennung sind die Hinweise nach Anlage 3 zu beachten.

Das Zertifikat darf nur unverändert und mit sämtlichen Anlagen vervielfältigt werden. Alle Änderungen der Voraussetzungen für die Anerkennung sind der VdS-Zertifizierungsstelle – mit/samt den erforderlichen Unterlagen – unverzüglich zu übermitteln.

This Approval is valid only for the specified component/system as submitted for testing

- together with the parts listed in enclosure 1
- documented in the technical documents according to enclosure 2
- for the use in the specified fire protection and security installations.

When using the subject of the approval the notes of enclosure 3 shall be observed.

This certificate may only be reproduced in its present form without any modifications including all enclosures. All changes of the underlying conditions of this approval shall be reported at once to the VdS certification body including the required documentation.

VdS Schadenverhütung GmbH
Amsterdamer Str. 174
D-50735 Köln

Ein Unternehmen des Gesamtverbandes der Deutschen Versicherungswirtschaft e.V. (GDV), durch die DAkkS akkreditiert als Zertifizierungsstelle für Produkte in den Bereichen Brandschutz und Sicherungstechnik

For more information, scan the following QR code:

LISTEC GmbH
Am Sandberg 34
D-84424 Isen, Germany
Phone: +49 (0) 80 83 53 85-0
Email: sales@listec-gmbh.de