

# **Conformity of photovoltaic installations**

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## 1 Project background

One of the tasks of the Finnish Safety and Chemicals Agency (Tukes) is to act as the electrical safety authority in Finland. Tukes maintains and promotes safety through supervision, development activities and communication.

The green transition, rising electricity prices and the need to save energy have strongly increased consumers' interest in acquiring a photovoltaic system for their property. As the number of systems has grown, Tukes has received an increasing number of enquiries regarding the installation and safety of photovoltaic systems, both from installers and consumers. Tukes has been informed of a considerable number of incorrect and unprofessional installations, as well as some installations completed by persons without the proper qualifications.

From the perspective of electrical and fire safety, it is essential that systems are installed in accordance with the technical requirements. Due to the special features of the DC components in photovoltaic systems, compliance with technical requirements, correct installation methods and careful installation work are especially important.

Based on the enquiries, operators already active in the industry and operators starting or considering the installation of such systems are uncertain about both the regulations guiding the operations and the technical requirements.

The enquiries, notifications and supervision observations indicate that some of the operators have not had the necessary professional expertise. Direct violations of the Electrical Safety Act (1135/2016) have also been detected.

Tukes has reacted to the situation with targeted supervision and by adding basic information about photovoltaic systems on its website. Observed issues have been highlighted in various connections, such as newsletters to professionals. A press release on the subject matter has been prepared, drawing the attention of consumers and clients to the procurement and requirements of such systems.

As a result of the media attention received by the press release, consumers' enquiries to Tukes increased even more.

At the end of 2022, Tukes launched a technical inspection project in which the conformity of photovoltaic installations and the extent of issues encountered were investigated.

The technical inspections required for the project were acquired from electrical inspectors accredited by Tukes. Link: [Inspection activities | Finnish Safety and Chemicals Agency \(Tukes\)](#)

The project was limited to systems operating in parallel with the electricity network, i.e. systems connected to the property's 230/400 V electricity connection. The focus of the project is on detached houses owned by private individuals and properties such as farms.

The information obtained through the project will be utilised in the planning and targeting of Tukes' risk-based supervision. The main objectives are to promote the expertise of operators in the electrical industry regarding the regulations and technical requirements, and to emphasise and improve the responsibility of operators. The project results will be utilised in communication, for stakeholder lectures and in supervision activities at the operators' facilities, for example.

## 2 Project implementation

The project was realised in geographically limited areas across Finland. The inspections were carried out by electrical inspectors providing their services in these areas.

Contact details of the sites to be inspected were requested from registers maintained by regional distribution network operators for the purpose of supervising electrical safety. According to the Electrical Safety Act (1135/2016), the distribution network possessor shall keep a register of connected electrical installations in its supply area. The register shall contain the information on the basis of which the type, installer, possessor or owner of the equipment can be appropriately established for the purpose of supervising electrical safety and investigating any accident.

The Tukes project team first contacted the possessors of the installations and enquired their willingness to have their installations inspected as part of the project. To avoid any ambiguity and misuse, the possessors of the installations to be inspected were sent an official letter by Tukes indicating the contact details of the project contact person in Tukes.

The scope of the technical inspection related to the project covered the photovoltaic system to the point where it is connected to the property's electrical system. This inspection and the available information were to be used to determine any technical installation defects and deficiencies. Other matters covered by the inspection included the preparation of the necessary documentation such as a commissioning inspection record as required by the Electrical Safety Act and the necessary drawings, diagrams and instructions, and handover of the documentation.

The inspections were technical audits in nature. However, the inspection had to comply with the designation requirements set for electrical installation inspection activities in the Electrical Safety Act.

The inspectors agreed on the inspection date with the possessors. The findings were reported through Webropol using a template prepared with the inspectors at a steering meeting.

The distribution network companies were asked to provide information on photovoltaic systems recently connected to the grid in different parts of Finland. Supervision of the operating authorisation required for electrical installation work was also carried out as part of the project. The details of the installers submitted to the distribution network companies were compared with the operation notifications entitling to electrical work submitted in Tukes's register of electrical contractors.

A total of 45 installed photovoltaic systems were selected for the technical inspections. The inspected photovoltaic systems were systems parallel to the distribution network. The inspections were targeted by including a sample of electrical contractors reported as installers, several types of properties and systems of different sizes.

## 3 Technical requirements for photovoltaic systems

The inspections performed by the project took place in the spring of 2023. The starting point was a technical inspection based on the requirements in Part 7-712 on photovoltaic systems of the 2017 edition of the SFS 6000 standard on low voltage electrical installations in properties.

SFS 6000 was renewed in the autumn of 2022. The changes to the requirements caused by the new edition of the standard were taken into account in the inspections when the installer stated that it had complied with the new edition of the standard, listed by Tukes from the beginning of 2023. Link: [List S10-2023 \(tukes.fi\)](https://tukes.fi/en/ajankohtaiset/2023/05/10/ajankohtaiset/2023/05/10/list-s10-2023)

According to the Electrical Safety Act, when a standard is replaced with a new standard or a new issue of the standard is published, an electrical installation under construction at the time of the updating of the list may be completed and put into service in accordance with the previous standard within three years of the updating.

The electricity section on the Tukes website contains basic information on photovoltaic systems, technical requirements and the required operating authorisations for electrical installation work: [Aurinkosähköjärjestelmät | Finnish Safety and Chemicals Agency \(Tukes\)](#).

#### 4 Analysis of the inspection reports

A summary of the extensive inspection reports is available in Appendix 1 to the report. The text for each section includes the inspectors' comments on nonconformities and recurring observations, taken from the inspection reports.

Photos from the inspections have been compiled in Appendix 2 to the report.

The possessor of each inspected installation will be provided with the report prepared for Tukes where the inspector specifies the sections where the installation did not meet the requirements or where it could not be determined to meet the set safety level during an inspection of this scope, in which case it is recommended/required that the possessor further investigates the matter to ensure safety.

#### 5 Summary of inspection results

Based on the results of the project inspections, the photovoltaic systems at many of the inspected sites have been carelessly, negligently or downright unprofessionally installed.

The inspection observations and the photographs of errors and nonconformities attached to the inspection reports are recurring and similar to the customer notifications received by Tukes.

The most significant errors and nonconformities can be divided into three parts: inadequate commissioning inspection and/or related documentation, improper non-standard installation of the wiring system, and noncompliance with the manufacturer's installation instructions.

The commissioning inspection record required by the Electrical Safety Act was available in approximately two-thirds of the inspected sites (70%). Of these records, only approximately one-third (32%) complied with both the regulations and the documentation requirement of the installation standard.

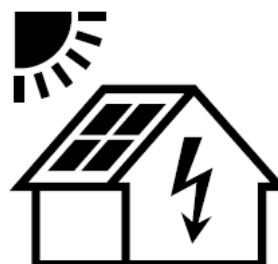
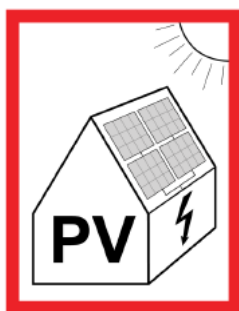
There were technical defects not related to documentation in forty (40) of the inspected forty-five (45) photovoltaic systems. In other words, approximately 11% of the installations were assessed as not having any defects that had a significant impact on conformity and operational safety.

A general nonconformity with the commissioning inspections was inadequate execution of commissioning inspections and measurements of the DC part of the system, or at least inadequate documentation of the inspections (SFS 6000 712.6.101 and SFS-EN 62446-1).

Defects involving the installation of wiring systems were focused on the cabling of the systems' DC parts. Cables and connectors had not been properly attached or supported and cable conduits had not been used as necessary, as a result of which the cables were hanging or resting incorrectly on the roof freely exposed to damage caused by flowing water and sliding snow and ice, among other hazards. On the other hand, some cables had been fixed with cable ties onto roof accessories such as catwalks and snow barriers. Some cables were caught between the eaves lead and ridge flashing in such a way that the cable sheath was in danger of being crushed and breaking against sharp edges.

The equipment manufacturer's instructions had not been followed at a number of sites where compliance with the previous edition (2017) of SFS 6000 had been reported. The nonconformities included incorrect placement of the inverter on a surface made from a combustible material and deficiencies involving equipotential bonding, which have since been included in the requirements for photovoltaic systems in SFS 6000 (the 2022 edition).

- Other common observations were deficiencies with warnings about there being a photovoltaic system at the property:



In the reports, the inspectors commented that it was challenging, if not impossible, to determine the conformity of the plugs and connectors for the DC components in the installed system. Each connector pair must be electrically and mechanically compatible and suitable for the operating environment. According to the 2022 edition of SFS 6000, products from different manufacturers are not to be used in a connection.

When comparing the data obtained from the distribution network companies' register with Tukes' register of electrical contractors, no unauthorised electrical work was detected by the project.

## 6 Photovoltaic systems must be installed with special care

The direct current (DC) circuits of a photovoltaic system differ technically from the conventional alternating current (AC) circuits of the electrical installations used in buildings, among other locations. Breaking DC circuits is more challenging than AC circuits because there are no electrical current zero points in DC as there are in AC. Disconnecting the current and extinguishing a generated arc is more difficult than with alternating current, because the current does not drop to zero by itself. Furthermore, the DC components of a photovoltaic system do not always have fault-disabling protective devices like the alternating current circuits in buildings.

In the event of a fault, the currents and voltages generated by the photovoltaic arrays in photovoltaic systems parallel to the network are so high that they could cause personal injury and fire damage.

When installing photovoltaic systems, it is therefore of paramount importance to observe due diligence, the safety requirements of the standards and the installation instructions provided by the component manufacturers.

## 7 Required corrective measures

The results of the project support the notion that during this strong period of growth, serious safety deficiencies in the installation of photovoltaic systems have occurred. Noncompliant installations have been observed significantly more often than in other 'traditional' electrical installations in similar properties. However, when examining the results, it should be noted that

the project inspections were targeted at certain types of properties and the inspected sample is quite small.

Electrical operators and appointed supervisors of electrical works must be aware of their responsibilities, ensure that the employees have adequate professional skills, verify proper self-monitoring and, above all,

ensure that the installations are safe and in the condition required by the Electrical Safety Act before commissioning and delivery.

Tukes pays special attention to the installation of photovoltaic systems during its supervisory activities and cooperates with stakeholders in the industry to promote safe practices and the responsibility of operators.

The responsibility for ensuring that the installation of a photovoltaic system in its entirety meets the requirements lies unambiguously with the electrical contractor that installed the system.

In terms of the overall safety, installation and use of photovoltaic systems, it is also necessary to take into account the recommendations of the rescue services to enable rescue operations, to take into account the occupational safety of rescue personnel and to realise good fire safety.

Link: [Fire safety instructions for photovoltaic systems | Rescue services](#)

In summary, a photovoltaic system that has been carefully built by a professional, that meets the safety requirements and that is properly maintained, will produce environmentally friendly clean energy.

## 8 Appendices

Report summary, Appendix 1

Photo attachment, Appendix 2