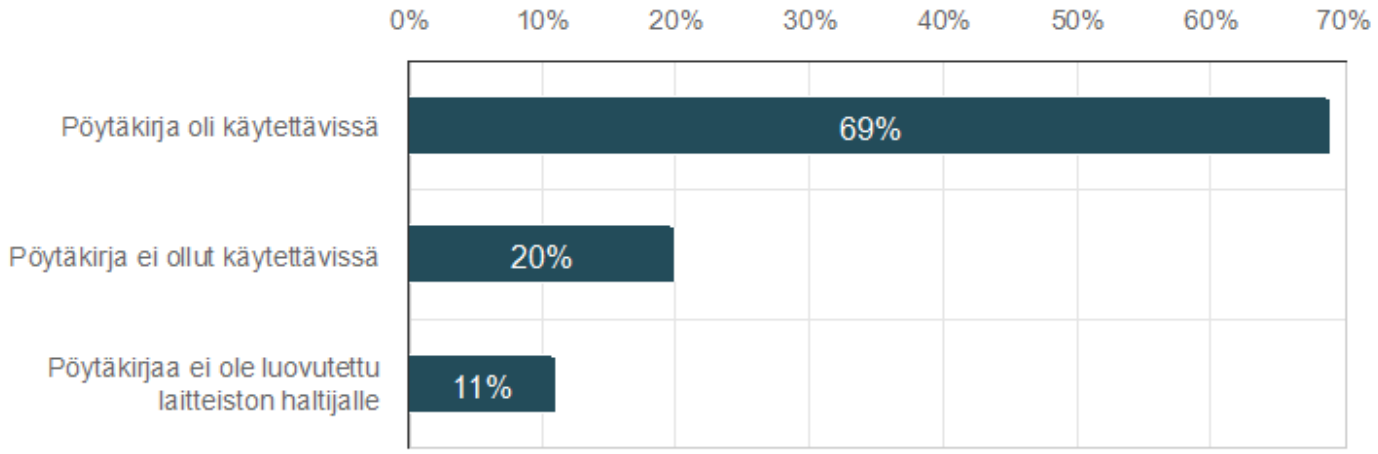
APPENDIX 1.

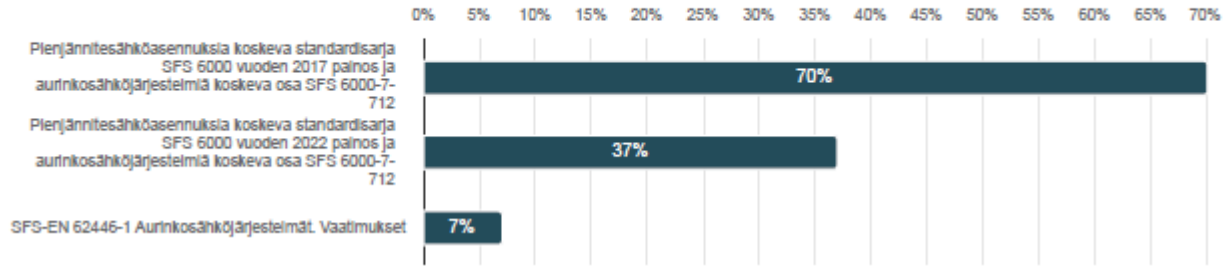
1. COMMISSIONING INSPECTION TO ENSURE THE SAFETY OF THE INSTALLATION AND RELATED DOCUMENTATION

1.1 A commissioning inspection record in accordance with the Electrical Safety Act (1135/2016) was available during the inspection, with which the installer confirmed that the installation met the relevant safety requirements:



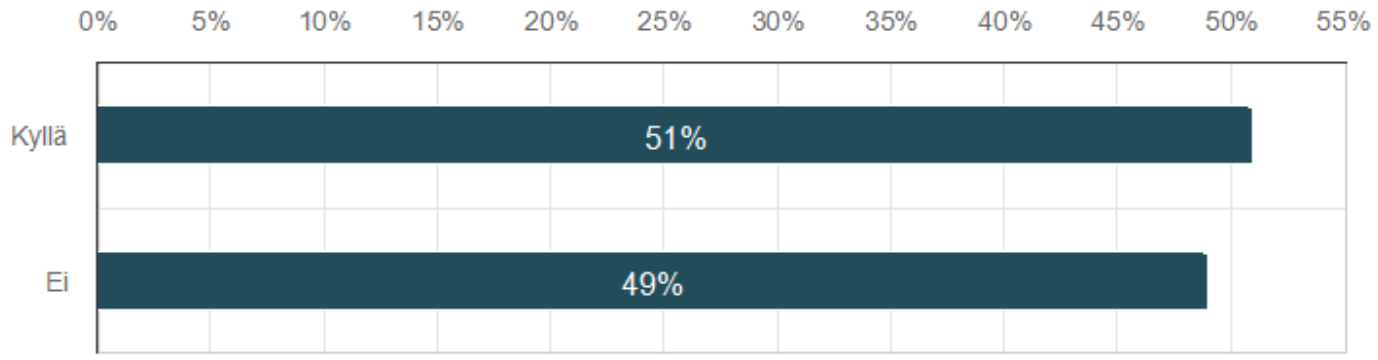
1.2 Standards indicated in the installation commissioning inspection record (list S-10 of the Finnish Safety and Chemicals Agency):

1.2. Asennuksen käyttöönottotarkastuspöytäkirjassa ilmoitetut standardit (Tukes luettelo S-10):

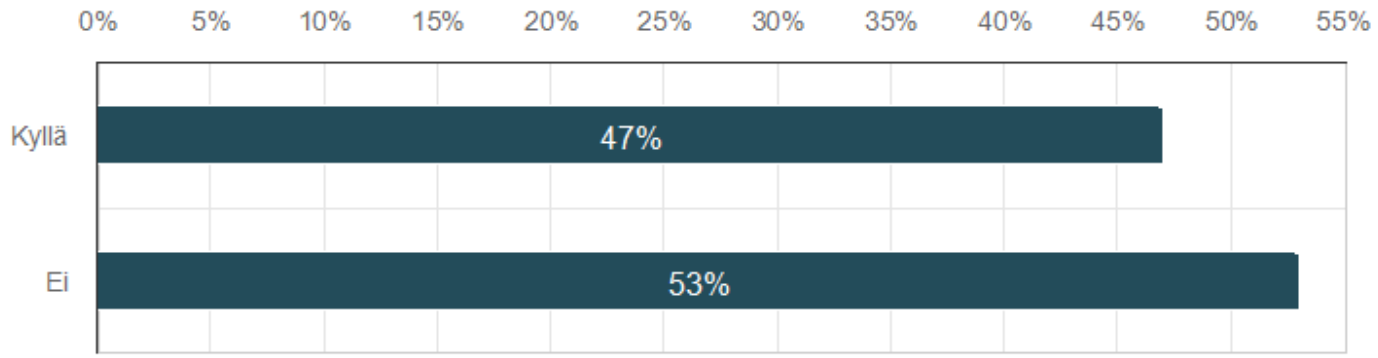


2. CONFORMITY OF THE COMMISSIONING INSPECTION RECORD

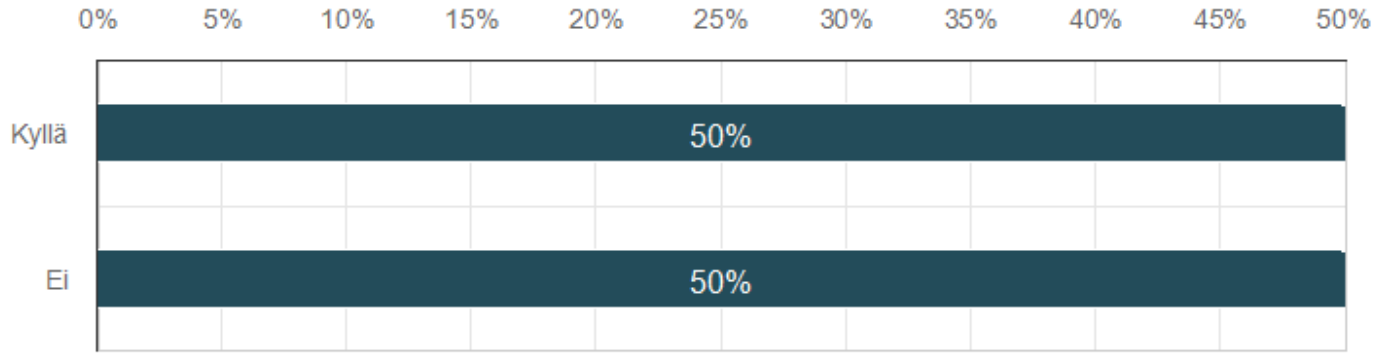
2.1 The record included the information required by the Government Decree on Electrical Installations (1434/2016, sections 4 and 5):



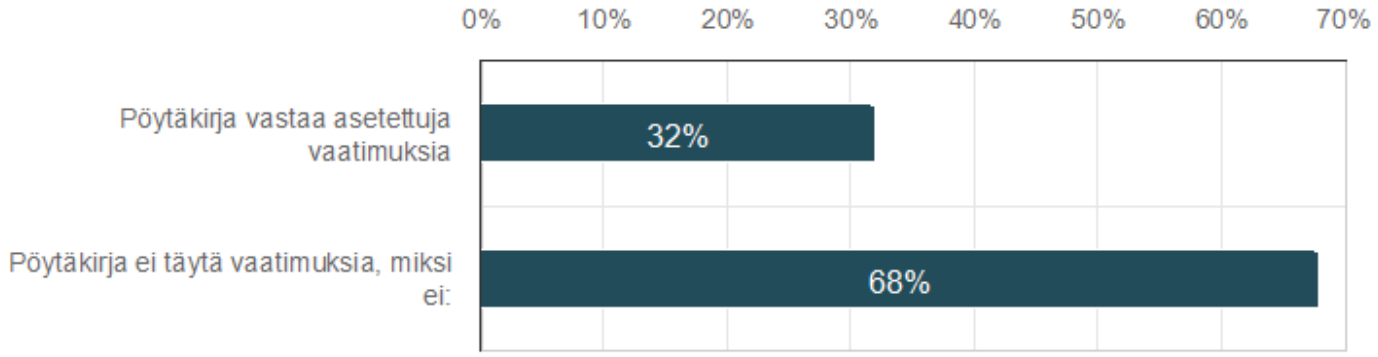
2.2 The record indicated the inspections and tests to be carried out during a commissioning inspection in accordance with Part 6 of the SFS 6000 standard on low-voltage electrical installations, together with the results:



2.3 The record indicated the visual inspections of the photovoltaic system required by SFS-EN 62446-1 and documented Category 1 commissioning tests and inspection results (SFS 6000 712.6.101):



2.4 Compliance of the commissioning inspection record used:



- The record was index form ST 55.36 from the ST card system, Section 1 of which states that the inspections according to SFS 6000-6 are in order and refers to the separate inspection record template ST 51.21.05 regarding the AC part of the system. However, the record template in question was not available for the installations (measurement results of the AC part).

- According to the possessor, no commissioning inspection record for the photovoltaic installations was delivered. The site has AC panels, and therefore the DC part inspections and tests are not required.

- The inspections required for a commissioning inspection in Part 6 of SFS 6000 had been inadequately performed or presented in the record.

- No record of inspections in accordance with SFS 62446-1 was available. The version of SFS-6000 used had not been specified.

- The only measurements performed were system insulation resistance (3.56 mΩ; not specified whether the measurement was on the AC or DC side), final circuit's short-circuit current (767 A) and continuity of earthing 0.3 Ω (not specified whether the measurement applied to the continuity of the AC final circuit protective conductor). No measurements in accordance with SFS-EN62446-1 in the DC part were documented.

- The name and contact details of the supervisor of electrical works were not indicated in the record. The record did not include the tests and inspections in accordance with SFS 6000 712.6.101 (in accordance with SFS-EN 624461-1).

- There were no DC-side measurements, no visual inspection, no reference to the standards used.

- Name and contact details of the supervisor of electrical works were missing. An overview of visual inspections was missing. The required measurements and tests were incomplete.

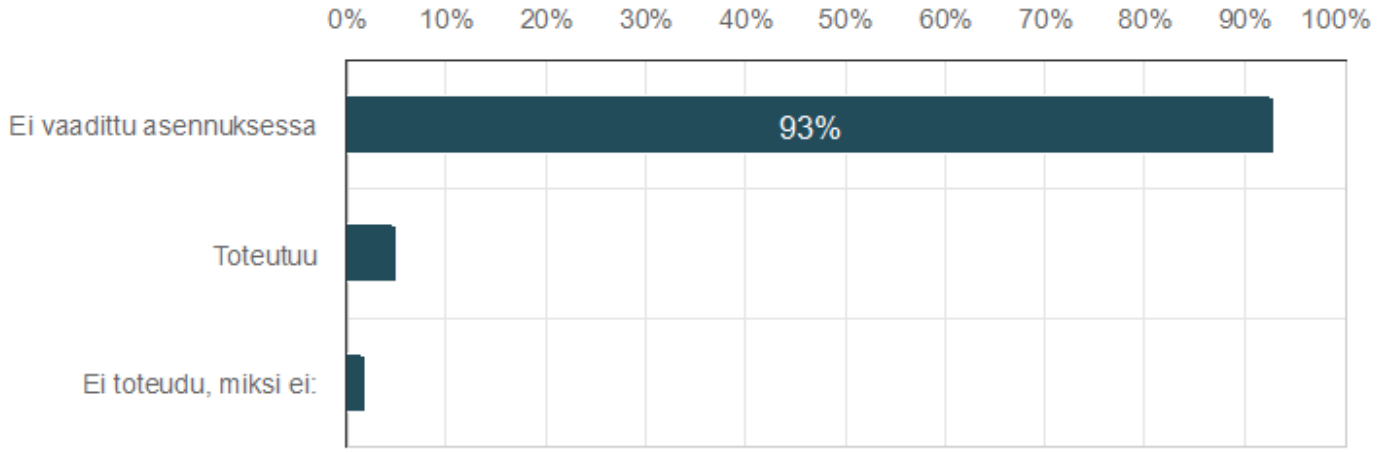
- The name and contact details of the supervisor of electrical works were missing. Some of the AC side measurements were missing. The section in the record on whether the installation meets the SFS 6000 requirements had not been completed. All measurement results from the DC side were missing. The visual inspections did not determine whether they applied to the AC or DC side, etc. The record was named 'Photovoltaic system commissioning inspection record'. The work site and work area had not been delimited either.

3. PROTECTION AGAINST ELECTRIC SHOCKS, OVERCURRENT PROTECTION AND AUTOMATIC SUPPLY CUT-OFF

3.1 A photovoltaic system must connected to the property's electrical system in such a manner that the electrical dimensioning requirements are not exceeded (e.g. rated current of the distribution board and overcurrent protection of related circuits from two directions during supply)

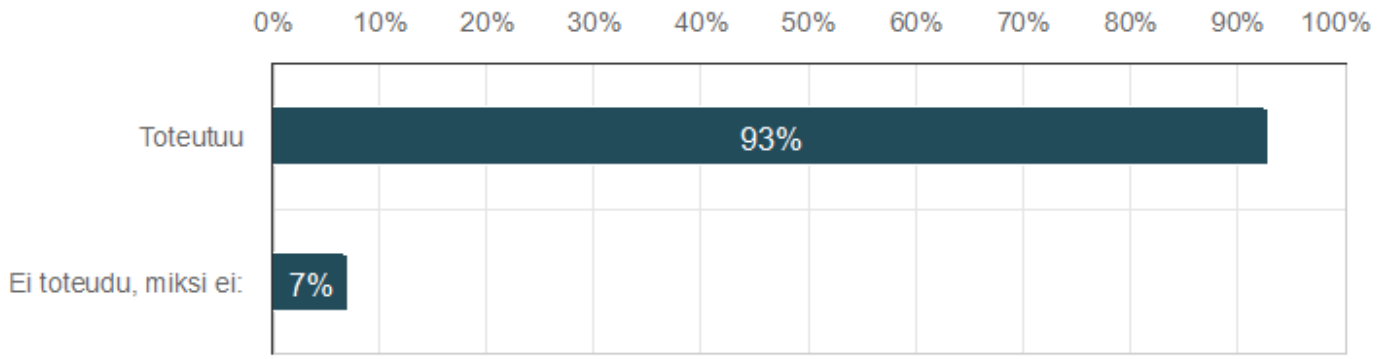
- The requirement was met in all (100%) of the inspected installations.

3.2 If required, the residual current protection (including 300 mA fire protection) of the alternating current part connecting the system must be implemented in compliance with the standard with a type B residual current device, with the exceptions allowed by the appropriate section of the standard (SFS 6000 712.530.3.101, SFS 6000 712.532.101)



- A type F residual current device has been installed. It was mentioned in the datasheet that a type B residual current device should be used.

3.3 Compliance of overcurrent protection of the supply circuit with the requirements of SFS 6000 (SFS 6000 712.433.104, 712.434.101)



- The maximum output AC current of the inverter was 16.04 A. For overcurrent protection of the system, circuit breakers of the KEMA KEUR brand (E series), B curve 16 A, had been used, which had been mounted so that they touched each other. The design principles of the circuit breaker manufacturer for the dimensioning of continuous flow were insufficient for the rated current of the circuit breaker. According to the inverter manufacturer's instructions, the maximum fuse must be a type B or C 25 A circuit breaker. Choosing the right overcurrent protection device will cause the need to review the dimensioning of the AC wire.

- The inverter's maximum AC current was 20 A, design current 18.9 A. Overcurrent protectors 3 x 16 A C curve. The inverter's maximum current had not been taken into account.

- The maximum AC current was the same as the rated current of the circuit breaker. The rated value for continuous flow of the circuit breaker should be considered based on the manufacturer's instructions in a situation where several circuit breakers are installed in parallel.

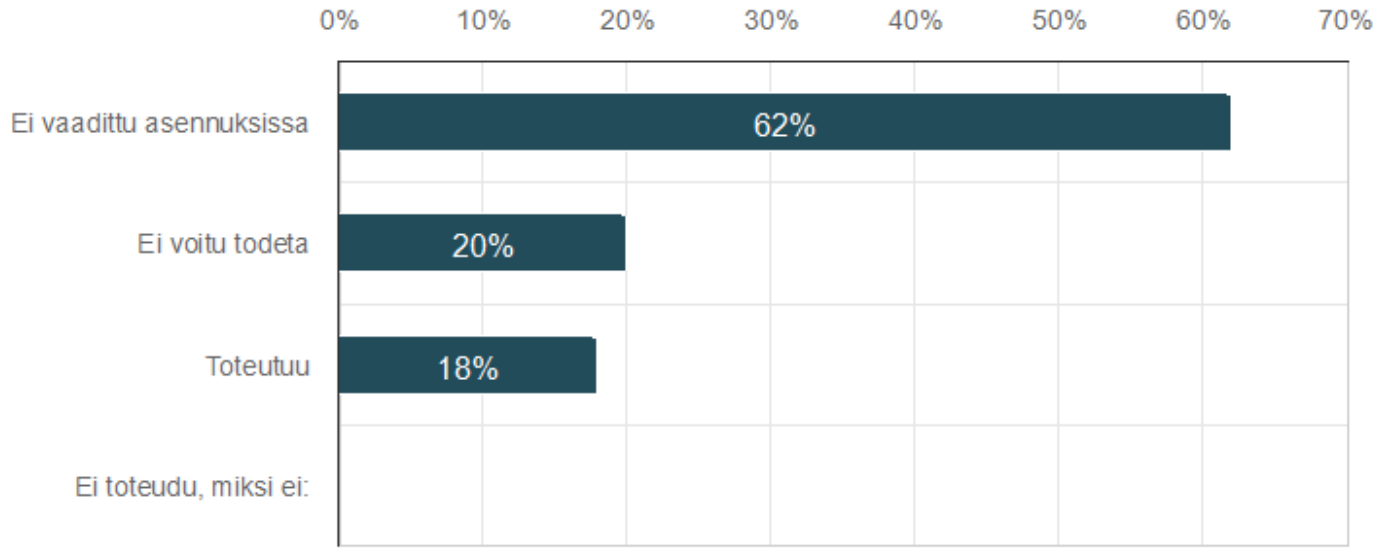
3.4 The structure of DC part installations complies with the requirements in the relevant section of the standard, e.g. double insulation or reinforced insulation, a class II structure (SFS 6000 712.410.102, SFS 6000 712.412.101)

- The requirement was met in all (100%) of the inspected installations.

3.5 The overcurrent protection must be implemented according to the requirements in case of a photovoltaic array with more than two parallel arrays (SFS 6000 712.431.101)

- The requirement was met in all (100%) of the inspected installations.

3.6 The overcurrent protection of the direct current part must be based on a gPV fuse or a fuse combination unit or switch in compliance with the applicable section of the standard (SFS 6000 712.533.101)

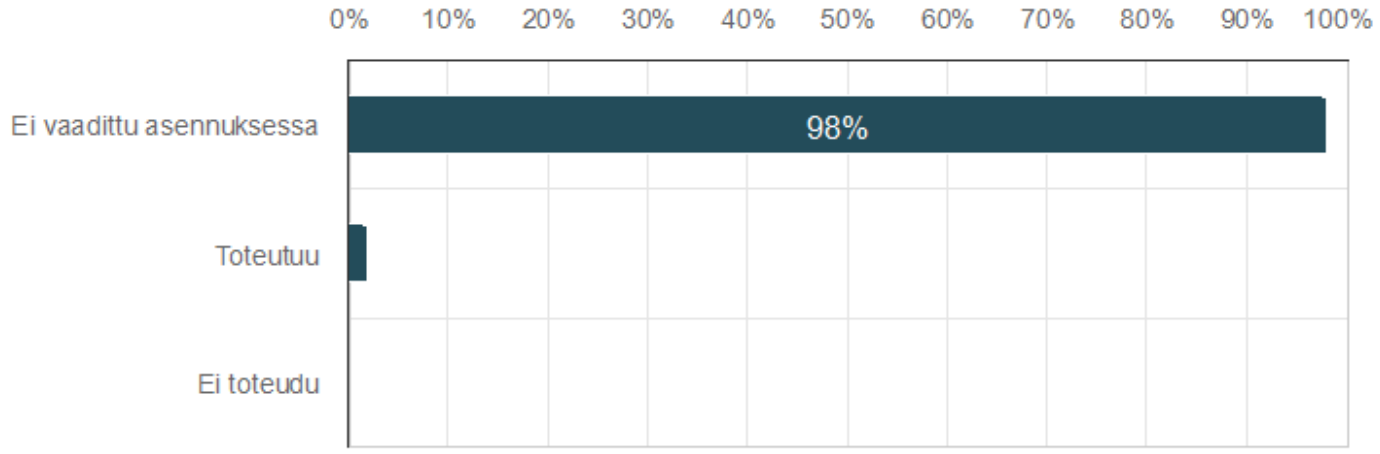


4. Overvoltage protection

4.1 If the photovoltaic system is installed in a space protected by a lightning protection system, the system must be separated from all parts of the lightning protection system (SFS 6000 712.534.101)

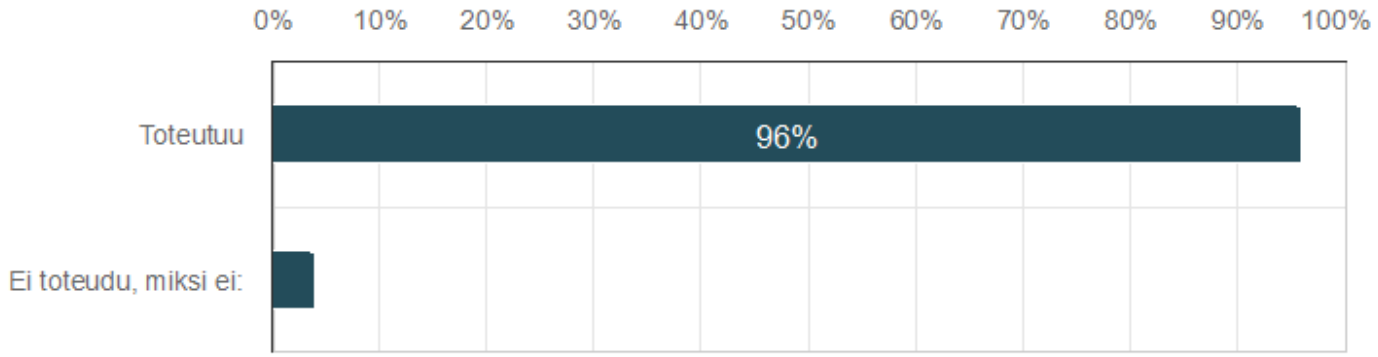
- The inspected installations did not have any lightning protection systems.

4.2 If necessary, there must be overvoltage protection of the alternating current part (risk assessment – lightning density, connected to an overhead cable network). The inverter must be located more than 10 m from the installation connection point, the surge arresters installed at the installation connection point must not be installed close to the inverter (SFS 6000 712.534.103).



5. SEPARATING DEVICES, INVERTER

5.1 The photovoltaic installation must be equipped with a separation device that can be used to separate it from the public distribution network (SFS 6000 801.551).



- The separation point was inside the distribution board, should be outside.

- The isolating switch was inside, should be outside.

(The separating device must be permanently available to the distribution network operator, unless an agreement on another procedure has been made between the subscriber and the distribution network operator.)

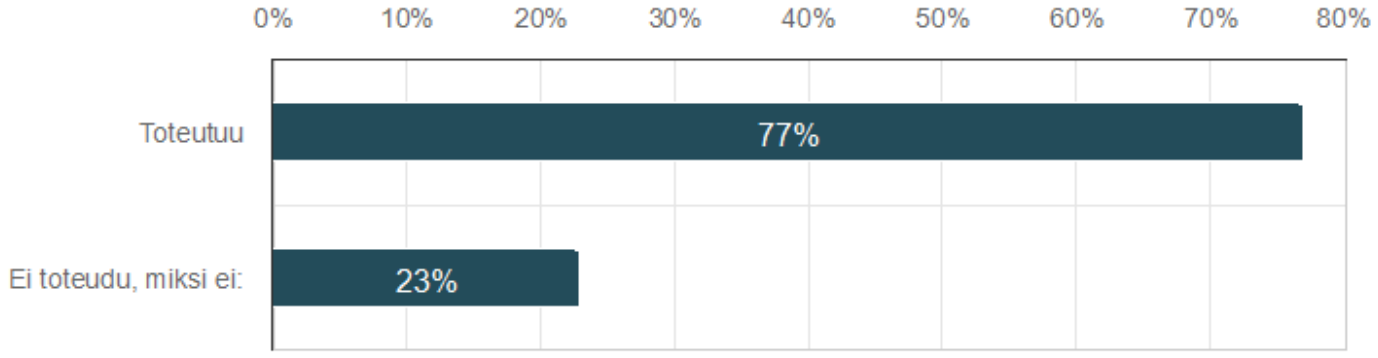
5.2 To enable maintenance and replacement of the inverter, a switch disconnector fuse or a circuit breaker suitable for separating the inverter from the DC and AC parts must be installed (SFS 6000 712.537.2.101).

- One of the inspected installations did not have a separate separating device at the disposal of the distribution network operator. The distribution network operator had access to the property's master switch or main fuse. The separating device for the photovoltaic system consisted of circuit breakers.

5.3 The maximum current and voltage values of the DC system must correspond to the rated values of the different parts of the system and be compatible with each other (SFS 6000 712.512).

- 56% of the inspected sites complied with the requirement; initial data was not available for the rest.

5.4 The components must be installed in accordance with the manufacturer's instructions and good installation practice. General requirements of SFS 6000 on enclosure, placement and environmental conditions must be met (including dust, farm environment, corrosive substances, water protection and direct sunlight).



- The installation cable to the roof from the board did not meet the thermal resistance requirements, as it had been installed under the roofing sheet. The ambient temperature can get really high under the black eaves sheet. The allowed maximum temperature for regular MMJ-type cables in continuous use is 70°C. This temperature can be reached on a hot summer day even without the cable load.

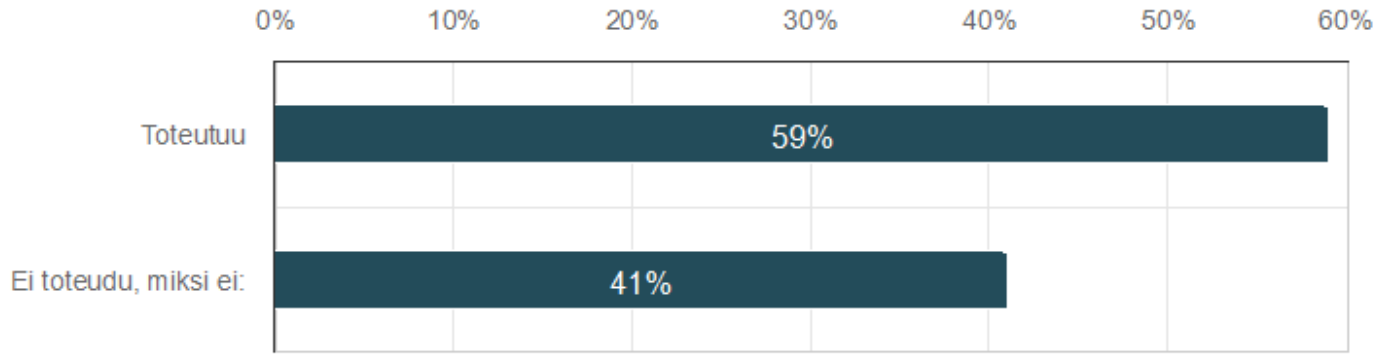
- Basic insulated conductors can be touched, screening requirement for the fuse box was not met.

- Plywood board had been used as the inverter mounting base. The manufacturer's instructions require a fire-resistant mounting base. The placement of the inverter or protection from direct sunlight should be checked, as the inverter had been installed at the western end where it was subjected to direct sunlight (the installation instructions require protection from direct sunlight). Furthermore, the inverter had not been protected from rainwater at the site in question (the manufacturer's installation instructions require protection from rainwater and splashing water).

5.5 System accessibility requirement must be met, the installation method must enable the use of a generator in connection with maintenance, for example (SFS 6000 712.513.101).

- The inspected sites complied with the requirement in other respects, but a working platform was required in one of the sites to achieve compliance with the requirement.

5.6 There must be fire-resistant materials behind and underneath the inverter and DC isolating switch if the base itself is not fire-resistant. If the fire-resistant material is highly heat conductive, a ventilated air space should be left between the fire-resistant material and the wooden mounting base (SFS 6000 712.420.101/2022 edition).

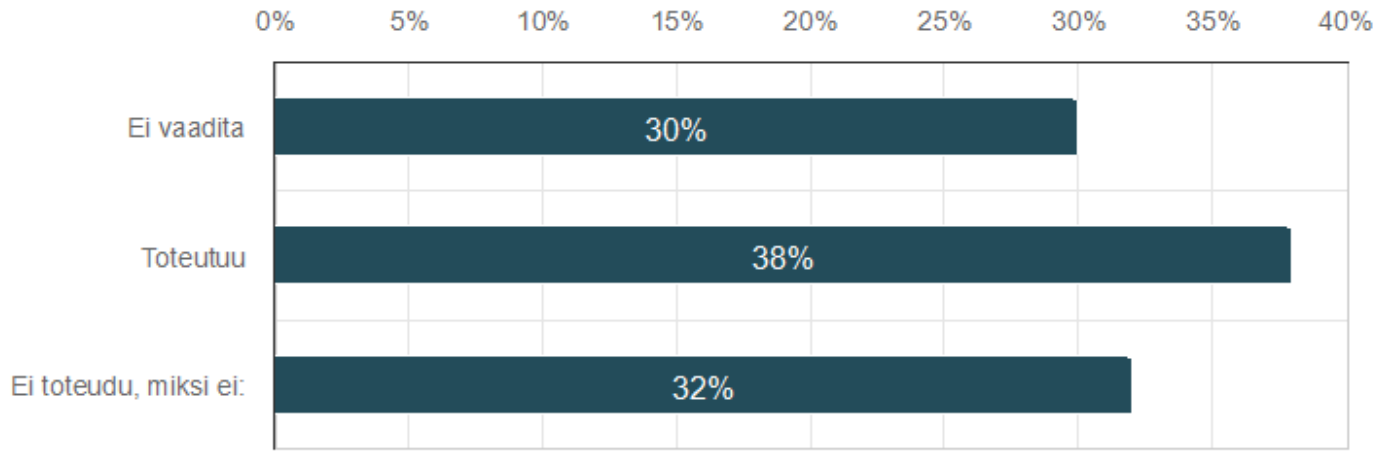


- A cover plate made from a fire-resistant material was missing from behind the DC isolating switch.

- The DC isolating switch was on top of a sheet of steel, which had been attached to a wall made from a flammable material.

- The inverter had been mounted directly on a timber wall.

5.7 A requirement according to the 2017 edition of the SFS 6000 standard series (please note: only if the manufacturer's instructions require it).



- The inverter was on a wainscotted wall. Section 5 of the inverter's Installation & Operation manual requires the following: Do not install the inverter on a building constructed of flammable or heat-resistant materials.

- The inverter installation instructions prohibit the installation of the inverter on a flammable surface.

- The manufacturer's installation instructions instruct to select a mounting base that is not flammable, such as a concrete or stone wall. The inverter had been mounted onto a timber wall. Waterproof plywood had been placed in between the inverter and the wainscotting.

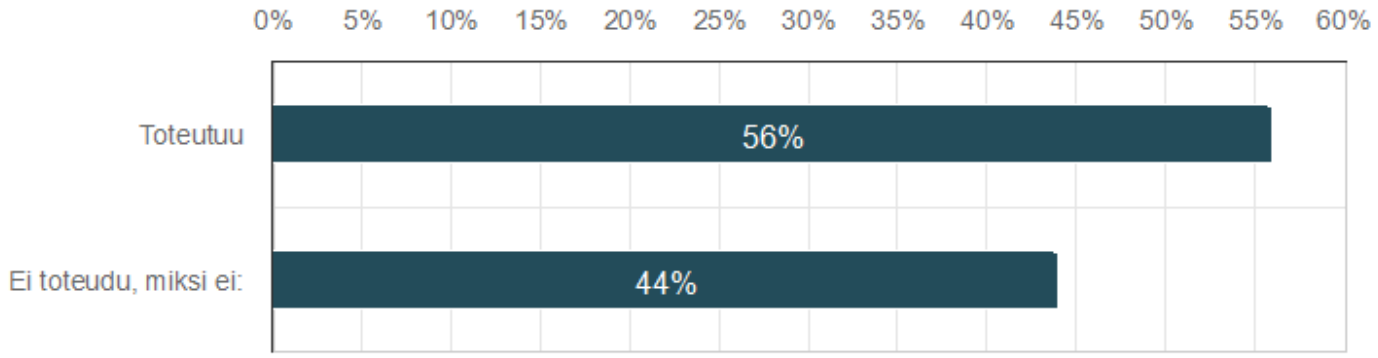
- The installation instructions state that the installation site must not contain any flammable or explosive materials. In addition, installation on a flammable wall is prohibited by an illustration. At the site, the inverter had been mounted onto board cladding.

5.8 The installation had separate DC switches, the use of which is not justified according to the applicable section of SFS 6000 712.537.2.2/2022.

- In addition to the inverter's DC isolating switch, one of the inspected sites had a separate DC isolating switch and additional MC4 connectors in the immediate vicinity of the inverter.

6. WIRING SYSTEM – Cabling and cabling routes

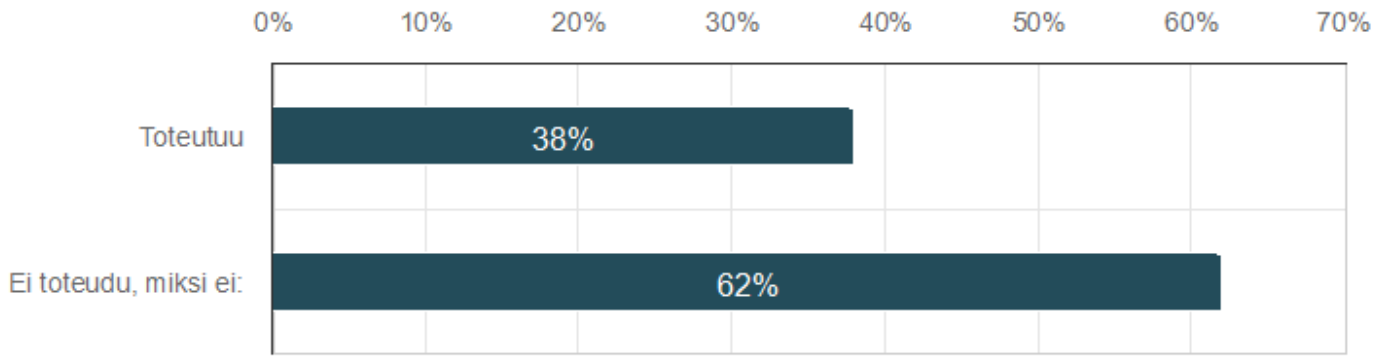
6.1 The installation of the wiring system (AC and DC) must comply with the general requirements on the installation of the wiring systems of low-voltage electrical installations in Part 5-52 of the SFS 6000 standard series (including mechanical protection, fixing and maximum capacity).



- Met otherwise, except that in the roof structures, the AC cabling was not fixed for a short distance (some 1–2 m) over the mineral wool insulation and the DC wiring on the roof touched the roof tiles under the panels.

- The alternating current cables between the inverters integrated into the panels had been installed against the roof surface. The cables had not been fixed in any way. The realisation of inverter connecting point strain relief could not be ascertained. Cable in between panels: a control cable of the type H07BQ-F 4 x 2.5 mm^2. The data sheets of corresponding cables promise UV resistance as well as a maximum operating temperature of 90°C. The panels had been chained together on the roof, with an unfixed junction box (AP 9) with supply from the building board on the roof under the panels. No earthing had been connected to the panel inverters. The cable from the board to the roof was an MMJ-type installation cable. The cable had not been fixed under the panels. Cabling from the roof down: snow barriers had been used as the installation route, with the cables tied onto them by cable ties. The cable was pressed against the sharp snow barrier mounting brackets. The rest had been installed under the eaves lead. The cable could be seen in between the eaves leads, partly against sharp sheet metal edges. In the case of these installations, the maximum capacity of the AC cables, the MMJ type cables in particular, should be investigated taking into account the ambient temperatures (under the roofing sheet and under the panels). In addition, the UV resistance of the MMJ-type cable should be checked. (There are differences between models. The exact type of cable used could not be ascertained.)

6.2 The cabling of the DC part must be realised using single-conductor cables without metal sheathing or insulated conductors installed separately in electrical conduits made from an insulating material. Cables are not to be installed directly onto the roof surface (SFS 6000 712.521.101).



- There were no DC cables at the site. The AC cables had been installed without fixing and support directly under the panels against the roof surface, subject to external stresses (snow, ice, water). In addition, the MMJ-type cable had been fixed onto a snow barrier with cable ties, partly against sharp sheet metal edges. The requirements of Part 522 of SFS 6000 had not been taken into account in the AC cabling (Section 522.8 and its subchapters in particular).

- The cables lay freely against the roof surface without any mechanical protection and fixing.

- On the roof, the DC wiring was touching the roof under the panels in some places.

- The cabling in between the panels was hanging and touching the roof surface. In addition, the DC cables to and from the roof were partly against the roof surface/inside and in between the roof structures without any mechanical protection. Some of the mechanical protection components used in the installation posed a risk of cutting damage to the cable sheath.

- There were DC cable loops hanging under the panels.

- There were DC cable loops hanging under the panels on the roof and wall.

- The cables had been laid against the roof surface. Mechanical protection of the cables was defective.

- Some of the DC cables were directly touching the roof surface.

6.3 To reduce induced voltages, wire loops should be kept to a minimum. Direct current cables and equipotential bonding conductors should be installed in parallel (SFS 6000 712.521.102).

- At two of the inspected sites:

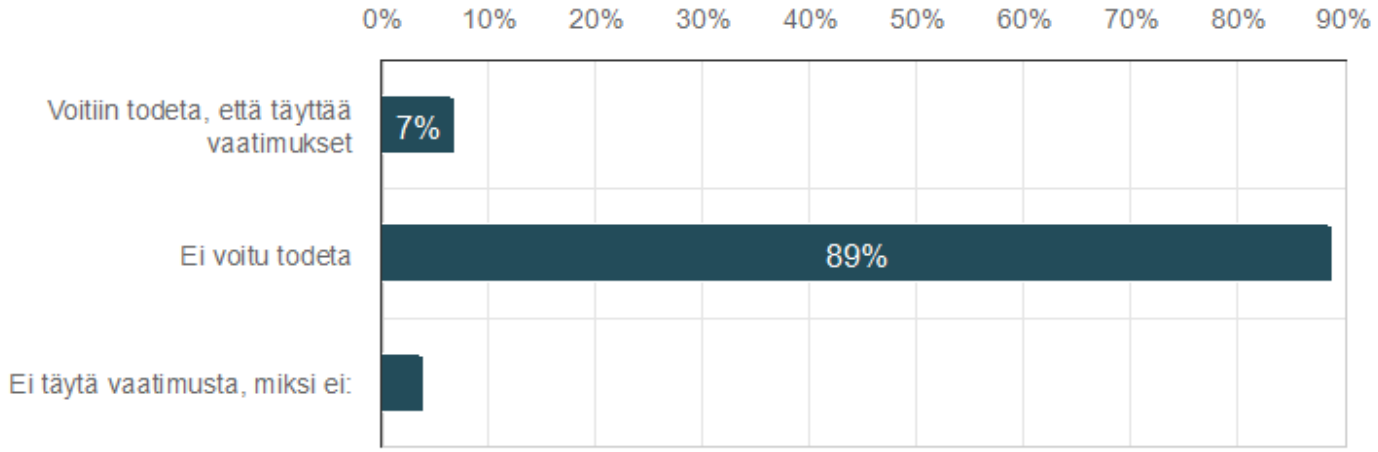
- The DC wiring of the panels on the roof was partially along different routes for the + and - cables near the roof ventilating pipes.

- The cabling of the DC part under the panels was completely loose, the size of the wire loops and the distance between them varied.

7. SELECTION AND PLACEMENT OF SYSTEM COMPONENTS

7.1 The connector pairs of the DC part must be electrically and mechanically compatible and suitable for the operating environment (SFS 6000 712.526.1/2017 edition).

The plug and socket outlets and connectors of the DC part must be of the same type and from the same manufacturer. Products from different manufacturers must not be used in the same connection (SFS 6000 712.526.101/2022 edition).



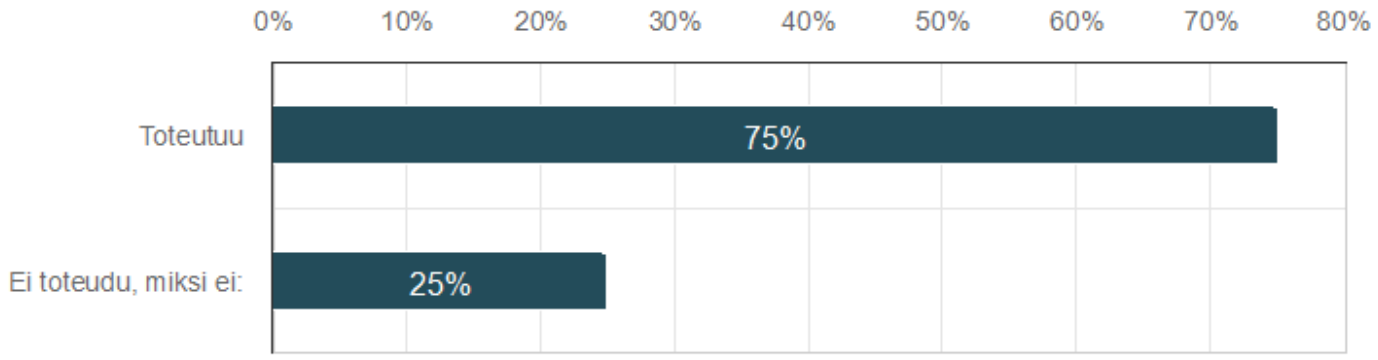
- The MC-4 connectors were from different manufacturers. For this reason, the requirement on the electrical and mechanical compatibility of the connectors was not met without mutual declaration of compatibility by the manufacturers. MC-4 is not a standardised connector type, so there can be significant differences in the dimensions and materials of connectors by different manufacturers, as a result of which the requirement on electrical or mechanical compatibility was not met. Both defects can result in a chain reaction causing increased transfer resistance of the connection point and spot heating over time, which can even cause a building fire risk.

7.2 If the connections are accessible to persons other than professionals and guided persons, detaching of the connections must only be possible with a key or tool, or the connection must be installed in an enclosure that can only be opened with a key or tool.
MC4 connectors need not be protected. (SFS 6000 712.526.101)

- The requirement was met at all (100%) of the inspected sites.

8. EARTHING AND PROTECTIVE CONDUCTORS

8.1 Whenever necessary (required by the manufacturer's instructions), equipotential bonding must be realised in accordance with the equipotential bonding instructions in the SFS 6000 standard series. Metal support structures of the panels and metal cable routes must be connected to the equipotential bonding (SFS 6000 712.542.101/2017 edition).



- The copper conductors had been fixed directly onto an aluminium rail by squeezing them in between a bracket. A copper-aluminium connector pair is not suitable without a bimetallic aluminium/copper connector such as a suitable cable clamp. Otherwise, the requirement was met.

- Installation instructions for the panels and the integrated inverters were not available. It was not possible to verify the earthing instructions. There was no earthing connected to the inverters.

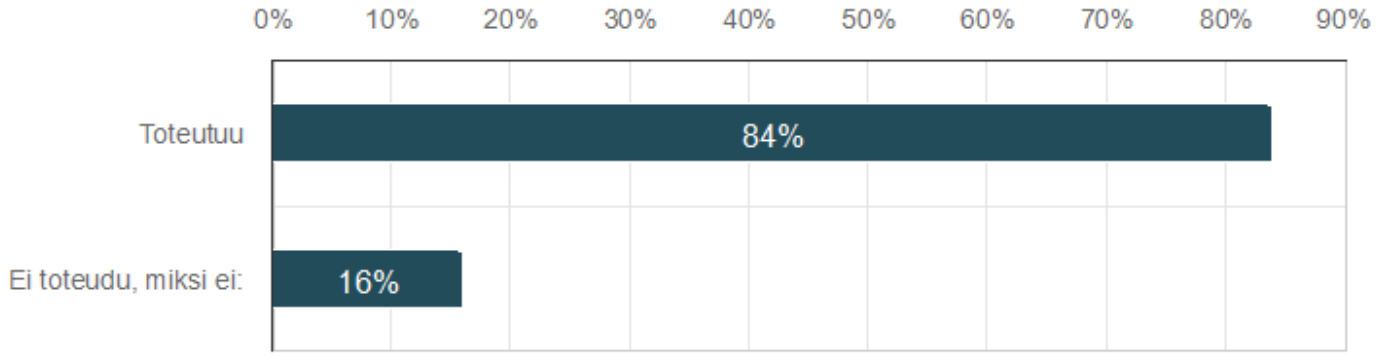
- The equipotential bonding requirements were otherwise met, but the inverter had not been connected to the equipotential bonding in accordance with the inverter installation instructions.

- The manufacturer recommends equipotential bonding for the photovoltaic arrays. The panels and their frames were not connected to equipotential bonding. (Please note: This is a recommendation in the panel manufacturer's installation instructions, not a requirement.)

- The equipotential bonding conductor had been installed from the inverter body only to one of the panel mounting systems (The panels were in one circuit but mounted as two separate entities on the roof. However, there was continuity through the fasteners and via the sheet metal roof also for the busbars without equipotential bonding.) Equipotential bonding between the inverter and the board relied on the protective earthing conductor of the MMJ 5 x 2.5 cable (the cable's cross-sectional area should be 6 mm²).

- Equipotential bonding had not been done!

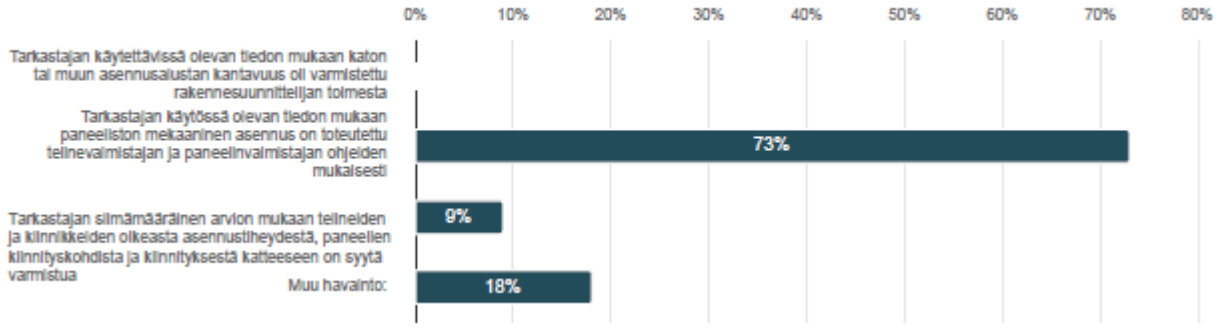
8.2 If the voltage of the photovoltaic array is less than 60 V, equipotential bonding is not necessary; otherwise, according to the relevant section of the standard. Equipotential bonding and any other conductive parts close to them must be connected (copper, 6 mm² or 16 mm², if there is an external lightning protection system) to the equipotential bonding (SFS 6000 712.542.101/2022 edition).



- Equipotential bonding was missing from the photovoltaic array support structures

- There was no equipotential bonding for the photovoltaic array at all!

9. ASSESSMENT OF THE MECHANICAL INSTALLATION OF THE PHOTOVOLTAIC ARRAY

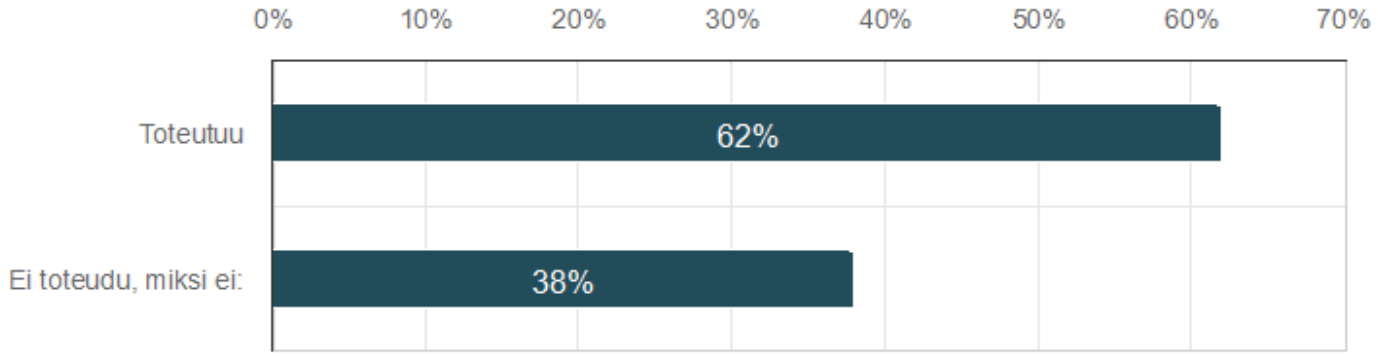


- The panels and the racks seemed securely fixed. Based on the data sheet for the panels, the mechanical resistance of the panels against snow and wind was also sufficient. The fixing of the racks to the roof or roof battens could not be verified. All the fixing elements were under the panels. According to the possessor, no construction drawings or other information on the building to ensure mechanical resistance had been requested from them.

- The mechanical installation could not be verified because there was no safe access to the roof, and there was no possibility to attach fall arrest equipment. The panels and cables were visually inspected from a ladder at the eaves.

10. IDENTIFICATION – Markings

10.1 The system must include warnings on a photovoltaic system installed in the building at, for example, the electrical installation connecting point, the electrical energy measurement point and the switchboard supplied by the inverter (SFS 6000 712.514.101, Fig. 712.514.101).



- The photovoltaic installations had not been marked or documented at all. The system connecting point (a distribution board) did not have any markings (on fuses or warning markings) related to the photovoltaic system. Also, there was no warning label about the photovoltaic system in the property's main distribution board.

- There was no warning label for the photovoltaic system in the main distribution board.

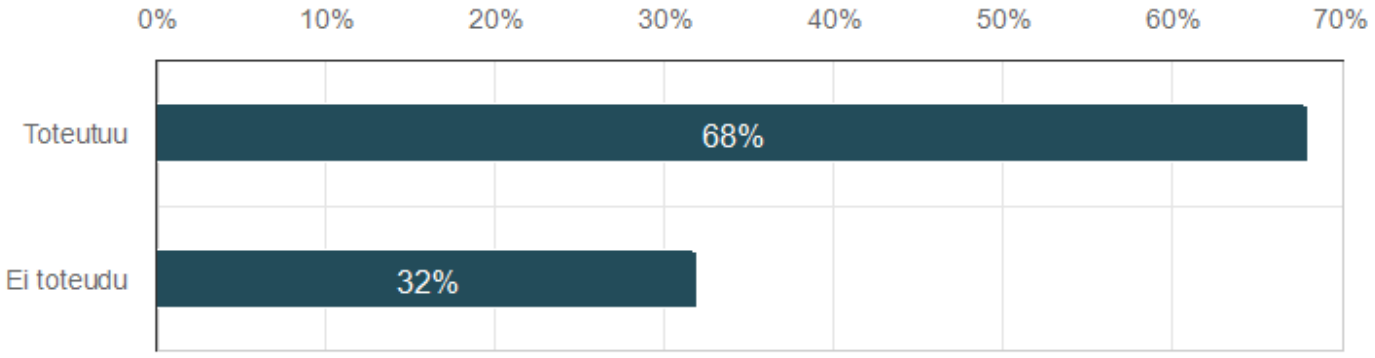
- The possessor had no other documentation for the installations in addition to the commissioning inspection record, the datasheet of the panels and the datasheet of the inverter. Board markings had not been updated in the fuses of the inverter's connecting point. There was no warning label on the photovoltaic system at the site.

- Power panelboards did not have any warning labels on the photovoltaic system.

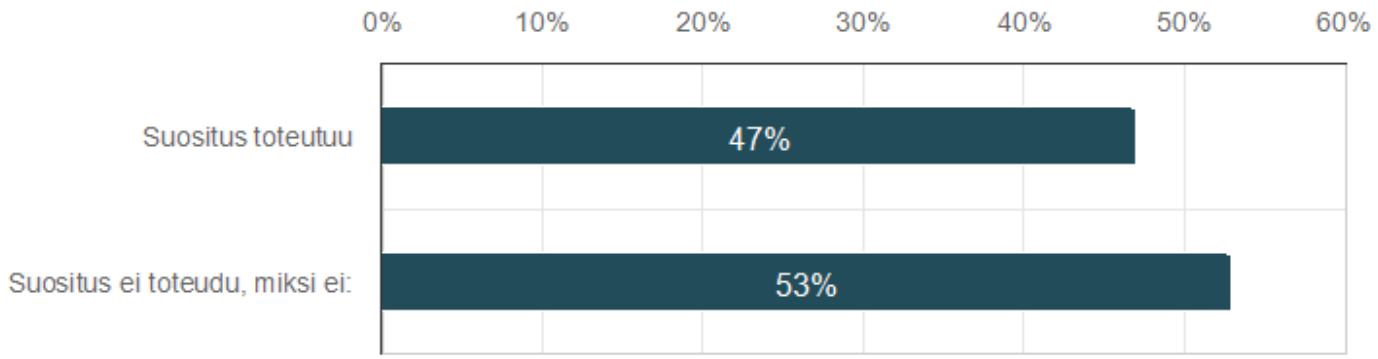
- Met now; the markings were added in arrears by a local electrical contractor.

- The main distribution board included a warning about reverse polarity voltage, but not on the photovoltaic system.

10.2 All devices in the DC part with live parts that can be accessed must be labelled with, for example, the text "Photovoltaic DC – live parts may be energised after separation" (SFS 6000 712.514.102).



10.3 Inverters should bear a label stating that the inverter must be separated from both the DC part and the AC part before any maintenance activities (SFS 6000 712.514.103).



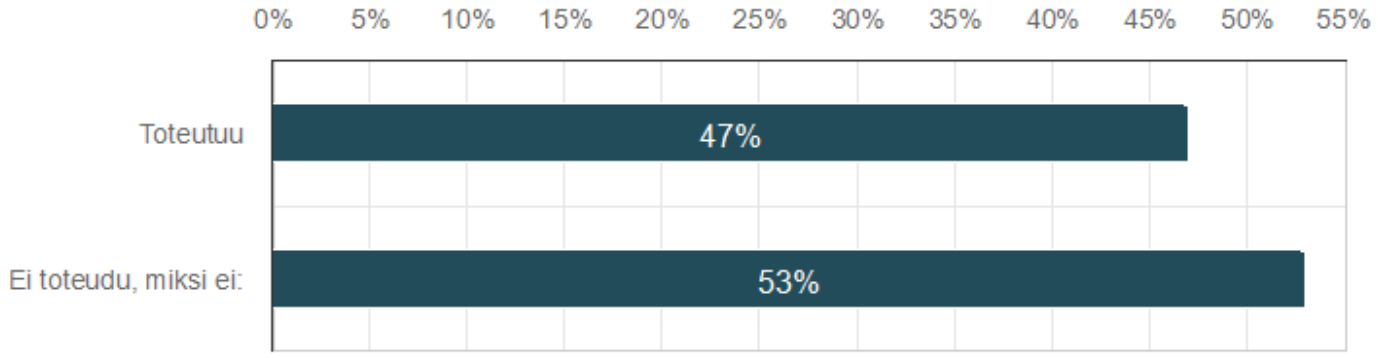
- The site did not include any operating and maintenance instructions, markings or warning texts related to the photovoltaic system.

- The inverters were integrated into the panels. No information on their markings was available, as the microinverter cannot be accessed while the panel is attached. In addition, there was a separate control device (IQ ENVOY) that identifies microinverters and gathers information, which was unmarked.

- Markings were missing.

11. EQUIPMENT INSTRUCTION MANUAL, DRAWINGS, CIRCUIT MARKINGS

11.1 An instruction manual for the photovoltaic system must be available, including instructions on de-energising the system and using any accumulators (SFS-EN 62446-1).



- No documentation on the installation or the system had been handed over to the possessor. Commercial documents only, showing only the type of the panels. The panel type was checked at the site. The system components were neither marked nor documented.

- Only a short maintenance manual for photovoltaic systems, prepared by the electrical contractor, was available, but it did not explain the operation of the brand-specific inverter, for example.

- There was no instruction manual at the site nor any instructions on the photovoltaic system.

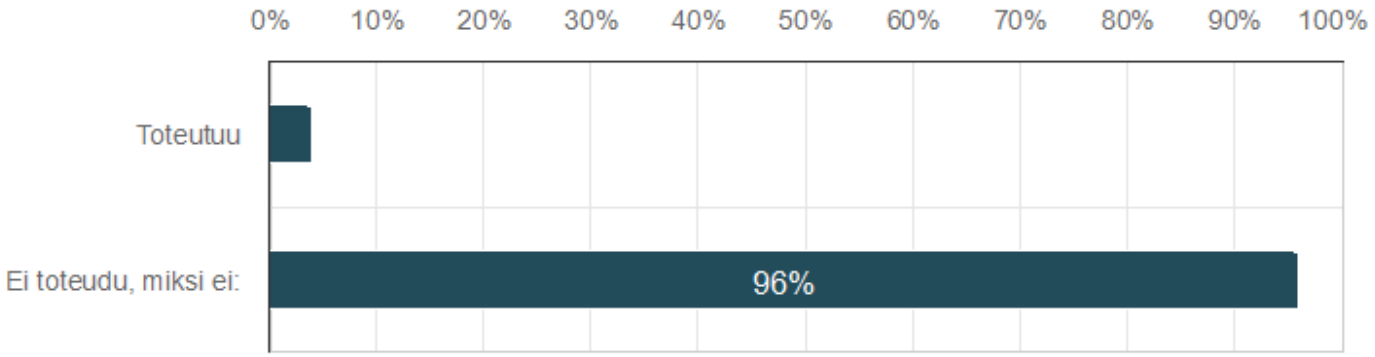
- The instruction manual had been "misplaced", could be found online if necessary.

- There was no instruction manual.

- No operating instructions had been delivered to the customer.

- There was no instruction manual or any emergency stop instructions. Only an incomplete commissioning inspection record had been provided for the installation.

11.2 Changes to the electrical circuit markings and drawings due to the installation of the system must be properly implemented (documentation according to SFS 6000 514.5), and there must be a wiring diagram for DC installations, for example (SFS-EN 62446-1 4.3).



- There was no DC installation wiring diagram available.

- There were no drawings available. Group markings on the address labels in the main distribution board were fine.

- There were no drawings or diagrams.

- The possessor did not have any documentation related to the system. The changes had not been updated in board markings, for example.

- The information of the photovoltaic system or circuit diagrams had not been added to the building's circuit diagrams.

- Circuit diagrams for the photovoltaic system were available. There were no circuit diagrams for the building's electrical equipment (built in the 1950s).

- The diagram of the photovoltaic system was not completely correct.

- Diagrams had not been updated.