**ELECTRICAL ACCIDENTS IN BUILDING SERVICES: CASE LASSILA & TIKANOJA**

Lappeenranta–Lahti University of Technology LUT

Master's degree programme in Electrical Engineering

2022

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Supervisor: Electrical Installation Supervisor Jukka Kuvaja

ABSTRACT

Lappeenranta–Lahti University of Technology LUT

School of Energy Systems

Electrical Engineering

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**Electrical Accidents in Building Services: Case Lassila & Tikanoja**

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The topic of the thesis was electrical accidents for electrical professionals. Survey data were collected from previous surveys of electrical accidents and statistics by insurance companies and authorities. The study aimed to identify common factors that have previously led to or could lead to electrical accidents.

A survey and literature review were used as the research method. The study looked at previous studies and publications related to electrical occupational safety. The literature review focused on the regulations, standards, and regulations in the electricity industry and occupational safety. However, the work revealed a few risk factors as well as problem areas. By developing these, it would be possible to improve electrical safety in the company. Based on the research results, risk factors include, for example, people who deviate from safe work practices by taking conscious risks, such as rushing and working alone.

The thesis was made to serve Lassila & Tikanoja's goals to develop its electrical occupational safety. The material of this thesis can be used as part of an introduction to electrical safety.

TIIVISTELMÄ

Lappeenrannan–Lahden teknillinen yliopisto LUT

Energiajärjestelmät

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Sami Järvinen

**Sähkötapaturmat talotekniikassa: tapaus Lassila & Tikanoja**

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Tarkastajat: 1. tarkastaja Apulaisprofessori Jukka Lassila

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Opinnäytetyön aiheena oli sähköalan ammattilaisille tapahtuvat sähkötapaturmat. Tutkimustietoja kerättiin aiemmista sähkötapaturmia käsittävistä tutkimuksista sekä vakuutusyhtiöiden ja viranomaisten tilastoista. Tutkimuksen tavoitteena oli tunnistaa yhteisiä tekijöitä, jotka ovat aiemmin johtaneet tai jotka toteutuessaan voisivat johtaa sähkötapaturmiin sekä löytää keinoja parantaa sähköturvallisuutta.

Tutkimusmenetelmänä käytettiin kyselytutkimusta sekä kirjallisuuskatsausta. Tutkimuksessa perehdyttiin aikaisempiin tutkimuksiin ja julkaisuihin, jotka liittyivät sähkötyöturvallisuuteen. Kirjallisuuskatsauksessa perehdyttiin sähköalan ja työturvallisuuden määräyksiin, standardeihin sekä säädöksiin. Työssä ilmeni kuitenkin muutamia riskitekijöitä sekä ongelmakohtia. Näitä kehittämällä olisi mahdollista parantaa sähkötyöturvallisuutta yrityksessä. Tutkimustuloksien perusteella riskitekijöinä voidaan mainita esimerkiksi henkilöt, jotka poikkeavat turvallisista työtavoista ottamalla tietoisia riskejä, kuten kiire ja yksintyöskentely.

Opinnäytetyö tehtiin palvelemaan Lassila & Tikanojan tavoitteita kehittää sähkötyöturvallisuuttaan. Tämän työn materiaalia voi käyttää osana sähköturvallisuuteen perehdyttämisessä.

# PREFACE

This master's thesis was carried out on the spark caused by Lassila & Tikanoja between March 2020 and March 2022. I would like to thank Lassila & Tikanoja for an exciting topic. Special thanks to Jukka Kuvaja, supervisor of electrical work, for directing the job and advising during the work. I would also like to thank all the employees of the Espoo Electricity Unit for their good working atmosphere.

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Nummela, 23 April 2022

Sami Järvinen

SYMBOLS AND ABBREVIATIONS

| | |
|---|---|
| AC | Alternating Current |
| AVI | Regional State Administrative Agency. An agency under the Ministry of Social Affairs and Health that manages, for example, occupational safety and health activities and related supervision |
| CEO | Chief Executive Officer |
| DC | Direct Current |
| HSE | The Health and Safety Executive |
| IAEA | The International Atomic Energy Agency |
| ISO | International Organization for Standardization |
| KTMp | Decision of the Ministry of Trade and Industry, now replaced with The Ministry of Employment and the Economy of Finland |
| L&T | Lassila & Tikanoja |
| OHSAS | Occupational Health and Safety Assessment Series |
| OOE | Occupational safety-Occupational health-Environmental issues |
| SESKO | National Electrotechnical Standardization Organization representing Finland in the electrotechnical engineering field as the National Committee of the International Electrotechnical Commission (IEC) |
| SETI | Personal and Company Assessment Ltd is an independent and objective assessor of electrical qualifications according to the Electrical Safety Act, nominated by TUKES |
| SFS | Finnish Standards Association SFS. Finnish Central Organization for Standardization |
| SFS-EN | A European standard that has been established as a national standard |
| STL | Electrical Safety Act |

| | |
|---|---|
| TR-meter | TR is a safety observation method for measuring occupational safety at construction sites. The abbreviation TR stands for the Finnish word for ‘residential construction.’ A similar method known as MVR is used for civil engineering works. |
| TTL | Occupational Safety and Health Act |
| TUKES | Finnish Safety and Chemicals Agency |
| TVK | Finnish Workers´ Compensation Center |
| VARO | TUKES Register that collects information, e.g., accidents involving dangerous chemicals, pressure equipment, mines, electrical equipment, and lifts |
| Vna | Government Decree |
| VTT | Technical Research Centre of Finland |

TERMS AND DEFINITIONS RELATED TO ELECTRICAL WORK

| | |
|---|---|
| Dead | The voltage is zero, or close to zero, i.e., there is no voltage and/or charge (SFS 6002:2015) |
| Dead working | Working in electrical installations which are not live nor charged, and which have taken all necessary measures to avoid an electrical hazard (SFS 6002:2015) |
| Electrical hazard | Cause of possible damage or damage to health due to electrical energy in the electrical installation (SFS 6002:2015) |
| High voltage | Voltage normally exceeding 1000 V AC voltage or 1500 V DC voltage (SFS 6002:2015) |
| Instructed person | Any person instructed by electrical professionals to avoid the dangers posed by electricity (SFS 6002:2015) |
| Injury (electrical) | Death or personal injury caused by electric shock, electrical fire, light bar, or electrical energy-ignited fire or explosion due to the use of electrical equipment. (SFS 6002:2015) |
| Low voltage | Voltage normally does not exceed 1000 V AC voltage or 1500 V DC voltage (SFS 6002:2015) |
| Live working | Work in which the worker intentionally either touches the voltage part or extends to the voltage work area, either with parts of his body or with tools, equipment, or equipment to be processed.<br><br>Note. The worker performs voltage work at low voltage when touching bare voltage parts with the tool. At high voltage, the worker extends to the voltage |

| | |
|---|---|
| | work area, regardless of whether the exposed live parts are touched (SFS 6002:2015) |
| Nominated person in control of an electrical installation | A person with acting responsibility for the operation of electrical installation. If necessary, parts of these tasks may be delegated to another person. (SFS 6002: 2015) |
| Notification | Oral or written instructions related to working in electrical installations (SFS 6002:2015) |
| Ordinary person | A person who is neither a professional nor guided (SFS 6002:2015) |
| Skilled person | A person with appropriate training and experience to assess risks and avoid potential hazards from electricity (SFS 6002:2015) |
| Voltage Tester | Removable device used to reliably identify the presence or absence of operating voltage and used to ensure installation is ready for the site (SFS 6002:2015) |
| Working in the vicinity of live parts | Work in which the worker with parts of his body, tools or any other object extends to the surrounding area but not to the voltage work area (SFS 6002:2015) |

**Table of contents**

Appendices

# 1 Introduction

This thesis deals with safety at electrical work based on the current Electrical Safety Act 1135/2016 and related regulations. Occupational safety is important in every profession. It is especially important to consider workplace safety in electrical work, as electricity brings risks to work tasks. People who do electrical work must be familiar with their tasks and sufficiently skilled not to endanger electrical safety. They must understand the risks associated with the job description and be able to avoid them. Unfortunately, there are still accidents at work in the electricity sector. Safety must be achieved at every worksite. Finnish workplaces have a widely accepted zero accident target (Rakennusteollisuus, 2015). The objective is demanding, and its implementation requires an examination of the activities throughout the working environment. Improving the working environment and working conditions enables a common goal of safety for the company and its personnel.

According to Reiman and Oedewald, safety is often taken for granted (Reiman & Oedewald, 2008). “Levä (2003) describes safety as a state free of factors that can cause damage to a person, property, or environment.” Safety is often defined as the opposite of risk or lack of danger. In the organization, safety aims at a space where risks and hazards are controlled. On closer inspection, the concept of safety turns out to be complex and difficult to define in a precise way. (Levä, 2003.)

The level of electrical safety at work in Finland is quite good, according to official statistics, serious electrical accidents occur quite rarely for electrical professionals (Eurostat, 2018). The work of an electrician is somewhat riskier than average in case of accidents (Työterveyslaitos, 2020). Electrical accidents among electricians are mainly minor, despite this, some accidents are severe, and electricians die in their work because of an electrical accident (TUKES, 2020). The thesis aims to gather information that could reduce electricians' electrical accidents. The result of the thesis can be used to assess how risks occur in one´s organization, and the work presents proposals for measures related to the identified risk factors in this case, which may also be applicable in other organizations performing electrical work.

This thesis was carried out using the literature review and the survey research method. The literature review section focused on the laws, rules, standards, and previous studies related to the research topic that regulates electrical occupational safety. The survey research method section focused on pre-selected questions for operations managers, electrical work supervisors, project managers, and electricians in the building services sector about electrical occupational safety. The prevailing practices in electrical occupational safety and electrical installation work performance were also familiarized in the thesis. Information on practical activities in the field was surveyed from electrical professionals. The original purpose was to collect the field's data using the interview method, but this had to be discontinued due to the coronavirus.

The thesis research is limited to the electrical occupational safety of electrical installers in the building services sector and is mainly carried out as a literature study. The work consists of the following parts, it studies electrical accidents of electricians, operating environment of electrical work, responsible business, and safety management, deals with survey research findings, and presents development proposals. The thesis also examines the accident statistics of Tukes and insurance companies.

Lassila & Tikanoja Oyj (L&T, 2021), is a Finnish service group focused on providing environmental and real estate support services. Its support services include cleaning and user services as well as property management. L&T Biowatti, a subsidiary of the Group, manufactures and supplies wood-based biofuels, recycled fuels, and secondary raw materials. In addition to Finland, the company operates in Sweden and Russia. The company started its operations as a wholesaler in Vaasa in 1905. The company has been listed on the Helsinki Stock Exchange since 1961. Lassila & Tikanoja Corporation took its current form on September 30, 2001, when the then Lassila & Tikanoja plc was divided into two separate companies. (Lassila & Tikanoja plc and Suominen Corporation, 2001.)

Lassila & Tikanoja plc operated as Säkkiväline's parent company until March 31, 2002, when Säkkiväline merged with its parent company. At the same time, the L&T brand was launched, covering all the company's industries: Environmental Services, Real Estate, User Services, and Industrial Services. This was the beginning of the early days of the electrical department.

# 2 Implementation of the study

The main goal of this thesis is to study and identify common factors that, if realized, have previously led or may lead to electrical accidents among electrical professionals in the future. The aim is also to find possible areas for development and suggestions for improvement in order to reduce accidents. Two different research methods were used in the thesis. Electrical occupational safety in Finland is at a relatively good level, despite which a considerable number of electrical accidents occur annually for electricity professionals (Elsäkerhetsverket, 2020; HSE, 2021). Electrical accidents are mainly mild, but some accidents are even fatal. Therefore, the measures to prevent electrical accidents have not been sufficient when examining the development of the number of electrical accidents over the last ten years.

## 2.1 Objective of the thesis

To prevent electrical accidents, we need identification of the current situation about accidents and measures for identified risk factors or, in this case, proposals for action. The thesis research aims to identify common factors that increase the risk of electrical accidents and create a data source based on research data for the use of electrical professionals to prevent electrical accidents now and in the future. The result of the thesis helps electricity companies as well as L&T in matters related to electrical occupational safety.

## 2.2 Limitation of research

The thesis will be focused on the electrical safety of electrical installers in the building services sector. The working methods in the industrial and network sector differ partly from those in the building services sector. Differences in working methods, instructions, and equipment are due, for example, to higher voltages and currents commonly applied to electrical installations in industry and distribution networks.

## 2.3 Research methods

The literature review was selected as one of the research methods of the thesis. The original purpose of the thesis was to apply not only a literature study but also an open interview method to the collection of research data. Literature reviews are typically classified into three different types, types include narrative (descriptive) literature review, systematic literature review, and meta-analysis. A narrative literary review is a very commonly used literary review. (Salminen, 2011.) The research data may consist, for example, of background information related to research issues or ready-made problem-solving models. The literature review begins with the selection and cropping of the material. Material that benefits ongoing research is selected for use in research (Jyväskylän yliopisto, 2018). The use of interview studies in professional studies is very common. Interviewing, especially a free-form or untrusted method, has recently increased. As a particularly flexible method, the interview is suitable for the acquisition of information on a wide range of studies (Hirsijärvi & Hurme, 2001).

This thesis's original purpose was to use an open interview method. The interviewer and the interviewee interact conversationally when using the open interview method. The interviewer strives to create the most open and natural discussion between the parties when using an open interview method. The interviewer aims to deepen the interviewee's answers and, at the same time, to move the discussion towards the following questions. (Hirsijärvi & Hurme, 2001.) To obtain research data, both the literature review and the survey were applied. Due to the coronavirus, the interview questions that were originally intended to be asked in connection with the unstructured interview were instead submitted via an e-mail survey.

### 2.3.1 Interview or questionnaire

Methods suitable for collecting information and thoughts include both interviews and surveys. There are several types of interviews and surveys. The use of a questionnaire is often justified by its ease of use. The use of surveys is quite common, and that is why people are sometimes reluctant to participate in answering these. The reluctance to answer questions on different types of forms has been influenced by people's fear that the information may end up into the so-called

wrong hands, especially in cases where personal data relating to an individual are processed. (Hirsijärvi & Hurme, 2001.)

However, the benefit of the questionnaire is their anonymity, where the respondent is in no way apparent from the information in the reply form. The advantages of the survey and the forms are economy, availability of the interviewee, and the availability of the material. According to sources such as (Floyd et al., 2003; Mouly, 1963), the interview and questionnaire would be almost identical methods, but (Hirsijärvi & Hurme, 2001), states that this is exaggerated and therefore not accurate.

### 2.3.2 Interviews

The thesis assumed that the interviewed persons have a different perspective on safety issues depending on whether they are entirely outside the contracting company (director of use, supervisor, etc.), in the contracting company in project management, as a supervisor of installers, or as an electrician. In addition to interviews conducted in connection with the results of electrical accident risks in electrical work, this thesis conducted interviews with people in different positions and responsibilities in electrical installation. The interviews aimed to map the respondents' perspectives, which were generally related to electrical accidents or electrical accidents experienced by electricity professionals themselves. The interview results were obtained as objectively as possible when the interviews were conducted for people in different activities in the same industry.

### 2.3.3 Research surveys

In the study of this thesis, the questionnaires were sent by e-mail to fifty-four people (n=54) representing different levels of responsibility in the field of electrical installation. The respondents work as operations managers, electrical work supervisors, project managers, and electricians in the building services sector. The surveys aimed to map the positions of persons in the same field but different activities about the electrical safety of electricians.

The surveys concerned electrical occupational safety in general, electrical accidents, working in live equipment, haste, working alone, subcontracting, and training. A list of questions was created for the survey, which was sent to the respondents by e-mail. The questions in the survey are presented in Appendix 1 of the thesis. The surveys in this thesis were only addressed to professionals in the Uusimaa region. Therefore, there is no relevant comparative information for Central Finland or Northern Finland. There is no foreign subcontracting to the same extent as in the Uusimaa region.

# 3 Electrical accidents and requirements for electrical work

This chapter deals with the main requirements related to the performance of electrical work, both from the point of view of legislation and standards. The chapter describes the general requirements related to electrical work in the Finnish environment.

## 3.1 Overview of the present status

Electricity poses a risk of an electrical accident to electricity professionals worldwide. It is commonly found that almost every electricity professional has experienced or seen another person become a victim of an electrical accident (Casini, 1993). In Finland, too, this can be verified by asking an electrician selected by a random sample about their experiences. Despite the prevalence of electrical accidents, reporting of accidents is very low. There are approximately 2.6 million employed people in Finland, with around 17,000 working as electrical professionals.

In Finland, legislation regulates very precisely who is allowed to work in the electricity sector and what level of education and work experience the performer must at least have. The regulations and mandatory standards define the working methods that consider electrical work safety related to the preparation of work, during work, and the termination of work quite precisely. However, serious electrical accidents occur to electrical professionals despite legislation and standards. Although it is rare. It is said that an accident teaches, and therefore practices may be changed for the better. Electrical accidents have not decreased in recent years despite continuous development work on electrical occupational safety (TUKES, 2020).

Based on the analysis of the research data carried out in the result doctoral thesis (Tulonen, 2010), it can be concluded that electrical accidents among electrical professionals are usually the result of negligence about occupational safety guidelines or working methods. Despite this, we have a relatively limited amount of information on why electrical professionals neglect oc-

cupational safety guidelines or working methods. In Finland, companies' visions and workplaces generally aim for zero accidents at work, which means that every electrical accident is too many. Despite companies' visions and investments in electrical safety, the reduction in the number of electrical accidents has not developed as desired. The prevention of electrical accidents by electricity professionals should begin with investigating an electrical accident or these underlying causes. In the future, we can prevent electrical accidents more individually and more effectively by identifying and analyzing the risks of an electrical accident. (Nurmi & Simonen, 2003; Tulonen, 2010).

## 3.2 General health and safety at work

General, occupational health and safety activities are part of the Ministry of Social Affairs and Health administration. The Occupational Safety and Health Authority tasks are allocated to the Regional State Administrative Agency. At the Ministry of Social Affairs and Health, its Equality Department guides the responsibilities of the Regional State Administrative Agencies for occupational safety and health. (Työsuojeluhallinto, 2020.)

The Regional State Administrative Agencies (AVI) have defined four occupational safety and health task areas:

- carry out controls related, for example, to chemicals to which the worker may be exposed at work and which may result in health risks or occupational diseases
- is responsible for occupational safety and health supervision, which may come from both a customer or authority initiative
- investigate severe accidents at work. In addition, AVI's tasks include studying the causes of occupational diseases and work-related illnesses and measures to prevent them in the future
- participates in legal proceedings concerning work offenses. (Työsuojeluhallinto, 2020.)

AVI cooperates closely with employers' and employees' organizations in connection with occupational safety and health issues (Työsuojeluhallinto, 2020). Regional State Administrative Agency will be notified in writing of the accident using the document Työtapaturmailmoitus työsuojeluviranomaiselle.pdf notification form. (Appendix 3.)

## 3.3 General information on accidents at work and electricity

In Finland, the Finnish Workers' Compensation Center (TVK) coordinates and develops matters related to accidents at work. It is also the responsibility of the TVK to maintain statistics on accidents at work and occupational diseases. Every insurance company that provides insurance against accidents at work and occupational diseases must be a member of the TVK by law. The position of the TVK and its tasks are laid down in the Act on Accidents at Work and Occupational Diseases TyTAL 459/2015. (Tapaturmavakuutuskeskus, 2020.)

As a rule, electrical accidents occur in low voltage (<1kV) electrical installations or equipment. Electrical accidents occur for both electrical professionals and ordinary persons. In addition, separate electrical accidents may occur annually for electrical professionals in high-voltage equipment-related work, which can be very serious. High-voltage electrical accidents in ordinary people are mainly related to unauthorized activities. In the event of a high-voltage electrical accident for ordinary people, for example, the roof of a train is climbed, or a substation is broken into. (TUKES, 2020.) One possible case is mentioned in Figure 1, from which an electric shock may occur.

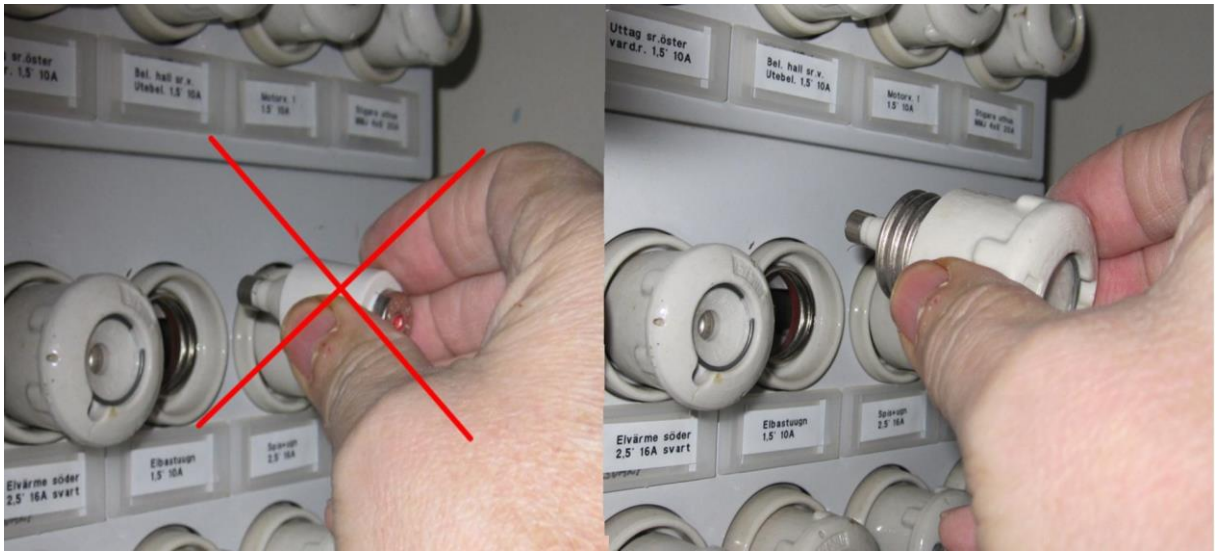


**Figure 1** Possibility of electric shock (AB Tronico Oy, 1989).

Electrical accidents occur almost invariably at AC voltage. DC voltage electrical accidents usually occur in work tasks involving batteries or capacitors, for example, during maintenance work.

What is classified as an electrical accident, according to the TUKES definition of an electrical accident, an electrical accident is:

> An accident in which the injury was caused by a direct electric shock or an electric light cycle. Falls and injuries indirectly caused by direct electric shock and arc are also classified as electrical accidents. (Author's own translation) (TUKES, 2020.)

Similarly, the definition, which follows the definition of the Occupational Safety and Health Administration and states that:

> “An occupational accident is a sudden and unexpected accident caused by external factors due to which the employee suffers injuries. As an occupational accident is considered an accident occurring in the work place premises or, on the way

home from work or vice versa or while the employee is away on a business trip or running an errand ordered by the employer." (Työsuojeluhallinto, 2020.)

### 3.3.1 Serious accident at work

Accidents at work are classified into different groups, and one of the groups is serious accidents at work, an example of such is illustrated in Figure 2. The occupational accident is severe if the employee dies or if he or she suffers a permanent or severe injury. (Työsuojeluhallinto, 2020).

Definitions of serious injury are described on the työsuojelu website (Työsuojelu, 2022). There are many definitions, and there are no unambiguous injuries or similar injuries related to an electrical accident. However, almost all the listed definitions may arise indirectly due to an electric shock or an accident caused by an arc (Duodecim, 2022).


**Figure 2** The illustration is an adaptation of Heinrich's Triangle (OSHA, 2021).

Severe injuries are for example:

- “long bone fractures or fractures which may need surgery, difficult spinal fractures, viscerocranial fractures, multiple rib fractures and hemothorax, severe skull compound fractures, severe fractures to neck, chest or lumbar spine
- severe dislocation causing permanent injury
- loss of limb for example a finger or part of it, shortening of limb
- brain injury leaving also light injuries.
- injury to the abdominal cavity organs requiring surgery
- loss or permanent weakening of speech, sight or hearing, loss of eyes
- burn or similar injuries to skin requiring skin transplantation, extensive burns or frostbites
- severely disfiguring deformities, for example loss of ear lobe or nose or part of it or other severe deformity
- permanent severe health harm or a life-threatening disease or lesion.” (Työsuojeluhallinto, 2020.)

“When the final severeness of the injury is not clear, the accident must be reported, as the nature of the injuries may become clear only through later examinations. Serious injuries must also be reported to the police, who must conduct a police investigation at the scene of the accident. Neglecting to report an accident to the Regional State Administrative Agency and the police is a penal offence as well as not reporting all accident to the insurance company.” (Työsuojeluhallinto, 2020).

### 3.3.2 Notification of accidents at work and electricity to the Authority

A severe accident at work must always be reported without delay to both AVI and the police. If the accident is classified as an electrical accident, TUKES must also be notified of the accident (Työsuojeluhallinto, 2020; TUKES, 2020). According to AVI's instructions, the notification must be submitted as quickly as possible by phone or email. The police are notified by

telephone using the general 112 emergency number. TUKES will be notified in writing of the accident using the document SL 4.doc notification form. (Appendix 2.) (Työsuojeluhallinto, 2020; TUKES, 2020).

## 3.4 Statistics related to electrical accidents

Officially, electrical accidents are recorded in Finland by TUKES and TVK. The TUKES register is called the VARO register. The TVK register is very comprehensive for all types of accidents at work, however, the information in the VARO register is correspondingly more detailed. The data in the TVK register is based on insurance companies' decisions on compensation for accidents at work, and therefore the statistics do not include accidents with electricity during their free time. (Työsuojeluhallinto, 2020; TUKES, 2020.)

The statistics of the TVK best describe the total number of electrical accidents, while the data in the VARO register are usually more detailed. Cases or chains of events that have ended up in the register have often been the scene of a case-by-case investigation. Accident investigations generally involve several parties who investigate their area of responsibility. The parties include, for example, an employer company researcher, an authority such as the police, and the Regional State Administrative Agency, which investigates in connection with the Occupational Safety and Health Administration. A distribution system operator may also be involved in high-voltage accidents, some of which have outsourced accident investigation to, for example, inspection bodies or the like. (Työsuojeluhallinto, 2020; TUKES, 2020.)

### 3.4.1 Fatal electrical accidents

In Finland, fatal electrical accidents have decreased since the 1950s, as shown by the data compiled by TUKES and Figure 3. As can be seen from the graph in the picture that fatal electrical accidents occur in Finland in about 1 to 2 years. The figure includes both professionals and ordinary people.

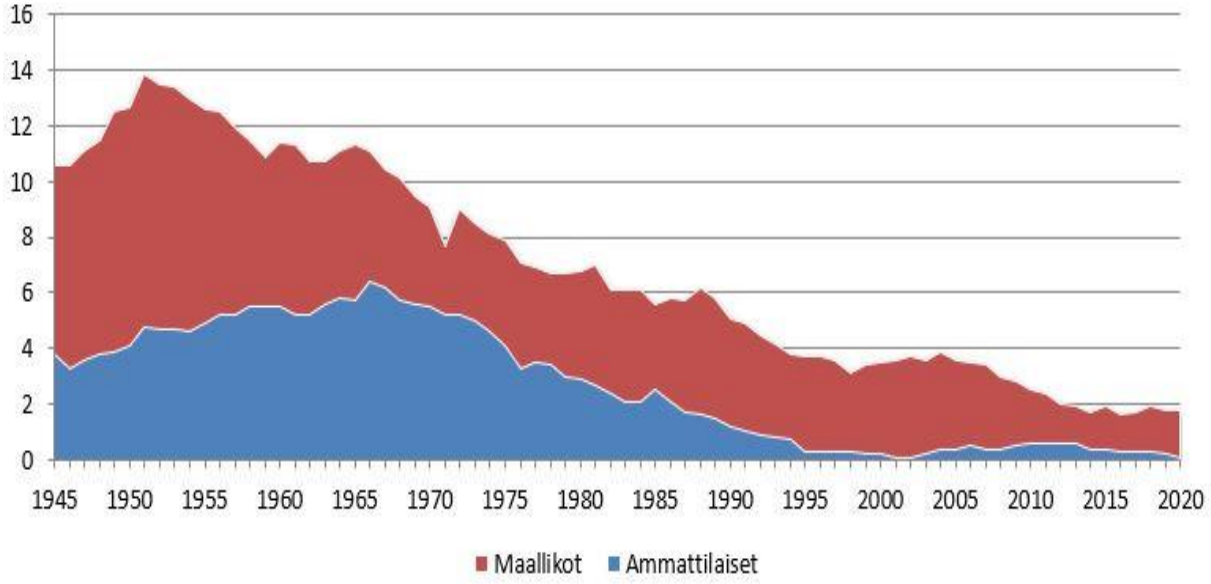


**Figure 3** Fatal electrical accidents in Finland 1945 - 2020 (TUKES, 2020).

The number of fatal electrical accidents has decreased since the 1950s, although electricity use has increased all the time. The graph shows accidents among professionals and ordinary people as a ten-year moving average. Finland's total energy consumption is illustrated in Figure 4.

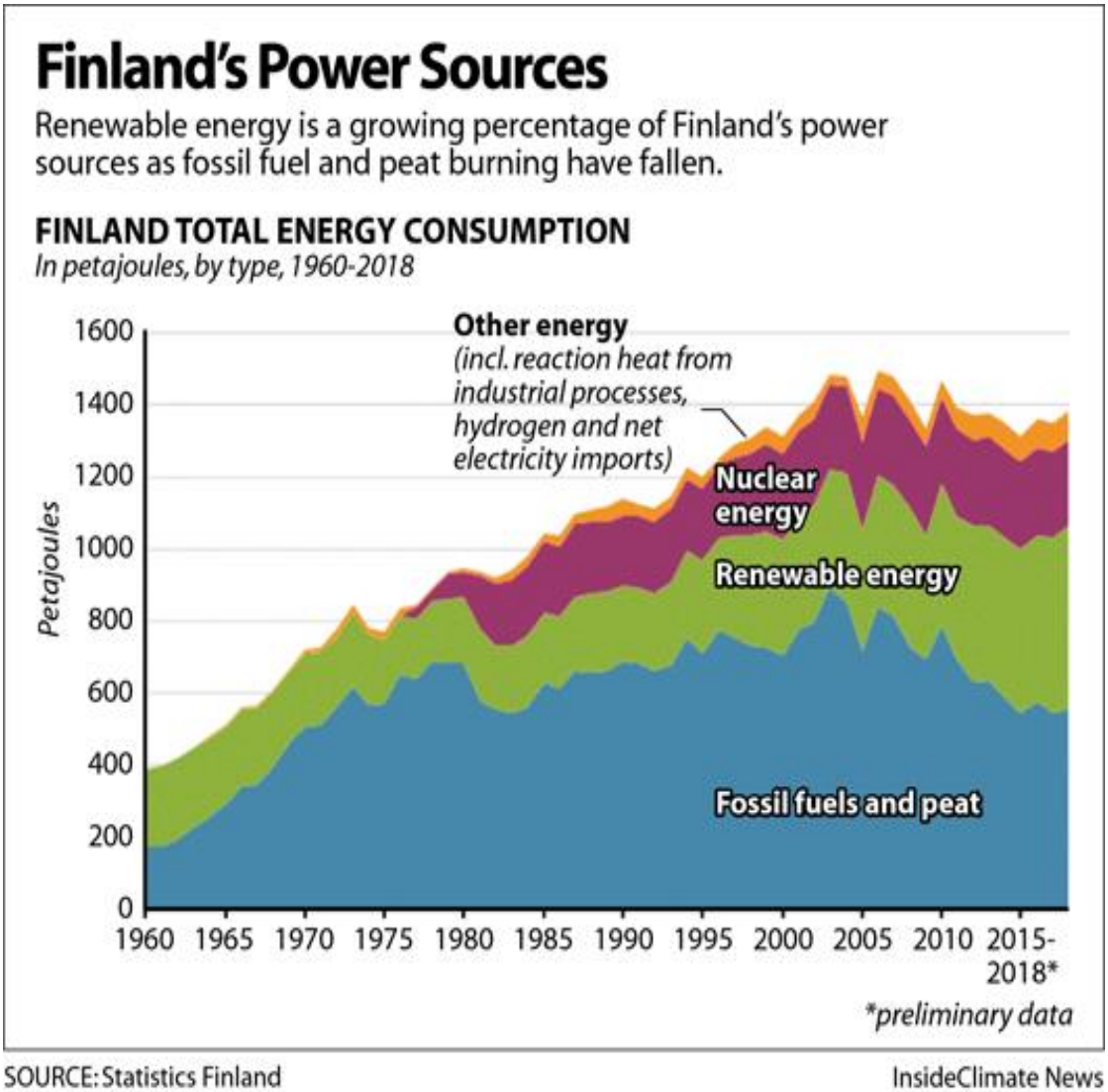


**Figure 4** Finland total energy consumption (Inside Climate News, 2020).

Tuuli Tulonen's thesis has created Table 1, which shows the accidents of electrical professionals from 1996-2008. Based on the data in Table 1, it can be concluded that fatal electrical accidents occur to electrical professionals at an average of fewer than 0.4 times per year over ten years (Tulonen, 2010).

**Table 1** Electrical accidents for electrical professionals 1996 - 2008 (Tulonen, 2010).

| **Outcome** | **96** | **97** | **98** | **99** | **00** | **01** | **02** | **03** | **04** | **05** | **06** | **07** | **08** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Death | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 0 |
| Serious injury | 1 | 3 | 4 | 2 | 2 | 3 | 7 | 1 | 7 | 6 | 2 | 5 | 2 |
| Other (≤ 30 days) or unknown | 16 | 15 | 22 | 13 | 22 | 15 | 17 | 21 | 13 | 12 | 16 | 20 | 28 |
| Altogether | 17 | 19 | 26 | 15 | 24 | 18 | 24 | 23 | 22 | 18 | 19 | 25 | 30 |

Electrical accidents resulting in the death of ordinary people are often the result of, for example, climbing onto the roof of a train on an electric railway or faulty electrical equipment and extension cables. The statistics on electrical accidents of ordinary people can be viewed in Table 2. From the statistics in Table 2. it can be stated that there has been a slight change in the number of these events between 2013 and 2020.

Electric shock and arc accidents are still very common, in practice around 700 a year, as shown in Table 2. The number includes electric shocks and arc accidents for professionals and ordinary people. The numbers vary somewhat from year to year, but the average is around 700 accidents per year over that reference period, but as seen from Table 2. the number of accidents has increased in recent years.

**Table 2** Number of electrical accidents 2013 - 2020 (TUKES, 2020).

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|
| **VARO register** (all) | **95** | **82** | **115** | **89** | **118** | **122** | **144** | **135** |
| VARO register (electrical professionals) | 37 | 32 | 47 | 37 | 55 | 55 | 67 | 68 |
| **TVK register, electric shocks** (all) | **582** | **600** | **607** | **798** | **785** | **831** | **914** | * |
| TVK register, electric shocks (electrical professionals**) | 144 | 164 | 150 | * | * | * | * | * |

*Information from the Accident Insurance Centre (TVK) is preliminary or unavailable. Statistics on accidents at work. Data retrieved 8 May 2020.

**Mode of damage: electric shock; Occupational category: electrician and telephone installers, electrical machine installers, electronics installers, bus installers, electricians, other electrical work

Electrical accidents often result in absences from work, the lengths of absences varying. Table 3 shows the duration and amounts of absences from electrical accidents recorded by the TVK. The information in Table 3 applies to all employed persons and is therefore not directed at electricians only. From the data in Table 3, absences related to electrical accidents have increased significantly between 2012 and 2016. The increased absenteeism almost invariably affects absences between zero and three days, which is a good thing, as this indicates that these accidents are unlikely to have been very serious.

**Table 3** Consequences of electrical accidents 2013 - 2019 (TUKES, 2020).

| Severity (absence from work) | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019* |
|---|---|---|---|---|---|---|---|---|
| **0-3 days** | 524 | 546 | 563 | 576 | 768 | 761 | 808 | 888 |
| **4-30 days** | 38 | 26 | 26 | 20 | 23 | 18 | 18 | 19 |
| **31-90 days** | 5 | 1 | 6 | 7 | 3 | 2 | 4 | 7 |
| **>91 days** | 3 | 7 | 5 | 3 | 4 | 2 | 1 | 0 |
| **deceased** | 0 | 2 | 0 | 1 | 0 | 2 | 0 | 0 |
| **TVK register, total** | **571** | **582** | **600** | **607** | **798** | **785** | **831** | **914** |

*Information from the Accident Insurance Centre (TVK) is preliminary or unavailable. Statistics on accidents at work. Data retrieved 8 May 2020.

## 3.5 Standards governing electrical safety

This section presents key regulations and standards that set requirements for electrical safety. The parts of the regulations that are relevant to the research have been raised.

### 3.5.1 Occupational safety and health act 738/2002

“The purpose of the Occupational Safety and Health Act is to improve the working environment and working conditions to safeguard and maintain the ability of workers to work and to prevent and combat accidents at work, occupational diseases, and other adverse effects on the physical and mental health of workers hereinafter referred to as health.” (TTL 738/2002.) The scope of the Occupational Safety and Health Act includes work performed based on employment relationships and public service relationships or work performed in public service relationships.

Section 82 of the Electrical Safety Act states that The Occupational Safety and Health Act 738/2002 shall be observed in electrical work, operational work, and work close to electrical

installations that may cause an electric shock or arc. The essential safety requirements laid down in this Act that apply to the designation of the person responsible for safety at the worksite, instructions and advice, tools used in work, working methods, use of warning markings, and the prevention of employees and outsiders from entering the dangerous area shall also be observed in work. (Author's own translation) (STL 1135/2016.)

In the case of electrical work, in addition to the Occupational Safety and Health Act, the essential safety requirements of the Electrical Safety Act 1135/2016 must be complied with. The Occupational Safety and Health Act covers almost all work and should therefore be considered with particular care when assessing or planning occupational safety issues. Section 8 of the Occupational Safety and Health Act states that the employer has a general duty of care for the health and safety of its employees. This means, for example, that the employer must plan, select, measure, and take the necessary and adequate measures to improve working conditions. (TTL 738/2002).

### 3.5.2 Electrical safety act 1135/2016

The new Electrical Safety Act (STL) 1135/2016 entered into force on January 1st, 2017, the exact date repealed STL 410/1996, Government Decree (Vna) 1466/2007, and Decisions of the Ministry of Trade and Industry (KTMp) 518/2011, 517/1996, 1193/1999 and 1694/1993 supplementing the Act and Regulation 498/1996 on electrical safety.

The new Electrical Safety Act 1135/2016 contains seven chapters:

- chapter 1 General provisions
- chapter 2 Requirements concerning electrical equipment
- chapter 3 Requirements concerning electrical installations
- chapter 4 Requirements for performing electrical and operational work
- chapter 5 Supervision
- chapter 6 Damage and inconvenience

- chapter 7 Miscellaneous provisions. (STL 1135/2016.)

The Electrical Safety Act 1135/2016 is also supplemented by government decrees (Vna):

- Government Decree on Electrical Installations 1434/2016
- Government Decree on Electrical Work and Operational Work of Electrical Installations 1435/2016
- Government Decree on the Electromagnetic Compatibility of Electrical Equipment and Installations 1436/2016
- Government Decree Safety of Electrical Equipment 1437/2016
- Government Decree about the Advisory Board for Electrical and Elevator Safety (Author's own translation) 1438/2016.

When reviewing a law or other required regulation, the purpose and scope of the law must be evaluated to ensure that the literature in question is appropriate for our purpose. The following paragraphs set out the quotations in Section 1 of the Act and Section 2 of the Act on the Safety of the Electrical Safety Act 1135/2016.

1§

Objectives of the Act

> “The objective of this Act is to ensure the safe use of electrical equipment and electrical installation, to prevent the harmful effects of electromagnetic disturbance arising from the use of electricity, and to safeguard the rights of those that have suffered harm through the electrical current or magnetic field of electrical equipment or electrical installation. The objective of the Act is also to ensure conformity and free movement of electrical equipment.
>
> This Act contains provisions on the requirements laid down for electrical equipment and electrical installations, demonstration of the conformity of electrical equipment and electrical installations, supervision of conformity, electrical work,

and its supervision, and the liability for damage of the possessor of electrical equipment and electrical installation.

This Act implements the Directive 2014/30/EU of the European Parliament and of the Council on the harmonization of the laws of the Member States relating to electromagnetic compatibility (recast), hereafter referred to as the EMC Directive, and the Directive 2014/35/EU of the European Parliament and of the Council on the harmonization of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits, hereafter referred to as the Low Voltage Directive." (STL 1135/2016.)

2§

Scope of application

"This Act applies to electrical equipment and electrical installations used for the generation, transmission, distribution, or use of electricity, the electrical or electromagnetic characteristics of which may be hazardous or cause a disturbance.

This Act also applies to radio equipment and communications networks in so far as they may cause danger to life, health, or property, or harmful disturbance on which no provisions are laid down in the Information Society Code (917/2014) or in the provisions issued under it." (STL 1135/2016.)

## 3.6 Conclusion

There are many notions involved in the occurrence of accidents. Perceptions and theories have changed and evolved. For decades, models have been developed to analyze accidents and prevent them. Accident models look for answers to the questions of why an accident occurs and how accidents start. The previous questions are used to try to predict when accidents will occur

and then prevent new accidents from occurring (Reiman et al., 2008). Also, this chapter discussed the most important laws regarding electrical safety and, in general, occupational safety. The number of fatal electric accidents has been declining for several years, while those affected by electric shock and on sick leave have increased.

The numbers and risks of accidents at work are measured based on various key figures. The key figures are calculated separately for accidents at work and commuting for both employees and white-collar workers. The indicators also indicate whether these are all accidents or only accidents resulting in an incapacity for work. The key figures created can be compared, for example, with the company's figures for the previous year and the industry average. And through this, develop areas where the company’s figures are below average.

# 4 Operating environment of electrical installation work

This section examines the electrical safety of electricians and the factors that affect its implementation. This section also looks at the job description of electrical installation supervisors and the persons in charge of the work, as well as their qualifications.

## 4.1 Electrical installation supervisor

Companies that perform electrical work, i.e., the construction, repair, and maintenance of electrical equipment, must have a designated electrical work supervisor (STL 1135/2016). The supervisor of electrical work must always be a natural person and must be employed or hired in the business in question (STL 1135/2016).

The electrical work supervisor must be appointed, and the company must notify the electrical safety authority TUKES, which keeps a register of electrical work supervisors. The same person may be appointed as the electrical supervisor of up to three companies simultaneously (STL 1135/2016). The operating conditions of an electrical work manager require that he or she hold a certificate of competency. In addition, their position in the company must be such that he or she has a real opportunity to perform their duties and the power to influence the matters he or she are responsible for. Electrical qualifications are divided into three different sections: Electrical competence 1 (S1), Electrical competence 2 (S2), and Electrical competence 3 (S3). In Finland, electrical qualifications are awarded by SETI Personal and Company Assessment Ltd (SETI, 2022).

In practice, the duties of the electrical work supervisor are related to supervising the work, assessing the competence of the employees, and instructing them. In addition, it is the responsibility of the electrical supervisor to ensure that the tools and work methods are compatible with the work tasks of the installers. The above requires the electrical work manager to ensure

that the Electrical Safety Act is complied with and to identify safety issues related to the performance of the work.

The electrical work supervisor is responsible for ensuring that:

> 1) “the electrical work is performed in accordance with this Act;
>
> 2) the condition of the electrical equipment and electrical installations is in accordance with the requirements laid down in this Act before they are put into service or transferred to other persons;
>
> 3) the persons performing the electrical work have the required professional skills and have received adequate instruction”. (STL 1135/2016.)

## 4.2 Electrician

The entire Technology Industry employs about 359,000 professionals in Finland (Tilastokeskus, 2021). An electrician can work on a construction site, industry, power plants, service shops, and electrical products companies. The tasks of an electrician can be the installation and maintenance of various electrical, telecommunications, computer, automation, and HVAC systems. In industry, the tasks of an electrician may include the installation of electrical distribution systems, production control and monitoring systems, various production machines, and service and maintenance. In industry, the working hours of an electrician can be the so-called three shifts. In the energy industry, the tasks of an electrician are related to the production and distribution of electricity. Worksites are often located in power plants and the electricity network’s construction and maintenance. The tasks include the installation of substations, overhead lines, underground cables, and the installation of control and protection systems. For electricians in the energy industry, network installers strive to ensure that electricity is available despite severe storms and snowfall, but this is not 100%.

In addition to the actual technical knowledge, the work of an electrician requires skill, accuracy, diligence, and an excellent ability to perceive and concentrate. In Finland, working in the electrical sector requires that a person meets the eligibility requirements. For a person to be a professional in the electrical industry, i.e., sufficiently skilled for independent work, he or she must meet the requirements of STL 1135/2016. In addition, the basic requirement for performing work in the electrical sector is that the person is sufficiently acquainted or instructed with the task, working conditions, safe working methods, and electrical safety requirements. It is the responsibility of the electrical supervisor appointed to the electricity company to ensure that the persons performing the electrical installation work are skilled and adequately instructed in their work tasks.

One training option for an electrician is to complete a professional bachelor's degree. After graduation, he or she still must work for a year under the supervision of a so-called senior installer. After this, the installer is only qualified enough to do the electrical work independently.

The electrical professional has the appropriate training and experience to assess the risks and avoid the hazards. He must be a sufficiently qualified and self-employed person who has been instructed in the job and who meets one of the following requirements:

A person who has received instruction in electrical and operational work corresponding to his/her training and work experience and meets the following requirements is considered to possess adequate professional skills for supervising and performing such work:

1) “suitable higher education degree in technical field and six months’ work experience in electrical work;

2) suitable electrical engineer’s or technician’s degree and six months’ work experience in electrical work;

3) suitable vocational upper secondary qualification, further vocational qualification, specialist vocational qualification, or a similar qualification obtained before that and six months' work experience in electrical work;

4) suitable vocational upper secondary qualification or a similar qualification obtained before that and one year's work experience in electrical work; or

5) six years' work experience in electrical work and adequate basic knowledge of the sector.

The work experience referred to in subsection 1§ above shall be of such nature that it helps the person in question to become familiar with the electrical and operational work in question. The person providing the instruction referred to in subsection 1§ shall meet the qualification requirements referred to in subsections 1§ and 2§. In electrical and operational work on similar type of electrical equipment, or on electrical installations similar to electrical equipment, a person with two years' work experience in the electrical work in question and adequate basic knowledge of the sector, or suitable electrical training and one year's work experience in the electrical work in question is, notwithstanding the provisions of subsection 1§, also considered to possess adequate professional skills for performing such work independently". (STL 1135/2016.)

## 4.3 Electrical safety supervisor during work

When constructing, modifying, or repairing electrical installations, it is important to adhere to safe working methods. This is how you can ensure electrical safety during work:

- prevent outsiders from entering the dangerous are and
- make sure the power cannot be switched on to inadequately protected parts through simple actions, such as replacing a removed fuse or turning a switch or circuit breaker.

The supervisor of electrical works appoints an electrical safety supervisor for the duration of the work for each job site. The safety supervisor can participate in or execute in full the electrical work in question. The supervisor of electrical safety during work gives the permission to start work and to turn the power back on after the job has been finished. (Author's own translation) (SFS 6002, 2015.)

If persons from several different companies are working on the same site the appointment of the supervisor of electrical safety during work should usually be carried out in writing to avoid any confusion. (SFS 6002, 2015).

## 4.4 Person responsible for the work

A nominated person in control of a work activity must be designated for each work performance. There may be a need for multiple people in responsible for the job in large locations. In this case, however, there must be one coordinating person in charge of the whole. (Työturvallisuuskeskus, 2019). According to the electrical work safety standard SFS 6002, the person responsible for an electrical installation is the person who has operational responsibility for all matters related to the performance of the work during electrical work. The duties of the person in charge of the work include ensuring that the work complies with the regulations, ordinances, requirements, and instructions relevant to the task as the electrical work progresses. In addition, it is the person’s responsibility in charge of the work to ensure that all persons performing electrical work in their area of responsibility are instructed, especially about hazards that the person cannot normally detect (SFS 6002, 2015).

The person responsible for the electrical contractor’s work is mainly the company's official electrical supervisor. If, for example, the supervisor of electrical work is unable to perform the task of the person responsible for the work himself/herself due to the number of personnel or the number of workplaces, etc., he or she must ensure that a suitably qualified (STL 1135/2016) electrical professional is appointed to the task. For the reasons mentioned above, the person in

charge of work in the electricity sector is often the foreman or project manager in the electricity sector. Figure 5, shows the electrical safety organization of Lassila & Tikanoja.

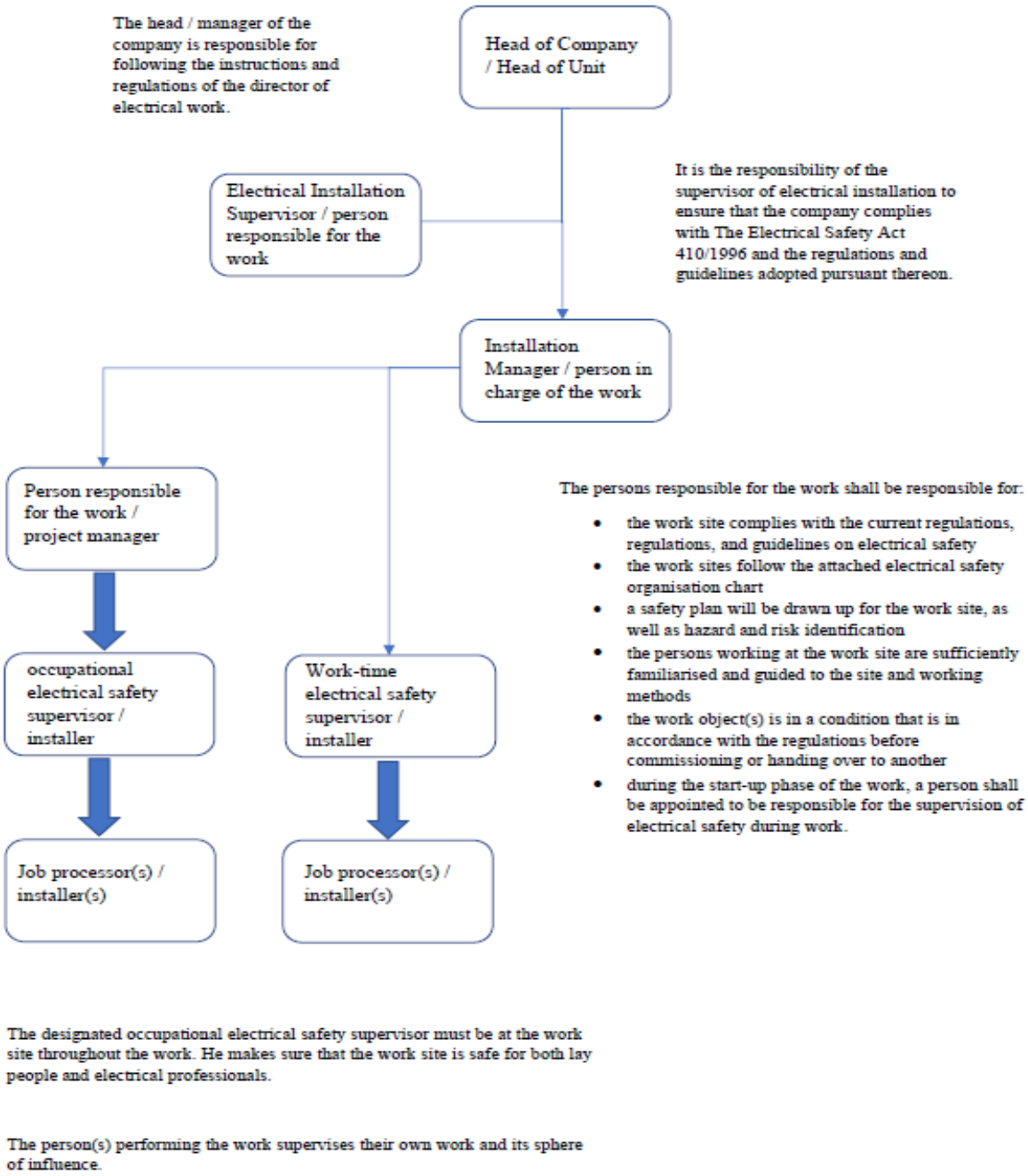


**Figure 5** Electrical Safety Organization.

In addition to those shown in Figure 1, there may also be other persons in the line organization who have operational responsibility for implementing safety at the worksite.

# 5 Responsible business and safety management

The responsible business consists of three main parts, which are economic (or financial), social, and environmental (or ecological) responsibility, this is illustrated in Figure 6. A responsible personnel management method creates the preconditions for implementing occupational safety in the company. From the point of view of occupational safety, the responsible way of managing personnel is mainly social responsibility. Without financial commitment, there are no preconditions for performing the task. Occupational safety is part of holistic safety thinking and emphasizes the principles of sustainable development: taking the environment into account, valuing health and workability, and preventing accidents at work.

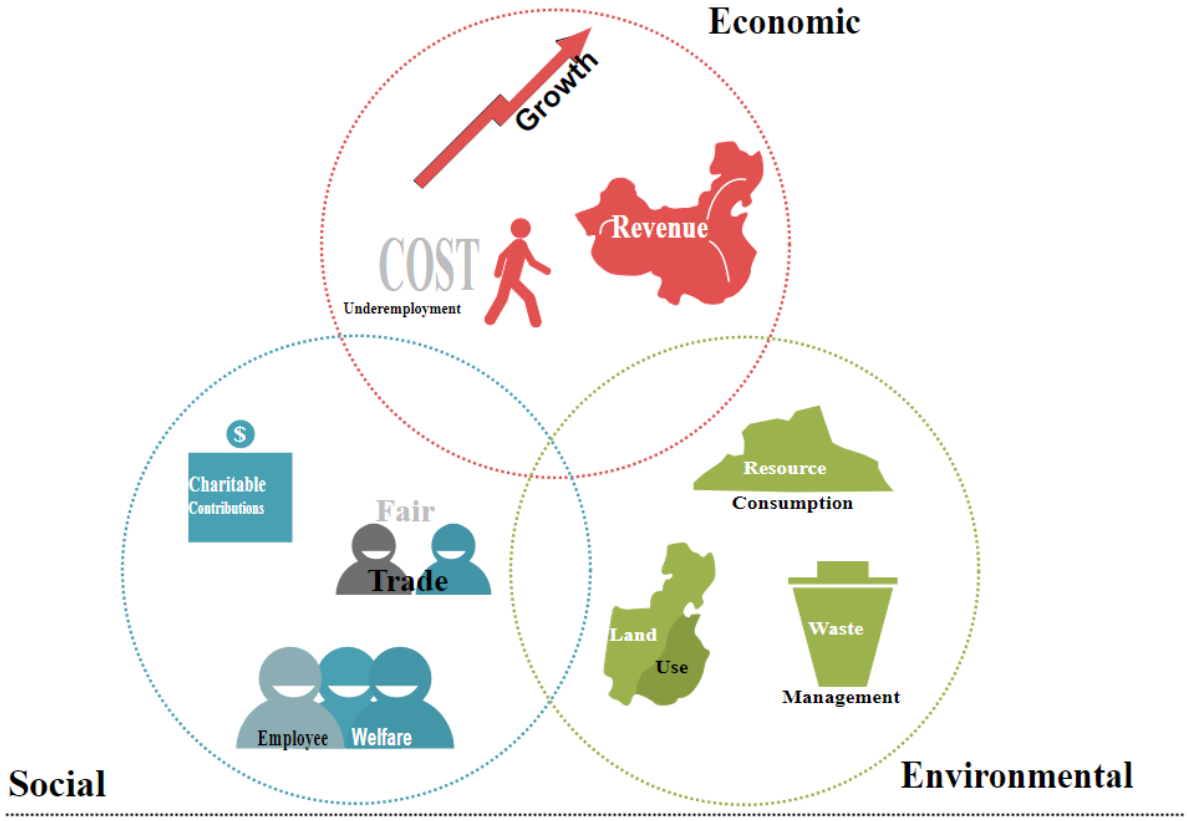


**Figure 6** Graphic describes the three bottom-line types (Wikipedia, 2022).

## 5.1 Risk management and hazard identification

Risk management is part of the company's day-to-day operations. Because only visible risks can be derived, it is essential to identify the hazards in advance. The purpose of risk management is to keep risks at an acceptable level. It identifies hazards, assesses their magnitude and significance, plans measures to prevent them, and monitors their effects (Kämäräinen et al., 2009).

Various tools are available to identify risks, such as risk maps. There are a wide variety of risks: business, personal, contractual, information, project, and environmental risk. Personal risk management is about occupational health and safety. The economic aspect is a motivating factor in occupational safety and health activities because the shortcomings of the work environment cause costs, while a correspondingly good work environment supports productivity. Accidents at work and illnesses of various causes strain the company's results. The costs and benefits of occupational health and safety remain to be considered by company management. Investing in the work environment is now perceived as an investment and not a cost factor. (Kämäräinen et al., 2009.)

The installer's risk management and ability to identify hazards are limited by the workplace's workload and occupational hygiene factors. When doing work, the installer interacts not only with the work environment but also with the job and related machines and equipment. The workload manifests itself differently and to varying degrees for each employee. Many adverse consequences can occur because of workload, especially if there is a large mismatch between the job requirements and the contractor's conditions. The disproportion can manifest as both underload and overload factors. As practical examples, it can be mentioned that: 1. heavy physical work puts a strain on a person, which can lead to a person making poor safety decisions 2. underloading (monotonous) work can lead to a person's loss of attention, which can also lead to poor safety decisions.

Occupational hygiene factors in the workplace include chemical, physical, and biological factors, as well as the indoor climate. Physical, and occupational hygiene factors include noise, vibration, radiation, lighting, thermal conditions (hot/cold), pressure (over/under), and electrical charges and currents. These factors mainly indirectly contribute to the occurrence of an electrical accident. However, there are physical factors that have a direct impact on the occurrence of an electrical accident, such as electrical charges and currents. Indirect factors include lighting, noise, heat, vibration, and radiation. Inadequate work lighting has the most significant indirect effect on the occurrence of an electrical accident. (Kämäräinen et al., 2009.)

## 5.2 Tools for responsible management

Management systems such as quality, environmental, occupational health, and safety systems have been created as tools for responsible management. A company can build its management systems or apply ready-made systems. These systems are intended as tools for operational management as they implement strategic management objectives. By coordinating management systems, the company creates a comprehensive operating system that considers quality, the environment, and occupational health and safety issues in the company's day-to-day operations. L&T uses ISO 9001 certified systems, and quality. ISO 14001, environment. ISO 45001, occupational health, and safety (L&T, 2021).

ISO 9001 is a quality management system standard. According to the standard boundary conditions, a quality system and a quality manual are built for the company. Acting by the instructions helps the company consider important factors for implementing occupational safety.

ISO 14001 is an environmentally friendly standard. This allows the company to develop its operations to be less harmful to the environment. The standard has no direct effects on the implementation of electrical safety. However, factors that indirectly affect the environment can also burden a person. This can reduce a person's ability to function, which exposes the person to accidents, such as electrical accidents.

ISO 45001 is an international occupational health and safety management system that provides a systematic, internationally validated safety management framework.

The introduction of the systems is intended to increase operational management efficiency. This is facilitated by the systems' requirement for transparency of responsibilities. The systems can reliably demonstrate to stakeholders how the corporate responsibility required for sustainable development is implemented in the company. Deploying management systems always incurs costs. However, systems should be implemented if the company believes that they provide added value to the company. The systems can add value to the company, such as financial, image and stakeholder matters.

The company's comprehensive operating system considers quality, the environment, and occupational health and safety issues in the company's day-to-day operations. The principle of a quality system should be such that it equally controls all the system’s content. In doing so, safety and health are also considered as a whole and not as a separate components, among other things. Occupational safety, quality, and productivity interact with each other, and for this reason, the best result is achieved by tying things together in everyday activities. A good working environment and safe working practices have a significant impact on electrical safety and the creation of good quality and productivity. (Rissa, 1999.)

## 5.3 Safety management

Safety management is an important part of proactive occupational health and safety. Safety management is about how occupational safety and health are managed and developed as part of overall safety and other management activities. The OHSAS 18001 standard can be used to build a company's safety management system. The Occupational Safety and Health Act 738/2002 requires the employer to take the necessary measures to ensure the safety of employees. The law also requires that the employer has an occupational health and safety action program.

Safety management refers to the activities of management and supervisors to continuously improve the level of safety and the competitiveness of the workplace. Safety management is the continuous development of processes, operating methods, working conditions, personnel skills, cooperation, and the work atmosphere. (Laitinen et al., 2009.) Comprehensive safety management is called OOE activities (occupational safety-occupational health-environmental issues). When a company invests in overall safety, it creates the conditions for itself to improve productivity, competitiveness, and the well-being of its personnel. The company can achieve a wealth of synergies in a comprehensive safety management model by bundling quality, safety, occupational safety, occupational health, and environmental issues together. (Rissa, 1999.)

The safety management model to be introduced in the company will be integrated into the company's quality system, making it a part of everyday operations. The goal is for the technology to be in order in the processes and work and for safe and smooth work practices to be followed in other practices. In addition, the management model should ensure that the personnel is professionally motivated and that the work atmosphere is encouraging and innovative. Safety is not separate but must be considered in all activities. The control functions of the quality systems are based on up-to-date measurement data. The construction industry uses TR quality measurement, which measures site safety factors. However, TR measurement does not delve into the electrical accident factors that an electrician may encounter in his work. For this reason, pre-identification of hazards and risks is particularly important in electrical work. When a company strives for a high-quality and profitable operating environment, it is essential that it has satisfied personnel, a safe work environment, and environmental impact management. Figures 7 and 8 show L&T´s operating methods, e.g., how the accidents are reported and the step-by-step notification procedure in Toyme. Toyme is L&T´s internal program.


**Figure 7** Accident reporting procedure in Toyme (Vahinkoilmoitukset, 2022).

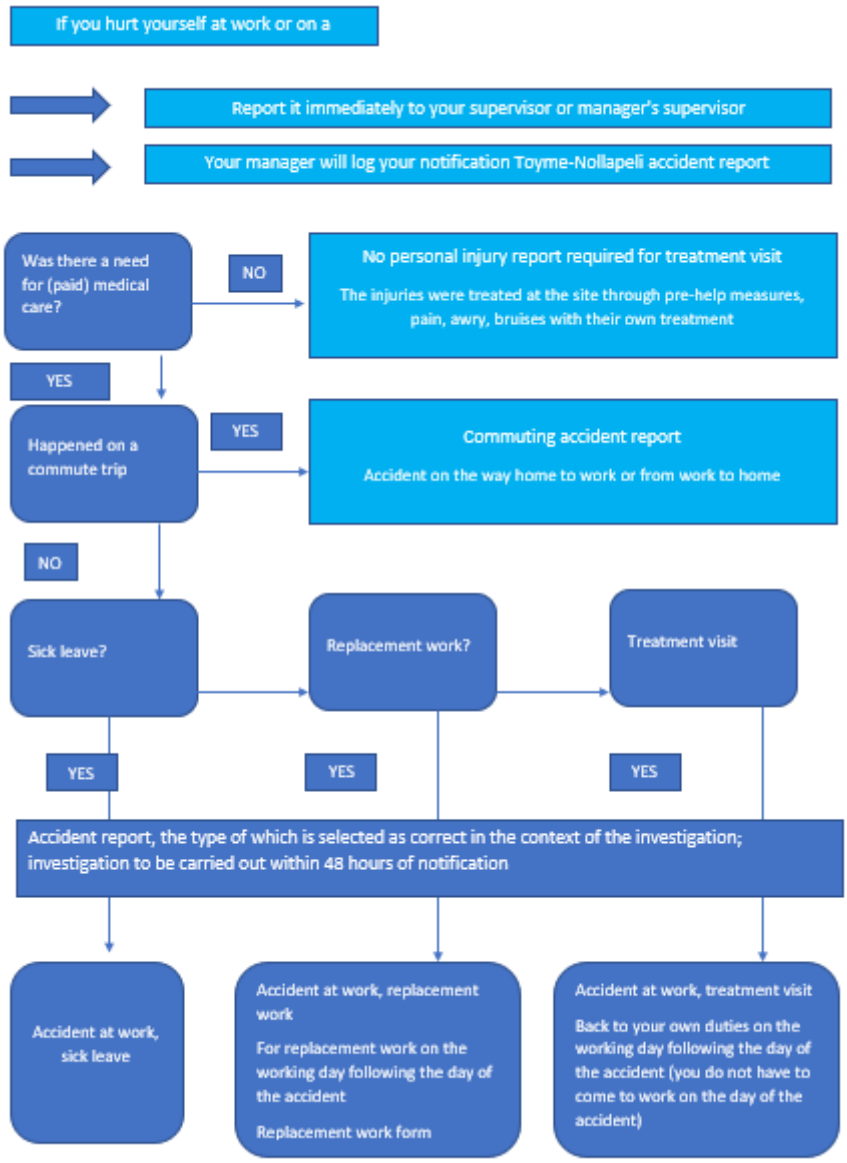


**Figure 8** Accident notification procedure in Toyme (Vahinkoilmoitukset, 2022).

## 5.4 Safety culture and occupational safety

Occupational safety is a process, just like the actual task. The objectives agreed in the work community are set for occupational safety, which is monitored, and the development assessed. Feedback is given in the development so the operations can be adapted so the safety development remains in line with the objective. Construction-related construction sites improve safety by making observations, eliminating identified hazards and risks, and modifying risky opera-

tions (Erkkilä-Häkkinen, 2016). Occupational safety is part of human values, activities, behavior, and attitudes to instructions. Occupational safety is also affected by environmental factors, tools, equipment, and their use and maintenance. Professional skills, training, and legislation can also have an impact on occupational safety. Occupational safety should always be proactive and preventive.

Safety culture is a way for a company, individual operator, or person to incorporate safe practices into their job? Safety culture is also the company's way of doing and acting. The safety culture reflects the work community's values, beliefs, norms, and assumptions. The safety culture is reflected in how risks and hazards are identified and managed, whether safe working methods are used and whether safety is an integral part of the work to be carried out. (Erkkilä-Häkkinen, 2016.)

In this context, safety culture refers to the active consideration of safety issues in the activities of the company and the persons working there. The safety culture is a constantly adaptable space in the company's operations, so it is especially important that the personnel are aware of the safety risks associated with the company's operations and personnel and that they follow the company's safety guidelines.

Safety culture is not an individual issue that the safety guideline author can embed as part of the electrical occupational safety guidelines. In a good safety culture company, safety has been well considered, and personnel is well placed to do their work well and safely. The safety culture also involves identifying risks and hazards, i.e., in practice, understanding and managing the basic work carried out in the company and the related places of performance (Reiman et al., 2008).

“The term 'safety culture' was only used after the Chernobyl nuclear power plant accident in 1986. Following the Chernobyl disaster, it was found that the cause of the accidents is not merely technical faults or a mistake made by an individual. After the accident, it was also found that the organization, management, and attitudes positively or negatively impact safety. Prior

to introducing the concept of safety culture, accidents were generally found to have been caused either by human neglect or error." (Flink et al., 2007.)

In the general debate, the concept of a safety culture is still so-called quite hollow. The concept is already being used fluently, but there is often a lack of common understanding of what safety culture is all about. The concept of safety culture can simply be defined as our way of working on safety issues. The minimum elements of a safety culture are shared values (which are important), beliefs (how things are and work), and standards of behavior (the way we do things here) (Nurmi & Simonen, 2003).

The International Atomic Energy Agency (IAEA) defines safety culture as follows:

> "A safety culture consists of organizational practices and the attitudes of individuals, because of which the factors influencing the safety of nuclear power plants each receive the attention required by their importance and are given priority in decision-making." (IAEA, 1991.)

The Health and Safety Executive, the HSE, defines a safety culture in the UK as follows:

> "An organization's safety culture is a product of individual and group values, attitudes, perceptions, competencies, and behaviors that define an organization's style and level of safety management and commitment to it. Features of organizations with a positive safety culture include communication-based on mutual trust, a shared understanding of the importance of safety, and trust in the effectiveness of proactive measures." (HSE, 1997.)

Even a good safety culture does not eliminate the possibility of error. In an organization with a good safety culture, mistakes are treated openly, with each case a learning opportunity. Safety

culture is about the organization being aware of the risks associated with its operations and striving to ensure the means to respond to them. In addition, efforts are made to consider the human factors related to the organization's operations. Good safety management is key when it comes to getting rid of accidents and incidents caused by the organization. The company's exemplary safety culture creates the conditions for successful risk management and hazard identification. (Flink et al., 2007; Rissa, 1999.)

The identification of risks and hazards is an essential part of electrical safety. An unidentified risk or hazard cannot be controlled, so it would also be particularly important to collect safety observations in electrical contracting companies. The company includes identified risks and hazards as part of the safety guidelines based on safety findings. A code of conduct will be developed in the safety guidelines to minimize hazards and risks based on the identified hazards and risks. Common identified hazards and risks in electrical work include, for example, urgency, attitude towards safety issues, working conditions, working alone, being used to risks, and conscious risk-taking. (Tulonen, 2010; Pulkkinen ym., 2009.)

## 5.5 Risk assessment in the workplace

What is risk assessment, and what does it mean? By the definition of risk assessment by the Occupational Safety and Health Centre, the risk assessment is and refers to:

> "A method for identifying work-related hazards in advance. The method also allows the level of risk and its significance to be determined." (HSE, 2020.)

Risk assessment is about proactive work-related protection, just as is the case with the electrical safety guidelines. Assess the current risks, in addition, to which accidents, accidents, and near misses have occurred in the past, will be considered. The risk assessment is intended to identify operational risks before they cause damage (HSE, 2020). The characteristics of a suitable risk assessment are:

- the risk assessment originates from the employer and involves different entities or levels of the company involved in its implementation. It is important that the following levels, employees, experts, and decision-makers participate in the evaluation
- risk assessment is always truthful. It shall honestly describe the circumstances and tasks as they are carried out in practice
- risk assessment is systematic. The risk assessment should cover all significant risk areas of the enterprise and be done systematically. The evaluation shall consider the task, the target, etc. the importance or importance of the undertaking based on which particularly important risk areas are examined in more detail than other
- good risk assessment is differentiative. It should highlight the sites that require development, i.t. development needs. A differentiated risk assessment can also reveal risks that do not need action when development needs are revealed. (Työturvallisuuskeskus, 2015.)

Risk assessment can be kept effective when we can focus on only a few key risks that are relevant to the company's operations (Työturvallisuuskeskus, 2015). According to Section 10 of the Occupational Safety and Health Act, 738/2002, work hazards and disadvantages in all workplaces must be identified and assessed.

# 6 Survey research findings

The survey was addressed to various parties to identify inconsistencies in the results of the survey. The various parties here mean project managers, foremans, and electricians. The survey participants' responses aimed to confirm the relevance of the questions in the survey and, on the other hand, to chart the current experience of electrical professionals in electrical workplace safety. The survey participants were able to answer questions in writing in a free-form manner, i.e., there were no ready-made answers to the questions.

## 6.1 Survey data summary

The following paragraphs discuss the answers to the survey-related query. The text raises the issue and summarizes the responses of the electricity professionals who responded to the survey. For some questions, information related to the distribution of responses has also been identified in the summary and review of the answers.

The survey topics were divided into seven different parts in the query. The survey covered the following topics: Electrical safety in general, electrical accidents, working in live equipment, urgency, working alone, subcontracting, and training.

### 6.1.1 Electrical occupational safety in general

Question 1. *How do you perceive the current electrical safety situation in general or in your company?*

Four out of six responded exhaustively to the fact that they feel that the electrical occupational safety situation is good. Some supplemented the answer with the phrase that safety can always be improved. In addition, the answers raised issues such as the fact that, in their experience,

electrical accidents happen very rarely, and those severe accidents have been avoided even when an electrical accident has occurred despite everything.

Question 2. *How do you think the electrical safety of electricians should be developed?*

The answers to this question highlighted two subjects beyond others, which were training and learning from near misses or mistakes. In addition, the following issues were raised in the responses, such as planting a positive safety culture in the organization, the power of example, and guidance from the management before work begins and during the project.

### 6.1.2 Electrical accidents

Question 3. *Have you had an electrical accident yourself? How did the electrical accident you experienced occur?*

This was the only question in the survey that achieved 100% consistency, all respondents (n=6) replied that they had not experienced an electrical accident.

Question 4. *Do you think there are common factors for electrical accidents? Could you name these?*

Four respondents (n=6) replied that urgency is the primary common factor for electrical accidents regarding this question. The answers also mentioned things such as carelessness, indifference, recklessness, and thoughtlessness.

### 6.1.3 Live working equipment

Question 5. *Electrical work is often done live, even if safety requires de-energization. How do you think unauthorized voltage work could be reduced?*

The responses of the respondents related to adequate and frequent guidance on not allowing live working to be carried out in the company. Methods were mentioned, such as talking, guiding, raising the issue quickly, clearly, and still fairly managed. One respondent (n=6) also rightly stated that the management should also justify to the workman why the electrical equipment must be made dead during the work.

Question 6. *Many do not verify that the worksite is de-energized. How could we ensure that this working phase (verifying de-energized worksite) is performed by everyone? How do you think unauthorized live working can be reduced?*

There was almost unanimity in the answers to this question because five out of six answered the question that the purpose of recalling and instructing is to make everyone aware that there are no live parts in the context of electrical work. In the answers, it was pointed out that the instructions and supervision of the supervisor of electrical work should be invested in. In addition, the replies stated that the management should ensure that everyone has at their disposal the appropriate tools necessary to detect the live parts.

### 6.1.4 Urgency

Question 7. *Urgency is generally seen as a degrading factor in electrical occupational safety. Do you agree with how the urgency manifests itself in you?*

All respondents (n=6) agreed that urgency is an occupational safety risk. The respondents also stated that the urgency hinders concentration, increases negligence and errors, and makes you

forget, for example, to say that there is no excitement. As for the emotional state associated with the rush, it was found that it is often a self-leaving state and that it may be fueled by "too" small human resources compared to tasks, as well as a short implementation schedule.

Question 8. *What means do you apply to control the sense of urgency?*

The link between the responses to this question can be prioritization, i.e., prioritizing subjects or issues. A good and relatively simple way, although it may not be suitable for avoiding all sense of urgency. Sometimes the rush was caused by the actions of others or by the event of some other unforeseen situation that could not be prepared for. However, in these situations, it is good to apply a method that one of the respondents highlighted, i.e., reflection, patience, and outline of the work before taking it.

### 6.1.5 Working alone

Question 9. *Working alone is generally identified as the second biggest risk factor for electricians after a rush. At what stage of work, etc., do you feel that working alone is or may be a risk factor?*

There was more disintegration in the answers to this question than in previous questions. The answers mentioned situations, work phases, and facilities such as working in confined spaces, switching on/off switchboards, live working, demolition work, and work requiring a partner. Some of the answers follow the responses of previous studies, i.e., responses such as connections to centers, voltage work, and cramped enclosed spaces. However, the replies clearly stated that all demanding work should be carried out by a working group of at least two people.

Question 10. *Whether it is possible to develop a less risk-a-risk risk associated with working alone. How would you develop?*

There was no clear answer to this question that would have risen above the others. The replies stated that we should avoid working alone, guidance on safe working practices, and clear instructions from management. The replies referred to the content of SFS 6002, it was found that, based on hazard identification and risk assessment, it is assessed whether future work can be carried out as a solo job or whether, for example, a two-person working group is needed.

### 6.1.6 Subcontracting

Question 11. *Using subcontractors in electrical work in the building services sector has become very common. Do you think there is an increased risk of electrical safety for subcontractors?*

In the answers to the question, the respondents agreed that there is an increased risk of electrical safety associated with the subcontractor’s use. Based on the responses, the risk related to the fact that the working methods of subcontractors, the qualifications of the personnel, and the culture of compliance with electrical safety cannot be certain. The replies also stated that efforts should be made to monitor because the practice has shown that the smaller the company, the more often they slip in electrical safety matters.

Question 12. *What factors increase the risk of electrical occupational safety of the subcontractor?*

The respondents assumed that the subcontractor was always a foreigner on this issue. The result is that their language skills, cultural differences in working and safety practices, and the lack of understanding of the country's customs would become factors that increase their risk of electrical safety. Factors such as fragmentation of work, undersized number of employees, and increased price pressure on contracts were also mentioned.

The answers indicate that the subscriber organization must ensure the performer's commitment to complying with the standards and guidelines of e-occupational safety.

Question 13. *How do you think subcontractors' potential risk of electrical occupational safety could be reduced?*

On this issue, the respondents' replies highlighted two apparent unifying factors. The organization of adequate supervision and the assessment of qualifications and training were factors that the respondents would use to reduce the subcontractor's occupational safety risk. In addition, TUKES' role was also highlighted in the answers, from which it is hoped that the guidelines will be tightened up and that the guidelines will be monitored. The replies also mentioned education supervision.

### 6.1.7 Training

Question 14. *Do you feel that the current SFS 6002 e-occupational safety training is necessary?*

There was no unanimous answer to this question. It was intended that all respondents would find SFS 6002 training necessary. However, one of the respondents did not feel that such training was necessary.

Question 15. *Do you think that the recurrence of the current SFS 6002 electrical safety training every five years is sufficient?*

There were two options in the answers to this question, as can deduct from the answers to the previous question. Five out of six responses stated that SFS 6002 training repeated every five years is adequate. However, the answers were conditional because they included a statement that SFS 6002 e-health training should be provided frequently enough. The flexibility of work tasks should be considered in the periodicity of the training. A refresher of the training or parts of it as needed for those who are performing demanding tasks. The replies also stated that, in

the context of the standard amendment, training should be provided in a shorter time than between five years, mainly if the information cannot otherwise be passed on to professionals. One respondent said that the training interval could be repeated every 15 years.

Question 16. *How do you experience the current electrical training?*

a. *Does a recent graduate have sufficient basic knowledge of the field when they graduate?*

Many respondents did not have experience with the skills of vocational school graduates because they had not worked with them. It was known that the amount of contact teaching had been reduced, and it was considered that this may not have improved the skills of the trainees. One of the respondents stated that the recent graduate who happened to him had sufficient basic knowledge and skills.

b. *If recent graduates have a lack of basic information, what are these?*

The respondents raised issues such as case-by-case shortcomings and were well-dependent on the person and the motivation to study.

c. *Is a possible lack of information a risk to a person's electrical safety?*

Almost all respondents stated that the lack of data is a risk to electrical safety. As corrective measures, the respondents proposed ways such as guidance for the person and encouragement of asking. Reminded that there are no stupid questions, but stupid ones who don't ask.

## 6.2 Conclusion

There is a widely accepted goal of *zero accidents* in Finnish workplaces, according to which all accidents are unreasonable and preventable. According to statistics, electrical accidents have not decreased in recent years (Elsäkerhetsverket, 2020; HSE, 2021). More and deeper information on electrical safety risks is needed to reduce electrical accidents. In addition, measures need to be developed to identify existing electrical safety deficiencies in the organization. Most accidents at work are possible because safety measures have been neglected when starting work. There is too little research into why confirmatory measures are not taken. Based on this and previous studies, there has been a clear need for research data that would have been sought to be collected from all electrical professionals. With the research data mentioned above, it would be possible to form a clearer picture of the types of safety risks that professionals face in their work.

An electrical accident is often the result of a failure to act safely. Verifying a de-energized worksite should be an obvious thing for an electrical professional, but failure to do so will very often prove to be the cause of the accident. For experienced installers, training is very easy to forget. According to installers, this is because the scheduling of the contract sites has been made too tight. Experienced and professional installers should be trained to be informed of new regulations and safety issues. This maintains the installer's professional skills and allows the installer to work safely. There are some problems with electricity training. The work experience is very one-sided and poor. There should be much more talk about occupational safety regulations. The young installer would then be able to demand the right tools for different situations. The installer should know what to do and how to do it, for example, working heights.

An electrical accident is rarely the result of a single cause or event. In addition to the tension, there is also a rush, which can be due to several different factors. Often, however, the rush is incorporated into problems caused by the organization. The issues of the organization are mainly related to the planning and implementation of projects. Sometimes the failure to act safely is also due to intentional and unintentional human factors.

Electrical professionals consider hurry and increasing work pressure to be a significant occupational safety risk. The rush often leads to omissions that result in dangerous situations. In a hurry, familiarization with the instructions and issues related to the implementation of the work remains too superficial. Pressure is also mentioned as causing the rush. The pressure makers are the subscriber, customer, owner, and supervisor. Excessively tight implementation schedules are also considered a security risk. Lack of time indirectly leads to haste, but primarily it means that the installer may, so to speak, correct their work, in which case, for example, the inspection of the work receives too little attention.

# 7 Development proposals based on the thesis

L&T's electricity services should be made transparent from the company's CEO all the way to the installer. It would be particularly important to identify responsibilities at the unit and site levels. Cooperation between services should be developed, and transparency should be made more visible. The organization and its responsible persons should be known to the installer.

As the organization changes all the time, there must be a system for informing the responsible persons through which the installers receive up-to-date information. The updated organizational structure and the information of the responsible persons could be brought to the installers' attention, for example, through the unit bulletin board, the construction area orientation folder, and/or the security folder of the construction worksite. The timeliness of the organization should also be monitored and updated continuously. Figure 9 shows essential persons involved in L&T´s Electrical Safety.

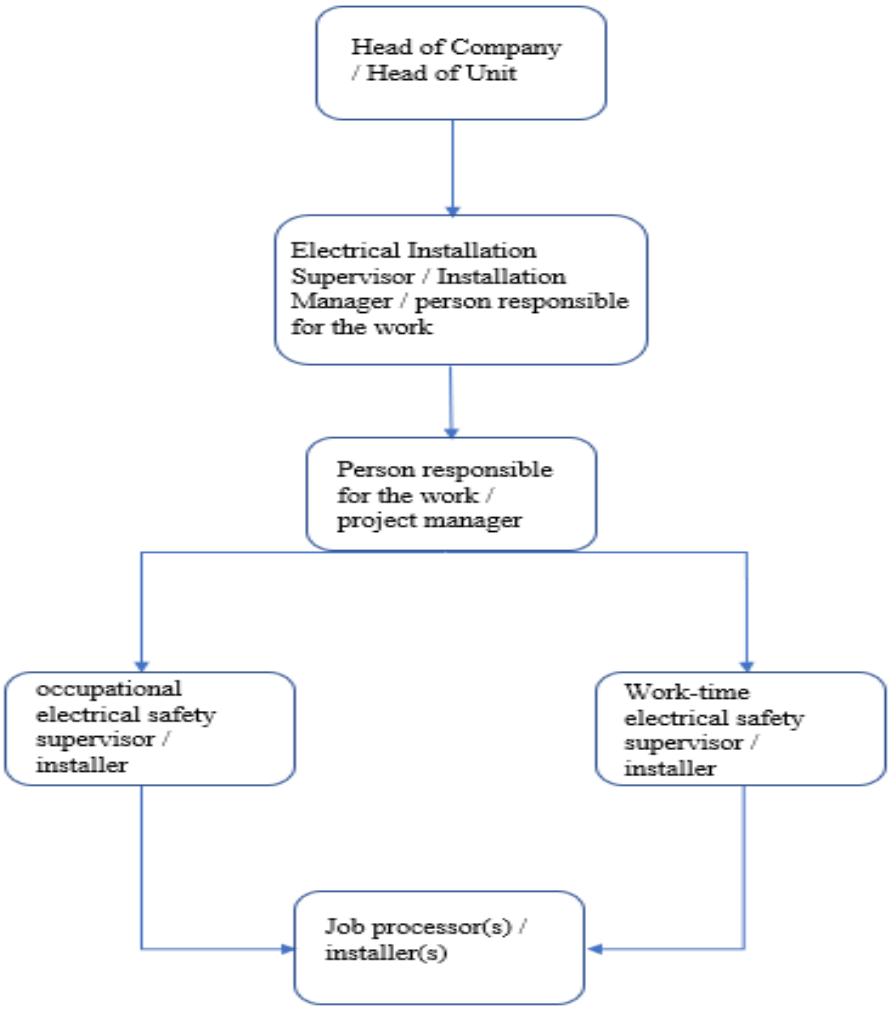


**Figure 9** Essential persons involved in Electrical Safety.

## 7.1 Electrical work organization from a safety perspective

The basic preconditions for risk management are the identification of risks and hazards. Part of this identification is identifying the organizational structure and its possible shortcomings. The current system is limited to sites/units and is not up to date for all sites. Deficiencies occur in some areas, such as the timely notification of designated responsible persons to the authorities (TUKES, 2020).

It should be remembered that the supervisor of electrical work is not just a technicality, but the person must be able to supervise and instruct the activities. This relates to risk management because if the supervisor of electrical work cannot be physically present at the sites under his responsibility, then the question arises as to how he will be able to identify hazards and risks and to create guidelines for them. The supervisor of electrical work can delegate tasks, but the responsibility is their personal responsibility.

### 7.1.1 Development proposals

L&T could appoint an e-work organization to develop a so-called coordinating electrical work supervisor. A coordinating electrical work supervisor would create a single model of the organizational structure to be followed in all units. Units would complement the model. The model should be introduced for all work related to electrical installation activities. The timeliness of the organization should also be reviewed. Supervision could be one of the tasks of this coordinating supervisor of electrical work.

This creates a need for further training. The answer to this could be information compiled by this coordinating supervisor of electrical works, which he would share with the people responsible for the work centrally. In addition, the supervisor of electrical work would work closely with the authorities and stakeholders, in which case they would have continuously the latest information on the standards, etc., interpretations of standards. This information would also be distributed centrally to sites. In addition, it is important that the responsible supervisor of electrical work for each unit is responsible for the implementation of the electrical work for the people working in the unit. This would ensure that responsibility would be realized and not grey, not anyone's responsibility. It should also be assured that the service production units also have appointed a supervisor of electrical work and other persons responsible by the Electrical Safety Act (STL 1135/2016).

In addition, it is proposed that a self-assessment of electrical safety, drawn up in cooperation between TUKES and VTT (Opas, 2020), be added to the guidelines, which are freely available

on the TUKES website. This list has subsequently been updated in cooperation with STUL and the Finnish Electrical Workers´ Union. The inspection list is intended as a tool for electrical professionals to carry out systematic self-assessment of electrical safety.

## 7.2 Responsibilities and resources of the supervisor of electrical works

Companies carrying out electrical work, i.e., construction, repair, and maintenance of electrical installations and repairs and maintenance of electrical equipment, must have a designated supervisor of electrical work.

The supervisor of electrical work is the most important person in charge of the electricity sector in the company. Their task is to ensure that there is no danger or disturbance in the electrical installation construction. In all cases, the supervisor of electrical work must ensure that all persons performing electrical work are sufficiently skilled in their duties and that electrical safety is not compromised.

As a result of accidents, TUKES may impose various sanctions on the supervisor of electrical work. Sanctions may be administrative or legal, depending on the injury severity caused by an electrical accident. As an administrative sanction, TUKES may refuse the Supervisor of Electrical Works the right to act as the director of the work. In certain cases, TUKES may prohibit the operator (company) from carrying out electrical work in order to ensure electrical safety. In the case of an electrical accident, there is always a sanction for severe injury or death, and it is much stricter than administrative sanctions. The supervisor of electrical work must always be a natural person (STL 1135/2016), for which reason he or she is personally responsible in court for possible sanctions. The supervisor’s role in electrical work is not just a technicality to meet the requirements of the law. The supervisor of electrical work has general supervisory responsibility in an electrical installation company. The supervisor of electrical works cannot delegate his supervisory responsibilities, but he may delegate the performance of the tasks. As a practical example, the supervisor of electrical work does not have to carry out installation inspections

himself/herself. Still, they must ensure that the inspections are done professionally, carried out, and documented.

The ability of the supervisor of electrical work to carry out their duties depends on the number of offices in the company, the geographical distance from each other, and the number of employees for which he is responsible. For this reason, the responsibilities of the supervisors of electrical work should be reviewed and updated as necessary. Sufficient time and financial resources should also be set in place to carry out the task responsibly, as the leadership of the work is the first step towards an accident-free work community. In addition, consideration should be given to increasing training for work managers. Today, knowledge is aging rapidly, and the electricity sector is no exception either. Various information systems (e.g., Toyme) could be used to maintain registers to ensure that all installers have sufficient qualifications and orientations for their duties.

## 7.3 Adequacy of expertise, competence, and orientation related to electrical safety

The basic requirement for carrying out electrical work is that the person is sufficiently familiarized or guided to the task, working conditions, safe working method, and electrical safety requirements. Orientating into tools and methods should be registered to make it easier to examine the state of orientating at a later stage.

Working alone requires the employer to ensure that the installer is qualified for the job; when allocating on-call duties, it must be assured that the person is qualified for the electrical work. In addition to the employer, written instructions concerning work tasks must be drawn up for employees participating in on-call duties. Responsibility should not be passed on to employees who often must do the work under pressure created by the customer.

### 7.3.1 Qualifications and guidance/orientation of installers

Mapping competence, as well as centralized management of such data in a large organization, is important from the point of view of electrical safety. The information helps supervisors choose sufficiently qualified and experienced installers for their work. When installers are borrowed from other sites for urgent assistance, the information in that register is of paramount importance, but now when the GDPR (General Data Protection Regulation) has entered into force, the introduction of the register is almost impossible to bring into use because the person responsible for the local work may not know the qualifications or work experience of the posted installers.

Increasing the qualifications of installers through voltage training would be likely to give them an additional tool for identifying hazards and risks in their work. There are also people for whom voltage training would be necessary for the job, but voltage training is not needed on all sites. These live works include commissioning inspection measurements to work related to battery and UPS equipment. In these jobs, from the point of view of electrical safety, the problem is the high current of the equipment or the high voltage, depending on the equipment.

At least one work phase involves a potential occupational safety risk in commissioning inspection measurements. For example, a short circuit current measurement. This is always done at a live working and, depending on the equipment, you might get an electrical shock when equipment touches live parts. Installation always works on the live part, so the work requires the use of voltage work methods and the right equipment.

The person responsible for the work shall also provide guidance to all persons involved on the dangers they are not normally able to identify. To ensure that the persons responsible for the work have practical experience of the work and the working methods used, this should be ensured. In addition, they would need sufficient time resources to be able to stay at the installation site for the necessary time to observe potential risks that the performer would normally not be able to identify. It is important to consider the employee's qualifications and work experience

in orientation or guidance. The tasks of orientation/guidance should be individual. This is because a person with less experience or training may need more thorough orientation than usual.

L&T's current policy is that electricians who are in service and maintenance at work are given a job orientation once a year. The purpose of the induction is to familiarize the electrician with the potential risks and hazards of the plant and to guide how the installer should act in their work to carry out the work safely.

### 7.3.2 Development proposals

Consideration should be given to providing voltage work training to all installers. The purpose of the training is not to increase the number of voltage work. However, the training would improve the ability of installers to assess electrical hazards and risks at their work sites. Suppose it is not possible to provide training to all installers. In that case, it should be more accurately identified at the sites to identify the work areas where voltage training should be given to those who carry out commissioning inspections, for example, as well as work-related to the battery and UPS equipment.

There is room for improvement in orientation. The problem is related to the introduction of new working methods or tools. This is a problem that is proposed for review. However, this would not need any special procedure to remedy. To solve this problem, it would be sufficient to identify the organization’s problem and focus on it with additional attention and resources.

## 7.4 Key factors that pose challenges to electrical safety

Measures to reduce electrical accidents are not always sufficient. More information is needed on the electrical safety risks electrical professionals face in their work. It is paramount to learn how to identify current electrical safety problems. The preventive action of accidents is complicated because accidents, especially near misses, are not reported.

### 7.4.1 Urgency

The survey results suggest that urgency is often due to overly tight schedules and pressure on workers. The means can be simple, for example, by investing in the activities of your immediate supervisor in removing the rush and removing the sense of urgency. The rush easily leads to deviations from safe working practices. The most common omission is that the worksite is not made dead, or the objects not live are not reliably established. These are small and simple things, but the rush causes the installer to take the risk. The installer may feel that the time spent on the actual work is short in relation to the time spent on occupational safety measures. In the face of time-saving, therefore, they may take a risk that sometimes saves time, but which on a bad day becomes an accident. Based on Tulonen´s (2010), research results, the reasons behind the rush are organizational reasons, such as problems in planning and implementing work. Based on the research survey findings, it was possible to establish that the urgency was due to excessively tight schedules and pressure.

### 7.4.2 Development proposals

The reasons that affect the rush are many. One reason is attitude. There are also a few essential things to see. There are often shortcomings in planning, division of labor, and work organization. These problems are significant issues. Often the schedule problems or changes to the schedule are reflected on the site. Changes at the site usually do not affect the schedule, which is a very problematic point. It is undeniable that the urgency sometimes causes non-compliance with safety instructions. For this reason, there is a matter of urgency stress that should be considered when planning work. For example, changes in timetables, so there is no choice but to increase the number of personnel to avoid a rush. However, there are situations where the urgency is not yet concrete, but the installer may feel that they are in a hurry. In these situations, it would be important for the management to have the psychological ability to calm the situation and thus make the situation safer in this regard. It is proposed to increase the psychological contribution to this problem in training those responsible for the work. Reflection, composure, and work rendering (planning) are good means that are generally applied even in normal situations, thus also giving us time to carry out an important work-related risk and risk assessment.

### 7.4.3 Working alone

Working alone is not necessarily a problem. Sometimes working alone is just an advantage, as is the case, for example, in tasks that require concentration. When working alone, it must always be ensured that the employee has the personal capacity and technical prerequisites to safely do the work in question. For solo work situations, adequate safety and other operating instructions should be drawn up.

There are also jobs in the electricity sector that must not be done alone. These include live working, fireworks, mast work, cramped and enclosed space work, and working in sweltering conditions. Live working is work that usually needs to be done in a group. However, when working in low-voltage equipment, some jobs can be done live working on your own. The voltage work carried out in the high-voltage equipment must always be carried out by a working group consisting of at least two electrical professionals trained in voltage work. Hazard identification and risk assessment, adequate guidance, and orientation are certainly among the best options on this issue. In addition, it would be a good idea to create a culture of discussion in the workplace, where the working group and its supervisor discuss occupational safety in general.

The responses to the survey mentioned situations, work steps, and facilities, such as working in cramped spaces, shift work in switchboards, excitement work, demolition work, and work requiring a partner. However, the responses made it clear that all demanding work should be done in a team of at least two people.

Based on Tulonen´s (2010), research results found that working alone was considered by electricity professionals to be one of the biggest risks to electrical safety at work. The same thesis also concluded that the worst problem with single work is not so much related to electrical safety but is linked to the fear that there is no one to help the victim in the event of an emergency.

### 7.4.4 Development proposals

This thesis did not provide a detailed answer to why installers feel that working alone is an occupational safety risk. However, the risk experienced by installers is linked to a possible electrical accident in which the installer is left without a helper because of working alone. The solution to this problem would be a system created by the organization, in which the installer sent to work alone should be contacted by a manager or colleagues. Communication should work in such a way that the person working alone is the person who is contacted at regular intervals.

### 7.4.5 Risk behavior/attitude

Risk behavior refers to when risks are taken at work consciously or unconsciously. Risk behavior has a clear link to risk perception because the higher the person assesses the risk they perceive, the more likely they are to miss the risk. However, the above rule does not always apply, as different situational and personality factors also influence risk-taking. The consequences of neglect can be negative or positive. Negative ones occur, for example, like electric shocks, while positives can manifest them as work is completed faster.

Based on Tulonen´s (2010), research results, risky behavior manifests itself as indifference, negligence, and an attitude problem. These may result in non-compliance with the regulations issued, which is manifested in unauthorized live working and other shortcuts in the safety instructions. The problem of attitude can manifest itself in over-confidence in one's skills, which can lead to the idea that nothing can happen to me. Tulonen (2010), considers that if an organization directly or indirectly values the neglect of safety measures and the efficiency it achieves, the following conclusions may arise for the employee. The employee begins to consider the time savings achieved by neglecting to be valuable and acceptable to the company and that financial factors are considered more important than safety. If the employee feels that the employer appreciates the time savings achieved by neglect, the employee may continue to work with that attitude. Such a pattern of behavior undermines the safety of the entire work community and, at worst, forces other working group members to neglect so that they can carry out

their work just as quickly. For this reason, the immediate supervisor must intervene in any omissions, even if it negatively affects the completion of the work in the short term.

## 7.5 Conclusion

Electricity services should look at the domains of the responsible persons to ensure that the conditions of the Electrical Safety Act are met. It should be remembered that the supervisor of electrical work is not just a technicality, it must be able to supervise and instruct the activities. This relates to risk management because if the supervisor of electrical work cannot be physically present at the sites under his responsibility, then the question arises as to how he will be able to identify hazards and risks and to create guidelines for them?

The supervisor of electrical work is a key person in charge of the electricity sector in the company. Their task is to ensure that there is no danger or disturbance in the construction of the electrical installation. In all cases, the supervisor of electrical work must ensure that all persons performing electrical work are sufficiently skilled in their duties and that electrical safety is not compromised.

With the work, electricity services can further improve the implementation of occupational safety, and thus also the well-being of employees and enjoyment at work. This work matters, as improving occupational safety is always in the interests of both the employee and the employer. Taking care of and investing in occupational safety increases employees' trust in the employer and comfort in the working environment. On the other hand, the employer will receive more committed employees, and avoiding accidents at work will prolong their working lives and reduce absences due to accidents. It can therefore be said that occupational safety is a company's duty and an advantage that benefits both the employee and the employer.

Attitudes towards safety are one of the most important things for the installer, as is the management. If the management does not strictly comply with or require safety issues in practice, the level of safety in the company will begin to decrease rapidly. Installers who have accumulated

a few years of work experience do not follow safety issues. Their attitude is indifferent. The working method emphasizes the importance of speed, which, although an inexperienced professional, can at worst lead to additional risk-taking and accidents at work or electrical accidents.

# 8 Summary

This thesis aimed to collect comprehensive information on electrical accidents/risks, as well as getting answers on how to prevent these. People who do electrical work must be familiar with their tasks and sufficiently skilled not to endanger electrical safety. They must understand the risks associated with the job description and be able to avoid them. Improving the working environment and working conditions enables a common goal of safety for the company and its personnel. The survey sought to obtain current information on how individuals rate the electrical safety situation at the moment.

The work was acquainted with the current regulations on electrical safety, laws, standards, and guidelines. Also, this thesis aimed to provide information on L&T plc's electrical department to develop electrical safety. In electrical occupational safety, as in other work related to occupational safety, it is essential to try in advance to identify the risks related to work and to carry out risk assessments on this basis. Based on the assessment, for example, the target or working method is defined as the individual means to reduce the likelihood of risk and to minimize the impact of the potential risk consequence. For example, probabilities can be reduced by instructing you to use only certain pre-planned and estimated safe working methods. The work orientates the reader to the different stages of research implementation, bringing up forms of questions that can be asked and how much information was extracted from the questions.

Studies in this thesis show that the most significant risks of electrical occupational safety in electrical contracting in the building technology sector are still being considered *Urgent*, *Working alone*, and *Subcontracting*. The surveys in this thesis were only addressed to professionals in the Uusimaa region.

The thesis results had not analyzed the work of a contract nature separately. Installation work carried out in the building services sector is very common, especially in new construction projects. In contract work, the aim is to minimize the use of installation time in relation to the number of installations, in which case this will have a positive impact on the installer's earned

income. The attitude of the company's management and supervisors towards safety, the safe working practices of your example, the use of protective equipment, risk-taking, and haste are very important. Management demonstrates its commitment to safe practices that positively impact employees' safety behavior and attitudes. Lassila & Tikanoja considers electrical work security to be important and to be invested in.

To sum up the thesis results, it can be said that the hectic and competitive spirit of modern society has also made its mark on the electricity sector. Electricians have many different things due to the factor of rush or a sense of urgency. Their supervisors are simultaneously responsible as well the security of subordinates that the effective operation of their unit. Because of this, the message of senior and middle management about the importance of safety in relation to performance is all the more critical. Above all, the problem seems to be the rush, the lack of time. In the longer term, the lack of time may also be reflected in an increase in electrical accidents for new workers, as older workers do not have time to familiarize themselves with new ones in a field where, due to its diversity, real work learning takes place only through practical work. It is always good to remember that preventing electrical accidents is continuous work.

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The questionnaire was submitted to fifty-four electrical professionals (n=54), and (12%) of them replied to the questionnaire

**Electrical occupational safety in general**

1. How do you experience the current electrical occupational safety situation in general or in your company?
2. How do you think the electrical safety of electricians should be developed?

**Electrical accidents**

3. Have you had an electrical accident yourself? How did the electrical accident you experienced occur?
4. Do you think there are common factors for electrical accidents? Could you name these?

**Live working equipment**

5. Electrical work is often done live, even if safety requires de-energization. How do you think un-authorized voltage work could be reduced?
6. Many do not verify that the worksite is de-energized. How could we ensure that this working phase (verifying de-energized worksite) is performed by everyone? How do you think unauthorized live working can be reduced?

**Urgency**

7. Urgency is generally seen as a degrading factor in electrical occupational safety. Do you agree with how the rush manifests itself to you?
8. What means do you apply in your work to control the sense of urgency?

**Working alone**

9. Working alone is generally identified as the second biggest risk factor for electricians after a rush. At what stage of work, etc., do you feel that working alone is or may be a risk factor?
10. Whether it is possible to develop a less risk-a-risk risk associated with working alone. How would you develop?

**Subcontracting**

11. Using subcontractors in electrical work in the building services sector has become very common. Do you think there is an increased risk of electrical safety for subcontractors?
12. What factors increase the risk of electrical occupational safety of the subcontractor?
13. How do you think subcontractors' potential risk of electrical occupational safety could be reduced?

**Training**

14. Do you feel that the current SFS 6002 e-occupational safety training is necessary?

The questionnaire was submitted to fifty-four electrical professionals (n=54), and (12%) of them replied to the questionnaire

15. Do you think that the recurrence of the current SFS 6002 electrical safety training every five years is sufficient?
16. How do you experience the current electrical training?
    a. Will recent graduates have sufficient basic knowledge of the field when they graduate?
    b. If recent graduates have a lack of basic information, what are these?
    c. Is a possible lack of information a risk to a person's electrical safety

**SÄHKÖTAPATURMAILMOITUS SL 4** 1(2)

tukes
Turvallisuus- ja kemikaalivirasto

Päivämäärä

Antamasi tiedot tallennetaan Tukesin (ao.) rekisteriin. Lisätietoja tukes.fi/tietosuoja.

| | | |
|---|---|---|
| **1. Lomakkeen täyttäjä** | Nimi | Puhelinnumero |
| | Lomakkeen täyttäjän yhteys sähkötapaturman uhriin<br>☐ uhri itse ☐ stj* ☐ kj** ☐ esimies ☐ muu työnantajan edustaja ☐ jakeluverkon haltija ☐ muu, mikä<br>*) sähkötöiden johtaja **) sähkölaitteiston käytön johtaja | |
| **2. Uhrin tiedot** | Sukupuoli<br>☐ Mies ☐ Nainen | Ikä (arvio)<br>vuotta |
| | Ammatti Työnantaja (Yrityksen nimi. Vain jos tapaturma on sattunut töissä) | |
| | Ammattitaito sähköalalla<br>☐ Sähköalan ammattilainen ☐ Sähköalan opiskelija/harjoittelija ☐ Maallikko | |
| **3. Tapahtuma** | Tapahtuman päivämäärä ja paikkakunta | |
| | Tapahtuman kuvaus lyhyesti (tapahtumaa kuvaava lause) | |
| **4. Kuvaus onnettomuudesta** | Tapahtumien kulku<br><br>Tapaturman syyt<br><br>Miten vastaavat tapaturmat estetään jatkossa | |

Pyydämme palauttamaan lomakkeen sekä mahdolliset tarkentavat liitteet, kuten kuvat työkohteesta tai laitteesta, sähköpostitse osoitteeseen varo@tukes.fi otsikolla "Sähkötapaturma paikkakunta päivämäärä" (esim. Sähkötapaturma Helsinki 8.3.2016) tai postitse: Turvallisuus- ja kemikaalivirasto (Tukes), VARO-rekisteri, Yliopistonkatu 38, 33100 TAMPERE

3/2017

**SÄHKÖTAPATURMAILMOITUS SL 4** 2(2)

tukes
Turvallisuus- ja kemikaalivirasto

| | |
|---|---|
| **5. Tapaturman tyyppi** | ☐ Työtapaturma ☐ Yrittäjälle sattunut työtapaturma ☐ Vapaa-ajan tapaturma ☐ Vaaratilanne |
| **6. Tapaturma-paikka** | ☐ Teollisuusympäristö<br>☐ Rakennustyömaa tai vastaava<br>☐ Sähkönjakeluverkko<br>☐ Muu ulkoalue (esim. katuvalaistus)<br>☐ Liike-, toimisto- tai julkinen rakennus piha-alueineen<br>☐ Asuinrakennus piha-alueineen<br>☐ Sähköradat<br>☐ Muu, mikä? |
| **7.Tapaturman aiheuttanut sähkölaite tai -laitteisto** | **Sähkölaitteisto**<br>☐ Sähkökeskus<br>☐ Muuntaja (esim. pylstomuuntamo)<br>☐ Sähköasema<br>☐ Sähköverkko: ☐ Avojohto ☐ AMKA ☐ PAS ☐ Maakaapeli ☐ Sähkörataverkko<br>☐ Muu, mikä? (esim. pistorasia, katuvalaistus…)<br>**Kone**<br>☐ Kone (EU:n konedirektiivin 2006/42/EY soveltamisalaan kuuluva), mikä?<br>Tapaturma sattui ☐ yksityiskäytössä ☐ ammattikäytössä |
| | **Sähkölaite**<br>Kerro mistä sähkölaitteesta on kyse:<br>Tapaturma sattui ☐ yksityiskäytössä ☐ ammattikäytössä<br>Onko sähkölaite ☐ kiinteästi asennettu ☐ pistorasiaan kytketty<br>Mikäli sähkölaite on pistorasiaan kytketty, onko kyseessä ☐ suora verkkojännite vai ☐ latauslaite tai ☐ verkkoliitäntäkoje<br>Sähkölaitteen (arvokilvestä) kauppanimi, malli tai tyyppimerkintä:<br>Sähkölaitteen hankintapaikka (myymälä, paikkakunta) ja ajankohta (pvm tai arvio): |
| **8. Jännitteen laji ja suuruus** | **Vaihtojännite**<br>☐ U ≤ 1000 V ☐ 1000V < U ≤ 24 kV ☐ U >24 kV<br>**Tasajännite**<br>☐ U ≤ 1500 V ☐ U > 1500 V |
| **9. Tapaturman syy** | ☐ Uuden käytöön otetun laitteen tai laitteiston rakenteellinen vika (tekninen vika)<br>☐ Käytössä (ajan myötä) vaaraliseksi tullut laite tai laitteisto (tekninen vika)<br>☐ Asennustyö tehty puutteellisesti tai virheellisesti<br>☐ Uhrin tai työryhmän onnettomuushetkellä tekemä inhimillinen virhe tai virheellinen toimintatapa<br>☐ Muu, mikä? |
| **10. Vamman syntytapa** | ☐ Sähköisku ☐ Valokaari ☐ Muu, mikä:<br>"Sähköisku" tai "Valokaari" kirjataan myös, jos se on ollut välillinen vamman syy (esim. sähköiskun aiheuttama putoaminen) |
| **11. Seuraukset (arvio)** | ☐ Hoitokäynti, ei sairauspäivä<br>☐ Hoitokäynti ja 1–30 sairauspäivää<br>☐ Yli 30 sairauspäivää<br>☐ Kuolema<br>On tärkeää hakeutua lääkärin aina sähköiskun tai valokaaren jälkeen, vaikka ensisilmäyksellä seurauksia ei itse havaitsisi.<br>☐ Vaaratilanne (ei sähköiskua, ei valokaaresta aiheutunutta loukkaantumista) |

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3/2017

Aluehallintovirasto

**TYOTAPATURMAILMOITUS TYÖSUOJELUVIRANOMAISELLE**

**Ilmoitus tulee tehdä mahdollisimman nopeasti puhelimitse tai sähköpostilla. Kaikkien tässä olevien asioiden ei tarvitse olla tiedossa ilmoitusta tehtäessä. Lisätietoja ilmoituksen tekemisestä saat Työsuojeluviranomaisten yhteisestä valtakunnallisesta puhelinneuvonnasta numerosta 0295 016 620.**

**Sattumispaikka**

| | |
|---|---|
| Kunta | |
| Työpaikka / työmaa | |
| Osoite | |
| Yhteyshenkilö | Asema |
| Sähköpostiosoite | Puhelinnumero |
| Työpaikan kieli<br>☐ Suomi ☐ Ruotsi ☐ Muu, mikä?_____ | |
| Sattumisaika<br>____ / ____ 20____ klo _____ | |

**Vahingoittuneen tiedot**

| | |
|---|---|
| Nimi (Sukunimi, etunimi) | Ammatti |
| Osoite | Puhelinnumero |
| Vammat | |
| Työnantaja | |
| Työnantajan osoite | Työnantajan puhelinnumero |

**Lyhyt selostus tapauksesta**

| |
|---|
| Mitä tapahtui? |

**Työtapaturmasta on ilmoitettu seuraaville**

☐ **Ilmoitettu poliisille** Tutkiva poliisi:_____ Puhelinnumero:_____

☐ Sähkö-/Räjähdystapaturmasta tehty ilmoitus Tukesille

Muut tiedot

**Ilmoittajan tiedot**

| Ilmoittaja | Asema |
|---|---|
| Yritys / Yhteisö | Puhelinnumero |

**Työsuojeluviranomainen täyttää**

Ilmoitus tehty _____ / _____ 20_____ klo _____

Ilmoituksen työsuojeluviranomaisessa vastaanotti

☐ Liite_____

| Etelä-Suomen AVI | Lounais-Suomen AVI | Länsi- ja Sisä-Suomen AVI | Itä-Suomen AVI | Pohjois-Suomen AVI |
|---|---|---|---|---|
| Työsuojelun vastuualue | Työsuojelun vastuualue | Työsuojelun vastuualue | Työsuojelun vastuualue | Työsuojelun vastuualue |
| PL 110 | PL 22 | PL 272 | PL 1741 | PL 229 |
| 00521 HELSINKI | 20801 TURKU | 33101 TAMPERE | 70101 KUOPIO | 90101 OULU |
| tyosuojelu.etela@avi.fi | tyosuojelu.lounais@avi.fi | tyosuojelu.lansi@avi.fi | tyosuojelu.ita@avi.fi | tyosuojelu.pohjoinen@avi.fi |

Tämä ilmoituslomake tallennetaan työsuojeluviranomaisen asianhallintajärjestelmään ja/tai valvontatietojärjestelmään ja siinä olevia tietoja käytetään työsuojeluviranomaisen valvontatoiminnassa. Tarkempia tietoja henkilötietojen käsittelystä työsuojeluviranomaisessa ja rekisteröidyn oikeuksista sekä rekisterinpitäjän ja tietosuojavastaavan yhteystiedot löytyvät osoitteesta www.tyosuojelu.fi/tietoa-meista/tietosuoja.

**Ohjeita vakavan työtapaturman arvioimiseksi**

Työnantajan on viipymättä ilmoitettava vakavasta työtapaturmasta poliisille ja aluehallintoviraston työsuojelun vastuualueelle. Ilmoitusvelvollisuus perustuu lakiin työsuojelun valvonnasta ja työpaikan työsuojeluyhteistoiminnasta.

Työtapaturma on vakava, jos työntekijä menehtyy tai hänelle aiheutuu pysyvä tai vaikealaatuinen vamma. Vaikealaatuisiksi vammoiksi on katsottu muun muassa

- pitkien luiden murtumat tai murtumat, jotka voivat vaatia leikkaushoitoa, vaikeahko selkärangan murtuma, kasvoluiden murtumat, kylkiluiden monimurtumat ja veririnta, vaikeahko pääkallon avomurtuma, vaikea kaula-, rinta- tai lannerangan murtuma
- vaikea sijoiltaanmeno, josta jää pysyvää haittaa
- ruumiinjäsenen, esimerkiksi sormen tai sen osan menetys, raajan lyhentymä
- leikkaushoitoa vaatinut vatsaontelon elinten vamma
- aivovamma, josta on jäänyt lievääkin haittaa
- puheen, näön tai kuulon kadottaminen tai pysyvä heikentyminen, silmän menetys
- ihonsiirtoja vaativat palo- tms. ihovauriot, laaja palovamma tai paleltuma
- pahasti rumentava epämuotoisuus, kuten korvalehtien menetys tai nenän tai sen osan menetys sekä muu vaikea ruumiinvirhe
- pysyväinen vaikea terveydenhaitta tai hengenvaarallinen tauti tai vioittuma.