Elder

European Bank
for Reconstruction and Development

Project C40021/10128/59978_C40022/444/8332

Root Cause Analysis and Accident Causation Within the Electricity Distribution Sector in Turkey

FINAL REPORT

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Abbreviations

ACSHB: Ministry of Family, Labour and Social Services

DSO: Distribution System Operator

EBRD: European Bank for Reconstruction and Development

EDS: Electricity Distribution Sector of Turkey

EKAT: The Regulation on Electrical High Current Installations

ELDER: Association of Electricity Distribution System Operators

EMRA: Energy Market Regulatory Authority

ENSAD: Energy-related Severe Accident Database

HV: High Voltage (1000-36000 Volts)

ILO: International Labour Organization Office in Ankara

KPI: Key Performance Indicator

LV: Low Voltage (0-1000 Volts)

LTI: Lost Time Injury

MENR: Ministry of Energy and Natural Resources

NCR: Non-Conformance Report

TEDAS: Turkish Electricity Distribution Corporation

TES-IS: Turkish Energy, Water and Gas Workers’ Union

OPEX: Operating Expenses

PPE: Personal Protective Equipment

PSI: Paul Scherrer Institut

SIP: Safety Improvement Plan

SSI: Social Security Institution of Turkey

WHO: World Health Organization

Foreword

In an effort to improve the quality of the energy network while protecting the health and safety of workers and communities, practices of the companies in the sector, European Bank for Reconstruction and Development (EBRD) has collaborated with The Association of Electricity Distribution System Operators of Turkey (ELDER) to conduct a Root Cause Analysis and Accident Causation within the Electricity Distribution Sector project in Turkey.

Prevention of accidents in the energy sector is a key aspect in a broad evaluation of Occupational Health and Safety (OHS), sustainability and energy security concerns. The safety performance of the electricity distribution sector is very important for the environmental, economic and social aspects of sustainability as well as availability, acceptability and accessibility of energy security.

In electricity distribution companies many accidents happen every year resulting in minor to major damages such as basic injuries to serious body injuries or fatalities. The most common major accidents are caused by electric shock, burning due to arc, falling from height and traffic collisions.

Electricity distribution sector (EDS) has a very unique characteristic of OHS risks and measures. Although identification of the hazards and risks in the sector seems uncomplicated, mitigation and controlling the known risks is challenging; thus, require multidimensional prevention strategies.

In the electricity distribution sector, the majority of the operational workforce work at distant multiple locations usually far from each other. Teams need to relocate and work at different work sites up to 10-12 times a single day when necessary. 80% to 90% of the routine works are performed unplanned due to several urgent needs such as failure intervention, new connection or fixation of street lighting, which agile working conditions are enforced in nature. The communication barriers in between the central teams and site teams, and the difficulties in monitoring, periodical inspections and supervision to ensure the application of safe work practices oblige workers to take their own initiative with insufficient protection unless workers have high risk-awareness, experience or skill.

For the field maintenance and monitoring works, the sector mostly employs electrical technicians with high school and vocational school degrees since the legislative requirements disallow working without certain certifications and diploma. On the other hand, contracted works are usually construction-related high-risk activities and the workforce is unskilled compared to registered electrical workers.

The classification of the electrical tasks and identification of fixed control measures is another complication. Similar tasks may have to be performed under various and dissimilar conditions and risks because of changing equipment, worksite, geography and the human factor.

This study was conducted by collecting and assessing the available incident data from 21 distribution system operators in Turkey, for the years 2016, 2017 and 2018[1] aiming to survey descriptive factors of injuries. Variables that are collected include accident time, age of injured worker, employment type, work experience, injury cause, educational background, and other information about accidents. During the study, several meetings, workshops, video conferences and site visits were realized to assess the current technical and administrative root-cause analysis, resources and their capabilities and the quality of corrective actions to prevent reoccurrence of accidents.

[1] The data is collected during the first three quarters of 2018

The availability of reliable incident data and unwillingness to share detailed information due to ongoing legal process were the limiting factors in this study. Accordingly, the scope of the project is focused on the understanding of the root causes of the major and fatal incidents and the companies' approach to prevent or at least reduce the work-related incidents in the sector.

Despite the given constraints, a realistic analytical framework and an applicable safety improvement plan are presented for the review of European Bank for Reconstruction and Development (EBRD) and the stakeholders for sustainable and progressive occupational health and safety (OHS) actions in the electricity distribution sector in Turkey.

Introduction

World Health Organization (WHO) defines an accident as an unintentional and/or unexpected event or occurrence that may result in injury or death [1]. The International Labour Organization (ILO) defines occupational accident as an unexpected and unplanned occurrence, including acts of violence, arising out of or in connection with work which results in one or more workers incurring a personal injury, disease or death [2].

ILO estimates that globally every 15 seconds a worker dies due to work-related accident or disease and every 15 seconds 151 workers have a work-related accident. Deaths and injuries take a particularly heavy toll in developing countries, where a large part of the population is engaged in hazardous activities, such as agriculture, construction, fishing and mining [3].

Accident causation theories address major factors leading the accidents. Therefore, the vast majority of occupational accidents are preventable by controlling these factors. However, in practice, countries and organizations struggle in creating and sustaining zero accident strategies since responsibilities and accountabilities are unclear and the strategies are poorly followed. Unfortunately, Turkey like most of the developing countries has experienced slow progress in OHS for years due to several complexities. As a consequence of the dynamic nature of production and work environment, OHS requires up-to-date and inclusive information [4]. In many of the developing countries including Turkey and in some developed countries accident data is missing especially for minor incidents [5].

Occupational Health and Safety Administration (OSHA) states that 12,976 lost workday injuries and 86 fatalities occur annually on average in power generation, transmission and distribution sector in Turkey. Therefore, OSHA recognizes electricity as a long-term serious hazard for employees and the public ending with electric shock, burns, fires and explosions [6].

In the electricity distribution sector, workers are exposed to significant hazards and potentially prone to risks that can result in accidents causing serious injuries and fatalities. These dangerous working conditions can include risks of falling from height and being exposed to electrical shock or burning due to electrical arc. Therefore, working with electricity requires thorough planning along with a safe system of work and most of all extreme care. Unintended energization or operation of equipment during the commissioning, maintenance and operation of electrical equipment can result in serious incidents.

Despite the improvements in regulations and implementation of safe working practices at workplaces, there is still a significant number of occupational incidents occurring in the electricity distribution sector. One of the reactive measures to prevent reoccurrence of the incidents is analysing every incident in detail and examining the contributing causes and the root causes. When the root cause is determined, it is usually found that many events were predictable and could have been prevented if the right actions were taken [7].

The objective of this study is to obtain the real incident data in EDS in order to increase our understanding of the root causes of major and fatal accidents and how the corrective actions in the proposed investigation reports correspond to these accidents. Also, the quality and the capability of the incident investigation system, relevancy and realism of determined immediate, contributing and root causes of the incidents were studied. Several meetings, workshops, video conferences, and site visits have been held with the electricity distribution companies to support the findings of incident data assessment. The key objective of this study is to identify possible causal factors for accidents under the headings of technical, organisational, behavioural, external factors and legislation and identify areas of weakness, as well as to develop a suggestion of Methods, Solutions and Development of the Safety Improvement Plan in the sector in Turkey.

Literature Review

Occupational accidents have been considered in many countries as one of the most serious threats to workers' lives, health, and well-being [8]. 17 million working days were lost in England due to accidents [9, 10]. Occupational injuries are mainly caused by work conditions as well as some personal characteristics [11], significant amounts of money are spent annually to compensate workers for work-related injuries, diseases, and disabilities. This imposes many damages to the active manpower of society. There are several contributing elements to the safety level at the workplace, with technical and organisational safety features functioning together. Social factors and informal behaviour can also contribute in an essential way [12].

Electrical hazards represent a serious occupational danger because it is widely used in every place and in every occupation [13]. Electricity can cause injury to the human body in three ways. First, eye injuries can be caused by the conversion of electrical energy into light energy. Second, by the conversion of electrical energy into heat energy causing arc flash burn. Third, the electrical current passing through the body causing ventricular fibrillation, so-called "electrical shock" [14]. Fourth can be said as falls as even though the small strength of currents that do no harm to the body may cause to falls while working at heights. Many workers are seriously injured by exposing electrical energy during their jobs [13].

Occupational electrocutions account for approximately 6% of all fatalities in the workplace each year [15]. The transportation and public utility industries had the next highest death rate, with 0.9 deaths per 100,000 employees in the US [15].

An arc flash is basically a short circuit of electrical current through the air, which occurs when excessive voltage "crushes" the air between two electrodes. It can occur in different pieces of electrical equipment, such as switching devices for protection, separators, circuit breakers, contactors [16]. An arc flash travels at a very high velocity and at a very high temperature releasing large amounts of energy in a short time. Electrical current, duration of the arc, length of the arc, distance from the arc and source voltage determines the amount of energy released in an electric arc flash. The temperature can increase up to 20.000 ^{O}C. Half of the energy of the arc is consumed by heating the air. Most of the energy dissipates as radiant heat. Main causes of an electrical arc are radiant heat and splashes of molten metal from the electrodes [16, 17].

According to assessments of lost time injury (LTI) and fatal statistics of Turkish Social Security Institution, there is a decrease in mortality rate between 2003-2011, 2016 and 2017 in EDS of Turkey. The mortality rate in accidents with injuries decreased from 9.35% to 4.35% in 2016 to 3.03% in 2017 when compared to 2003-2011. The study concluded that this decrease is related to the development of opportunities in terms of training, experience and equipment of the field workers and the reduction of risk elements in the system infrastructure [18].

Electric shocks, fires, or explosions are one of the main reasons for lethal injuries according to a survey conducted by the Ministry of Labour in Greece. It is stated that 429 fatal injuries occurred between 2007 and 2012 in Greece. Serious injury and death could occur during the service, installation, or maintenance in an unintended energization of equipment. Hence, it is important to make sure that the power is off and remains off [19].

Electricity is one of the main causes of death. An average of 411 workers died (totally 5.348 workers) by contacting with electrical energy in the USA, between 1980 to 1992 within 12 years period [13]. Moreover, electricity can also cause serious fatal injuries in many of the incidents [14].

An electric power distribution network is a segment of the electricity system, consisting of primary and secondary electrical networks. These networks can be both overhead and underground [16]. Although the overhead transmission system is preferable for some of the easier maintenance and commissioning advantages, it is impossible to use overhead transmission lines for transmission and distribution of electricity everywhere. Consequently, an underground network can be preferable where an overhead network is technically not feasible or not permitted by legislation such as in urban networks [16, 20].

Increasing usage of underground distribution systems and the ageing of the networks within several years together with the lack of maintenance and cross-sectional to other nearby underground networks like sewage, water or gas systems, has caused many highly dangerous accidents in electrical distribution works [16]. Manhattan has a secondary electrical grid of 21.000 miles of underground cable that can be accessible from 51.000 manholes. This grid is a developing system that started over a century ago, the cables of different age, quality and reliability. Fires, explosions and smoking manhole events occur in Manhattan, New York every year [21]. It has been observed that even in low voltage secondary networks, several arc flashes have happened resulting in explosions in the underground system of Quebec, Montreal, Canada [22].

In a study in Iran which was conducted in an electricity distribution company for a five-year period to examine the factors that contributed to occupational injuries, no significant relationship was found between work experience and the distribution of the accidents. On the other hand, there was a significant relationship between the educational level and the consequences of the accidents statistically. A significant relationship was shown between the workdays lost per accident in both the permanent and temporary workers [23, 24]. Another study in Iran about electricity distribution workers showed that most of the accidents had happened in the summertime. It was found that 17.6% of the accidents were on the rest days. Lack of protective equipment, negligence and tools and unsafe environment were determined as the causes of the accidents. However, this study does not mention any accident root cause analysis nor root causes of the accidents. The study recommends carrying out and develop a comprehensive safety plan and revise existing plans to address electrical safety in the workplace [23].

National Institute for Occupational Safety and Health (NIOSH) has studied accident fatalities among 10 different jobs in Ohio USA. The study has indicated that the highest number of fatal injuries are within utility line workers (linemen) among all the other occupations, despite utility line workers (linemen) typically receive extensive training in electrical safety and the hazards associated with electrical energy [13]. The study presents that 66% of the incidents were involved more than 600 Volts. It expresses that 76% of the incidents involved distribution voltages (7.200 – 13.800 V) and 15% of the incidents involved transmission voltages (> 13.800 V). It also indicates that most of the accidents happened in the months where weather conditions were more favourable for working outside. There was no safety program or established, written safe work procedures for 35% of the workers. The study demonstrates 80% of the victims had some type of electrical safety training and 41% of the victims had been on the job for less than 12 months. Despite many companies had comprehensive safety programs, in many of the cases they were not completely implemented.

Therefore, it is declared that developing and implementing a comprehensive safety program by employers is a must [13].

In a comprehensive study in Finland, it is indicated that the failure of following electricity safety instructions is often the result of an electrical arc accident. It is stated that insufficient information by a subcontractor on the structure of the electrical enclosure led to some accidents. Most of the accidents occurred in low voltages with the short circuit current up to 38.5 kA and with a switching time between 0.1 to 1.2 s. It is declared from the study that because of the serious accidents are always investigated and reported strictly, the study has a focus on the most serious accidents. Furthermore, a large proportion of the electrical accidents are estimated unreported by the Finnish safety authorities [17]. In the same study, safety personnel had difficulties in getting the statistics on near misses because the supervisors or workers had not always reported them. 13 companies reported 22 accidents. Twenty-two companies reported 43 near-miss cases. However, there was no information from the rest of them [17].

According to a survey that is conducted in Quebec Canada, 63 fatalities were reported. However, only 57 of them had incident investigation reports. In this report, 90.2% of the fatalities are classified into two groups: electrical tasks indoors and non-electrical task outdoors. The report of the survey declares that about 57% of the victims which are in the first group, had the electrocution by direct contact with a voltage of fewer than 10.000 volts. On the other hand, the remaining part of them, as the second group, had been electrocuted by the intermediary of a vector with a voltage of higher than 10.000 Volts [20].

Explaining the course of events is the main target of an accident investigation. One of the essential questions is how the event could have happened. Accordingly, analysing how the safety system failed is a complementary goal of any investigation [12].

Lessons learned from incidents are the base of prevention strategies. The safety personnel need to carry out a thorough investigation to learn about the causes of the incident in order to take actions for mitigating or removing those causes. In order to prevent the reoccurrence of the incident, the root causes of the incident should be isolated by studying the favourable factors that may likely cause the incident [20].

Electricity Distribution Sector in Turkey

Turkish Electricity Distribution Corporation (TEDAS), a state enterprise established in 1993, operated electricity distribution and sales activities until 2004. Following a successful privatization program, Turkey's electricity distribution network was divided into 21 distribution areas and operation rights have been transferred to 21 private sector companies.

Fig. 1: Electricity distribution companies and areas of operation in Turkey

The sector has a crucial role in the Turkish economy in many ways. According to the 2018 data, sector serves 43.65 million customers, with 177.910.826,19 MW/hannual consumption, 54,756 workers, 468,755 transformers, 1,164,170 km distribution lines and 4.91 Billion Turkish Lira annual investment [25].

Due to the large size and the area of impact, the sector also plays an important role in workers' health and safety as well as overall wellbeing.

The Association of Electricity Distribution System Operators of Turkey (ELDER) is a non-governmental organization conducting its activities as an umbrella organisation for all electricity distribution companies found throughout Turkey. It represents a completely privatized sector, which has 21 members in and serving over 43 million customers in Turkey.

ELDER has been contributing to the development of electricity distribution services in Turkey in compliance with the economic principles stipulated in the Constitution of the Turkish Republic and the legislation on concessions, privatization and energy market and, making researches taking into account the international laws and agreements on electrical energy and energy policies, technical requirements, economic developments of the country. As a part of this contribution, improving occupational health and safety (OHS) standards is one of the most important topics within the ELDER's scope of work.

The European Bank for Reconstruction and Development (EBRD) was established to help for building a new, post-Cold War era in Central and Eastern Europe. It has since played a historic role and gained unique expertise in fostering change in the region - and beyond -, investing more than €130 billion in a total of over 5,200 projects [26].

Safeguarding the environment and a commitment to sustainable energy have also always been central to the EBRD's activity. A commitment to promote 'environmentally sound and sustainable development' was made explicit at its founding. More recently, the Green Economy Transition approach has made climate finance a key measure of the Bank's performance. In 2018 such finance accounted for 36 per cent of its total annual investment.

EBRD also aims to improve the quality of the energy network while protecting the health and safety of workers and communities. As indicated in EBRD's 2014 Environmental and Social Policy (ESP), ensuring workers are provided with a safe and healthy work environment is an essential part of the Bank's mandate and is firmly embedded within the Bank policy.

In order to support the improvement of the occupational, health and safety standards, practices of the companies in the sector, EBRD has collaborated with ELDER and appointed them under the Bank's OHS Framework to conduct a Technical Cooperation project on Root Cause Analysis and Accident Causation within the Electricity Distribution Sector in Turkey.

Root Cause Analysis and Key Tasks Conducted under the Technical Cooperation Project

This technical cooperation (TC) project included the following key tasks:

Task 1. Identification of Key Partners

Task 1 aimed to review the existing relevant stakeholder groups in Turkey who could become key partners in delivering detailed OHS and incident information.

Turkish Energy, Trade Unions such as Water and Gas Workers Union (TES-IS), Ministry of Energy and Natural Resources (MENR), International Labour Organisation (ILO) Turkey, Energy Market Regulatory Authority (EMRA), Ministry of Family, Labour and Social Services (MFLLS) are affiliated to the OHS conditions in EDS. It was observed that there is no satisfactory collaboration between the institutions in terms of sector related OHS targets and incident data collection. Therefore, the team paid utmost importance to establish a better collaboration on sectoral OHS issues as part of tis TC project.

The Association of Electricity Distribution System Operators of Turkey (ELDER), representing all 21 Distribution System Operators (DSOs) in Turkey, has a crucial role in the sector. ELDER has established an OHS workgroup to discuss OHS issues like defining of minimum requirements for safety equipment. These minimum requirements helped sector companies to select the correct protective and electrical equipment. Besides that, group has a session for sharing risks, knowledge and experience including accident data among DSOs on every meeting. OHS workgroup is structured by executives from all 21 DSOs, which all of them are the decision makers in their companies on OHS. Group sets OHS meetings generally on every month. Additionally, this group defines needs for the sector on OHS and organise a congress every two years. Electrical arc flash, protective clothes, live working on distribution systems, working at height, safety culture and grounding listed for the group's working topics and these were the main headlines of congresses set before. Additional OHS awareness-raising activities are suggested to be done in a more systematic way to encourage the DSOs for further improvements as an outcome of this TC.

Task 2. Assessment of Current Situation

Task 2 aimed to collect the incident data to make a detailed analysis of immediate, contributing and root causes of the major and fatal occupational accidents in EDS.

Generation of an intensive data set which includes specific incident information such as date, time, location, age, experience and educational level of victims, possible causes of accidents, lost time etc. was accomplished. Despite the fact that the data is shared by the companies voluntarily in this study, the reliability and correctness of data is an issue due to the accountability concerns. DSOs which pay greater attention to incidents have more reliable data than contractors which are unwilling to share the data due to potential controversial legal and commercial effects.

Strengthening the contractor management systems and increasing enforcements on contractors may help betterments in the data collection and sharing lessons learned in EDS.

Task 3. Identifying Possible Causal Factors and Areas of Weakness

Under Task 3, causal factors of incidents and weaknesses of the safety practices in the Turkish EDS has been assessed. The data set was analysed to find the correctness of immediate and root causes as well as the legitimacy of major and fatal occupational accident investigations and relevancy of proposed corrective actions.

Burning due to electrical arc, falling from a height, motor vehicle accidents and electric shock cases were determined as four immediate causes which are sector-related and constitute most of the major and fatal accidents. A multifaceted effort was put to collect further information on safety practices and post-accident actions in EDS. The observations in the site visits and the voice of sector representatives in the workshops were collectively analysed.

Task 4. Suggestion of Methods, Solutions and Development of the Safety Improvement Plan

Based on the previous studies and the analysis of results, sectoral safety improvement plan (SIP) is developed to prevent reoccurrence of major and fatal accidents in EDS. The technical, organisational, behavioural, external factors and legislation factors were classified in the SIP and possible solutions with relevant parties are proposed.

Task 5. Policy Dialogue and Dissemination of Project Findings and Safety Improvement Plan

The dissemination of the findings and the SIP is to be made to National and European stakeholders who have influence in policy and decision making in the electrical distribution sector. In order to achieve a wider impact, the project results will be publicised via a press release, social media such as Facebook, Twitter, LinkedIn, ELDER websites and e-bulletins. Also, a project-specific policy dialogue session will be held in 2020 ELDER Occupational Health and Safety International Congress which governmental and non-governmental organisations, international finance institutions, trade unions, suppliers, distribution companies, and academics are invited.

Methodology

All minor and major incident data has been collected and assessed. Five of the 21 Distribution System Operators (DSOs) are volunteered to host the workshops and other five volunteer DSOs were visited for onsite assessments. The followings are summarising the current methodology used.

Data Collection and Assessment

Under the scope of the project, all minor and major incident data was collected, sorted them into spreadsheets and filtered accordingly. After filtering the reliable data, all major & fatal work-related incident data for 2016, 2017 and the first three-quarters of 2018[1] were assessed for 21 Distribution System Operators (DSOs) in Turkey.

The data provides the following intensive information:

- LTI (lost time injury) and fatal accidents distribution
- Employer, contractor distribution
- Incident and severity rates of incidents
- Direct causes of incidents
- Shift hours and times of accidents
- Victim age, work experience and educational background

Under the scope of the project, the occupational accidents of whole 2016, 2017 and only the first three-quarters of 2018[1] were collected and assessed since the data collection was completed at the end of September 2018. Therefore, 2018[1] notation is used in the following parts of the report as a reminder.

The assessment of fatal and major accidents' data included the following:

- Data regarding occupational accidents, reactive measures, similarities and differences in the companies of the electricity distribution sector,
- Repeating trends of the accidents, the relevancy between age, work experience and educational level.

In order to ensure an open/transparent dialogue, ELDER signed a confidentiality agreement with DSOs. Therefore, the company/individual names will not be provided in this report.

Video Calls and Company Presentations

Electricity Distribution System Operators presented company approaches for the incidents and the methods of incident investigations. In these video calls, post-accident management systems, accident investigation procedures and incident investigation teams' competency have been discussed. The detailed incident investigation history with photos from the investigation scenes, root cause analysis and the precautions taken, in case of fatalities in the years 2016, 2017 and first three-quarters of 2018[1] as well were gathered. The incidents and incident reporting systems helped to improve our understanding of the investigation capabilities. All this information was verified by site visits.

[1] The data is collected during the first three quarters of 2018

Site Visits

Site visits and field observations in five volunteered Distribution System Operators in different regions of Turkey were conducted for a better understanding of company safety policies and incident investigation systems in place. It was also helped for the verification of the previous tasks of analysing the incident data and video calls.

In these site visits;

- Various operations (such as high voltage, low voltage works, opening trenches, switchyard operations, safety grounding, new installations, commissioning, works at height with or without man-lift and circuit breaker manoeuvres in dealing with maintenance and fixing the failures) at the field where accidents happened were observed and assessed in different site visit-locations.
- In addition, face to face interviews with some of the workers including field workers and managers were conducted in order to identify and raise awareness about the key issues that are causing incidents in field works.
- Some of the key questions raised to the participants were:
    - What credible risks are associated with this task, situation?
    - What energy sources are present?
    - How could there be an unexpected release or contact with that energy source?
    - Are these energy sources addressed in risk assessment?
    - What are people doing (or not doing) that might increase the risk of a major incident or a credible risk of personal injury?

Workshops with Distribution System Operators

Under the scope of this task, interactive workshops and several focus group meetings were held with five Distribution System Operators who volunteered to take part from different regions of Turkey in order to identify the causes of the incidents and proposed solutions listed under three topics; namely,

- Technical factors
- Human factors
- Organizational factors

118 people from five volunteered DSOs including senior and mid-level managers, human resources personnel, contractors and subcontractors, field technicians, SCADA engineers, workers representatives, safety experts and occupational physicians of volunteered DSOs attended workshops.

Additional Stakeholder Meetings

The meetings were made with public institutions and related organizations to brief the project and exchange information about their contributions;

- Ministry of Family Labour and Social Services: The meeting was held with the participation of managers and experts under the leadership of the General Director of Occupational Health and Safety Department in the Ministry. Being the authority to prepare the health and safety legislations in Turkey, the Directorate has important impact on all sectors including Energy Distribution.

- Energy Market Regulatory Authority (EMRA): a meeting was held with a high-level attendance under the chairmanship of the Vice President of the Energy Market Regulatory Authority (EMRA). EMRA is one of the most important stakeholders in Energy sector, it regulates the electricity, natural gas, downstream petroleum and liquefied petroleum gas markets in Turkey.
- TES-IS Trade Union: the president of the Turkish Energy, Water and Gas Workers Union (TES-IS), senior management and occupational safety unit managers participated in the meeting. As a counterparty in collective labour contract agreements, TES-IS is an important party in EDS.
- Ministry of Energy and Natural Resources (MENR) General Directorate of Energy Affairs senior managers, occupational safety unit managers and technical team of were present. The main duty of the Directorate is to reconstruction and liberalization of electricity and natural gas market in Turkey as well as ensuring the electricity distribution security.
- ILO Turkey with the participation of an expert on occupational safety, project summary information was shared. ILO brings together governments, employers and workers of 187 member States, to set labour standards, develop policies and devise programmes promoting decent work for all women and men on international level.

Key Findings

In the literature there is no common definition for the term "severe accident", i.e. each database uses different criteria to separate and record accidents with respect to their specific scope and purpose [27].

As well as Turkish OHS legislation, there is no common definition or agreed terminology of 'major accident' among DSOs. A number of companies use the term 'critical accident' instead of 'major accident' while some define a major accident as the incidents resulting above 3 or 10 days of lost time. Furthermore, a few of DSOs keep data only for severe injuries or disregard motor vehicle accidents. Therefore, incident data logs differ due to the fact that the DSOs have their own recording systems in place. Paul Scherrer Institut (PSI) initiated in the early 1990s a long-term research activity, with the Energy-related Severe Accident Database (ENSAD) constituting its quantitative foundation [28]. ENSAD clearly focuses on severe accidents because industry, decision-makers, regulators and the general public are most concerned about these. Furthermore, a much higher level of completeness and accuracy in accident reporting among countries can be assured, which is a necessary prerequisite for worldwide comparisons. It should be mentioned that ENSAD also contains accidents with smaller consequences, but these are not collected with the same rigour and effort, and differences among countries are potentially larger because of considerable differences in reporting [29].

Similarly, in this study, the completeness, accuracy and robustness of the collected incident data and terminological differences in explanations of a major accident are the utmost difficulties. All incidents in the electrical distribution sector from all of 21 DSOs are collected for the period 2016-2018[1].

The data set is primarily filtered by using the results of the incidents per lost time, the number of fatalities, contractor activities and direct causes found by the DSOs.

The results are given in several subheadings. The attitude towards reporting of the incidents by the DSOs and their contractors differs. Collected incident data is analysed based on Lost Time Injury (LTI) and the number of fatalities. Incident rate and severity rate are also discussed. Without an understanding of the incident causes, it is not possible to prevent accidents. Therefore, the Pareto principle is applied to find the major causes. In an effort to find out the causation of the incidents, the occurrence times of the incidents are analysed. Victim specific data is also examined in detail to understand the relation between the incidents and the parameters such as age or experience of the victim.

The results of the performed site visits, workshops and stakeholder meetings were very helpful to identify the areas open for improvement.

These analyses and study results are discussed below.

Assessment of Incident Data

Upon completion of data collection from Distributor System Operators, the incident data was filtered, rearranged, missing information and uncertainties were clarified and added to the main register supported by the findings of video calls, site visits and questionnaire. Consequently, a more reliable data set was developed for the benefit of the study. In this section, all findings, tables, figures and discussion are based on this developed data set.

The definition of Lost Time Injury (LTI) is "an occupational injury which prevents the employee from reporting to work on the next regularly scheduled workday following the incident" [30]. Under the scope of this project, Lost Time Injury is defined as one calendar day or above lost time due to the occupational incidents including fatalities.

According to the collected data, 2644 LTIs were reported in the years of 2016, 2017 and 2018[1] in Electricity Distribution Sector of Turkey. In some cases, multiple employees are involved in the accidents, thus a total of 2825 workers got either injured with one calendar day or above lost time or killed due to the occupational accidents.

Table 1. LTI & Number of Fatalities in 21 DSO in Turkey between 2016-2018[1]

	2016		2017		2018[1]	
DSO	**LTI**	**Fatal**	**LTI**	**Fatal**	**LTI**	**Fatal**
1	26	1	145	0	109	5
2	56	0	72	0	58	0
3	14	0	27	1	34	0
4	15	2	17	0	8	0
5	44	1	46	2	35	0
6	15	0	17	0	21	1
7	26	3	139	2	117	1
8	5	0	20	5	17	1
9	25	0	74	0	64	0
10	8	0	16	0	4	1
11	40	0	101	1	117	0
12	58	1	71	1	52	2
13	2	2	0	0	0	0
14	14	0	15	2	28	1
15	12	0	9	3	8	2
16	77	5	148	2	133	1
17	23	1	27	2	19	0
18	10	0	25	2	15	2
19	18	2	36	3	22	1
20	44	0	46	4	17	0
21	59	3	68	1	56	0
TOTAL	**591**	**21**	**1119**	**31**	**934**	**18**

The number of LTI and fatalities is tabulated in separated columns in Table 1 which indicates the total number of LTIs are 2644 resulting in 2825 injuries of fatalities between 2016 and 2018[1] in EDS of Turkey. In 2016, 591 LTIs occurred and 21 workers lost their lives in these incidents. In 2017, 1119 LTIs occurred and 31 workers lost their lives in these incidents. In 2018[1], 934 LTIs occurred causing 18 fatalities.

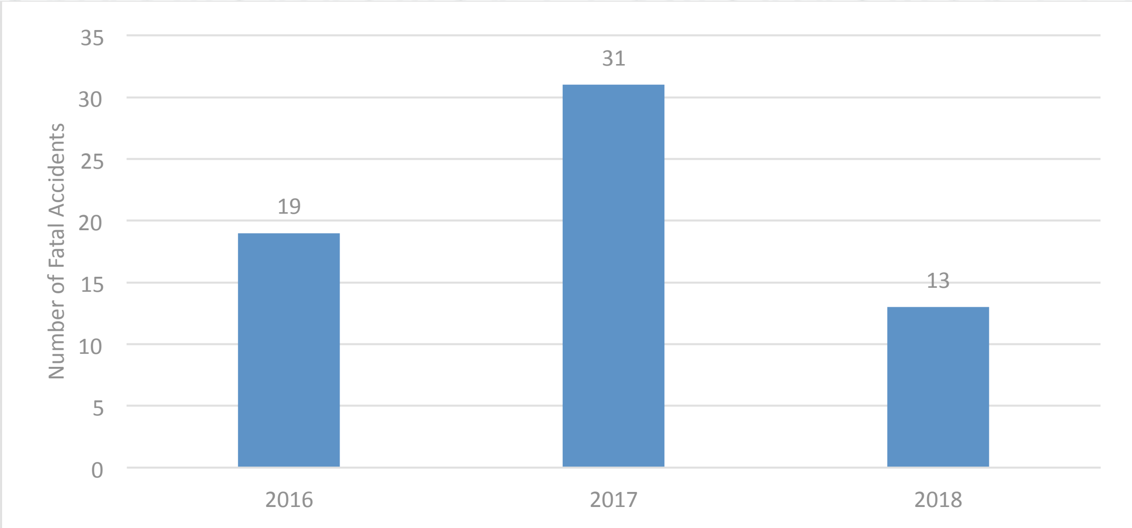

Fig 2. Number of Work-Related Fatal Accidents

Although the number of fatalities is reported as 21, 31 and 18, it was comprehended that the reported fatalities such as heart attack (1 victim), suicide (1 victim) and terror attacks (3 victims) are not directly linked to occupational reasons and considered to be irrelevant for this study purpose and excluded from the given accident data. Also, some fatal accidents result in multiple injuries. Therefore, Fig. 2 explicates the actual number of work-related fatal accidents only as 19 in 2016, 31 in 2017 and 13 in 2018[1] in Electrical Distribution Sector, Turkey.

The EDS still has an increasing trend in employment and offer new job opportunities. In the last 3 years, employment has increased by approximately 10% in the sector reaching 55,619 in 2018.

Table 2. Number of Employees in EDS in Turkey between 2016-2018[1]

	2016	2017	2018[1]
Number of DSO Employees	15,211	16,199	22,576
Number of Contractor Employees	35,359	38,198	33,043
Total Number of Employees	50,570	54,397	55,619

Table 2 tabulates the number of employees in Distribution System Operators and the Contractors (including Subcontractors). In EDS there is no common contractor utilization criteria, thus DSOs utilize one or more Contractors and Subcontractors for different tasks such as Repair & Maintenance, Investment or Meter Reading etc. In this study 'Contractor' is used as a general term including subcontractors.

This increase in employment also increases the skilled workforce and job-specific training demand. In Turkey, mandatory OHS training is regulated in Article 11 of the Regulation on the Procedures and Principles of the Employees' Health and Safety Training. This article states that; "Training to be given to employees shall be made within the periods determined during the entry of the employees and during the continuity of the work; at least sixteen hours annually for very dangerous workplaces. However, this training curriculum frames general topics and does not provide improvement in the job-specific risks in electrical works.

Table 3. Number of Lost Time Injuries in 21 DSO and Contractors in Turkey between 2016-2018[1]

[1] The data is collected during the first three quarters of 2018

DSO	2016		2017		2018[1]	
	DSO	Contractors	DSO	Contractors	DSO	Contractors
1	20	5	65	9	54	10
2	7	51	2	69	2	50
3	2	12	2	25	0	34
4	6	38	8	38	6	29
5	8	7	9	8	13	8
6	49	7	52	20	47	11
7	14	12	117	22	106	11
8	8	36	0	46	1	16
9	1	22	0	27	0	19
10	2	16	2	34	0	22
11	0	5	2	18	2	15
12	1	11	0	9	4	4
13	4	11	14	3	6	2
14	8	0	13	3	3	1
15	40	0	101	0	117	0
16	0	14	0	15	1	27
17	77	0	52	96	41	92
18	3	7	14	11	4	11
19	0	2	0	0	0	0
20	0	59	2	66	5	51
21	19	7	104	41	87	22
TOTAL	**269**	**322**	**559**	**560**	**499**	**435**

As seen in Table 3, the number of LTI in DSO and Contractors are 269, 322 in 2016, 559, 560 in 2017 and 499, 435 in 2018[1]. Although these numbers seem comparably close, the number of workers under DSO payroll is generally much lower than the number of Contractor employees.

In order to analyse and compare LTI data further, it is validated by using the number of workers. British Health and Safety Executive's Incident Rate formula is used for common understanding [31].

$$Incident\ Rate = \frac{Injuries\ per\ year}{Employment} \times 100.000$$

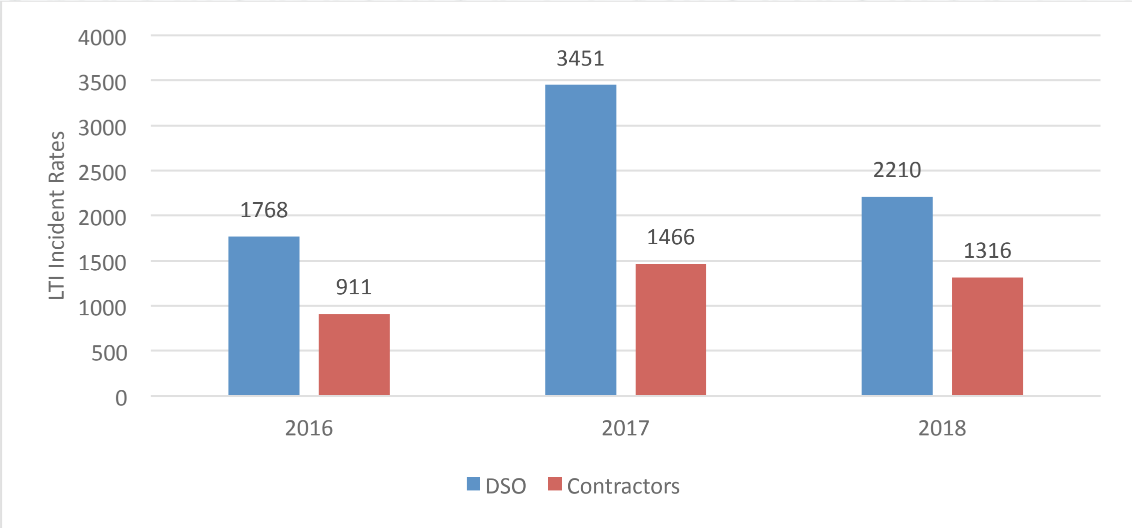

Fig 3. LTI Incident Rates of DSO and Contractors in 2016, 2017, 2018[1]

Figure 3 suggests that Contractors have fewer incident rates compared to DSOs, in other words, Contractors perform better than DSOs in terms of the number of incidents. However, considering the difficulties of incident data collection especially from the Contractors, it shall be noted that Contractors' recording and notification systems appear to be inadequate and this is the main reason for lower accident rates in the contractor companies working in the sector.

The incident rate is an important safety metric but knowing how severe those injuries completes the picture of safety performance. Some injuries impede productivity and escalate costs far more than others, and this should be taken into consideration. The injury severity rate represents the number of lost workdays experienced per 100 workers. As the name implies, the injury severity rate attempts to measure how critical the injuries experienced by a certain group of employees (in a given workplace or across an entire industry) by using the number of days lost as a proxy for severity.

Injury severity rate can be calculated by the following formula [32]:

$$Severity\ Rate = \frac{Time\ lost\ per\ year}{Hours\ worked\ per\ year} \times 200.000$$

According to OECD data, average annual working hours for OECD countries is calculated as 1734 hours in 2018 [33]. Applying this formula and OECD annual working hours, the Severity Rate is shown in Fig 4.

[1] The data is collected for the first three quarters of 2018

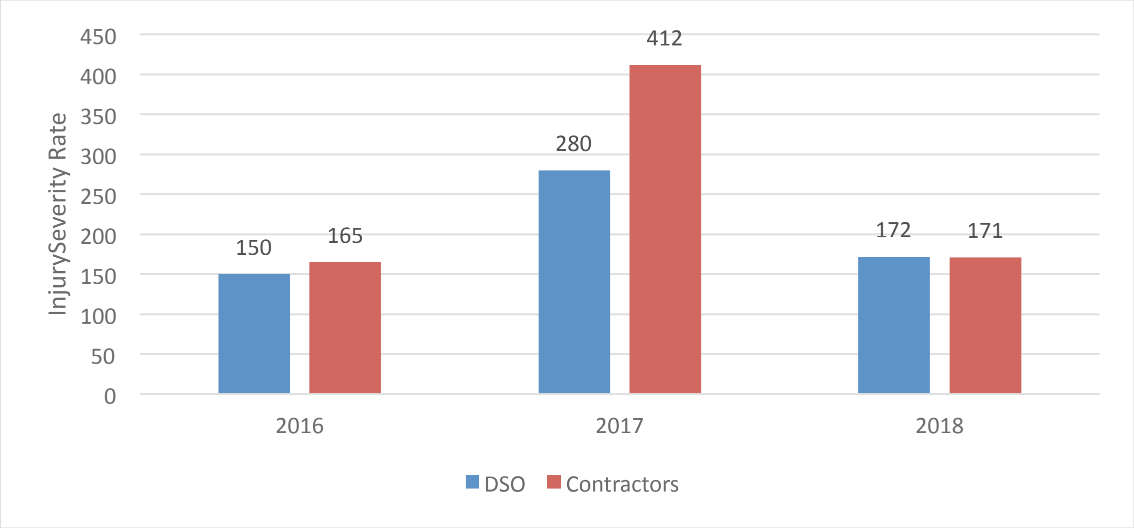

Fig 4. Injury Severity Rates of DSO and Contractors in 2016, 2017, 2018[1]

Figure 4 indicates that the DSOs have LTI injury severity rates of 150, 280 and 172 while Contractors have 165, 412 and 171 in 2016, 2017 and 2018[1].

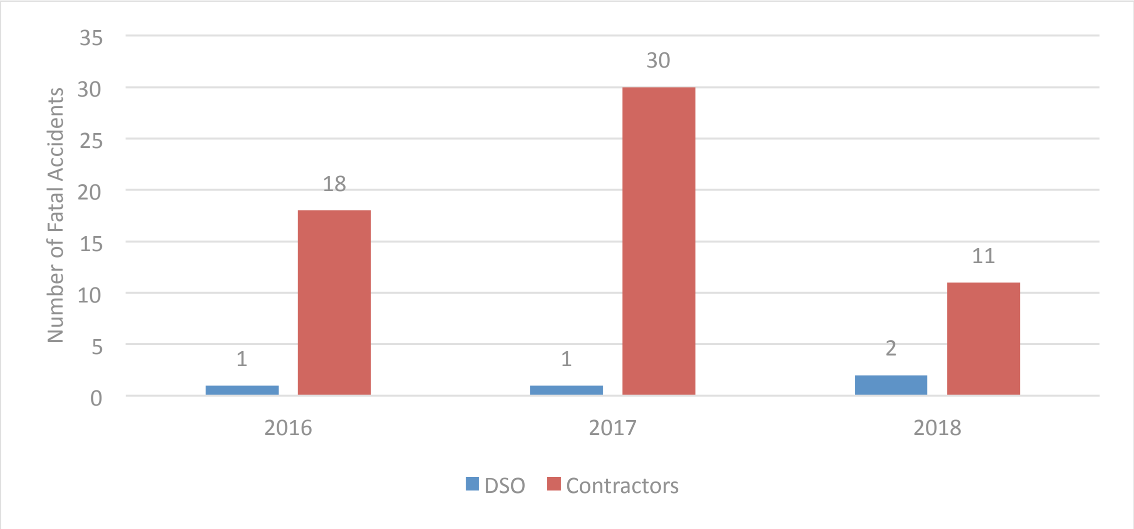

Fig 5. Number of Fatal Accidents of DSO and Contractors in 2016, 2017, 2018[1]

Figure 5 clearly indicates that the number of fatal accidents is much higher in Contractors with 18, 30 and 11 where DSO's has 1, 1 and 2 in 2016, 2017 and 2018[1] respectively.

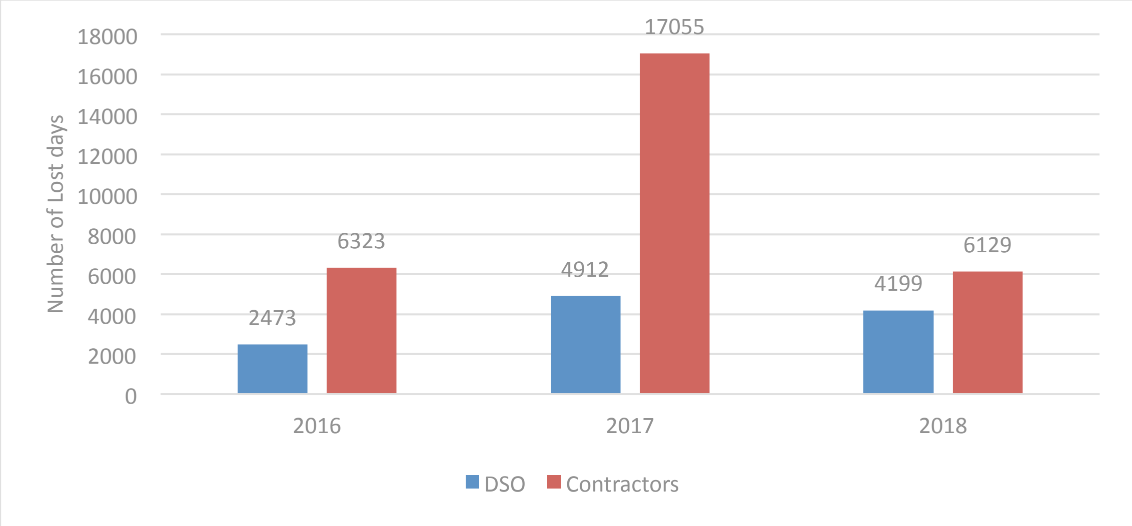

Fig 6. Number of Lost Days of DSO and Contractors in 2016, 2017, 2018[1]

Figure 6 shows the total number of lost days due to the work accidents in DSO and Contractors in 2016, 2017 and 2018[1]. For DSOs, 269 incidents resulted in 2473 lost days, 559 incidents resulted in 4912 lost days and 499 incidents resulted in 4199 lost days in 2016, 2017 and 2018[1] respectively. For the contractors 322 incidents resulted in 6323 lost days, 560 incidents resulted in 17055 lost days and 435 incidents resulted in 6129 lost days in 2016, 2017 and 2018[1] respectively.

The analysis of LTI, incident rates, injury frequency rates and the number of fatal accidents of DSOs versus Contractors states that contractor workers are exposed to more severe accidents and contractors report only if major accident occurs.

Although the utilization of contractors varies in different Distribution System Operators, all DSOs utilize Contractors in Investment Works, which are mainly construction activities such as trenching for underground lines, pole erection and cable connections in overhead lines, building transformer vaults and switchyards etc. Since the investment works are classified under construction activities, the majority of the investment contractors originally operate in the energy construction business. According to Construction Sector Action Plan for 2014-2016 period in National Employment Strategy, for (2014 – 2023) it is very clearly emphasized that the Occupational Health and Safety awareness in the sector will be the highest priority in construction [4]. The assessment of the data combined with the knowledge collected in site visits, workshops and interviews support that the Contractors have lower safety awareness, work in higher-risk tasks and LTI reporting is not reliable due to the challenges in monitoring daily activities of contractors in a wide geographical area.

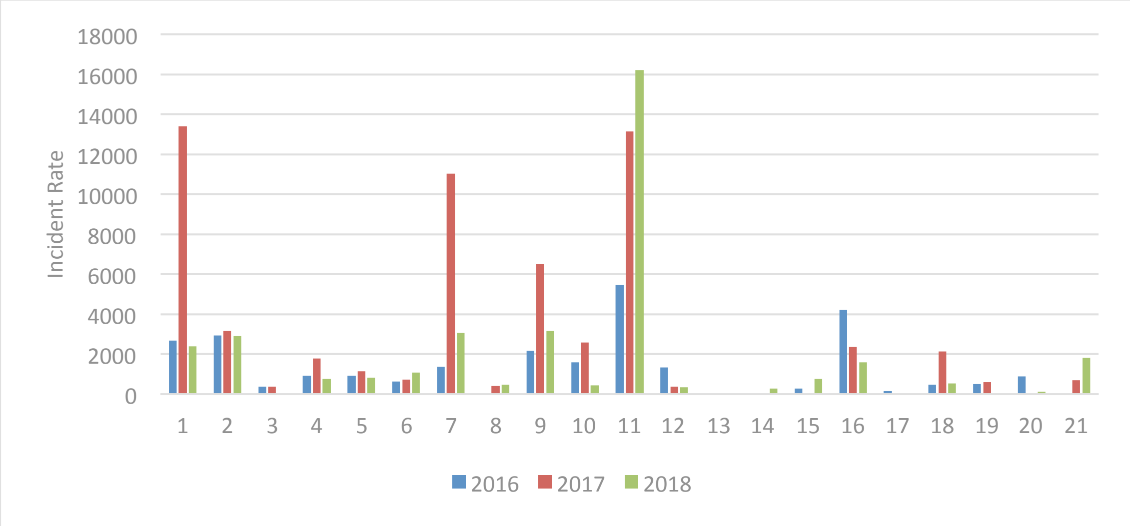

Fig 7. Incident Rates of 21 DSO in 2016, 2017, 2018[1]

Assessing the incident rates of 21 DSOs own workers' incidents, specifically, the first three companies that have the highest number of employees show the highest incident rates on a three-year average. Unexpectedly site visits, workshops and questionnaire findings do not suggest that these 3 companies have weaker OHS practices; on the contrary, the reporting and investigation quality of these three DSOs is above the sector average in the EDS.

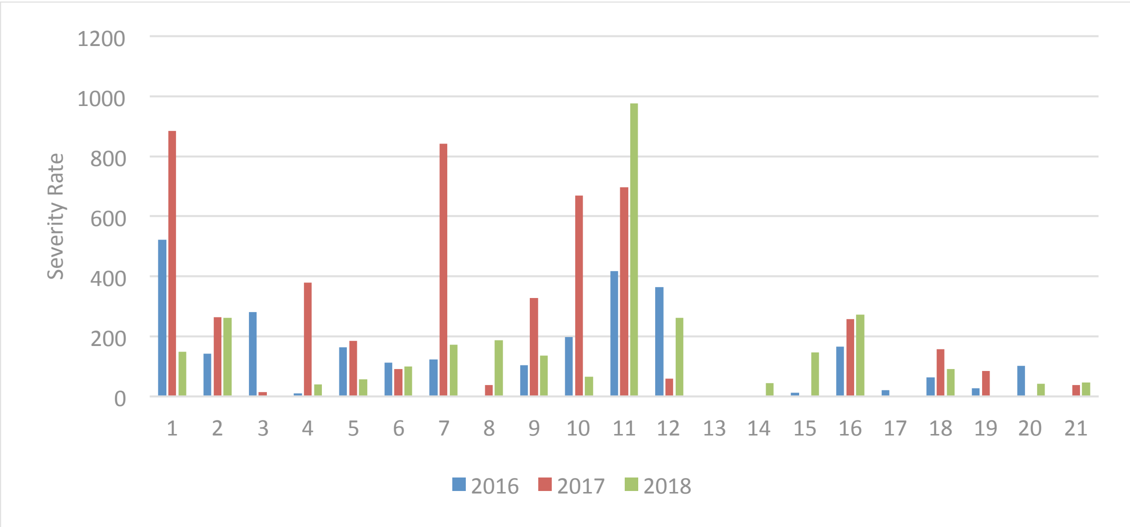

Fig 8. Severity Rates of 21 DSO in 2016, 2017, 2018[1]

Similar to the Incident Rates, the same first 3 DSOs have the highest Severity Rates on a three-year average.

Assessment of Causation of Incidents

Accidents are defined as unplanned occurrences which result in injuries, fatalities, loss of production or damage to property and assets. Preventing accidents is extremely difficult in the absence of an understanding of the multilayer causes of incidents. Many attempts have been made to develop a prediction theory of accident causation, but so far none has been universally accepted. Researchers from different fields of science and engineering have been trying to develop a theory of accident causation which will help to identify, isolate and ultimately remove the factors that contribute to or cause accidents.

Reported incidents occurred in 2016, 2017 and 2018[1] has been ordered according to the number of repetitions of the same causes of Lost Time Injuries in Electrical Distribution Sector, Turkey.

Table 4: Causes of Injuries in 21 DSOs & All Contractors for 2016, 2017 and 2018[1] in Turkey

Injuries	**Number**
Slips, Falls & Trips (At Same Level)	610
Burning due to the Electrical Arc	345
Falling from Height	325
Motor Vehicle Accident	263
Electric shock	224
Struck By/Against Material	174
Animal Attack	164
Physical Assault	163
Miscellaneous	116
Caught Between Objects	115
Sharp Tools (Cut & Prick)	113
Manuel Lifting & Handling	52
Falling Object	51
Explosion	34
Operating of Equipment & Vehicle	25
Sliding or Caving Material (earth, rocks, stones, snow)	17
Hand Tools	16
Powered Hand Tools	10
Food Poisoning	3
Exposure to Hazardous Substances	2
Fire	2
Natural Disaster	1

In Table 4, the direct causes of injuries are shown. Slips, falls and trips from the same level is the highest cause of injuries with 610 cases out of 2825 casualties in 2016, 2017 and 2018[1].

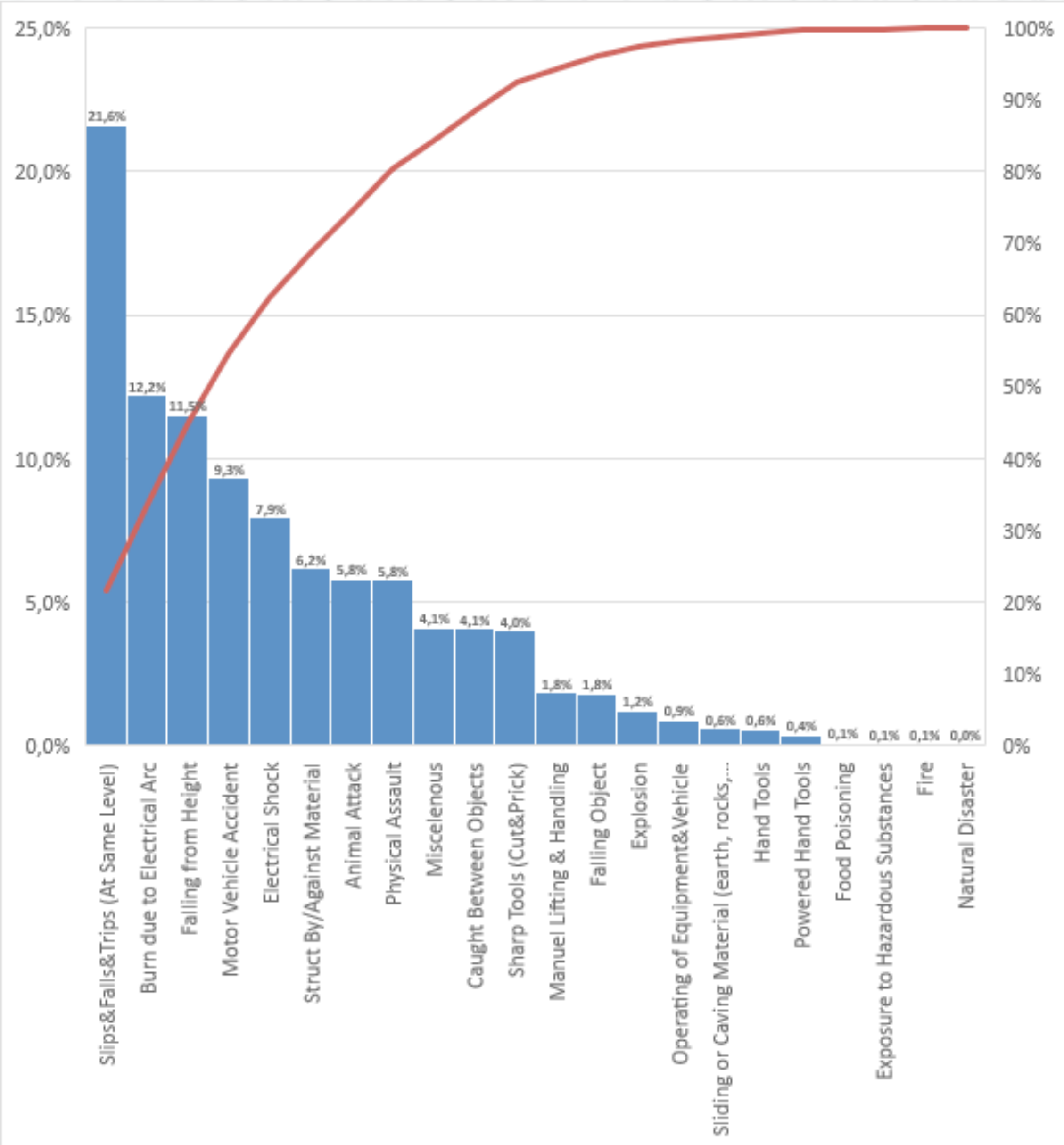

Fig 9. Causes of Injuries & Pareto Analysis

The Pareto principle was first applied in the 1940s to eliminate the causes of defects in quality engineering. The principle is based on an empirical relationship in which 20% of the causes generate 80% of the effects [34]. In principle, an analysis of accident rates and types shows that 20% of the most predominant irregularities contribute to approximately 80% of the accidents [36].

Applying the Pareto principle to the incident data, it was found that approximately 80% of all injuries are caused by 8 causes which are slips/falls/trips, burning due to electrical arc, falling from height, motor vehicle accident, electrical shock, struct by or against material, animal attack and physical assault. The Pareto principle is used to analyse the incidents and to focus on most common incidents in EDS.

Further analysis of the data shows that 33% of all injuries are caused by 3 main types of incidents; slips/falls/trips, animal attack and physical assault. These incidents generally result in minor injuries and do not cause long-lasting adverse health impacts on the victims. Also, these types of accidents are difficult to be prevented by conventional safety measures. Therefore, in this study instead of focusing on the hard to prevent causes, a 'Simplified LTI[2]' approach has been implemented. 'Simplified LTI' is referred to the injuries excluding slips/falls/trips, animal attack and physical assaults to ease focusing on direct causes of the sector related preventable incidents.

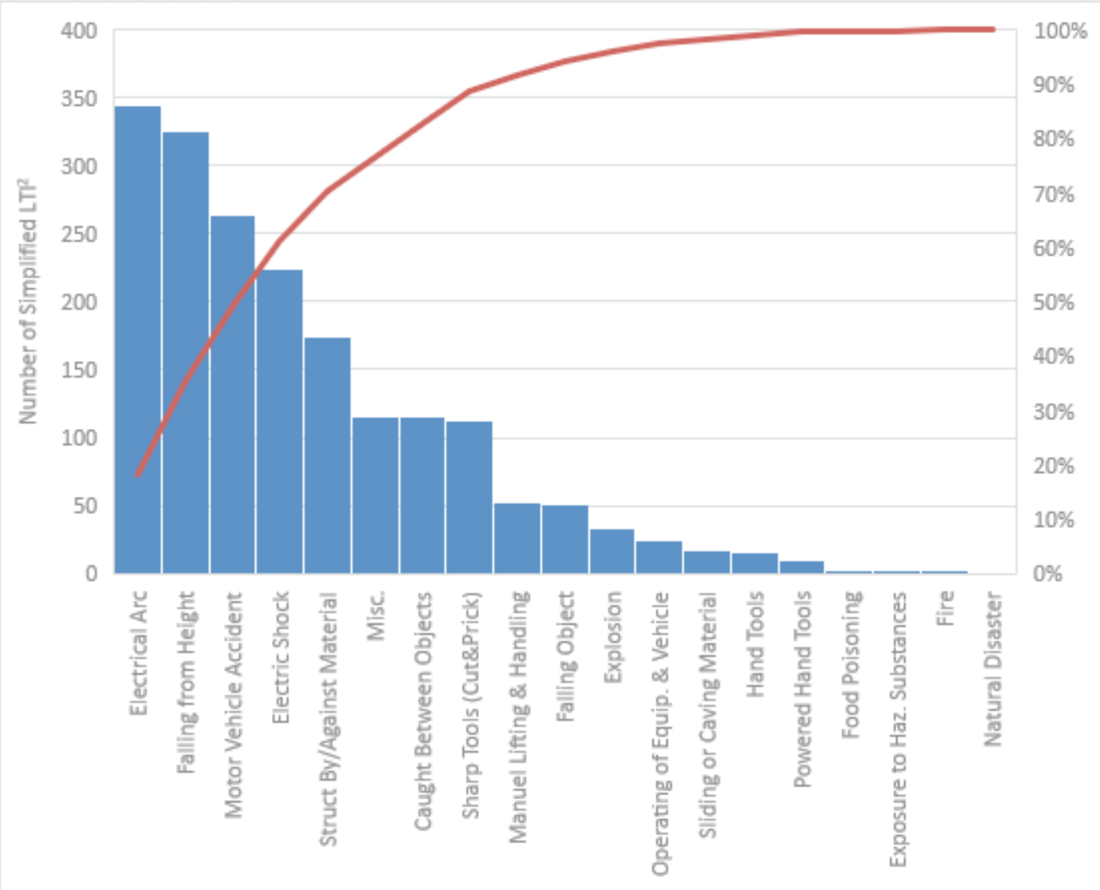

Fig 10. Causes of Simplified LTI[2] & Pareto Analysis

Among simplified LTIs the most common causes are electrical arc (18.3%), falling from height (17.2%), motor vehicle accident (13.9%), electrical shock (11.9%) and mainly due to lifting operations struck by/against materials (9.22%) and caught between objects (6.14%). Pareto analysis indicates that these five accident causes consist of 76.5% of all simplified LTIs. In other words, if these five causes of accidents are eliminated, 76.5% of injuries in the sector could be prevented theoretically.

[2] Simplified LTI refers to injuries excluding slips/falls/trips, animal attack and physical assaults

Table 5: Causes of Fatal Accidents in 21 DSOs & All Contractors for 2016, 2017 and 2018[1] in Turkey

Fatal Accidents	Number	%
Electric shock	39	61.90
Falling from Height	9	14.29
Motor Vehicle Accident	4	6.35
Falling Object	2	3.17
Miscellaneous	1	1.59
Struck By/Against Material	1	1.59
Electrical Arc	1	1.59
Not classified	6	9.52
TOTAL	63	100

As indicated before, excluding terror, heart attack and suicide at work, 63 fatal accidents were reported in 2016, 2017 and 2018[1]. **By causing 39 fatal accidents, electrical shock is the uppermost cause of fatal accidents.** Applying 80/20 approach, electrical shocks, falling from height and motor vehicle accidents contributes 82.54% of all fatal accidents with 61.9%, 14.29% and 6.35% respectively. Also, nonignorable 9.52% of the fatal accidents were recorded as not classified due to lack of information on specific details of causation, supporting the difficulties of trustworthy data acquisition mentioned previously.

In order to understand the electric shock cases further, detailed analysis is needed since 61.9% of fatal accidents and 11.9% of simplified LTIs are caused by coming into contact with electricity.

Table 6: Electric Shock Accident Data per LV & HV

	Number of Injuries	Number of Fatal Accidents
Low Voltage (LV)	122	12
High Voltage (HV)	102	27
TOTAL	224	39

Among 224 electric shock cases, 122 occurred in Low Voltage (LV) works and 102 accidents in High Voltage (HV), which is 54.5% and 45.5% of the total electric shock accidents respectively. In these recorded injuries, 39 workers lost their lives due to electrical contact, concluding 17.4% of the whole electric shocks ended up with a fatality.

Although fewer accidents were encountered in activities under HV, the number of fatalities show that the severity of HV works is higher than the ones under LV activities. According to the data, 27 workers died in 102 incidents in HV works, meaning 26% of HV electric accidents caused a fatality, 12 workers died in 122 incidents in LV works, meaning 10% of LV electric accidents caused a fatality.

The less severe yet higher number of accidents in LV activities leads a presumption that the workers do comparably underestimate the electrical risks in LV works compared to HV works, thus fundamental safe working practices such as lock out tag out (LOTO), power cutting and testing before touching or PPE use is not followed during LV works.

Assessment of Incidents per the Occurrence Times

The incident data were categorized in terms of accident time, work shifts, and accident causes to analyse the relationship between accidents and time.

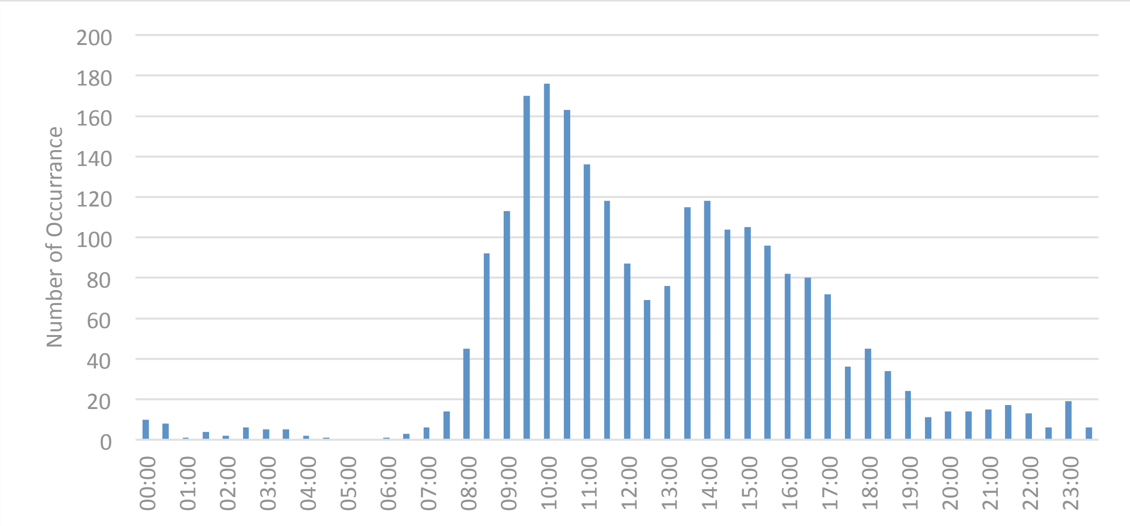

Fig 11. Number of Occurrences According to Time of Injuries

In EDS it is a common practice to work as 3 shifts (8:00-16:00 (morning), 16:00-24:00 (afternoon), 24:00-8:00 (night)) whereas the majority of work is done during day shifts. Therefore, the majority of incidents was reported during day shifts between 8:00 and 16:00. In Fig. 11, the occurrence time of 2339 injuries were assessed among 2825 injuries since the time of accidents were reported unknown for the rest. The highest occurrences are recorded in two hours between 9:30 and 11:30. 170, 176, 163 and 136 injuries were reported between 9:30-10:00, 10:00-10:30, 10:30-11:00 and 11:00-11:30, respectively. In between this two-hour work period (9:30 to 11:30), a total of 645 injuries were reported which contributes 22.8% of all injuries.

It always has been a matter for studies whether shift works or extended working hours affect the risk of occupational accidents or not. In industrialized countries, occupational accidents increase in the afternoon and night shifts while in developing countries both afternoon and night shifts had a lower accident frequency than morning shifts. One reason for this could be that there are fewer supervisors during afternoon and nights shifts and accidents are not registered as often as during morning shifts [37].

Table 7: Summary of Injuries Across Three Shifts in EDS Turkey

	Morning	Afternoon	Night
Number of Injuries	1783	488	68

Shift works are more suitable for the plant-based manufacturing activities in which the works have to continue 24 hours a day. However, in industries such as EDS, the vast majority of the activities and routine works are carried out during day shifts yet minimized workforce is set ready for responding to the failures during night shifts. In EDS of Turkey, since the number of night-time activities significantly decreases and possibly reporting of incidents is reduced, the number of injuries decreases significantly in parallel as shown in Table 7.

Beyond the work shifts, it is more important to assess the effect of extended work hours on occupational accidents. According to the studies, extended daily working hours and weekly-based overtime works increase the risk of accidents significantly. Based on the National Longitudinal Survey of Youth, among the US construction workers, working over 50 hours per week increases the risk of occupational injury. The risk was double for those working over 60 hours per week compared to those working 40 hours [37].

Also based on the same data set, working at least 12 hours per day increases the risk of occupational injury by 37%. Working over 60 hours per week raises the injury risk by 23%, whereas working in a job with overtime (for overtime pay) increases it by 61% [38].

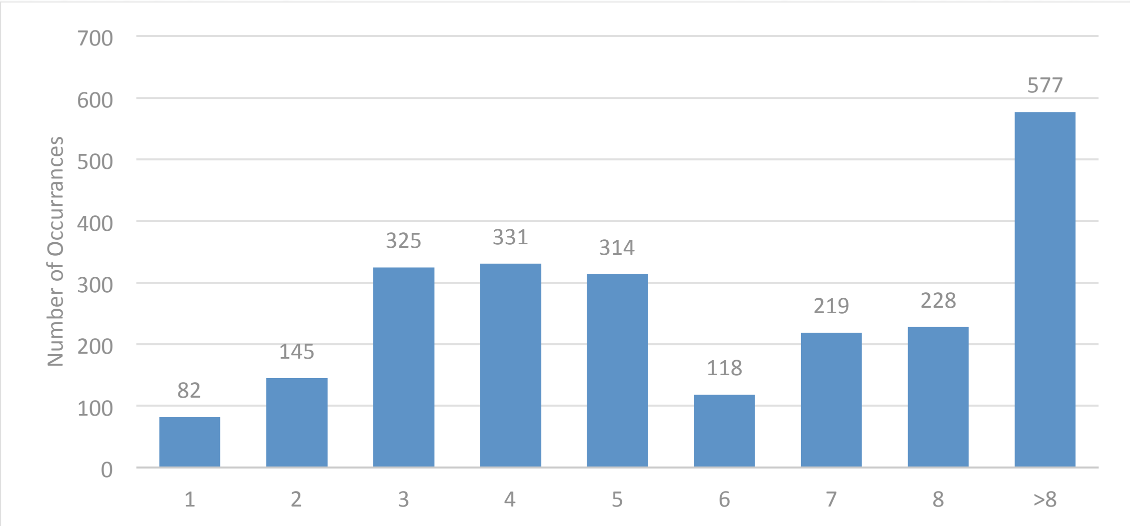

Fig 12. Number of Occurrences According to Time (hours) in the Shift

Labour-intensive industries require large quantities of physical effort to complete necessary tasks. EDS site works are considered as labour-intensive tasks which affect fatigue-sensitive behavioural and physiological performances of workers. Fig. 12 indicates that extended working hours has a substantial effect on occupational accidents in EDS of Turkey. 577 of 2339 injuries occurred during extended working hours due to hurrying, decreased concentration, fatigue and tiredness.

Assessment of Incidents per the Victim Information

The assessment of victim information such as the age, work experience, qualification and educational background has utmost importance to understand the contributing risk factors which can impair the safety of EDS workers.

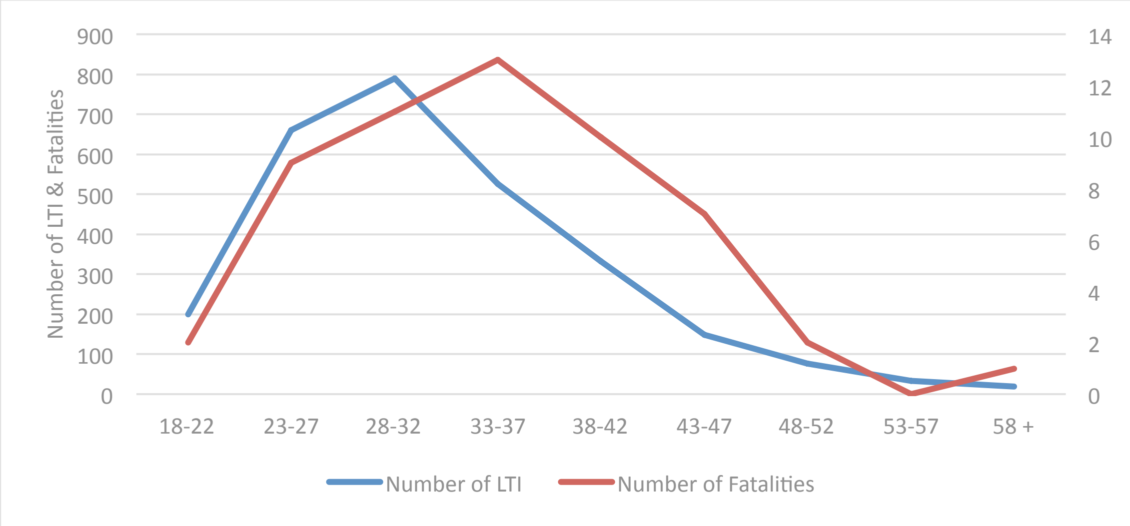

Fig 13. Age Intervals vs Number of LTI and Fatalities

The number of LTI and fatalities have similar trends in terms of the age distribution of victims with a slight difference of that the LTI peaks at ages between 28-32 where fatalities peaks between 33-37.

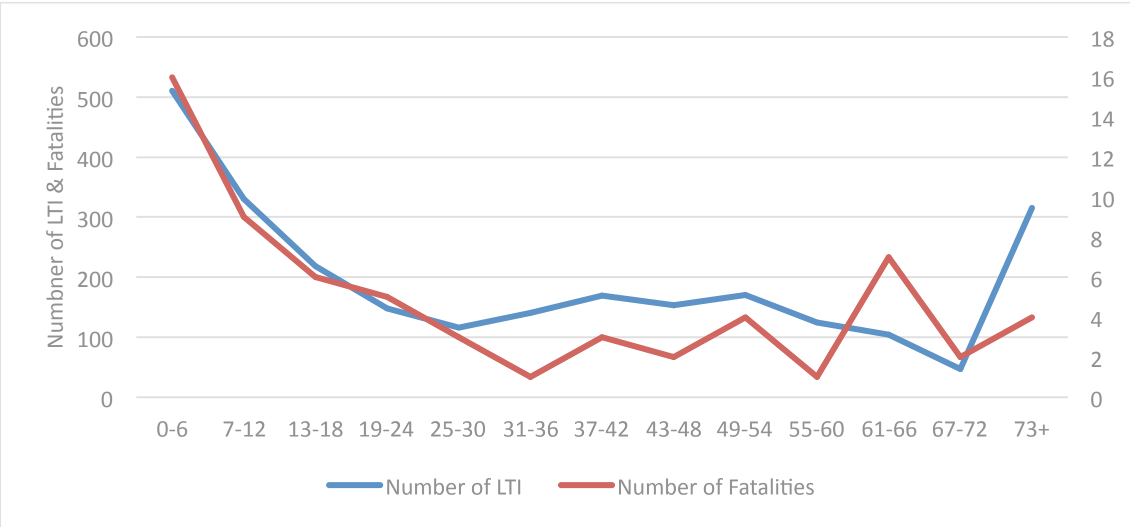

Fig 14. Number of LTIs & Fatalities According to Work Experience (months)

Figure 14 clearly shows that accident proneness decreases when the worker's experience in DSO increases. In fact, 33.03% of all LTI occurs if the worker has one year or less experience; 47.41% of all LTI occurs if the worker has two years or less experience in DSO or the Contractor. Here it is also important to note that the contracts between DSOs and Contractors are usually made for two-year terms, therefore contractor changes also increase the turnover of the workforce.

The fatality occurrence trend shows similar patterns with the LTI's as the number of accidents are high in the early years of work and after a drop, it increases after 5-6 years of experience.

Fig. 14 indicates that the workers often lose their lives in work accidents in the early years of work. 39.68% of all fatalities occur if the worker has one year or less experience; 57.14% of all fatalities occur if the worker has two years or less experience. Due to short terms of contracts with the contractors and unavailability of qualified workers especially in rural areas, workers mandatorily change their companies if another contractor is awarded in the tender.

DSOs have different contractor management practices in safety requirements during a tender, site works monitoring and disciplinary actions. The DSOs, which have stronger contractor management procedures, also influence and improve contractors' safety culture due to joint liability. The frequent turnover in contractors due to procurement rules, diminishes the efforts of DSOs to create and spread better safety culture among the contractors. This not only affects the safety of the workers but also cause the workers to feel insecure about their future work due to fixed-term employment contracts.

The assessment of the data indicates that there is a strong need for an effective orientation program and high-quality safety training before the start date of employment in EDS and in their contractors. Also, a selection and accreditation of contractor companies and the workers need to be clarified by the regulator and the DSOs.

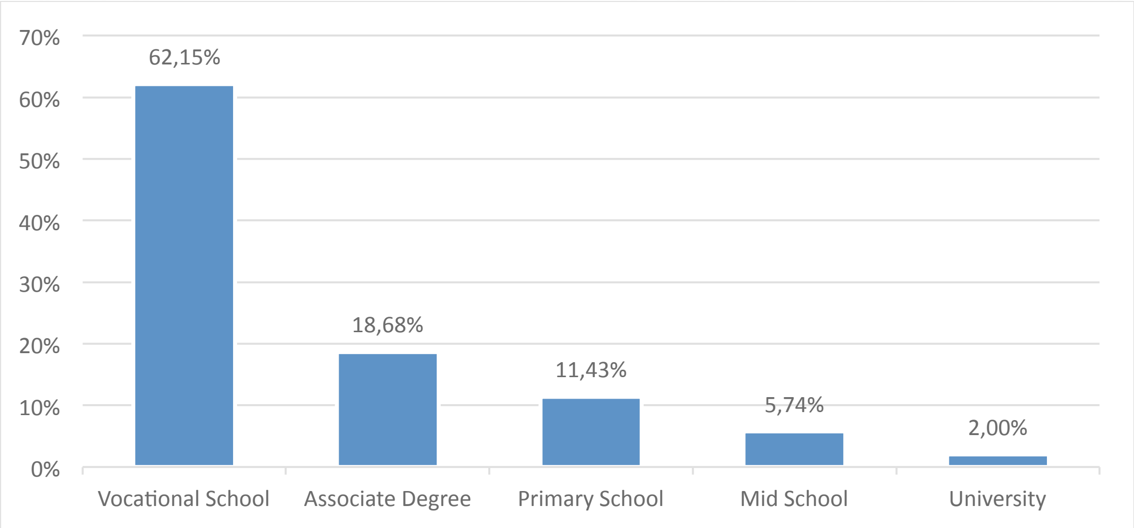

Fig 15. Simplified LTI[2] According to Educational Background

62.15% of the victims are vocational school graduates, then associate degree, primary school, mid-school and university graduates with 18.68%, 11.43%, 5.74% and 2% respectively.

Vocational Qualification Law no.5544 aims to develop qualified and certified workforce under the name of the European Union and in the name of National Qualifications System in Turkey. The Law regulates the principles of national qualifications in technical and vocational fields, based on national and international occupational standards. The law orders the establishment of the Vocational Qualifications Authority which will determine the working methods and principles and arrange matters related to the Turkish Qualifications Framework in order to establish and operate the national qualification system necessary for carrying out activities related to auditing, measurement and evaluation and certification [4].

Regulation on Electric Power Installations which has been published in the Official Gazette No. 24246 dated 30 November 2000 aiming to protect the asset and people also requires a permission certificate for the electricians.

Since the regulations oblige vocational education or electrician certification to conduct electrical works in EDS, the majority of field workers are selected among vocational school or associate degree graduates.

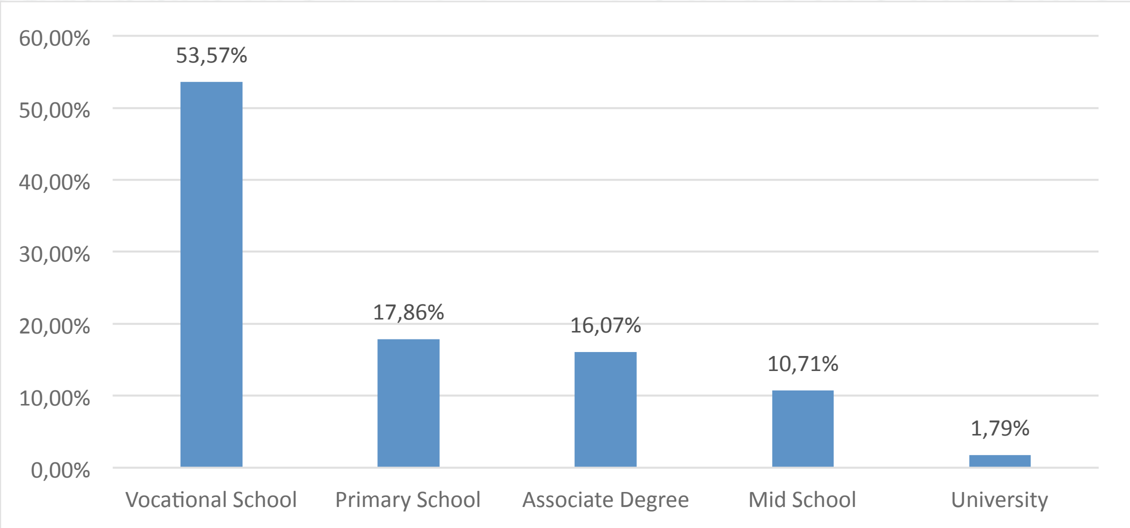

Fig 16. Fatalities According to Educational Background

According to the assessment of fatalities, 53.57% of the victims have vocational school degrees, 17.86% have a primary school degree, 16.07% have an Associate degree, 10.71% and 1.79% are Mid school and University graduates respectively.

It is important to note that certified electricians having associate or vocational school degree with a necessary qualification are involved in 80.83% of simplified LTI and 69.74% of fatalities. This fact indicates that the current education system and training programs do not sufficiently give safe working skills and knowledge to protect the labours.

The theoretical training programs need to be improved with more site practices and making apprenticeships to be more efficient and qualitative. Also, integration of national vocational education system and DSO vocational training will empower the EDS safety for the middle and long term, decreasing the work accidents as well as increasing the productivity in the sector.

Observations of the Site Visits

Five volunteer companies were visited among 21 companies operating in Turkey. Country has seven geographical regions, in this study five of the regions were visited to represent wider different coverage area in Turkey. These companies represent nearly %25 customers of the sector. All site visits started with an Opening Meeting where the top and mid-level management, safety team and contractor representatives attended. The attendees were informed about the previous stages of the project, findings and inception report including common approaches by DSOs root causes of the major and fatal accidents.

In the meetings, company representatives presented an overview of the OHS management system in place, contractor organizations including competency and contractor selection criteria.

In order to understand the site organizations, working practices and past accidents Field Visit were held with the attendance of DSO & Contractors' safety teams and operating personnel.

In the site visits;

- Selected high risk works such as work at height, HV and LV operations, trenching, rural works and high-density urban works was prioritized
- Randomly and/or previously selected fields were visited
- Announced and unannounced field visits were conducted
- The observed safety aspects are
    - Team structures
    - Safety monitoring practices
    - Skill & competency of site workers
    - Occupational knowledge of site workers
    - Ways of Communication
    - Implementation of OHS Procedures
    - Use of PPE and other safety equipment
    - Risk-taking habits & awareness
    - Root causes of accidents

In order to examine the workflow from start to finish and safety practices on site, the following tasks have been watched closely:

- Replacement of blown NH Blade Fuse on LV Switchboard
- Installation and feeding of new distribution station from the existing station
- Troubleshooting to find fault on HV line using the test vehicles
- Repair work on lines
- Residential power distribution transformer operations
- Work on pole type transformer
- Simultaneous operations of the teams

Table 8: Key Observations

Factors	Description of Observation
Communication	Poor communication was observed between site workers and operation centre about the failure history of the unit to be repaired. Single line diagrams are mostly outdated, incorrect and not examined by the workers before the commencement of the work. In rural work, locations may be out of the service area of cell phones or radio units.
People & Behaviour	As discussed in the accident data assessment, there is a lack of risk perception, especially in LV activities. Safe working practices such as lock out tag out (LOTO), power cutting and testing before touching or PPE use is not followed during LV works. When HV exists at proximity to LV works, inadequate attention is paid to details and hazards of the job. Grounding is occasionally bypassed to gain time due to the number of work orders received by the workers. Testing before touching is ignored where workers feel confident about the power cut. Use of incorrect equipment such as screwdrivers in switchboards increases the risk of electric shock and arc incidents. External network interference, mostly by customers, puts the workers at risk due to unpredictable changes in the network.
Supervision	Inadequate supervision has been identified as one of the factors contributing to the occurrence of accidents. Due to the workload and size of the field, supervision is difficult.
Training/ Competency	Inadequacy of training leads workers to take initiatives based on their personal experience and knowledge. Supervisors need advanced safety knowledge and should be encouraged to implement best practices such as zero tolerance. Safety professionals need practical training in the field. Mostly they are not competent enough to instruct workers about the safe operations in work at height and electrical tasks.
Design of Facilities, or Equipment	Missing equipment and protective devices such as the absence of the main switch and guarding in the LV distribution panel is one of the contributing factors for accidents. Insufficient examination of multiloop distribution systems causes electric shock even the power is cut from one source. Pole type transformers require a combination of electrical safety and safe work at height. Proper ladders and man baskets are not provided all the time.
Quality of Materials	Network infrastructure and utilities are old, unpredictable and in poor condition which affects the safety of workers.

The site observations show that although there are already occurred accidents that can be taken as examples, the potential major and fatal accident causing factors, breaches and unsafe practices still remain unchanged or conditions are slightly improved in some findings. Furthermore, the observed common and repeating unsafe conditions and acts are similar to the immediate, contributing and root causes of the previous accidents. Although DSOs have sorrowful experience of major and fatal accidents, they may be unable to sufficiently implement lessons learned even within their current operations reactively.

As the most common activity type in the EDS, responding to failures has a unique feature. First, the site conditions are non-similar due to unknown facility and equipment conditions. The complexity of the problem is unknown and workers on duty may not be skilled enough to overcome the problem. Lastly, these activities are unplanned; the duration of work cannot be forecasted and rarely end up with an extension of 8-hour shifts which has an incremental effect on occupational accidents in EDS of Turkey as discussed in accident assessment data previously.

Site observations support that rush due to the public pressure, skipped work breaks, irregular mealtimes increase physical stress factors, lack of concentration, fatigue and tiredness. In the accident investigation reports, these factors are usually not analysed deep enough thus the actions cannot be taken effectively.

In the field works, usually, very small (two-men) teams were established. Once a team leaves the dispatch office in the early times of the shift, they do not return to the offices until the end of the shift because either the locations are far from town centers or they are assigned to tasks one after the other. In the two-men teams, the more experienced staff acts as the team leader and instruct the other worker. Team leader's knowledge, skills or safety awareness directly become the standard of the team; and if the role model fails to follow safe working procedures, the other is put at risk as well.

Assessment of the Workshops

Five interactive workshops were held to share the findings of preliminary data assessment and site visit observations. In each site visit, senior and mid-level managers, human resources personnel, contractors and subcontractors, field technicians, SCADA engineers, workers representatives, safety experts and occupational physicians of the volunteer DSO attended to multidisciplinary workshops to better understand all departments perspectives and activities improve accident investigation performance, assess past accidents and develop a safety improvement plan to avoid reoccurrence.

The outcomes of accident data were presented and discussed in the workshops. The gaps in the OHS system was assessed, problems were identified, and solution suggestions of the attendees have been collected. In order to overcome the incident causing factors, sector representatives define the needs as follows:

- **Technical Factors**

Although theoretically there is a limited number of risks such as electric shock, arc and falling from a height, each work is in some way unique and safe working practices are decided by the field workers due to different workplaces. This requires high problem-solving skills and technical knowledge to make instant safe decisions while operating the tasks. There is an immediate need for safe working guidelines to be referred by the field workers and engineers when a problem arises. This guideline must include as many possible scenarios classifying field works, potential specific risks and to-do list for prevention.

The use of advanced technology is one of the demands of EDS employees. Connected technology automatically monitors safety requirements (PPE, LOTO and grounding etc.), easy access to historical information (service, repair and maintenance information) of the utility such as an inventory tracking system to monitor the poor conditioned and aged grids and equipment are applicable or not. The benefit-cost analysis of such technologies should be further assessed and planned accordingly.

- **Human Factors**

DSO's upper and mid-management sincerely look for improvement suggestions to prevent incidents. Despite of willingness of the management, technical and organizational arrangements are not always sufficient to prevent OHS issues/risks. Behavioural change at any level of the company is the key factor to activate safety culture. Visible leadership and conflict management skills need to be improved for the managers in the EDS to help them make right decisions in the advantage of safety. Under the stressful conditions with ambiguities, managers must prioritize safety to show their determination and fairness.

For the field workers, background check for those who involved in recurring errors and violations to find out the psychological factors behind these errors and to consider in task allocations and keeping these records in personal file is a necessity. The underlying reasons for unsafe acts should further be investigated to understand whether these are skill, knowledge or rule-based mistakes.

- **Organizational Factors**

In the field works, communication between the field workers, operation or SCADA centers, contractor workers and safety supervisors is extremely important. Especially coordination between teams in simultaneous operations working on the same grid, past repeating failures of equipment need to be known by all parties.

Considering unplanned activities such as responding to failures increases the risk of major and fatal accidents, preparation of equipment inventory, assessment of equipment conditions, resource allocation to define repair and maintenance plan must be done proactively.

The EDS already defined the demand for advanced training programs in addition to mandatory vocational and safety training. In order to meet this demand and leverage training effectiveness, many DSOs established their own training centers. However, the utilization of these training centers is not as high as expected and the contractors do not have training centers. The use of training centers should be encouraged, the diversity of the equipment should be increased and realistic scenarios from past accidents should be reconstructed.

Outcomes of the Key Stakeholder Meetings

Following the site visits and workshops, stakeholder visits were made to public institutions and related organizations to brief the project, exchange information and collaborate further for the contribution of all sides. This study will be shared with all key stakeholders to establish a mutual cooperation for further actions.

Meeting with ILO Turkey:

A meeting was held at the International Labour Organization (ILO) Turkey with the participation of experts on occupational health and safety and they were briefed about the technical cooperation project. Two key areas for cooperation with ILO were discussed during the meeting:

- ILO's International Training Centre can provide educational materials and training support for the EDS on OHS issues.
- Also if the financial resources are secured, joint projects can be implemented in cooperation with ELDER and with DSOs to prevent future accidents at workplaces in electric distribution sector.

Elder will continue to engage ILO and cooperate with them in future studies and projects aiming to improve the capacity of the sector in addressing OHS issues, risks at their workplaces.

Meeting with Ministry of Family Labour and Social Services:

The meeting with the Ministry of Family Labour and Social Services was held with the participation of managers and experts under the leadership of the General Director of Occupational Health and Safety Department of Ministry of Labour.

Project information, objectives and summary of findings were shared with the OHS General Directorate of the Ministry of Family, Labour and Social Services.

- It is stated that the OHS Directorate works on a five-year evaluation report in power generation, transmission and distribution sector, which will be published upon completion.
- It is discussed that the safety specialists working in private sector have lack of sectoral safety knowledge, therefore, an intensive program is conducted to prepare training modules by the Turkish Ministry with the collaboration of Institute for Occupational Safety and Health in Germany.
- In the meeting with Ministry of Energy and Natural Resources officials, it was stated that the incident data collection is invaluable in the EDS and the outcomes of the project may make a great contribution for the future legislative amendments.

Meeting with Energy Market Regulatory Authority (EMRA)

During the meeting with Energy Market Regulatory Authority (EMRA), a meeting was held with a high-level attendance under the chairmanship of the Vice President. During the meeting, EMRA stated that they are open to opinions about the works that can be done for the regulation of legislation for the prevention of occupational accidents and that a specific study can be done especially for the prevention of accidents due to generator returns.

EMRA has an incentive program to encourage the DSOs to eliminate fatal accidents. The program offers a bonus of 0,5% of operating expenses (OPEX) to the DSOs which do not have a fatal occupational accident. This incentive is promising for the sector to increase awareness and invest further on safety to protect lives. During Task 5, visits were made to public institutions and related organizations to brief them about the project and exchanged information about their contributions. The final report will be shared with the EMRA and ELDER will continue to collaborate with them to prevent the potential incidents in the sector.

Meeting with the Trade Unions

The TES-IS Union President, senior management and occupational safety unit managers participated in the meeting. During the meeting TES-IS President stated that the project is a very important data source for the safety of the employees of the sector; the union is ready to provide any support for co-operation in this regard.

As a trade union, it was stated that there is a need to prepare a guidance document which will describe how and by whom hazardous tasks will be done.

During the meeting with the Directorate of Energy Affairs senior managers, occupational safety unit managers and technical team were present. Project summary information was shared in the meeting. The management revealed that they are open to cooperation, they will discuss the issues needed in the action plan for the prevention of occupational accidents and support cooperation and communication.

Assessment of Accident Investigation Data

Occupational accidents are rare events compared to the number of workdays successfully completed without accidents. At company level usually, the reactive corrective efforts reach at a maximum level right after an accident occurs. From top to down, all employees take urgent actions and safety campaigns are held to raise safety awareness. However, the number of accidents is generally too low to keep this level of awareness and to support continuous improvement. Therefore, accident investigation is a rarely available useful tool for the OHS management to understand failures in safety system and to develop lessons learned.

The main purpose of accident investigations is to analyse why accidents are occurring and what can be improved, and to do so the most effective way is to classify main incidents and causes in order to make easier the analysis [39]. Although all 21 DSOs investigate major accidents as a common good practice, they have different terminologies with different definitions to classify the accidents such as “major accident”, “critical accident”, “lost day incident”, “medical treatment”, “first aid” etc. Therefore, recording and reporting of accidents vary significantly. Also, among the 21 DSOs, the identified causes of accidents; direct, contributing and root causes are inconsistent.

The causes of accidents should be classified as immediate causes (unsafe acts, unsafe conditions) and contributing causes (safety management performance, the mental condition of workers and physical conditions of workers) according to the Encyclopaedia of International Safety Organization Part VIII-Chapter 56 (International Labour Organization, 1998). Accident investigations involve both immediate and environmental causes in order to explain both the accident’s physical event and the latent conditions that contributed to the accident occurrence. Any classification system should address all these categories of causes [39].

In the EDS of Turkey, using common terminology and sharing experiences with information from accident investigations can be used to create a valuable data set which helps safety professionals to obtain a wider proactive database of risks and to improve the overall safety performance in the sector.

Table 9: Summary of DSOs Accident Investigation Tools

DSO	Investigation Form	Investigation Procedure	Investigation Method
1	YES	YES	YES
2	YES	YES	YES
3	YES	NO	NO
4	YES	YES	NO
5	YES	NO	NO
6	YES	NO	NO
7	YES	YES	YES
8	YES	NO	YES
9	YES	YES	YES
10	YES	YES	YES
11	YES	YES	NO
12	YES	NO	NO
13	YES	NO	NO
14	YES	NO	NO
15	YES	YES	YES
16	YES	NO	NO
17	YES	YES	YES
18	YES	NO	NO
19	YES	NO	NO
20	YES	YES	NO
21	YES	YES	YES

Although there is not any standard in the EDS, all of 21 DSOs keep accident data, establish accident investigation teams and make investigations to learn from mistakes.

Table 9 is created according to the information collected in the video calls and company presentations. It indicates that all 21 DSOs use their own Accident Investigation Form, 11 companies (46.6%) have a written Accident Investigation Procedure and 9 (42.9%) companies use a known method (i.e. 5 Why, Fishbone etc.) to analyse the root cause of the accident.

Accident Investigation Form is the minimum legal requirement for accident notification, and it is the most uncomplicated form of documentation enabling collection of accident information such as date, time, short description of accident, victim information and result of the accident. The advantage of the form is its simplicity allowing inexperienced investigation teams to gather basic information. On the other hand, it usually does not guide the investigators to find contributing and root causes of the accident.

As indicated before, accident investigation is a rarely available tool for the OHS management to take corrective actions only if the accident investigation is well-performed and root causes are correctly defined.

9 out of the 21 DSOs do not have an accident investigation procedure or investigation method; they only use an accident investigation form -a simple document- to record the investigations. In order to perform a satisfactory accident investigation that can be used to find contributing and root causes, the use of an accident investigation method is essential. The most used accident investigation methods show that there are at least four different levels: work and technological system, staff, management and company level and those accident investigation methods need to be aligned to the accident causation model. In addition, the accident model needs to include at least three subsystems: technical, human factors and organisation [39].

In 8 (38.1%) of 21 DSOs, the accident investigation teams consist of safety specialists, occupational physician, supervisors, technicians, contractors and different level managers according to the severity of the incident. In 13 (61.9%) of DSOs, accident investigation teams mainly consist of safety specialists and technical staff only. The lack of procedures, experience and knowledge of investigators obstacle finding useful conclusions. In 15 (71.4%) of DSOs investigation team members received no specific training, 2 (9.5%) of the investigation teams are only informed on filling the investigation forms and procedures, 4 (19.1%) of them received specific accident investigation and root cause analysis training. Due to the low quality of investigations, important information is disregarded or lost resulting in an immature action plan. Agreeing on a method in the EDS and providing technical training on accident investigation for the investigation teams has a priority to achieve short term improvement.

A theory-based maturity assessment method is generated to understand safety culture in a multidimensional way by providing descriptions of an organisation with respect to a range of key aspects of safety culture [40]. For the purpose of this study, the fatal accident investigation reports were collected, and the maturity level of reporting, investigation and analysis was assessed using the safety culture maturity matrix on one aspect only.

Among 21 Distribution System Operators, fatal accidents occurred in 19 of those between 2016 and 2018[1]. The detailed assessment of fatal work accidents, investigation methods, reporting quality, immediate, contributing, root causes, strength and relevancy of actions is conducted.

Table 10. Assessment of Accident Investigations According to the Maturity Model

	Pathological	Reactive	Calculative	Proactive	Generative
Incident/ accident reporting, investigation and analysis	Many incidents are not reported. Investigation only takes place after a serious accident. Analyses don't consider human factors or go beyond legal requirements. Protect the company and its profits.	There is an informal reporting system and investigation is aimed only at immediate causes, with a paper trail to show an investigation focuses on finding guilty parties. There is little systematic follow up and previous similar events are not considered.	There are procedures producing lots of data and action items, but opportunities to address the real issues are often missed. The search for causes is usually restricted to the level of the local workforce.	There are trained investigators, with systematic followup to check that change has occurred and been maintained. Reports are sent companywide to share information and lessons learned. There is little creativity in imagining how the real underlying issues could affect the business	Investigation and analysis driven by a deep understanding of how accidents happen. Real issues identified by aggregating information from a wide range of incidents. Follow up is systematic, to check that change occurs and is maintained.

According to the maturity model, accident reporting, investigation and analysis can be used as an indicator to qualitatively define how companies react to accidents. Per the assessment, companies can be categorized into five groups; pathological, reactive, calculative, proactive and generative.

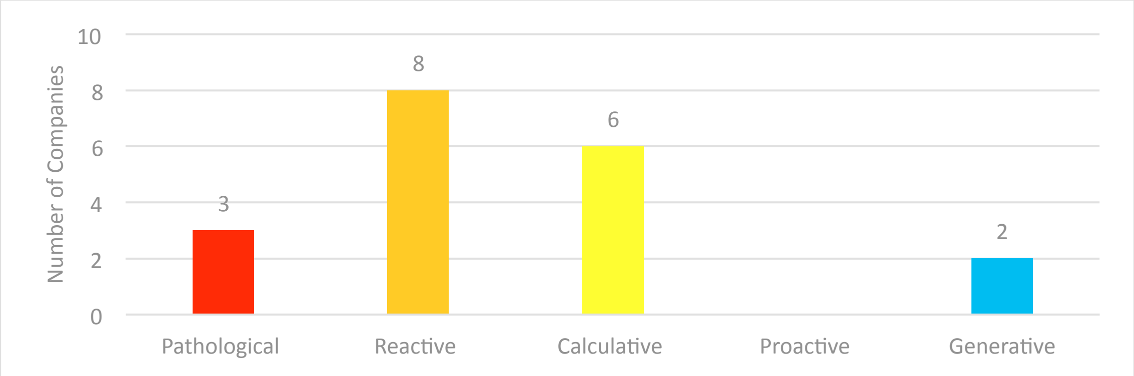

Fig 17. Number of Companies According to Maturity Level

Fig. 17 shows only fatality cases. Therefore 2 of the DSOs are not shown since no fatality was reported between 2016 and 2018[1]. The DSOs available fatal accidents were assessed with the maturity model. The assessment shows that 3 out of 21 DSO is at pathological phase, 8 in reactive, 6 in calculative and 2 in the generative phase.

Although 63 fatal accidents occurred between 2016 and 2018[1], 58 of these has available investigation reports. The detailed analysis is presented in the Annex of this report and the summary of 58 accidents' investigation quality, the precision of immediate, contributing, root causes and proposed actions using the maturity model is as follows:

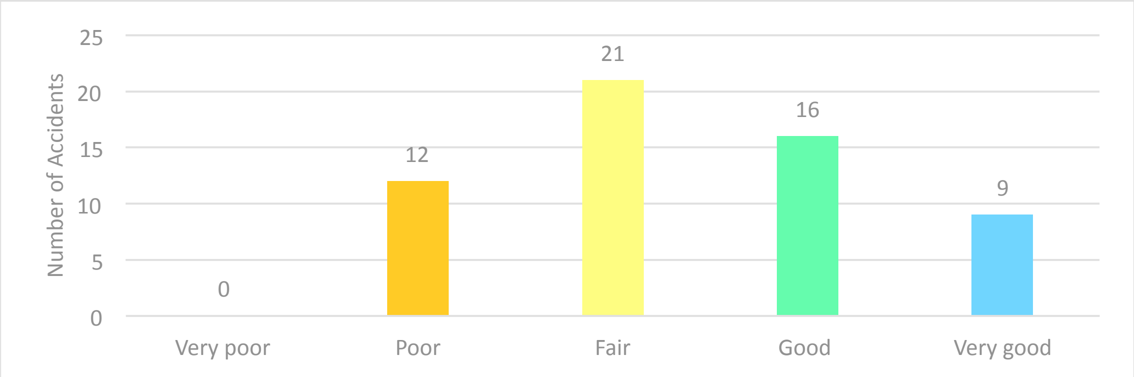

Fig 18. Number of Accidents According to Quality of Investigation

Fig. 18 indicates that 9 of the accidents have a very good quality of investigation with a deep understanding of how the accident happened, sufficient information is collected, and the achievable actions are suggested. According to the assessment, investigations for 16 of the accidents are adequate, 21 of them are fair and 12 are poor.

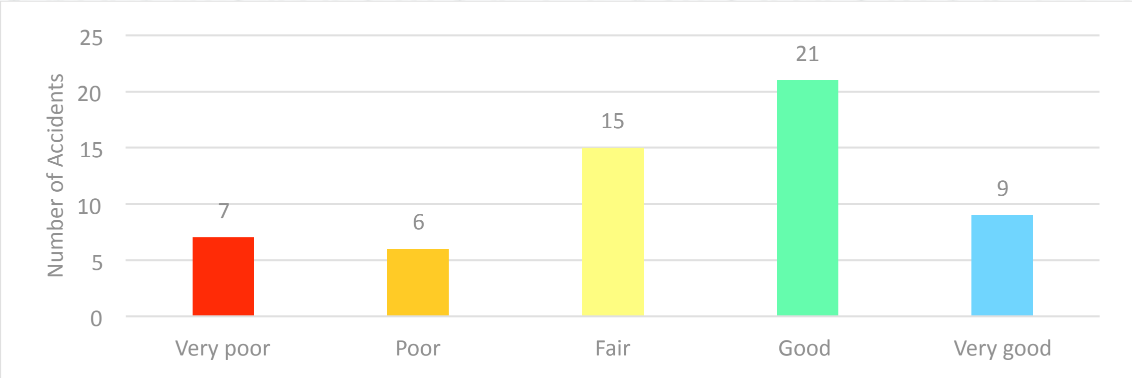

Fig 19. The Precision of Immediate Causes

Fig. 19 indicates that 9 of the accidents' immediate causes are determined precisely according to the collected information. 21 of the incidents are good, 15 are fair, 6 are poor and 7 are very poor in terms of the determination of immediate causes.

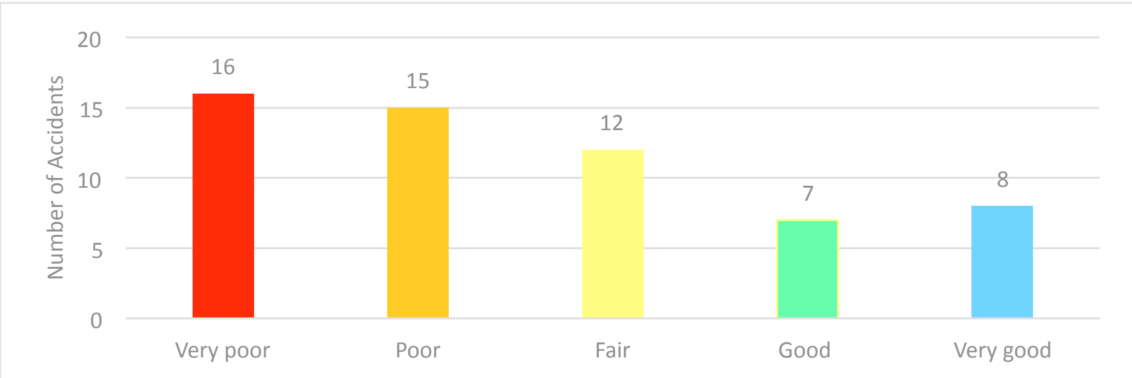

Fig 20. The Precision of Contributing Causes

Fig. 20 indicates that 8 of the accidents' contributing causes are determined precisely according to the collected information. 7 of the incidents are good, 12 are fair, 15 are poor and 16 are very poor in terms of the determination of contributing causes.

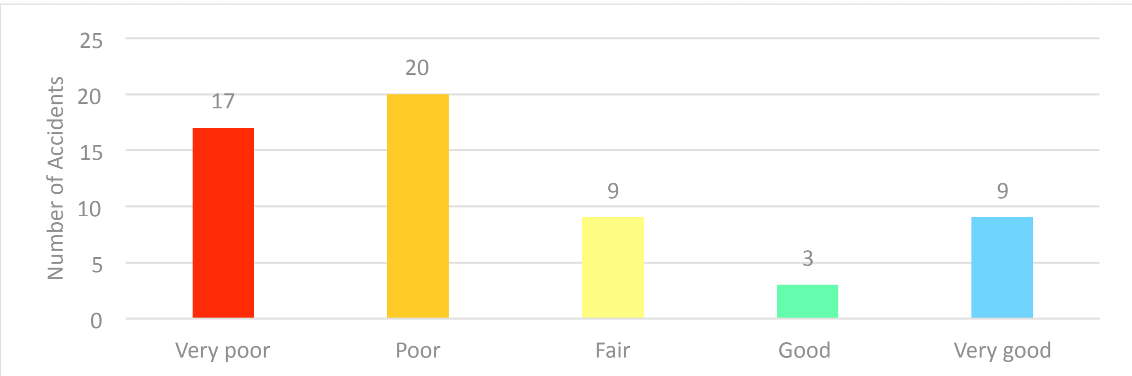

Fig 21. The precision of Root Causes

Fig. 21 indicates that the root causes of 9 accidents were precisely identified, 3 of the root causes are good, 9 are fair, 20 are poor and 17 are very poorly identified.

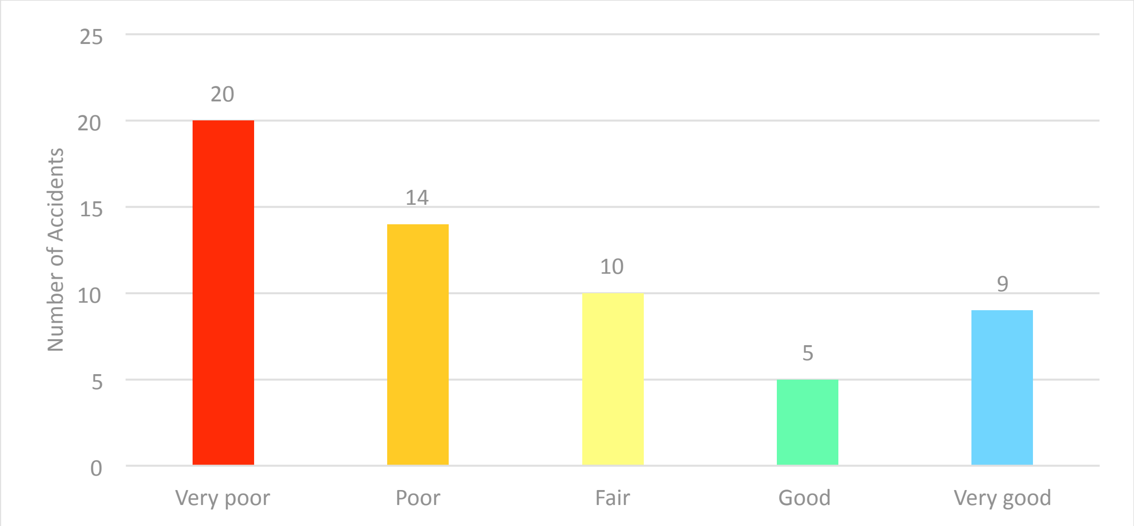

Fig 22. Actions Suggested

A well-performed accident investigation determines the immediate, contributing and root causes precisely and most importantly suggest achievable and realistic actions to prevent the reoccurrence if implemented. Fig. 22 indicates that 9 of the suggested actions are very good, 5 are good, 10 are fair, 14 are poor and 20 are very poor in addressing the problems.

Analysis of all data shows that DSOs are comparably successful in accident investigation and in finding immediate causes. DSOs have an area for improvement in finding contributing causes, root causes and especially for the actions which are usually irrelevant or very weak to prevent reoccurrence of similar incidents. Actions usually suggest training and or awareness-raising activities, which are not specific, measurable, acceptable, realistic or time-bound.

Upon completion of project tasks; data assessment, company presentations, site visits, workshops and detailed accident investigation assessments, the summary of the findings as the specific and most common causes of major and fatal accidents can be summarized as follows:

Immediate Causes:

- Unsafe acts
    - Working without de-energizing the utilities from the correct point
    - Working without lock-out/tag-out
    - Working without grounding
    - Not testing the electricity before the commencement of work
    - Not following the safe work steps
    - Working with defective electric tools
    - No use or improper use of PPE
    - Unavailability of man baskets & lifts
    - Ignoring the single line diagrams before the commencement of work
    - Lack of competency
    - Lone working and insufficient supervision
    - Staying close to energized equipment and lack of sturdy material between worker and a potential blast source

- Unsafe conditions
    - Aged grid and equipment
    - Improper repair and breeches in previous works
    - Defective test devices
    - Incorrect single line diagrams
    - Insufficient means of communication
    - Back feeding from the residential/commercial type diesel generators

Contributing Causes:

- Stress due to workload
- Economic conditions and job insecurity of workers
- High turnover rates
- Ineffective training of workers and H&S experts
- Poor risk assessments
- Insufficient pre-work procedures
- Poor information methods on practical safe work procedures
- Inconsistent selection and use of existing electrical grid elements
- Shortcuts in repair works
- Lack of disciplinary actions or unwillingness to use disciplinary tools
- Poor contractor selection criteria
- Fatigue due to overload
- Lack of vocational knowledge
- Low-risk perception
- Poor engineering
- Poor communication between shifts
- Poor registry of previous failures
- Improper work planning
- Ineffective safety target setting & follow up
- One pole fed by multiple substations

Root Causes:

- Poor leadership
- Underestimated mid-level safety ownership
- Lack of vocational knowledge at mid-level management level on site
- Wrong or ineffective communication
- Poor risk management and inefficient use of specific risk assessments
- Poor contractor management
- Weak accountability at upper management level
- Poor design
- Poor change management practices

Road Map for a Safety Improvement Plan

The main outcome of the study is an applicable safety improvement plan (SIP) which is a recommended guideline for the use of DSOs to prevent reoccurrence of major and fatal accidents in EDS.

In order to implement any improvement plan, target setting is a requisite for performance measurement. Target setting should be prioritized to reengage DSOs safety vision, direction, and safety approach. Among 21 DSOs, 12 companies only have accident-related targets such as zero fatality, reduction in LTI and incident rate. Only five of the DSOs have quantitative, measurable, proactive targets with a specified method of follow up. For the rest of DSOs, the targets are mainly reactive, responsibilities and accountabilities are undefined. Therefore, follow up is not possible.

The suggested SIP roadmap and key recommendations to implement the SIP for the EDS is as follows:

OHS Performance Management

Manage safety performance by setting specific, measurable, acceptable, realistic and time-bound targets

OHS Management and Organization

Review and solicit input for safety direction, guiding principles, and overall safety improvement plan
Analyse safety culture
Encourage safety climate development programs such as reward and recognition
Collaborate with stakeholders to improve safety
Discuss enhancement of bonus program offered by EMRA
Define a simple set of company rules, communicate and implement with zero tolerance

Visible Leadership

Top and mid-level management to drive stronger accountability, compliance and expectation setting through visible leadership

Safety Training Development

Develop an OHS Guideline for the Sector
Improve vocational training with more practical safety applications for workers
Identify advanced practical safety induction and refresher training for field workers and safety teams
Ensure hands-on orientation program for new workers for first 6-12 months
Enhance mid management field engagement capabilities such as safety auditing
Engage two-men team leaders in driving risk awareness, problem-solving and operational compliance skills

Contractor Management

Place a contractor accreditation system with safety criteria
Enhance the contractor management process to include selection criteria, effective monitoring, and performance management, implementation of reward and recognition system in order to standardise OHS requirements within the supply chain.
Decrease turnover of contractor workers through better procurement systems/processes
Effective management of labour/OHS related complaints and NCRs

Incident Investigation & Reporting

Focus on critical accidents which repeat and result in major or fatal accidents and raise awareness through sector-wide campaigns focusing on top 5 causes of major and fatal incidents
Develop incident investigation procedure and use a method in investigations
Improve depth of accident investigations and report quality with stronger relation of causality
Encourage incident, near miss and/or unsafe acts reporting including the contractors
Enhance incident investigation abilities through increasing investigators' technical knowledge and competency in accident investigations
Develop a standard format and terminology in the EDS to build an incident dataset to benefit sector-wide lessons learned, share experiences of accidents within the company and the sector
Improve LV accident investigation reports and communicate LV accidents sector-wide

Operational Discipline

Create an inventory of network equipment to plan maintenance and replacement
Prioritize preventive maintenance
Define a method to improve safety in simultaneous operations
Implement sectoral best practices such as online streaming and confirmation, a work permit system enabling simultaneous video streaming
Improve communication between field workers and operation centers
Avoid overtime working including the contractors
Ensure supervision and monitoring for high-risk tasks including contractors, enhance site supervisors qualitative and quantitatively
Ensure that teams are trained and equipped with required test devices, protective equipment and PPE
Ensure single line diagrams are kept up to date
Develop and use daily checklists to control man lifts and baskets

OHS Risk Management

Develop case-specific guidelines referring to lessons learned from previous incidents
Create job-specific risk assessments using lessons learned from previous incidents

Conclusions

The safety related problems can be overcome by the contribution of all stakeholders in the sector. Policy makers and regulatory governmental agencies have an important role in improving overall safety in EDS. Thus, improving the collaboration between these agencies, private sector and non-governmental organizations will activate more effort to increase OHS conditions in the sector.

Learning from incidents not only helps to prevent similar incidents but also improve overall safety performance. Without a proper investigation, it is not possible to coherently and consistently analyse the causes and suggest actions. Furthermore, without a common terminology and classification, it is not possible to analyse the data of the whole sector.

Analysis of incident data has covered the different causations for specific accidents in the EDS of Turkey. The results initially show that the incident reporting in the EDS needs an immediate improvement with better transparency including the contractors. Statistical analysis of the incident causation patterns indicates that fighting against occupational accidents in the EDS is easy since the direct causes of incidents are common, but as much difficult due to the uniqueness of each case.

Electrical arc, falling from a height, motor vehicle accidents, electrical shocks, struck by/against materials and caught between objects are the main common direct causes of major and fatal accidents. Therefore, developing an OHS Guideline for the sector including an accident investigation procedure and improvement of investigation quality with an accepted method and well-defined relation of causality possess great importance to prevent reoccurrences. The competency of investigation teams with different backgrounds should primarily be increased to understand and agree on useful conclusions. The training of accident investigation teams is one of the immediate actions to deepen accident investigations, to strengthen injuries and to suggest solid corrective actions. Some cultural effects that may cause the occurrence of the incidents that have been identified could be minimised by these training programs. To imitate the safety behaviour of the elderly or more experienced co-worker is an example of this kind of cultural effect. Underestimating the low voltage electrical risks is another behavioural effect that can be decreased by education.

Unless a common incident investigation system is adopted, the identification and learning can be difficult as far as each DSO uses different criteria in the accident reports. In order to benefit the sector-wide experience, a well-established sectoral database with common terminology and classification is a necessity. Also sharing the experience to improve safety specialists' knowledge proactively supports the betterment of job-specific risk assessments and development of safe working practices.

Due to the fact that the contractors' incident reporting and overall safety performance is not at an expected level, DSOs' contractor management system needs to be improved with an accreditation system including the selection criteria, incentives, performance assessment and site monitoring evaluations.

Eventually, the labour-intensive work is conducted in the field. The skills, knowledge and the observance of the field workers determine the overall safety performance. Mandatory OHS training and vocational training is far from meeting the job-specific training needs. Therefore, elongated work orientation and more effective practical training based on real incident scenarios are strongly suggested to improve the EDS's safety performance.

Annex Detailed Assessment of Investigation Reports with Maturity Model

Table A1: Detailed Assessment of 58 Accidents Investigation Reports with Maturity Model

FATALITY #1	Very poor	Poor	Fair	Good	Very good
Accident investigation					x
Immediate causes					x
Contributing causes					x
Root causes					x
Actions					x
FATALITY #2	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes	X				
Contributing causes	X				
Root causes	x				
Actions	x				
FATALITY #3	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes			x		
Contributing causes			x		
Root causes		x			
Actions			x		
FATALITY #4	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes				x	
Contributing causes			x		
Root causes	x				
Actions	x				
FATALITY #5	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes			x		
Contributing causes		x			
Root causes				x	
Actions				x	
FATALITY #6	Very poor	Poor	Fair	Good	Very good
Accident investigation					x
Immediate causes					x
Contributing causes					x
Root causes					x
Actions					x

FATALITY #7	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes			x		
Contributing causes		x			
Root causes		x			
Actions	x				
FATALITY #8	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes			x		
Contributing causes	x				
Root causes	x				
Actions	x				
FATALITY #9	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes				x	
Contributing causes	x				
Root causes		x			
Actions			x		
FATALITY #10	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes				x	
Contributing causes	x				
Root causes	x				
Actions			x		
FATALITY #11	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes				x	
Contributing causes				x	
Root causes				x	
Actions				x	
FATALITY #12	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes				x	
Contributing causes			x		
Root causes			x		
Actions		x			

FATALITY #13	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes				x	
Contributing causes			x		
Root causes			x		
Actions		x			
FATALITY #14	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes	x				
Contributing causes	x				
Root causes	x				
Actions	x				
FATALITY #15	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes			x		
Contributing causes		x			
Root causes			x		
Actions			x		
FATALITY #16	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes			x		
Contributing causes		x			
Root causes			x		
Actions				x	
FATALITY #17	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes			x		
Contributing causes		x			
Root causes		x			
Actions	x				
FATALITY #18	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes	x				
Contributing causes	x				
Root causes	x				
Actions	x				

FATALITY #19	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes	x				
Contributing causes	x				
Root causes	x				
Actions		x			
FATALITY #20	Very poor	Poor	Fair	Good	Very good
Accident investigation					x
Immediate causes					x
Contributing causes	x				
Root causes					x
Actions					x
FATALITY #21	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes			x		
Contributing causes		x			
Root causes		x			
Actions		x			
FATALITY #22	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes		x			
Contributing causes	x				
Root causes	x				
Actions	x				
FATALITY #23	Very poor	Poor	Fair	Good	Very good
Accident investigation					x
Immediate causes					x
Contributing causes					x
Root causes					x
Actions					x
FATALITY #24	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes			x		
Contributing causes			x		
Root causes		x			
Actions		x			

FATALITY #25	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes			x		
Contributing causes			x		
Root causes	x				
Actions		x			

FATALITY #26	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes				x	
Contributing causes			x		
Root causes			x		
Actions			x		

FATALITY #27	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes		x			
Contributing causes		x			
Root causes		x			
Actions		x			

FATALITY #28	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes	x				
Contributing causes	x				
Root causes	x				
Actions	x				

FATALITY #29	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes				x	
Contributing causes		x			
Root causes			x		
Actions			x		

FATALITY #30	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes				x	
Contributing causes				x	
Root causes		x			
Actions			x		

FATALITY #31	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes				x	
Contributing causes		x			
Root causes		x			
Actions	x				
FATALITY #32	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes		x			
Contributing causes		x			
Root causes		x			
Actions	x				
FATALITY #33	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes				x	
Contributing causes				x	
Root causes		x			
Actions		x			
FATALITY #34	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes				x	
Contributing causes	x				
Root causes		x			
Actions		x			
FATALITY #35	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes				x	
Contributing causes	x				
Root causes	x				
Actions	x				
FATALITY #36	Very poor	Poor	Fair	Good	Very good
Accident investigation					x
Immediate causes					x
Contributing causes					x
Root causes					x
Actions					x

FATALITY #37	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes				x	
Contributing causes	x				
Root causes		x			
Actions	x				

FATALITY #38	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes		x			
Contributing causes			x		
Root causes			x		
Actions		x			

FATALITY #39	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes				x	
Contributing causes			x		
Root causes			x		
Actions				x	

FATALITY #40	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes			x		
Contributing causes			x		
Root causes		x			
Actions			x		

FATALITY #41	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes	x				
Contributing causes	x				
Root causes	x				
Actions	x				

FATALITY #42	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes				x	
Contributing causes		x			
Root causes			x		
Actions			x		

FATALITY #43	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes				x	
Contributing causes		x			
Root causes		x			
Actions		x			
FATALITY #44	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes	x				
Contributing causes	x				
Root causes	x				
Actions	x				
FATALITY #45	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes			x		
Contributing causes	x				
Root causes		x			
Actions			x		
FATALITY #46	Very poor	Poor	Fair	Good	Very good
Accident investigation					x
Immediate causes					x
Contributing causes					x
Root causes					x
Actions					x
FATALITY #47	Very poor	Poor	Fair	Good	Very good
Accident investigation					x
Immediate causes					x
Contributing causes					x
Root causes					x
Actions					x
FATALITY #48	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes			x		
Contributing causes		x			
Root causes	x				
Actions	x				

FATALITY #49	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes		x			
Contributing causes				x	
Root causes		x			
Actions	x				
FATALITY #50	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes			x		
Contributing causes			x		
Root causes		x			
Actions	x				
FATALITY #51	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes				x	
Contributing causes		x			
Root causes		x			
Actions		x			
FATALITY #52	Very poor	Poor	Fair	Good	Very good
Accident investigation		x			
Immediate causes		x			
Contributing causes		x			
Root causes	x				
Actions	x				
FATALITY #53	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes				x	
Contributing causes				x	
Root causes		x			
Actions		x			
FATALITY #54	Very poor	Poor	Fair	Good	Very good
Accident investigation					x
Immediate causes					x
Contributing causes					x
Root causes					x
Actions					x

FATALITY #55	Very poor	Poor	Fair	Good	Very good
Accident investigation				x	
Immediate causes				x	
Contributing causes				x	
Root causes	x				
Actions	x				
FATALITY #56	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes				x	
Contributing causes				x	
Root causes				x	
Actions				x	
FATALITY #57	Very poor	Poor	Fair	Good	Very good
Accident investigation					x
Immediate causes					x
Contributing causes					x
Root causes					x
Actions					x
FATALITY #58	Very poor	Poor	Fair	Good	Very good
Accident investigation			x		
Immediate causes			x		
Contributing causes			x		
Root causes	x				
Actions		x			

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