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Assessing Occupational Safety Performance in the European Energy Sector: Analysis of Accident Trends and ESG Safety Reporting Challenges

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Abstract

Occupational safety has become an increasingly important component of Environmental, Social, and Governance (ESG) reporting as stakeholders, investors, and regulatory institutions place greater emphasis on corporate social performance. Within the European utility sector, occupational safety information is commonly disclosed in sustainability and ESG reports; however, considerable differences remain in reporting methodologies, indicator definitions, normalisation bases, contractor inclusion practices, and disclosure transparency. These methodological differences create significant challenges for the interpretation and comparability of occupational safety performance across organisations.

This study investigates occupational safety reporting practices within the European utility sector through a qualitative comparative research design. The research combines an analysis of occupational accident trends in Europe between 2019 and 2023 using Eurostat statistics with a directed qualitative content analysis of occupational safety disclosures published by six major European utility companies. Particular attention is given to commonly reported occupational safety indicators, including fatal and non-fatal accident rates, Lost Time Injury Frequency Rate (LTIFR), Total Recordable Injury Frequency Rate (TRIFR), Injury Rate (IR), contractor-related safety reporting, and occupational safety management practices.

Rather than establishing direct quantitative rankings, the study examines how occupational safety performance is defined, measured, and communicated within ESG and sustainability reporting frameworks. The comparative analysis evaluates reporting transparency, methodological consistency, calculation methods, reporting boundaries, operational scope, and contractor inclusion practices to assess the extent to which occupational safety information supports meaningful comparison between organisations.

The findings demonstrate that substantial methodological differences exist not only between companies but, in some cases, also within the same organisation over time. Variations in key performance indicators, normalisation bases, reporting boundaries, and contractor reporting practices significantly influence the interpretation and comparability of occupational safety performance. The study further shows that high ESG ratings do not necessarily correspond to greater methodological transparency in occupational safety reporting. Overall, the research highlights the importance of greater methodological harmonisation within ESG reporting frameworks and provides practical recommendations for improving the transparency, consistency, and comparability of occupational safety disclosures across the European utility sector.

Keywords: Occupational Safety, ESG Reporting, Sustainability Reporting, Utility Sector, Occupational Accidents, LTIFR, TRIFR, Eurostat, Safety Disclosure, European Energy Sector.

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Chapter 1

Introduction

1.1 Occupational Safety and Industrial Risks

Occupational safety is considered one of the fundamental components of sustainable industrial development and worker protection. Every year, millions of occupational accidents and work-related diseases occur worldwide, resulting in severe social, economic, and human consequences. According to the International Labour Organization (ILO), occupational accidents and illnesses continue to represent a major global challenge despite advances in technology, industrial automation, and safety management systems [1]. In addition to human suffering and fatalities, occupational accidents also generate substantial economic costs through productivity losses, compensation expenses, operational disruptions, and reputational damage for organizations [2].

Industrial sectors such as manufacturing, construction, mining, transportation, and energy are generally associated with higher occupational risks due to the presence of hazardous machinery, high-energy processes, chemical exposure, confined spaces, electrical systems, and complex operational activities. Workers operating within these environments are often exposed to multiple hazards simultaneously, increasing the probability of injuries and fatal accidents [3, 4]. Consequently, governments and international organizations have progressively strengthened occupational health and safety regulations in order to reduce accident frequency and improve workplace conditions.

Over the last decades, occupational safety management has evolved from reactive approaches toward more preventive and risk-based strategies. Traditional safety practices mainly focused on responding to accidents after their occurrence, whereas modern occupational safety systems emphasize hazard identification, risk assessment, accident prevention, worker training, and continuous monitoring of safety performance indicators [5, 6]. International standards such as ISO 45001

have further encouraged companies to integrate occupational health and safety management into broader organizational and sustainability strategies.

Despite these improvements, occupational accidents remain a persistent issue in many industrial sectors. Statistical reports published by Eurostat indicate that thousands of fatal and non-fatal occupational accidents are still recorded annually across European countries [7]. Although several European nations have shown improvements in workplace safety performance over time, accident rates continue to vary significantly between sectors and countries due to differences in industrial structure, national regulations, workforce composition, safety culture, and reporting methodologies [8, 7].

Among industrial sectors, the energy sector presents unique occupational safety challenges. Energy-related activities frequently involve high-risk operations such as electricity generation and distribution, maintenance of large infrastructures, offshore activities, high-pressure systems, thermal processes, and contractor-intensive operations. In addition, the transition toward renewable energy systems has introduced new operational environments and technologies that may create emerging occupational risks [9, 10]. As a result, occupational safety has become an increasingly important issue within the energy sector, particularly for large multinational utility companies operating across multiple countries and regulatory frameworks.

In response to growing societal expectations and regulatory pressure, occupational safety is increasingly recognized not only as a legal obligation but also as a strategic component of corporate responsibility and sustainability performance. Investors, stakeholders, and regulatory institutions now pay greater attention to occupational safety indicators when evaluating company performance and long-term sustainability strategies [11, 8]. Consequently, occupational safety reporting has become more integrated within broader Environmental, Social, and Governance (ESG) frameworks and sustainability reporting practices.

For these reasons, understanding occupational accident trends and evaluating occupational safety reporting practices have become increasingly relevant within industrial and energy-sector research. Analysing how companies and countries report and manage occupational safety performance can provide important insights into current safety challenges, reporting limitations, and future opportunities for improving workplace safety transparency and sustainability practices.

1.2 Occupational Accidents in the Energy Sector

The energy sector is widely recognized as one of the most complex and high-risk industrial sectors due to the nature of its operational activities, large-scale infrastructures, and hazardous working environments. Energy production, transmission, and distribution activities often involve exposure to electrical hazards, high-pressure

systems, thermal processes, heavy machinery, offshore operations, confined spaces, and chemical substances. These conditions increase the probability of occupational accidents and require advanced safety management systems to minimize operational risks [9, 2].

In particular, utility companies operating within the electricity and energy sector face continuous occupational safety challenges associated with maintenance activities, infrastructure inspection, field operations, and contractor-based work. Many operational tasks are performed under hazardous environmental conditions, including work at heights, live electrical systems, underground facilities, and extreme weather conditions. As a result, occupational safety management has become a strategic priority for major European utility companies [4, 7].

Occupational accidents in the energy sector can generally be classified into fatal and non-fatal incidents. Fatal occupational accidents refer to accidents resulting in worker deaths, while non-fatal accidents include injuries causing temporary or permanent absence from work. Both indicators are commonly used to evaluate workplace safety performance and are frequently reported by governmental institutions and companies through occupational safety statistics and sustainability reports [12, 8].

According to Eurostat statistics, accident rates in the European energy sector vary considerably among countries and across different years. Several factors may influence these variations, including national safety regulations, workforce size, technological development, maintenance practices, contractor management, safety culture, and reporting methodologies [7]. Recent studies have suggested that occupational accident trends in the energy sector are increasingly influenced by infrastructure modernization, renewable energy integration, and outsourcing intensity within utility operations [13, 14]. In some countries, accident rates have gradually decreased due to improvements in occupational safety policies and technological modernization, whereas other countries continue to report relatively higher accident levels within energy-related activities.

An additional challenge in the energy sector is the extensive use of subcontractors and external workers. Large utility companies frequently outsource maintenance, engineering, construction, and operational services to contractors. However, contractor-related occupational accidents are not always reported consistently across companies. Some organizations include subcontractors within their official safety indicators, while others report only internal employee accidents. This creates difficulties when comparing occupational safety performance between companies and countries [15, 12].

The transition toward renewable energy systems and decarbonization strategies has also introduced new occupational safety considerations. Renewable energy infrastructures such as wind farms, solar installations, battery systems, and smart grids require new technical competencies and operational procedures. Although

renewable energy systems are generally associated with environmental benefits, they may still involve occupational hazards related to installation, maintenance, electrical exposure, and field operations [10, 9].

Because of these factors, analysing occupational accident trends within the energy sector provides valuable insight into the effectiveness of current safety practices and reporting systems. Understanding how accident rates evolve over time can help identify sector-specific challenges, evaluate occupational safety priorities, and support the development of more transparent and comparable safety reporting practices within the European energy industry.

1.3 Sustainability and ESG Reporting

Sustainability is commonly defined as the ability to satisfy present needs without compromising the ability of future generations to satisfy their own needs. Within the corporate context, sustainability extends beyond financial performance and includes environmental protection, social responsibility, and sound governance practices. To assess and communicate sustainability performance, companies increasingly adopt Environmental, Social and Governance (ESG) frameworks, which provide a structured approach for evaluating non-financial performance.[12, 8].The Environmental pillar focuses on issues such as climate change, emissions, resource use, and waste management. The Social pillar addresses topics related to employees, health and safety, diversity, labour practices, and community engagement. The Governance pillar concerns corporate leadership, business ethics, risk management, compliance, and organizational oversight. ESG reports have therefore become an important tool for communicating sustainability performance to investors, regulators, and other stakeholders.[12, 16, 8].

Due to increasing regulatory pressure and stakeholder expectations, sustainability reporting practices have become progressively more standardized worldwide. International reporting frameworks such as the Global Reporting Initiative (GRI), Sustainability Accounting Standards Board (SASB), and ESG rating methodologies developed by organizations such as MSCI are widely used to evaluate and communicate sustainability performance [12, 16, 11]. In Europe, recent regulations including the Corporate Sustainability Reporting Directive (CSRD) have further strengthened requirements related to non-financial disclosure and sustainability transparency [8].

In the energy and utility sector, ESG reporting has become particularly important due to the strategic role of the energy transition, public attention toward sustainability issues, and increasing regulatory expectations. Major European utility companies now publish annual sustainability reports alongside financial

disclosures, providing detailed information regarding environmental targets, renewable energy investments, occupational safety management systems, and governance strategies [9, 11]. Occupational safety performance is often presented as evidence of corporate social responsibility and long-term sustainability commitment.

For these reasons, sustainability and ESG reports should not be interpreted solely as quantitative performance measurements. Instead, they provide valuable insights into how companies communicate occupational safety priorities, transparency practices, contractor management approaches, and long-term safety commitments within broader sustainability strategies. Therefore, a comparative assessment of occupational safety reporting practices can contribute to a better understanding of current reporting approaches and comparability challenges within the European utility sector. These developments have also increased academic and industrial attention toward the role of occupational safety indicators within ESG frameworks, particularly within high-risk sectors such as the energy industry.

1.4 Occupational Safety within ESG Frameworks

In recent years, occupational safety has become an increasingly important component of ESG and sustainability reporting frameworks. Within ESG structures, occupational health and safety indicators are generally included under the Social pillar, reflecting growing stakeholder attention toward employee well-being, workplace safety, and corporate social responsibility practices [12, 17].

The growing importance of ESG investing has significantly increased stakeholder attention toward non-financial performance indicators and sustainability disclosure quality [18, 19]. Investors, regulatory institutions, rating agencies, and financial markets increasingly evaluate companies not only based on profitability but also according to social responsibility and sustainability-related risk management practices.

As a result, occupational safety indicators such as Lost Time Injury Frequency Rate (LTIFR), Total Recordable Injury Rate (TRIR), work-related fatalities, contractor safety performance, and occupational health initiatives are now commonly disclosed within sustainability and ESG reports [12, 15, 20]. Several international frameworks have contributed to the expansion and partial standardization of sustainability reporting practices. In particular, GRI 403 specifically addresses occupational health and safety reporting, encouraging organizations to disclose information related to safety management systems, hazard identification, occupational health services, worker participation, and safety performance indicators [12].

In Europe, sustainability reporting requirements have become progressively stricter due to increasing regulatory pressure and stakeholder expectations. Recent

regulations such as the Corporate Sustainability Reporting Directive (CSRD) aim to improve transparency, comparability, and consistency in ESG-related disclosures across European companies [21]. These regulatory developments have encouraged major European utility companies to publish more detailed sustainability reports, often integrating occupational safety performance into broader corporate sustainability strategies.

Recent studies have also emphasized that sustainability reporting may involve impression management strategies, where organizations selectively highlight positive sustainability achievements while minimizing operational weaknesses and negative performance indicators [22]. Therefore, careful assessment of sustainability disclosures becomes particularly important when evaluating how occupational safety information is represented and communicated within ESG frameworks.

For these reasons, this study adopts a comparative assessment approach to analyse occupational safety reporting practices among selected European utility companies. Rather than attempting to establish direct causal relationships between ESG scores and occupational accident rates, the research focuses on evaluating reporting approaches, transparency levels, methodological differences, contractor inclusion practices, and the overall representation of occupational safety within corporate sustainability and ESG reporting frameworks.

1.5 Fatal and Non-Fatal Occupational Accidents

Occupational accidents remain one of the most widely used indicators for evaluating workplace safety performance across industries [1, 7]. Occupational accidents are generally classified into two main categories: fatal accidents and non-fatal accidents.

Fatal occupational accidents refer to work-related incidents that result in the death of a worker as a consequence of occupational activities or workplace exposure [1, 7]. Although less frequent than non-fatal incidents, fatal accidents represent the most severe outcome of occupational safety failures and are commonly used as key indicators of workplace risk and safety performance.

Non-fatal occupational accidents include work-related incidents that cause injury or illness without resulting in death [7]. These incidents may range from minor injuries requiring medical treatment to severe cases leading to long-term disability or extended absence from work. Because non-fatal accidents occur more frequently, they often provide a broader representation of workplace safety conditions and operational risks.

The consequences of occupational accidents extend beyond individual workers. Fatal and non-fatal incidents may generate substantial economic costs, productivity losses, operational disruptions, legal liabilities, and social impacts for organizations and society [23, 1]. For this reason, occupational accident indicators are

widely monitored by regulatory authorities, occupational safety institutions, and international organizations.

Within ESG and sustainability reporting frameworks, occupational accident indicators have become increasingly important components of the Social dimension, providing stakeholders with information regarding employee protection, safety management effectiveness, and organizational commitment to responsible business practices [12, 21].

1.6 Challenges in Occupational Safety Data Comparability

Although occupational safety indicators are increasingly disclosed within sustainability and ESG reports, substantial challenges remain regarding the comparability, consistency, and interpretation of reported safety data across companies and sectors. In recent years, several researchers have emphasized that ESG-related datasets frequently suffer from methodological inconsistencies, incomplete standardization, and significant divergence between reporting frameworks and rating agencies [24, 25, 18]. These limitations become particularly relevant when analysing occupational safety indicators within high-risk industries such as the energy sector.

One of the primary challenges concerns the lack of standardized definitions for occupational safety indicators. Companies often report different metrics such as Lost Time Injury Frequency Rate (LTIFR), Total Recordable Injury Rate (TRIR), Injury Rate (IR), or Total Injury Frequency Rate (TIFR). Even when companies use similar terminology, calculation methodologies may differ substantially [12, 15]. Some organizations calculate injury rates based on one million working hours, while others apply alternative normalization approaches or workforce-based calculations. Consequently, direct numerical comparison between companies may lead to misleading interpretations.

Another important limitation relates to reporting boundaries and workforce inclusion practices. Large utility and energy companies frequently rely on contractors and subcontractors for engineering, maintenance, operational, and construction activities. However, contractor-related incidents are not always included consistently within occupational safety statistics. Some companies report combined employee and contractor accident data, while others disclose only internal employee incidents [15, 20]. In certain cases, contractor data are partially disclosed or reported separately, further complicating cross-company comparisons.

Differences in disclosure transparency also represent a major challenge within ESG-based occupational safety analysis. Previous studies have shown that companies may vary considerably in the level of detail provided within sustainability

reports [19, 26]. While some organizations publish detailed explanations regarding calculation methodologies, reporting scopes, accident categories, and safety management systems, others disclose only limited quantitative indicators without methodological clarification. As a result, interpreting occupational safety performance requires careful contextual evaluation rather than purely numerical assessment.

The divergence between ESG ratings themselves further complicates the interpretation of occupational safety performance. Research by Berg et al. [24] and Christensen et al. [25] demonstrated that ESG rating agencies often produce significantly different evaluations for the same companies due to differences in weighting systems, indicator selection, and methodological assumptions. Consequently, ESG scores may reflect disclosure quality and reporting transparency more strongly than actual operational safety performance.

Another challenge concerns the influence of external operational factors on occupational accident trends. Accident rates may be affected by multiple variables including workforce size, operational complexity, technological modernization, outsourcing practices, national safety regulations, maintenance activities, organizational safety culture, and economic conditions [6, 17]. In the energy sector, additional complexities arise from the transition toward renewable energy systems, infrastructure modernization, and the integration of new operational technologies [9, 10].

Recent literature has also highlighted concerns regarding impression management within sustainability reporting practices. Companies may selectively emphasize positive sustainability achievements while providing limited visibility regarding operational weaknesses or negative performance indicators [22]. Therefore, sustainability reports should not be interpreted solely as objective performance measurements but also as corporate communication tools shaped by strategic disclosure practices.

These limitations demonstrate that occupational safety indicators disclosed within ESG frameworks should be interpreted cautiously, particularly when comparing companies operating across different regulatory and operational environments. Consequently, a comparative evaluation of occupational safety indicators and reporting practices may provide more meaningful insights into reporting transparency, methodological consistency, and disclosure practices within the European utility sector.

1.7 Research Gap

Despite the rapid expansion of ESG reporting and sustainability disclosure practices, important limitations remain regarding the representation and evaluation of occupational safety performance within corporate ESG frameworks. Recent

literature has increasingly emphasized that ESG-related datasets often suffer from methodological inconsistencies, fragmented reporting structures, limited comparability, and substantial divergence between rating agencies [24, 25, 18]. Although ESG disclosure practices have expanded considerably in recent years, occupational safety indicators remain less standardized and less extensively analysed compared to environmental sustainability metrics [24, 25, 18, 26, 19].

Previous studies have primarily focused on the relationship between ESG performance and financial outcomes, corporate reputation, environmental disclosure, and governance practices [27, 28, 29]. While some research has examined occupational health and safety within broader sustainability frameworks, comparatively limited attention has been given to how occupational safety performance is represented and communicated within ESG reporting practices of major European utility companies.

Existing literature also demonstrates that occupational safety indicators may differ substantially between organizations due to variations in reporting methodologies, normalization approaches, contractor inclusion practices, and disclosure transparency [15, 12, 20]. Consequently, direct quantitative comparison between companies may produce unreliable or oversimplified interpretations of occupational safety performance. A comparative assessment of reporting practices and disclosure methodologies may therefore provide a more meaningful understanding of occupational safety performance within ESG frameworks.

Another important limitation concerns the coexistence of national occupational accident statistics and company-level ESG disclosures. While institutions such as Eurostat provide sector-level occupational accident statistics, corporate sustainability reports disclose organization-specific indicators using heterogeneous methodologies and reporting boundaries. These differences create important challenges for the interpretation and comparison of occupational safety performance across companies and countries. Consequently, the comparability of occupational safety indicators remains a significant challenge within ESG reporting practices and continues to receive growing attention in the literature.

Recent studies have additionally highlighted concerns regarding disclosure quality, transparency, and impression management within sustainability reporting practices [22, 26, 19]. Companies may selectively emphasize positive sustainability achievements while providing limited contextual explanation regarding operational limitations and occupational safety methodologies. Therefore, comparative analysis of sustainability disclosures has become increasingly important for understanding how occupational safety performance is communicated within ESG frameworks.

To address these limitations, this study investigates occupational accident trends in the European energy sector between 2019 and 2023 and evaluates the comparability of occupational safety indicators reported in ESG and sustainability disclosures of major European energy companies. Particular attention is given to differences in reporting methodologies, indicator definitions, contractor inclusion practices,

disclosure transparency, and reporting boundaries. Rather than ranking companies according to safety performance, the study focuses on identifying challenges that affect the consistency and comparability of occupational safety reporting within ESG frameworks. [24, 25].

1.8 Research Questions

Based on the identified research gaps and challenges related to occupational safety reporting within ESG frameworks, this study aims to address the following research questions:

- How have fatal and non-fatal occupational accident trends evolved in selected European energy-sector countries between 2019 and 2023?
- How do major European utility companies report occupational safety information within ESG and sustainability frameworks?
- What occupational safety indicators are most commonly disclosed by selected utility companies?
- What differences exist in reporting methodologies, contractor inclusion practices, and disclosure transparency between companies?
- What challenges affect the comparability and interpretation of occupational safety indicators within ESG reporting frameworks?
- What recommendations can improve the comparability and transparency of occupational safety reporting within ESG frameworks?

1.9 Aim and Objectives

The main aim of this study is to assess occupational safety performance in the European energy sector by analysing occupational accident trends and evaluating the comparability of occupational safety indicators reported within ESG and sustainability disclosures of major European utility companies.

The study seeks to investigate how occupational safety performance is represented within corporate sustainability frameworks, identify the main indicators used for safety reporting, and examine the methodological and transparency challenges that affect the consistency and comparability of occupational safety information across companies.

To achieve this aim, the following research objectives were defined:

- To analyse fatal and non-fatal occupational accident trends in the European energy sector between 2019 and 2023 using Eurostat statistics;
- To identify and examine occupational safety indicators disclosed within ESG and sustainability reports of selected European utility companies;
- To compare occupational safety reporting methodologies, normalization approaches, and contractor inclusion practices across companies;
- To assess differences in reporting transparency and disclosure quality within ESG frameworks;
- To identify challenges affecting the consistency, interpretation, and comparability of occupational safety indicators;
- To provide a qualitative comparative assessment of occupational safety reporting practices among selected European utility companies.

This study contributes to the growing discussion on ESG transparency and occupational safety disclosure by providing a qualitative comparative assessment of occupational safety reporting practices and highlighting key challenges associated with the comparability of occupational safety indicators within the European energy sector.

The following chapter provides a comprehensive review of recent literature related to occupational safety management, ESG reporting practices, sustainability disclosure frameworks, and methodological challenges associated with the comparability of occupational safety indicators within the European energy sector.

Chapter 2

Literature Review

2.1 Occupational Safety in High-Risk Industries

Occupational safety in high-risk industries has received increasing academic attention due to the complexity of modern industrial operations and the persistence of serious work-related accidents. High-risk sectors such as energy, construction, manufacturing, mining, transport, and process industries are characterized by hazardous technologies, complex infrastructures, dynamic work environments, and exposure to multiple physical, chemical, electrical, and organizational risks [30, 31].

Recent literature emphasizes that occupational safety should not be understood only as the absence of accidents, but as a continuous organizational process involving risk identification, prevention, monitoring, worker participation, and safety culture development [30, 32]. Safety management systems have therefore become central tools for reducing workplace risks, improving organizational learning, and integrating safety into daily operational decision-making.

In high-risk industries, accidents are rarely the result of a single technical failure. Instead, they often emerge from interactions between human factors, organizational decisions, inadequate risk perception, unsafe work conditions, contractor management issues, and weaknesses in safety communication [31, 6]. This perspective highlights the importance of moving beyond purely technical safety controls toward broader organizational and managerial approaches.

Recent studies have also shown that new and emerging occupational risks are reshaping the safety landscape. Digitalization, automation, Industry 4.0 technologies, changing employment patterns, outsourcing, and psychosocial risk factors introduce new challenges for occupational health and safety management [33, 34]. These developments are particularly relevant for energy and utility companies, where technological modernization and the energy transition are changing work processes and risk profiles.

Another important topic in recent occupational safety literature is the role of psychosocial and organizational factors in accident prevention. Derdowski et al. [31] highlight that psychosocial working conditions can influence safety behaviour and safety outcomes in high-risk industries. This suggests that occupational safety performance depends not only on technical controls, but also on workload, communication, leadership, training, and organizational safety climate.

The energy sector represents one of the most safety-critical industries due to its exposure to high-risk activities such as electrical operations, work at heights, offshore activities, heavy equipment operation, and contractor-intensive projects. In addition, the ongoing energy transition introduces new technologies and operational challenges that further increase the importance of effective occupational safety management. For these reasons, occupational safety has become a key concern within the energy sector and deserves specific attention.

Overall, the literature indicates that occupational safety in high-risk industries requires an integrated approach combining technical risk control, organizational learning, safety management systems, worker participation, and transparent reporting practices.

2.2 Occupational Safety Challenges in the Energy Sector

The energy sector is widely recognized as one of the most operationally complex and high-risk industrial sectors. Energy generation, transmission, and distribution activities involve hazardous working environments, high-voltage electrical systems, thermal processes, confined spaces, offshore operations, heavy equipment, and large-scale infrastructures [9, 2]. Consequently, occupational safety management has become a critical component of operational reliability and sustainability within utility and energy companies.

Recent literature has highlighted that occupational risks within the energy sector are strongly influenced by technological complexity, aging infrastructures, contractor-intensive operations, and the increasing integration of renewable energy systems [14, 13]. Utility companies frequently perform maintenance and operational activities under hazardous environmental conditions, including work at heights, electrical exposure, underground operations, and adverse weather conditions. These factors significantly increase the probability of occupational injuries and fatal accidents.

Contractor and subcontractor management remains an important occupational safety challenge within the energy sector. Large utility companies frequently rely on external contractors for maintenance, engineering, and operational activities, which may introduce additional safety management and communication complexities [35,

20].

The transition toward renewable energy systems has also introduced new occupational safety challenges. Although renewable energy technologies are associated with environmental sustainability benefits, they also generate emerging operational risks related to wind turbine maintenance, solar panel installation, battery storage systems, hydrogen technologies, and smart grid infrastructures [10, 36]. In particular, maintenance activities within offshore wind farms and high-capacity battery systems have been identified as growing areas of occupational safety concern.

Another important issue discussed in recent literature is the impact of digitalization and Industry 4.0 technologies on occupational safety within the energy sector. Automation, artificial intelligence, remote monitoring systems, and digital infrastructures may improve operational efficiency and risk monitoring; however, they may also create new forms of technological dependency, human-machine interaction risks, and cybersecurity-related operational challenges [33, 37]. Consequently, occupational safety management systems must continuously adapt to evolving technological and operational conditions.

Several researchers have also emphasized the importance of organizational safety culture within energy-sector companies. Safety performance is influenced not only by technical systems and regulatory compliance, but also by leadership commitment, communication quality, employee participation, training effectiveness, and organizational learning practices [6, 31]. A positive safety culture may contribute significantly to accident prevention and long-term operational resilience within high-risk industries.

Recent accident analyses within the energy sector further indicate that occupational accident trends are affected by multiple contextual factors including workforce composition, infrastructure age, outsourcing intensity, economic pressure, maintenance strategies, and national regulatory systems [13, 14]. As a result, direct comparison of occupational safety performance between countries and companies remains methodologically complex.

In response to increasing societal expectations and sustainability-related pressures, many utility companies have expanded occupational safety disclosure practices within ESG and sustainability reporting frameworks. Nevertheless, substantial differences remain regarding the transparency, consistency, and comparability of safety-related indicators disclosed by organizations [20, 24]. These limitations reinforce the importance of examining the comparability of occupational safety indicators and reporting practices within the European energy sector.

2.3 ESG Reporting and Sustainability Disclosure

Environmental, Social, and Governance (ESG) reporting has become one of the most influential developments in contemporary corporate sustainability management. Over the last decade, investors, regulatory institutions, financial markets, and stakeholders have increasingly demanded greater transparency regarding non-financial corporate performance, sustainability-related risks, and long-term organizational resilience [27, 28]. As a result, ESG disclosure frameworks have evolved into central instruments for evaluating corporate sustainability practices across multiple industrial sectors.

The rapid growth of sustainable finance and ESG investing has significantly accelerated the expansion of sustainability reporting practices worldwide. According to recent literature, ESG-related investment strategies have become increasingly integrated into financial decision-making processes, particularly within environmentally sensitive and high-risk industries such as energy, utilities, transportation, and manufacturing [18, 26]. Consequently, companies are under growing pressure to disclose reliable information regarding environmental performance, governance structures, social responsibility, and occupational safety practices.

Recent academic studies have emphasized that ESG reporting is no longer limited to voluntary corporate social responsibility initiatives, but has progressively evolved into a strategic governance and risk management mechanism [29, 19]. Sustainability disclosure now influences investor confidence, reputational performance, regulatory compliance, and access to sustainable financing opportunities. This transition has increased the importance of disclosure quality, transparency, methodological consistency, and data comparability within ESG frameworks.

Several international reporting frameworks currently guide sustainability disclosure practices. The Global Reporting Initiative (GRI), Sustainability Accounting Standards Board (SASB), Task Force on Climate-related Financial Disclosures (TCFD), and ESG rating methodologies developed by organizations such as MSCI are among the most widely adopted systems used to evaluate corporate sustainability performance [12, 16, 11]. These frameworks encourage companies to disclose information related to environmental impacts, governance practices, social responsibility, labour conditions, occupational health and safety, and sustainability-related risk management.

Within the European Union, sustainability reporting regulations have become progressively stricter in recent years. The introduction of the Corporate Sustainability Reporting Directive (CSRD) represents one of the most important recent developments in ESG disclosure regulation [21]. The CSRD aims to improve the transparency, comparability, reliability, and standardization of sustainability disclosures across European companies. Recent literature suggests that these regulatory developments may significantly reshape ESG reporting practices within European

industries, particularly regarding social and governance-related indicators [38, 39].

Furthermore, emerging literature published between 2024 and 2026 increasingly emphasizes the need for greater harmonization and standardization of ESG disclosures, particularly regarding social indicators and occupational safety reporting [20, 38]. Researchers argue that the growing regulatory complexity and expansion of sustainability frameworks may improve transparency but may also introduce additional reporting challenges for multinational organizations operating across multiple regulatory environments.

Overall, the literature demonstrates that ESG reporting has become a critical component of modern corporate sustainability governance. However, important limitations related to disclosure quality, methodological consistency, transparency, and comparability remain unresolved. These issues are particularly relevant within the European utility sector, where occupational safety performance represents an increasingly important component of sustainability disclosure practices. These developments have contributed to the increasing integration of occupational safety indicators into ESG assessment and sustainability disclosure practices.

2.4 Occupational Safety within ESG Frameworks

In recent years, occupational safety has become an increasingly important component of ESG and sustainability reporting practices. Within ESG frameworks, occupational health and safety indicators are generally positioned under the social dimension, reflecting the growing recognition that employee well-being, workplace safety, and labour protection are essential elements of sustainable corporate performance [12, 18]. Consequently, investors, regulatory institutions, rating agencies, and stakeholders have progressively expanded their attention toward occupational safety disclosure practices within sustainability evaluations.

The integration of occupational safety into ESG frameworks has been strongly influenced by the development of international sustainability reporting standards. Among these frameworks, the Global Reporting Initiative (GRI) has become one of the most influential systems guiding occupational health and safety disclosure practices [12]. In particular, GRI 403 establishes reporting requirements related to occupational health and safety management systems, hazard identification, worker participation, incident reporting, injury rates, occupational illnesses, and preventive safety measures.

Recent literature suggests that occupational safety disclosure has evolved from a compliance-oriented activity into a broader strategic sustainability issue [39, 38]. Companies increasingly recognize that occupational accidents, contractor safety incidents, and inadequate safety management practices may generate not only human and operational consequences but also reputational, financial, and

ESG-related risks. As a result, occupational safety indicators have become increasingly integrated into sustainability governance strategies and ESG performance assessments.

Several ESG rating agencies and sustainability assessment systems now incorporate occupational safety indicators within their social evaluation criteria. Common indicators include the Lost Time Injury Frequency Rate (LTIFR), which measures the number of work-related injuries resulting in lost work time per million hours worked, and the Total Recordable Injury Rate (TRIR), which includes all recordable occupational injuries and illnesses normalized by working hours. Companies also frequently report fatality rates, representing work-related deaths occurring during work-related activities. Additional indicators may include safety training metrics, which measure employee participation in occupational safety programs, employee well-being indicators related to physical and mental health, and contractor safety performance indicators that assess safety outcomes among outsourced workers and subcontractors. These metrics are commonly considered within ESG evaluations because they provide insight into the effectiveness of occupational health and safety management systems. Nevertheless, the weighting and interpretation of occupational safety indicators may vary considerably across rating systems [11, 20].

Recent studies have also highlighted the growing importance of social sustainability indicators within ESG investing strategies [18, 40]. Historically, ESG assessments were often dominated by environmental indicators such as carbon emissions and climate-related disclosure. However, recent regulatory developments and stakeholder expectations have increased the visibility of social indicators including occupational health and safety, diversity, labour rights, and employee well-being.

The European regulatory environment has further accelerated the integration of occupational safety within ESG disclosure practices. The Corporate Sustainability Reporting Directive (CSRD) and related European Sustainability Reporting Standards (ESRS) increasingly encourage companies to provide more transparent and standardized disclosure regarding social sustainability indicators, including occupational safety performance [21, 41]. Recent literature suggests that these regulatory developments may significantly improve reporting comparability and transparency across European industries in the coming years.

Overall, recent literature demonstrates that occupational safety is becoming an increasingly central component of ESG and sustainability reporting frameworks. Nevertheless, important challenges related to indicator comparability, methodological consistency, transparency, and disclosure interpretation remain unresolved. These limitations reinforce the importance of qualitative approaches when evaluating occupational safety disclosure practices within ESG frameworks, particularly within high-risk sectors such as the European utility industry.

2.5 Challenges in ESG Safety Reporting and Occupational Safety Data Comparability

Recent literature increasingly emphasizes that significant challenges remain regarding ESG-related occupational safety reporting across companies and industries. These challenges include differences in reporting scope, indicator definitions, contractor inclusion practices, disclosure transparency, and data comparability. Such issues are particularly relevant in high-risk sectors such as energy and utilities, where operational complexity and heterogeneous reporting practices strongly influence the interpretation of occupational safety performance.

One of the main challenges affecting ESG-based occupational safety assessment concerns the divergence of ESG ratings between rating agencies. Previous studies have demonstrated that ESG scores assigned to the same company may differ significantly depending on the methodology, weighting system, indicator selection, and interpretation framework applied by rating organizations [24, 25]. Berg et al. [24] identified substantial inconsistencies among ESG ratings, arguing that differences in scope, measurement approaches, and weighting methodologies contribute to low comparability between rating systems. Consequently, ESG scores should not be interpreted as fully objective or standardized representations of corporate sustainability performance.

These inconsistencies are also reflected in occupational safety reporting practices. Companies frequently use different occupational safety indicators such as Lost Time Injury Frequency Rate (LTIFR), Total Recordable Injury Rate (TRIR), Total Injury Frequency Rate (TIFR), Injury Rate (IR), or raw Lost Time Injury (LTI) counts [12, 15]. Even when companies disclose similarly named indicators, substantial methodological differences may still exist regarding calculation procedures and normalization approaches. Some organizations calculate injury rates per million working hours, while others use workforce-based normalization methods or alternative reporting formulas. As a result, direct quantitative comparison between companies becomes methodologically problematic. Beyond differences in indicator definitions, reporting boundaries also vary substantially among organizations, creating additional challenges for the interpretation and comparison of occupational safety performance.

Another important issue concerns contractor inclusion within occupational safety statistics. Utility and energy companies frequently outsource maintenance, engineering, operational, and construction activities to contractors and subcontractors. However, contractor-related incidents are not consistently reported across organizations [35, 20]. Some companies include contractor accidents within official safety indicators, whereas others disclose only internal employee incidents. In certain cases, contractor data are reported separately or only partially disclosed,

significantly reducing cross-company comparability.

The heterogeneity of sustainability disclosures further complicates occupational safety analysis. Previous research has shown that companies differ considerably in disclosure transparency, reporting scope, and methodological explanation [19, 26]. While some organizations provide detailed descriptions regarding occupational safety management systems, reporting boundaries, and calculation methodologies, others disclose only limited quantitative indicators with minimal contextual explanation. Consequently, the interpretation of occupational safety performance often requires qualitative assessment rather than purely numerical evaluation.

Recent literature has also emphasized that ESG reporting quality may be influenced by strategic disclosure practices and impression management behaviour [22]. Companies may selectively emphasize positive sustainability achievements while reducing visibility regarding operational limitations or negative safety outcomes. Therefore, sustainability reports should not be interpreted solely as objective performance measurements but also as corporate communication instruments shaped by stakeholder expectations and reputational considerations.

The introduction of new sustainability regulations within the European Union has further highlighted the need for reporting comparability, transparency, and methodological consistency. Regulations such as the Corporate Sustainability Reporting Directive (CSRD) aim to improve consistency and standardization in ESG disclosures across European companies [21]. Nevertheless, recent studies indicate that important differences in reporting practices and disclosure quality still remain, particularly regarding social and occupational safety indicators [18, 19].

Another challenge concerns the interpretation of occupational safety performance itself. Accident rates may be influenced by multiple contextual factors including workforce size, infrastructure age, operational complexity, technological modernization, maintenance intensity, outsourcing practices, organizational safety culture, and national regulatory environments [6, 31]. Consequently, occupational safety performance cannot be fully understood through isolated numerical indicators alone.

Taken together, these challenges demonstrate that occupational safety reporting within ESG frameworks remains characterized by substantial heterogeneity. Differences in reporting scope, indicator definitions, contractor inclusion, transparency levels, and disclosure quality limit the possibility of direct quantitative comparison between companies. Consequently, comparative analysis represents a suitable methodological approach for examining occupational safety reporting practices, as it allows a deeper assessment of reporting transparency, methodological consistency, and the broader representation of occupational safety within corporate sustainability strategies.

Table 2.1: Key Challenges in ESG Safety Reporting and Occupational Safety Data Comparability

Study	Focus Area	Main Findings
Berg et al. (2022)	ESG rating divergence	Significant inconsistencies exist between ESG rating methodologies and evaluation systems.
Christensen et al. (2021)	ESG rating interpretation	ESG evaluations may vary substantially depending on disclosure quality and methodological assumptions.
Kotsantonis and Serafeim (2023)	ESG data limitations	ESG datasets suffer from low comparability and methodological heterogeneity.
Wang and Zhang (2024)	Occupational safety disclosure	Occupational safety reporting in high-risk industries lacks full standardization and transparency.
Albrechtsen et al. (2021)	Contractor safety management	Contractor inclusion practices significantly affect occupational safety reporting consistency.
La Torre and Sabelfeld (2024)	CSRD and ESG transparency	Recent EU regulations aim to improve sustainability reporting comparability and disclosure quality.

2.6 Research Gap in Current Literature

Recent literature has significantly expanded the discussion surrounding ESG reporting, occupational safety management, and sustainability disclosure practices. Numerous studies have investigated ESG rating methodologies, sustainability transparency, safety culture, contractor management, and occupational risk factors within high-risk industries [24, 25, 30, 31]. However, despite the growing body of research, several important gaps remain within the existing literature, particularly regarding the integration of occupational safety analysis within ESG frameworks in the European utility and energy sector.

First, much of the current ESG literature focuses primarily on environmental performance, climate-related disclosure, carbon emissions, green finance, and corporate governance mechanisms, while occupational safety indicators often receive comparatively limited analytical attention [18, 26]. Although the social dimension of ESG has become increasingly important in recent years, occupational accident indicators are still less standardized and less extensively studied than environmental indicators.

Second, previous studies frequently rely on broad ESG datasets or aggregated

sustainability scores without examining the methodological differences underlying occupational safety disclosures [24, 25]. Consequently, important issues such as contractor inclusion practices, LTIFR and TRIR calculation differences, reporting boundaries, and disclosure transparency are often insufficiently explored. This creates a significant gap in understanding how occupational safety performance is actually represented within sustainability reporting practices.

Another important limitation concerns the lack of sector-specific studies on occupational safety reporting within ESG frameworks. Existing research commonly investigates ESG reporting at a general cross-sector level, while relatively few studies focus specifically on utility and energy companies operating within Europe [14, 13]. The energy sector presents unique operational challenges related to high-voltage systems, infrastructure maintenance, contractor-intensive activities, renewable energy technologies, and complex industrial environments. Consequently, sector-specific analysis is necessary to better understand how occupational safety information is reported, disclosed, and interpreted within ESG and sustainability reporting practices in the European energy sector.

Furthermore, many previous studies attempt to establish direct quantitative relationships between ESG scores and safety performance indicators. However, recent literature has increasingly recognized that substantial methodological inconsistencies and disclosure heterogeneity reduce the reliability of direct numerical comparisons between companies [15, 19]. Variations in occupational safety definitions, reporting methodologies, workforce normalization methods, and contractor inclusion practices create significant comparability limitations across organizations.

Another research gap concerns the interpretation of occupational safety performance within sustainability reporting. Existing literature has shown that sustainability reports may also function as strategic communication instruments shaped by stakeholder expectations, reputational concerns, and impression management practices [22]. Nevertheless, limited research has provided a comparative assessment of how utility companies describe, contextualize, and communicate occupational safety performance within ESG frameworks, particularly regarding reporting transparency, methodological consistency, and comparability challenges.

In addition, the recent implementation of European sustainability regulations such as the Corporate Sustainability Reporting Directive (CSRD) has created new expectations regarding disclosure transparency, comparability, and social reporting quality [21]. However, academic research evaluating how occupational safety reporting practices align with these evolving European sustainability frameworks remains limited, particularly for large utility companies.

To address these limitations, the present study provides a comparative assessment of occupational safety reporting practices among selected European utility companies between 2019 and 2023. The study examines how occupational safety indicators are defined, reported, and disclosed within ESG and sustainability

frameworks, with particular attention to reporting comparability, methodological consistency, contractor inclusion practices, transparency, and disclosure challenges.

This research therefore contributes to the existing literature by providing a sector-specific assessment of occupational safety reporting practices within ESG frameworks in the European utility sector. Furthermore, it contributes to the ongoing discussion on the comparability, transparency, and interpretation of ESG-related occupational safety indicators in sustainability reporting.

Chapter 3

Methodology

3.1 Research Design

This research adopts a comparative assessment design to examine occupational safety reporting practices within ESG and sustainability frameworks in the European energy sector. Rather than ranking companies through purely numerical benchmarking, the study focuses on how occupational safety information is reported, disclosed, and interpreted within corporate sustainability communications.

A comparative assessment was considered the most appropriate methodological choice due to the substantial inconsistencies that exist in ESG-related occupational safety reporting. Previous studies have shown that companies frequently apply different reporting boundaries, normalization methods, contractor inclusion approaches, and indicator definitions, making direct numerical comparison difficult and potentially misleading [24, 25, 15, 19]. Consequently, the study emphasizes reporting comparability, methodological consistency, and disclosure practices rather than statistical benchmarking.

The research follows a comparative strategy involving several major European utility companies operating within similar industrial environments. This approach makes it possible to identify recurring reporting patterns, similarities and differences in disclosure practices, and variations in the way occupational safety performance is presented within ESG and sustainability reporting frameworks [30, 31].

The methodological orientation of the study is exploratory. Although ESG reporting and occupational safety disclosure have received increasing academic attention in recent years, limited research has specifically examined occupational safety reporting practices and comparability challenges within the European utility sector [18, 38]. For this reason, the study investigates current reporting approaches, methodological limitations, transparency issues, and challenges affecting the comparability of occupational safety indicators.

The analysis is based on a structured review and comparative assessment of occupational safety disclosures contained in sustainability reports, ESG reports, annual reports, and related corporate publications. Particular attention is given to reporting transparency, methodological explanations, contractor inclusion practices, terminology consistency, and the interpretation of occupational safety indicators within ESG frameworks [20, 26].

Secondary statistical data obtained from Eurostat are additionally used to provide contextual understanding of occupational accident trends within selected European countries [7]. However, these data are not used to establish direct quantitative comparisons between companies. Instead, they provide contextual information that supports the interpretation of occupational safety reporting practices within the broader European energy sector.

Overall, the selected research design provides a structured framework for assessing occupational safety reporting practices while addressing the comparability challenges and methodological limitations identified in recent ESG literature.

3.2 Research Scope and Study Period

The study focuses on occupational safety reporting practices within the European utility and energy sector. More specifically, it examines how selected European utility companies disclose and communicate occupational safety information within ESG and sustainability reporting frameworks during the period between 2019 and 2023.

The European utility sector was selected because of its strategic economic importance, operational complexity, and increasing relevance within sustainability and energy-transition policies [9, 14]. Utility companies operate in high-risk industrial environments involving electricity generation, transmission infrastructure, maintenance activities, field operations, and contractor-intensive work [13, 2]. In recent years, the sector has also undergone significant technological and organizational transformation due to renewable energy integration, digitalization, decarbonization strategies, and evolving sustainability regulations [10, 33]. These developments have increased stakeholder attention toward both sustainability performance and occupational safety management.

Large European utility companies were considered particularly suitable for this research because they generally publish detailed sustainability reports and ESG disclosures on a regular basis [12, 20]. In addition, such organizations are increasingly exposed to regulatory pressure, investor expectations, and public scrutiny regarding transparency and non-financial disclosure practices [21, 39]. As a result, these companies provide relevant case studies for examining the role of occupational safety within ESG communication strategies.

The selected study period covers the years 2019 to 2023. This timeframe was chosen for several reasons. First, ESG reporting practices expanded significantly during these years, particularly within European industries [18, 38]. Second, recent regulatory developments, including the Corporate Sustainability Reporting Directive (CSRD), increased attention toward disclosure transparency and reporting consistency [21]. Finally, the selected period provides sufficient longitudinal coverage to identify reporting trends and methodological developments while remaining focused on contemporary disclosure practices.

The scope of the research includes publicly available sustainability reports, ESG disclosures, annual reports, occupational safety statements, and related corporate publications issued by the selected companies during the study period. Eurostat occupational accident statistics are also incorporated to provide additional context regarding occupational accident trends within selected European countries [7].

The objective of the study is not to establish direct causal relationships between ESG scores and occupational accident performance. Instead, the research focuses on assessing the comparability of occupational safety reporting practices, including reporting transparency, methodological consistency, contractor inclusion practices, and the disclosure of occupational safety indicators within ESG and sustainability reporting frameworks [24, 25].

Overall, the defined research scope allows a focused and context-sensitive examination of occupational safety disclosure practices within the European utility sector while acknowledging the methodological challenges associated with ESG reporting comparability.

3.3 Data Sources

The study relies primarily on secondary qualitative and quantitative data obtained from publicly available institutional and corporate sources. Using multiple data sources allows broader evaluation of occupational safety disclosure practices and supports comparative interpretation of sustainability reporting within the European utility sector [24, 25].

The main body of corporate data consists of sustainability reports, ESG reports, annual reports, occupational health and safety disclosures, and other non-financial reporting documents published by selected European utility companies between 2019 and 2023. These reports provide information regarding occupational safety indicators, safety management systems, contractor inclusion practices, occupational accident statistics, sustainability initiatives, and ESG-related disclosure approaches [12, 20].

Special consideration was given to reports prepared according to internationally recognized sustainability reporting frameworks such as the Global Reporting

Initiative (GRI) and the Sustainability Accounting Standards Board (SASB) [12, 16]. These frameworks offer structured guidance regarding occupational safety disclosure and facilitate comparative evaluation of reporting transparency and methodological consistency across organizations.

In addition to corporate disclosures, institutional statistical data were collected from Eurostat. Eurostat occupational accident statistics were used to provide additional context regarding fatal and non-fatal occupational accident trends within selected European countries and sectors [7]. These data support interpretation of occupational safety reporting practices within the broader European occupational safety environment.

Additional contextual information was obtained from publications issued by organizations and regulatory institutions including the International Labour Organization (ILO), the European Commission, the International Energy Agency (IEA), and occupational safety agencies [1, 8, 9]. These sources contributed to the understanding of sustainability regulations, occupational safety trends, ESG reporting developments, and sector-specific operational risks.

The study additionally incorporates findings from recent academic literature related to occupational safety management, ESG reporting, sustainability disclosure, contractor management, and reporting comparability challenges. Peer-reviewed articles published mainly between 2020 and 2026 were prioritized to ensure inclusion of recent developments and emerging research perspectives [30, 31, 38].

All collected documents were reviewed and comparatively assessed with emphasis placed on disclosure transparency, occupational safety terminology, reporting boundaries, methodological explanations, contractor inclusion practices, and the communication of occupational safety performance within ESG frameworks [19, 26].

Overall, the combination of corporate disclosures, institutional statistics, regulatory publications, and academic literature provides a comprehensive basis for evaluating occupational safety reporting practices within the European utility sector.

3.4 Company Selection Criteria

The companies included in this research were selected through purposive sampling based on their relevance to the research objectives and the availability of occupational safety disclosures. The objective of the selection process was to identify large European utility companies with significant operational relevance, established sustainability reporting practices, and publicly accessible occupational safety disclosures.

The research concentrates on major utility and energy companies operating

within Europe because these organizations are characterized by high-risk industrial activities, complex infrastructures, and contractor-intensive operational environments. Furthermore, large utility companies generally publish relatively detailed ESG reports and sustainability disclosures, making them suitable for comparative qualitative analysis.

Several criteria guided the company selection process. First, companies were required to operate primarily within the utility or energy sector, including activities related to electricity generation, transmission, distribution, or related industrial energy operations. This criterion ensured greater sectoral consistency and improved the relevance of cross-company comparison.

Second, companies were selected according to the availability and continuity of sustainability and ESG disclosures during the study period between 2019 and 2023. Organizations with incomplete reporting coverage or very limited occupational safety disclosure were excluded from the analysis in order to maintain sufficient consistency across the selected sample.

Third, the selection process considered the extent of occupational safety disclosure within corporate reporting documents. Particular focus was placed on companies reporting indicators such as Lost Time Injury Frequency Rate (LTIFR), Total Recordable Injury Rate (TRIR), fatality statistics, contractor-related safety information, occupational health initiatives, and safety management practices.

Another important selection criterion was the availability of different occupational safety reporting approaches among the selected companies. Including organizations with varying disclosure practices increased the diversity of the sample and provided a broader representation of reporting practices within the European utility sector.

The final sample therefore represents a purposive group of European utility companies selected for their relevance to the research objectives rather than for statistical representativeness. The selected companies provide sufficient diversity in reporting practices to support the comparative assessment of occupational safety disclosures within ESG and sustainability reporting frameworks [24, 25].

Overall, the selected companies provide an appropriate basis for examining how occupational safety performance is disclosed and interpreted within ESG and sustainability reporting frameworks across the European utility sector.

3.5 Occupational Safety Indicators and Reporting Aspects Examined

This study examines occupational safety indicators and reporting practices disclosed within sustainability reports, ESG reports, annual reports, and related corporate publications issued by selected European utility companies between 2019 and 2023.

The assessment focuses on both the occupational safety indicators reported by companies and the manner in which these indicators are presented, defined, and explained within ESG and sustainability reporting frameworks. Particular attention is given to the comparability of disclosures, reporting transparency, methodological consistency, and contractor inclusion practices.

Several occupational safety indicators commonly reported in the energy and utility sector were examined. These include the Lost Time Injury Frequency Rate (LTIFR), Total Recordable Injury Rate (TRIR), Total Injury Frequency Rate (TIFR), Injury Rate (IR), fatal occupational accidents, and non-fatal occupational accidents when such information was publicly available. The study also considers the definitions and calculation methods used for these indicators, since differences in reporting methodologies may affect comparability between companies.

Because contractor activities represent a substantial component of operations within the European utility sector, special attention was given to contractor-related safety reporting. The analysis evaluates whether organizations include contractors and subcontractors within official occupational safety statistics, report contractor incidents separately, or provide limited information regarding contractor safety performance.

In addition to numerical indicators, the study examines broader occupational safety disclosures contained in corporate reports. These disclosures include information related to occupational health and safety management systems, employee training programs, hazard identification processes, incident investigation procedures, occupational health initiatives, risk prevention measures, and organizational safety culture. The assessment also considers how occupational safety performance is integrated into wider ESG and sustainability communication strategies.

Furthermore, methodological explanations provided within corporate reports were reviewed, including reporting boundaries, normalization approaches, indicator definitions, disclosure scope, and transparency regarding data collection practices. These aspects are particularly important because previous studies have identified significant differences in occupational safety reporting methodologies and disclosure practices across organizations and ESG frameworks [24, 25, 15].

The objective of the assessment is not to establish rankings or direct performance comparisons between companies. Instead, the study evaluates how occupational safety information is disclosed, contextualized, and communicated, with particular emphasis on reporting transparency, methodological consistency, contractor inclusion, and the comparability of occupational safety indicators.

Overall, the selected indicators and reporting aspects provide a structured basis for assessing occupational safety disclosure practices and identifying challenges related to the comparability of occupational safety information within ESG and sustainability reporting frameworks.

3.6 Comparative Analysis of ESG Safety Indicators and Reporting Practices

The study applies a comparative analytical approach to evaluate occupational safety reporting practices within ESG and sustainability disclosure frameworks among selected European utility companies. This methodological approach was adopted in response to the substantial comparability limitations and methodological inconsistencies identified within ESG-related occupational safety disclosures in recent literature.

Previous studies have demonstrated that occupational safety indicators disclosed within sustainability reports are frequently influenced by differences in reporting methodologies, normalization procedures, contractor inclusion practices, disclosure boundaries, and indicator definitions [24, 25, 15]. As a result, direct numerical benchmarking between companies may produce oversimplified or potentially misleading interpretations of occupational safety performance.

For this reason, the present research emphasizes comparative interpretation rather than purely quantitative benchmarking. The analysis examines how organizations define, contextualize, explain, and communicate occupational safety indicators within ESG and sustainability reporting frameworks. Emphasis was placed on reporting transparency, methodological clarity, contractor inclusion approaches, disclosure consistency, and the broader representation of occupational safety within sustainability communication strategies.

The comparative evaluation was conducted through systematic review of sustainability reports, ESG disclosures, annual reports, and occupational safety statements published by selected companies between 2019 and 2023. Relevant occupational safety information was identified, categorized, and comparatively interpreted according to recurring thematic dimensions observed across the collected documents.

Several qualitative analytical dimensions were considered throughout the evaluation process. These include the type of occupational safety indicators disclosed, reporting transparency, methodological explanation, contractor inclusion practices, terminology consistency, disclosure continuity across reporting years, safety management descriptions, and the integration of occupational safety within ESG communication strategies.

The analysis also considers how companies interpret occupational safety performance within broader sustainability narratives. This includes evaluation of how organizations explain accident trends, describe safety initiatives, communicate organizational safety culture, and present occupational safety performance to stakeholders.

In addition, the study evaluates the extent to which occupational safety disclosures align with internationally recognized sustainability reporting frameworks

such as GRI 403 and other ESG-related disclosure standards. Particular consideration was given to the consistency between reported indicators and accompanying methodological explanations.

The comparative analytical approach adopted in this study does not seek statistical generalization across the entire energy sector. Instead, the objective is to provide deeper contextual understanding of occupational safety disclosure practices, reporting heterogeneity, and methodological comparability challenges within selected European utility companies. This methodological orientation is consistent with exploratory qualitative research emphasizing interpretation, contextual analysis, and comparative understanding rather than purely quantitative measurement [30, 38].

Overall, the selected analytical approach provides an appropriate framework for examining the complexity of occupational safety disclosure practices within ESG reporting while addressing the limitations associated with direct quantitative comparison between companies.

3.7 Limitations of the Study

Several limitations should be considered when interpreting the findings of this research.

The findings of this study are based entirely on publicly available sustainability reports, ESG reports, and related corporate disclosures. Consequently, the analysis reflects reported occupational safety information rather than independently verified operational safety performance. In addition, sustainability reports may partially reflect corporate communication priorities and stakeholder expectations [22, 19].

The selected study period between 2019 and 2023 may also limit the long-term generalizability of the findings. ESG reporting frameworks, sustainability regulations, and occupational safety disclosure practices continue to evolve rapidly, particularly following the introduction of new European sustainability regulations such as the Corporate Sustainability Reporting Directive (CSRD) [21]. As a result, future reporting practices may differ from those examined within the present study.

Furthermore, the research focuses specifically on a selected group of large European utility companies with relatively developed sustainability reporting systems. Therefore, the findings cannot be generalized to all organizations operating within the energy sector, nor to companies operating under different regulatory and geographical contexts.

Finally, the study relies exclusively on document-based analysis and does not include interviews, surveys, or direct engagement with company representatives. Consequently, interpretations are limited to the information disclosed within publicly available reports and cannot fully capture internal reporting processes or

decision-making mechanisms.

Despite these limitations, the study provides valuable insights into occupational safety reporting practices, transparency, and disclosure approaches within ESG frameworks in the European utility sector.

The following chapter presents the qualitative comparative analysis of occupational safety reporting practices among selected European utility companies based on the methodological framework established in this study.

Chapter 4

Results and Discussion

This chapter presents the results of the occupational safety analysis conducted at both sectoral and corporate levels. The analysis is divided into two main parts. First, occupational accident trends in the European energy sector are examined using Eurostat statistics for the period 2019–2023. Both fatal and non-fatal occupational accident rates are analysed in order to identify overall trends and differences among European countries.

For the sector-level analysis, average accident rates were calculated by taking the arithmetic mean of the annual national accident rates for all countries included in the dataset. The calculations were performed using Microsoft Excel based on Eurostat data. This approach was adopted to provide an overall representation of occupational accident trends within the European energy sector while reducing the influence of year-to-year fluctuations observed in individual countries.

The second part of the chapter focuses on occupational safety reporting practices within ESG and sustainability reporting frameworks. Sustainability reports, ESG reports, and related corporate disclosures published by selected European utility companies are analysed and compared. Particular attention is given to occupational safety indicators, reporting transparency, contractor inclusion practices, methodological approaches, and the communication of occupational safety performance within sustainability disclosures.

The objective of this chapter is not only to evaluate accident trends but also to examine how occupational safety performance is represented and interpreted within corporate sustainability reporting. By combining sector-level accident statistics with company-level ESG disclosures, the analysis provides a broader understanding of occupational safety performance and reporting practices within the European utility sector.

The chapter begins with an examination of occupational accident trends across Europe and subsequently presents a comparative analysis of occupational safety reporting practices among selected European utility companies.

4.1 Occupational Accident Trends in the European Energy Sector

4.1.1 Average Non-Fatal Occupational Accident Trends in Europe (2019–2023)

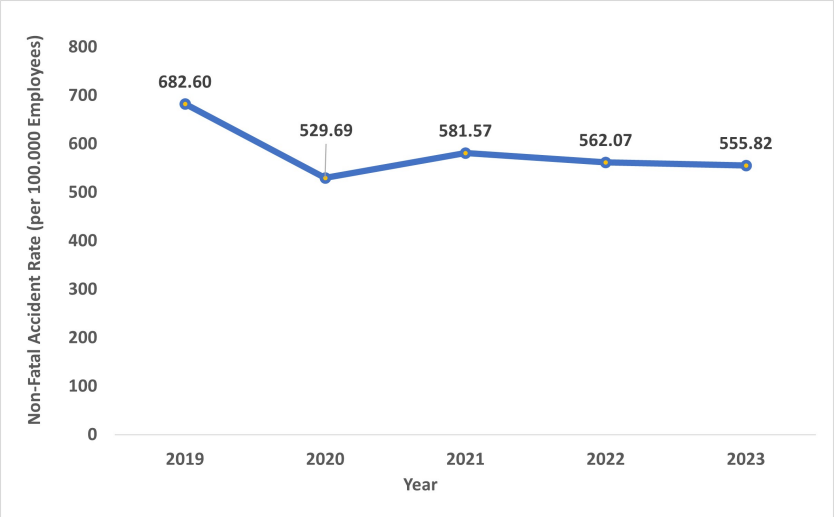

Figure 4.1: Average Non-Fatal Occupational Accident Rate in the European Energy Sector (2019–2023)

Figure 4.1 showed an overall downward trend during the study period. The indicator decreased from 682.6 cases per 100,000 employees in 2019 to 529.69 in 2020, followed by a moderate increase in 2021. During the subsequent years, accident rates remained relatively stable, fluctuating between 562 and 555 cases per 100,000 employees. By 2023, the average rate was approximately 18.6% lower than the level observed at the beginning of the study period.

4.1.2 Comparison of Average Non-Fatal Occupational Accident Rates by Country (2019–2023)

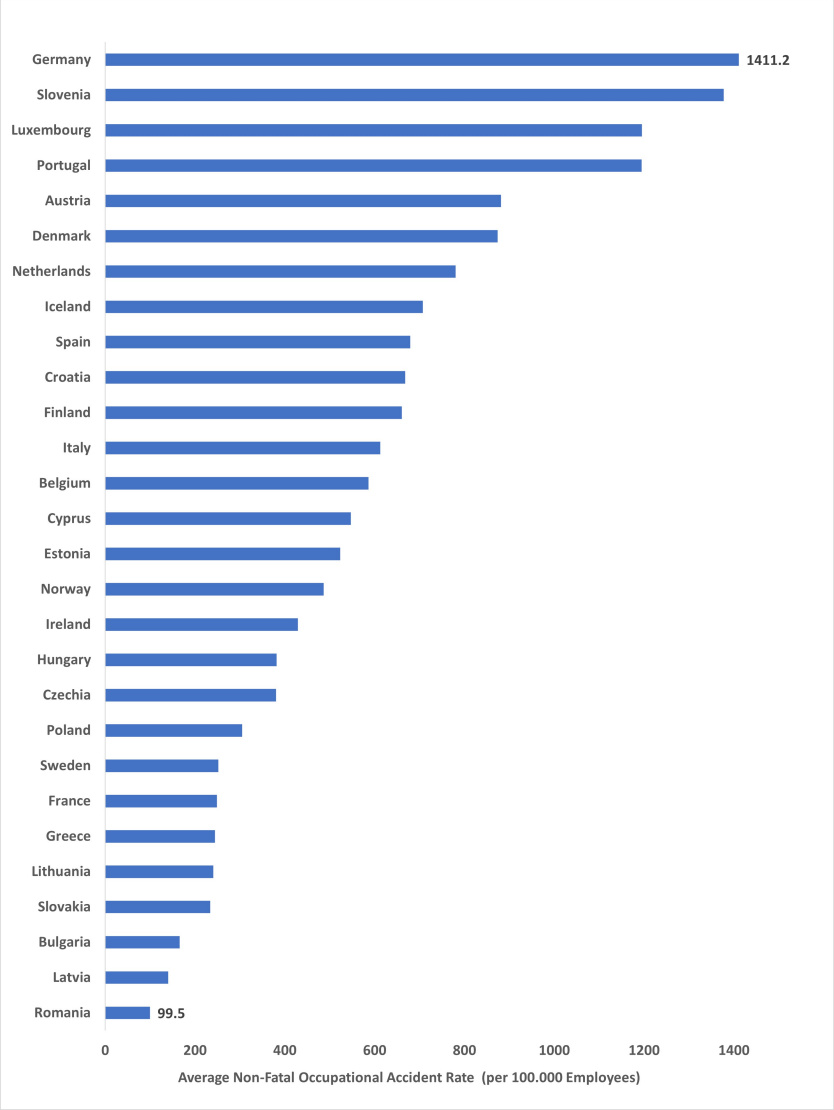

Figure 4.2: Average Non-Fatal Occupational Accident Rates by Country in the European Energy Sector (2019–2023)

Figure 4.2 compares the average non-fatal occupational accident rates reported by European countries in the energy sector during the period 2019–2023. Considerable variation can be observed across countries.

Germany recorded the highest average non-fatal occupational accident rate,

followed by Slovenia, Luxembourg, and Portugal. In contrast, Romania reported the lowest average rate, followed by Latvia and Bulgaria. The results indicate substantial differences in occupational safety performance among European countries. While several countries consistently reported relatively high non-fatal accident rates throughout the study period, others maintained considerably lower levels. These findings highlight the heterogeneous nature of occupational accident occurrence within the European energy sector.

It should be noted, however, that differences between countries may also reflect variations in national reporting systems and statistical methodologies. In particular, the Eurostat database identifies a *break in the time series* for Germany, indicating that changes in reporting procedures may have influenced the comparability of the reported accident rates across years. Consequently, country-level comparisons should be interpreted together with the methodological notes provided by Eurostat [42].

The results indicate substantial differences in occupational safety performance among European countries. While several countries consistently reported relatively high non-fatal accident rates throughout the study period, others maintained considerably lower levels. These findings highlight the heterogeneous nature of occupational accident occurrence within the European energy sector.

4.1.3 Percentage Change in Non-Fatal Occupational Accident Rates (2019–2023)

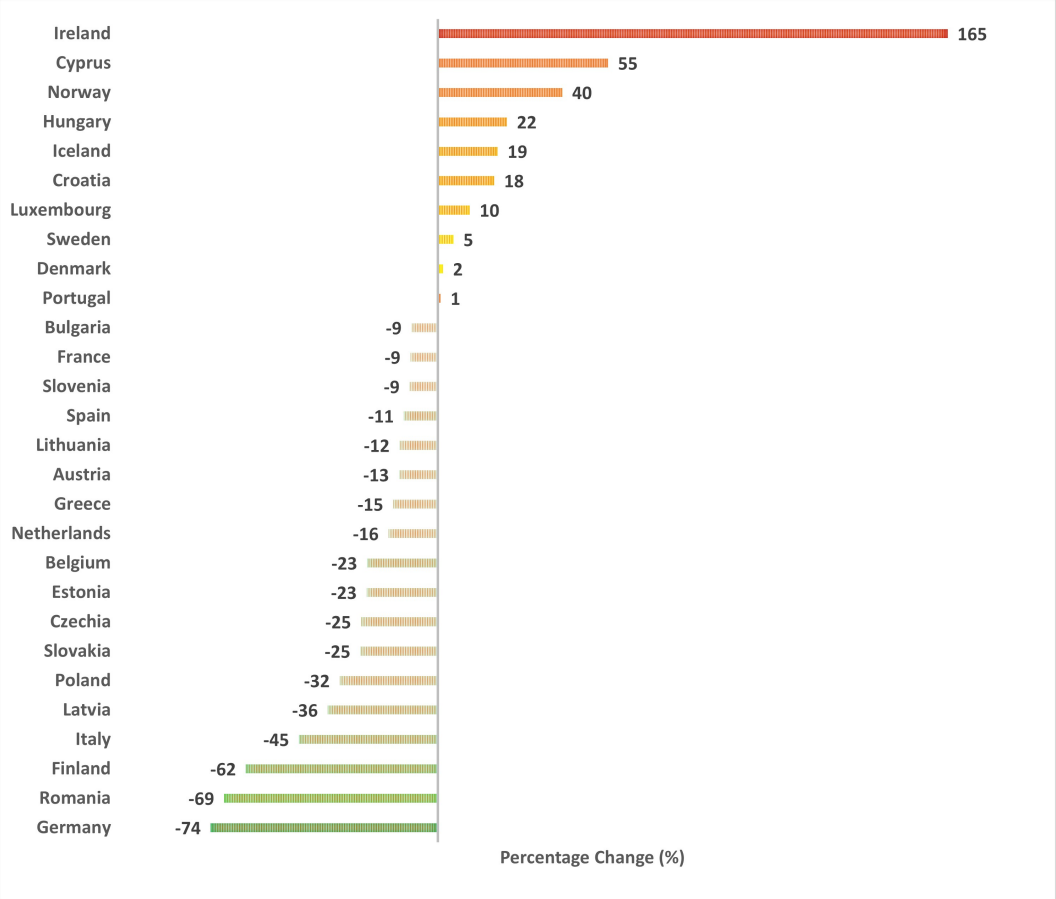

Figure 4.3: Percentage Change in Non-Fatal Occupational Accident Rates in the European Energy Sector (2019–2023)

Figure 4.3 presents the percentage change in non-fatal occupational accident rates between 2019 and 2023. Negative values indicate a reduction in accident rates, while positive values indicate an increase during the study period. Germany recorded the largest decrease (-74%), followed by Romania (-69%) and Finland (-62%). In contrast, Ireland showed the largest increase (+165%), followed by Cyprus (+55%) and Norway (+40%). These results indicate substantial differences in the direction and magnitude of non-fatal accident-rate changes among European countries.

4.1.4 Average Fatal Occupational Accident Trends in Europe (2019–2023)

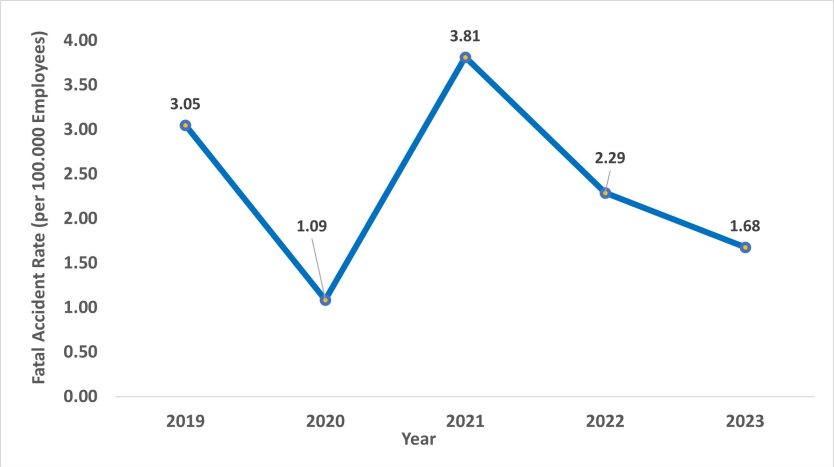

Figure 4.4: Average Fatal Occupational Accident Rate in the European Energy Sector (2019–2023)

Figure 4.4 exhibited considerable fluctuations during the study period. The rate decreased from 3.05 fatalities per 100,000 employees in 2019 to 1.09 in 2020, before increasing sharply to 3.81 in 2021, representing the highest value recorded during the five-year period. Subsequently, the indicator declined to 2.29 in 2022 and further to 1.68 fatalities per 100,000 employees in 2023. Despite the year-to-year variability, the fatal occupational accident rate in 2023 remained approximately 44.9% lower than the level observed in 2019.

4.1.5 Comparison of Average Fatal Occupational Accident Rates by Country (2019–2023)

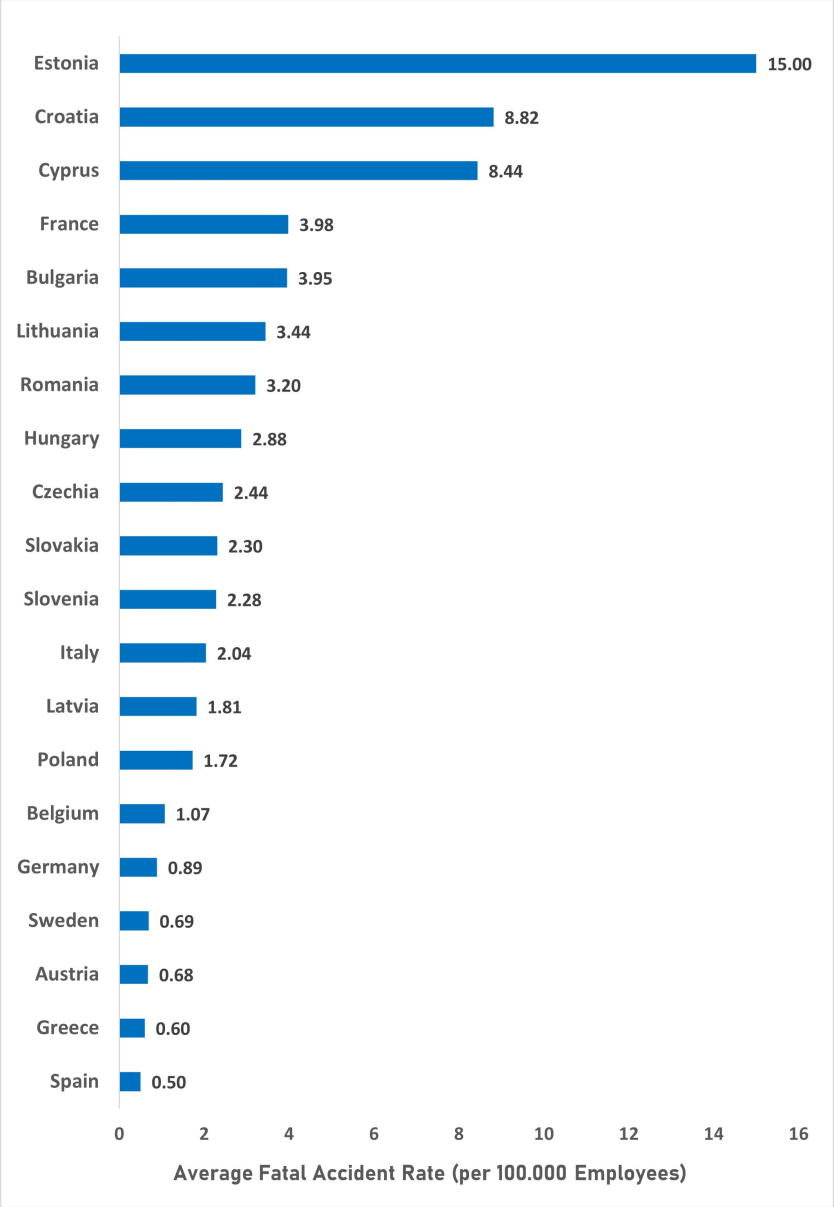

Figure 4.5: Average Fatal Occupational Accident Rates by Country in the European Energy Sector (2019–2023)

Figure 4.5 presents the average fatal occupational accident rates recorded in the European energy sector during the period 2019–2023. Considerable variation can

be observed among the analysed countries. Estonia reported the highest average fatal accident rate (15.0 fatalities per 100,000 employees), followed by Croatia (8.82) and Cyprus (8.44). In contrast, Spain (0.50), Greece (0.60), Austria (0.68), and Sweden (0.69) recorded the lowest average rates. Overall, the results indicate a heterogeneous distribution of fatal occupational accident rates across European countries during the study period.

The exceptionally high fatal occupational accident rates observed for countries such as Estonia and Cyprus should also be interpreted with caution. Because these countries have relatively small workforces in the energy sector, a limited number of fatal accidents can produce disproportionately high rates when expressed per 100,000 employees. Therefore, country-level comparisons based solely on fatal accident rates may overstate differences in occupational safety performance and should be interpreted together with the size of the underlying workforce and the statistical characteristics of the reported data [42].

4.1.6 Color-Coded Table of Fatal Occupational Accident Rates Across European Countries (2019–2023)

Fatal Occupational Accident Rates in the European Energy Sector (per 100,000 employees)					
	2019	2020	2021	2022	2023
Germany	1.5	0.7	1.1	0.4	0.7
Italy	1.3	3.9	3.9	0.0	1.2
Belgium	0.0	0.0	5.3	0.0	0.0
Denmark	0.0	0.0	0.0	0.0	0.0
Spain	2.5	0.0	0.0	0.0	0.0
France	6.7	3.3	1.7	4.1	4.1
Netherlands	0.0	0.0	0.0	0.0	0.0
Sweden	3.4	0.0	0.0	0.0	0.0
Bulgaria	0.0	0.0	6.5	6.6	6.6
Czechia	0.0	5.0	2.5	0.0	4.7
Estonia	19.1	0.0	20.1	35.8	0.0
Ireland	0.0	0.0	0.0	0.0	0.0
Greece	0.0	0.0	0.0	0.0	3.0
Croatia	17.7	5.9	5.5	6.4	8.6
Cyprus	0.0	0.0	42.2	0.0	0.0
Latvia	9.1	0.0	0.0	0.0	0.0
Lithuania	0.0	0.0	9.1	8.1	0.0
Luxembourg	0.0	0.0	0.0	0.0	0.0
Hungary	6.8	4.2	0.0	0.0	3.4
Portugal	0.0	0.0	0.0	0.0	0.0
Poland	1.2	2.8	2.0	1.5	1.0
Romania	4.7	4.6	1.1	1.2	4.5
Austria	0.0	0.0	0.0	0.0	3.4
Slovenia	11.4	0.0	0.0	0.0	0.0
Slovakia	0.0	0.0	5.8	0.0	5.7
Finland	0.0	0.0	0.0	0.0	0.0
Iceland	0.0	0.0	0.0	0.0	0.0
Norway	0.0	0.0	0.0	0.0	0.0

Figure 4.6: Color-coded table of fatal occupational accident rates in the European energy sector across European countries (2019–2023).

Figure 4.6 presents a color-coded table illustrating the distribution of fatal occupational accident rates across European countries between 2019 and 2023. The colour intensity facilitates the visual identification of temporal patterns and geographical differences in fatal occupational accident rates. Several countries, including Denmark, the Netherlands, Ireland, Luxembourg, Portugal, Finland, Iceland, and Norway, reported zero fatal occupational accidents throughout the entire five-year study period. In addition, Spain, Slovenia, Latvia, Sweden, and Austria recorded zero fatalities in four of the five analysed years.

Conversely, a limited number of countries experienced comparatively high fatal occupational accident rates during specific years. The highest values were observed in Cyprus (42.2 fatalities per 100,000 employees in 2021) and Estonia (35.8 fatalities per 100,000 employees in 2022), followed by Croatia, Lithuania, and Bulgaria in individual years. However, these exceptionally high rates should be interpreted with caution, as countries with relatively small workforces are more sensitive to fluctuations in rate-based indicators. Consequently, a very limited number of fatal accidents may result in disproportionately high fatality rates per 100,000 employees. Overall, the results indicate that fatal occupational accidents in the European energy sector were concentrated within a relatively small number of countries, whereas most European countries maintained consistently low or zero fatal occupational accident rates throughout the study period.

4.2 Company-Level Safety Performance Analysis

Following the analysis of occupational accident trends across the European energy sector, a company-level assessment was conducted to investigate how major utility companies manage, measure, and report occupational health and safety performance. While sector-wide and country-level statistics provide an overview of accident trends, company-level data offer valuable insights into the implementation of safety management systems and the effectiveness of prevention strategies.

Six leading European energy companies were selected for analysis: EDF, Engie, E.ON, Enel, Iberdrola, and Vattenfall. These companies were chosen based on their relevance within the European energy sector, the availability of publicly disclosed occupational safety information, and their inclusion in sustainability and ESG reporting frameworks.

The assessment focuses on several key aspects, including Lost Time Injury Rates (LTIR), work-related fatalities, safety targets, reporting methodologies, contractor inclusion practices, transparency of disclosures, and safety management approaches. Particular attention is given to the comparability of occupational safety indicators, as differences in reporting boundaries and calculation methodologies may influence the interpretation of performance results.

By examining both quantitative safety indicators and qualitative management practices, this analysis provides a broader understanding of how major European energy companies address occupational health and safety challenges and contribute to the reduction of workplace accidents and fatalities.

4.2.1 EDF

EDF (Électricité de France) is one of the largest electricity utility companies in Europe and a global leader in low-carbon electricity generation. Headquartered in France, the company operates across the entire electricity value chain, including power generation, transmission, distribution, and energy services. Although EDF maintains a particularly strong presence within the European energy market, the Group also conducts operations internationally through activities in North America, Asia, and other regions. During the study period, EDF managed a diverse portfolio comprising nuclear, hydroelectric, renewable, and conventional electricity generation assets, employing approximately 165,000–180,000 workers and contractors worldwide. Given the scale and complexity of its operations, occupational health and safety management represents a critical component of the company's sustainability strategy [43, 44, 45, 46, 47].

Safety Management and Reporting Methodology

Between 2019 and 2023, EDF maintained a comprehensive occupational health and safety management system covering both employees and service providers (contractors). Throughout the study period, the company consistently prioritised the prevention of serious and fatal accidents through the implementation of its "10 Golden Safety Rules", behavioural safety programmes, High Potential Event (HPE) reporting, safety audits, and mandatory safety training. The elimination of fatal accidents was repeatedly identified as one of EDF's principal safety objectives [43, 44, 45, 46, 47].

EDF progressively strengthened its safety governance framework during the study period through the introduction of the BEST reference framework, expansion of ISO 45001 and MASE certifications, systematic analysis of High Potential Events (HPEs), and increased emphasis on contractor safety management. These initiatives were intended to improve safety culture, enhance risk awareness, and reduce the occurrence of both occupational injuries and fatal accidents [44, 45, 46, 47].

To ensure comparability across business units and operational activities, EDF reported the Global Lost Time Injury Rate (Global LTIR) as its primary occupational safety performance indicator. According to the company's methodology, Global LTIR is calculated as the number of lost-time injuries per million hours worked and includes both employees and contractors. This reporting approach provides a broader representation of occupational safety performance than indicators limited solely to direct employees.

It should be noted that EDF's Global LTIR and fatality indicators are reported at the Group level and therefore reflect occupational safety performance across the company's worldwide operations rather than European activities only. The reporting boundary includes employees and contractors working within EDF's consolidated operational activities in all geographical regions where the Group operates. Consequently, the occupational safety indicators presented in this analysis represent EDF's global workforce and should not be interpreted as European-only performance indicators.

In addition to Global LTIR, EDF annually disclosed work-related fatality data and consistently included contractor-related incidents within its safety reporting framework. The inclusion of contractors in both LTIR calculations and fatality reporting contributes to a relatively high level of transparency and improves the comparability of occupational safety performance across the Group's operations [43, 44, 45, 46, 47].

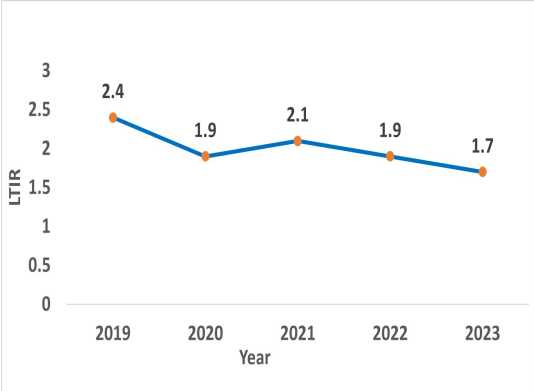

Figure 4.7: Trend of global LTIR reported by EDF (2019–2023).

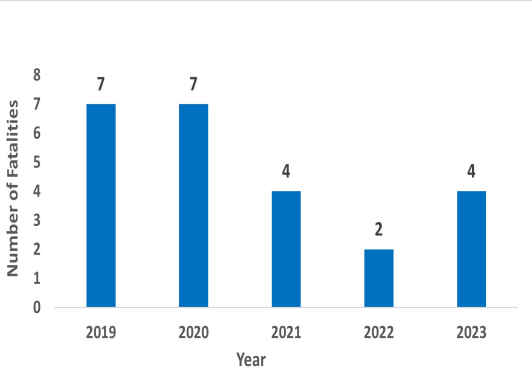

Figure 4.8: Number of work-related fatalities reported by EDF (2019–2023).

The evolution of EDF's Global LTIR is presented in Figure 4.7. Overall, the indicator exhibited a downward trend, decreasing from 2.4 in 2019 to 1.7 in 2023, corresponding to an overall reduction of approximately 29%. Although a temporary increase was observed in 2021, the long-term trend suggests a gradual improvement in occupational safety performance and a reduction in the frequency of lost-time injuries across EDF's global operations. The declining LTIR indicates that EDF's prevention programmes and safety management initiatives were generally effective in reducing the occurrence of less severe occupational injuries and lost-time incidents [43, 44, 45, 46, 47].

Figure 4.8 presents the number of work-related fatalities reported by EDF during the same period. The company recorded seven fatalities in both 2019 and 2020, followed by a reduction to four fatalities in 2021 and two fatalities in 2022. In 2023, the number increased slightly to four fatalities. While the overall trend reflects an improvement compared with the beginning of the study period, the continued occurrence of fatal accidents demonstrates that high-consequence risks remain present across EDF's global operations despite reductions in overall injury frequency [43, 44, 45, 46, 47].

The combined analysis of LTIR and fatality data provides additional insight into EDF's safety performance. Although occupational injury frequency declined substantially over the study period, this improvement was not fully mirrored by fatality performance. This finding suggests that reductions in routine occupational injuries do not necessarily eliminate severe or high-potential incidents. Consequently, the prevention of fatal accidents remains a major challenge requiring continued attention to contractor management, operational risk control, safety leadership, and organisational safety culture.

Overall, EDF demonstrated measurable progress in occupational safety performance between 2019 and 2023 through reductions in injury frequency, expanded

safety governance mechanisms, and relatively transparent reporting practices. The inclusion of contractors within both LTIR calculations and fatality reporting strengthens the credibility and comparability of the company's disclosed safety performance indicators. Nevertheless, the continued occurrence of fatal accidents throughout the study period highlights the challenges associated with controlling high-consequence risks across a large and geographically diversified global workforce [43, 44, 45, 46, 47].

4.2.2 ENGIE

ENGIE is a multinational energy company headquartered in France and one of the largest utility providers in Europe. The company operates across a broad range of activities, including electricity generation, renewable energy development, natural gas infrastructure, energy networks, and energy services. In addition to its extensive presence within Europe, ENGIE conducts operations across North America, Latin America, Africa, the Middle East, and Asia-Pacific. Through its diversified international portfolio, the company plays a significant role in both the European energy transition and the global development of low-carbon energy systems [48, 49, 50, 51, 52].

Safety Management and Reporting Methodology

Occupational health and safety represent a fundamental component of ENGIE's sustainability strategy. During the period 2019–2023, the company maintained a comprehensive health and safety management system covering employees, temporary workers, and subcontractors operating under ENGIE's operational control. Health and safety performance was monitored through dedicated governance structures and integrated into the company's broader ESG and sustainability reporting framework [48, 49, 50, 51, 52].

Throughout the reporting period, ENGIE implemented several initiatives aimed at preventing serious and fatal accidents, including the deployment of Life-Saving Rules, High Potential Incident (HiPo) reporting, safety leadership programmes, internal safety audits, Stop-Work Authority practices, and safety culture development activities. Following a series of serious accidents, the company further strengthened its safety governance through the implementation of the ENGIE One Safety transformation programme, which focuses on the prevention of high-consequence events and the reinforcement of safety leadership across all operational activities [50, 51, 52].

ENGIE reports the Lost-Time Injury Frequency Rate (LTIFR) as its principal occupational safety indicator. According to the company's reporting methodology, LTIFR is calculated as the number of lost-time injuries per million hours worked and

includes employees, temporary workers, and subcontractors working on sites under ENGIE's operational control. Fatal accidents are reported as the total number of work-related deaths occurring during professional activities. Although contractors are included within the reporting boundary, contractor-specific performance indicators are not disclosed separately. In addition to LTIFR and fatalities, ENGIE also reports severity rates, occupational illnesses, and several leading indicators related to proactive risk management and safety culture development [48, 49, 50, 51, 52].

It should be noted that the occupational health and safety indicators reported by ENGIE are based on the Group's global operations rather than its European activities only. The reporting boundary includes entities and activities under ENGIE's operational management across all geographical regions in which the company operates. Consequently, the LTIFR and fatality figures presented in this analysis reflect the company's worldwide workforce, including employees, temporary workers, and subcontractors operating under ENGIE's responsibility [48, 49, 50, 51, 52].

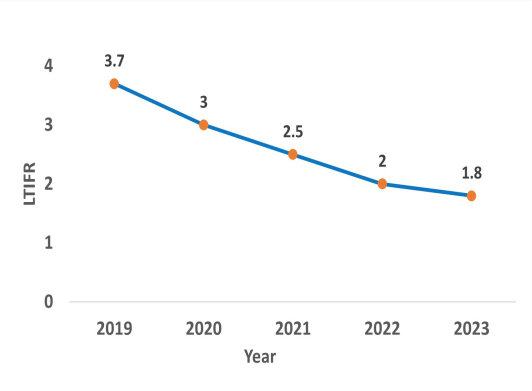

Figure 4.9: Trend of LTIFR reported by ENGIE (2019–2023).

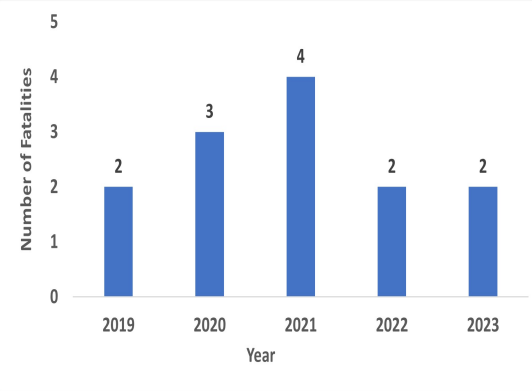

Figure 4.10: Number of work-related fatalities reported by ENGIE (2019–2023).

The evolution of ENGIE's LTIFR is presented in Figure 4.9. The indicator decreased continuously from 3.7 in 2019 to 1.8 in 2023, representing an overall reduction of approximately 51% over the five-year period. This consistent downward trend suggests a substantial improvement in occupational safety performance and a reduction in the frequency of lost-time injuries across ENGIE's global operations. The progressive decline in LTIFR also indicates that ENGIE's safety management initiatives, including safety leadership programmes, Life-Saving Rules, HiPo reporting, and the ENGIE One Safety programme, contributed positively to accident prevention and risk reduction [48, 49, 50, 51, 52].

Figure 4.10 presents the number of work-related fatalities reported by ENGIE during the same period. Unlike LTIFR, fatality performance did not follow a

consistent downward trend. The number of fatalities increased from two cases in 2019 to three in 2020 and reached four fatalities in 2021 before declining to two fatalities in both 2022 and 2023. Although the company achieved a significant reduction after 2021, the fluctuation observed throughout the study period demonstrates that improvements in injury frequency do not necessarily translate into equivalent improvements in the control of high-consequence risks across ENGIE's global operations [48, 49, 50, 51, 52].

The combined analysis of LTIFR and fatality data provides important insights into ENGIE's occupational safety performance. While the continuous reduction in LTIFR indicates a successful decrease in overall accident frequency, the temporary increase in fatal accidents observed between 2019 and 2021 highlights the limitations of relying exclusively on traditional lagging indicators. This finding supports ENGIE's strategic shift toward proactive safety management practices, including High Potential Incident reporting, Life-Saving Rules, Stop-Work Authority programmes, and safety culture initiatives aimed at preventing severe and fatal accidents before they occur.

Overall, ENGIE demonstrates a mature occupational health and safety management approach characterised by comprehensive reporting practices, contractor inclusion within safety indicators, and the integration of both lagging and leading safety indicators. The company's emphasis on proactive risk management and organisational safety culture distinguishes its reporting approach from many traditional safety management systems. Nevertheless, the continued occurrence of fatal accidents during the study period indicates that achieving the long-term objective of zero fatalities remains a significant challenge requiring sustained management commitment and continuous improvement efforts across a large and geographically diversified global workforce [48, 49, 50, 51, 52].

4.2.3 Enel

Enel is a multinational energy company headquartered in Italy and one of the largest integrated utility groups in Europe. The company operates across the entire electricity value chain, including power generation, transmission, distribution, renewable energy development, energy services, and smart infrastructure. Although Enel originated in Italy, the Group has a strong international presence, with operations across Europe, North America, South America, and several other regions worldwide. During the study period, Enel managed a large workforce consisting of both employees and contractors engaged in activities with significant occupational risk exposure, including power generation, transmission networks, renewable energy facilities, and infrastructure projects. Consequently, occupational health and safety management represents a strategic priority within the company's sustainability framework [53, 54, 55, 56, 57].

Safety Management and Reporting Methodology

Between 2019 and 2023, Enel maintained a comprehensive occupational health and safety management system based on ISO 45001 principles and supported by the Group's Health and Safety Policy and Stop Work Policy. Throughout the study period, the company consistently emphasised the prevention of occupational injuries and fatalities through risk assessment, safety leadership programmes, contractor management systems, safety training, behavioural safety initiatives, and continuous improvement processes [53, 54, 55, 56, 57].

A distinctive characteristic of Enel's safety management approach is the extensive integration of contractors within both operational safety programmes and performance reporting. The company implemented several initiatives aimed at improving contractor safety performance, including Contractor Assessments, Supplier Performance Management systems, Evaluation Groups, Contractor Safety Indexes, and Extra Checking on Site (ECoS) programmes. In addition, Enel progressively expanded the use of technological solutions such as artificial intelligence, drones, remote inspection systems, wearable technologies, and digital monitoring tools to reduce worker exposure to high-risk activities [54, 55, 56, 57].

According to Enel's reporting methodology, occupational safety performance was assessed using the Lost Time Injury Frequency Rate (LTIFR) throughout the study period. However, the reporting methodology evolved between 2019 and 2023. The 2019 and 2020 sustainability reports presented LTIFR normalised per 200,000 hours worked and reported employee and contractor performance separately. From 2021 onwards, Enel adopted a normalisation basis of one million hours worked and reported occupational safety performance using a combined employee and contractor indicator. To enable consistent trend analysis across the five-year period, the LTIFR values reported for 2019 and 2020 were converted to an equivalent basis of one million hours worked in this study. Work-related fatalities were reported annually at Group level throughout the study period. Consequently, the occupational safety indicators analysed in this study represent Enel's global operations rather than its European activities alone.

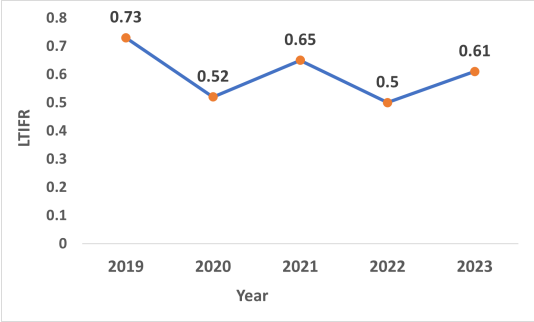

Figure 4.11: Trend of LTIFR reported by Enel (2019–2023).

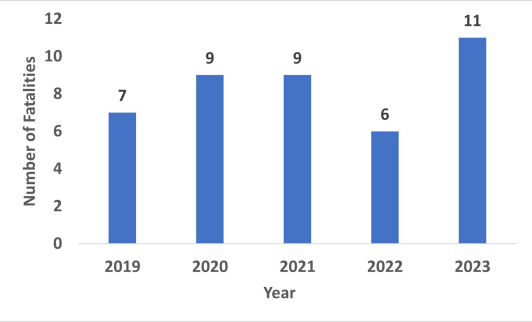

Figure 4.12: Number of work-related fatalities reported by Enel (2019–2023).

Note: The LTIFR values reported for 2019 and 2020 were converted from a normalisation basis of 200,000 hours worked to one million hours worked to ensure consistency across the five-year study period.

The evolution of Enel's LTIFR is presented in Figure 4.11. Following the harmonisation of the 2019 and 2020 LTIFR values to a normalisation basis of one million hours worked, the indicator exhibited an overall downward trend during the study period, decreasing from 0.73 in 2019 to 0.61 in 2023, corresponding to an overall reduction of approximately 16%. Although some fluctuations were observed, including an increase in 2021 and again in 2023 compared with 2022, the long-term trend suggests an improvement in occupational safety performance and a reduction in the frequency of lost-time injuries across Enel's global operations. Nevertheless, the interpretation of the trend should take into account that Enel changed its reporting boundary from separate employee and contractor reporting to a combined indicator from 2021 onwards, which may have influenced year-to-year comparability. The lowest reported LTIFR value was observed in 2022 (0.50), indicating continued progress in injury prevention [53, 54, 55, 56, 57].

Figure 4.12 presents the number of work-related fatalities reported by Enel during the same period. The company recorded seven fatalities in 2019, followed by nine fatalities in both 2020 and 2021. Fatalities decreased to six cases in 2022 but increased substantially to eleven fatalities in 2023. Unlike the LTIFR trend, fatality performance did not show a consistent improvement. The increase observed in 2023 indicates that severe and high-consequence risks remained present despite the overall reduction in injury frequency rates [53, 54, 55, 56, 57].

The combined analysis of LTIFR and fatality data provides important insight into Enel's occupational safety performance. While injury frequency indicators improved gradually during the study period, fatality performance remained more volatile and even deteriorated in 2023. This finding suggests that reductions in routine occupational injuries do not necessarily translate into equivalent reductions in severe accidents. Consequently, the prevention of fatalities and high-potential events

remains a major challenge requiring continued attention to contractor management, operational risk control, safety leadership, and technological innovation.

Overall, Enel demonstrated a mature occupational health and safety management system characterised by comprehensive reporting practices, strong contractor integration, extensive use of leading and lagging indicators, and continuous investment in safety innovation. The company also demonstrated a relatively high level of methodological transparency by clearly documenting changes in its occupational safety reporting methodology during the study period. Nevertheless, the transition from separate employee and contractor reporting to a combined reporting approach illustrates how methodological changes can influence the interpretation and comparability of occupational safety indicators over time. This observation further supports one of the principal findings of this research, namely that methodological consistency is essential for meaningful comparison of occupational safety performance across companies and reporting periods. [53, 54, 55, 56, 57].

4.2.4 E.ON

E.ON is a multinational energy company headquartered in Germany and one of the largest utility companies in Europe. The company primarily operates in energy networks, customer solutions, and energy infrastructure services. Although E.ON maintains a strong presence within the European energy market, its occupational health and safety (OHS) indicators are reported at Group level and therefore reflect the performance of its consolidated operations rather than individual national subsidiaries. Due to the nature of its activities, including network operations, maintenance work, electrical installations, and field-based technical services, occupational health and safety constitutes a key element of the company's sustainability and risk management strategy [58, 59, 60, 61, 62].

Safety Management and Reporting Methodology

Between 2019 and 2023, E.ON maintained a Group-wide occupational health and safety management system based on its "Caring Culture" approach and the long-term objective of achieving zero harm. The company's OHS strategy integrates risk prevention, contractor management, incident investigation, safety leadership, employee well-being, and continuous improvement into a unified management framework. Occupational health and safety activities are supported by certified management systems, including ISO 45001, and by the PRISMA incident management platform, which is used to record, investigate, and analyse accidents, near misses, unsafe conditions, and corrective actions throughout the organisation [58, 59, 60, 61, 62].

E.ON reports several occupational safety indicators, including the Total Recordable Injury Frequency (TRIF), Lost-Time Injury Frequency (LTIF), Serious Incident and Fatality Rate (SIF), Near Miss Frequency Rate (NMFR), and work-related fatalities. TRIF is defined as the number of recordable occupational injuries per one million hours worked, whereas LTIF represents the number of injuries resulting in lost working time per one million hours worked. Both employees and contractors are included within the company's safety reporting framework. In addition, E.ON places considerable emphasis on proactive safety management through near miss reporting, root cause analysis, contractor safety oversight, and employee health programmes [58, 59, 60, 61, 62].

A methodological consideration should be noted regarding the selection of injury frequency indicators. While LTIF values were reported separately for employees and contractors throughout the study period, a consistently reported combined LTIF indicator was not available for all five years. In contrast, Combined TRIF values were disclosed consistently between 2019 and 2023 and included both employees and contractors. Therefore, Combined TRIF was selected as the principal injury frequency indicator for the present analysis in order to ensure methodological

consistency and comparability across the entire study period. However, since TRIF includes all recordable occupational injuries rather than only lost-time injuries, direct numerical comparisons with LTIFR or LTIR values reported by other companies should be interpreted with caution. Consequently, the indicator is used primarily to assess trends within E.ON over time rather than to establish direct performance rankings against other companies.

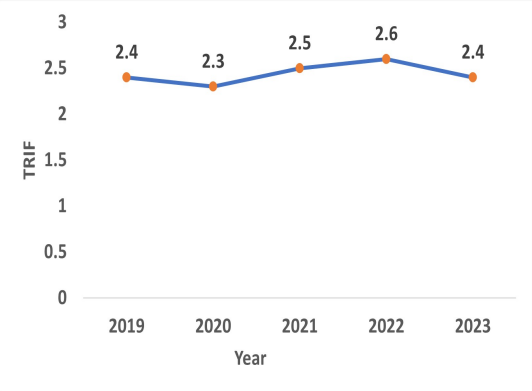

Figure 4.13: Trend of combined TRIF reported by E.ON (2019–2023).

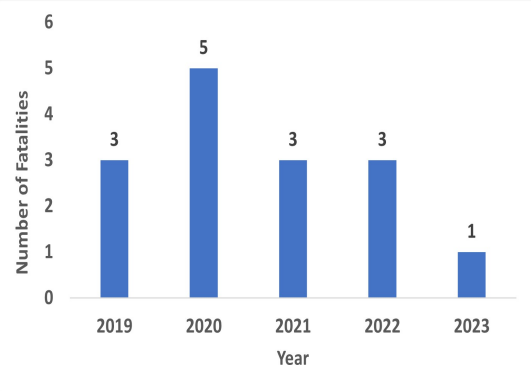

Figure 4.14: Number of work-related fatalities reported by E.ON (2019–2023).

The evolution of E.ON's Combined TRIF is presented in Figure 4.13. The indicator remained relatively stable during the study period, fluctuating between 2.3 and 2.6 recordable injuries per one million hours worked. Combined TRIF decreased slightly from 2.4 in 2019 to 2.3 in 2020, increased to 2.5 in 2021 and 2.6 in 2022, and subsequently returned to 2.4 in 2023. Overall, the results indicate a relatively stable injury frequency performance, with no clear long-term downward trend observed over the five-year period [58, 59, 60, 61, 62].

Figure 4.14 presents the number of work-related fatalities reported by E.ON during the same period. The company recorded three fatalities in 2019, followed by five fatalities in 2020. Fatality numbers subsequently declined to three cases in both 2021 and 2022 and further decreased to one fatality in 2023. Although fluctuations were observed throughout the study period, the reduction achieved in the final reporting year suggests an improvement in the management of high-consequence occupational risks [58, 59, 60, 61, 62].

The combined analysis of injury frequency and fatality data provides additional insight into E.ON's occupational safety performance. While Combined TRIF remained relatively stable, fatal accident performance improved towards the end of the study period. This finding suggests that improvements in the prevention of severe and fatal incidents may occur independently of broader injury frequency trends. E.ON's emphasis on Caring Culture, PRISMA-based incident reporting,

root cause analysis, contractor safety management, employee well-being, and organisational learning reflects a preventive and learning-oriented approach to occupational health and safety management.

Overall, the information disclosed in E.ON's sustainability and integrated annual reports indicates the presence of a structured occupational health and safety management system supported by certified standards, contractor inclusion, proactive reporting tools, and continuous improvement mechanisms. Nevertheless, the relatively stable injury frequency performance observed over the study period suggests that further efforts may be required to achieve additional reductions in occupational injury rates while maintaining progress in the prevention of severe and fatal incidents [58, 59, 60, 61, 62].

4.2.5 Iberdrola

Iberdrola is a multinational electricity utility company headquartered in Spain and one of the leading energy companies in Europe. The Group operates across the entire electricity value chain, including power generation, transmission, distribution, renewable energy, and energy services, with operations extending beyond Europe to North and South America. Given the diversity of its activities and workforce, occupational health and safety (OHS) constitutes a key component of the company's sustainability strategy [63, 64, 65, 66, 67].

Safety Management and Reporting Methodology

Between 2019 and 2023, Iberdrola reported occupational health and safety information through its Statement of Non-Financial Information in accordance with the GRI Standards. A distinctive feature of the company's reporting approach is the separate disclosure of safety performance for direct employees and subcontracted personnel. Unlike EDF, ENGIE and E.ON, Iberdrola does not use Lost Time Injury Frequency Rate (LTIFR) as its principal safety indicator. Instead, it reports the Injury Rate (IR), defined as the number of work-related accidents with lost time per one million hours worked. The reporting methodology remained unchanged throughout the study period, allowing direct comparison across years. During the COVID-19 pandemic, Iberdrola also expanded its occupational health programmes through remote working arrangements, health monitoring, vaccination campaigns, mental health support and wellbeing initiatives. [64, 65, 66, 67].

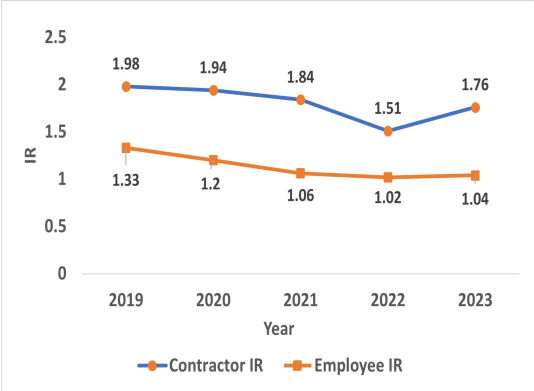

Figure 4.15: Injury Rate (IR) reported for employees and subcontractors (2019–2023).

Figure 4.16: Work-related fatalities reported by Iberdrola (2019–2023).

Figure 4.15 presents the Injury Rate reported separately for employees and subcontracted personnel. Employee IR decreased from 1.33 in 2019 to 1.04 in 2023, while contractor IR declined from 1.98 to 1.76 over the same period. Although both indicators showed an overall improvement, contractor IR remained consistently higher than employee IR throughout the study period, demonstrating a greater exposure to occupational risks among subcontracted workers. A slight increase in contractor IR in 2023 further suggests that contractor safety continues to require particular attention.

Figure **??** shows the evolution of work-related fatalities among employees and subcontracted personnel. Total fatalities increased from five cases in 2019 to eight in 2020 before decreasing to seven cases in both 2021 and 2022 and finally declining to three cases in 2023. Throughout the study period, contractor fatalities accounted for the majority of fatal accidents, suggesting that subcontracted activities may represent areas of elevated occupational risk and therefore require continued safety attention [63, 64, 65, 66, 67].

Overall, Iberdrola demonstrates a transparent occupational safety reporting approach through the separate disclosure of employee and contractor performance and the consistent application of the Injury Rate (IR) indicator. The long-term reduction in both employee and contractor injury rates, together with the marked decline in fatalities by 2023, indicates continuous improvements in the company's occupational health and safety management system. Nevertheless, the consistently higher Injury Rate observed among subcontractors, combined with the greater proportion of contractor fatalities throughout the study period, suggests that outsourced activities continue to present higher occupational risks than those performed by direct employees. These findings highlight contractor safety management as one of Iberdrola's principal occupational health and safety challenges and emphasise

the importance of maintaining targeted preventive measures for subcontracted personnel in addition to company-wide safety initiatives [63, 64, 65, 66, 67].

4.2.6 Vattenfall

Vattenfall is a European state-owned energy company headquartered in Stockholm, Sweden, and one of the leading utility companies in Northern Europe. The company operates primarily in Sweden, Germany, the Netherlands, Denmark, Finland and the United Kingdom, with activities covering electricity generation, distribution, renewable energy, district heating and energy services. Unlike several multinational energy companies included in this study, Vattenfall's operations are mainly concentrated within Europe. Consequently, the occupational health and safety indicators presented in this analysis represent the company's European operations rather than a global workforce [68, 69, 70, 71, 72].

Safety Management and Reporting Methodology

Between 2019 and 2023, Vattenfall maintained an occupational health and safety management system based on ISO 45001 principles, supported by hazard identification, incident investigation, contractor management, behavioural safety programmes and, more recently, Critical Control Management (CCM). Throughout the study period, the company emphasised its long-term ambition of achieving zero accidents, injuries and work-related illnesses. During the COVID-19 pandemic, additional initiatives such as remote working arrangements, digital safety communication, mental health support and employee well-being programmes were introduced to protect employees while maintaining operational continuity [69, 70].

Vattenfall reports Lost Time Injury Frequency (LTIF) as its principal occupational safety performance indicator. A distinctive feature of the company's reporting methodology is the separate disclosure of occupational safety data for employees and contractors. However, LTIF is reported only for employees because Vattenfall states that contractor exposure hours are insufficient to calculate a reliable contractor LTIF. Consequently, contractor safety performance is assessed mainly through the number of lost-time injuries and work-related fatalities rather than injury frequency indicators. This reporting approach provides transparency regarding contractor safety outcomes while limiting direct comparison of injury frequency between employees and contractors [68, 69, 70, 71, 72].

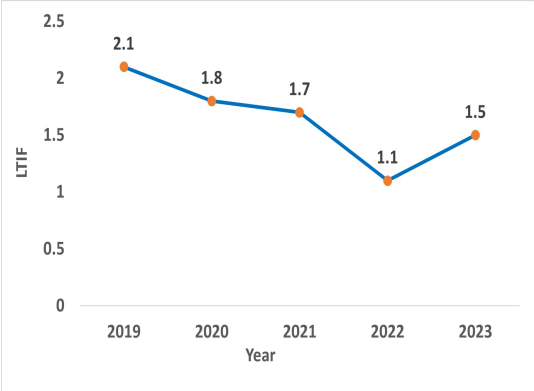

Figure 4.17: Employee LTIF trend (2019–2023).

Figure 4.18: Employee and contractor fatalities (2019–2023).

The evolution of employee LTIF is presented in Figure 4.17. The indicator decreased steadily from 2.1 in 2019 to 1.1 in 2022, representing an overall reduction of approximately 48%. This trend indicates continuous improvement in employee safety performance and suggests that the company's preventive safety programmes, leadership commitment and systematic risk management contributed to reducing lost-time injuries. However, employee LTIF increased to 1.5 in 2023, indicating that the improvement achieved in previous years was not fully maintained. According to the sustainability report, this increase was mainly associated with a higher number of electrical incidents and work-related accidents resulting in lost workdays, prompting the company to strengthen electrical safety measures and accelerate the implementation of Critical Control Management across its operations [72].

Figure 4.18 presents the number of work-related fatalities reported separately for employees and contractors. No fatalities were reported in either 2019 or 2022, whereas two fatalities occurred in both 2020 and 2021. In 2023, one contractor fatality was reported while no employee fatalities occurred. Throughout the study period, contractor fatalities accounted for most of the reported fatal accidents, suggesting that contractor activities may represent areas requiring particular safety attention. The separate reporting of employee and contractor fatalities provides valuable insight into the distribution of safety risks across the workforce and reinforces the importance of contractor safety management within Vattenfall's occupational health and safety strategy [68, 69, 70, 71, 72].

Overall, Vattenfall demonstrates a transparent occupational health and safety reporting approach through the separate disclosure of employee and contractor safety outcomes and the consistent reporting of employee LTIF. Nevertheless, the absence of a reliable contractor LTIF limits direct comparison of injury frequency between workforce groups and reduces comparability with companies that report frequency indicators for both employees and contractors. While the long-term

reduction in employee LTIF indicates substantial progress in occupational safety performance, the increase observed in 2023 together with the occurrence of a contractor fatality demonstrates that high-consequence risks remain an important challenge requiring continued attention to contractor management, electrical safety and Critical Control Management [68, 69, 70, 71, 72].

4.3 Comparative Synthesis of Occupational Safety Performance and ESG Reporting

Following the individual assessment of the selected utility companies, a comparative synthesis was conducted to integrate the findings obtained from both the Eurostat analysis and the company-level assessment. This section examines the overall occupational safety trends identified across the European energy sector while comparing the methodological characteristics of the occupational safety indicators reported within ESG and sustainability frameworks. Particular attention is given to accident trends, reporting methodologies, contractor inclusion, reporting boundaries, and methodological transparency in order to evaluate the comparability of occupational safety performance across the selected companies.

4.3.1 Integration of Sectoral and Company-Level Safety Trends

The findings presented throughout this chapter reveal a high degree of consistency between the occupational accident trends observed at the European sector level and the safety performance reported by the analysed utility companies. Although the Eurostat database and company sustainability reports represent different levels of analysis, both indicate that occupational safety performance generally improved during the period 2019–2023 while also highlighting persistent challenges that are not fully reflected by conventional injury frequency indicators.

At the European level, non-fatal occupational accident rates followed an overall downward trajectory throughout the study period. Although the annual trend exhibited temporary fluctuations, particularly following the marked reduction observed in 2020, the average accident rate recorded in 2023 remained substantially lower than the baseline year of 2019. This overall improvement suggests that occupational safety practices within the European energy sector have continued to evolve positively despite changing operational conditions.

Although the overall trend indicates a reduction in non-fatal occupational accident rates across the European energy sector, the interpretation of this finding requires caution. Germany reported an exceptionally high non-fatal accident rate in 2019, which substantially influenced the unweighted arithmetic mean presented

in Figure 4.1. Moreover, the Eurostat database identifies a *break in the time series* for Germany, indicating that changes in statistical reporting or data collection procedures may have affected the comparability of the data across different years. Consequently, part of the reduction observed between 2019 and 2020 may reflect changes in reporting methodology in addition to genuine improvements in occupational safety performance. Future research could improve the robustness of European trend analyses by employing employment-weighted averages or complementary statistical measures such as median values.

In contrast, fatal occupational accidents exhibited greater year-to-year variability and a less uniform distribution across European countries. The country-level analysis demonstrated that while many countries maintained zero-fatality performance for several consecutive years, a limited number of countries experienced isolated years with comparatively high fatal accident rates. These findings indicate that fatal occupational accidents remain relatively uncommon at the European level but continue to occur sporadically, reflecting the complex nature of high-consequence occupational risks within the energy sector.

The company-level assessment revealed a comparable pattern. Across the analysed utility companies, most organisations reported a progressive reduction in lost-time injury indicators, although the reported metrics varied between LTIF, LTIFR, TRIF, and Injury Rate (IR). Despite these methodological differences, the overall direction of change was generally consistent, suggesting continuous improvements in occupational safety management. Nevertheless, work-related fatalities were not completely eliminated, and several companies continued to report isolated fatal incidents despite improvements in injury frequency indicators.

Taken together, these findings suggest that the reduction of occupational injury frequency does not necessarily imply equivalent progress in preventing high-consequence events. Consequently, evaluating occupational safety performance solely through traditional lagging indicators may provide an incomplete picture of organisational safety performance. A more comprehensive assessment requires consideration of both accident trends and the methodologies used to define, calculate, and disclose occupational safety indicators. This provides the foundation for the subsequent cross-company comparison of ESG safety reporting practices and the identification of the principal factors affecting the comparability of occupational safety performance across the European energy sector.

4.3.2 Comparative Synthesis of Occupational Safety Reporting Practices

Although all analysed companies disclose occupational safety information within their sustainability or ESG reports, the comparative analysis demonstrates that the reporting of occupational safety indicators is far from fully harmonised. Beyond

the numerical values of injury frequency indicators, substantial differences were identified in the methodologies used to define, calculate, and disclose occupational safety performance. These methodological variations directly influence the comparability of reported results and represent one of the principal challenges identified throughout this study.

The comparison revealed differences in several key dimensions of occupational safety reporting. These include the choice of safety performance indicators (e.g., LTIF, LTIFR, TRIF or Injury Rate), the normalisation basis adopted for frequency calculations, the definition of reporting boundaries, contractor reporting practices, the transparency of methodological explanations, and the geographical scope of company operations. Since these aspects vary across organisations, direct comparison of occupational safety performance based solely on reported injury frequency indicators may lead to misleading conclusions if the underlying reporting methodology is not simultaneously considered.

To facilitate a systematic comparison, Table 4.1 summarises the principal characteristics of occupational safety reporting identified across the six selected European utility companies. Rather than ranking companies according to safety performance, the comparison focuses on the methodological characteristics that influence the transparency, consistency, and comparability of occupational safety reporting within contemporary ESG frameworks. Furthermore, the inclusion of the 2023 MSCI ESG Rating provides additional contextual information regarding each company's overall ESG performance, allowing discussion of whether high ESG ratings are consistently associated with transparent occupational safety reporting practices.

Table 4.1: Comparative matrix of occupational safety reporting practices among the selected European utility companies

Company	Main KPI	Norm. Basis	Reporting Boundary	Contractor Reporting	Methodological Transparency	Operational Scope	MSCI ESG Rating (2023)
EDF	LTIR	1M hours	Employees + Contractors	Separate	High	Global	AA
ENGIE	LTIFR	1M hours	Employees + Contractors	Combined	Medium	Global	AA
E.ON	TRIF	1M hours	Employees + Contractors	Combined	High	Europe	AA
Enel	LTIFR	200K hours (2019-2020);1M hours (2020-2023)	Employees + Contractors	Separate (2019-2020); Combined (2021-2023)	High	Global	AAA
Iberdrola	IR	1M hours	Employees + Contractors	Separate	Medium	Global	AAA
Vattenfall	LTIF	1M hours	Employees + Contractors	Separate	Medium	Northern Europe	AAA

Notes:
LTIF = Lost Time Injury Frequency;
LTIFR = Lost Time Injury Frequency Rate;
TRIF = Total Recordable Injury Frequency;
IR = Injury Rate.
Norm. Basis refers to the normalisation factor used for calculating occupational injury frequency indicators.
Methodological Transparency was qualitatively assessed based on the level of methodological information disclosed in each sustainability report.
Operational Scope refers to the principal geographical coverage of each company.
MSCI ESG Ratings (2023) are included solely as an external sustainability benchmark and should not be interpreted as a direct measure of occupational safety performance.

One of the most significant findings emerging from the comparative analysis is the absence of a fully harmonised methodology for occupational safety reporting among the selected European utility companies. Although all organisations disclose occupational safety information within their ESG or sustainability reports, considerable differences remain in the selection of key performance indicators, calculation methodologies, reporting boundaries, and disclosure practices. Consequently, occupational safety indicators should not be interpreted independently of the methodologies used to generate them. This finding directly addresses one of the principal research questions of this study, demonstrating that methodological inconsistencies continue to represent one of the main barriers to meaningful benchmarking of occupational safety performance across the European energy sector.

The comparison further demonstrates that companies adopt different approaches to measuring occupational safety performance. While LTIF remains the most frequently reported indicator, other organisations use LTIFR, TRIF, or Injury Rate (IR) as their primary safety metric. Differences were also identified in the normalisation basis used for calculating injury frequency indicators. Although most companies report injury frequency per one million hours worked, methodological differences remain evident. Enel reported LTIFR using a normalisation basis of 200,000 hours worked in 2019 and 2020 before adopting a one-million-hour basis from 2021 onwards, whereas Iberdrola consistently reports its Injury Rate using a denominator of 200,000 hours worked. These findings demonstrate that methodological differences may exist not only between companies but also within the same organisation over time. Consequently, direct comparison of occupational safety indicators requires careful consideration of the underlying calculation methodology.

Additional differences were identified in reporting boundaries, contractor inclusion practices, and operational scope. Although all analysed companies disclose occupational safety information for their direct employees, the treatment of contractors is not fully consistent. Some companies report contractor data separately, whereas others combine employee and contractor statistics or provide only limited methodological explanations regarding contractor inclusion. Furthermore, reporting approaches may also evolve over time. For example, Enel reported employee and contractor performance separately in 2019 and 2020 but adopted a combined reporting approach from 2021 onwards. Such methodological changes further complicate longitudinal and cross-company comparisons of occupational safety performance. In addition, the analysed companies differ considerably in their geographical scope of operations, ranging from predominantly European utilities to multinational organisations operating on a global scale. These differences expose companies to diverse regulatory environments, workforce structures, operational risks, and contractor management practices, all of which may influence both occupational safety performance and the reporting of safety indicators.

The comparative assessment also reveals noticeable differences in the transparency of methodological disclosures. Companies such as EDF, E.ON, Enel, Iberdrola, and Vattenfall provide relatively comprehensive explanations regarding indicator definitions, calculation methodologies, reporting boundaries, and reporting practices, whereas ENGIE presents comparatively less methodological detail. At the same time, the inclusion of MSCI ESG Ratings indicates that a high overall ESG rating does not necessarily correspond to greater transparency in occupational safety reporting. While several companies with AAA MSCI ratings demonstrate comprehensive safety disclosures, methodological transparency remains organisation-specific and cannot be inferred solely from external ESG assessments. Therefore, MSCI ratings should be regarded as complementary indicators of overall ESG performance rather than direct measures of occupational safety reporting quality.

Overall, the comparative analysis demonstrates that differences in occupational safety reporting extend beyond the reported accident statistics themselves. Variations in reporting methodologies, including changes in normalisation basis, reporting boundaries, contractor inclusion practices, operational scope, and the transparency of methodological disclosures, substantially influence the interpretation of occupational safety indicators. Consequently, meaningful benchmarking of occupational safety performance requires consideration of both quantitative safety outcomes and the qualitative characteristics of the underlying reporting methodology.

These methodological inconsistencies may also affect external benchmarking, investment decisions, ESG assessments, and cross-company performance evaluations. Therefore, greater standardisation of occupational safety reporting would enhance the transparency, comparability, and reliability of safety performance assessments across the European energy sector.

Collectively, these findings emphasise the importance of methodological harmonisation within ESG reporting frameworks. The present analysis demonstrates that methodological differences may occur both between organisations and within the same organisation over time, reinforcing the need for consistent reporting practices. This finding highlights that methodological consistency is as important as the reported safety outcomes themselves when evaluating occupational safety performance within ESG reporting frameworks. Establishing more transparent and harmonised occupational safety reporting practices would improve the comparability, transparency, and reliability of occupational safety indicators, thereby supporting more robust benchmarking and better-informed decision-making by companies, investors, regulators, and other stakeholders.

Chapter 5

Conclusions

5.1 Overall Conclusions

This study assessed occupational safety performance in the European energy sector by combining the analysis of sector-level occupational accident statistics with a comparative evaluation of occupational safety reporting practices disclosed by major European utility companies within ESG and sustainability frameworks. Unlike previous studies that primarily focused either on accident statistics or on corporate sustainability reporting, this research integrated both perspectives to provide a broader understanding of occupational safety performance and the factors affecting the comparability of reported safety indicators.

The analysis of Eurostat data demonstrated that occupational safety within the European energy sector generally improved between 2019 and 2023. Non-fatal occupational accident rates showed an overall downward trend despite temporary fluctuations during the study period, while fatal accident rates also declined overall although considerable year-to-year variability remained. Furthermore, substantial differences were identified among European countries, indicating that occupational safety performance is influenced by national regulatory frameworks, operational conditions, workforce characteristics, and safety management practices.

The company-level assessment further demonstrated that occupational safety has become an integral component of ESG and sustainability reporting among major European utility companies. All analysed organisations disclosed occupational safety information within their annual sustainability reports and reported key safety indicators together with descriptions of occupational health and safety management systems. Nevertheless, the comparison revealed that companies employ different safety indicators, including LTIF, LTIFR, TRIF and Injury Rate, reflecting the absence of a common reporting approach across the sector.

One of the principal findings of this research is that methodological differences

represent the greatest obstacle to meaningful comparison of occupational safety performance. Although companies frequently report similar types of safety information, important differences remain in the normalisation basis adopted for injury frequency calculations, reporting boundaries, contractor inclusion practices, and the level of methodological transparency provided within sustainability reports. Consequently, numerical comparisons of occupational safety indicators should be interpreted cautiously unless the underlying reporting methodologies are simultaneously considered.

The comparative assessment also demonstrated that occupational safety reporting quality extends beyond the disclosure of quantitative indicators. The transparency with which companies explain calculation methodologies, reporting assumptions, and workforce coverage plays a critical role in determining the reliability and comparability of reported safety information. Similarly, differences in operational scope, ranging from regional European utilities to globally operating organisations, introduce additional complexity when comparing occupational safety performance across companies operating under diverse regulatory and operational environments.

The inclusion of MSCI ESG Ratings as an external sustainability benchmark provided additional context regarding the overall ESG maturity of the analysed companies. However, the findings indicate that higher ESG ratings should not be interpreted as direct evidence of superior occupational safety performance or greater reporting transparency. While companies with strong ESG ratings generally demonstrated comprehensive sustainability reporting practices, methodological transparency remained organisation-specific and depended primarily on individual reporting approaches rather than external ESG assessments alone.

Overall, this research confirms that occupational safety reporting within the European energy sector has become increasingly comprehensive and aligned with broader ESG reporting practices. However, the absence of fully harmonised reporting methodologies continues to limit the comparability of occupational safety indicators across organisations. The findings therefore highlight the importance of further standardisation of occupational safety reporting within ESG frameworks, particularly under the evolving European sustainability reporting landscape established through the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS). Greater methodological consistency would improve transparency, facilitate more meaningful benchmarking, and strengthen the role of occupational safety information in supporting sustainable corporate decision-making.

Ultimately, improving the consistency and transparency of occupational safety reporting would not only strengthen ESG disclosures but also contribute to more effective occupational risk management and continuous safety improvement across the European energy sector. As occupational safety becomes increasingly integrated

into corporate sustainability strategies, the quality of safety reporting will play an increasingly important role in supporting informed decision-making by companies, regulators, investors, and other stakeholders.

5.2 Research Contributions

This study contributes to the existing literature on occupational safety and ESG reporting by providing an integrated assessment of occupational accident trends and corporate occupational safety disclosures within the European energy sector. While previous studies have generally focused either on national accident statistics or on sustainability reporting practices, this research combines both perspectives to provide a more comprehensive understanding of occupational safety performance and its representation within contemporary ESG frameworks.

The first contribution of this study is the integration of Eurostat occupational accident statistics with company-level sustainability reporting. By analysing both sector-level accident trends and corporate ESG disclosures for the same study period (2019–2023), the research provides a broader perspective on occupational safety performance that cannot be achieved through either dataset independently.

The second contribution is the comparative assessment of occupational safety reporting practices among six major European utility companies. Rather than evaluating companies solely according to reported accident rates, the study systematically compares the methodologies used to measure, calculate, and disclose occupational safety performance. This approach provides additional insight into the methodological factors that influence the interpretation and comparability of occupational safety indicators.

A further contribution is the identification of key methodological challenges affecting the comparability of occupational safety reporting. The analysis demonstrates that differences in safety indicators, normalisation approaches, reporting boundaries, contractor inclusion practices, methodological transparency, and operational scope substantially influence the interpretation of reported safety performance. These findings highlight that meaningful benchmarking requires consideration of both quantitative safety outcomes and the methodological context in which they are reported.

Finally, this research contributes to the ongoing discussion regarding ESG reporting standardisation within Europe. The findings support current regulatory initiatives, including the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS), by demonstrating the need for greater consistency and transparency in occupational safety reporting. The comparative reporting matrix developed in this study may also provide a useful reference for future research and for organisations seeking to improve the

comparability of occupational safety disclosures within ESG reporting frameworks. Furthermore, the methodological framework adopted in this study may be adapted for comparative analyses in other industrial sectors where occupational safety constitutes a key sustainability concern.

5.3 Practical Recommendations

Based on the findings of this study, several practical recommendations can be proposed to improve the transparency, consistency, and comparability of occupational safety reporting within the European energy sector.

Greater harmonisation of occupational safety indicators should be encouraged across ESG reporting frameworks. Although most analysed companies disclose injury frequency indicators, differences in terminology, calculation methods, and normalisation bases significantly reduce the comparability of reported results. The adoption of more standardised definitions and calculation methodologies would facilitate more reliable benchmarking between organisations and improve the interpretation of occupational safety performance by external stakeholders.

Companies should provide more comprehensive methodological disclosures within their sustainability reports. Clear explanations regarding indicator definitions, reporting boundaries, contractor inclusion, and calculation procedures would improve the transparency and credibility of occupational safety information. Standardised methodological notes accompanying reported safety indicators would also reduce the risk of misinterpretation by investors, researchers, and regulatory authorities.

Contractor-related occupational safety reporting should be further strengthened. As contractors perform a substantial proportion of operational activities within the energy sector, consistent reporting of contractor accidents is essential for obtaining a complete representation of occupational safety performance. Future reporting frameworks should encourage organisations to clearly distinguish between employee and contractor data while simultaneously providing harmonised reporting criteria for both groups.

Future ESG reporting requirements under the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS) should continue promoting greater consistency in occupational safety disclosures. More detailed guidance regarding occupational safety indicators, reporting boundaries, and methodological transparency would improve the comparability of sustainability reports across companies and sectors.

Organisations should progressively increase the disclosure of leading occupational safety indicators, such as near-miss reporting, safety observations, training participation, and proactive risk management activities. Reporting both leading and lagging indicators would provide stakeholders with a more comprehensive

assessment of organisational safety performance and safety culture.

Finally, organisations should recognise that occupational safety reporting should not be viewed solely as a compliance exercise but as an important management tool supporting continuous improvement, organisational learning, stakeholder confidence, and long-term corporate sustainability. Transparent and comparable occupational safety reporting can strengthen internal safety management while also enhancing the credibility of ESG disclosures and corporate accountability.

5.4 Limitations

Although this study provides a comprehensive assessment of occupational safety reporting practices within the European energy sector, several limitations should be acknowledged.

The company-level analysis was limited to six of the largest publicly listed European utility companies. Although these organisations represent some of the most influential companies in the sector, the findings cannot be considered fully representative of the entire European energy industry. Smaller utilities, privately owned companies, and organisations operating in other energy subsectors may adopt different occupational safety reporting practices.

The analysis relied exclusively on publicly available sustainability reports, ESG disclosures, and Eurostat statistics. Consequently, the assessment reflects only the information disclosed by the companies and does not include internal occupational safety records, unpublished incident investigations, or confidential operational data. Differences in corporate disclosure practices may therefore influence the level of detail available for comparative analysis.

Another limitation relates to the heterogeneity of occupational safety reporting methodologies. As demonstrated throughout this research, companies apply different safety indicators, calculation methods, reporting boundaries, contractor inclusion practices, and levels of methodological transparency. Although these methodological differences constitute one of the principal findings of this study, they also limit the possibility of performing direct quantitative comparisons of occupational safety performance across organisations.

Finally, this study focuses exclusively on the 2019–2023 period. While this timeframe provides valuable insight into recent occupational safety trends and ESG reporting practices, future regulatory developments, particularly the implementation of the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS), may substantially influence occupational safety reporting practices in the coming years.

5.5 Future Research

The findings of this study provide several opportunities for future research. First, similar comparative analyses could be extended to a larger number of companies, including utilities operating outside Europe or organisations from other high-risk industrial sectors such as oil and gas, mining, manufacturing, and chemical industries. Such studies would provide broader evidence regarding the comparability of occupational safety reporting across different industrial contexts.

Future research could also evaluate the impact of the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS) on occupational safety reporting practices after their full implementation. Longitudinal studies may determine whether these regulatory developments contribute to greater methodological consistency and improved comparability of occupational safety indicators across companies.

Another promising research direction involves the integration of leading occupational safety indicators, such as safety training, near-miss reporting, safety observations, and proactive risk management measures, alongside traditional lagging indicators including injury frequency and fatality rates. Combining both types of indicators may provide a more comprehensive assessment of organisational safety performance.

Finally, future studies could investigate the relationship between occupational safety reporting quality, actual safety performance, and broader ESG outcomes using larger datasets and quantitative statistical methods. Such research could contribute to a better understanding of whether improvements in reporting transparency are associated with measurable improvements in workplace safety performance and long-term corporate sustainability.

Appendix A

Supplementary Eurostat Data

A.1 Non-Fatal Occupational Accident Rates

The complete Eurostat datasets used in the statistical analysis presented in Chapter 4 are provided in this appendix for reference. The tables contain the country-level non-fatal and fatal occupational accident rates in the European energy sector between 2019 and 2023, together with the summary indicators used throughout the analysis.

Table A.1: Non-fatal occupational accident rates in the European energy sector by country (2019–2023) (per 100,000 employees). Source: Eurostat.

Country	**2019**	**2020**	**2021**	**2022**	**2023**	**Average**	**Change (%)**
Germany	3638.17	953.36	763.97	739.86	960.63	1411	-74
Italy	831.22	696.66	587.93	490.57	457.11	613	-45
Belgium	655.74	612.90	572.19	586.02	505.21	586	-23
Denmark	856.07	630.55	1105.12	907.70	870.49	874	2
Spain	796.48	628.64	620.77	641.33	708.15	679	-11
France	267.84	232.48	253.94	245.64	243.88	249	-9
Netherlands	385.19	507.14	836.67	1850.00	323.53	781	-16
Sweden	224.14	206.67	276.67	316.67	235.48	252	5
Bulgaria	192.37	159.19	162.87	138.80	175.90	166	-9
Czechia	427.00	345.60	425.74	384.34	320.53	381	-25
Estonia	515.27	603.62	421.69	681.00	396.20	524	-23
Ireland	303.91	352.75	390.39	294.12	805.54	429	165
Greece	262.66	266.67	234.92	233.13	224.55	244	-15
Croatia	713.86	534.12	579.55	668.36	844.10	668	18
Cyprus	464.14	504.20	590.72	456.43	720.00	547	55
Latvia	172.41	169.49	118.34	129.74	110.89	140	-36
Lithuania	258.96	211.42	328.47	177.71	226.70	241	-12
Luxembourg	1190.48	971.43	1483.52	1016.04	1313.13	1195	10
Hungary	332.43	421.54	389.21	357.88	406.84	382	22
Portugal	1454.14	908.07	1163.79	978.95	1466.91	1194	1
Poland	388.89	274.11	327.23	268.26	265.09	305	-32
Romania	188.59	128.00	70.37	52.82	57.97	100	-69
Austria	956.59	840.98	866.17	907.17	835.59	881	-13
Slovenia	1242.87	1767.39	1571.75	1177.80	1128.32	1378	-9
Slovakia	283.77	176.74	265.90	229.10	212.40	234	-25
Finland	1046.88	676.69	619.40	562.96	395.68	660	-62
Iceland	662.65	650.89	662.65	769.23	790.96	707	19
Norway	400.00	400.00	594.12	476.47	561.11	486	40

A.2 Fatal Occupational Accident Rates

Table A.2: Fatal occupational accident rates in the European energy sector by country (2019–2023) (per 100,000 employees). Source: Eurostat.

Country	**2019**	**2020**	**2021**	**2022**	**2023**	**Average**
Germany	1.53	0.75	1.10	0.36	0.70	0.89
Italy	1.27	3.86	3.85	0.00	1.23	2.04
Belgium	0.00	0.00	5.35	0.00	0.00	1.07
Denmark	0.00	0.00	0.00	0.00	0.00	0.00
Spain	2.51	0.00	0.00	0.00	0.00	0.50
France	6.72	3.30	1.66	4.15	4.08	3.98
Netherlands	0.00	0.00	0.00	0.00	0.00	0.00
Sweden	3.45	0.00	0.00	0.00	0.00	0.69
Bulgaria	0.00	0.00	6.51	6.61	6.64	3.95
Czechia	0.00	5.01	2.48	0.00	4.71	2.44
Estonia	19.08	0.00	20.08	35.84	0.00	15.00
Ireland	0.00	0.00	0.00	0.00	0.00	0.00
Greece	0.00	0.00	0.00	0.00	2.99	0.60
Croatia	17.70	5.93	5.47	6.37	8.61	8.82
Cyprus	0.00	0.00	42.19	0.00	0.00	8.44
Latvia	9.07	0.00	0.00	0.00	0.00	1.81
Lithuania	0.00	0.00	9.12	8.08	0.00	3.44
Luxembourg	0.00	0.00	0.00	0.00	0.00	0.00
Hungary	6.78	4.17	0.00	0.00	3.42	2.88
Portugal	0.00	0.00	0.00	0.00	0.00	0.00
Poland	1.22	2.82	2.04	1.49	1.05	1.72
Romania	4.66	4.57	1.14	1.20	4.46	3.20
Austria	0.00	0.00	0.00	0.00	3.38	0.68
Slovenia	11.40	0.00	0.00	0.00	0.00	2.28
Slovakia	0.00	0.00	5.78	0.00	5.74	2.30
Finland	0.00	0.00	0.00	0.00	0.00	0.00
Iceland	0.00	0.00	0.00	0.00	0.00	0.00
Norway	0.00	0.00	0.00	0.00	0.00	0.00

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