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Advancing the Sustainability of Risk Assessments within the Renewable Energy Sector—Review of Published Risk Assessments

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Abstract: Repeated regulatory incident investigations demonstrate the insufficiency of company risk assessments and the vulnerabilities that this exposes to the business and its duty holders who are, ultimately, culpable for the subsequent legislative breaches. While the epistemology and taxonomy of the traditional risk assessment are well established, there is a paucity of information that allows the verification and validation of the risk assessment content. Using evidence-based methodologies such as Content Analysis, Thematic Analysis, and validating the outputs using a survey, it became possible to "reverse engineer" the risk assessment content. This analysis of the published risk assessments, kindly supplied by six different Renewable Energy businesses, established that deterministic and behavioristic risk management methodologies had been adopted. These methodologies permitted and guided the use of vague and imprecise terminology and phraseology, numerical inconsistencies resulting in data ossification, and flawed assumptions. This analysis enables the duty holders to make informed and rational judgements about the adequacy of the risk assessment documents, and the process that permitted and guided their creation.

Keywords: risk assessment; conformation bias; conflicting goals; renewable energy; compliance; determinism; linearity; causation; cognitive dissonance; total recordable injury rates (TRIR)

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1. Introduction

Assessing risk is a well-established process. It is frequently legally mandated across a variety of legal frameworks, and considerable industrial and academic time has been invested in the creation of a variety of scoring mechanisms, templates, and guidelines. The audience for risk assessment would seem to be very clear. Employers are legally required to protect their employees and others from harm [1]; however, other guidance offers a slightly different perspective. A risk assessment will protect workers and the business and help to comply with the law [2,3]. Therefore, the etiology of risk occurs at all levels of an organization, where there are multiple stakeholders who may have differing agendas and different priorities. These differences have the potential to lead to poor health and safety outcomes, the loss of credibility, integrity, and reputation, legal vulnerability, and, ultimately, poor decision making in the Renewable Energy sector.

This study examined the reliability of the published and "live" risk assessments used in the Renewable Industry environment. The risk assessments analyzed were supplied by six different businesses operating internationally in the onshore and offshore wind energy sectors. The assessments examined hazards that were identified as part of manufacture, pre-assembly, construction, service, major component exchange, and fault finding.

It is suggested that the traditional idea of reliability is the repeated analysis of a phenomena resulting in the truth [4]; therefore, a total of 102 published risk assessments were examined, all kindly supplied by six different Renewable Energy companies. Each individual risk assessment contained a variety of risk reduction measures (1018 in total),

which were intended to reduce the risk of the stated hazard realization to a satisfactory level and fulfil the mandated requirement to manage the workplace risks suitably and sufficiently [5]. The qualitative content was analyzed using a combination of Content Analysis, Thematic Analysis, and Semiotic Analysis. Reliability was estimated by comparing different versions of the same measurement [6]. By analyzing the terminology trends, and contrasting them with the phraseology adopted, it became possible to code the risk assessment content, which enabled an evidence-based assessment of the reliability of the risk assessment documents.

The word reliability can be defined as the consistency and trustworthiness of a measure [7,8]. For a risk assessment barrier to be reliable, the communication must be clear and unambiguous to the reader. Any misunderstanding or differing interpretation represents a quiescent error, described as: "*a silent and therefore hidden error which has the illusion of normality, but its unforeseen consequences have the potential to endanger*" [9] (p. 289).

The standard risk assessment now forms a fundamental part of any safety management system. However, like all systems, the environment in which they exist is constantly changing and evolving. Renewable Energy businesses function because of the systems and processes that are at the heart of their operation. Each business may likely thrive or fail depending on the quality and efficiency of its system management. An interesting definition of a system comes from Systems Science, which advises that: "*Systems do not exist in the sense of physical objects. In a certain sense, the term could be regarded as artificially made up to generate order*" [10].

The idea of creating order from potential chaos is intriguing as it mirrors the complexity of managing workplace health and safety. It also reinforces the deterministic values. Deterministic models suggest that future events can be calculated precisely without the possibility of randomness. The conflict between the deterministic theory of the universe by Einstein (1879–1955), which was based upon Newton's (1643–1727) work, is contrasted by the probabilistic and challenging theory of Quantum Mechanics, which was championed by Bohr (1885–1962). Quantum theory challenges, undermines, and could potentially invalidate many of the foundations on which health and safety management systems are built. Quantum theory has profound implications on the way in which the world is viewed, by advising that the world is not deterministic as we cannot measure the present state of the universe precisely [11]. Quantum theory is relevant to this research as generic and deterministic methodologies are frequently used in the management of health and safety.

The implication that the world is not deterministic is far reaching as this would dictate that reverse causality, which is the basis of risk assessment and incident investigations, is a fallacy. As Planck (1858–1947) advised: "*Hitherto the principle of causality was universally accepted as an indispensable postulate of scientific research, but now we are told by some physicists that it must be thrown overboard. The fact that such an extraordinary opinion should be expressed in responsible scientific quarters is widely taken to be significant of the all-round unreliability of human knowledge. This indeed is a very serious situation*" [12]. Additionally, Bohr advised that "*Causality may be considered as a mode of perception by which we reduce our sense impressions to order*" [13]. Bohr additionally stated that "*prediction is very difficult, especially about the future*" [14]. Einstein advised that "*Reality is merely an illusion, albeit a persistent one*" [15]. Risk assessments in most industries, including the Renewable Energy sector, rely heavily on predicting events and predicting potential outcomes.

From a philosophical perspective, a 19th century philosopher, Nietzsche (1844–1900), suggested that to trace something unfamiliar back to something familiar is at once a comfort and a satisfaction [16]. Interestingly, Nietzsche went on to suggest a first principle, which is that any explanation is better than none at all [16]. Nietzsche's philosophical views have been further developed by acknowledging that while any cause certainly has an effect, the idea of reverse causality is purely an assumption [17], which has driven the potentially misguided thinking that the world is linear, and that all incidents have causes that can be identified and therefore prevented. Risk assessments are based upon a series of

assumptions, purposely designed to assure the reader; therefore, analyzing the reliability of the assumptions is of fundamental importance.

Perhaps the best and most applicable description of the deterministic and probabilistic paradox resonating in the management of health and safety was depicted by the CERN (European Center for Nuclear Research) particle physicist Bell, (1928–1990), who said: "*Bohr was inconsistent, unclear, willfully obscure, and right. Einstein was consistent, clear, down-to-earth, and wrong*" [18].

More recently, probabilistic approaches have been used to enhance the idea of system frailty. Poor management processes and poor design have become more prevalent. For example, it is now estimated that approximately 94% of all business troubles emanate from common causes or faults within its systems, which are a management responsibility [19].

By examining the risk management approaches of the Renewable Energy sector, we can observe that the introduction of new technology or new personnel into established systems makes the system reverberate, and the introduction of new capabilities introduces new complexities [20]. The problems with systems of any kind, including human interaction with them, are therefore well-established. Although health and safety management systems, including the creation of risk assessments, offer a deterministic suggestion of clarity, order, and structure, all are susceptible to the substitution myth, which advises that: "*a common assumption that artefacts are value neutral in the sense that their introduction into a system only has the intended and no unintended effects*" [21].

This view is fundamental and pivotal as it contradicts the traditional deterministic approach to managing the complexity of human involvement. Taylor (1856–1915) suggested that workers needed strict control and supervision so that they follow the most efficient and scientific way of undertaking their duties [22]. The Tayloristic approach has been adopted by others who support the compliance and supervisory-based approaches, by suggesting that the safety policies, practices, and procedures of an organization are a mechanism for valuing company safety [23], and that any deviation could be described as a level of carelessness [23]. These views are of considerable interest for research purposes as they imply that the system in which the worker operates is safe; therefore, the worker is the hazard that needs to be managed.

This research challenges the generic approaches adopted to manage the prospect of hazard realization in the Renewable Energy sector. It also examines the flawed and counterfactual methodologies adopted by the risk assessment authors by analyzing the style and content of the published and approved risk control and mitigation measures in the Renewable Sector. The principal aim of this research is to offer evidence-based insight into the prevailing ideology and psychology demonstrated by the risk assessment authors and to identify the prevailing culture in the Renewable Energy business that created and approved the risk assessment documentation. This research examines the aspects of technical and operational risks in the context of the legislative vulnerability of the business and its duty holders [1].

2. Methodology

Figure 1 gives an overview of the methodology adopted to analyze the content of the published Renewable Sector risk assessments. The research had four phases:

1. Phase 1 analyzes the terminology adopted by the risk assessment.
2. Phase 2 analyzes the research outputs.
3. Phase 3 verifies the research outputs.
4. Phase discusses the results of the research and discusses the recommendations.

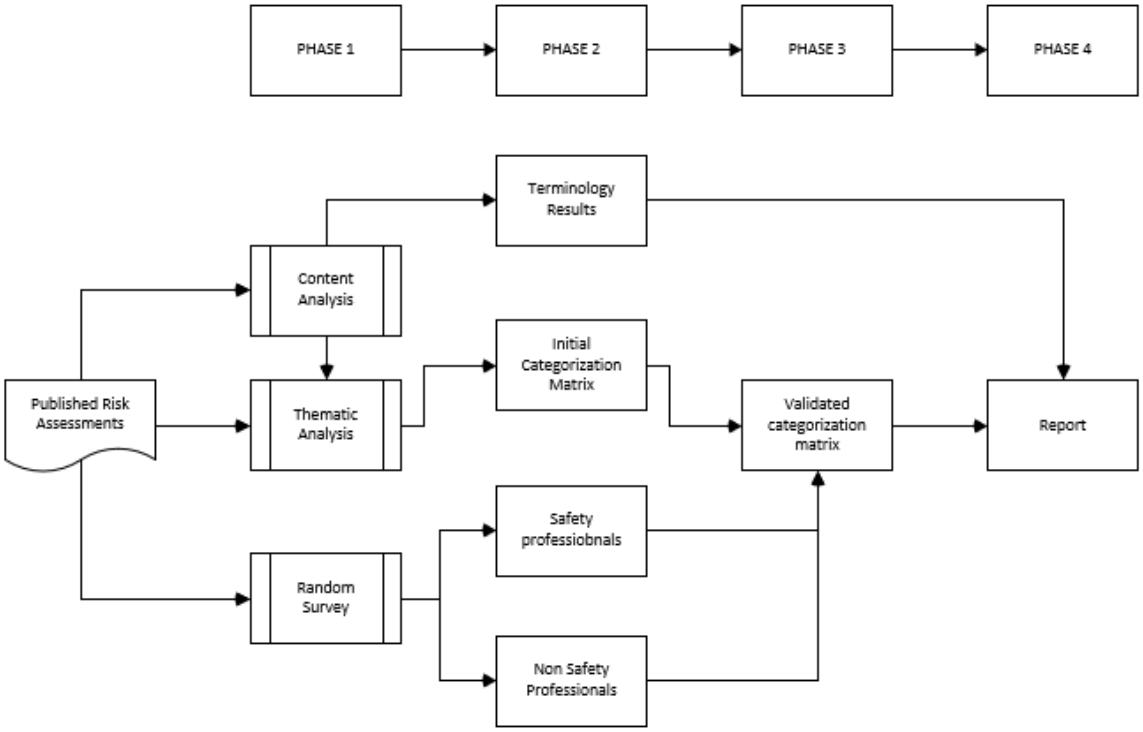

Figure 1. EBRAET model and phases on implementation.

By combining the outputs from the Content Analysis, the Thematic Analysis, and the results from the random surveys, it was possible to gain an insight into the methodology adopted by the authors of the document. The combined results from the analysis provide insight into the Renewable Energy business and industry attitudes towards risk management were demonstrated.

2.1. Content Analysis

The initial step in the analysis of the published risk assessments was to perform a Content Analysis. The Content Analysis enables the researcher to systematically describe and quantify phenomena [24], which subsequently allows the researcher to build models and conceptually map the categories for analysis [25]. The Content Analysis and Thematic Analysis were performed using the NVIVO software (version 12) to assist in the collation and interpretation of the collected data.

2.2. NVIVO Software

There are a variety of software packages that can assist the researcher in the analysis of qualitative research data, such as NVIVO, MaxQDA, and Dedoose. Regardless of which package is selected for use, it is important to remember that the software is simply a tool, and like all tools, its use depends on the skill of the operator and quality of the data that are input for analysis. The software is unable to supply theoretical frameworks, it simply facilitates data analysis [26]. Additional considerations include license costs, back-up facilities, and technical support, all of which require careful thought and consideration. Open-source software was certainly considered; however, the sensitive content of the published risk assessments that contain site details and the potential for security breaches meant that such software could not be recommended. Therefore, the selection of software was based upon license fees, technical support costs, and availability.

2.3. Thematic Analysis

The second step in the process of the risk assessment analysis was to undertake a Thematic Analysis of the assessment content. The Thematic Analysis can be described

as a descriptive method that reduces the data in a flexible way, dovetailing with other data analysis models [25]. The analysis began with a detailed analysis and reading of the risk assessment text and concepts, from which ideas can be generated and themes can be created [27]. Once the Thematic Analysis developed a series of themes, the creation of coding began [28]. Once the coding was complete, an initial categorization matrix was created to test the research concepts and hypotheses [29].

2.4. Survey

To validate the outcomes of the Thematic Analysis and the initial categorization matrix, a random survey was created. Surveys are described as the collection of information from a sample group using their responses to questions [30]. As this research analysis was based within the Renewable Energy industry, there was a considerable risk that those being surveyed who work within the Renewable Energy businesses will display an element of confirmation bias in their replies. Confirmation bias is described as the interpretation of evidence that aligns with existing beliefs or hypotheses [31]. Confirmation bias is also described as cognitive inclinations in human thinking that may not comply with reasoning and plausibility [32]. This definition is of interest as it suggests that individuals may unconsciously be subject to external events that influence or guide their responses. Additionally, Cognitive Dissonance is described as a conflict between two opposing beliefs, which can lead the survey participant into a dilemmic situation where their loyalty to the company and all that entails is potentially contrary to their professional or competent view [33]. It is also claimed that Cognitive Dissonance may be inevitable as individuals may not be able to align their personal beliefs with the behavior expected. The causes of cognitive dissonance could include an element of mandated compliance where the individual potentially disagrees with the action, or has limited decision-making opportunities. Cognitive Dissonance can also be caused by the undervaluing of the effort that the individual has applied to deliver an outcome. Individuals are more likely to view difficult tasks positively even if this causes a moral disagreement [33].

2.5. Survey Issues

One of the principal steps in establishing the reliability of the outputs of the Content Analysis and the Thematic Analysis is to test the outcomes by conducting a survey. The use of surveys is not without criticism. There are three common problems with surveys: firstly, the survey may not have been designed to answer the question of interest in the research, or it may ask questions that cannot be generalized beyond the survey participants; secondly, the answers to the survey questions may not provide the information needed to address the issue [34]; finally, it is suggested that to create an unbiased decision, every piece of information requires critical analysis, and such an undertaking is unrealistic [35]. To counter the potential impact of Confirmation Bias or Cognitive Dissonance resulting from poor survey design, it is suggested that Confirmation Bias and Cognitive Dissonance effects can be minimized by adopting an alternative hypothesis, which also has the potential to deliver a more dynamic form of evidence gathering [33].

In this research, every effort has been made to ensure that the survey results are unaffected by Confirmation Bias and Cognitive Dissonance. To achieve this, four mitigations were implemented:

1. The survey participants would not be asked to rate or score the language used as a risk safeguard. They would be asked to categorize the safeguards under the themes developed in the Thematic Analysis/Content Analysis.
2. The survey design and the questions asked were independently reviewed and approved by the University Ethics team.
3. The participants in the survey were volunteers suggested by the Institute of Occupational Safety and Health (IOSH). They were all chartered safety professionals; however, they had no knowledge or experience of the Renewable Energy industry. This approach was adopted as the hazards described in the published risk assessments

were generic in nature; therefore, they occur in other industries. They include working at height, exposure to hazardous substances, exposure to hazardous energies, and slips, trips, and falls.

4. The safety professionals nominated by IOSH were also asked to nominate friends or family who had no knowledge of the Renewable Industry and no formal health and safety background.

3. Results

3.1. Content Analysis Results

Table 1 indicates the top ten words used within the text of the Renewable Energy risk assessments. The search criteria examined the individual words containing five or more letters to avoid grammatical conjunctions, such as "and", "the", "so", etc. The types of words frequently chosen by the risk assessment author(s) were of interest as they contained a mixture of nouns (7), verbs (2), and adjectives (1).

Table 1. Word frequency content analysis of 1012 risk assessment barriers.

Word	Length	Count	Similar Words
Requirements (common noun)	12	249	require, required, requirement, requirements, requirements', requiring
Competent (adjective)	9	241	competent, competency, competent
Lifting (Gerund verb)	7	214	lifting, lifts
Equipment (common noun	9	213	equipment
Works (abstract noun)	5	205	worked, working, works
Isolations (common noun)	10	191	isolated, isolation, isolations
Assessments (common noun)	11	182	assess, assessed, assessment, assessments, assessment, assessments
System (abstract noun)	6	173	system, systems
Persons (common noun)	7	171	person, personal, persons
Ensure (verb)	6	169	ensure, ensured, ensuring

The analysis demonstrated that there were five common nouns used that were described as a type of person, type of thing, or place [36]. Additionally, there were two abstract nouns used that were described as conceptual and non-physical [36]. The use of the adjective word "competent", which was the second highest scoring word, was also indicative. Adjectives are described as words that are descriptive of the qualities of something or someone, and words that modify nouns or pronouns [37]. The only verb in the top ten frequently used words was the Gerund verb, "lifting". In Gerund verbs, an "ing" is simply added to a verb to form a noun [38].

A further output of the risk assessment Content Analysis was the identification and frequency of repeated text. The repeated use of barriers that had been used in other risk assessments indicated a widespread use of "copying and pasting", described in this research as "cloning". In the traditional use of the word "cloning", the definition refers to "identical or virtually identical copies of an organism or cell" [39]. For the purpose of this research, cloning signified where identical or similar text from a variety of sources was applied generically. The results of the Content Analysis identified that 170 barriers, equivalent to 16.7% of the total risk assessment barriers, were cloned.

3.2. Thematic Analysis Results

Table 2 demonstrates the initial Thematic Analysis results and coding themes adopted. As the risk assessments symbolized the surface level elements of the organization culture, measuring the constituent parts of a published risk assessment was of value. A measurement was defined as: "*a quantitatively expressed reduction of uncertainty based on one or more observations*" [40].

Table 2. Initial Thematic Analysis categorization matrix.

Coding	Choices	Reference	Competence	PPE	Instruction	Statement	Unknown
%	12%	4%	16%	12%	36%	20%	0%

The categorization matrix, which was created as part of the initial analysis, certainly reduced the level of uncertainty regarding the reliability of the published risk assessments and, dependent on duty holder requirements, the initial categorization may be sufficient. However, defining reliability in a qualitative manner can be problematic. It has been suggested that the traditional idea of reliability is the repeated analysis of a phenomena resulting in the truth. With qualitative research, it must be acknowledged that human behavior can be erratic, and measurements and observations can fluctuate when human interactions are being studied [4].

3.3. Survey Results

A total of five safety professionals and five non-safety professionals were surveyed, and the results are listed in Table 3. Provided that a subject group was randomly selected, the "rule of five" was 93.75% accurate in identifying the mean [40]. Table 3 enables the contrasting of results from the initial analysis compared with the survey results supplied by randomly selected safety and non-safety professionals.

Table 3. Thematic Analysis comparison of results.

	Choice	Refer	Competency	PPE	Instruct	State	Unknown
Initial analysis	12%	4%	16%	12%	36%	20%	0%
5 safety professionals	16%	9%	15%	7%	33%	17%	3%
5 non-safety professionals	6%	5%	9%	6%	57%	13%	5%

3.4. Combined Results

While a simple observation can identify that there are some differences between the results obtained, it is important to understand that these differences were expected. The research assumption advises that "*Safety means different things to different people at different times and in different environments*" [9], and that "*the lack of having an exact number is not the same as knowing nothing*", as having a range of values delivers a 90% confidence level [40] (p. 109).

Table 4 demonstrates the ranges of values obtained in random surveys and, in doing so, provides the risk owner with an evidence-based evaluation of the reliability of their published risk assessments.

Table 4. Established content ranges.

Choices	Reference	Competence	PPE	Instruction	Statement	Unknown
6–12%	4–9%	9–16%	6–12%	33–57%	13–20%	3–5%

Of the six codes used to categorize the risk assessments, between 33% and 57% of the risk assessment barriers provided the reader with additional instructions, while between 13% and 20% provided generic statements. The examples include:

- "*The products for the work are to be identified to the team leader, and additional controls are implemented*".
- "*Barrier creams are made available for daily use*".
- "*Adequate ventilation shall be ensured*".
- "*Take regular breaks*".
- "*Only approved tooling shall be used*".

As the supply of instructions is a legally mandated requirement [41], it is suggested that this type of content should only appear in formal work instructions and not form part of a risk assessment that examines the realization of a specific hazard. The inclusion of legally mandated requirements is of research interest. Risk assessment documentation is created to protect the risk duty holder [1]. The inclusion of additional instructional information in the risk assessment documentation illustrates that the document authors may have a limited understanding of business risk ownership.

Other legally mandated requirements contained in the risk assessments included the application of competency and PPE requirements. Current legislation clearly defines the requirement to suitably train employees to a sufficient level [41], yet this makes up between 9% and 16% of the total content. Similarly, the requirement for the employer to supply suitable protective equipment is also legally mandated [41], but it is suggested as a risk mitigation in 6% to 12% of the risk assessment content.

Examples of legally mandated requirements that are used as risk mitigations include:

- "*Wear suitable PPE as stated in relevant Control of Substances Hazardous to Health (COSHH) assessment when coming into contact with substances hazardous to health*".
- "*Refer to COSHH assessment for required PPE*".
- "*Statutory inspections in accordance with legislation shall be completed for all lifting equipment and copies of certificates kept at the site*".
- "*Only trained and competent technicians to carry out lifting work*".
- "*A written scheme of examination shall be prepared by a competent person and implemented by management*".

It is also evident from the categorization matrix and the developed ranges that between 6% and 12% of the risk assessment content informs the reader or the stakeholder that an element of choice is available. The research analysis also revealed that between 4% and 9% of the published risk assessment documentation asked the reader to refer to the additional documentation.

Such approaches could certainly be perceived as an indication of a generic methodology or the delegation of risk ownership to the end user of the risk assessment document.

Examples of offering readers of the risk assessment a level of choice or instructing them to read or examine additional documentation include:

- "*Waste shall be disposed of in accordance with the relevant CoSHH assessment*".
- "*Work areas and access ways to be kept clear of unnecessary materials and equipment*".
- "*Refer to Method Statement for all CoSHH products to be used for the task*".
- "*Where possible, a suitable-sized approved lifting bag in good condition shall be used*".
- "*Avoid exposure to the body where possible*".

3.5. Identification of Key Words

In this research, the selection of key words is based on the literature review, the examination of 1018 risk assessments barriers, and the examination of the key aspects of the research. The key elements of this research are the creation of RISK ASSESSMENTS within the RENEWABLE ENERGY sector and the factors that could influence their design, including CONFIRMATION BIAS and COGNATIVE DISSONACE. This research established that the published risk assessments are DETERMINISTIC and adopt LINEAR

methodologies that utilize basic CAUSATION models, resulting in the application of health and safety measurement systems, such as TOTAL RECORDABLE INJURY RATES. The most frequently used sources of reference materials include:

- Health and Safety Regulators
- Sage Publications
- Journal of Marine Engineering and Technology
- Harvard Business School
- Cambridge University Press
- Journal of Advanced Nursing
- Center for Advanced Engineering Study
- Encyclopedia of Behavioral Neuroscience (Elsevier)
- Reliability Engineering and System Safety

4. Discussion

During the analysis of the published risk assessments, it became evident that each of the risk assessment barriers attracted a risk reduction score, regardless of the viability of the barrier. The most common approach used in the risk assessment was for the authors to score the hazard realization in terms of severity and probability of occurrence. The individual notional scoring of severity and probability was purely judgmental, and there seemed to be limited evidence to support the ratings applied. The multiplication of severity and probability scoring to develop an overall risk score was also without evidential basis. Once a risk score was established, each risk assessment barrier was allotted a risk reduction score, which was an additional judgment made by the risk assessment authors. Nominal scaling was qualitative, where the numbers had no real value as they should only be used as labels to classify the specific categories [42]. Additionally, ordinal scales demonstrated the relative order of the assessment; therefore, they were not units of precise measurement. Nominal scales should not be multiplied like other measures, such as distance or mass [40].

As part of the risk assessment analysis, it also became evident that 16.7% of the examined risk assessments had been cloned. This established that a generic risk assessment methodology was regarded by the business as an acceptable part of the risk management process. A generic risk assessment methodology also demonstrated that, despite potential changes to the constituent parts of the analyzed risk due to equipment, environmental factors, competency, and other aspects, these fluctuations were deemed to be "cost-neutral" to the risk assessment creation process. For such a belief to be maintained, it was required that the relevant management systems and procedures supporting and governing the risk management process condoned or guided the suggested approach. Such a linear approach negatively impacted the reliability of the published documents.

Lagging safety metrics are commonplace in most business safety management systems. The most common metric is Total Recordable Injury Rate (TRIR), which is adopted within the Renewable Energy (wind) environment. In its annual report declaring a variety of health and safety statistics for the global offshore wind industry, the Energy Institute advised that the TRIR had declined from 3.28 in 2021 to 2.82 in 2022 [43]. The TRIR is defined by the Energy Institute as: "*The number of recordable injuries (fatalities + lost workday injuries + restricted workday injuries + medical treatment injuries) per 1,000,000 h worked*". However, there were a few anomalies that required discussion and interpretation.

What is classified as a reportable incident in one country-specific legal framework may not be reportable in another. Under United Kingdom (UK) reporting requirements, a report should be submitted to the regulator where: "*Any person at work is incapacitated for routine work for more than seven consecutive days*" [44]. Under similar requirements specified by the United States Department of Labor (2022), the reporting requirement is different and advises that: "*Any work-related injury or illness that results in a loss of consciousness, days away from work, restricted work, or transfer to another job*" [45].

How the Energy Institute reconciles the differences between the two legislative frameworks is unclear. Although the American Occupational Safety and Health Authority

(OHSA) advises against using TRIR as a performance indicator comparator, its use remains commonplace [46]. Unfortunately, the TRIR calculation is affected by the number of employees in any business and the hours worked, resulting in incident rates increasing as the business size decreases [47].

The use of imprecise language in the published risk assessment, used in parallel with the arbitrary and inconsistent scoring mechanisms, suggested that the demonstrated risk assessment process was flawed and may not accurately describe the hazard or its controls and mitigations. The results revealed that the use of vague and imprecise language is an acceptable norm in the creation of risk assessment barriers. The prevalence of non-actionable nouns in the risk assessment content caused interpretation issues, which impacted the reliability of the published risk assessment document and the guiding safety management system.

The problem of managing the interpretation of information to make informed decisions is not new. The ancient Greek philosopher Socrates said that: "*no two people will ever hear or see the same thing in an identical way and consequently will never perceive sensory information in the same way either*" [48].

Nietzsche suggested in his notes that "facts do not exist, only their interpretations" [49]. This comment then evolved into the frequently used quotation that "all things are subject to interpretation, and whichever interpretation prevails at a given time is a function of power and not truth". It is unclear if Nietzsche ever actually said those precise words, but the implications of the statement are of interest.

The psychological way that humans interpret data suggests that bias interferes with rationality and impartiality as we develop our own heuristics or "rules of thumb" [40]. Motivational bias is defined as the vulnerability to opinion changes based upon incentivization, organizational pressures, and self-interest, all of which have the potential to impact any risk assessments and scoring mechanisms adopted to justify the required risk reduction [50]. It is also suggested that businesses operate in an environment with multiple and often conflicting goals, which can be generated in social and organizational contexts [40] (p. 168). The suggestion that as humans, we perceive and understand differently, poses considerable issues for managing workplace health and safety, where objectivity rather than subjectivity will be required.

The risk assessment authors and their businesses are confusing risk management with compliance to statutory or procedural requirements. The compliance to requirements is the expectation of the regulator and business stakeholders. Recent UK case law has demonstrated that officers of the company who organize their business to be ignorant of any risks will not avoid charges [51], perhaps better described as "ignorance of the law is no excuse" [52].

By identifying that the existing safety management systems that control, condone, and guide the creation of risk assessment documentation have potential weaknesses, it became possible to examine the varied psychological aspects that were evident at the individual and corporate levels.

The business environment in which Renewable Energy companies operate has seen a steady unit price decline as the demand for clean energy has grown. In 2019, the prices obtained were approximately a third less than the prices obtained in 2017 and almost two-thirds less than the prices obtained in 2015 [53]. This unit price reduction is certainly good news for consumers; however, the effects on wind turbine manufacturers have been less favorable. While original equipment manufacturers (OEM) have steadily increased their prices, the pace of wind farm growth globally and the increasing raw material costs have led to major manufacturers returning negative earnings before interest and tax (EBIT) [54].

There can be little doubt that wind turbine manufacturers are operating in a neoliberal business environment. Neoliberalism favors private enterprise over governmental interventions and promotes free markets and capitalism [55]. Neoliberalism is perhaps best described in the Renewable Energy sector as "bigger, faster, cheaper" [56]. In order to reduce costs and ensure efficiency in production, a "*Tayloristic*" approach toward the

management of employees and their subsequent health and safety has been adopted. Taylorism dictates that employees require strict control, and the only way to undertake a task is the most efficient way [22]. This inevitably leads to deterministic attitudes where a lack of free will or random events are not considered [57]. This ultimately leads to behavioristic methodologies, which propose that any person can be trained to perform any task within their physical limits, and all that is required is the correct psychological conditioning [58].

For the risk assessment authors, strict adherence to process and procedure required under the deterministic safety management system leads to elements of Cognitive Dissonance, where conflicting attitudes or beliefs lead to mental discomfort [59]. This discomfort may be relieved by the influence of Conformity Bias, where individuals choose to behave like those around them rather than using their own judgment [60]. In order to balance the ill effects of Cognitive Dissonance and Conformity Bias, the authors may seek to support the company and group views by unconsciously only searching for views or data that support the approaches adopted by their employer; therefore, perhaps they have unknowingly become susceptible to confirmation bias [61].

It is now evident that compliance, which is defined as the adherence to applicable rules and laws and also includes country-specific laws and the requirements of the regulatory authorities [62], should not be confused with risk management, which is defined as a state of uncertainty where some of the possibilities involve loss, injury, or any undesirable outcome [40] (p. 80). Arguably, the noncompliance to statutory or mandated requirements could be considered a risk. However, it is suggested that advising the business to comply with the mandated requirement cannot be described as a risk control or mitigation and, adding little to the risk assessment process.

It is further suggested that many risk assessments documents, and the safety management systems in which they reside, have been created and subsequently evolved to accommodate a variety of stakeholders, all of whom are susceptible to both Confirmation Bias and Cognitive Dissonance. These biases can impair judgment when estimating risk exposure. Additionally, the accuracy of risk estimation has been the subject of a variety of academic studies. Humans are primarily guided by emotion; therefore, they are distracted by trivial details and are insensitive to the differences between low and negligibly low probabilities [63]. It is further suggested that if the only evidence presented is subjective in nature and supplied by those who support the suggested approach, there is no reason to believe that the method would not deliver a negative outcome [40] (p. 17). This is a pivotal point as "for a critical issue like risk management, we should require positive proof that it works—not just a lack of proof it does not" [40] (p. 17).

Proving a negative is certainly problematic as the absence of evidence is not evidence of the absence of evidence [64]. Unfortunately, however, the reliance on history to predict future outcomes is prevalent within the Renewable Sector.

5. Conclusions

To comply with the statutory requirements for providing a safe and healthy workplace, the risk assessments published by businesses should be legally defensible to protect both the business and its nominated duty holders from external scrutiny. This is a crucial aspect of establishing the reliability of business-published risk assessments. Under various UK and international legal frameworks, a reverse burden of proof is placed upon the defendant to provide evidence that they have fulfilled the requirements to manage risks within their business to an "as low as reasonably practicable" (ALARP) level. When the reverse burden of proof exists, the defendant must prove, "*on the balance of probability*", that they have done all that could be expected of them [51]. Therefore, it is essential that any informed judgment that plays a significant role in setting gross disproportionality multipliers, which appropriately balance the risk of hazard realization against potentially costly safety improvements [65], is evidenced and legally defensible.

Interestingly, while an ALARP decision is made by the duty holder to manage a risk suitably and sufficiently, the validation of that judgment will ultimately be tested under

the balance of the probability principles if an incident is brought to the court's attention. The balance of probabilities means that "the court is satisfied that an event occurred if the court considers that the evidence indicates that the event more likely occurred than it did not" [66]. Therefore, this is a considerably lower burden of proof threshold than the traditional "beyond all reasonable doubt" standard of proof, which is applicable in criminal actions. The key phrase in the definition of the balance of probability is that "*the court considers the evidence indicates*". To demonstrate why the health and safety judgments are made, the evidence provided in defense of the business duty holder needs to be of an evidential standard.

To deliver a suitable and sufficient risk assessment, not just in the Renewable Sector but in all industries, that is legally defensible, the published documents should be evidence-based and supportive of any business decisions taken. Therefore, a fundamental requirement is that the phraseology and terminology used in the risk assessment are precise, accurate, and relevant. It has become evident from the analysis of the risk assessments and their barriers used in the Renewable Energy sector that they are frequently vague, generic, and imprecise, which could prove problematic if the quality of the business safety management system and the published risk assessment were to be legally scrutinized.

By undertaking a Thematic Analysis and a Content Analysis of the published risk assessments and validating the resultant categorization matrix using a randomly conducted survey, it became evident that making generic statements and offering levels of choice within the risk assessment content indicated that the authors' choice of imprecise phraseology could be caused by levels of doubt about the reliability of the barriers. Subsequently, this permits the influence of confirmation and conformity bias to deliver a response that aligns with the deterministic safety management system.

The principal purpose of this research was to establish the reliability of published and "live" risk assessments used in the Renewable Energy sector. The research aim was to develop an evidence-based tool that permits insight into the prevailing ideology and psychology demonstrated by the risk assessment authors and identify the prevailing culture within the business that created and approved the risk assessment documentation. The results obtained from the Content Analysis and the Thematic Analysis, which were verified by the survey responses, allowed the creation of a categorization matrix that clearly demonstrated the risk assessment themes adopted by the authors. If it is assumed that the document authors had no deliberate intention to deceive the readers of the risk assessment, it becomes clear that the business safety management system that is driving the documentary outputs is flawed.

The outputs of this research were not intended to produce a notional scoring system that somehow classified the reliability of the published risk assessments. Instead, what has been produced is a tool that can be used to analyze the published documents, enabling the duty holder the ability to make informed decisions on the risk assessment documents that they are ultimately responsible for. It also evidences the health and safety culture of their business, which may or may not align with their expectations.

Therefore, it is recommended that the authors of the risk assessments in the Renewable Energy sector ensure that the terminology and phraseology adopted within their risk assessments are precise and accurate, enabling a shared understanding of the content. The risk reduction benefits claimed should be evidence-based and avoid the use of mandated legislative requirements, generic and ambiguous statements, and the referencing of other documents or processes. Additionally, offering the risk assessment reader an element of choice and claiming a risk reduction benefit regardless of which option is taken is a flawed methodology; therefore, it should be avoided. A further recommendation is that the business-specific health and safety Management systems that guide and condone the risk assessment creation processes are re-evaluated to align with an evidential approach.

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