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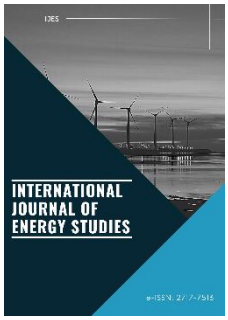


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# The impact of societal culture and organizational culture on nuclear safety culture: an analysis from the perspective of Hofstede's cultural dimensions model[ϕ]

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**Highlights**

- The recognition that nuclear safety cannot be ensured solely through technical or engineering-based measures has necessitated the adoption of a holistic approach that encompasses technical, mechanical, and human factor dimensions.
- Safety culture constitutes a sub-dimension of organizational culture, while organizational culture itself is embedded within the broader societal culture.
- In circumstances where societal culture does not foster a positive safety culture, the values internalized and promoted within the organization may serve to compensate for this gap.
- Among the five dimensions of Hofstede's Cultural Dimensions Model, high power distance, high uncertainty avoidance, collectivist orientation, femininity, and short-term orientation are identified as cultural traits that adversely influence the development of a positive nuclear safety culture.

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## ABSTRACT

This study examines the interaction between societal culture and organizational culture, and investigates how this relationship shapes nuclear safety culture within the framework of Geert Hofstede's Cultural Dimensions Model. It underscores that societal culture is transmitted into organizational culture through individuals, thereby providing the foundational values upon which organizational norms and practices are built. Based on Hofstede's Cultural Dimensions Model, the study conducts a comparative analysis of five key dimensions of societal culture—power distance, uncertainty avoidance, individualism versus collectivism, masculinity versus femininity, and long-term versus short-term orientation—alongside the ten positive nuclear safety culture traits identified by the Institute of Nuclear Power Operations (INPO) and the World Association of Nuclear Operators (WANO). The findings reveal that cultural profiles characterized by low power distance, low uncertainty avoidance, individualism, masculinity, and long-term orientation tend to reinforce positive nuclear safety culture traits, particularly a questioning attitude, an environment for raising concerns, personal accountability, safety communication, and decision-making. Conversely, cultural patterns marked by high power distance, high uncertainty avoidance, collectivism, femininity, and short-term orientation may hinder the early identification of risks, constrain critical evaluation processes, and reduce the prioritization of safety, thereby failing to support positive traits—especially a questioning attitude, an environment for raising concerns, and personal accountability. In conclusion, the study affirms that the development and reinforcement of nuclear safety culture should give primary consideration to societal cultural factors. It further emphasizes that fostering a positive nuclear safety culture is a collective responsibility shared by all personnel, while leaders hold a pivotal role in shaping, guiding, and sustaining this culture over time.

**Keywords:** Safety culture, Nuclear safety culture, Organizational culture, Geert Hofstede cultural dimensions model, Chernobyl nuclear power plant accident.

## 1.INTRODUCTION

The industrialization and mass production accelerated by the Industrial Revolution brought new risks to workplaces in terms of health and safety. In this process, rules and regulations were introduced to protect against mechanical, physical, and chemical hazards threatening occupational safety, and systematic efforts were undertaken to prevent occupational accidents [1].

When examining the historical development of occupational safety, these efforts can be seen to have evolved in three distinct periods. The first period (1800–1940) focused on eliminating errors originating from machines and equipment; the second period (1940–1960) brought the human factor to the forefront, directing attention to human resources practices such as recruitment processes, the development of employees' skills, and enhancing motivation. The third period, beginning in the 1980s, emphasized that the main causes of accidents were human errors and organizational conditions, prompting improvements in these areas [2].

In the nuclear energy sector, the concept of safety culture emerged following the 1979 Three Mile Island Nuclear Power Plant accident in the United States, when the influence of technical, human, and organizational factors on safety began to be discussed [3]. However, the term "safety culture" entered the literature after the 1986 Chernobyl Nuclear Power Plant accident. Up to that point, technical and engineering measures had been the primary focus of nuclear safety. The Three Mile Island and Chernobyl accidents demonstrated that nuclear safety could not be ensured solely through technical and engineering measures, and that human and organizational factors must also be considered [4]. Given the socio-technical nature of nuclear power plants, the technical and social dimensions cannot be evaluated separately [5], and it began to be emphasized that nuclear safety should be approached holistically, integrating technical–mechanical–human factor dimensions [6].

In ensuring human–machine compatibility, safety culture which shapes human attitudes and behaviors plays a critical role [7]. Safety culture is a component of organizational culture, and organizational culture, in turn, is part of the broader societal culture [8]. In this context, this study examines the interaction between societal culture and organizational culture, and the reflections of this relationship on nuclear safety culture within the framework of Geert Hofstede's Cultural Dimensions Model. First, the fundamental concepts forming the theoretical basis of the study—societal culture, organizational culture, safety culture, and nuclear safety culture—will be discussed. Second, the relationship between societal and organizational culture will be examined in the context of Hofstede's Cultural Dimensions Model, revealing how cultural dimensions shape organizational culture and guide employees' attitudes in the workplace. Third, the relationship

between Hofstede's cultural dimensions and nuclear safety culture will be comparatively analyzed. Finally, the Chernobyl nuclear power plant accident will be evaluated in terms of the impact of societal culture and organizational culture on nuclear safety culture.

This study is particularly significant in the current context, as Turkey's first nuclear power plant project in 70 years began in 2010, and efforts are now underway to commission its first unit. Investigating how societal cultural dimensions influence the nuclear safety culture of employees in institutions and organizations related to nuclear power plants will contribute to filling the gap in the existing literature on the effects of societal culture on safety culture, specifically in the context of nuclear safety culture.

Currently, commissioning work is underway for the first unit of the nuclear power plant initiated in 2010—the country's first such project after a 70-year interval. Examining how societal cultural dimensions influence the nuclear safety culture of employees working in institutions and organizations related to nuclear power plants will help address the gap in the existing literature on the effects of societal culture on safety culture, specifically within the context of nuclear safety culture.

## 2. CONCEPTUAL FRAMEWORK

Society and culture are two fundamental and inseparable concepts. Any assessment related to society reflects its cultural attributes, whereas any assessment related to culture refers back to the society that creates and maintains it [9]. Culture is a kind of "brand" that defines the unique identity of a society and its individuals, distinguishing them from other societies [10]. Differences between cultures are rooted in the unique values and norms embraced by each society. Some cultural structures value individualism, while others prioritize collectivism and social harmony [11]. Societies with different historical backgrounds exhibit differing cultural structures; conversely, societies with similar historical origins, religious beliefs, ethnic compositions, or geographic locations tend to share similar cultural characteristics [12].

As outgrowths of society, organizations are artificial social systems created by humans, functioning like miniature societies with their own internal dynamics. These structures form a unique culture through both tangible and intangible elements such as values, beliefs, norms, symbols, management approaches, and technologies [13, 14]. Organizational culture is not shaped solely within the organization but exists in continuous interaction with societal culture. Societal culture is transmitted into organizations through individuals, who reinterpret their values within the new social system upon joining the organization [15,8]. In this sense, organizational culture

can be considered a subculture within the broader societal culture [16]. Ultimately, organizational culture refers to the shared fundamental beliefs, values, norms, and behavioral patterns that shape the actions of its members [17].

Schein classifies the elements of organizational culture into three layers, ranging from the superficial to the profound and from the tangible to the intangible: symbols, behaviors, values, and assumptions [18]. Accordingly, when culture is compared to an iceberg, the layer visible above the surface consists of "artifacts produced by individuals," such as observable objects and behavioral patterns; the middle layer represents "values," which are shared but unobservable judgments among employees; and the deepest layer, "basic assumptions," refers to mental constructs embedded in individuals' minds, which are likewise unobservable [19]. Basic assumptions are among the deepest and most abstract cultural elements, exerting the greatest influence on employees' attitudes and behaviors within organizations. Defined as "the unconscious principles of existence that form the frame of reference for acting, thinking, and even feeling for individuals or groups," assumptions are most notable for being accepted without question. Situated at a deeper level than values, assumptions also shape those values and, in this respect, emerge as a strong source of resistance to cultural change [20]

The concept of safety culture first appeared in the literature after the 1986 Chernobyl Nuclear Power Plant accident [4], and its comprehensive definition was provided in the 1991 report of the International Atomic Energy Agency (IAEA). According to the IAEA, safety culture is the set of characteristics and attitudes that make safety in nuclear facilities the highest priority. This culture includes accountability, a questioning attitude, avoidance of complacency, commitment to excellence, and encouragement of corporate self-regulation in safety [21]. In IAEA documents, unless otherwise stated, the term "safety" refers to "nuclear safety," which is defined as the protection of workers, the public, and the environment from unnecessary radiation risks by establishing proper operating conditions, preventing accidents, and mitigating their consequences [22]. The OECD-NEA, on the other hand, defines safety culture as an environment that encompasses an organization's fundamental safety values, attitudes toward quality, continuous learning and improvement processes, and in which employees are free to express safety concerns without fear of punishment [23].

In the nuclear energy sector, the term *"safety culture"* refers specifically to *nuclear safety culture,* whereas in other sectors it is generally used in the sense of *occupational health and safety (OHS).* From this perspective, the difference between safety culture used broadly across all sectors in the sense of OHS and nuclear safety culture specific to the nuclear energy sector can be evaluated in

terms of attitudes-behaviors and technical scope. In this context, areas 1 and 2 in Figure 2 relate to the technical scope, while area 3 is concerned with attitudes and behaviors.

When both concepts are considered from the perspective of attitudes and behaviors, increasing OHS awareness in workplaces to foster a safety culture is valid across all sectors, including the nuclear energy sector. At the same time, the features of nuclear safety culture developed by INPO and WANO can be applied in any workplace without restriction [24]. For example, features such as *"questioning attitude," "an environment where concerns can be expressed,"* and *"a respectful work environment"* are part of nuclear safety culture but also support OHS culture. Therefore, the difference between OHS culture and nuclear safety culture does not stem from safety culture features that reflect attitudes and behaviors but rather from the technical scope of OHS and nuclear safety, as illustrated in areas 1 and 2 of Figure 1.

From the perspective of technical scope, OHS generally applies to all sectors and encompasses hazards and risks that may threaten employees' health or safety. In contrast, nuclear safety is broader and based on stricter regulations, distinguishing between *"safety-related structures, systems, and components"* and *"non-safety-related structures, systems, and components"* with reference to radiation exposure. According to the IAEA [22], safety-related structures, systems, and components are defined as *"those whose failure or malfunction could result in the plant staff or the public being exposed to radiation in excess of acceptable limits."*

At this point, as shown in areas 1 and 2 of Figure 1, both safety-related and non-safety-related structures, systems, and components fall within the scope of OHS. However, the OHS scope in these areas remains limited to radiation and chemical leaks, explosion and fire risks, radiation level measurements, periodic inspections, and the use of appropriate protective equipment by workers. For this reason, OHS practices in nuclear facilities or power plants do not fully meet all safety requirements. As illustrated by area 1 in Figure 1, there is naturally a need for a separate field of *nuclear safety* beyond OHS. In this field, it is essential to apply the fundamental principles of nuclear safety, through engineering expertise, to safety-related structures, systems, and components [25].

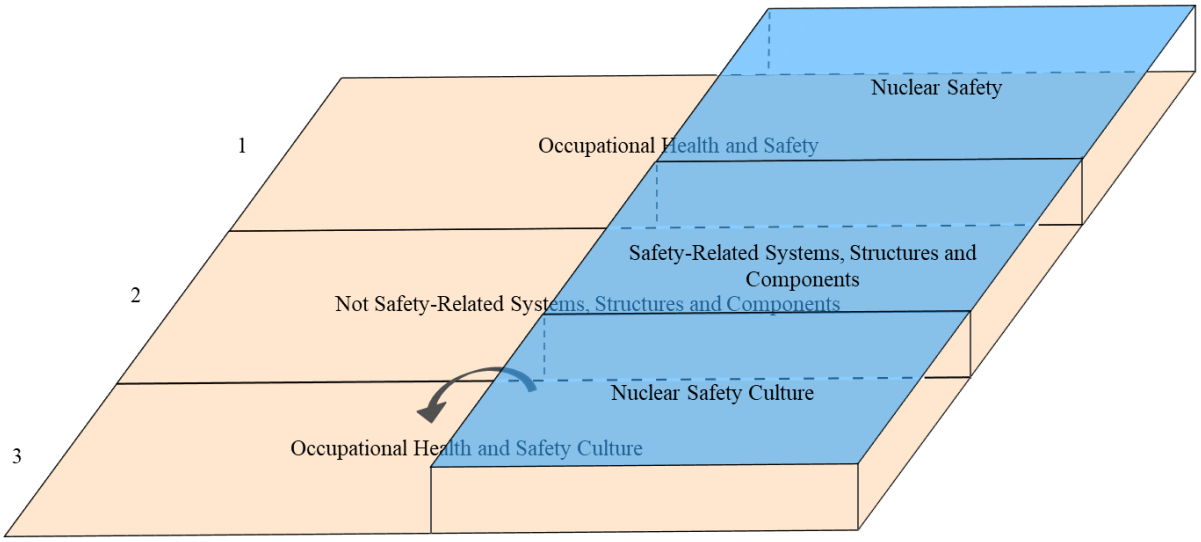


**Figure 1.** Relationship between OHS (Culture) and Nuclear Safety (Culture)

**Source:** Created by the author based on literature data.

Following the distinction between safety culture and nuclear safety culture illustrated above, it is important to emphasize the critical role of leadership in shaping and fostering both safety culture and organizational culture within organizations. According to the IAEA [26], managers at all levels of an organization are regarded as leaders in matters of safety and play a critical role in the development of safety culture. Leadership means guiding individuals and groups, uniting employees around common goals and values, and influencing their commitment to achieving fundamental safety objectives. According to INPO [27], safety culture consists of the values and attitudes shaped by the exemplary behaviors of leaders and internalized by members, making nuclear safety the foremost priority. Leaders reflect the organization's core values, motivate employees, establish safety policies, set goals and strategies, approach safety holistically—beyond the technical dimension—in the context of human–organization–technology, identify behaviors aligned with nuclear safety culture, take steps to enhance the culture, involve employees in the process, and encourage individual responsibility, a questioning attitude, and the reporting of safety violations [28,26]. Employees, in turn, are expected to prioritize nuclear safety, adhere to safety principles, and maintain a questioning approach [4].

The establishment of a safety culture in the workplace under the leadership of managers requires not only the transfer of knowledge but also the realization of a cultural transformation and its reflection in behavioral change; however, this cannot be achieved in a short period of time [8]. While training is essential for this transformation, perfunctory or non-practical training does not contribute to the development of a safety culture [29]. The most common mistake is conducting short-term training instead of long-term programs, resulting in safe behaviors being abandoned

before they reach the level of habit. Yet, for safe behaviors to become habitual, consistency and repetition are fundamental. Although proper training may be delivered, converting knowledge into actual behavior remains a lengthy and difficult process; knowledge by itself cannot ensure a change in behavior. Behavioral change occurs through the successful completion of the following stages: acquiring knowledge about the new behavior, validating the acquired knowledge, believing in the usefulness of the new behavior, performing the behavior, and advocating the behavior to others. For these stages to be successfully completed, employees must be prevented from acting under the influence of subconscious values and assumptions—acquired during the socialization process within family, school, and peer environments—that are inconsistent with safety culture. Once this is achieved, the knowledge provided through training will be more easily internalized and transformed into behavior by employees [30].

## 3. THE RELATIONSHIP BETWEEN SOCIETAL CULTURE AND ORGANIZATIONAL CULTURE IN THE CONTEXT OF HOFSTEDE'S CULTURAL DIMENSIONS MODEL

Among the pioneering studies that systematically analyze cultural differences are the research projects of Geert Hofstede. In the 1970s, IBM initiated research to understand the operational differences across its branches in various countries, and this process laid the foundation for Hofstede's Cultural Dimensions Model. These studies revealed the significant impact of the cultural backgrounds of individuals working in similar organizational structures on work processes, providing significant insights for international management strategies [31,32].

The data obtained from surveys administered to 116,000 IBM employees in 40 countries between 1968 and 1972 demonstrated how cultural differences influence universal work values. In subsequent similar studies, Hofstede identified four fundamental cultural dimensions: **power distance, uncertainty avoidance, individualism/collectivism,** and **masculinity/femininity** [33]. Later, through a values survey conducted in China, a fifth dimension—**long-term/short-term orientation—**was conceptualized and added to the model [34,35].

These five cultural dimensions provide a strong theoretical basis for explaining how organizations are shaped within the context of societal culture and how individuals' attitudes in the workplace are influenced. Hofstede's model serves as a key reference for understanding organizational behavior and adapting management practices, particularly in multicultural environments. Within this framework, Hofstede's five cultural dimensions are explained below from the perspective of the societal culture–organizational culture relationship.

### 3.1. Power Distance

Hofstede defines power distance as the degree to which the distribution of power within a group is unequal. A more balanced distribution of power among group members indicates **low power distance,** while situations where power is concentrated among certain individuals or groups—thus unequally distributed—are considered **high power distance** [36]. High power distance is commonly observed in collectivist cultures in Latin America, Southeast Asia, and Africa, while low power distance is prevalent in individualist cultures such as Anglo-Saxon, Germanic, and Scandinavian countries [37]. The degree of power distance in societies shapes many organizational behaviors—such as perceptions of hierarchy, leadership style, participation in decision-making processes, and equality among individuals—and is also linked to social indicators such as lifestyle and income distribution [38].

In high power distance organizations, subordinates and superiors are viewed as unequal individuals; hierarchy is built upon this inequality, and subordinates wait for instructions [39]. Decision-making is centralized, and managers engage in limited consultation with subordinates [40], and orders are followed without question [41]. Employees tend to avoid disagreement and often prefer autocratic or paternalistic management styles [39]. In situations involving danger or risk, hierarchical distance often leads to problems being ignored [1], resulting in cultures that neglect safety rather than prioritize it [42].

In low power distance organizations, subordinates and superiors view each other as equals; hierarchy is flatter, and subordinates are consulted before decisions are made, with the final decision given by the manager [39]. Managers adopt a people-oriented and participatory leadership style, relationships are based on mutual respect, and senior managers are accessible and display humility. Problems are sought in the functioning of the system rather than in individuals [43]. Employees freely express their opinions [44], and managers share decision-making authority with lower levels. In such cultures, employees believe more strongly that they should have a say in decision-making [45], and the participatory environment encourages employees to voice their views [46].

### 3.2. Uncertainty Avoidance

Uncertainty is defined as the inability to classify a situation clearly due to a lack of information [47]. Uncertainty avoidance is the extent to which structured situations are preferred over unstructured ones; such structures may be defined by explicit written rules or traditions [36]. According to Hofstede, this dimension reflects the degree of threat societies feel in the face of

uncertainty and unpredictability, as well as the coping strategies they develop [49]. Some cultures accept uncertainty as natural [48], while others impose strict rules to control it, value expertise and job stability, and maintain a more distant attitude toward differing opinions. Consequently, individual responses vary: some experience anxiety and tension, while others remain calm and flexible [41].

In high uncertainty avoidance organizations, employees and managers expect long-term employment and job security, and work relationships are defined by detailed laws and rules [39]. There is strong reliance on experts, technical solutions, and rules that reduce uncertainty. In risky work, employees cope with uncertainty by trusting and obeying their managers, even if they have doubts [42]. Managers are expected to give explicit instructions, and subordinate initiative is limited. Different opinions and unconventional approaches are viewed as dangerous sources of uncertainty, leading to intolerance toward new ideas [43]. Change is approached cautiously, and even when deficiencies in the system are recognized, maintaining the status quo is prioritized [50].

In low uncertainty avoidance organizations, rules are created only when necessary, and many issues are resolved through social consensus and common sense without formal regulations. There is high tolerance for differing opinions and unconventional behavior, and deviations from general approaches are seen as diversity rather than a threat [39]. There is no strong quest for lifetime job security, and willingness to take risks is higher [43].

### 3.3. Individualism/Collectivism

Individualism refers to the extent to which people prefer to act independently rather than as part of a group. Its opposite is collectivism. In collectivist cultures, individuals learn from an early age to respect their group, differentiate between in-group and out-group, maintain group membership, and expect to be protected by the group in times of need. They believe they must remain loyal to their group throughout life. In individualist societies, individuals grow up with an “I” rather than a “we” consciousness, stand on their own feet, and do not rely on group loyalty [51].

In individualist organizational cultures, individuals act independently from the groups to which they belong, prioritize personal goals over group goals, and base their behavior largely on personal attitudes [52,50]. Conversely, in collectivist cultures, individuals develop interdependent relationships within groups such as family or community, prioritize group goals, and shape their behavior according to group norms. In intra-group conflicts, they tend to seek conciliatory solutions to maintain relationships [52].

In collectivist organizations, the employer–employee relationship is seen as one based on mutual loyalty and responsibility, resembling a family bond. While employees show loyalty to their employer, the employer protects the employee; thus, low performance is not directly considered grounds for dismissal, reflecting the principle of not excluding a family member. However, task allocation is determined by the employee's skills and performance. In individualist societies, the employer–employee relationship is a market-based employment contract, operating as a buyer–seller relationship. In this context, low performance or accepting a better job offer is both legitimate and socially acceptable grounds for ending the employment relationship [39].

### 3.4. Masculinity/Femininity

Although individuals are biologically categorized as male and female, at the cultural level this distinction gains meaning through "masculine" and "feminine" values [53]. In Hofstede's Cultural Dimensions Model, this binary structure is evaluated based on the values prioritized by societies to determine whether a culture is predominantly masculine or feminine [39]. Societies where competitiveness, career success, advancement, and personal assertiveness are emphasized are considered **masculine,** while those where compassion, understanding, loyalty, politeness, and sensitivity prevail are classified as **feminine** [54].

While gender roles vary across all societies, the degree of difference changes from country to country. In societies where the difference is pronounced, dominant values are masculine, with a stricter structure focused on achievement and performance. In masculine cultures, women may also hold competitive and strong values, though not as dominantly as men. In societies where the difference between male and female roles is relatively small, feminine values dominate. These societies prioritize well-being, quality of life, and harmony, and adopt a softer approach toward individuals. In feminine cultures, even men display more sensitive, understanding, and cooperative attitudes [51].

Barutçugil [55] notes that feminine cultures encourage humility, sensitivity in relationships, harmony, and social solidarity, while Seymen et al. [56] emphasize that in these cultures individuals avoid self-promotion, value human relationships over material gain, and focus on improving quality of life. In masculine cultures, ambition, achievement, and recognition are primary motivators, whereas in feminine cultures importance is placed on maintaining healthy relationships with managers, sustaining workplace cooperation, and ensuring conditions that provide satisfaction in one's living environment [57].

In masculine cultures, gender-based discrimination is frequently observed in managerial positions, often manifesting indirectly through "glass ceiling" barriers. Power, money, competition, intelligence, and "macho" identities are valued. Success is measured by performance, and individuals typically "live to work." In feminine cultures, there is no marked gender discrimination in professional roles; modest individuals are appreciated, quality of life is prioritized, and people "work to live" [43].

### 3.5. Short-Term/Long-Term Orientation

The short-term/long-term orientation dimension reflects the balance between the importance given to the past and the meaning assigned to the future. Short-term oriented cultures approach change cautiously, emphasizing adherence to traditions and rules, while long-term oriented cultures embrace change, focus on progress, and display a determined attitude toward building the future [58]. Accordingly, short-term oriented societies focus on the past and present, while long-term oriented societies focus on the future [39].

Long-term orientation—characterized by patience, perseverance, frugality, and investment in the future—differs from Western cultures that focus on short-term success and immediate gains. In high long-term orientation cultures, status-based relationships and persistence are valued, while societies with low long-term orientation emphasize reciprocity, traditional rituals, and preservation of the existing structure [59].

Long-term oriented cultures are defined by values such as adapting traditions to new conditions, personal flexibility, and the belief that life's significant events will occur in the future [60]. In such cultures, individuals are expected to be patient, make decisions aligned with long-term goals, and accept that benefits will be realized over time [61]. Long-term orientation is associated with strategic thinking, future-oriented goals, and determination; short-term orientation is associated with living in the moment, strong adherence to traditional values, and the expectation of quick gains [62].

## 4. THE RELATIONSHIP BETWEEN SOCIETAL CULTURE, ORGANIZATIONAL CULTURE, AND NUCLEAR SAFETY CULTURE

Following the analysis of the relationship between societal culture and organizational culture within the framework of Hofstede's Cultural Dimensions Model, this section addresses the interaction between these two in the context of nuclear safety culture. Organizations such as the IAEA, OECD-NEA, INPO, WANO, NEI, and NRC have conducted various studies on nuclear

safety culture. The first and foundational work in this area was carried out by INPO in the United States, and on a global scale, WANO has developed and continued these efforts. Accordingly, in **Table 1,** the first column lists those of Hofstede's five cultural dimensions considered to have a direct impact on nuclear safety culture, while the second column lists the **ten positive nuclear safety culture traits** identified by INPO and WANO. At this point, with the aim of contributing to the understanding of a positive nuclear safety culture, the characteristics of a negative nuclear safety culture can be listed as follows [63]: the failure to regularly update procedures related to nuclear facility operations; the lack of systematic and in-depth analysis of events occurring during nuclear facility operation and the failure to learn lessons from such events; a significant increase in the number of corrective actions addressing the root causes of events; failure to address and resolve employees' safety concerns without delay; insufficiently open communication channels between employees and senior management; an excessive focus on technical matters while attempting to eliminate human-related weaknesses through engineering solutions; underreporting of near-miss events or faulty conditions; and the lack of self-assessment processes for determining the current state of nuclear safety culture.

In this study, the relationship between societal culture and nuclear safety culture is addressed within the framework of Hofstede's Cultural Dimensions Model as follows.

**Table 1. Nuclear Safety Culture in terms of Cultural Dimensions Model**

| **Cultural Dimensions** | **Positive Nuclear Safety Culture Traits** |
|---|---|
| • Power Distance<br>• Uncertainty Avoidance<br>• Individualism/Collectivism<br>• Short-Term/Long-Term Orientation | Personal Accountability |
| • Power Distance<br>• Uncertainty Avoidance<br>• Short-Term/Long-Term Orientation | Leadership Accountability |
| • Power Distance<br>• Uncertainty Avoidance<br>• Individualism/Collectivism | Respectful Work Environment |
| • Power Distance<br>• Uncertainty Avoidance<br>• Individualism/Collectivism<br>• Masculinity/Femininity<br>• Short-Term/Long-Term Orientation | Questioning Attitude |
| • Power Distance<br>• Uncertainty Avoidance<br>• Individualism/Collectivism | Environment for Raising Concerns |

| | |
|---|---|
| • Masculinity/Femininity | |
| • Power Distance<br>• Uncertainty Avoidance<br>• Individualism/Collectivism | Problem Identification and Resolution |
| • Power Distance<br>• Uncertainty Avoidance<br>• Individualism/Collectivism | Safety Communication |
| • Power Distance<br>• Uncertainty Avoidance<br>• Individualism/Collectivism<br>• Short-Term/Long-Term Orientation | Decision-Making |
| • Power Distance<br>• Uncertainty Avoidance<br>• Individualism/Collectivism<br>• Short-Term/Long-Term Orientation | Continuous Learning |
| • Power Distance<br>• Uncertainty Avoidance | Work Processes |

**Source:** Adapted from [64,65,66,39].

### 4.1. Personal Accountability

In a positive nuclear safety culture, personal accountability refers to employees personally owning their safety-related actions and decisions [67]. Regarding personal accountability, every employee should be aware that they bear personal responsibility for ensuring nuclear safety and should shape their behavior with this awareness. Across every tier of the organization, the effective implementation of practices that ensure individuals assume responsibility and are held accountable for instances of non-compliance with established standards is essential [64].

While personal accountability ideally entails that all employees take ownership of their safety-related responsibilities, cultural values shape this process in varying ways. In organizational cultures characterized by high power distance and strong uncertainty avoidance, the unquestioned execution of superiors' directives may erode employees' self-confidence, diminishing their readiness to take initiative and accept responsibility, and thus adversely impacting personal accountability [7, 68]. Conversely, in cultures with low power distance and low uncertainty avoidance, an atmosphere of trust, solidarity, and collaboration increases motivation to take initiative and creates a strong foundation for personal accountability [33,69]. On the other hand, while personal responsibility is prioritized in individualistic organizational cultures [8], group harmony is the determining factor in collectivist cultures [38]. In individualistic organizational cultures, the ability of employees to freely express their opinions and act independently of their colleagues supports personal accountability. In contrast, collectivist cultural values, where group

harmony takes precedence over individual opinions, may not align with the concept of personal accountability.

Furthermore, in short-term oriented organizational cultures, an emphasis on short-term success and **mindfulness of the present moment** [59], a cautious stance toward change [58], and a low perception of risk [70] may undermine employees' personal ownership of safety-related actions and decisions [67]. In contrast, in long-term oriented organizational cultures, being future-focused [59], embracing change and progress [58], and being more sensitive to potential future risks stemming from today's actions [42] are factors that can strengthen personal responsibility in implementing nuclear safety measures and thus support personal accountability.

### 4.2. Leadership Accountability

In a positive nuclear safety culture, leadership accountability requires keeping personnel, equipment, procedures, and other critical resources always ready, adequate, and operational to ensure the continuity of nuclear safety. Leaders actively engage in field activities to observe, provide guidance, reinforce practices by clearly communicating standards and expectations, promptly detect deviations in operations, and take corrective actions without delay. They prioritize nuclear safety in all decisions and practices, plan activities accordingly, define duties, responsibilities, and authorities clearly to eliminate uncertainties, regularly assess the safety culture, address deficiencies, and monitor improvement opportunities [64].

Leadership accountability is influenced differently by various organizational cultures. Long-term oriented cultures focus on change and progress, assuming that major life events will occur in the future [58,60]. In this context, ensuring the continuity of nuclear safety, keeping personnel and equipment always ready, providing guidance, addressing deviations, planning activities with safety as a priority, and continuously monitoring the safety culture align with long-term oriented values and strengthen leadership accountability.

However, in short-term oriented organizational cultures, low risk perception [70], a focus on quick results and profit maximization [39], and considering safety issues as cost factors to be postponed [8] may push the principle of "treating nuclear safety as the top priority in all decisions and practices" into the background.

### 4.3. Respectful Work Environment

A respectful work environment, as required by a positive nuclear safety culture, encourages employees to voice concerns about nuclear safety, make suggestions, and openly ask questions.

Various perspectives are expressed freely and different opinions are acknowledged with respect. Across the organization, a climate that fosters trust and open communication among employees and teams is encouraged [64].

In organizational cultures with high power distance, subordinates tend to implement decisions of higher authority without question, avoid disagreeing with leaders, and are excluded from decision-making processes [7]. Additionally, communication typically flows top-down and is one-way [70]. Taken together, these cultural traits indicate that employees are generally expected to comply with superiors' decisions without questioning them. In such structures, an environment conducive to sharing concerns and voicing different opinions does not develop.

In contrast, in organizational cultures with low power distance, there is a more egalitarian relationship based on mutual respect between superiors and subordinates [43]. This enables employees to express their thoughts openly and actively participate in decision-making processes [44,45]. In such a cultural setting, employees are able to express their concerns or personal ideas to their superiors with ease.

In organizational cultures with low uncertainty avoidance, there is a high level of trust among individuals, differing ideas are tolerated, and disagreements are accepted as natural [50,33]. Conversely, in cultures with high uncertainty avoidance, adherence to authority is prioritized, order and harmony are valued more than diversity of opinion, and leaders are expected to give clear instructions to reduce uncertainty. Ideas that deviate from established norms are perceived as risks that could lead to unpredictable outcomes [33,43].

In individualistic organizational cultures, individuals tend to express their own opinions openly, whereas in collectivist cultures, adherence to group norms and collectivist thinking is fundamental. This can make it difficult to raise safety culture issues due to the suppression of views that may disrupt group harmony [71]. Moreover, in collectivist cultures, individuals often shape their opinions based on others' views and tend to avoid potential conflicts [39].

Within this framework, in cultures with low uncertainty avoidance where new ideas are not excluded but rather encouraged, individuals feel free to express themselves, and individualistic cultures can more easily thrive in a respectful work environment. In contrast, in collectivist cultures, the primacy of group norms makes it harder to create a basis for the free expression of individual opinions.

### 4.4. Questioning Attitude

Within the scope of a positive nuclear safety culture, the characteristic of a questioning attitude is based on employees critically assessing safety processes and continually reviewing existing practices. In this context, employees constantly assess all risks in detail. They make preventive plans by considering the most adverse possibilities without underestimating any risk. They carefully analyze 'near-miss' events and develop necessary measures by anticipating how such events could turn into actual accidents. They critically question assumptions whose accuracy is uncertain and the conventional mindset of 'it has always been done this way,' and they do not become complacent despite expected success. They adopt a cautious approach by always taking into account the possibility of error and unforeseen problems, explicitly articulate worst-case scenarios, and conduct systematic discussions on potential hazards and possible solutions by asking questions such as 'what if this happens?' [64,21,72].

In high power distance organizational cultures, subordinates' unquestioned compliance with decisions from higher authority, lack of participation in decision-making, and avoidance of disagreements with leaders [7] restrict employees' individual evaluation and critical thinking skills. As a result, features of a questioning attitude, such as challenging existing assumptions, investigating potential risks in uncertain situations, and analyzing possible errors even when there are no apparent issues, cannot be realized. In contrast, in cultures with low power distance, the more egalitarian relationship based on mutual respect between superiors and subordinates [43] and employees' ability to express themselves openly and participate actively in decision-making [44,45] contribute to the development of a questioning attitude.

In high uncertainty avoidance organizational cultures, obedience to the leader's word even in the presence of doubt [42], prioritizing the continuation of the system over addressing detected errors [50], and defending "unchangeable truths" by rejecting different opinions due to concerns about increasing uncertainty [54] are common traits. However, obeying a leader's view without questioning or failing to investigate an issue despite evident risks directly contradicts the core principle of a questioning attitude in a positive nuclear safety culture.

Conversely, in low uncertainty avoidance organizational cultures, tolerance toward differing opinions [51], valuing knowledge instead of seeing it as a source of uncertainty, and attempting to interpret detected clues [54] align with the questioning attitude. Tolerance for diverse ideas enriches thinking and strengthens the applicability of the questioning approach. Valuing knowledge enhances motivation to evaluate different scenarios and analyze new risks. Attempting

to interpret clues rather than ignoring them provides a solid basis for a questioning attitude by focusing on small details to identify hidden dangers and potential risks.

Furthermore, in individualistic organizational cultures, the ability of individuals to act as independent agents rather than as part of a group [50] and to express their opinions freely without pressure to conform to group harmony creates a favorable environment for questioning different ideas [8]. In contrast, in collectivist organizational cultures, individuals' avoidance of expressing different views [71] significantly limits the development of critical thinking and the implementation of a questioning attitude.

The values of feminine cultures—such as affection, compassion, solidarity, cooperation, group-based decision-making, avoidance of conflict, pursuit of consensus, and pressure for harmony—may hinder decisive action in the face of situations that violate safety rules. These cultural traits can suppress critical thinking due to concerns that voicing different opinions may create conflict [57,33,54]. On the other hand, traits emphasized in masculine cultures—such as independent decision-making, self-confidence, determination, and individual initiative—can be said to support the development and application of a questioning attitude [54,33].

In short-term oriented organizational cultures, a cautious approach to change [58], focus on quick results and profit maximization [39], and viewing safety issues as cost factors to be postponed [8] are incompatible with a questioning attitude, which requires prioritizing change and nuclear safety, even if it entails additional costs. Conversely, in long-term oriented organizational cultures, the main tendency is to foresee future risks and outcomes rather than focusing on immediate gains, and to patiently strive for lasting achievements [42,61]. Within this cultural structure, the primary factors that nurture a questioning attitude are the avoidance of time pressure and the obligation to maximize profits, along with valuing long-term and stable efforts in critical areas such as nuclear safety culture over hasty decisions.

### 4.5. Environment for Raising Concerns

For the implementation of a nuclear safety culture, it is essential to establish a work environment where employees can raise safety-related concerns without fear of retaliation or discrimination [64,67]. Such freedom of expression not only facilitates the investigation and reporting of the causes of incidents and near misses but also ensures that mistakes are seen as opportunities for learning rather than grounds for punishment. An environment where employees can report errors and deficiencies without fear of blame is critical to fostering a safety culture that promotes continuous improvement [73].

In organizational cultures with high power distance, limited managerial inclination to consult with subordinates [40], top-down and one-way communication [70], and subordinates' unquestioning compliance with the decisions of higher authority [7] may hinder the free expression of concerns without fear of retaliation. Conversely, in low power distance cultures, a more egalitarian relationship based on mutual respect between superiors and subordinates [43], employees' ability to express their opinions freely [44], and their active participation in decision-making processes [46] can facilitate the expression of concerns without pressure or discrimination.

In high uncertainty avoidance cultures, employees often tend to avoid discussions, openly raising issues, and adopting a critical approach, as such behaviors are generally perceived negatively and assumed to pose a risk of conflict [74]. By contrast, in low uncertainty avoidance cultures, alternative perspectives and suggestions developed outside of established approaches are evaluated positively [43], and differences of opinion are regarded as a natural part of the workplace [33]. Therefore, in cultures with low uncertainty avoidance, employees are more likely to express concerns openly and articulate critical opinions with ease.

Considering that in individualistic and masculine cultures individuals tend to directly express personal opinions, while in collectivist and feminine cultures values such as group harmony, cooperation, and solidarity often act as an internal control mechanism over individual opinions [33,71], it can be stated—though exceptions exist—that, in general, individualistic and masculine cultures provide a more conducive environment for employees to openly express their concerns.

### 4.6. Problem Identification and Resolution

As one of the core requirements of a positive nuclear safety culture, problem identification and resolution involve carefully detecting factors that may affect safety, subjecting them to multi-faceted evaluations, developing effective solutions, and implementing necessary corrective actions. Throughout the process, the priority and significance of each issue addressed are taken into account [64].

In high power distance organizational cultures, unquestioning compliance with superiors' decisions, lack of participation in decision-making processes, and avoidance of disagreements can result in overlooking or failing to report safety risks [7,1]. Top-down and one-way communication limits employees' ability to provide opinions and feedback [70]. Consequently, in such cultures, the inability to identify potential problems in time and the failure to voice risks openly may allow situations that jeopardize nuclear safety to persist.

In contrast, in low power distance cultures, the presence of egalitarian, mutually respectful relationships between superiors and subordinates [43] enables employees to express their ideas openly, provide feedback, and actively participate in decision-making processes [44,45]. This open communication environment facilitates early detection of nuclear safety culture-related issues within the organization and allows for multi-dimensional analyses with contributions from diverse perspectives. Thus, solutions are developed from a broader perspective by incorporating not only senior managers' views but also those of employees.

In high uncertainty avoidance cultures, reluctance to develop innovative approaches to safety issues and strict adherence to rules limit the capacity to produce creative and adaptable solutions to changing risk conditions [41,75]. Conversely, in low uncertainty avoidance cultures, the flexible application of rules and openness to different ideas allow for multi-faceted analyses and the development of effective strategies to address safety-related issues [43].

In individualistic organizational cultures, employees' tendency to express safety concerns directly and openly facilitates early detection of problems and ensures that potential risks are not overlooked [55]. The sense of personal responsibility supports employees' active participation in resolution, enabling timely interventions in critical areas such as nuclear safety. In contrast, in collectivist organizational cultures, the emphasis on speaking on behalf of the group and the tendency to avoid expressing differing opinions [8] can suppress diverse perspectives and lead to blind spots in problem identification.

### 4.7. Safety Communication

In a positive nuclear safety culture, safety communication requires leaders to ensure transparency by clearly and promptly sharing the rationale behind decisions, and employees to communicate honestly, openly, and based on trust with all stakeholders, regardless of hierarchy. This approach is also maintained in relationships with nuclear regulatory authority. Leaders consistently emphasize that nuclear safety is the top priority and reinforce this through their behavior, making it a lasting element of organizational culture [64].

The effectiveness of safety communication is closely related to the level of power distance in organizational culture. In high power distance cultures, leaders have limited tendency to consult with subordinates, and communication is generally top-down and one-way [40,70]. This structure undermines trust among employees, leading them to avoid open communication [33] and, by hindering open, honest, and trust-based information sharing—critical for nuclear safety—limits the timely reporting of risks and the involvement of employees in problem-solving processes.

In low power distance cultures, more egalitarian and mutually respectful relationships develop between leaders and employees. In this cultural structure, employees not only share information but also actively participate in decision-making processes, thereby strengthening internal safety communication [8]. As a result, information about nuclear safety risks can be conveyed upward, potential problems can be detected early, and solutions can be developed.

In high uncertainty avoidance cultures, employees are generally inclined to comply with leaders' instructions without questioning [42]. In such structures, leaders are expected to provide clear, precise, and detailed instructions [33], and individuals tend to avoid openly expressing problems for fear of conflict [74]. This may hinder the development of transparency, openness, and mutual feedback—core requirements of nuclear safety communication—and make it difficult to share and discuss critical risks freely.

Conversely, in low uncertainty avoidance cultures, there is greater tolerance for different ideas, and information sharing is seen not as a threat to rules but as a valuable process for understanding risks and generating solutions [43]. This cultural framework enhances safety communication and supports employees in voicing concerns more freely, reporting potential hazards at an early stage, and contributing possible solutions.

In individualistic organizational cultures, open and direct communication tends to prevail. Employees feel more at ease in expressing their thoughts and concerns straightforwardly [55]. This is a significant advantage for the transparent information sharing, mutual feedback, and proactive risk reporting required in nuclear safety communication.

In collectivist organizational cultures, however, the tendency to preserve group harmony results in more indirect communication [49]. Conflict avoidance and hierarchical sensitivities can make it difficult for employees to express safety-related concerns openly. This can weaken safety communication by preventing the timely sharing of critical information and the early detection of potential hazards.

### 4.8. Decision-Making

In a positive nuclear safety culture, decision-making is based on employees carefully evaluating potential risks, prioritizing prudence, and making decisions that place safety above all else [64].

In high power distance organizational cultures, unquestioning compliance with managerial orders limits employees' ability to make individual assessments and leads to avoidance of disagreements [41,8,39]. The inability of employees to participate actively in decision-making processes results in organizational decisions being made from a narrow perspective [7]. This conflicts with

WANO's requirements for decision-making in a positive nuclear safety culture, as it prevents comprehensive analysis of potential risks and may weaken nuclear safety-focused decision processes.

In low power distance cultures, employees can freely report risky or hazardous situations at an early stage, openly express their opinions, and are not reluctant to disagree with leaders [8,44,33]. In such organizational structures, employees' views and evaluations are taken into account during decision-making processes, enabling potential risks to be addressed comprehensively and laying the groundwork for prudent decision-making.

In high uncertainty avoidance cultures, intolerance toward differing opinions [36], employees' obedience to superiors even when in doubt [42], and prioritization of maintaining the existing system despite clear faults [50] can restrict questioning in decision-making, lead to the disregard of alternative solutions, and cause critical safety issues to be overlooked.

In low uncertainty avoidance cultures, greater tolerance for different ideas and acceptance of conflicts of opinion as natural in the workplace [36,33] make it easier for employees to take a multi-dimensional approach to events and clearly articulate potential risks.

In individualistic organizational cultures, employees act independently in decision-making processes and may have the courage to challenge the decisions of other team members. In collectivist cultures, however, speaking on behalf of the group, maintaining harmony, and unity take precedence, which may prevent open expression of differing views [8]. Therefore, while individualistic cultures contribute to comprehensive risk assessment and the development of creative solutions, the failure to voice differing opinions in a timely manner in collectivist cultures is inconsistent with the decision-making requirements of a positive nuclear safety culture.

In long-term oriented organizational cultures, efforts to anticipate and avoid future risks [42] align with WANO's principles [64] for decision-making, which emphasize prudent analysis, consideration of long-term impacts, and safety-prioritized decisions. Conversely, in short-term oriented organizational cultures, decisions are made primarily with the goal of achieving maximum benefit quickly, leading to the frequent postponement of safety-related measures that increase costs [8]. Furthermore, under the pressure of financial gain, new ideas may be adopted quickly but abandoned just as quickly [39], resulting in superficial and short-term approaches dominating decision-making, insufficient analysis of potential risks, and reliance on temporary measures rather than permanent solutions.

### 4.9. Continuous Learning

A learning organization benefits not only from its own experiences but also from the experiences of others, sharing this accumulated knowledge with other stakeholders [63]. To achieve continuous improvement in a nuclear safety culture, it is essential for organizations to periodically conduct both self-assessment and external evaluation processes. Through these evaluations, "blind spots" in current practices should be identified, areas open to improvement should be determined, and the experiences of high-performing external stakeholders should be systematically utilized [73,67].

Both internal and external experiences must be thoroughly analyzed, and the lessons learned should be implemented without delay. The continuity of learning is only possible not merely by acquiring knowledge but also by transforming it into behavior and system improvements. Therefore, organizations should routinely assess their programs, practices, and safety performance in a self-critical and objective manner, and convert these assessments into concrete improvement actions [64].

In high power distance organizational cultures, leaders consult with subordinates to a limited extent [40], and managerial statements are generally accepted as correct without being questioned [70]. This leads to a top-down, one-way flow of information, preventing employees' experiences and observations from contributing to learning processes.

In low power distance cultures, employees can freely express their thoughts [44] and actively participate in decision-making processes [46]. This enriches the organization with diverse perspectives and strengthens collective learning capacity through experience sharing. Thus, the learning process becomes multi-voiced and dynamic rather than top-down and unilateral.

In high uncertainty avoidance cultures, risks are typically managed through unquestioning obedience to superiors [42] and strict adherence to legislation, rules, and procedures [48]. This tendency to distance oneself from different viewpoints and solution proposals [41] can limit innovative thinking and learning processes. Conversely, in low uncertainty avoidance cultures, deviations from generally accepted approaches are welcomed [43], and openness to diverse perspectives enriches and sustains organizational learning.

In individualistic cultures, employees' ability to make independent decisions and challenge the decisions of team members [8] encourages critical thinking and multi-dimensional evaluations within the organization. This facilitates the open expression of safety-related problems [55] and creates opportunities to learn from mistakes. In contrast, in collectivist cultures, avoidance of openly expressing different views [8] and the reluctance to share risks and safety gaps due to

concerns about disrupting group harmony can cause organizations to miss learning opportunities and repeat similar mistakes.

In long-term oriented organizational cultures, the embrace of change with the aim of building the future [58] supports continuous learning processes, openness to innovation in line with long-term organizational goals, and constant self-improvement based on lessons learned. In contrast, in short-term oriented cultures, the focus on immediate gains and short-term success [39] and the cautious approach to change [58] can restrict learning processes.

### 4.10. Work Processes

An organization adopts nuclear safety as a core priority and structures all planning, control, and implementation processes in accordance with this understanding. Each work process is based on the careful identification of potential nuclear safety risks and their effective management, in line with the scope of the work to be carried out. To ensure that processes are conducted in alignment with nuclear safety culture, comprehensive, accurate, and up-to-date documentation is prepared, reviewed regularly, and updated as needed. Employees contribute to the sustainability of the nuclear safety culture by fully adhering to processes, procedures, and work instructions [64].

To ensure that nuclear safety is prioritized in all organizational processes and to prevent compromising safety due to technical or administrative arrangements, integrated management systems are applied that provide a holistic approach encompassing safety, health, environment, security, quality, human and organizational factors, and social and economic considerations [26]. The manner in which nuclear safety risks are identified in these processes varies according to organizational culture.

In high power distance cultures, work processes are largely directed from the top down. Employees' tendency to follow superiors' instructions without questionioning [55] may lead them to refrain from acting even if they notice risks during work, relying instead on managerial statements, and consequently delaying the timely reporting of potential hazards [8]. Conversely, in low power distance cultures, employees are more willing to report risky situations without delay [8]. This participatory approach enables work processes in which nuclear safety is prioritized to be carried out more effectively and proactively.

In high uncertainty avoidance cultures, employees are expected to comply fully with procedures and instructions [64]. However, defining safety processes with overly detailed regulations and rigid rules can reduce flexibility in decision-making, hinder rapid response to dynamic risks, and foster an attitude resistant to different perspectives and innovative solutions [76,41,75]. This can

reduce work processes to mere regulatory compliance, turning the safety culture into a formalistic and rule-bound structure [38].

## 5. AN EVALUATION OF THE CHERNOBYL NUCLEAR POWER PLANT ACCIDENT IN TERMS OF THE IMPACT OF SOCIETAL AND ORGANIZATIONAL CULTURE ON NUCLEAR SAFETY CULTURE

Employees working in organizations related to nuclear power plants are at the same time members of the broader societal culture. Organizational culture is regarded as a subculture shaped by the societal culture in which it exists, and societal culture is transferred into the organization through individuals. The values, attitudes, and behaviors adopted during the process of socialization in society also influence organizational culture [16,8]. Within this framework, it is of importance to evaluate whether the societal cultural values of Ukraine, where the Chernobyl Nuclear Power Plant Accident occurred, supported the characteristics of a nuclear safety culture. According to Hofstede's Cultural Dimensions Model, Ukraine's cultural values show the following scores (out of 100): high power distance (92), high uncertainty avoidance (90), low individualism (25), relatively low masculinity (45), and high long-term orientation (86) [33, 39]. Before examining the impact of these cultural values on the Chernobyl Nuclear Power Plant Accident and nuclear safety culture, it would be appropriate to consider the factors that led to the accident. Looking at the sequence of events that caused the accident, the following points stand out:

- The nuclear plant operators cut the steam supply to the turbine generator in order to determine whether the residual energy of the turbine generators could continue to power the plant's vital systems for a short time in the event of a loss of off-site power. The flow of cooling water from the pumps began to decrease. As the coolant flow decreased and due to turbine generator inertia, boiling intensified because of the positive void coefficient, and power levels rapidly increased [81]. The factor that caused the increase in power was that only 6–8 control rods were left engaged instead of the minimum of 30 required by safety standards, while the remaining rods were withdrawn. However, in the case of a sudden power surge, lowering the control rods to shut down the reactor took about 20 seconds. Although the operators attempted to raise all the control rods manually to increase the power to 700 MWt, the reactor stabilized at around 200 MWt. Nevertheless, the operators decided to continue with the test [78]. When the reactor power could not be brought back to the targeted 700 MW(th) level, instead of halting and evaluating the situation, the operating staff directly altered the test conditions according to the existing circumstances [79].

- At the 36th second of the test, the operators attempted to lower the control rods, but an insufficient number of rods entered their positions. In less than three seconds, the power rose to 530 MWt, the fuel heated rapidly, and a massive steam explosion followed [81].

- The INSAG-1 report states that the disabling of the Emergency Core Cooling System was a practice contrary to procedures, yet at Chernobyl it was actually permitted with the chief engineer's approval [79]. Just before the start of the test, computer printouts had warned operators that the reactor was losing its emergency shutdown capability. However, the late hour, operator fatigue, and impatience led to managerial insistence on completing the test. If the test could not be completed, the next opportunity would have required waiting until the following annual maintenance period [81].

When the role of the societal cultural values of employees working in organizations related to the Chernobyl Nuclear Power Plant in the chain of events leading to the accident is evaluated from the perspective of Hofstede's Cultural Dimensions Model, the following assessments can be made:

Despite encountering an unexpected situation in the process of increasing power generation to 700 MWt, where the reactor stabilized at around 200 MWt, the operators continued to try to raise the power by fully withdrawing all control rods. Accordingly, when the reactor became unstable, they sought to lower the control rods once more [81,78]. While all this was happening, instead of halting the test as they should have, the operators altered the existing test conditions and continued the experiment. This demonstrates that there was organizational pressure to complete the test, and that this pressure caused operators to violate procedures [79]. Noncompliance with procedures and ad-hoc decision-making contributed to the rapid escalation of the accident [79,84,85]. The test start time had been delayed due to electricity production demands, causing it to extend into the nighttime hours and forcing fatigued operators to make decisions under high pressure [81]. In the conflict between potential economic gains from electricity production and the requirements of safety, priority was given to economic factors and power generation. The system of incentives and penalties for operating personnel, combined with the ingrained habit of achieving targets "at any cost" when encountering difficulties in the test program, created pressure that led to violations of operating procedures [79].

The issues summarized above, which demonstrate the weakness of the safety culture in the organizations where the operators and other personnel involved in the sequence of events leading to the Chernobyl Nuclear Power Plant Accident were employed, reflect organizational cultural

characteristics such as high power distance, high uncertainty avoidance, low individualism, low masculinity, and high short-term orientation. Explanations on this matter are presented below.

Although it was contrary to procedures, the deactivation of the Emergency Core Cooling System with the authorization of the chief engineer [79], together with the operators' decision to continue the test by altering conditions rather than halting it and their improvisational deviation from procedures, illustrates that instructions from hierarchically superior managers were executed without question. Indeed, in organizations with high power distance, work processes are largely directed from the top down. Employees tend to follow orders from superiors without questioning them [55]. This situation leads employees, even if they notice risks during work, to refrain from acting according to their own judgment and from reporting potential dangers in a timely manner, because they place trust in the statements of their managers [8].

In organizations with high power distance, the tendency toward uncertainty avoidance is also generally high [8]. In such organizations, employees cope with uncertainty by obeying their superiors' words, even when they have doubts [42]. While, on the one hand, managers are expected to give clear instructions in these organizations [43], on the other hand, even when deficiencies and errors in the system are recognized, maintaining the existing system is considered the primary priority [50], and those in positions of authority are preferred not to be questioned [44]. This situation produces a cultural structure where safety is disregarded rather than prioritized [42]

In organizational cultures characterized by low individualism and high collectivism, employees tend to conform to the general opinion of the group rather than voice their own ideas. Maintaining group harmony is regarded as more important than individual accuracy [39]. In feminine organizational cultures, emphasis is placed on social relations and group harmony [55], whereas in masculine cultures, individual opinions are prioritized [54]. As seen in the case of disabling the Emergency Core Cooling System despite the fact that it was against procedures—yet continuing with the test based on the approval of the chief engineer [79]—all operators involved acted by prioritizing group harmony rather than expressing individual concerns. This demonstrates the characteristics of a highly collectivist and feminine organizational culture.

On the other hand, while short-term oriented organizational cultures focus on short-term profits and outcomes, long-term oriented organizational cultures emphasize strategic goals and greater future returns [39]. At the Chernobyl Nuclear Power Plant, prioritizing economic factors and electricity production over safety requirements in the conflict between electricity-related profits and safety considerations; the system of incentives and penalties applied to operating personnel; the aim of achieving predetermined goals at any cost when encountering difficulties in the test

program [79]; and the insistence on completing the test to avoid postponement until the following year's maintenance period [81] all reflect characteristics of a short-term oriented organizational culture. However, according to Hofstede's study, Ukraine—where the Chernobyl Nuclear Power Plant Accident occurred—culturally belongs to the group of long-term oriented countries [39]. This seemingly contradictory situation can be explained by the fact that no generalization is valid for all individuals and organizations within a society; rather, generalizations reflect an average trend for that culture [86].

When the Chernobyl Nuclear Power Plant Accident is examined in terms of nuclear safety culture characteristics, the following assessments can be made:

During the test process, the fact that cutting the steam supply to the turbine generator would reduce coolant flow, which in turn would intensify boiling in the reactor and lead to a rapid increase in power and the disintegration of fuel elements; that maintaining only 6–8 control rods instead of the minimum 30 required by safety standards would not be sufficient to safely shut down the reactor [78]; and that the graphite tips located at the lower ends of the control rods in RBMK reactors would adversely affect the SCRAM emergency shutdown system during the test [79] were not questioned. A cautious approach was not applied in these matters, and the STAR principle—which summarizes a prudent approach in cases where safety concerns are suspected, consisting of Stop–Think–Act–Review—was ignored [80].

Conducting the test after disabling the safety system demonstrates that, on the part of employees, "personal accountability"—defined as personally owning decisions, assuming responsibility, and being accountable—was low; and on the part of managers, "leadership accountability"—defined as ensuring that nuclear safety is the overriding priority in all decisions and actions—was also low. It further shows that potential risks were not carefully evaluated and that decisions were not taken with a prudent approach. As the IAEA has pointed out, most nuclear incidents and accidents stem from the absence of preventive measures or the failure to question decisions with a cautious mindset [6].

As a result of managerial insistence, the continuation of the test in violation of procedures is considered to have negatively affected not only the aforementioned nuclear safety culture characteristics of "personal accountability," "leadership accountability," "questioning attitude," and "decision-making," but also the following additional characteristics: subordinates' avoidance of disagreements with managers undermined the characteristic of a "respectful work environment" [7]; employees' reluctance to adopt a critical stance due to the risk of conflict weakened the characteristic of an "environment for raising concerns" [74]; subordinates' tendency to ignore

safety-related problems to avoid conflicts with superiors undermined the characteristic of "problem identification and resolution" [7,1] and the predominantly top-down and one-way nature of communication negatively affected the characteristic of "safety communication" [70].

On the other hand, although the fuel damages that occurred in Unit 1 of Leningrad in 1975 and in Unit 1 of Chernobyl in 1982 served as serious warnings in terms of reactor safety, due to insufficient communication and information sharing among operating organizations, the Chernobyl personnel were not aware of the causes and consequences of these accidents [79]. In this context, the failure to take past lessons into account and, instead, the unquestioned obedience to superiors' instructions undermined the characteristic of "continuous learning." Moreover, the failure to define all work processes by considering potential nuclear safety risks and to update them regularly, as well as the employees' failure to fully comply with processes and procedures [64], negatively affected the characteristic of "work processes."

## 6. CONCLUSION

Societal culture constitutes the foundation of safety-related values and attitudes, which in turn play a critical role in shaping the safety culture of organizations [8]. The perception of safety developed in individuals through the process of socialization directly affects employees' understanding of safety in the workplace [70]. Individuals' social values are primarily shaped by the societal culture in which they live [39]. Indeed, a study conducted on employees of multinational companies found that organizational culture influences individuals' safety behavior, while societal culture influences organizational culture [82].

Nevertheless, although the influence of societal culture on organizational culture is recognized, the role of organizational culture in shaping safety culture must also be acknowledged. In cases where societal culture does not support the required safety culture, the values instilled within the organization can bridge this gap [8]). Organizational culture represents the shared beliefs, values, norms, and behaviors of its members [17], and can become distinctive through the contributions of employees from different societal backgrounds, thereby shaping their safety-related behaviors [83]. Each organization possesses a safety culture aligned with its own organizational culture, which develops through its unique dynamics [8]. In this context, it is essential for leaders to act as role models by implementing nuclear safety culture, while employees need to assume responsibility for embracing and practicing this culture [26,65].

The understanding that nuclear safety cannot be ensured solely through technical or engineering measures has brought the human and organizational dimensions to the forefront, revealing the reality that in nuclear power plants—socio-technical systems—technical and social factors cannot

be evaluated separately [5]. In this context, the IAEA [6] emphasizes that nuclear safety must be addressed holistically in its technical, mechanical, and human factor dimensions. Although engineering and technological solutions can be developed for mechanical problems, if there is a lack of safety culture among the human actors implementing these solutions, such measures cannot be effectively realized. Therefore, while focusing on engineering and technology, it becomes imperative not to relegate the human factor in the context of safety culture to a secondary position. When the impact of the five dimensions of societal culture on the attributes of nuclear safety culture is evaluated on the basis of Hofstede's Cultural Dimensions Model, it can be observed that, as in the organizational cultures operating the Chernobyl Nuclear Power Plant, cultures characterized by high power distance, high uncertainty avoidance, collectivism, femininity, and short-term orientation lead to outcomes such as uncritical compliance with higher authority's decisions and avoidance of disagreement with leaders [7]; consideration of thoughts outside customary patterns as a source of threat and risk due to their unpredictable consequences [43]; suppression of opinions that may disrupt group harmony, thereby preventing safety-related issues from being voiced [71]; conflict avoidance and pursuit of consensus in line with values of solidarity and cooperation [57]; prioritization of quick results and profit maximization [39]; and the deferral of safety issues when regarded as cost factors [8]. These outcomes, in turn, negatively affected the fundamental components of a positive nuclear safety culture—particularly personal accountability, a respectful work environment, a questioning attitude, a suitable environment for raising concerns, and safety communication, as well as all other safety culture attributes.

On the other hand, it can be argued that cultures characterized by low power distance, low uncertainty avoidance, individualism, masculinity, and long-term orientation would have the opposite effects, thereby positively influencing the characteristics of a positive nuclear safety culture.

## DECLARATION OF ETHICAL STANDARDS

The author of the paper submitted declares that nothing which is necessary for achieving the paper requires ethical committee and/or legal-special permissions.

## CONTRIBUTION OF THE AUTHOR

**Necati Yamaç:** Conceptualization, Writing, Review & Editing.

## CONFLICT OF INTEREST

There is no conflict of interest in this study.

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