

IPRA Tool Compatibility Test for the International Nuclear Power Plant Construction

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This paper introduces the risks for nuclear power plant construction. The relative risks of the nuclear plant projects are investigated using content analysis. The determined risk elements are organized by the types of resources such as Material, Money, Manpower, and Machinery. These terms are called ‘4M’ in the construction industry. This paper addresses five resource types, namely ‘5M’ by adding ‘Management’ as a considerable resource for nuclear power plant projects because management supplies, supports, and aids the construction project to meet the expectations of the project participants. The frequency of determined risks are then counted by consistency analysis to identify the corresponding risks. Last, this paper proposes the relative risk assessment elements of the International Project Risk Assessment (IPRA) tool for the pre-project development of the nuclear power plant construction.

Key Words: Pre-Project Development, International Project Risk Assessment, Cause and Effect Analysis, Nuclear Power Plant Construction

Introduction

Nuclear power comes to the fore as an energy resource, even though various other resources have been on the rise (Cres, 2014). Because natural energy resources are restricted as promising energy sources, nuclear energy is a sustainable resource that uses minimal resources to generate maximum energy (Ahearne, 2012). The global demands for nuclear power plants reflect the significance of nuclear power as shown in Figure 1. In 2012, 14 countries ordered 66 nuclear reactors (Brutoco, 2014), 13 countries were in progress for construction of 60 nuclear power plants in 2013 (WNA, 2013), and 72 nuclear energy facilities are being constructed in 2014 all over the world (NEI, 2014). This constant global demand shows nuclear power is a practical promising solution as a substitutive energy resource (Salazar, 2011).

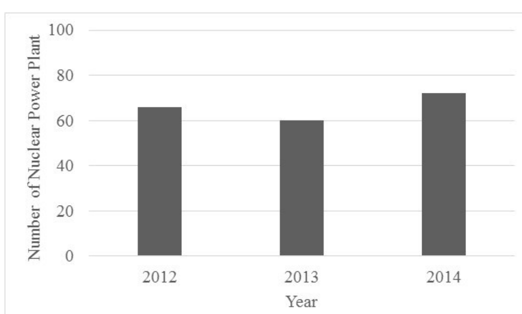

Figure 1: Recent Number of Nuclear Power Plant Constructions

The humanity has seen the advantages of nuclear power as a substitute energy source and many countries keep have an abiding interests in constructing power plants. However, nuclear and radiation accidents can be fatal and it is difficult to clean up radioactive contamination when nuclear power plants are damaged by natural or the man-made disasters. Table 1 shows the seriousness of the radioactive pollution in some nuclear disasters.

Table 1

List of three nuclear power plant accidents

Jurisdiction	Direct Victim	Indirect Victim	INES	Date	Country	Reference
Kyshtym	49 – 55	6,000	Level 6	Sep. 29 1957	USSR	(William, 2009)
Chernobyl	30	4,000	Level 7	Apr. 26 1986	Ukraine	(IAEA, 2011)
Fukushima	0	People who are exposed to radiation	Level 7	Mar. 11 2011	Japan	(WHO, 2013)
Note. The direct victims are those who died in the accident. (Approximately) The indirect victims are those who died due to radiation exposure. (Approximately) International Nuclear Event Scale (INES): Index of the significance of radioactive contamination						

The best techniques must be considered for nuclear power plant projects to avoid the nuclear disasters. The countries that are seeking nuclear energy import the relative techniques of the nuclear reactor and the plant construction to prevent accidental radioactive spills. Thus, nuclear power plant constructions have become international projects usually because six countries, France, Japan, America, Russia, Canada, South Korea and Argentina are world-class experts in nuclear power and export their nuclear techniques for power plant construction to other countries (IAEA, 1978) (NPP Exporters, 2008). Thus, each country that has a plan to build a power plant needs to pay close attention when selecting nuclear technology among the world's main vendors of nuclear power plants.

Problem Statements

Nuclear power plant project participants, including international construction project participants, need to set up a strong project coordination meeting to be on the same page for enhanced project performance without relative risks. However, the existing risk analysis studies of nuclear power plants are limited to case studies. Thus, the major risks need to be determined for future nuclear plant projects. Last, a tailored project coordination meeting is needed for international project risk assessment, especially nuclear plant construction.

Methodology

Qualitative Conventional Content Analysis

The conventional content analysis which is a way to code categories that originated from the texts is used to determine the main risks (Hsiu-Fang, H., 2005). Five representative papers are picked among relative papers to determine the most often mentioned risk elements as shown below.

1. The Future of Nuclear Power in the United States by John F. Ahearne et al., 2012
2. The US Nuclear Industry: Current Status and Prospects under the Obama Administration by Sharon Squassoni, 2009
3. Nuclear Power – Global Status and Trends by Yuri Sokolov & Alan McDonald, 2006
4. The Future Role of Risk Assessment in Nuclear Safety by R. Niehaus, 1985
5. Risk Management of Knowledge Loss in Nuclear Industry Organizations by IAEA, 2006

Paper 1. The Future of Nuclear Power in the United States by John F. Ahearne et al. 2012

In summary the major aspects of this paper include (Ahearne, 2012):

- Public Mistrust – Overcoming public mistrust is one of the major risk elements after the Fukushima disaster.

- Licensing – A complicated licensing process is a risk. The Energy Policy Act wanted to resolve this time consuming procedure by a simple licensing process for new nuclear reactors in 1992.
- Financing –Nuclear projects are planned as government policy. Thus, nuclear power plant construction totally relies on the loan guarantees of the administration.
- Competitive Unit Cost – Basically, nuclear power plant construction costs are higher than other types of plant constructions.
- Lack of Standardization – The paper emphasizes standardization in construction processes. Incorrect estimated baseline cost is considered one of the failed regulatory standardization policies. The weak standardization results in a rise in the costs of construction materials, equipment, workforces, and engineering efforts. The Nuclear Regulatory Commission (NRC) highlights that minor changes created by a lack of standardization become the major changes of the entire system.
- Inability to Accurately Estimate – Complicated and cutting-edge technologies regarding nuclear reactors are susceptible to the closest cost estimation.
- Changing Regulation – Unstable regulations result in additional actions to make up for the changing regulations. Plant design should be changed to meet the increasing awareness of risks.

Paper 2. The US Nuclear Industry: Current Status and Prospects under the Obama Administration by Sharon Squassoni, 2009

In summary the major aspects of this paper include (Squassoni, 2009):

- Lack of Standardization – Insufficient rigor in radioactive contamination protection standards, reactor safety, and project siting were some of the safety and regulation concerns.
- Cost Overruns – Improvements have been proposed to decrease cost overruns that include new licensing procedures to obtain construction and operating licenses simultaneously. In 2005, the Energy Policy Act introduced an incentive combination that contains tax credits, loan guarantees, and insurance.
- Changing Regulation – Non-fixed regulation is a risk that causes projects to fail.
- Design Change – A slight design change causes other relative parts of the design change.
- Financing – Project budget procurement is another risk because a nuclear project requires immense initial costs.
- Fee Increase by Contract Type – Nuclear power plant construction usually uses a cost-plus construction contract to shift risks to the government. Since the plant is constructed for the public, the proper contract is a cost-reimbursement. However, the contract types of international projects depend on the domestic government's preference. Thus, the contract type influences the contractor's profit.
- Competitive Unit Cost – Coal and natural gas are still cost-effective and nuclear power plant construction is far more complicate than other plant constructions. Nuclear energy projects need to have competitive and viable options with a long-range view to generate energy for the public.
- Lack of Construction Experience – Since nuclear energy projects involve complicated procedures including licenses, design, and regulations, it is difficult for the contractors to have adequate construction experience. This risk is related to final project quality.
- Need for Outsourcing – Nuclear power plant projects compete with other large infrastructure projects such as oil infrastructures exacerbating finding and hiring a qualified workforce to build the power plant.
- Lack of a Safe Waste Repository – The Nuclear Regulatory Commission policy does not allow a license to operate a nuclear power plant without a safe waste repository. Thus, the development of permanent waste repositories affects nuclear reactor constructions.

Paper 3. Nuclear Power – Global Status and Trends by Yuri Sokolov & Alan McDonald, 2006

In summary the major aspects of this paper include (McDonald, 2006):

- Economics –Cost-competitiveness compared to substitute energy resources is a risk to the acceptance of nuclear power plant construction.

- Financing – The high capital costs and financing available are challenges for developing countries to cover the entire nuclear power plant project lifecycle include the required support infrastructure such as the cooling system, waste management system, and fuel cycle management system.
- Regulatory Risk – Since a nuclear energy project needs various approvals such as legal processes, political support, and licensing, the project can be delayed.
- Unique Characteristics and Situations for Various Countries – No single solution exists for plant projects. The topographic conditions of each country should be considered in selecting the proper plant system. If it is difficult to construct the cooling system in some countries, the nuclear power plant projects are not the right resource to generate energy.

Paper 4. The Future Role of Risk Assessment in Nuclear Safety by R. Niehaus, 1985

In summary the major aspects of this paper include (Niehaus, 1985):

- Design factors – Nuclear power plant design is a significant risk. There are 40 critical design factors that reduce design related risks. However, design problems still exist.

Paper 5. Risk Management of Knowledge Loss in Nuclear Industry Organizations by IAEA, 2006

In summary the major aspects of this paper (IAEA, 2006) include:

- Talent Loss, Recruitment Difficulties – The international nuclear contractor is challenged to find a qualified workforce and local suppliers in the domestic country due to the lack of experience of the workforce with nuclear energy projects. The inexperienced local workforce needs to complete a training program before working on complicated nuclear power plant projects.

Cause and Effect Analysis

The fishbone diagram, shown in Figure 2, displays the content analysis results which are overall causes of hazards of nuclear power plant projects.

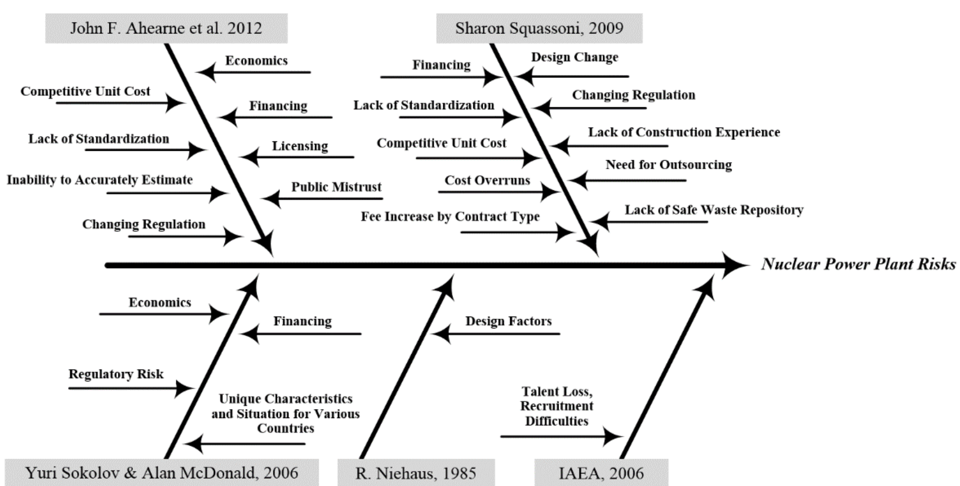

Figure 2: Fishbone Diagram of Content Analysis Results

Results

After reviewing the relative risk elements, which are in the discrete conditions, six overlapping risks were discovered. The meaning of repeated risks is that those risks can be major risks for the next generation of nuclear energy projects. The emphasized risks are shown in Table 2.

Table 2

Emphasized Risks for the Nuclear Power Plant Construction

No.	Repeated Risks
1	Financing
2	Changing Regulations
3	Lack of Standardization
4	Design Change
5	Economics
6	Recruitment Difficulties

Re-Categorized Nuclear Power Plant Construction Risks

Identified risks are sorted by the types of typical resources which are manpower, machinery, materials, and money (Moavenzadeh, 2007). For nuclear power plant construction, the seven determined risks are difficult to put in the existing '4M' resource categories. Thus, management is added as a category of resources because management supplies, supports, and aids the construction project. Thus, the risks are re-categorized as '5M' for the consistency analysis to verify the emphasized degrees of the identified risks as shown in Figure 3. Numbers are assigned as the risk item numbers and color coded items are the repeated risks.

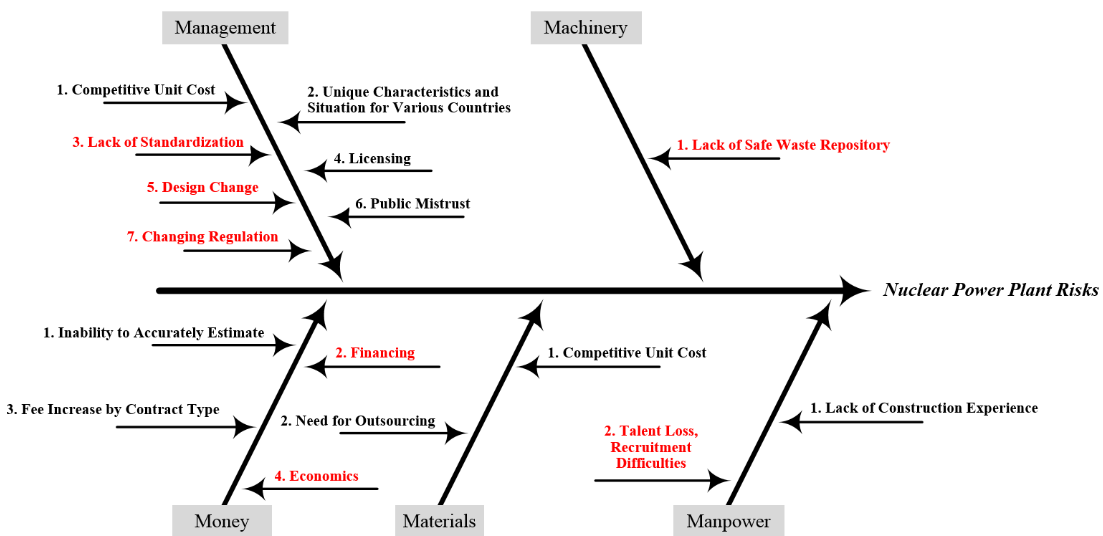

Figure 3: Rearranged Identified Risks for the Nuclear Power Plant Construction

Consistency Analysis Results

The determined nuclear power plant project risks are verified by a consistency analysis to determine how many times the identified risks appeared on five representative papers. The lack of a safe waste repository, which is not overlapped in the content analysis results, appeared eight times through the consistency analysis. This means that this is a unique risk that should be considered significant for nuclear power plant construction only. It relates to the licensing and permitting issues of the project. The most significant risks can be design change, financing, and economics. Thus, this risk can be considered as an extension of the licensing risk. This means that the design of a nuclear plant is complicated and any minor design changes can result in major design changes that cause cost overruns and the re-engineering. Also, a stronger design is required to prevent radiation leak by a natural disaster to after the Fukushima disaster in 2011. Basically, the government is essential for loan support because private industry or the utility providers have higher risks in constructing the nuclear power plant. Thus, the government invites bids from the international professional contractors for sound nuclear power plant construction. To support the international projects, financing sources and economics are important considerations from the beginning of the project to the end. Estimation about whether the government can secure the financing is a key at the feasibility study step where the global economic conditions and the government financial conditions are considered before giving notice to the international vendor to proceed. Changing regulations are derived from complicated approvals, legal procedures and political support. Last, the recruitment risk is derived from the difficulty of hiring a qualified and experienced local workforce because nuclear power plant constructions are basically international projects and the nuclear reactor systems should be dealt with carefully to prevent any accidents. The consistency analysis results are shown in Table 3.

Table 3

Consistency Analysis Results

No.	Element Description	Frequency
1	Design Change	17
2	Financing	12
3	Economics	9
4	Lack of Safe Waste Repository	8
5	Lack of Standardization	7
6	Changing Regulation	5
7	Recruitment Difficulties	3

Required Perspective for the Nuclear Power Plant Project Risk Assessment Tool

The major project participants are made up with the international contractors and a domestic owner also known as a government. The risk assessment tool requires the transition perspective which is public-private partnership between the business and the government to assess the project soundly. The well-balanced transition risk assessment tool is key to coordinate both the government and business participants for the nuclear power plant projects because both public and private parts have imperative actions and their demands as shown in Figure 4 (KPMG, 2012).

Figure 4: Imperative Actions of Public-Private Coordinated Project

International Project Risk Assessment (IPRA) tool for the Nuclear Power Plant Project

The value of this tool is evaluated as the best practice status of the Construction Industry Institute (CII) because it has well-balanced perspectives between the international contractor and the domestic owner. Also, the IPRA tool has a hierarchy structure that contains four sections that break down into 16 categories that have 82 risk elements with the likelihood of occurrence and relative impact for the project assessment as shown in Figure 5 (Walewski, 2005).

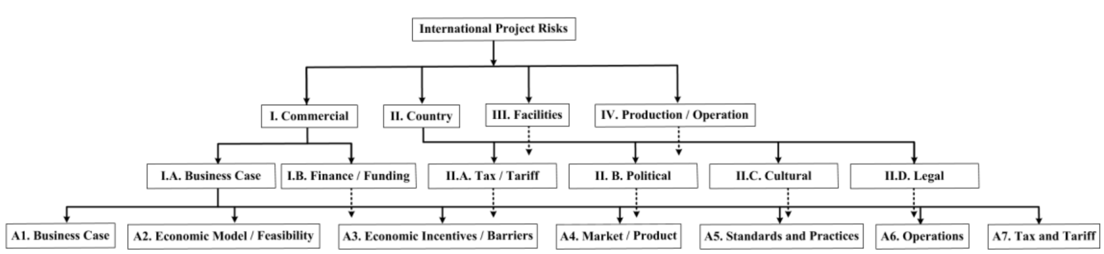

Figure 5: IPRA Breakdown Structure

Discussion

Examination of Variable Relationships

Thus, the assessment results are considered to decide whether the owner should give the notice to proceed. Since the IPRA tool deals with the identified risks, the IPRA tool can apply for the international nuclear power plant projects. The relationship between the items of the casual fishbone diagram and the possible corresponding IPRA elements of the fishbone diagram is as shown in Figure 6. The color codes are the likelihood of risks occurring with the relative IPRA elements. The meaning of an asterisk is that the relative element is from the 'I.B. Finance/ Funding' category.

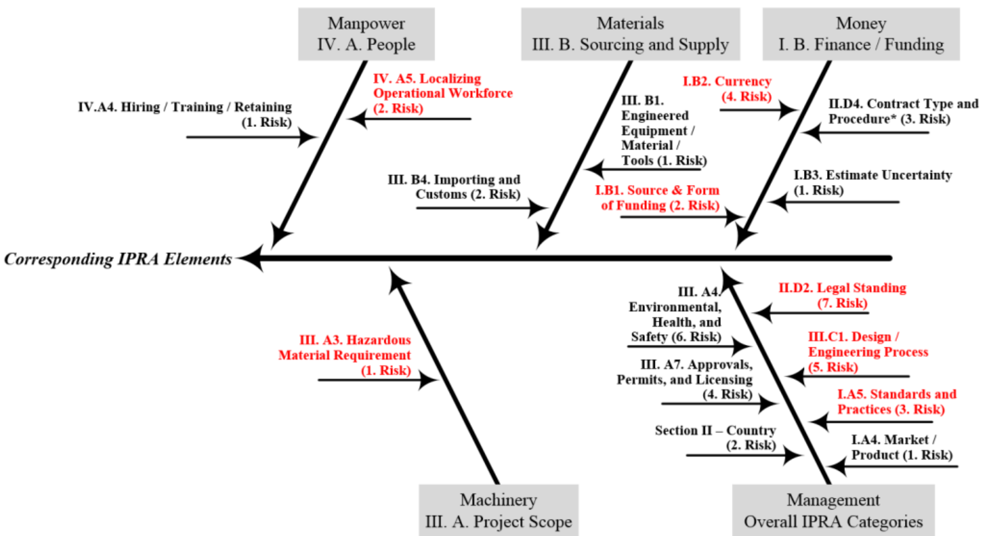

Figure 6: Corresponding IPRA Elements for the Determined Nuclear Power Plant Risks

Conclusion

Nuclear fuel is a sustainable and eco-friendly energy resource. Thus, nuclear power plants are substitute energy plants for the next generation. However, misused nuclear has hazardous aspects at the same time. Thus, this paper determines nuclear power plant risks and verify the identified risks through various analysis. Also, the project participants need to use the adequate risk assessment tool at the pre-project development step. This paper proposes the IPRA as the one of the possible international nuclear power plant project risk assessment tools that contains the well-balanced perspective for the public-private coordinated projects. Last, this paper shows the corresponding IPRA elements with the determined risks.

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