RISK FRAMEWORK

FOR THE NEXT GENERATION NUCLEAR POWER PLANT

CONSTRUCTION

A Thesis

by

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ABSTRACT

Uncertainty can be either an opportunity or a risk. Every construction project begins with the expectation of project performance. To meet the expectation, construction projects need to be managed through sound risk assessment and management beginning with the front-end of the project life cycle to check the feasibility of a project.

The Construction Industry Institute's (CII) International Project Risk Assessment (IPRA) tool has been developed, successfully used for a variety of heavy industry sector projects, and recently elevated to Best Practice status. However, its current format is inadequate to address the unique challenges of constructing the next generation of nuclear power plants (NPP). To understand and determine the risks associated with NPP projects, the goal of this thesis is to develop tailored risk framework for NPP projects that leverages and modifies the existing IPRA process.

The IPRA has 82 elements to assess the risks associated with international construction projects. The modified IPRA adds five major issues (elements) to consider the unique risk factors of typical NPP projects based upon a review of the literature and an evaluation of the performance of previous nuclear-related facilities. The modified IPRA considers the sequence of NPP design that ultimately impacts the risks associated with plant safety and operations. Historically, financial risks have been a major chronic problem with the construction of NPPs. This research suggests that unstable regulations and the lack of design controls and oversight are significant risk issues.

This thesis includes a consistency test to initially validate whether the asserted risks exist in actual conditions. Also, an overall risk assessment is performed based on the proposed risk framework for NPP and the list of assessed risk is proposed through a possible scenario. After the assessment, possible mitigation strategies are also provided against the major risks as a part of this thesis.

This study reports on the preliminary findings for developing a new risk framework for constructing nuclear power plants. Future research is needed for advanced verification of the proposed elements. Follow-on efforts should include verification and validation of the proposed framework by industry experts and methods to quantify and evaluate the performance and risks associated with the multitude of previous NPP projects.

ACKNOWLEDGEMENTS

The English word ‘Coach’ comes from the word ‘Kocs’ in Hungarian language. ‘Kocs’ is one of the Hungarian villages that first invented the carriage in the 15th century. The ‘Coach’ carried passengers to their destination and ‘Coach’ helps the sports players to get to their destinations in modern times. I sincerely thank my advisor Dr. John A. Walewski. My various goals were realized with his patience and guidance. I believe that I arrive at my first destination without problems through his positive and progressive coaching.

I truly thank Dr. Ivan D. Damnjanovic, and Dr. Jose Fernandez-Solis. When I was lost in my research, their kindness helped me find the way. Without my committee members, I believe that I would have never arrived at my destination as well. Thank you very much.

I really appreciate my good colleague Amy A. Kim. Her patience and understanding solved every concern or problem. During the difficulty of my first semester studying abroad, I was strongly encouraged by your help. Also, I will never forget her advisor, Dr. Stuart D. Anderson’s thoughtful consideration.

‘Your beginnings will seem humble, so prosperous will your future be’ [Job 8:7]. When I lost my way, my parents always supported me with this line. Here is the fruit of my labor. I dedicate my thesis to my parents. I hope that this thesis will make my parents proud. Lastly, give thanks to God for everything.

Jaeheum Yeon, College Station, Texas, October 2012

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CHAPTER I

INTRODUCTION

The exhaustion of the Earth's natural energy resources has been an ongoing problem. The complete depletion of the energy resources will appear as a realistic problem someday. To avoid global panic, prompt countermeasures should be prepared with sustainable energy resources for the world. Even though many substitutable resources have been on the rise, nuclear energy takes center stage nowadays (Cres, 2012). Typical and well-known energy resources such as coal, oil, or natural gas are not sustainable resources (Ahearne, et al., 2012). To cover appearing problems, nuclear power plant construction is a practical promising solution (Salazar, 2011). For such reasons, the new wave of nuclear power plant construction has become the recent construction trend all over the world. According to the Nuclear Energy Institute reports on May, 2012, 14 countries have already ordered 66 new nuclear power plants to procure the new energy resources for home countries.

Assessing risk factors and preparing countermeasures at the Front-End Planning step of every classic construction project lifecycle is a key to drive to an exact project target as shown in Figure 1 (Walewski, International Project Risk Assessment, 2005). For a plant construction, the risk assessment is more important than any other types of construction projects. Plentiful risks such as plant technologies, design and construction innovations, financing, and regulatory requirements should be considered at the very first part of a plant project (Squassoni, The US Nuclear Industry: Current Status and Prospects under the Obama Administration, 2009). After a nuclear plant project execution, the project struggles with budgeting and scheduling to go along as planned. Realistically, the efforts of on-time and on-budget nuclear power plant construction turn into dreadful results. 75 reactors had cost overruns which is 207 percent higher than the average cost overruns and 100 reactor orders cancelled between 1966 and 1977 in the United States (United States Congressional Budget Office, 2008). Safety, waste, and long term health effects came through the recent Fukushima incident (McClure, 2012). Nonetheless, a nuclear resource verifies a sustainable energy resource and operating nuclear plants is the lowest-cost producer of base load electricity, owners and contractors will meet enormous challenges to build cost effective plants for the next generation (George S. Tolley, 2007).

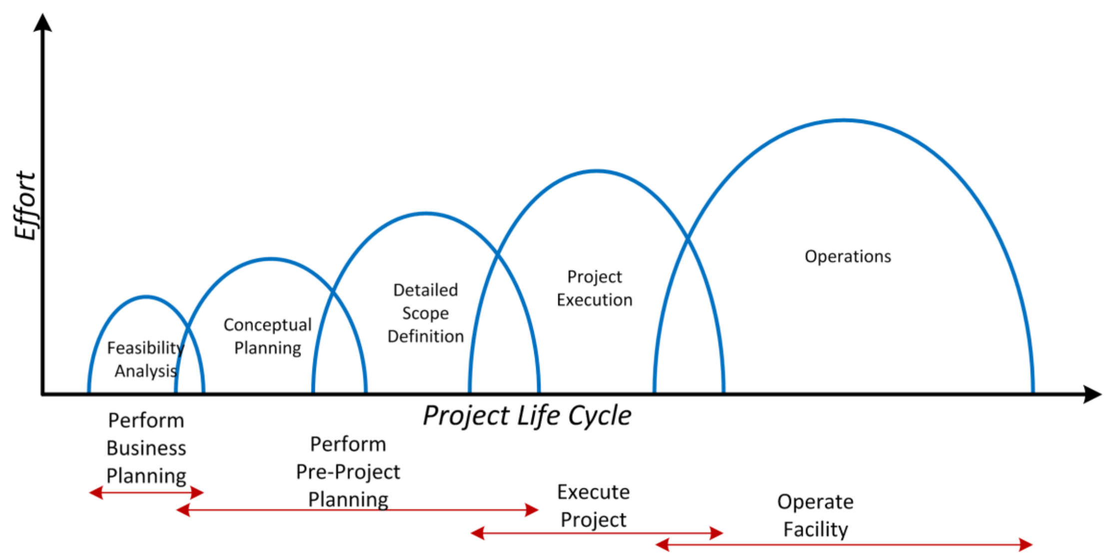

Figure 1 Project life cycle diagram (Walewski, International Project Risk Assessment, 2005)

Even though a well-prepared mitigation strategy is key for a successful project, determining the risk causes is not an easy task. Furthermore, the nuclear power plant projects have more complicated causes with environmental issues than any other construction projects (Ross, 1993). Using the verified risk assessment tool is essential to set-up the proper strategies. One of the spotlighted construction institutes, the Construction Industry Institute (CII) designated the International Project Risk Assessment (IPRA) tool as the best practice nowadays (Walewski, What Is the IPRA?, 2005). For the nuclear power plant project, the existing IPRA with additional proposed elements will be used for risk assessment.

1.1. Problem statement

Many construction risk management reports and tools exist in the real world. Ironically, there are few construction risk assessment reports and tools (Walewski, J., Gibson, E. G., 2003). To assess the NPP synthetically, sound and verified risk assessment tools are required. ASN (Autorite De surete Neclearire) issues the report for NPP safety (Autorité De Sûreté Nucléaire, 2011). However, this report focuses only on the safety area. To figure out the exact risk of a NPP project with overall viewpoints, various considerations should be taken into account. The other assessment methodology is issued by the IAEA (International Atomic Energy Agency), namely, the INPRO (The International Project on Innovative Nuclear Reactors and Fuel) methodology that assesses the overall NPP project. This tool looks like the best assessment methodology and only focuses on technical approaches (IAEA, Lessons learned from nuclear energy system assessment (NESA) using the INPRO methodology. A report of the international project on innovative nuclear reactors and fuel cycles, 2009). This tool does not deal with legal issues and the relationship between the owner and the contractor. Especially, for international projects, understanding, exact communication and the relationship between the host country and the international firms are key factors for a successful project (Walewski, International Project Risk Assessment, 2005). However, the INPRO does not catch various risks because it has a lack of risk considerations.

Furthermore, U.S. NRC developed Probabilistic Risk Assessment (PRA) to assess the NPP projects. This assessment tool has a good logical flow for a NPP. For people's safety, PRA tries to stop the origin of risks. PRA asserts that problems originate from the design. If the design of a NPP is perfect, the problem will not extend to other areas. However, PRA is lacking the same parts as INPRO. The problem is that the well-balanced perspective between the owner and the contractor is insufficient and the broken balance between the host country and the international construction firms is contained.

To cover the inadequacies of the INPRO and PRA, the IPRA can be tailored to assess the NPP projects.

1.2. Research objectives

The primary purpose of this research is to provide a risk framework based on the existing IPRA with identified unique risks for a NPP. Since the existing IPRA focused on general projects such as heavy industry, infrastructure, and building, a plant project has some unique points to be considered as risks such as licensing, permitting, and local suppliers. NPP design should consider the impact of possible natural disasters.

Radioactive contamination is a consequence of the lack of design considerations. Exposure to radioactivity will threaten the safety of people, eventually. Therefore, risks of a NPP should be considered by a proper risk assessment tool at the feasibility step of a project lifecycle. This thesis provides a possible risk breakdown structure with respect to adequate elements of a NPP.

1.3. Research hypothesis

The first hypothesis of this research is that unique risk factors of a NPP can be determined by various literature reviews. Since there are not enough papers that include representative NPP risks, representative NPP risks are defined in this thesis. The second hypothesis of this research is that determined unique risk factors can be matched with the existing international NPP cases. To check consistency between determined NPP risks and the occurred problems of actual NPP projects, consistency is tested by the established global NPP projects. The third hypothesis is that a possible risk breakdown structure can be designed based on the existing IPRA. To assess the risks, the assessment tool should be redesigned with respect to the project characteristics. The last hypothesis is that risk mitigation strategies are feasible suggestions.

CHAPTER II

BACKGROUND

For this topic, an extensive literature review must be utilized. To understand the current trend and problems of Nuclear Power Plant (NPP), deep reviews of presentation slides and reports of the IAEA workshop on construction technology for new nuclear power plants come under the thesis. Among many prominent research institutes, the CII (Construction Industry Institute) has developed some practical risk assessment tools. The IPRA, one of the CII tools, includes the best practices. The IPRA is used to assess the NPP with additional elements. Before the IPRA, the PDRI was used as a matrix. Therefore, the history of project risk assessment tools is reviewed by this thesis.

2.1. The International Atomic Energy Agency (IAEA)

The IAEA was established to prohibit nuclear weapons, use nuclear energy in a peaceful way, and issue nuclear inspection. The IAEA was organized 29 July 1957 and is an independent organization created by the UN. Currently, 155 countries have joined the IAEA. The majority of non-member countries are underdeveloped countries. Specifically, North Korea is one of non-member countries, used nuclear weapons for its own foreign relations. For this problem, IAEA is still trying to do a nuclear inspection. The IAEA opens an annual workshop to solve the chronic problems of nuclear power plants and share the new techniques of NPP. (IAEA, Advanced construction methods for new nuclear power plants, 2012)

2.1.1. IAEA risk assessment methodology for nuclear power plant

IAEA develops the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) as a risk assessment tool to judge whether a constructed NPP is sustainable or not. To determine risks, each NPP risk is selected by Member States such as Research, Development, and Demonstration (RD&D) and any organizations that are interested in a NPP on a national, local, and international perspective at first. Secondly, filtered NPP shortages will be compared by a global standard. Lastly, discrete improvement factors are determined as shown Figure 2 (IAEA, Lessons learned from nuclear energy system assessment (NESA) using the INPRO methodology. A report of the international project on innovative nuclear reactors and fuel cycles, 2009).

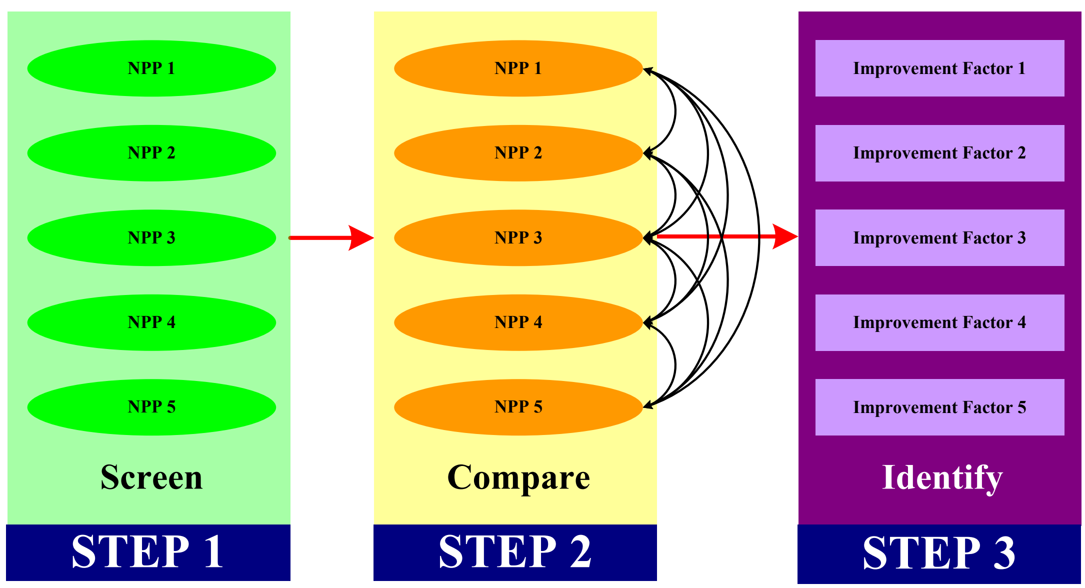

Figure 2 INPRO risk assessment steps

(In here, each displayed number represents the counting of NPP.)

2.2. United States Nuclear Regulatory Commission (U.S. NRC)

The primary purpose of U.S. NRC establishment was the energy reorganization in 1974. Nowadays, the extended roles of U.S. NRC are checking international reactor safety, licensing, renewal, controlling radioactive material, managing the fuel lifecycle. (U.S. NRC, 2011)

2.2.1. U.S.NRC risk assessment methodology for nuclear power plant

U.S. NRC developed Probabilistic Risk Assessment (PRA) as a risk assessment methodology. Before running PRA through a computer, the lack of design, the shortage of the electric system are considered as 'Internal events', and natural disasters are considered as 'External events'. The lack of NPP design (level 1 PRA) can pollute the environment. As a result, the contamination (level 2 PRA) influences people. After all, the design problems impact the safety of people as shown in Figure 3 (U.S.NRC, 2012).

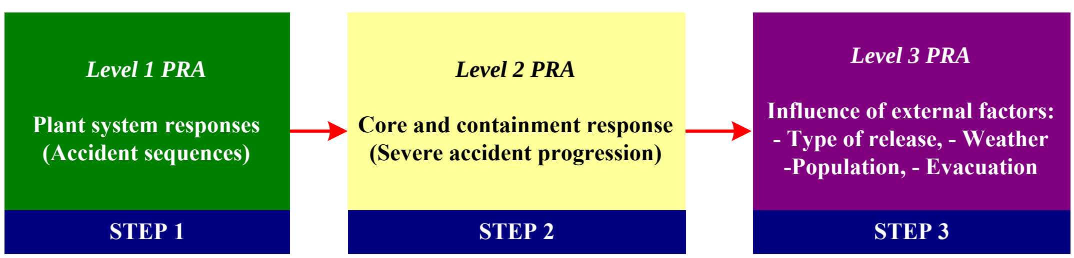

Figure 3 PRA analysis steps (U.S.NRC, 2012)

(In here, each displayed level represents the progress step of NPP.)

2.3. Construction Industry Institute (CII)

For the improvement of overall construction management areas, CII was established in 1983. CII has a great ripple effect in the overall construction area. Many company leaders, faculty members, experts are in CII. CII provides many sound tools for better construction management. Many useful reports are issued by CII continuously (Walewski, What Is the IPRA?, 2005).

2.3.1. CII risk assessment methodology for nuclear power plant

CII has well-developed risk assessment tools. However, there is no risk assessment tool for a NPP. Among many CII risk assessment tools, the IPRA can be tailored for a NPP because a NPP is one of the representative international projects and the IPRA can be modified easily by users. However, experts should verify the designed sections.

2.4. Nuclear power plant (NPP)

Nuclear resources were developed for nuclear weapons initially during World War II. This invention of nuclear resources is also known as the Manhattan project. After the war, the U.S. government tried to use nuclear resources in a positive way. Hence, the Atomic Energy Commission (AEC) was established in 1946. This was a stepping stone to generate electricity with nuclear reactors. After that, the AEC tried to systemize a nuclear power plant. Nowadays, 19.635% of electricity is generated by NPP as shown in Figure 4 (U.S. Department of Energy, 1995).

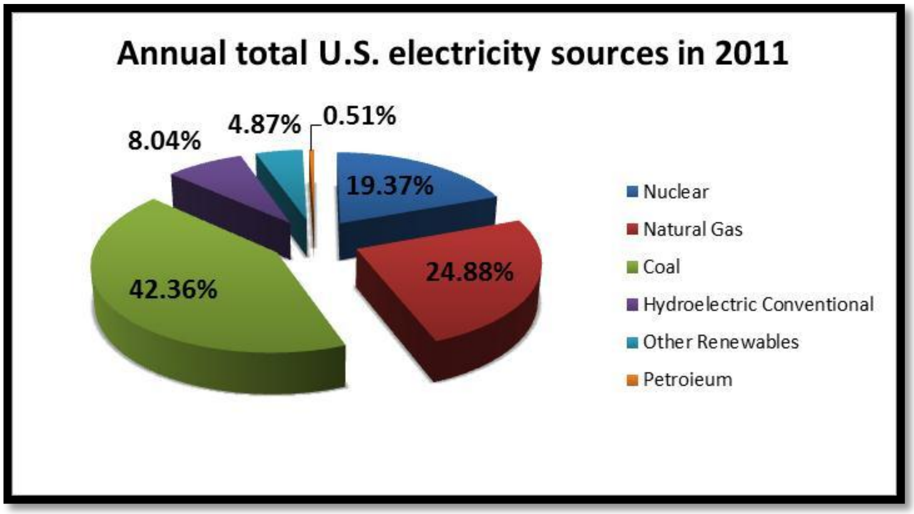

Figure 4 Annual total U.S. electricity sources in 2011 (U.S. Energy Inforamtion Administration, 2012)

2.4.1. Global nuclear power plant status

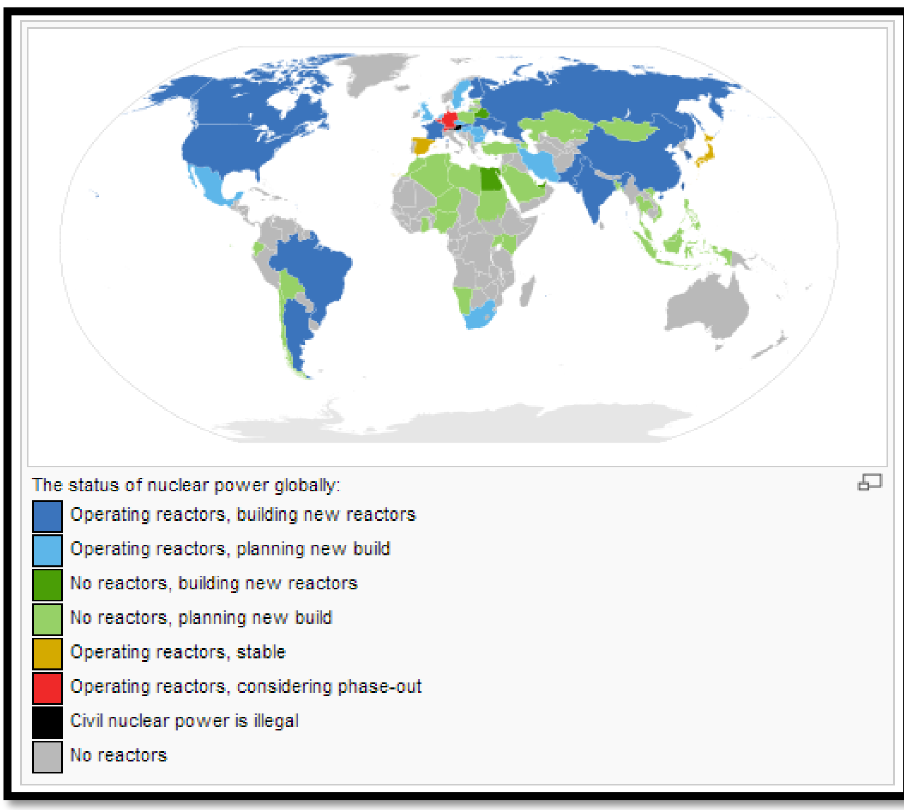

Figure 5 Global NPP status (International Atomic Emergency Agency, 2012)

Figure 5 shows the status of nuclear power plants globally. Except some underdeveloped and developed countries, the majority of countries possesses or is trying to possess atomic power plants. Specifically, NPP constructions are emerging in China because China has observed the advantages of nuclear projects through many countries. Hence, the NPP construction trend increased exponentially until 2010. After the Japan, Fukushima NPP accident on March 2011, the construction trend decreased dramatically as shown in Figure 6.

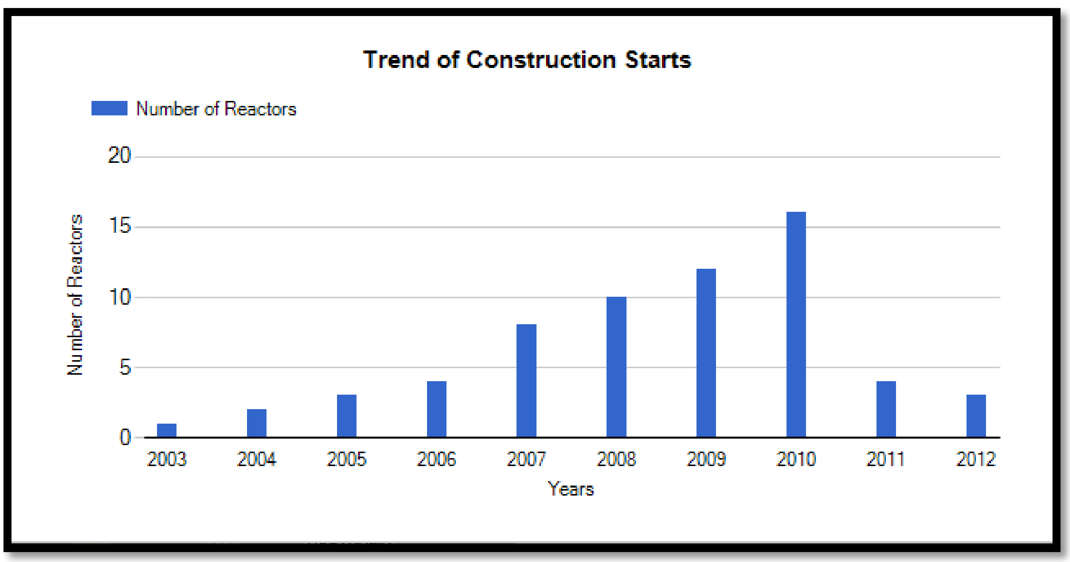

Figure 6 Global NPP construction trend (International Atomic Emergency Agency, 2012)

2.4.2. Current trend of nuclear power plant

A nuclear power plant has a light water reactor as a coolant or a heavy water reactor as a moderator to control the heat of a nuclear reactor. Since a continuous supply of cold water is essential to avoid the overheating of a nuclear reactor, construction of waterfront nuclear power plants is one of the essential conditions for nuclear power plant safety (K. Dobasgi, 1997). Since the weather at the waterfront is variable and harsh with storms, tsunamis, and earthquakes, a nuclear plant is always exposed to dangerous weather and natural disasters. Recently, the Fukushima radioactivity drain incident was a representative incident that was influenced by a natural disaster (Acton J.M., 2012). Radioactivity discharge is connected with the most dangerous and irretrievable disaster. One instance was the Chernobyl nuclear accident in 1986. Chernobyl explosion in 1991 resulted in 4,000 dead and more than 600,000 patients (Burton, 2006). Although NPP is intergraded by enhanced technologies nowadays, people worry about the NPP construction relative to their area. On the financial side, immense capital is usually invested in nuclear power plant projects. To obtain a principal, a plant project takes over 20 years usually. Before final sign up to order a project, the investor needs to recognize waste treatment risks, operational risks, and a long pay-back period (Valerie Levkov, 2011).

Nevertheless, there is no doubt about the nuclear power plant as the next generation sustainable energy resources. The generation unit cost is a more economical and high efficiency resource than any other energy resources. The nuclear energy discharges less carbon dioxide than any other resources as well. It activates all day long with large scale load generation. The possession of nuclear power plant and construction techniques can be a steppingstone to becoming an advanced country (Jean-Marie Bourdaire, 1997)

2.5. Literature review

2.5.1. The project lifecycle of nuclear power plant

Nuclear power plant construction has a unique project lifecycle as shown in Figure 7. A general construction project has 4 steps: perform business planning, perform pre-project planning, execute project, and operate facility. Even though a nuclear power plant project has 4 stages, the same as a general construction project, a lifecycle of a nuclear power plant project has unique steps. A nuclear project progresses two types of life cycles simultaneously. One of the project lifecycles related with preparation of operation capability improvement to generate the nuclear energy. Training to operate a nuclear plant is one of the significant stages. Since training is related with safety directly, experienced instructors, training centers, and national standard education system are required. Another project lifecycle is similar with general construction projects. However, permitting is a significant stage for a nuclear power plant for licenses, approval, and an interest with a local resident. To soothe a high initial investment, local suppliers need to be hired for a nuclear project (Valerie Levkov, 2011).

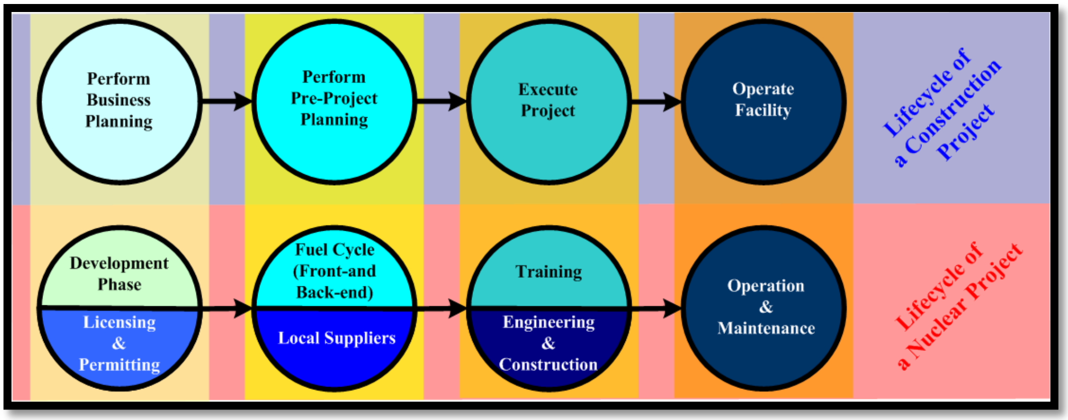

Figure 7 Lifecycle comparison between a general project and a nuclear project (Valerie Levkov, 2011)

Since existing nuclear power plants spend enormous amounts of money over a long construction duration, experts in the construction field insist on a new type of nuclear power plant. The new nuclear power plant has economical construction strategies and an optimized construction schedule. Eco-friendly plans such as global warming mitigation strategy, carbon emission soothing strategy, and nuclear waste storage costs are considered for the new nuclear power plant. After the Fukushima disaster, the construction of nuclear power plant faces the new phase that emphasizes the new earthquake-resistant design (Mujid Kazimi, 2011).

2.5.2. Summary of literature reviews

Many papers were reviewed by the author. After deep literature reviews, the author realized that every paper asserts the same problems. Some major papers with representative risks will be introduced in detail for this thesis. Also, these papers have overlapped risks. To summarize literature reviews of the papers, the fishbone diagram is used as shown in Figure 8. Also, the list of main representative risks is as shown in Table 1.

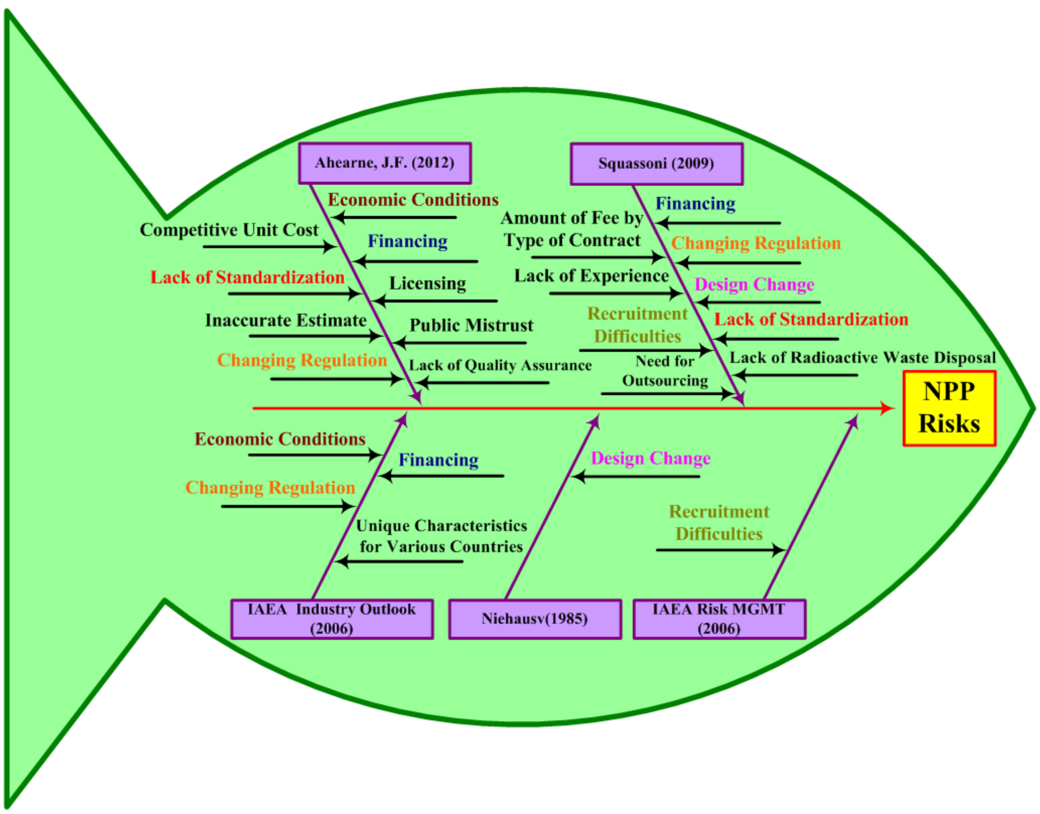

Figure 8 Fishbone diagram for the summary of literature reviews

Table 1 Overlapped risk factors of NPP

Overlapped Significant Risk Factors of NPP
Financing
Changing Regulation
Lack of Standardization
Design Change
Economic Conditions
Recruitment Difficulties

2.5.3. The future of nuclear power in the United States (Ahearne, 2012)

In Summary the major aspects of this paper include:

- **Public Mistrust** - After the Fukushima nuclear disaster, overcoming public mistrust can be one of the major risk factors for NPP construction.
- **Licensing** - Changing and complicated licensing procedures can be a risk factor. The 1992 Energy Policy Act tried to resolve this issue by creating a "one-step" licensing procedure for new nuclear reactors.
- **Financing -** Because of the private market's unwillingness to invest in NPP, the worldwide nuclear industry relies on the government loan guarantee. Thus, the feasibility of the project depends on how much the congress appropriates for loan guarantees for nuclear power plant facilities.

Even with an innovative financing mechanism, the government is essential in supporting the next generation NPP by providing back-end guarantees because the risk is too high for private industry and utility providers.

- **Competitive unit cost -** According to a study by MIT (Lester, 2009), the higher cost of generating electricity compared to other means is a disadvantage and an impediment to building new nuclear power plants.
- **Lack of standardization -** The paper stresses the standardization in construction processes to motivate new construction. According to the Atomic Industrial Forum (AIF), failures to meet the baseline cost estimations were identified as failure of regulatory standardization policies and increased documentation to meet safety standards. Lack of standardization and increased documentation processes leads to increase material, equipment, labor, and engineering effort. Even with standardized design elements, NRC emphasizes and puts forth review efforts of potential changes regarding site features and how these design changes might affect the entire system.
- **Inability to accurately estimate -** Since NPP construction is naturally complex, complicated and new technologies are susceptible with cost underestimation.
- **Changing regulation -** In addition, regulatory standardization is dynamic. It evolves as more knowledge about nuclear technology and side effects become available. Plant designs can continually be modified to meet the growing awareness of threats.

- **Design change brings more change -** Design changes can bring ripple effects. The redesign of one component of the NPP can bring detrimental effects to the entire system leading to cost overruns and accidents. The "Brockett Report" published in early 1971 provides a report of then-current emergency core cooling (ECCS) technology where design inadequacies resulting from not considering the entire functional capability of the system lead to design-based accidents.
- **Lack of Quality Assurance -** Although Quality Assurance (QA) standards are designed to assist and assure quality construction and operation, it is many times overlooked and not properly carried out. The Zimmer plant is an example. NRC inspection found that the deficiencies and defects were too many to carry out and complete the construction. NRC issued a stop-work order. The owner eventually cancelled the project when the new cost estimate to amend the problem became too large to fund. (Ahearne, 2012)
A complicated workforce with hundreds of contractors and subcontractors on site make it challenging to construct NPPs. Nuclear construction work needs high levels of quality control and assurance processes for document activities as well as a strong paper trail of record keeping.
- **Economic conditions -** External risk factors include economic conditions. The construction risk can grow when the demand for electrical power starts to decrease and the commodity costs increase which the owner has no control over.

2.5.4. The US nuclear industry: current status and prospects under the Obama administration (Squassoni, 2009)

In Summary the major aspects of this paper include:

- **Lack of standardization** - Insufficient rigor in radiation protection standard, reactor safety, plant siting, and environmental project were some of the safety and regulation concerns of critics. This problem is connected with cost overruns easily.
- **Cost overruns** - This problem exists for the first generation NPP and the second generation NPP. Improvements have been implemented and proposed to reduce cost overruns in construction of next generation NPP. These include new licensing procedures that combine receiving both construction and operating licenses limiting the interventions that led to delays. The Energy Policy Act of 2005 provides a combination of incentives including tax credits, loan guarantees and insurance.
- **Changing regulation** - These needs also meet changing regulatory requirements. Flexible regulation is the worst risk factor which may drive the project to go wrong.
- **Design change brings more change** - Incomplete designs need to be re-engineered during construction. Since the design of NPP is complicated, a slight change of design can connect with many other parts of the design change.

- **Financing** - NPP construction needs high financing costs. Especially, the initial cost of a NPP project is immense. Thus, the procurement of a project budget is another risk factor.
- **Fee increase with type of contract strategy** - Cost-plus construction contracts are used for NPP usually because the contractor can shift some risks to the government. Basically, the primary purpose of NPP is to benefit the public. Thus, cost-reimbursement contracts are proper. However, some international governments do not prefer this type of contract. Thus, the contractor's profit depends on the type of contract.
- **Competitive unit cost** - The potential growth for NPP depends on its competitors. Coal is still cost-effective and generation of natural gas is also cheaper. Cost of NPP construction is also far more complex than other methods of generating electricity. Significant improvement in construction or subsidies is required to make nuclear energy a competitive and viable option.
- **Lack of construction experience** - Infrastructure challenges include the lack of nuclear construction experience and an aging labor force. With this shortage, the project will be delayed and the final project quality may suffer, as well.
- **Need for outsourcing** - Relying on foreign manufacturers coupled with aging workforces may delay the construction process.

- **Competition with other large infrastructure building** -NPP constructions need to compete with other type of large investment projects such as oil infrastructure exacerbating the need to find qualified workforces to build NPP. Competition among construction of other foreign NPP will create competition for resources.
- **Lack of safe waste repository** - Lack of a permanent waste repository affects the building of nuclear reactors. Without a safe waste repository, the NRC (Nuclear Regulatory Commission) policy will not continue to license reactors. The new NRC regulation is a key to nuclear energy growth.

2.5.5. NPP global status and trends (Sokolov, Y., McDonald, A., 2006)

In Summary the major aspects of this paper include:

- **Economics** - The most important factor is the cost-competitiveness compared to other alternatives to generating electricity. This also depends on what kind of alternative options some countries have and the overall electricity demand.
- **Financing** - Depending on the type of financing available, construction of NPP may or may not be attractive. Challenges within the developing countries are noted as high capital costs, and enough funding to cover infrastructure requirement, waste management and fuel cycle.
- **Regulatory risk** - Depending on the various approvals, legal processes and political support, the investment risk may rise.

- **Unique characteristics and situation for various countries** - There is no single solution for making energy choices. A factor that influences or promotes NPP is growing energy needs, energy security concerns and environmental conscious efforts to reduce greenhouse gas emissions.

2.5.6. Future role of risk assessment in nuclear safety (Niehaus, 1985)

In summary the major aspects of this paper include:

- **Design factors** - 40 possible design factors are critical to reduce the risks relative with design. However, design problems still exist as a significant risk factor currently.

2.5.7. Risk management of knowledge loss in nuclear industry (IAEA, 2009)

In summary the major aspects of this paper include:

- **Talent loss, recruitment difficulties –** Many countries are faced with talent loss with retirement of experienced employees and recruitment challenges as current workforces are seeking opportunities in other regions or industry offering more stability and appreciation for their skills. Similar challenges will occur as the nuclear power industry is anticipated to grow. Lack of qualified workforces coupled with global dynamics present further difficulties in recruiting qualified workers from other countries.

2.6. Rearrangement of risk factors based on “5M’s” with fishbone diagram

Risk factors can be sorted by “5M’s” (Manpower, Machinery, Materials, Money, and Management) as shown in Figure 9. According to Figure 9, 7 risk factors related to management, 4 risk factors are relative with money, materials have 2 risk factors each, and machinery has 1 risk factor. These risk factors are not all about NPP risks. But these risk factors can represent negative impacts for NPP.

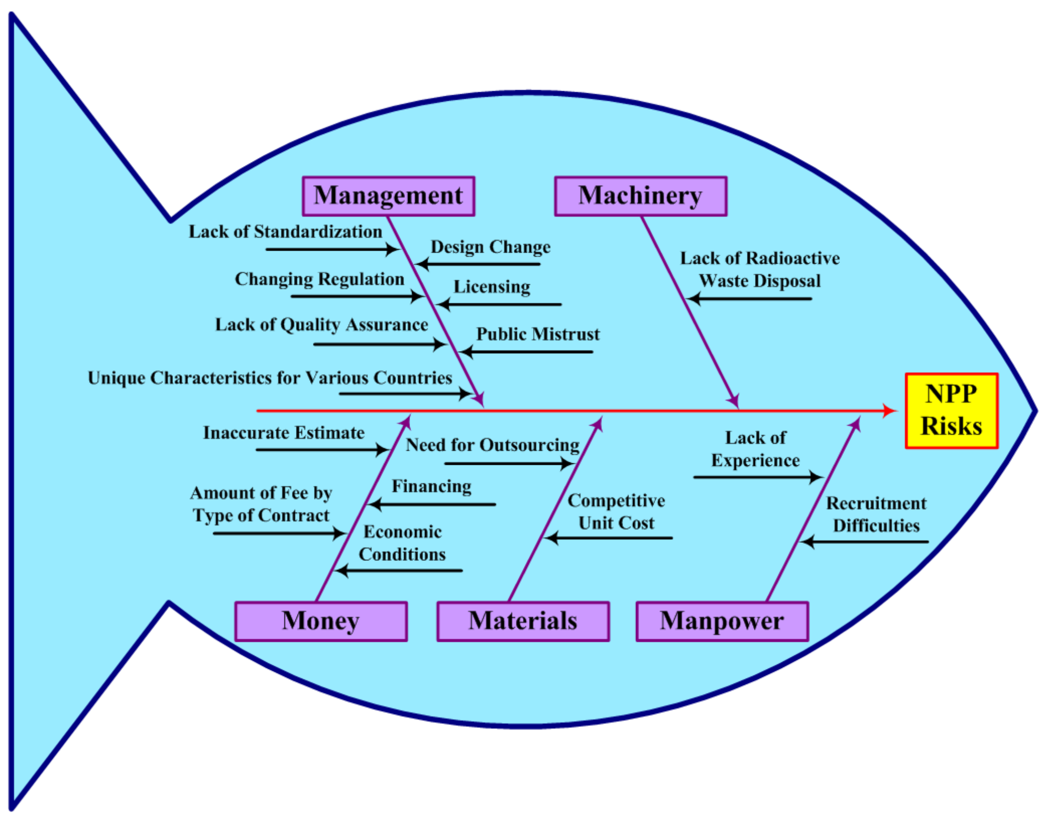

Figure 9 Risk factor rearrangement

2.7. Unique risk factors for construction nuclear power plants

The entire 82 IPRA risk elements were evaluated. The research team hypothesized that there may be other significant risk factors that are unique to constructing nuclear power plants. Key sources of relevant publications and proceedings were reviewed which originated from International Atomic Energy Agency (IAEA), Nuclear Regulatory Commission (NRC), Organization for Economic Co-operation and Development (OECD) and Center for International Governance Innovation (CIGI).

2.7.1. The three key issues identified as most significant were

2.7.1. A. Design changes (III. C1.)

Incomplete designs required re-engineering during the construction phase. Since the design of NPP is complicated, a slight change of design correlated with many other parts of the system leading to cost overruns and, in severe cases, lead to accidents. NPP design changes with respect to stronger seismic designs have been emphasized frequently after the Fukushima disaster.

2.7.1. B. Financing (I. B1.)

Since private market's unwillingness to invest in nuclear power, the US nuclear industry relies on the government loan guarantee. Thus, the feasibility of the project depends on how much the congress appropriates for loan guarantees for nuclear power plant facilities. Even with innovative financing mechanisms, the government is essential in supporting the generation of next generation NPP by providing back-end guarantees because the risk is too high for private industry and utility providers.

2.7.1. C. Economic conditions (I. B2.)

External risk factors include economic conditions. The construction risk can grow when the demand for electrical power starts to decrease and the commodity costs increase which the owner has no control over.

2.7.2. Four additional issues that seemed to be problematic (in order of significant frequency) were included

2.7.2. A. Radioactive waste management (V. A1. – the NEW element)

The delay and failure of disposal of spent nuclear fuel and waste bring a negative image of nuclear energy. Without adequate space for waste repository, licensing new construction of nuclear power plants is also questionable.

2.7.2. B. Lack of standardization (I. A5)

Insufficient rigor in radiation protection standards, reactor safety, plant siting, and environmental projects were some of the safety and regulation concerns of critics. According to Atomic Industrial Forum (AIF) failure to meet the baseline cost estimations were identified as failure of regulatory standardization policies and increased documentation to meet safety standards. Lack of standardization and increased documentation processes lead to increase in material, equipment, labor and engineering effort and eventually cost overruns.

2.7.2. C. Changing regulation (II. D2.)

Depending on the various approvals, legal processes and political support the investment risk may rise.

2.7.2. D. Recruitment (IV. A5)

Infrastructure challenges include the lack of US nuclear construction experience and aging labor force. NPP constructions need to compete with other type of large investment projects such as oil infrastructure exacerbating the need to find qualified workforce to building NPP.

Table 2 summarizes the most significant issues as identified from existing database based on frequency. Elements are described with the corresponding IPRA Element number.

Table 2 IPRA risk elements with significant frequency

IPRA Element	Element Description	Frequency
III. C1.	Design Change	17
I. B1.	Financing	12
I. B2.	Economic Conditions	9
V. A1.	Radioactive Waste Management	8
I. A5	Lack of Standardization	7
II. D2.	Changing Regulation	5
IV. A5.	Recruitment Conditions	3

2.7.3. Data mining through relative bibliography

The author counted the identified risks through bibliography manually. Basically, the author tried to count the identified risks as the word itself. Also, the author considered the relative contents as counting when the author counted the identified risks. The list of bibliography is shown in below.

- IAEA Annual Workshop Presentation Data (December, 2011)
    - ✓ IAEA role in developing infrastructure for new NPPs and activities in construction
    - ✓ New nuclear build (Why becoming a strong owner / operator is essential?)
    - ✓ Reactors & services experience in design and construction
    - ✓ Nuclear research reactors in support to nuclear development
    - ✓ Regulation of nuclear safety and radiation protection in France
    - ✓ Institute for radiation protection and nuclear safety
    - ✓ Nuclear power program in the Czech Republic
    - ✓ Construction technology for new nuclear power plants
    - ✓ Modularization construction experiences of World first AP 1000 unit
    - ✓ OL3 project in France
    - ✓ Nuclear consultancy and engineering services

- ✓ Current status and plans for nuclear construction in South Africa
- ✓ Flamanville 3 EPR construction oversight
- ✓ Safety analysis methodology for the EPR institute for radiation protection and nuclear safety
- ✓ Construction experience feedback lessons learned
- ✓ AFCEN general organization and ETC-C code roadmap
- ✓ Earthquake-proof pads of JHR project
- ✓ Preparation for long term operation
- ✓ Experience feedback processing in France
- ✓ Challenges & successes of Candu energy in nuclear construction: Case study of China and Romania
- ✓ Key factors siting issues
- ✓ Site selection process
- ✓ Construction technology in ATMEA1
- ✓ Supply chain organization
- ✓ TSNP general introduction
- ✓ NP experience in SGR-RPRZ and RPVHR
- ✓ Flamanville 3
- ✓ Pre-operations
- ✓ French sites for nuclear power plants public consultation and stakeholder engagement
- ✓ State oriented approach, independent nuclear safety line

- IAEA Constructing a Model for Safe Nuclear Energy (2010)
- IAEA Averva OL3 Project Status (2011)
- IAEA Building Nuclear Power Egypt EIDesoky NPPA (2011)
- IAEA Comparative Energy Option (1999)
- IAEA Con, Commission Experience (2004)
- IAEA Development Infrastructure for New NPP (2011)
- IAEA Environmental Consideration (2011)
- IAEA Finance NPP (2012)
- IAEA Managing the First NPP (2007)
- IAEA Risk Assessment (2001)
- IAEA Risk In UK Nuclear Safety Decision-Making (2011)
- IAEA Risk MGMT Knowledge Loss (2006)
- IAEA Role of Risk Assessment (2011)
- IAEA Safety Standard (2000)
- IAEA Waste Trend (2002)
- IAEA Advanced Construction Method (2010)
- IAEA Industry Outlook (2006)
- IAEA Nuclear Energy Future Paper (2009)
- IAEA Nuclear Energy Report (2012)

- IAEA / IIASA Joint Research Project for Risk Assessment
- US NRC US Nuclear Regulatory Commission Retrieved from US NRC (2011)
- US NRC Atomic Energy Commission (2012)
- US Congressional Budget Office, Nuclear Energy's Role in Generating Electricity 2 (2008)
- US Energy, The History of Nuclear Energy (1995)
- MIT EIP Drivers of NPP (2009)
- MIT The Growth of Nuclear Power: Drivers and Constraints (2009)
- OECD Outlook (2008)

2.8. Fukushima nuclear accident emphasizes the design change of a NPP

A strong earthquake and tsunami struck Fukushima, Japan on March 11, 2011. The Fukushima NPP was damaged as a result of this natural disaster. To protect nuclear projects from harsh natural disasters, many actions are suggested by organizations and experts; such as stronger seismic designs and emergency actions. Most of all, the enhanced designs are emphasized. Released radioactive is spreading through the Pacific as shown in Figure 10. To prevent nuclear disaster, the design changes have been emphasized frequently after the Fukushima accident.

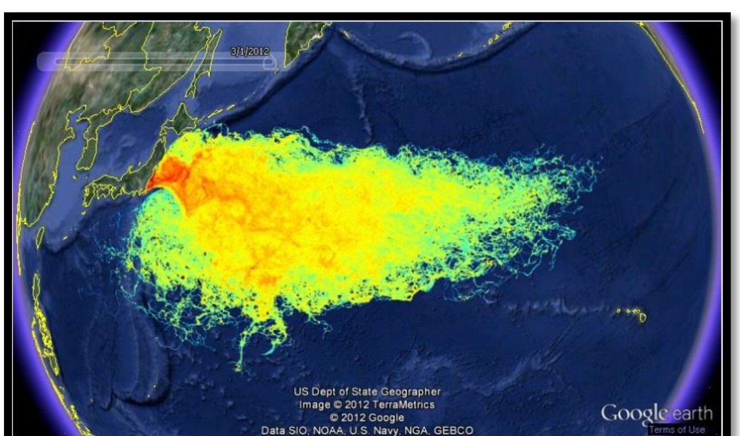

Figure 10 Radioactive seawater impact map on March 2012 (Natural News, 2012)

2.9. Verifications of unique risk for NPP

2.9.1. Consistency test

The purpose of consistency test is to confirm whether the risks that identified with the extensive bibliography are impacted to the actual nuclear power plant projects or not. The test was performed by the author with the global perspective. Consistency test was focused on cost performance and schedule performance to check the construction performance. Also, the causes of poor construction performance are provided through Table 3.

In order to verify that the issues identified are significant to constructing nuclear power plants, a preliminary list of project performance data were collected. 130 actual international NPP projects were observed to find project performances as shown in Table 3.

Summarized 17 actual international cases with project performances were included cost and schedule information and identified or recorded causes for poor performance as shown in Table 4.

Table 3 Historical project performance information

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
1	Embalse	EMbalse, Cordoba, Argentina.	No info	No info	No info	No info
2	Atucha 1	Buenos Aires, Argentina	No info	No info	No info	No info
3	Metsamor	Mersamor, Armenia	2	Ongoing, But already over budget	Ongoing	**Lack of standardization**
4	Doel	Doel, Belgium	No info	No info	No info	No info
5	Tihange	Tihange, Belgium	No info	No info	No info	No info
6	Angra 1	Angra, Brazil	No info	No info	No info	No info
7	Kozloduy	Kozloduy, Bulgaria	No info	No info	No info	No info
8	Qinshan	Qinshan, China	No info	No info	No info	No info
9	Temelín	Temelín, Czech Republic	1	Over budget	Behind Schedule	**Recruitment Conditions**

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
10	Dukovany.	Dukovany, Czech Republic.	No info	No info	No info	No info
11	Olkiluoto	Olkiluoto, Finland	2	Over budget	Behind Schedule	**Radioactive Waste Management**, **Lack of Standardization**
12	Loviisa	Loviisa, Finland	No info	No info	No info	No info
13	Paluel	Paluel, France	No info	No info	No info	No info
14	Flamanville	Flamanville, Manche, France	1	Over budget	Behind Schedule	**Design Change**
15	Penly	Penly, France	No info	No info	No info	No info
16	Gravelines	Gravelines, France	No info	No info	No info	No info

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
17	Chooz	Chooz, France	No info	No info	No info	No info
18	Cattenom	Cattenom, France	No info	No info	No info	No info
19	Nogent	Nogent, France	No info	No info	No info	No info
20	Dampierre	Dampierre, France	No info	No info	No info	No info
21	Belleville	Belleville, France	No info	No info	No info	No info
22	Saint-Laurent	Saint-Laurent, France	No info	No info	No info	No info
23	Chinon	Chinon, France	No info	No info	No info	No info
24	Civaux	Civaux, France	No info	No info	No info	No info
25	Blayais	Blayais, France	No info	No info	No info	No info
26	Golfech	Golfech, France	No info	No info	No info	No info
27	Bugey	Bugey, France	No info	No info	No info	No info
28	Saint-Alban	Saint-Alban, France	No info	No info	No info	No info

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
29	Superphénix	Superphénix, France	2	Over budget	Behind schedule	Economic Conditions
30	Cruas	Cruas, France	No info	No info	No info	No info
31	Phénix	Phénix, France	No info	No info	No info	No info
32	Tricastin	Tricastin, France	No info	No info	No info	No info
33	Marcoule	Marcoule, France	No info	No info	No info	No info
34	Cadarache	Cadarache, France	No info	No info	No info	No info
35	Kahl am Main	Kahl am Main, Germany	No info	No info	No info	No info
36	Rheinsberg	Rheinsberg, Germany	No info	No info	No info	No info
37	Obrigheim	Obrigheim, Germany	No info	No info	No info	No info
38	Greifswald	Greifswald, Germany	No info	No info	No info	No info
39	Stendal	Stendal, Germany	No info	No info	No info	No info

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
40	Kaiga	Kaiga, India	2	Over budget	Behind schedule	**Financing**
41	Kakrapar	Kakrapar, India	No info	No info	No info	No info
42	Madras	Kalpakkam, India	No info	No info	No info	No info
43	Narora	Narora, India	No info	No info	No info	No info
44	Rajasthan	Rajasthan, India	No info	No info	No info	No info
45	Tarapur	Tarapur, India	No info	No info	No info	No info
46	Fugen	Fugen, Japan	No info	No info	No info	No info
47	Monju	Tsuruga, Japan	1	Over budget	Behind schedule	**Incident**
48	Fukushima Daiichi	Fukushima Daiichi, Japan	No info	No info	No info	No info
49	Fukushima Daini	Fukushima Daini, Japan	No info	No info	No info	No info

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
50	Genkai	Genkai, Japan	No info	No info	No info	No info
51	Hamaoka	Hamaoka,Japan	No info	No info	No info	No info
52	Higashidōri	Higashidōri, Japan	No info	No info	No info	No info
53	Ikata	Ikata, Japan	No info	No info	No info	No info
54	Kashiwazaki–Kariwa	Kashiwazaki–Kariwa, Japan	No info	No info	No info	No info
55	Maki	Maki, Japan	No info	No info	No info	No info
56	Mihama	Mihama, Japan	No info	No info	No info	No info
57	Ōi	Ōi, Japan	No info	No info	No info	No info
58	Onagawa	Onagawa, Japan	5	On budget	Ahead schedule	No info
59	Sendai	Satsumasendai, Japan	No info	No info	No info	No info
60	Shika	Shika, Japan	No info	No info	No info	No info

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
61	Takahama	Takahama, Japan	No info	No info	No info	No info
62	Shimane	Kashima-chou, Japan	4	On budget	On time	No info
63	Tōkai	Tōkai, Japan	No info	No info	No info	No info
64	Tomari	Tomari, Japan	No info	No info	No info	No info
65	Tsuruga	Tsuruga, Japan	No info	No info	No info	No info
66	Kori	Gijang, South Korea	No info	No info	No info	No info
67	Uljin	Uljin, South Korea	No info	No info	No info	No info
68	Wolseong	Wolseong, South Korea	No info	No info	No info	No info
69	Yeonggwang	Yeonggwang, South Korea	No info	No info	No info	No info
70	Laguna Verde	Alto Lucero, Mexico	No info	No info	No info	No info
71	Borssele	Borssele, Netherlands	No info	No info	No info	No info
72	Karachi	Karachi, Pakistan	No info	No info	No info	No info

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
73	Chashma	Chashma, Pakistan	No info	No info	No info	No info
74	Cernavodă	Cernavodă, Romania	No info	No info	No info	No info
75	Beloyarsk	Sverdlovsk Oblast, Russia	2	Ongoing	Ongoing	**Financing**
76	Kola	Murmansk Oblast, Russia	No info	No info	No info	No info
77	Bilibino	Bilibino, Russia	No info	No info	No info	No info
78	Leningrad	Sosnovy Bor, Russia	No info	No info	No info	No info
79	Kalinin	Udomlya, Russia	No info	No info	No info	No info
80	Smolensk	Smolensk, Russia	No info	No info	No info	No info
81	Kursk	Kursk, Russia	No info	No info	No info	No info
82	Novovoronezh 1	Voronezh Oblast, Russia	No info	No info	No info	No info
83	Novovoronezh 2	Voronezh Oblast, Russia	No info	No info	No info	No info

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
84	Balakovo	Balakovo, Russia	No info	No info	No info	No info
85	Rostov	Rostov Oblast, Russia	No info	No info	No info	No info
86	Mochovce	Mochovce, Slovakia	No info	No info	No info	No info
87	Bohunice	Jaslovské Bohunice, Slovakia	No info	No info	No info	No info
88	Almaraz	Almaraz, Spain	No info	No info	No info	No info
89	Santa María de Garoña	Santa María de Garoña, Spain	No info	No info	No info	No info
90	Trillo	Trillo, Spain	No info	No info	No info	No info
91	Ascó	Ascó, Spain	No info	No info	No info	No info
92	Vandellòs	Vandellòs, Spain	No info	No info	No info	No info
93	Cofrentes	Cofrentes, Spain	No info	No info	No info	No info
94	Forsmark	Forsmark, Sweden	No info	No info	No info	No info

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
95	Ågesta	Ågesta, Sweden	No info	No info	No info	No info
96	Ringhals	Varberg Municipality, Sweden	No info	No info	No info	No info
97	Oskarshamn	Oskarshamn, Sweden	No info	No info	No info	No info
98	Beznau	Döttingen, Switzerland	No info	No info	No info	No info
99	Leibstadt	Leibstadt, Switzerland	1	Over budget	Behind schedule	**Changing Regulation**
100	Gösgen	Däniken, Switzerland	1	Over budget	Behind schedule	**Design Change**
101	Mühleberg	Mühleberg, Switzerland	No info	No info	No info	
102	Jinshan	Jinshan, Taiwan	No info	No info	No info	No info
103	Kuosheng	Kuosheng, Taiwan	No info	No info	No info	No info

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
104	Longmen	Longmen, Taiwan	2	Over budget	Behind schedule	**Lack of Standardization**
105	Maanshan	Maanshan, Taiwan	No info	No info	No info	No info
106	Rivne	Rivne, Ukraine	No info	No info	No info	No info
107	Khmelnitskiy	Khmelnitskiy, Ukraine	No info	No info	No info	No info
108	South Ukraine	Yuzhnoukrainsk, Ukraine	No info	No info	No info	No info
109	Zaporizhia	Zaporizhia, Ukraine	No info	No info	No info	No info
110	Hunterston	Hunterston, UK	No info	No info	No info	No info
111	Torness	Torness, UK	No info	No info	No info	No info
112	Hartlepool	Hartlepool, UK	2	Over budget	Behind schedule	**Design Change**
113	Wylfa	Wylfa, UK	No info	No info	No info	No info
114	Hinkley Point	Hinkley Point, UK	No info	No info	No info	No info

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
115	Sizewell A	Sizewell, UK	2	Over budget	Behind schedule	**Design Change**
116	Sizewell B	Sizewell, UK	5	On budget	On time	-
117	Dungeness	Dungeness, UK	1	Over budget	Behind schedule	**Design Change**
118	Shoreham	New York, USA	1	Over budget	Behind schedule	**Changing Regulation**
119	3 Mile Island	Pennsylvania, USA	No info	No info	No info	No info
120	Browns Ferry	Alabama, USA	No info	No info	No info	No info
121	Pilgrim	Massachusetts, USA	No info	No info	No info	No info
122	Peach Bottom	Pennsylvania,, USA	No info	No info	No info	No info
123	Nine Mile Point	New York, USA	No info	No info	No info	No info
124	Millstone	Connecticut, USA	No info	No info	No info	No info

Table 3 Continued

No	Project Name	Location	Financial Performance 1 to 5 scale[1]	Cost Info	Schedule Info	Cause if poor performance
125	Crystal River 3	Florida, USA	No info	No info	No info	No info
126	Davis-Besse	Ohio, USA	No info	No info	No info	No info
127	Vermont Yankee	Vermont, USA	No info	No info	No info	No info
128	West Valley	New York, USA	1	Over budget	Behind schedule	**Changing Regulation**
129	Allied-General	South Carolina, USA	1	Over budget	Behind schedule	**Financing**
130	GE	Illinois, USA	1	Over budget	Behind schedule	**Financing**

1 Scale of 1 to 5 with 1 being falling far short of expectations to 5 being far exceeding expectations.

Table 4 Poor performance cases of the international NPP

No	Project / Location	Cost Info	Schedule Info	Cause	Reference
1	Mersamor, Armenia	Over Budget, Ongoing) ($4 billion → $ 5.2 ~ 7.2 billion)	Ongoing (Tentatively 2011 ~ 2017)	Lack of standardization	(Metsamor Nuclear Power Plant Construction, 2012)
2	Temelín, Czech Republic	Over Budget (35 billion CZK → 98.6 billion CZK)	Behind Schedule (1991 → 2000)	Recruitment Conditions	(Dolejší, 2006) (Temelín Nuclear Power Station Constrction, 2012)
3	Olkiluoto, Finland	Over Budget (€2.5 billion → € 5.8 billion)	Behind Schedule (2009 → 2015)	Radioactive Waste Management / Lack of Standardization	(Boxell, 2012) (Olkiluoto Nuclear Power Plant Construction, 2012)
4	Flamanville, France	Over Budget (€3.3 billion → $8.5 billion)	Behind Schedule (2012 → 2016)	Design Change	(International Nuclear Engineering., 2011) (World Nuclear News, 2007)

Table 4 Continued

No	Project / Location	Cost Info	Schedule Info	Cause	Reference
5	Superphénix, France	Over Budget (€9.1 billion → No info as a number)	Behind Schedule (1974 → 1981)	Economic Conditions	(Superphénix Nuclear Power Plant Construction, 2012)
6	Kaiga, India	Over Budget ($141.75 million → $429.98 million)	Behind Schedule (1996 → 1999)	Financing	(Kaiga Atomic Power Station Construction, 2012)
7	Monju, Japan	Over Budget (¥160-170 billion → ¥1.08 trillion)	Behind Schedule (1995 → 2010)	Incident	(Kyodo, 2012) (Monju Nuclear Power Plant Construction, 2012)
8	Beloyarsk, Russia	Ongoing (No info as a number → $1.2 billion)	Ongoing (Tentatively 2012 ~ 2015)	Financing	(Nikiforov, 2001)

Table 4 Continued

No	Project / Location	Cost Info	Schedule Info	Cause	Reference
9	Leibstadt, Switzerland	Over Budget (2 billion francs → 5billon francs)	Behind Schedule (No clear info as a number)	Changing Regulation	(Global Energy Observatory, 2010) (Leibstadt Nuclear Power Plant, 2012) (Leibstadt IAEA Information, 2012)
10	Gösgen, Switzerland	Over Budget (No info as a number)	Behind Schedule (February → November 1979)	Design Change	(Gösgen Nuclear Power Plant Construction, 2012)
11	Longmen, Taiwan	Over Budget (\$6.77 billion → \$46.77 billion)	Behind Schedule (2009 → 2011)	Lack of Standardization	(Longmen Nuclear Power Plant Construction, 2012)
12	Hartlepool, UK	Over Budget (Increasing £25 million)	Behind Schedule (NPP is delayed in 1970)	Design Change	(Patterson, 1985)
13	Sizewell A, UK	Over Budget (£56 million → £65 million)	Behind Schedule (No info as a number)	Design Change	(International Nuclear Engineering, 2007)

Table 4 Continued

No	Project / Location	Cost Info	Schedule Info	Cause	Reference
14	Shoreham, USA	Over Budget ($ 350 million → $5.4 billion)	Behind Schedule (No info as a number)	Changing Regulation	(Squassoni, The US nuclear industry: Current status and prospects under the Obama administration, 2009)
15	West Valley, USA	Over Budget (Additional $2 billion)	Ongoing (From 1980)	Changing Regulation	
16	Allied-General, USA	Over Budget (No info as a number)	Behind Schedule (No info as a number)	Financing	
17	GE, USA	Over Budget (The final cost was $ 64 million)	Behind Schedule (No info as a number)	Financing	

2.9.2. Consistency test results

According to the Figure 11, consistency test results show that identified NPP risks are matched well (94.18 %) with the actual international cases. One case, Monju, Japan, is out of determined NPP risks. The identified NPP risks with frequency are confirmed by the consistency test with the international actual cases. Therefore, the asserted NPP risks are confidential results.

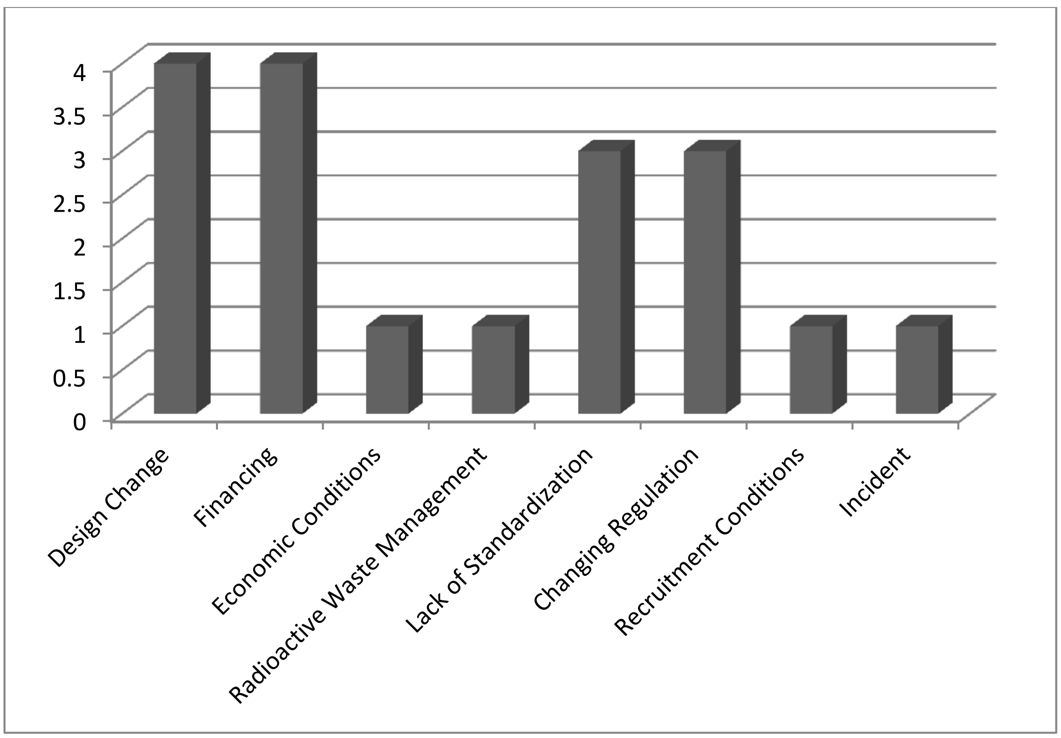

Figure 11 Consistency test results with actual cases

CHAPTER III

A POSSIBLE SCENARIO WITH THE PROPOSED RISK FRAMEWORK

3.1. Nuclear power plant assessment with the IPRA

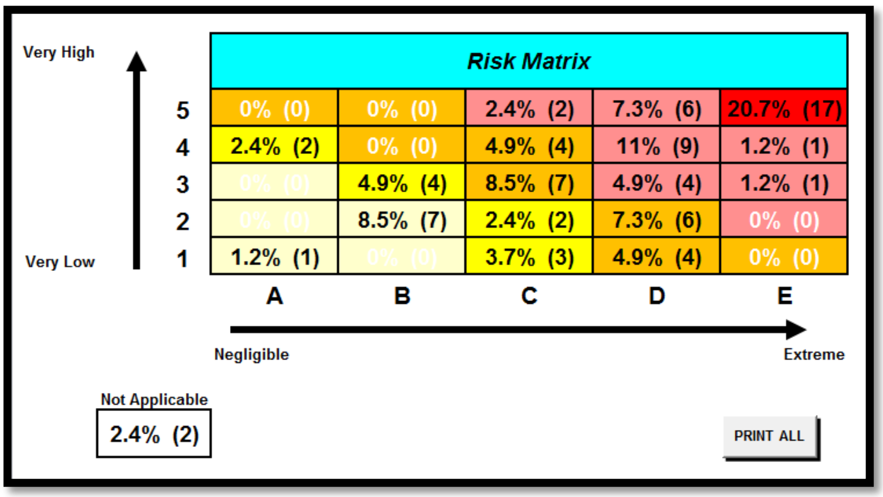

Figure 12 Total risk assessment for a nuclear power plant with the IPRA

According to the Figure 12 of assessment results, many significant risk factors are hidden in the nuclear plant project. Since a nuclear plant project is deeply related with life, several extreme risk factors (seventeen, 20.7%) are determined by the IPRA. With secondary hazardous risk factors, risk factors are spread as much as 28% of the total risk factors. These risk factors need to prepare proper strategies for the nuclear project to avoid or mitigate the possible risks. The remaining percentage (51.3%) is in the controllable range.

3.1.1. Commercial

Section I

5	0	0	0	1	1
4	0	0	0	1	0
3	0	2	0	2	0
2	0	2	0	1	0
1	1	0	0	0	0
	A	B	C	D	E

Figure 13 Commercial section risk matrix

The primary purpose of a nuclear power plant is ‘public welfare and public use’. Since a commercial purpose is not in pursuit of profit, a commercial purpose is not strongly related with a NPP. A commercial section is assessed at the feasibility step of a project life cycle. Also, a feasibility study should accompany a commercial study to identify the project purpose, strategy, and ripple effect of a project. The most hazardous impact element is ‘standards and practices’ of a commercial section for a NPP as shown in Figure 13.

3.1.1. A. Business plan

SECTION I - COMMERCIAL														
CATEGORY	Likelihood of Occurrence (L)						Relative Impact					Coordinate L	Coordinate I	Baseline
	Very Low → Very High						Negligible → Extreme							
	N/A	1	2	3	4	5	A	B	C	D	E			
I.A. BUSINESS PLAN														
I.A1. Building Case												2	B	E
I.A2. Economic model/feasibility												4	D	E
I.A3. Economic Incentives/Barriers												2	B	D
I.A4. Market / Product												3	D	E
I.A5. Standards and Practices												5	E	D
I.A6. Operations												3	D	D
I.A7. Tax and tariff												3	B	D

Figure 14 Relative Impact Value Components sheet of business plan category

According to Figure 14, the unstable standard of a NPP design is the most hazardous risk factor. Design changes can bring ripple effects. The redesign of one component of the NPP can bring detrimental effects on the entire system leading to cost overruns and accidents.

3.1.1. A1. Building case

Basically, the exact scope of a project needs to be defined at the feasibility step with historical data, social issue, and experiences, etc. Since a clear purpose of a NPP is sustainable energy generation and dissemination, building case does not have a significant project purpose. Technical feasibility studies, potential financial support organizations, and partnering considerations can be considered by the IPRA.

3.1.1. A2. Economic model / feasibility

Overall economic feasibility checks are the purpose of this element. A NPP is susceptible with a contract type because it connects with the fee amount. A NPP project needs an immense amount of money for construction and construction cost will be debt.

Tax is a major source to pay a debt with a long compensation period. A tentative compensation period can be determined by this element.

3.1.1. A3. Economic incentives / barriers

Economic incentives and barriers need to be considered according to this element. Based on many literature reviews, there are no unique impacts. The level of economic incentives and barriers are similar with a common heavy industry level.

3.1.1. A4. Market

Since a primary purpose of a NPP does not prefer a pursuit of profits, a market does not have intense competitions. However, the potential growth for NPP depends on its competitors. Coal is still cost-effective and generation of natural gas is also cheaper. Cost of NPP construction is also far more complex than other methods of generating electricity. Significant improvement in construction or subsidies is required to make nuclear energy a competitive and viable option.

3.1.1. A5. Standards and practices

According to Atomic Industrial Forum (AIF) failure to meet the baseline cost estimations were identified as failure of regulatory standardization policies and increased documentation to meet safety standards. Lack of standardization and increased documentation process leads to increase in material, equipment, labor and engineering effort. Even with the standardized design elements, The Nuclear Regulatory Commission (NRC) emphasizes and puts forth review efforts of potential changes regarding addressing site features and how these design changes might affect the entire system.

3.1.1. A6. Operations

NPP constructions need to compete with other types of large investment projects such as oil infrastructure exacerbating the need to find qualified workforce to building NPP. Competition among construction of other foreign NPP will create competition for resources. For operations, the manpower resource can be considered. A study about similar projects around the NPP jurisdiction is required to procure labors.

3.1.1. A7. Tax and tariff

One of the major taxes is 'carbon dioxide tax' for a NPP to mitigate global warming and protect the environment. Carbon dioxide tax is asserted under the name of environmental protection. Also, a regular tax is the major source of income for a NPP.

3.1.1. B. Finance / funding

SECTION I - COMMERCIAL														
CATEGORY	Likelihood of Occurrence (L)						Relative Impact					Coordinate L	Coordinate I	Baseline
	Very Low → Very High						Negligible → Extreme							
	N/A	1	2	3	4	5	A	B	C	D	E			
I.B. FINANCE/FUNDING														
I.B1. Sources& form of funding												3	B	E
I.B2. Currency												2	D	E
I.B3. Estimate uncertainty												5	D	E
I.B4. Insurance												1	A	E

Figure 15 Relative Impact Value Components sheet of finance / funding category

Unsure estimations appear often for a NPP project because a NPP has a complex technology and design without a fixed standard. Thus, estimate uncertainty is the major impact of finance / funding category as shown in Figure 15.

3.1.1. B1. Sources & form of funding

Since a nuclear power plant is a public facility that is owned by the government, the majority of tax uses to compensate the initial investment to meet a principal and to provide higher quality energy when it has a gain. However, the amount of tax is not big enough to cover the immense amount of initial investment for nuclear power plant construction and therefore takes a long time to meet a principal. Steadily supplying the small amount of tax can be a solution for a nuclear power plant. Thus, a plant project is not influenced by the cash flow.

3.1.1. B2. Currency

External risk factors include economic conditions. The construction risk can grow when the demand for electrical power starts to decrease and the commodity costs increase which the owner has no control over.

3.1.1. B3. Estimate uncertainty

Basically NPP construction is complex. Complex and new technologies are susceptible to cost underestimation.

3.1.1. B4. Insurance

The small part of a plant project risk can be covered by the private insurance. Since the risk of a nuclear power plant is extreme, full coverage is impossible.

3.1.2. Country

Section II

5	0	0	0	2	4
4	0	0	1	3	0
3	0	0	1	0	1
2	0	1	0	2	0
1	0	0	3	4	0
	A	B	C	D	E

Figure 16 Country section risk matrix

Risk factors of country section are spread widely on the matrix as shown in Figure 16. In here, the most hazardous risk factors are strongly correlated with a legal part because the public facilities are strongly influenced by the law of each host country.

3.1.2. A. Tax / tariff

SECTION II - COUNTRY														
CATEGORY		Likelihood of Occurrence					Relative Impact					Coordinate L	Coordinate I	Baseline
		Very Low →				Very High	Negligible →				Extrem			
	N/A	1	2	3	4	5	A	B	C	D	E			
II. A. TAX/TARIFF														
II.A1. Tariffs/duties												2	D	C
II.A2. Value added tax												1	D	B
II.A3. Legal entity establishment												5	E	B
II.A4. Application of tax laws and potential changes												3	E	C
II.A5. Technology tax												4	C	A
II.A6. Personal income tax												N/A		A
II.A7. Corporate income tax												N/A		B
II.A8. Miscellaneous taxes												3	C	A

Figure 17 Relative Impact Value Components sheet of tax / tariff

The law related to licenses has an important role for a NPP as shown in Figure 17. Tax is a main way to repay a debt for a NPP.

3.1.2. A1. Tariffs / duties

Tariffs are taken into account for international projects. Especially, the advanced technologies or techniques of a nuclear power plant are applied to the planned countries. The new techniques are already standardized as much as possible. In the case of new nuclear power plant, tariffs and duties can work as a significant factor.

3.1.2. A2. Value Added Tax

VAT can be an additional source of money when a project is ordered. Usually, some fixed percentage of the total amount of construction price is requested. The amount of VAT depends on the total project cost. Usually, the amount of VAT is $ 6 or $ 9 billion for each 1,100 MW (synapse).

3.1.2. A3. Legal entity establishment

Changing and complicated licensing procedures can be a risk factor. The 1992 Energy Policy Act tried to resolve this issue by creating a “One Step” licensing procedure for new nuclear reactors.

3.1.2. A4. Application of tax laws and potential changes

Tax laws are strongly correlated with a NPP project. The main income is tax for a NPP. Hence, deep understanding of tax laws and possible changes influence the overall NPP project with a long term.

3.1.2. A5. Technology tax

Nowadays, the new construction trend is 'a smart structure'. A nuclear power plant installs the new computer technologies for a control and monitoring room. In this case, some technology tax works for the total construction price.

3.1.2. A6. Personal income tax

Since a nuclear power plant project is a public project, personal income tax does not work for a plant project.

3.1.2. A7. Corporate income tax

Since a nuclear plant is constructed for the public, corporate income tax does not influence a nuclear project.

3.1.2. A8. Miscellaneous tax

Hidden taxes can appear on an ongoing project. Each country can assign a unique tax on a project. Thus, many unexpected taxes can pop up under the name of miscellaneous tax.

3.1.2. B. Political

SECTION II - COUNTRY														
CATEGORY		Likelihood of Occurrence					Relative Impact							
		Very Low →				Very High	Negligible →				Extrem	Coordinate L	Coordinate I	Baseline
	N/A	1	2	3	4	5	A	B	C	D	E			
II. B. POLITICAL														
II.B1. Expropriation/nationalism												1	D	C
II.B2. Political Stability												1	D	D
II.B3. Social unrest/violence												1	C	D
II.B4. Repudiation												2	D	A
II.B5. Government's participation/control												1	C	D
II.B6. Relationship w/gov't/owner												5	E	E
II.B7. Intellectual property												2	B	C

Figure 18 Relative Impact Value Components sheet of political

Interestingly, political issues do not appear very often. But the relative impacts are huge when those impacts appear during construction as shown in Figure 18. A NPP project is a government project. Thus, the key to project success depends on the relationship between the government and the contractor.

3.1.2. B1. Expropriation and nationalism

Unreasonable requests can occur during international projects. This kind of problem does not appear too often. But it can be connected with unexpected risks such as confidential problems, project quality problems, and exceeded budgets.

3.1.2. B2. Political stability

A long-term item will be strongly influenced by political stability. During construction, project quality, economical condition, and schedule can be steadily and synthetically influenced by a chaotic political atmosphere. A nuclear project has a relatively shorter schedule than a typical heavy infrastructure project.

3.1.2. B3. Social unrest / violence

A construction project can be influenced by an unstable society. The international civil construction projects are executed in underdeveloped countries and developed countries. These countries are that construction site atmospheres are unstable. Riots and violations appear regionally. Since a nuclear plant will be searched after every fundamental resource has been almost exhausted, a nuclear plant project works in a measured country. Thus, fewer chances will be met with different types of projects.

3.1.2. B4. Repudiation

The attitude of government can change suddenly after the construction's completion. In this case, a retainage or a debt can be representative examples. In this case, a wrap up construction will not meet a planned quality or standard. Also, a credit problem between the government and a contractor can appear and then influence both sides with negative perspectives.

3.1.2. B5. Government involvement and control

The majority of civil infrastructure has long construction duration. Relatively, nuclear power plant construction duration is not too long. Thus, it has fewer chances to meet government policy changes and a wide range of government involvement.

3.1.2. B6. Relationship with government / owner

A relationship between government and owner is an invisible key factor to be a success project. Government is able to allow permits at adequate times to keep work on the site without obstacles. For a nuclear project, reducing construction duration is a major key to be a successful project for an owner and a government.

3.1.2. B7. Intellectual property

Some intellectual properties are applied for a nuclear plant project. However, if a plant applies new technologies, intellectual property needs to be protected by a law.

3.1.2. C. Cultural

SECTION II - COUNTRY														
CATEGORY		Likelihood of Occurrence					Relative Impact					Coordinate L	Coordinate I	Baseline
		Very Low →			Very High		Negligible →				Extrem			
	N/A	1	2	3	4	5	A	B	C	D	E			
II.C. CULTURAL														
II.C.1. Traditions and business practices												1	C	E
II.C.2. Public opinions												5	D	D
II.C.3. Religious differences												1	D	B
II.C.4. Constructability												4	D	D

Figure 19 Relative Impact Value Components sheet of cultural

One of the major characteristics of a plant is reduction of a project schedule. Also, public opinions do not welcome the nuclear energy project construction as shown in Figure 19. The total project duration can be impacted by special religious obligations.

3.1.2. C1. Traditions and business practices

Each host country has unique traditions. The cultural differences can cause misunderstanding between the host country and the contractor. It may seem like a slight misunderstanding but incorrect orders, resentment, or poor etiquette can occur as the result. If participants hire language proficiency interpreters, this risk can be controlled.

3.1.2. C2. Public opinion

Based on sound advertisements about cutting edge techniques, people of the host country will allow the NPP construction. Public opinion is a big obstacle for nuclear power plants. The public cannot recognize the lack of resources easily and Nimbyism works for a nuclear plant project. Thus, public opinion has a significant role for a nuclear plant.

3.1.2. C3. Religious differences

Religious differences influence the extension of a total project schedule. For example, during Ramadan, Muslims fast and periodically pray. If a project will be set up in an Islamic country, especially a nuclear power plant project will be damaged by the extended construction duration because the key to a successful nuclear plant project is reducing construction duration. In contrast, it can be controlled by scheduling a project to avoid a religious holiday.

3.1.2. C4. Constructability

Hiring local workers is one of the most significant factors to reduce a project budget. A nuclear plant project, especially, should cherish local manpower. However, there is a slight variance of constructability between local workers and imported experts. Adequate training should be provided for local laborers.

3.1.2. D. Legal

SECTION II - COUNTRY														
CATEGORY		Likelihood of Occurrence					Relative Impact							
		Very Low → Very High					Negligible → Extrem					Coordinate L	Coordinate I	Baseline
	N/A	1	2	3	4	5	A	B	C	D	E			
II.D. LEGAL														
II.D1. Legal Basis												5	E	B
II.D2. Legal standing												5	E	B
II.D3. Governing law/contract formalities and language												4	D	D
II.D4. Contract type and procedures												5	D	E
II.D5. Environmental permitting												4	D	D
II.D6. Corrupt business												2	B	C

Figure 20 Relative Impact Value Components sheet of legal

NPP projects are sensitive to legal issues as shown in Figure 20. Since many licenses are required with the NPP, flexible legal standing can cause delay and cost overrun. A fee is determined by a contract type as well.

3.1.2. D1. Legal basis

Depending on the various approvals, legal processes and political support the investment risk may rise. Improvements have been implemented and proposed to reduce cost overruns in construction of next generation NPP. These include new licensing procedures that combine receiving both construction and operating license, limiting the interventions that led to delays. Energy Policy Act of 2005 provides combination of incentives including tax credits, loan guarantees and insurance.

3.1.2. D2. Legal standing

Legal standing is a significant factor for a nuclear power plant. The proper licenses and adequate registrations should accompany with a plant project.

3.1.2. D3. Governing law / contract language and formalities

For an international project, language is the biggest barrier. Miscommunication can raise questions about special meaning or a local expression. For a nuclear project, exact communication is significant in order to satisfy the safety standards.

3.1.2. D4. Contract type and procedures

Cost-plus construction contracts are widespread for a NPP. A NPP project strongly depends on a contract type. Fee is determined by a contract type. Thus, a contract type of the NPP project is susceptible with fee.

3.1.2. D5. Environmental permitting

A nuclear power plant project is strongly related with environmental permitting. All activities of a project may minimize the impact on the project area. Also, it may require environmental legal permits.

3.1.2. D6. Corrupt business practices

Basically, accepting bribes for convenience of the project process and advantages is illegal. For cooperation, project performance should be clear and positive between government and construction firms.

3.1.3. Facilities

Section III					
5	0	0	1	3	7
4	2	0	0	4	1
3	0	1	5	1	0
2	0	3	1	2	0
1	0	0	0	0	0
	A	B	C	D	E

Figure 21 Facilities section risk matrix

A NPP project has more machines than other same size projects. Machineries of a NPP are very dependent on permits. Thus, the facilities section involves more sensitive risks than other parts as shown in Figure 21.

3.1.3. A. Project scope

SECTION III - FACILITIES														
CATEGORY	Likelihood of Occurrence						Relative Impact					Coordinate L	Coordinate I	Baseline
		Very Low → Very High					Negligible → Extreme							
	N/A	1	2	3	4	5	A	B	C	D	E			
III.A. PROJECT SCOPE														
III.A1. Scope dev't process												2	C	D
III.A2. Technology												4	A	D
III.A3. Hazardous mat'l req'ts												3	C	B
III.A4. Env., health, and safety												2	D	C
III.A5. Utilities/basic infrastructure												3	C	C
III.A6. Site selection/clear title												5	E	B
III.A7. Approvals/permits/												5	E	B

Figure 22 Relative Impact Value Components sheet of project scope

It is hard to find the proper site for a plant project. Residents do not want to allow NPP construction. The US announced a safety review after Japan's Fukushima Daiichi NPP. Overcoming public mistrust will be a big hurdle. Permits and approvals should be acquired punctually to finish a project on time. This is key to the success of a project. Therefore, permits and approvals exist as high relative impact factors as shown in Figure 22.

3.1.3. A1. Scope development process

Determining a project scope is significant. Sometimes a cost overrun and a delayed schedule can expose the overlooked factors. On the other hand, a change order can be issued by the owner. This case is acceptable. But the basic project scope should be determined before launching a project.

3.1.3. A2. Technology

Heavy civil infrastructures are under construction usually in underdeveloped and developed countries. In contrast, developed countries are working in those kinds of countries to set up the planned infrastructures. In this case, advanced technologies cannot be used in those kinds of countries without preparing advancements such as wireless Wi-Fi connection, the Internet network, etc. For a nuclear power plant, many cutting-edge technologies must work. Thus, a control room should be prepared with consideration of a country's technology acceptance level.

3.1.3. A3. Hazardous material requirements

Hazardous materials are used for the majority of civil projects. In the U.S, laborers are protected under the OSHA. However, many countries need to set up a protection law. For nuclear power plants, some general dangerous factors exist before the reactor is running.

3.1.3. A4. Environmental, health, and safety

Nuclear project jurisdiction requires many cranes to implant a reactor before the top is closed. To reduce project duration, nuclear plant structures are prefabricated. To assemble those sections, mega size cranes are essential machines. Even though cranes are evaluated, unforeseen risk factors can pop up at the site. In this case, it can endanger a worker's life.

3.1.3. A5. Utilities and basic infrastructure

There are basic infrastructures to launch a project. Utilities, water issues, and roads are needed to ensure the progress of a project. A nuclear project is no exception. The majority of plants are built around coastlines to cool the temperature of the reactor. Therefore, the project sites can also exist in underdeveloped areas. These environmental factors need to be assessed at the feasibility step.

3.1.3. A6. Site selection and clear title

Site selection is one of the biggest barriers for a nuclear power plant project. Many residents witnessed the terrible disaster nuclear power plant disasters at Chernobyl and Fukushima. Thus, the people do not readily consent to nuclear plant construction. Verified construction techniques and skills should be advertised to assure residents of the safety of NPP project.

3.1.3. A7. Approvals, permits, and licensing

To progress the NPP project, various permits are required. Lack of permanent waste repository affects building nuclear reactors. Without a safe waste repository the NRC (Nuclear Regulatory Commission) policy will not continue to license reactors. The new NRC regulation is the key to nuclear energy growth.

3.1.3. B. Souring and supply

SECTION III - FACILITIES														
CATEGORY	Likelihood of Occurrence						Relative Impact					Coordinate L	Coordinate I	Baseline
		Very Low ⟶ Very High					Negligible ⟶ Extreme							
	N/A	1	2	3	4	5	A	B	C	D	E			
III.B. SOURCING AND SUPPLY														
III.B1. Engineered equipment/material												4	A	C
III.B2. Bulk materials												5	D	B
III.B3. Subcontractors												5	E	D
III.B4. Importing and customs												2	D	B
III.B.5 Logistics												5	D	C

Figure 23 Relative Impact Value Components sheet of sourcing and supply

A clear difference between the NPP project and the typical construction projects is the use of Very Heavy Lift (VHL) cranes. To implant the nuclear reactor vessel, and steam generators, VHL cranes are utilized. To close the open top, VHL cranes areas are required as well. Therefore, local subcontractors that procure VHL cranes have high relative impacts as shown in Figure 23.

3.1.3. B1. Engineered equipment / material

Super cranes are major equipment for a nuclear plant because it is constructed with prefabricated sections. In this case, a project owner needs to rent the equipment instead of purchasing. Also, assembling work is not long-term work; thus, renting a crane is more economical.

3.1.3. B2. Bulk materials

Big cranes represent the bulk materials for a nuclear plant project. Thus, it needs to be ordered earlier than any other equipment to ensure timely delivery. This element influences to the entire project lifecycle for schedule and cost.

3.1.3. B3. Subcontractors

To reduce the project cost, contracting with local subcontractors are essential. Especially, hiring the local suppliers' is an essential step in a project lifecycle for a nuclear power plant. One of the big advantages of host subcontractors is that they are aware of local conditions and the contractor can save the indirect costs.

3.1.3. B4. Importing and customs

Some countries' level of ethic is not enough to meet an international perspective. Thus, there are illicit dealings when importing something. It may cause the schedule and cost to be over the original plan.

3.1.3. B5. Logistics

The waterfront construction is not an avoidable option for a nuclear power plant. To avoid natural disasters such as earthquake, tsunami, and storms around waterfront, some complicated constructions such as aseismatic design, strong and deep foundations should be considered. In this case, complicated works required.

3.1.3. C. Design / engineering

SECTION III - FACILITIES														
CATEGORY	Likelihood of Occurrence						Relative Impact					Coordinate L	Coordinate I	Baseline
		Very Low ⟶ Very High					Negligible ⟶ Extreme							
	N/A	1	2	3	4	5	A	B	C	D	E			
III.C. DESIGN/ENGINEERING														
III.C1. Design/engineering process												5	E	D
III.C2. Liability												3	C	C
III.C3. Local design services												5	E	D
III.C4. Constructability												3	C	D

Figure 24 Relative Impact Value Components sheet of design / engineering

Regulatory standardization is dynamic. It evolves as more knowledge about the nuclear technology and side effects become available. Plant designs can continually be modified to meet the growing awareness of the threats. Therefore, NPP designs should be considered as the most critical risk factor as shown in Figure 24.

3.1.3. C1. Design / engineering process

Basically, the NPP has complicated technologies. Also, a small design change will impact the overall design. Since the standard of the NPP design is not clear and not eco-friendly, consideration around the site and a clear standard should be set up for the NPP.

3.1.3. C2. Liability

A gap exists between the host country and an international project team. For design errors and omissions, providing institutional strategies should be accompanied such as insurances and professional licensing requirements. A nuclear plant project needs these institutional strategies to cover the wrong things as well.

3.1.3. C3. Local design services

To reflect unique local conditions, the international management team needs to hire the local design firms. Understanding about the environment around the site is important to reduce the schedule and cost.

3.1.3. C4. Constructability

Constructability is directly related with safety, quality, and schedule of the entire project lifecycle. Since the benefit of a construction firm closely connects with constructability, this should be assessed at the first part of a project flow.

3.1.3. D. Construction

SECTION III - FACILITIES														
CATEGORY	Likelihood of Occurrence						Relative Impact					Coordinate L	Coordinate I	Baseline
		Very Low ⟶ Very High					Negligible ⟶ Extreme							
	N/A	1	2	3	4	5	A	B	C	D	E			
III.D. CONSTRUCTION														
III.D1. Workforce avail./skill						■					■	5	E	C
III.D2. Workforce logistics/support				■					■			3	C	A
III.D3. Climate						■			■			5	C	A
III.D4. Construction deliv. method				■						■		3	D	A
III.D5. Construction permitting						■					■	5	E	A
III.D6. General contractor avail.						■				■		5	D	B
III.D7. Contractor payment					■					■		4	D	A
III.D8. Schedule					■					■		4	D	C
III.D9. Insurance			■					■				2	B	A
III.D10. Safety during construction					■						■	4	E	A
III.D11. Comm. and data transfer				■				■				3	B	C
III.D12. Quality					■					■		4	D	A

Figure 25 Relative Impact Value Components sheet of construction

Workers' experience has a significant impact on a schedule. Also, permitting should be supported on time to avoid a delayed schedule. Safety of laborers has high priority during a project as shown in Figure 25.

3.1.3. D1. Workforce availability and skill

One significant factor for a successful NPP project is local workforce availability and skill. Thus, international level trainings of local manpower will be helpful.

3.1.3. D2. Workforce logistics and support

To enhance laborer's work ability, adequate welfare should be provided by the management team. In extreme cases, it can become a worker's safety issue.

3.1.3. D3. Climate

Workers' performance is strongly influenced by weather. Laborers in climates with high temperatures need to begin to work early in the morning to procure rest hours during the daytime. In contrast, workers in low temperature climate areas need to warm up and focus on daytime to work. For a nuclear power plant, the manager needs to focus on the weather forecasting around the waterfront.

3.1.3. D4. Construction delivery method

Project delivery methods should be clearly identified for the owner and the contractors. Also, a proper contract method needs to be determined. Clearer set-up of a project delivery method will enable smooth communication.

3.1.3. D5. Construction permitting

Permitting is very significant for a nuclear power plant project. Basically, jurisdiction's permitting is required and IAEA's permitting should be earned for a project as a worldwide standard.

3.1.3. D6. General contractor availability

Collaboration with local firms is essential for the international projects. Local firms are a positive financial aspect. Thus, sufficient identification is needed for the international projects.

3.1.3. D7. Contractor payment

Payment is connected with cash flow. Retainage or late payment, sometimes, is strongly influenced by the exchange rate, currency, and etc. The initial estimated value will be changed by late cash flow. As a result, contract payment is important.

3.1.3. D8. Schedule

A project schedule needs to meet the important milestones. For an NPP project, the first part of total schedule is the most significant because prefabricated parts are assembled at this moment.

3.1.3. D9 Insurance

Insurance is a sound way to cover the unexpected risks for the international projects. It is almost impossible for nuclear power plants to obtain full coverage for everything, including nuclear accidents. Insurance works partially for nuclear projects.

3.1.3. D10. Safety during construction

The importance of safety must be seriously considered during construction. Even though the construction turns into a successful project, it is hard to justify the project when fatal injuries or deaths have occurred. A plant project requires the higher level of safety similarly to a general construction project.

3.1.3. D11. Communication and data transfer

Communication is one of the most important factors for the international scaled projects. Since many cutting edge technologies are applied in a nuclear project, communication and data transfer is very crucial.

3.1.3. D12. Quality

Quality assurance is important for an NPP project because some projects were failed by the lack of quality assurance. Therefore, strict quality standards are required.

3.1.3. E. Start up

SECTION III - FACILITIES														
CATEGORY	Likelihood of Occurrence						Relative Impact					Coordinate L	Coordinate I	Baseline
		Very Low → Very High					Negligible → Extreme							
	N/A	1	2	3	4	5	A	B	C	D	E			
III.E. START UP														
III.E1. Trained workforce												4	D	D
III.E2. Facility turnover												2	B	C
III.E3. Feedstock/util. reliability												4	C	B

Figure 26 Relative Impact Value Components sheet of start up

Trained workforce and facility checkup are important whether the performance meets the plan or not for a project as shown in Figure 26.

3.1.3. E1. Trained workforce

Schedule depends on a trained workforce. Experienced workers work effectively without trials and errors. Thus, startup day can be advanced with these skilled laborers.

3.1.3. E2. Facility turnover

The final project needs to be checked by commissioning teams whether it works well or not. Also, a planned performance can be checked through this step.

3.1.3. E3. Feedstock and utilities reliability

For a nuclear plant, a circulation of cold water is the most important. If cold water is not properly provided, the generator will heat up soon and explode. The exploding of a nuclear generator would cause a fatal disaster. An adequate supply of electricity is a necessary function for a nuclear plant operator.

3.1.4. Production / operations

Section IV

	A	B	C	D	E
5	0	0	1	0	5
4	0	0	3	1	0
3	0	1	1	1	0
2	0	1	1	1	0
1	0	0	0	0	0

Figure 27 Production / operations section risk matrix

For a NPP project, a local workforce is needed to reduce project cost. Also, legal issues are important for a NPP as well as shown in Figure 27. In this section, the level of importance clearly exists between both factors and the other factors.

3.1.4. A. People

SECTION IV - PRODUCTION/OPERATIONS														
CATEGORY		Likelihood of Occurrence (L)					Relative Impact					Coordinate L	Coordinate I	Baseline
		Very Low → Very High					Negligible → Extreme							
	N/A	1	2	3	4	5	A	B	C	D	E			
IV.A. PEOPLE														
IV.A1. Operational safety												2	D	D
IV.A2. Security												2	B	C
IV.A3. Language												5	C	C
IV.A4. Hiring/training/retaining												2	C	D
IV.A5. Localizing op. workforce												5	E	C

Figure 28 Relative Impact Value Components sheet of people

Guarantee of the site safety is important as usual. However, localizing workforce is strongly correlated with a key of NPP project as shown in Figure 28.

3.1.4. A1. Operational safety

Conservative standard for safety is required by the laborers and the managers. A seemingly small accident can lead to a big problem such as the death of workers.

3.1.4. A2. Security

Workers should be protected by security system against theft and terrorism. Since the civil projects usually construct in underdeveloped areas, laborers' safety should be guaranteed through security systems.

3.1.4. A3. Language

English is usually used as a representative communication language for an international project. However, miscommunication can happen from a lack of language proficiency. To order precisely, interpreters should be allocated on the project areas.

3.1.4. A4. Hiring, training, retaining

Adequate and qualified rest time for laborers is essential for a sound project. Workers' efficiency will be influenced by the quality of retaining. Education and experience have a significant role to satisfy project quality.

3.1.4. A5. Localizing operational workforce

For a nuclear plant project, local laborers should be hired by the management team. The majority of projects hire around 80% local laborers. In contrast, a nuclear plant needs to hire more than 90% local laborers for the cost down. Reducing costs is the core for a nuclear plant project success.

3.1.4. B. Legal

SECTION IV - PRODUCTION/OPERATIONS														
CATEGORY		Likelihood of Occurrence (L)					Relative Impact							
		Very Low → Very High					Negligible → Extreme					Coordinate L	Coordinate I	Baseline
	N/A	1	2	3	4	5	A	B	C	D	E			
IV.B. LEGAL														
IV.B1. Gov'g law/op. liability						x					x	5	E	C
IV.B2. Permitting						x					x	5	E	C
IV.B3. Insurance				x				x				3	B	B
IV.B4. Expatriates				x						x		3	D	A
IV.B5. Env. compliance						x					x	5	E	C

Figure 29 Relative Impact Value Components sheet of legal

Government law and permitting are the most important things for a NPP as shown in Figure 29. Also, environmental permitting is significant as well. Laws should be standardized and environmental permitting and various permitting should be allowed by the government of the host country.

3.1.4. B1. Governing law / operational liability

To control design and operation of a nuclear plant, each country has a government agency such as Nuclear Regulatory Commission. This organization procures laws and guidance. The majority of laws of nuclear power plant address specific technical specification, safety, and some laws deal with local laws, etc. To satisfy a local condition, hiring local legal assistance is the most important.

3.1.4. B2. Permitting

A nuclear power plant project is dominated by permitting. A plant project needs to consider local standard permitting to global standard permitting. A plant project's standard is a significant factor.

3.1.4. B3. Insurance

Fundamental levels of insurance such as workers' health, emergency medical, and laborers' safety can be covered by the insurance. For a nuclear power plant, full coverage is impossible because the range of nuclear disasters is uncontrollable. Thus, the basic standard of insurance is supported by a nuclear project.

3.1.4. B4. Expatriates

To satisfy the minimum construction requirements and to display workers' ability, the host country needs to support expatriates. In the nuclear case, the majority of laborers are local workers. The management teams are supplied by an advanced country. Thus, the host country should support the international experienced management team.

3.1.4. B5. Environmental compliance

A nuclear plant project correlates strongly with environmental compliance issues. A local relationship is necessary to launch a project. Since the loss or damage of a nuclear disaster is huge, local residences strongly oppose the plant construction. Also, local residents are apprehensive about contamination. Since a nuclear plant is located near the waterfront, ocean pollution is point of concern for the local residents who work in the fishing industry.

3.1.4. C. Technical

SECTION IV - PRODUCTION/OPERATIONS														
CATEGORY		Likelihood of Occurrence (L)					Relative Impact					Coordinate L	Coordinate I	Baseline
		Very Low → Very High					Negligible → Extreme							
	N/A	1	2	3	4	5	A	B	C	D	E			
IV.C. TECHNICAL														
IV.C1. Logistics/warehousing				x							x	3	E	B
IV.C2. Facilities mgmt./maint.				x					x			3	C	C
IV.C3. Infrastructure support					x				x			4	C	B
IV.C4. Technical support					x					x		4	D	C
IV.C5. Quality assur./control					x					x		4	D	C
IV.C6. Op. shutdowns/startups		x									x	1	E	B

Figure 30 Relative Impact Value Components sheet of technical

Quality assurance is a significant factor in this category as shown in Figure 30. If a small part does not meet the required performance, that part will influence the other parts with the domino effect. In here, shutdowns / startups of a NPP do not appear too much because a shutdown of a NPP influences the overall electric demand of the host country and the overall economy.

3.1.4. C1. Logistics and warehousing

In some special countries, some required environmental conditions exist to maintain the material characteristic or performance quality of materials. If a nuclear plant project sets a plan in the high temperature country, concrete paste need to be maintained in a cold condition to avoid hardness of concrete before concrete is pumped into the mold.

3.1.4. C2. Facilities management and maintenance

During a construction period, basic facilities are required to progress the project. For the basic facilities, maintenance is vital as well. It seems like a small part of a project, but facilities can ensure a smooth project.

3.1.4. C3. Infrastructure support

To transport the construction materials well to the construction site, infrastructure should be well-developed. Infrastructure influences the project schedule and cost overrun. Especially, a long term project strongly correlates with the development level of infrastructure. Since usually a nuclear plant project's construction is not too long, a total project life is not influenced much by infrastructure condition. But temporary access roads should be constructed for better accessibility.

3.1.4. C4. Technical support

Technical support is significant for a nuclear project as well. The control room has cutting edge systems; therefore, experts should be hired for the operation of a control room. To provide experts constantly, a systemized training system is required.

3.1.4. C5. Quality assurance and control

The lack of quality assurance is the main risk factor for the NPP. Most of all, standardization, eco-friendly design should be supported for the next generation NPP project.

3.1.4. C6. Operational shutdowns and startups

A nuclear plant never stops operating because the supply of electricity for a country majorly depends on the nuclear plant operation. Many experts believe that a nuclear plant is more a practical sustainable energy resource with high capacity than any other energy resources. If a nuclear generator is damaged by the natural disaster, the generator should be shut down by an operation team immediately. However, the government of Japan hesitated whether they should stop to operate the Fukushima nuclear plant or not because the relative impacts are immense such as the lack of electricity supply, unstable economic condition, and uncomfortable life, etc. Controlling operation is fundamental for a nuclear plant.

3.2. The risk framework for a NPP development process

3.2.1. Proposed section for a NPP

3.2.1. A. Radioactive external damage

Section V

	A	B	C	D	E
5	0	0	0	0	1
4	0	0	0	3	0
3	0	0	0	0	0
2	0	0	1	0	0
1	0	0	0		0

Figure 31 Radioactive external damage risk matrix

This section covers the unique characteristics of a NPP. The most hazardous risk factor is radioactive waste management design as shown in Figure 31. The NPP design should consider the management plan for radioactive waste disposal because radioactive waste occurs in every NPP. Occurrence is frequent and incorrect or faulty management will pollute the surrounding environment.

3.2.1. B. Radioactive contamination protection design

SECTION V - Radioactive External Damage														
CATEGORY		Likelihood of Occurrence (L)					Relative Impact							
		Very Low ⟶ Very High					Negligible ⟶ Extreme					Coordinate L	Coordinate I	Baseline
	N/A	1	2	3	4	5	A	B	C	D	E			
V.A. RADIOACTIVE CONTAMINATION PROTECTION DESIGN														
V.A1. Radioactive waste management design												5	E	E
V.A2. Environmentally friendly design												4	D	D
V.A3. Design for proliferation resistance												4	D	D
V.A4. Nuclear inspection satisfy design												4	D	E
V.A5. Fuel cycle assessment												2	C	C

Figure 32 Relative Impact Value Components sheet of radioactive contamination protection design

Basically, 5 elements are related with a design of NPP. First of all, radioactive waste management methods such as nuclear disposal should be considered at the design step. Eco-friendly design, also, is considered for the environment around jurisdiction. Light water reactors use water as a cooler, but it requires a large amount of water to decrease the reactor's heat. Light water reactors make steam to generate energy. In contrast, heavy water reactors make uranium to generate energy. Nuclear weapons can be easily created from uranium. Thus, proliferation resistance needs to be considered for NPP. Also, the design of NPP should satisfy the level of nuclear inspection. The NPP design with respect to fuel cycles can be assessed as shown in Figure 33 (U.S. NRC, 2011).

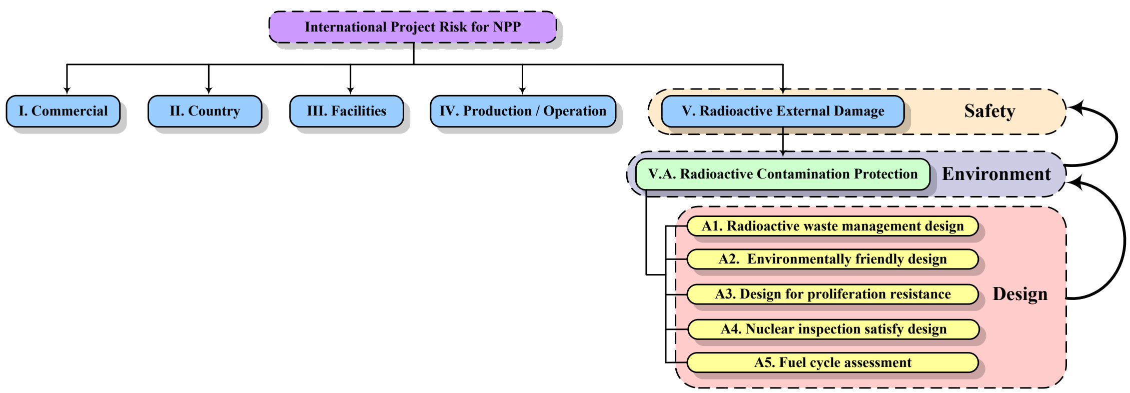

Figure 33 Concepts of designed risk frame

The NPP design negatively influences the environment with radioactive release, if a core of NPP is impacted. The situation will threaten the safety of people causing them to become ill and the environment will be contaminated by released radioactivity as shown in Figure 33.

3.2.2. Total risk assessment with the designed NPP elements

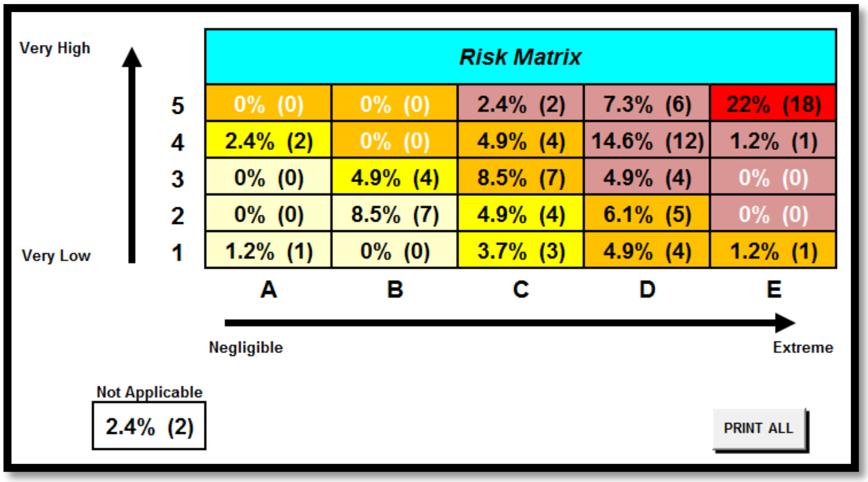

Figure 34 Total risk assessment with NPP elements

18 elements are determined by the IPRA with designed elements for NPP. 1 dangerous risk factor is added on the matrix. Also, three significant factors appear as the result of assessment as shown in Figure 34. Design problems are connected with dangerous incidents; also, incidents of NPP projects can be irreversible disasters. The extreme hazardous risks are 22 % among all risks. Through the total risk assessment for NPP, the risks relate with lack of standardization, legal issues for permitting and licensing, the importance of NPP designs to prevent the spreading of radioactive, the relationship between the host country and the hired international construction firms, the importance of hiring local firms, and the jurisdiction selection with the resident's relax about the nuclear safety. Assessed elements are listed as shown in Table 5.

Table 5 The list of assessed elements

No.	IPRA Element	Descriptions
1	I. A5.	Standards and Practices / Business Plan / Commercial
2	II. A3.	Legal Entity Establishment / Tax or Tariff / Country
3	II. B6.	Relationship with Government or Owner / Political / Country
4	II. C2.	Public Opinions / Cultural / Country
5	II. D1.	Legal Basis / Legal / Country
6	II. D2.	Legal Standing / Legal / Country
7	III. A6.	Site Selection or Clear Title / Project Scope / Facilities
8	III. A7.	Approvals or Permits / Project Scope / Facilities
9	III. B3.	Subcontractors / Sourcing and Supply / Facilities
10	III. C1.	Design Engineering Process / Design or Engineering / Facilities
11	III. C3.	Local Design Services / Design or Engineering / Facilities
12	III. D1.	Workforce Avail. or Skill / Construction / Facilities
13	III. D5.	Construction Permitting / Construction / Facilities
14	IV. A5.	Localizing Op. Workforce / People / Production or Operations
15	IV. B1.	Govern. Law or Op. Liability / Legal / Production or Operations
16	IV. B2.	Permitting / Legal / Production or Operations
17	IV. B5.	Environmental Compliance / Legal / Production or Operations
18	V. A1.	Radioactive Waste Management Design

CHAPTER IV

POSSIBLE RISK MITIGATION STRATEGIES

Possible risks can be mitigated by well-prepared strategies. A NPP requires the set of clear standards for baseline cost estimation or legal standard to mitigate the risk factors.

4.1. Strategy 1. Baseline cost estimation standardization

The baseline cost estimations should be identified with regulatory standardization policies. This standardization will be a basic guide. Trials and errors can be reduced by standardization. To set up standardization, strong reviews should be accompanied by many existing projects.

4.2. Strategy 2. Local firms

Local firms need to be hired by a NPP management team. Since the construction budget of NPP is huge, local firms within jurisdiction are an effective way to reduce the indirect costs. Also, VHL cranes can be rented from the surrounding jurisdictions to assemble pre-fabricated sections and implant a nuclear reactor.

4.3. Strategy 3. Design standardization

Design should be standardized with respect to IAEA inspection standards, radioactive waste management system, and eco-friendly design. A NPP project is exposed to natural disasters such as earthquakes, tsunamis, and hurricanes directly. Especially, after the Fukushima disaster, stronger earthquake-resistant designs are required by the site's environment.

4.4. Strategy 4. A high moral plane

A nuclear weapon can be made by uranium with a slight alteration. It will threaten countries surrounding jurisdiction. Also, an annual nuclear inspection of IAEA should be allowed by the host country. To hinder contamination, nuclear waste should be disposed of clearly and safely in a highly ethical way. In contrast, residents do not welcome NPP construction in their area because they have witnessed the results of a nuclear disaster through some NPP incidents.

4.5. Strategy 5. New nuclear power plant construction methods

4.5.1. Open top installation

Use of open top installation in combination with modularization has reduced schedule delays. Although the use of Very Heavy Lifting (VHL) cranes adds to the construction cost, the extra cost was compensated by shortening the construction schedule as shown in Figure 35. Open top installation has replaced the previous construction which required temporary openings that allowed for entry of large equipment as shown in Figure 36 (IAEA, Advanced construction methods for new nuclear power plants, 2012).

Figure 35 A steam generator installs with VHL crane (IAEA, Advanced construction methods for new nuclear power plants, 2012)

Figure 36 Open top installation for a steam generator (IAEA, Advanced construction methods for new nuclear power plants, 2012)

4.5.2. Prefabrication, pre-assembly

Use of prefabricated and pre-assembled materials and components such as structural elements, piping, tubing and ladders have reduced on-site workforce and site congestion as shown in Figure 37, 38 and 39. Reducing on-site workforce also meant improving accessibility for personnel and material transportation (IAEA, Advanced construction methods for new nuclear power plants, 2012).

Figure 37 Assembling prefabricated parts (IAEA, Advanced construction methods for new nuclear power plants, 2012)

Figure 38 Installing the upper drywell super large scale module (IAEA, Advanced construction methods for new nuclear power plants, 2012)

Figure 39 Installing the dome module of NPP (IAEA, Advanced construction methods for new nuclear power plants, 2012)

4.5.3. Advanced welding techniques

Use of automatic welding equipment allows welding for hard-to-reach spaces, in turn decreasing construction times and human workforce. Advancement in welding technologies have also improved welding quality and reduced welding time, all of which affect the total construction schedule as shown in Figure 40 (IAEA, Advanced construction methods for new nuclear power plants, 2012).

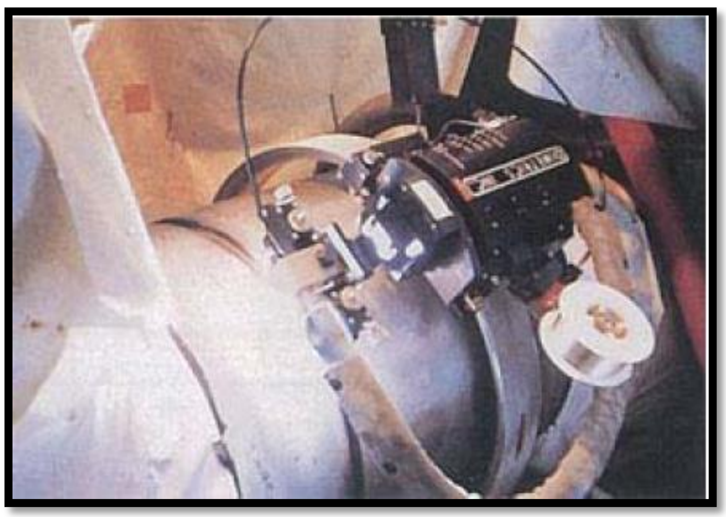

Figure 40 Automatic welding techniques (IAEA, Advanced construction methods for new nuclear power plants, 2012)

4.5.4. Use of steel plate reinforced concrete

Use of steel plate reinforced concrete and slip-forming allow sections to be modularized and prefabricated off-site as shown in Figure 41. The only necessary step is placement and welding on-site. Conventional reinforced concrete requires placement of external forms and reinforcing bars prior to pouring the concrete. The entire process to pour and then to remove the forms is considerable (IAEA, Advanced construction methods for new nuclear power plants, 2012).

Figure 41 Steel-concrete composite concrete (IAEA, Advanced construction methods for new nuclear power plants, 2012)

4.5.5. Use of all-weather cover dome

To guarantee that work can continue throughout the day in any kind of external weather conditions, an all-weather cover dome can be placed over the reactor building. This method was used in Japan.

Use of advanced materials such as concrete, excavation tools, and improvement in cable installation method allow for improved construction (IAEA, Advanced construction methods for new nuclear power plants, 2012).

4.5.6. Use of advanced scheduling method

Area completion schedule management method allows for dividing each level of the building into zones. This replaces the conventional approach of design and procurement schedule that uses progress system by system. The area completion schedule has been successfully used in Korea and allowed for a more detailed breakdown of scheduling allowing for smooth transition and priority setting for integrated installation work (IAEA, Advanced construction methods for new nuclear power plants, 2012).

4.5.7. Use of computer system for information management and control

Use of advanced computer systems for information management and control is common for large engineering and construction projects including power plants. Use of 3-D models and even 4-D models linking the schedule help identify conflicts well in advance for resolutions (IAEA, Advanced construction methods for new nuclear power plants, 2012).

CHAPTER V

CONCLUSION

5.1. Review research objectives

Nuclear power plants are promising and sustainable energy generators for the next generation. To provide a proper risk assessment tool for a NPP, some effective tools are reviewed. Also, detailed explanations about the IPRA are provided. Before suggesting the risk framework for a NPP, unique risks of a NPP are determined, followed by the global scale verification test. After that, identified risks are merged with the IPRA to provide a possible risk framework. Lastly, some mitigation strategies are proposed.

5.2. Identified results related to the research hypothesis

The first identified result of the research hypothesis that unique NPP risk factors are well determined by literature reviews. The second identified hypothesis is that determined unique risk factors are matched well with the occurring problems of existing international NPP cases. The third confirmed hypothesis is that a possible risk breakdown structure can be designed based on the IPRA with determined risks. The last confirmed hypothesis is that risk mitigation strategies are feasible suggestions.

5.3. The conceptual structure of risk framework in this thesis

The Analytic Hierarchy Process (AHP) is used widely in the industry field to determine the opinion through organizing and analyzing for complicated decisions. Also, Work Breakdown Structure (WBS) is used to determine and gather a project's elements as discrete conditions. The conceptual structure of the AHP or WBS and the risk framework are based on the same shape of breakdown structure. In this thesis, the level of proposed risk framework for a NPP is the same as the structure of AHP and WBS. To decide risk elements certainly, various verification methods were used. The focus is on providing unique risks of a NPP and possible risk framework for atomic projects. The proposed risk framework will be a foundation of the IPRA for a NPP with fixed and verified risk elements in the future.

5.4. Conclusion

An NPP can be assessed by the proposed risk framework for a NPP. The result shows that relatively extreme hazardous risk factors are 22 % of all risk factors. The dangerous risk factors are related with the lack of design standardization, design change, safety, contamination, construction time reduction, budget saving, and radioactive waste disposal. Most of all, uranium of heavy water type NPP can be converted into nuclear weapons. Thus, the host countries should manage NPP transparently with respect to the international standard. Also, periodical nuclear inspection of jurisdictions should be accompanied by the IAEA. To avoid contamination around the jurisdiction, environmental friendly design and strong NPP structures are required for the safety of people. It will prevent the secondary and third impacts as well. Since NPPs require many inspections, legal standards of host countries should be set up for a smooth construction process. Also, construction time reduction is one of the significant factors because NPP projects require an immense budget at the initial step. Adequate and skillful local suppliers should be hired by the project team to save the construction cost.

5.5. Recommendation and future research

Basically, the designed risk framework is effective to determine the risks of NPP. However, for higher level verification of asserted new elements, the baseline of new designed elements should be confirmed by experts through workshops, conferences, and regular meetings. Since the IPRA can be tailored by scientific, experienced and credible opinions for almost every construction project, the IPRA have potential to be commercialized with the reliable assessment for a NPP in the actual construction field.

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APPENDIX A

The international project risk assessment (IPRA)

Background

The project definition rating index (PDRI)

It is within bounds to say that success or failure of construction projects depend on the Front-End Planning. To be a successful construction project, a project manager has to put the right man in the right place with adequate resources for the contractor. He should also report potential risks to the owner to retain appropriate financial support. To figure out the exact standard of each resource within each stage of the project scope, the Front-End Planning step has the most significant role as a feasibility study step to secure resources and funds before the owner orders the project. Even though many project managers know the importance of the Front-End planning, there was no general risk factor integrated management tool at the Front-End Planning step. To solve these problems, Construction Industry Institute (CII) developed a user-friendly tool, namely, the Project Definition Rating Index (PDRI) to prepare proper countermeasures against risk factors. One of the advantages of the PDRI is that the construction manager is able to organize tailored appeasement strategies with respect to the unique risks of each project. For the owner, the PDRI provides well-prepared projects, alignment work groups, further practical risk assessment, and advanced project portfolio. For designers and contractors, in contrast, the PDRI offers measured project scopes, establishing a bridgehead for vital communication among participants. This also closes the gap of different perspectives based on standardized scope package, and tracking the project process. Presently, the PDRI takes center stage in the construction area because it contains essential sufficient strategic information and users can easily control the weight of each element to take account of unique project characteristics. As the Front-End Planning progressed, further detailed potential risks can be determined by several attempts of the PDRI on each step as shown in Figure 10.

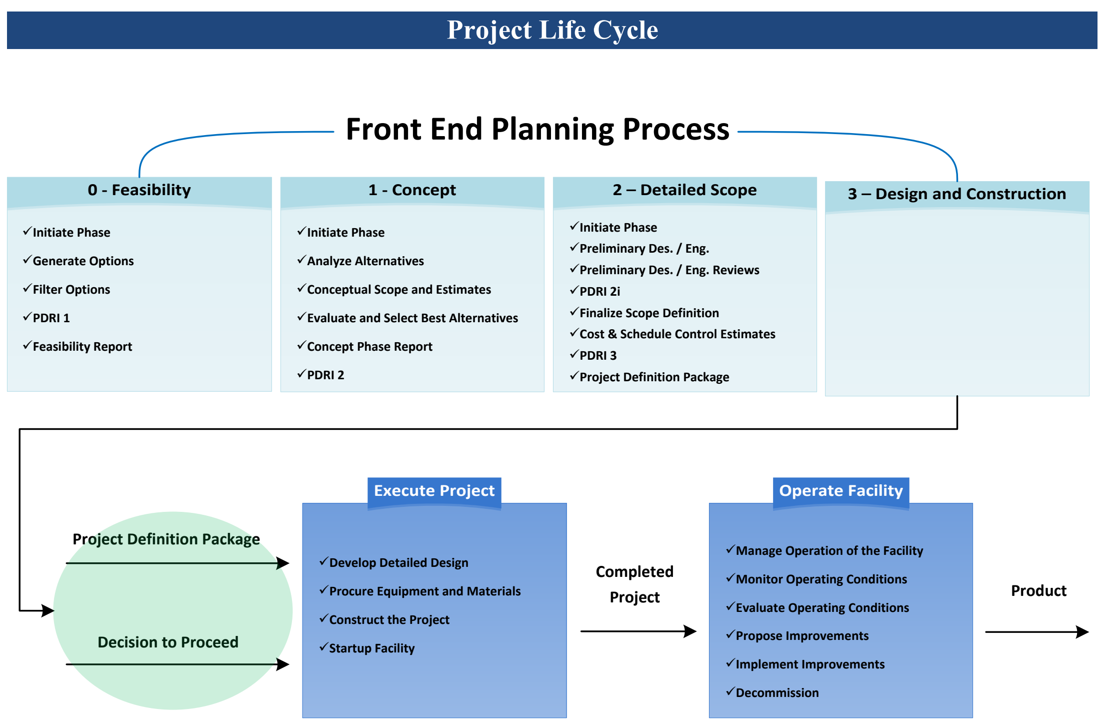

Figure 42 . Project Life Cycle with emphasize to Front-End Planning Process

Basically, the IPRA took the basic concepts and frames from the PDRI. Also, the elements of the IPRA were redefined by many specific literature reviews and existing distinguished industry methodologies to identify project risks as an international scale (Walewski, International Project Risk Assessment, 2005). Although constructions look like inert and stagnant projects, constructions are vital and dynamic projects with a life cycle. As time goes on, a project enters upon new phases. Also, as a project develops on, risky factors are changed by new conditions. Therefore, risk assessments are steadily translated into action on each phase. Since the IPRA risk frame reflected a life cycle when it was broken down with 82 elements under 14 categories with 4 main sections, the IPRA can apply not only to Front-End Planning, but also to on-going projects. The IPRA compatibility is beyond the limitation of the PDRI's limited compatibility (Walewski, International Project Risk Assessment, 2005).

International project risk breakdown structure

The origins of project risks are complicated and correlated with each other. Even though a project risk appears in a certain figure, a project risk is not derived from a cause. It is no exaggeration to say that all project risks originate from complex causes. Thus, the risks are hard to predict and figure out. To recognize the potential risks, a construction manager needs to regress into the origins as smaller components. Smaller components can be defined and grouped as discrete elements. Typically, the risk frame has a hierarchy structure that helps to determine the risks based on certain causes. Also, because the IPRA deals with international level issues, the risk frame should keep the international perspective when the risk is broken down into basic elements.

An international risk is broken down as 4 sections in the first row of a risk frame by IPRA as shown in Figure 43. The first section is 'Commercial' which deals with very important business issues with the development of business plans and financial issues. Specific risks of country issues, constructions, and facility productions and operations are provided in section 2 to section 4 (Walewski, International Project Risk Assessment, 2005).

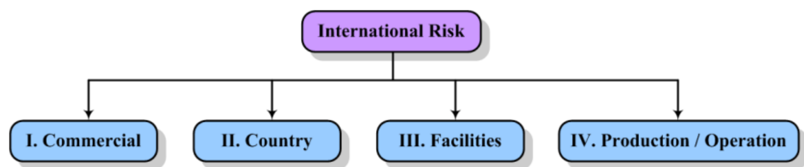

Figure 43 The main 4 sections of the IPRA (Walewski, International Project Risk Assessment, 2005)

Element descriptions

International Project Risk Frame can be explained by the following descriptions of each element. The concept of each element is clearly described through each section. Also, 82 elements are covered by each detailed breakdown structure.

Section I – Commercial

This section shows all about the commercial issues of international projects-whether the project can be supported throughout its duration. Through this section, the project management team can prepare the mitigation strategies of project financial risk based on predicted potential risks. The breakdown frame of the commercial part is as shown in Figure 44.

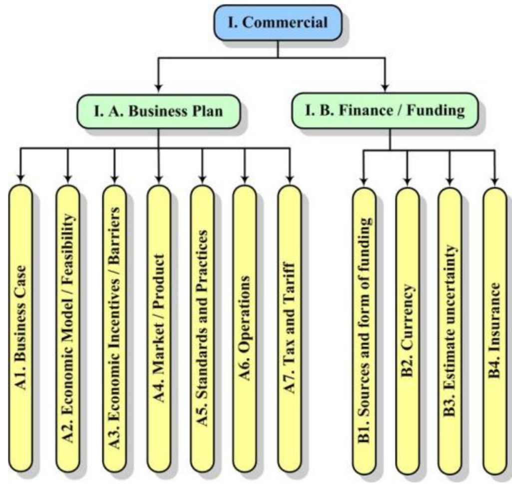

Figure 44 International project risk frame of commercial section (Walewski, International Project Risk Assessment, 2005)

I.A. Business plan

The business plan category is explained with respect to the economic and market conditions for the project. The decision of project order can be determined with economic flows, additional partial prices, and market conditions for the project.

Element I. A1. Business case

This part of the elements shows the business objectives with related strategies and assumptions to support the feasibility study of the international project. This part accompanies the elements to consider the overall social atmosphere for each international project as shown in Figure 45.

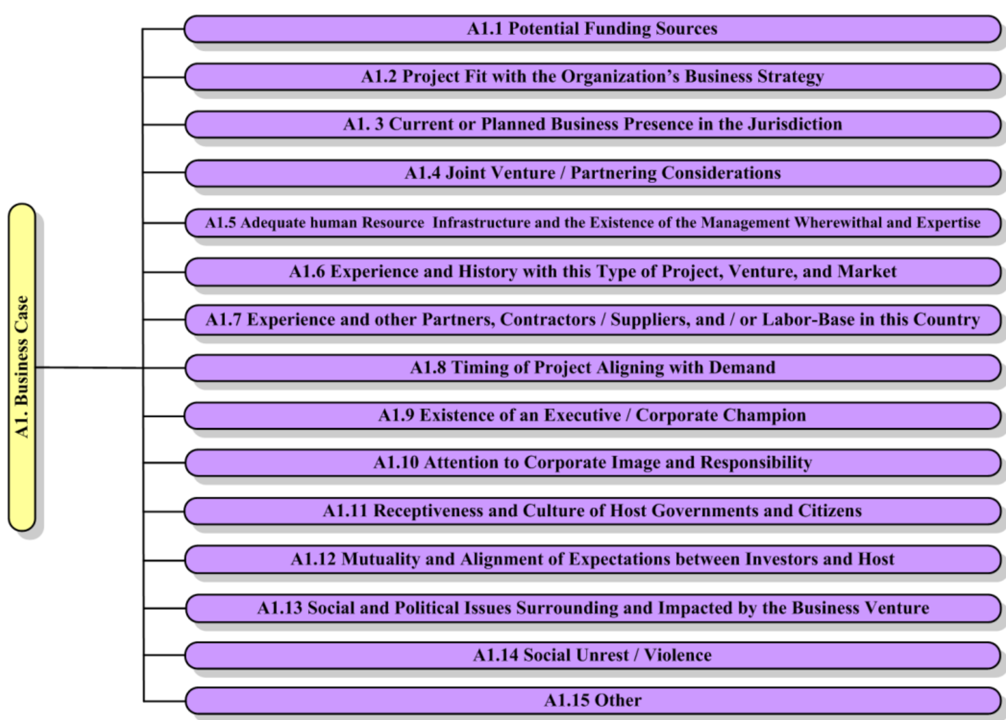

Figure 45 Risk elements of business case (Walewski, International Project Risk Assessment, 2005)

Element I. A2. Economic model / feasibility

Since economic consideration is the significant part same as the schedule part, the unique economic model is required to predict the project cost including the cost uncertainty intervals as shown in Figure 46. The economic model connected with project's financial feasibility as well.

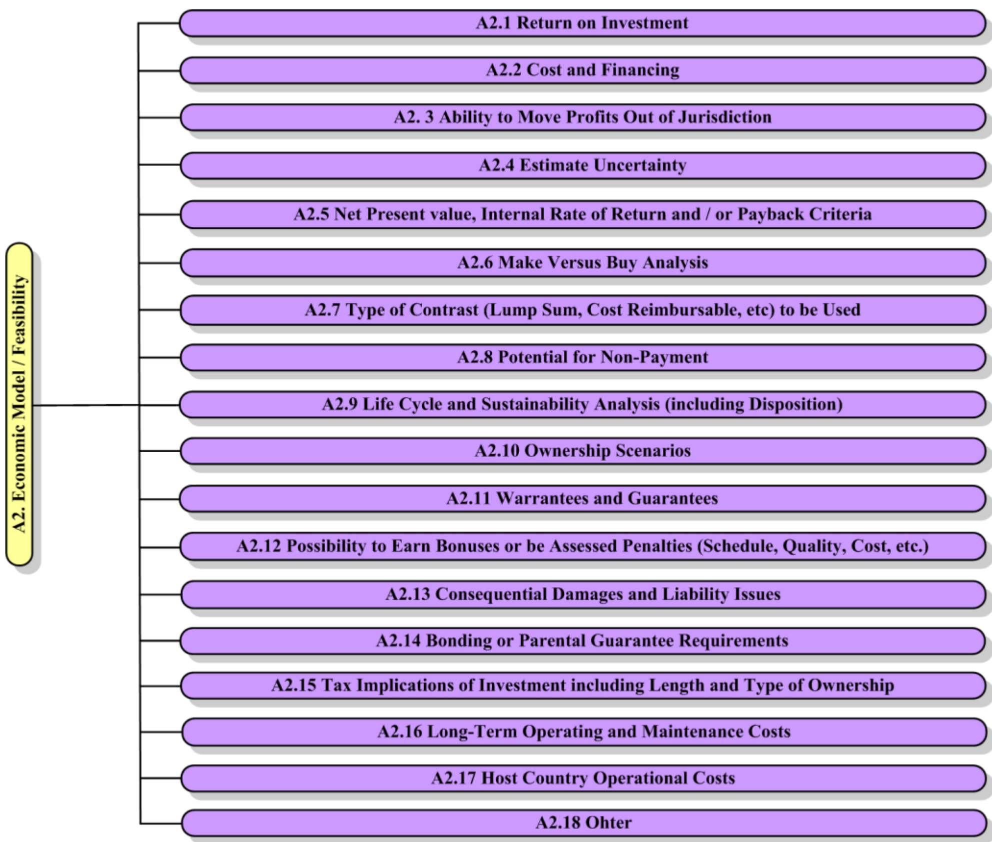

Figure 46 Risk elements of economic model / feasibility (Walewski, International Project Risk Assessment, 2005)

Element I. A3. Economic incentives / barriers

To encourage the workers, proper incentives have a good role as a catalyst. This part considers the market structure to figure out economic incentives as shown in Figure 47. On the same approach, in contrast, economic barriers can be figured out through this element of hierarchical frame. Through determined bad factors, detour or mitigation tailored strategies can be prepared for international projects.

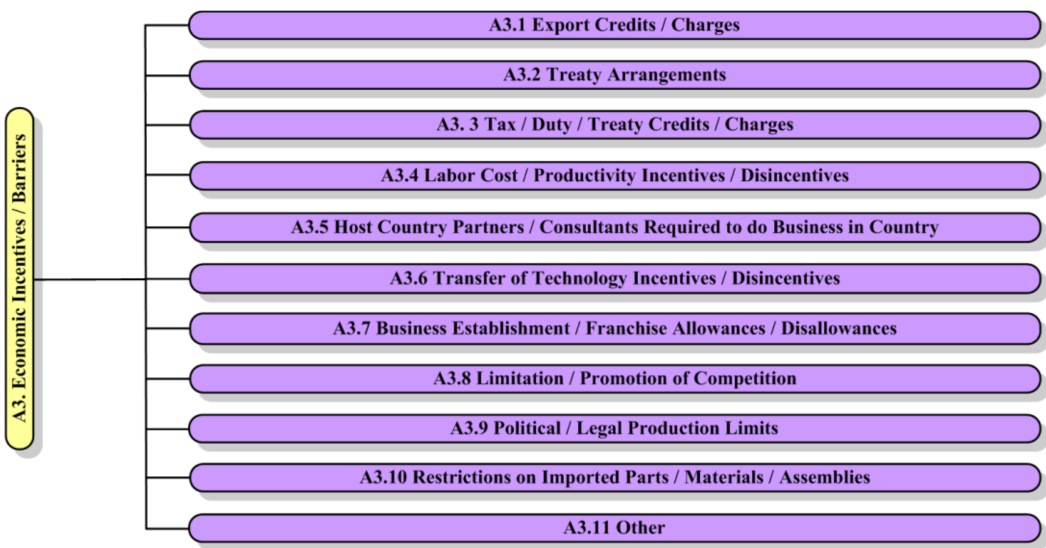

Figure 47 Risk elements of economic incentives / barriers (Walewski, International Project Risk Assessment, 2005)

Element I. A4. Market / product

To enter into the market, the market and product strategy should be developed based on elements as shown in Figure 48. The market strategy prepared as the level of the business plan with cost, schedule, quality, contracts, and incentives.

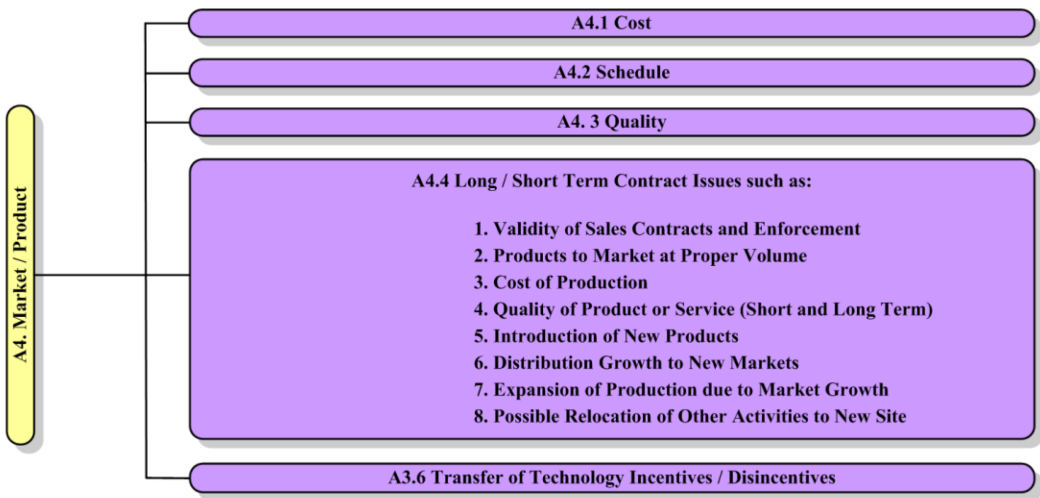

Figure 48 Risk elements of market / product (Walewski, International Project Risk Assessment, 2005)

Element I. A5. Standards and practices

It is hard to establish a standard with international projects because each country has different unique conditions. However, technical standards and practices should be prepared for the international projects. The unique characteristics of each country are narrowed down to a standard through established elements of standards and practices as shown in Figure 49.

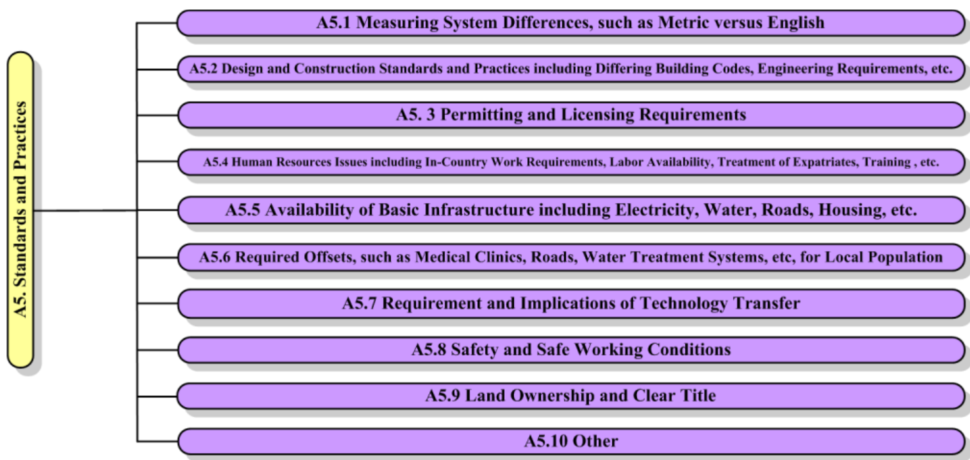

Figure 49 Risk elements of standards and practices (Walewski, International Project Risk Assessment, 2005)

Element I. A6. Operations

The business planning category needs to evaluate long-term and short-term operations at the Front-End Process step. Safety issues and legal issues should be dealt with in this element as shown in Figure 50.

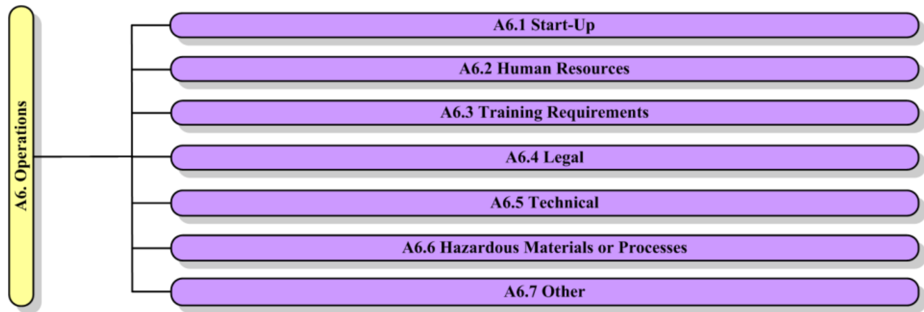

Figure 50 Risk elements of operations (Walewski, International Project Risk Assessment, 2005)

Element I. A7. Tax and tariff

Tax and tariff can be a big part of the international projects. This additional cost looks like a small part of the total price of project. However, international projects have a large amount of extra costs such as tax and tariff. Also, an economic flow will influence the total price including an extra percentage of tax and tariff based on pure cost estimating and local laws. Figure 51 shows elements of the risk frame that should be considered by tax and tariff.

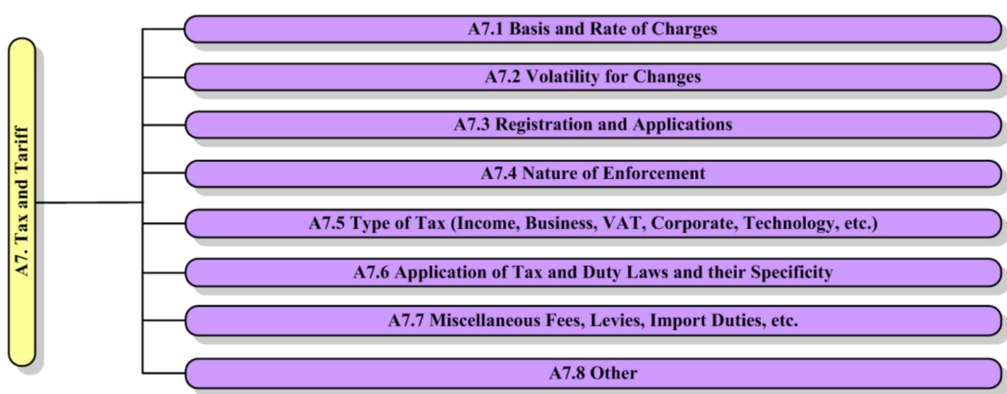

Figure 51 Risk elements of tax and tariff (Walewski, International Project Risk Assessment, 2005)

I.B. Finance / funding

The practical cost estimate of a project can be covered by the Finance / Funding category. This part is more important for the international project than the domestic project because the international project is very sensitive to the currency change. Thus, the project budget can be procured under bad economic conditions and release the saved budget under good economic conditions to get ahead of schedule with stable financial support.

Element I. B1. Sources and form of funding

Funding sources are needed to be systemized by the financial structure. In this part, the funding sources can be formulated based on the typical types and forms of financing after adding project participant and funding on the typical types as shown in Figure 52. Local funding sources' condition can be considered with project participants and funding based on overall typical types and forms of financing.

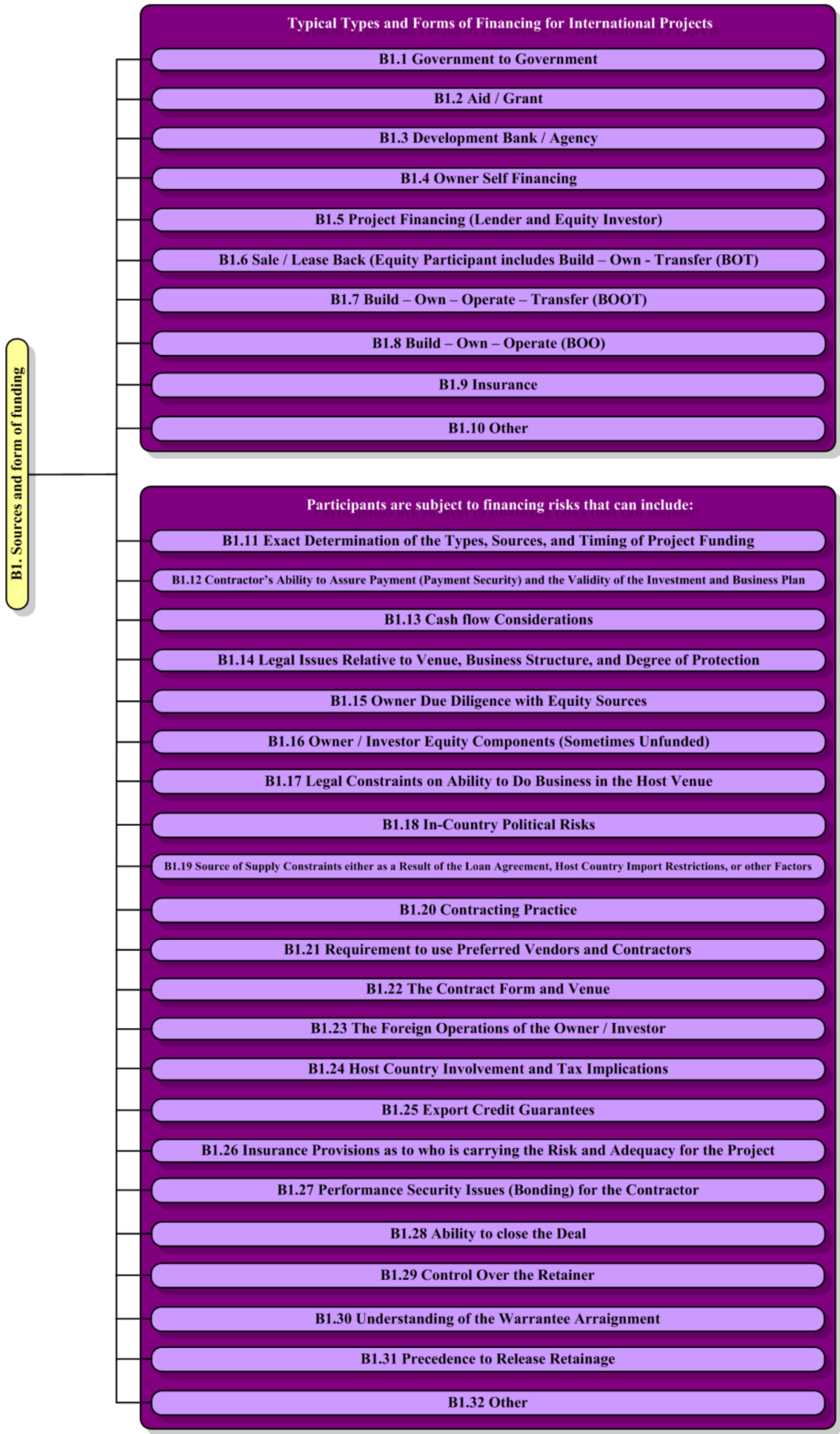

Figure 52 Risk elements of sources and form of funding (Walewski, International Project Risk Assessment, 2005)

Element I. B2. Currency

Currency is impossible to define in one way. Currency fluctuated every moment. Also, the exact prediction of currency is almost impossible for the future. The cost estimating of an international project is based on the approximated rate of currency trend. Especially, international projects are sensitive with the currency rate. This part cannot be ignored to figure out the international level risk as shown in Figure 53.

Figure 53 Risk elements of currency (Walewski, International Project Risk Assessment, 2005)

Element I. B3. Estimate uncertainty

The word 'Estimate' already includes 'Uncertainty' in the meaning. The results of estimates are various. The majority of cost estimates appear as under-estimating. However, over-estimating often appears during international projects because the value of estimating includes many spare factors to cover the high probability of uncertainty. Thus, the estimation of international projects is hard to determine as an accurate number. Risk frame of international projects can be determined as shown in Figure 54.

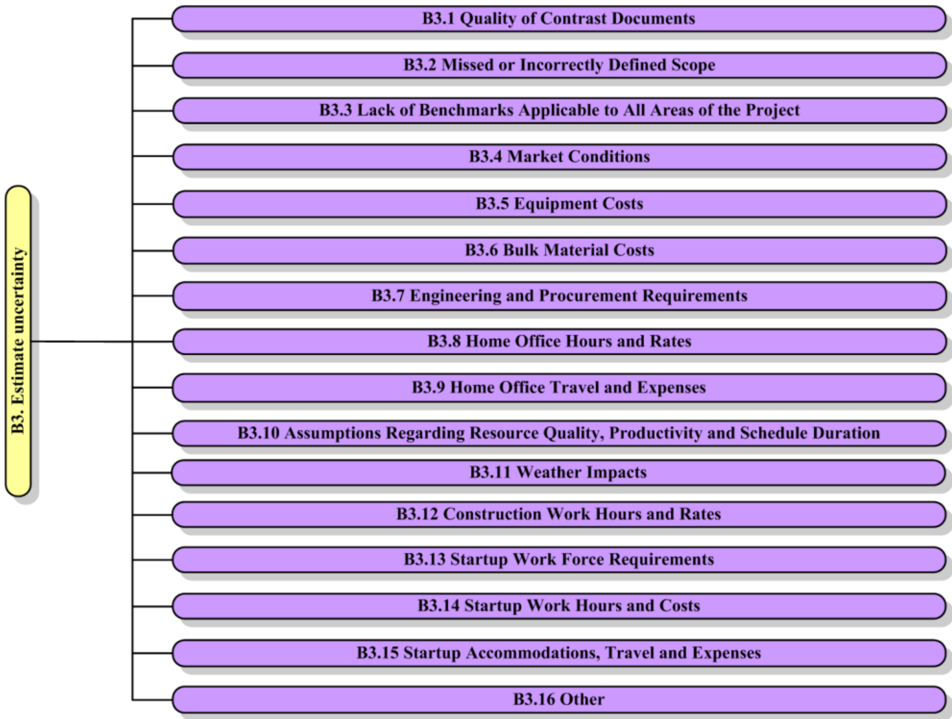

Figure 54 Risk elements of estimate uncertainty (Walewski, International Project Risk Assessment, 2005)

Element I. B4. Insurance

One of the typical mitigation strategies for risks is insurance. Since every project has the complicated origins of problems, insurance is the most convenient way to cover the risks. However, the approximate value of risk needs to be recognized to buy an insurance plan. Figure 55 shows the hierarchy structure to evaluate an approximate insurance value.

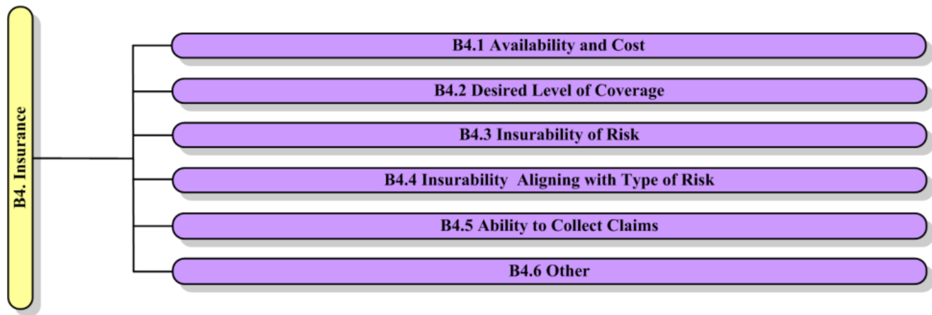

Figure 55 Risk elements of insurance (Walewski, International Project Risk Assessment, 2005)

Section II – Country

The existence of this section makes the difference between the IPRA and the PDRI. The regional unique factors should be considered as a significant factor to assess the international project. Country Section is split by 4 categories as shown in Figure 56.

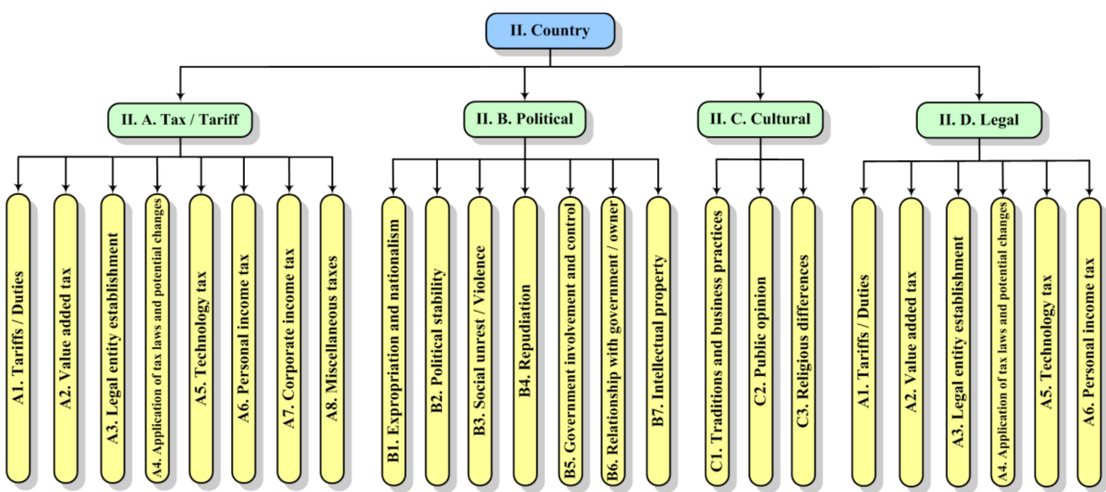

Figure 56 International project risk frame of country section (Walewski, International Project Risk Assessment, 2005)

Category II. A. Tax / tariff

Element II. A1. Tariffs / duties

Each country has different rates of tariffs and duties. Tax and tariff impact the international project significantly. This part should be considered from the viewpoint of facility construction and operation. To figure out the further clear value of tax and tariff, understanding of the local language should be accompanied to understand better political events and to comply with the local laws. The Figure 57 shows the risk hierarchy structure that should be evaluated for the total value.

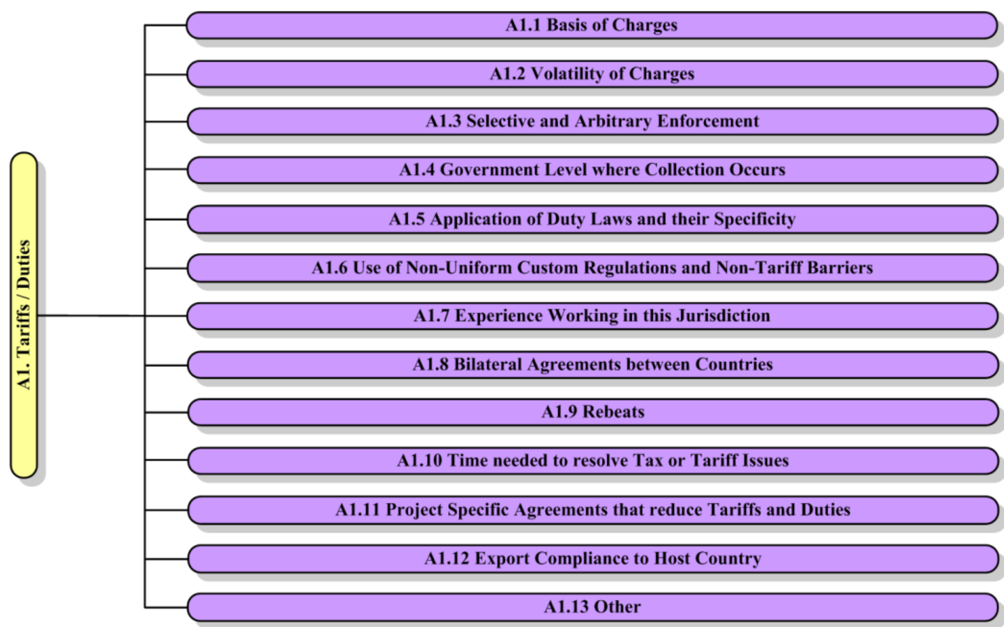

Figure 57 Risk elements of tariffs / duties (Walewski, International Project Risk Assessment, 2005)

Element II. A2. Value Added Tax

VAT is one of the procedures to determine the final pricing. Naturally, the negative cash flow is related with project risks. Also, VAT is related with a dynamic cash flow. Thus, VAT is hard to predict as an exact number. Considerable factors as shown in Figure 58.

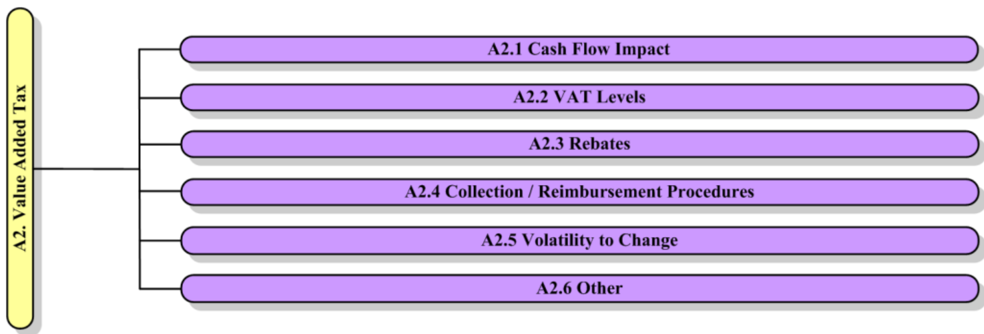

Figure 58 Risk elements of Value Added Tax (Walewski, International Project Risk Assessment, 2005)

Element II. A3. Legal entity establishment

The project should be launched under the law. The legal entity has protection and authority with licenses, registrations, and the official notice to proceed. Under the law, importing materials, equipment, and servicing supports the project with adequate resources. In addition, international projects are confronted with unique country laws. Thus, local laws need to be respected by the projects for the successful projects. The risk elements can help to gain approval from the legal entity. Considerable factors are shown in Figure 59.

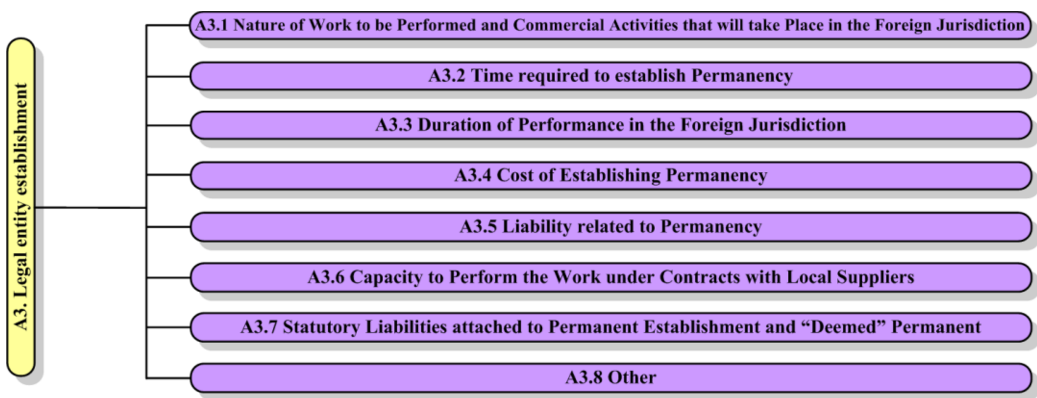

Figure 59 Risk elements of legal entity establishment (Walewski, International Project Risk Assessment, 2005)

Element II. A4. Application of tax laws and potential changes

The tax laws are changed by the local economy conditions. Also, the tax laws are strongly correlated with the performance of projects. Thus, the tax laws should be monitored and evaluated until the end of the project by the risk elements as shown in Figure 60.

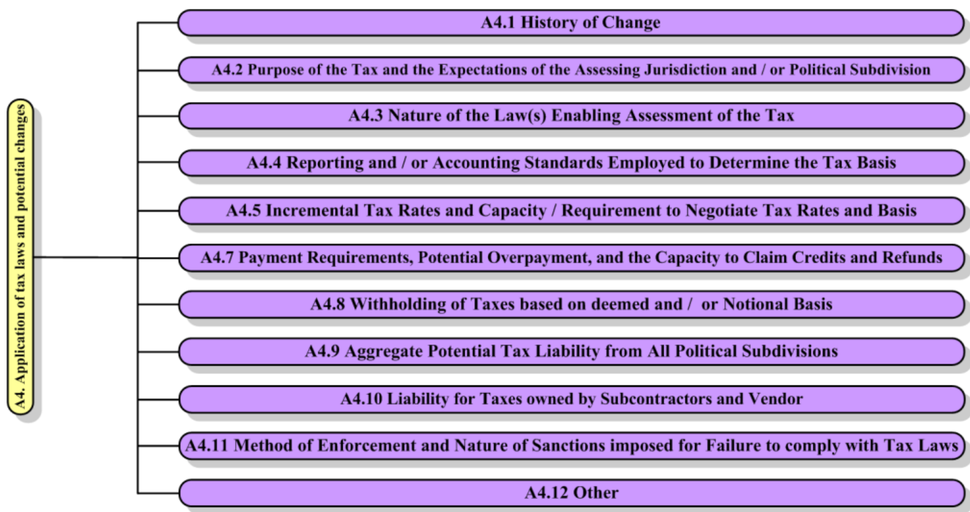

Figure 60 Risk elements of application of tax laws and potential changes (Walewski, International Project Risk Assessment, 2005)

Element II. A5. Technology tax

Construction projects integrated with technology are a trend nowadays. A fee should be charged when professional technologies are borrowed by the investors or project managers. Technology tax can be considered through Figure 61.

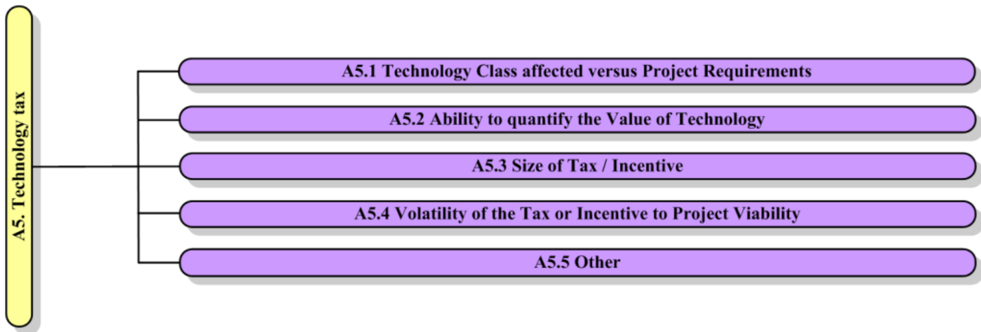

Figure 61 Risk elements of technology tax (Walewski, International Project Risk Assessment, 2005)

Element II. A6. Personal income tax

Personal income tax of all over the world is not same. Some countries assign half of a foreign worker's income as tax. Thus, Figure 62 helps to understand the personal income tax of international projects.

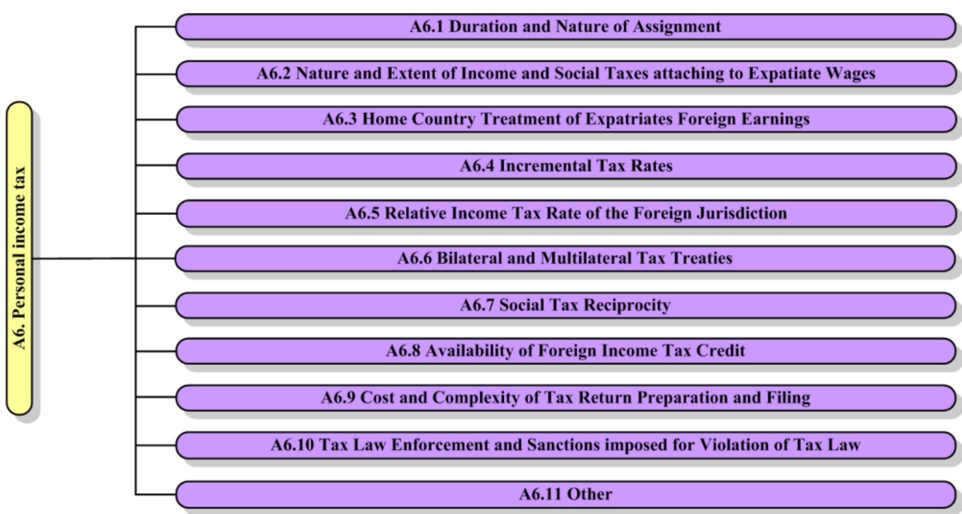

Figure 62 Risk elements of personal income tax (Walewski, International Project Risk Assessment, 2005)

Element II. A7. Corporate income tax

The companies have a responsibility to pay an income tax. This part, also, has a high uncertainty to decrease the profit. Thus, corporate income tax should be well considered with risk elements as shown in Figure 63.

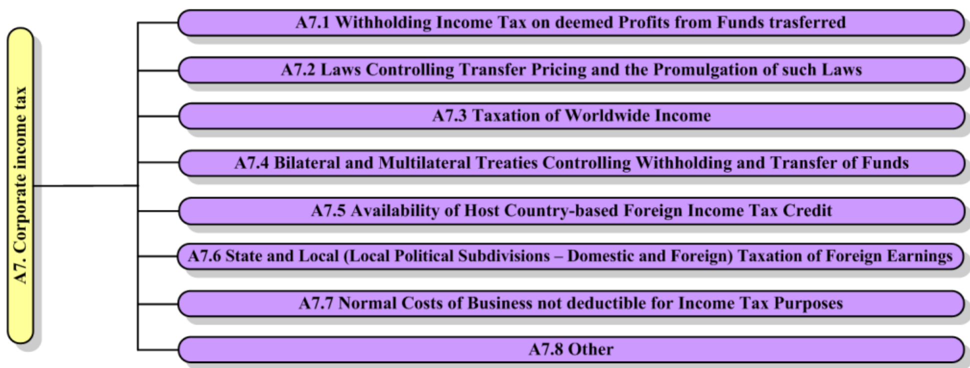

Figure 63 Risk elements of corporate income tax (Walewski, International Project Risk Assessment, 2005)

Element II. A8. Miscellaneous taxes

Even though risks figured out with these risk elements, it is possible that there are some hidden risks. Thus, the out of risk element's boundary can be figured out with the miscellaneous risk frames as shown in Figure 64.

Figure 64 Risk elements of miscellaneous taxes (Walewski, International Project Risk Assessment, 2005)

Category II. B. Political

Element II. B1. Expropriation and nationalization

If the international projects coincide with the public purpose, the country can expropriate the project. Elements of Figure 65 are consideration subjects for expropriation and nationalization.

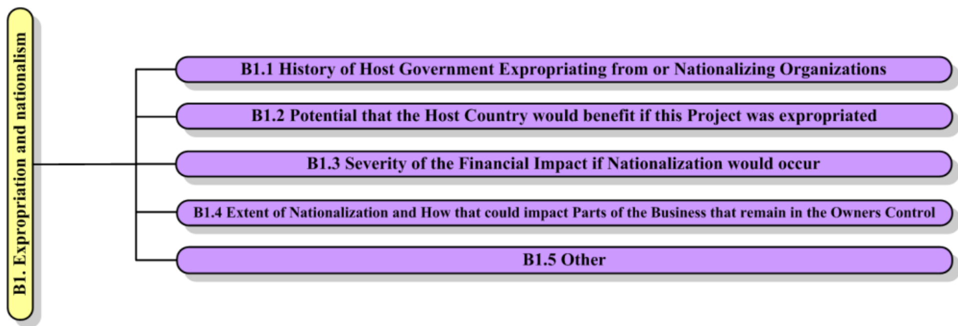

Figure 65 Risk elements of expropriation and nationalization (Walewski, International Project Risk Assessment, 2005)

Element II. B2. Political stability

The construction projects are exposed to political stabilities. Naturally, political risks increase when the atmosphere of a country is unstable. Political issues are not short-term issues. Also, the construction project is very sensitive with economic policy and changing regime. Figure 66 shows the elements of political stability for the international projects.

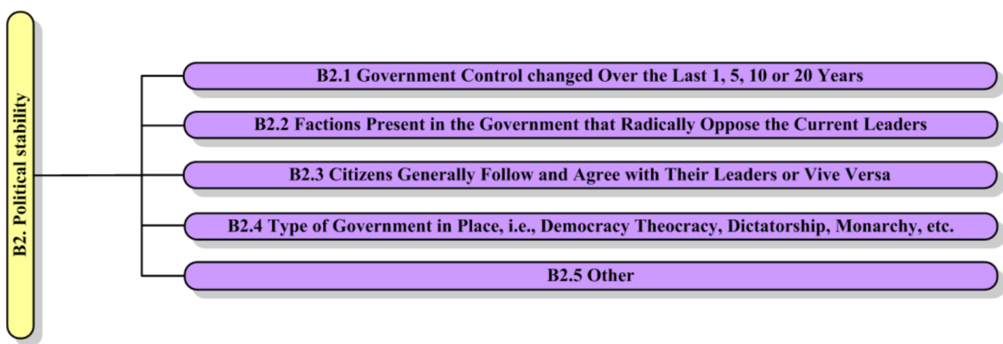

Figure 66 Risk elements of political stability (Walewski, International Project Risk Assessment, 2005)

Element II. B3. Social unrest / violence

The majority of international infrastructure projects are constructed in the developed and underdeveloped countries. The majority of developed and underdeveloped countries have an unstable economy and unprofessional government. Against the insecure atmosphere, riot, disturbance, and wars can happen. Workers' safety and construction projects can be threatened by social unrest. Considerable facts are as shown in Figure 67.

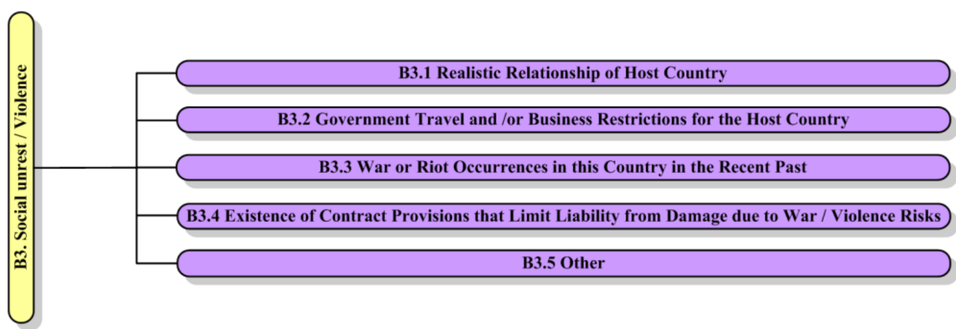

Figure 67 Risk elements of social unrest / violence (Walewski, International Project Risk Assessment, 2005)

Element II. B4. Repudiation

Sometimes the government does not want to repay a debt or obligation. Repudiation does not appear often. But it will bring enormous economic damage to the company. Figure 68 shows elements of repudiation risks.

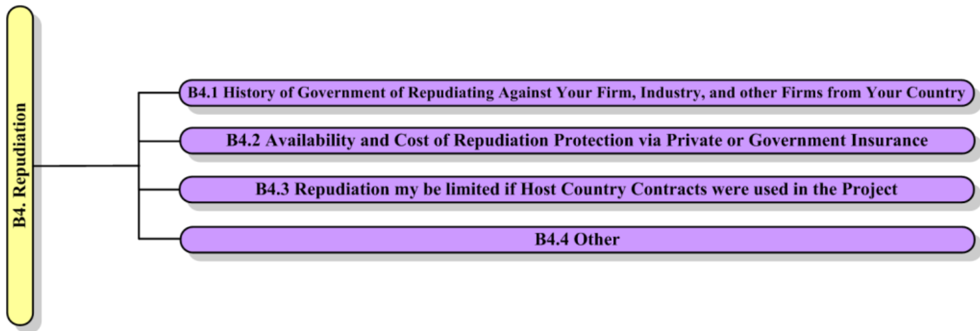

Figure 68 Risk elements of repudiation (Walewski, International Project Risk Assessment, 2005)

Element II. B5. Government involvement and control

The main characteristics of international projects are large scale, long construction duration, and public construction projects. Thus, international projects are strongly related with government policy. Issues to consider are included in Figure 69.

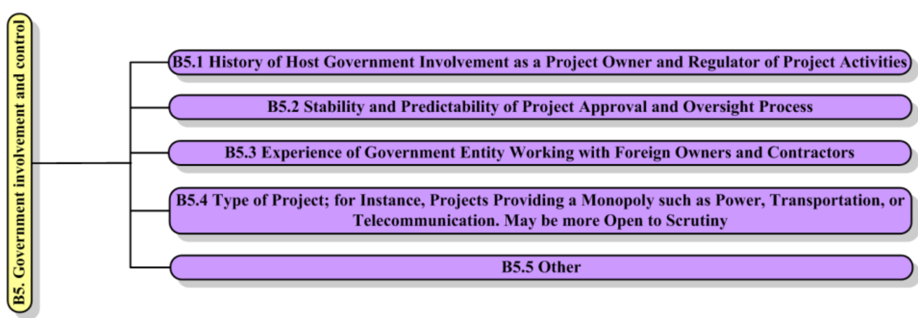

Figure 69 Risk elements of government involvement and control (Walewski, International Project Risk Assessment, 2005)

Element II. B6. Relationship with government / owner

A good relationship between government and owner is a key for a successful international project. To keep a good relationship, a fair contract can be a bridge between the owner and the government. The contractor should construct according to the owner's expectations. In contrast, the owner has to make a payment on time. A good relationship can be considered by the risk frame as shown in Figure 70.

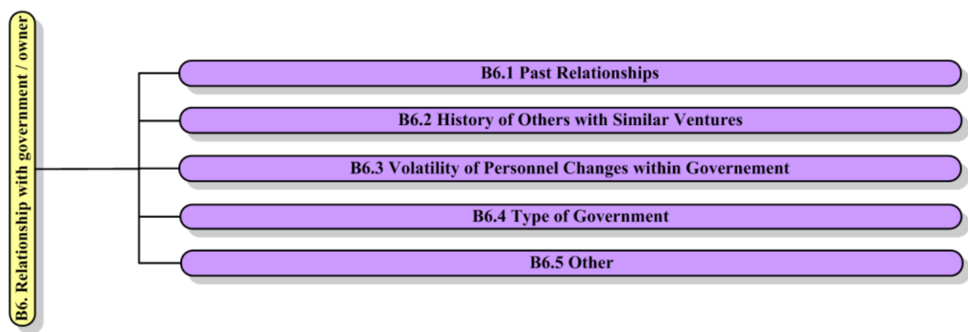

Figure 70 Risk elements of government involvement and control (Walewski, International Project Risk Assessment, 2005)

Element II. B7. Intellectual property

New methods of construction, cutting-edge technologies are integrated into construction nowadays. Construction sites are exposed, thus, it is hard to avoid the applied new technologies in every construction project. However, the intellectual property should be considered as an ethical issue. To figure out the risk factors, Figure 71 is a list of possible elements.

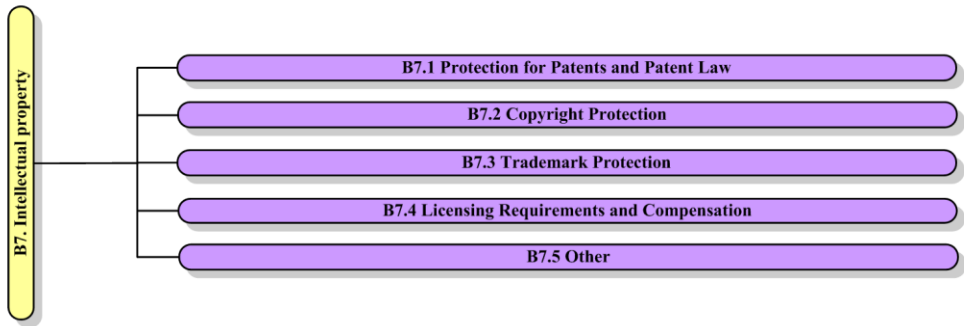

Figure 71 Risk elements of intellectual property (Walewski, International Project Risk Assessment, 2005)

Category II. C. Cultural

Element II. C1. Traditions and business practices

Culture shock is a factor when a contractor works in another country. Thus, a clear understanding of the owner's intent is the most important to reach to the ideal goal. For complete understanding, traditions and cultures should be reviewed and workers and management teams should be educated as shown in Figure 72.

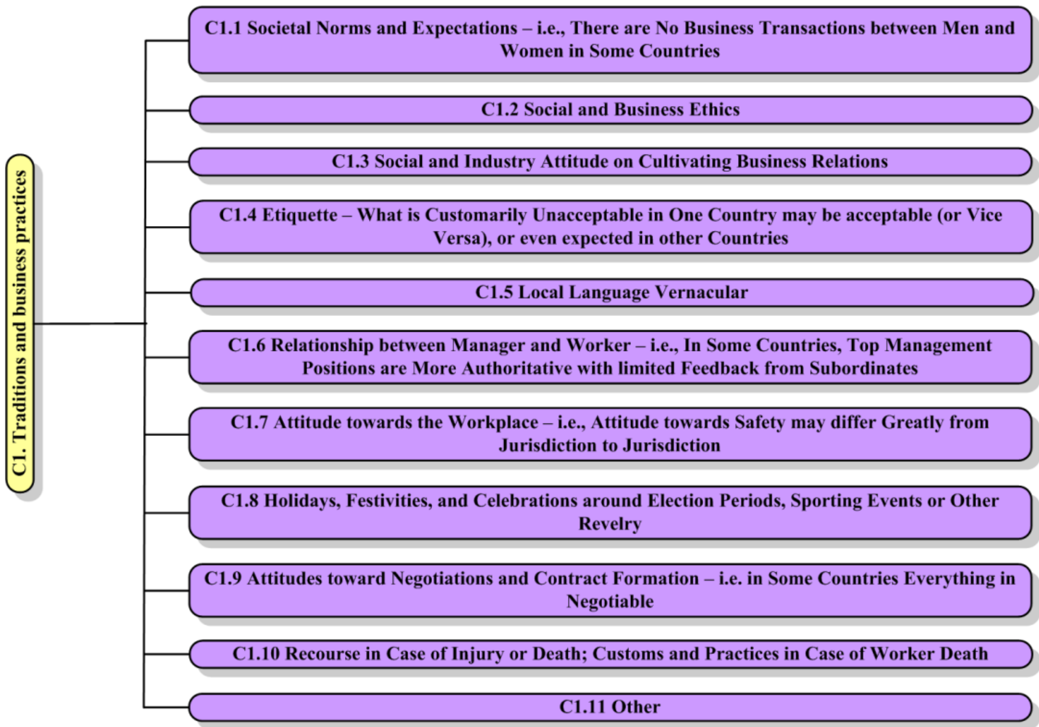

Figure 72 Risk elements of traditions and business practices (Walewski, International Project Risk Assessment, 2005)

Element II. C2. Public opinion

Construction projects often run into strong public resistance because construction sites can be an obstacle or a hindrance to maintain their everyday life. Public opinions can be considered according to Figure 73.

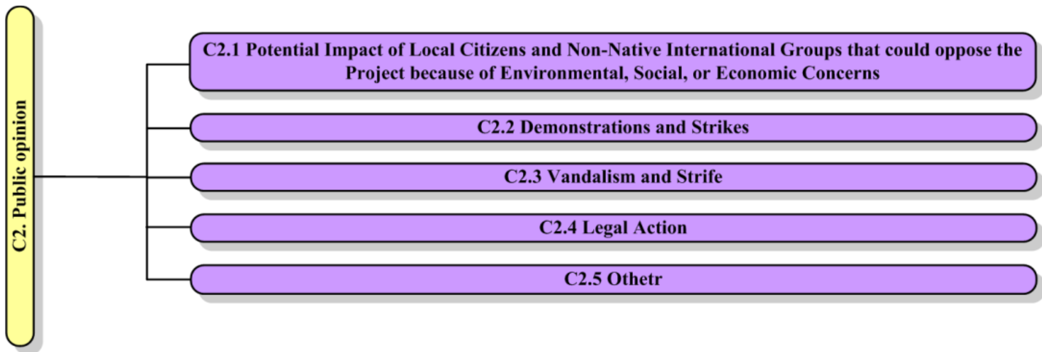

Figure 73 Risk elements of public opinion (Walewski, International Project Risk Assessment, 2005)

Element II. C3. Religious differences

Religious differences could be impacted by the unique design of structure. Also, workers try to avoid work on religious holidays. Thus, the project schedule can be delayed or the cost increased by religious issues. This part can be considered by Figure 74.

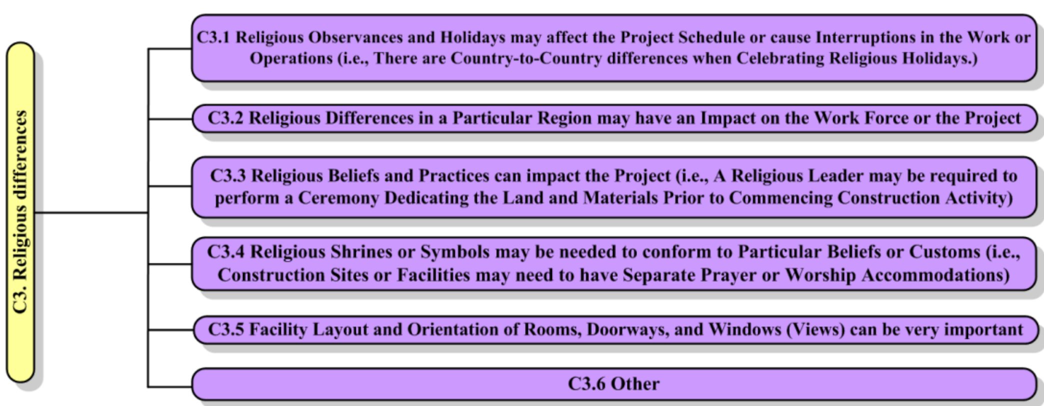

Figure 74 Risk elements of religious differences (Walewski, International Project Risk Assessment, 2005)

Category II.D. Legal

Element II. D1. Legal basis

The law exists to support the rights and duties for each part under the common law. Slight variations of the law exist in each country. However, the primary purpose of law is still the same. In other words, the law works for better communication between each division. To work smoothly, Figure 75 needs to be considered to drive the exact goal of project.

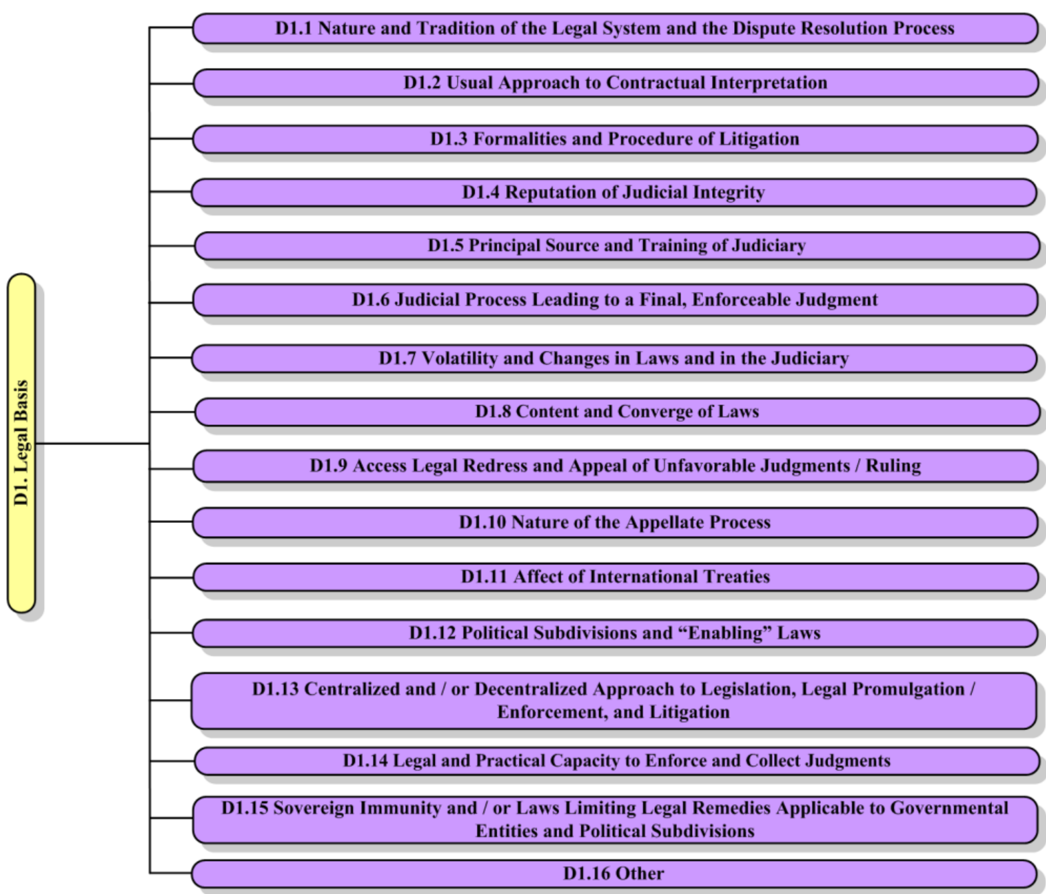

Figure 75 Risk elements of legal basis (Walewski, International Project Risk Assessment, 2005)

Element II. D2. Legal standing

Projects outside the boundaries of the law are considered illegal because it constructs general rules without a contract as a document. In this case, the project cannot work officially with the organization. Thus, ordering materials, payments, and legal rights do not work for the business. Legal standing elements are shown in Figure 76.

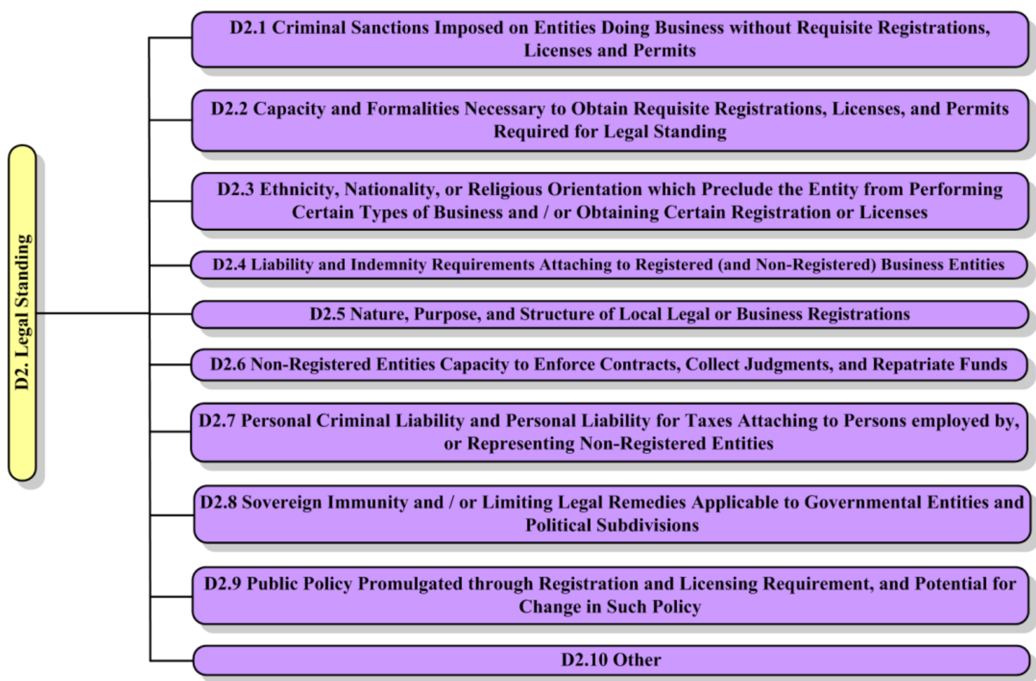

Figure 76 Risk elements of legal standing (Walewski, International Project Risk Assessment, 2005)

Element II. D3. Governing law / contrast language and formalities

It is possible that some divisions cannot benefit from the law and local legal system. Arbitration requires solving a legal problem. Therefore, the regional language should be accompanied with legal issues. Agreements or treaties are possible ways to avoid or mitigate these problems. In this section, Figure 77 presents possible risks.

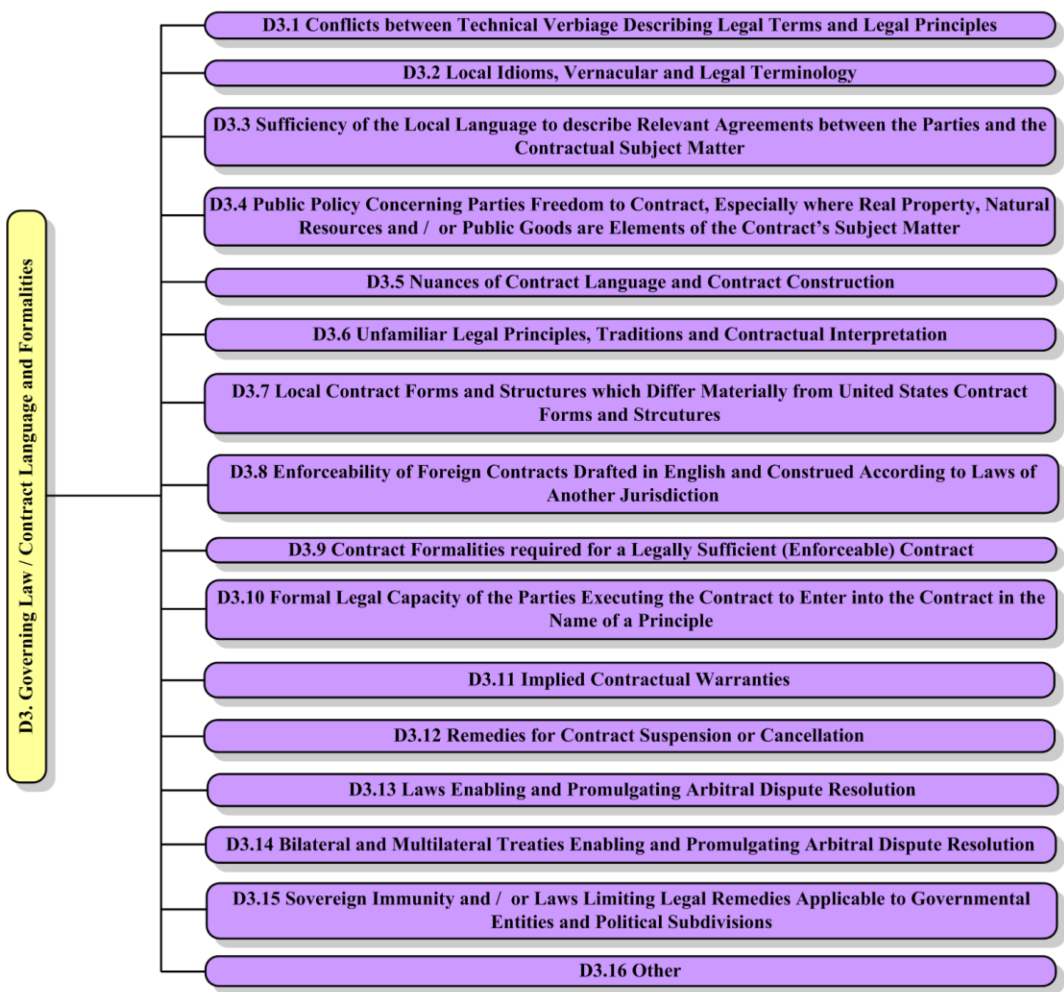

Figure 77 Risk elements of government law / contract language and formalities (Walewski, International Project Risk Assessment, 2005)

Element II. D4. Contract type and procedures

Contract type should be tuned for the unique type of construction projects. These contract types must adjust to the project issues and each country's conditions. To consider the domestic characteristics of the project for the contract type, Figure 78 would be helpful.

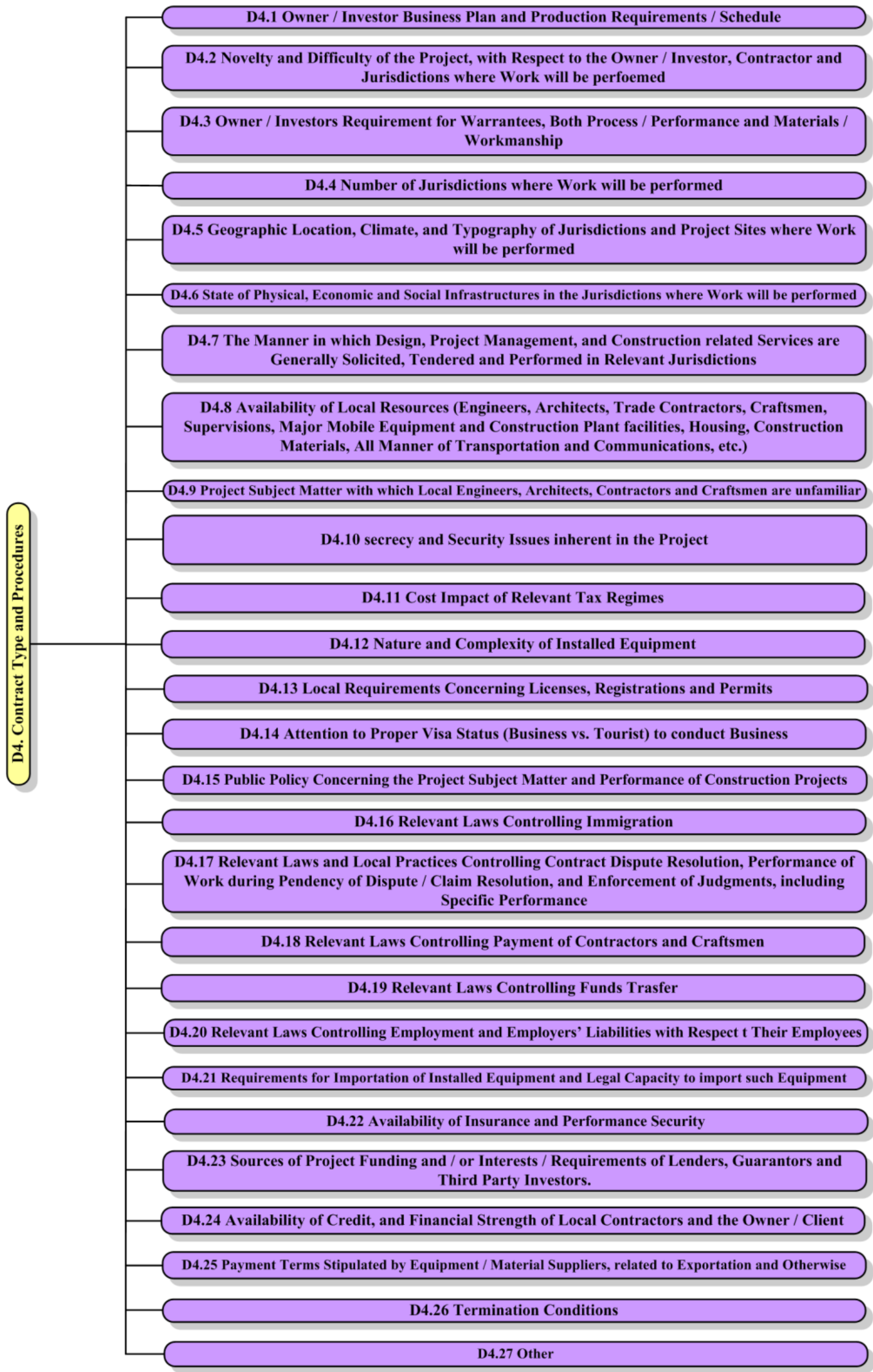

Figure 78 Risk elements of contract type and procedures (Walewski, International Project Risk Assessment, 2005)

Element II. D5. Environmental permitting

Environmental-friendly construction is a hot issue in the construction field. A contractor should consider the contamination around construction areas. Bad impacts on the environment may be faced with the resistance of civil groups. In this case, the project may be delayed, redesigned, or issued fines. To consider the environmental permitting, risk elements can be helpful as shown in Figure 79.

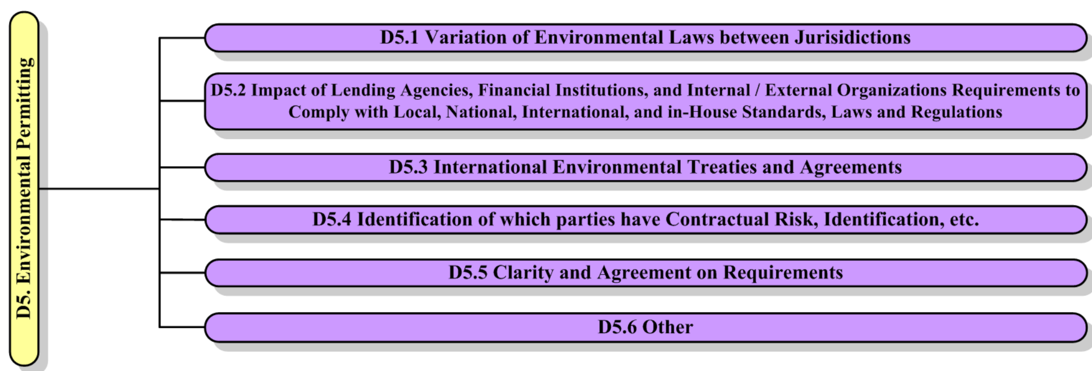

Figure 79 Risk elements of environmental permitting (Walewski, International Project Risk Assessment, 2005)

Element II. D6. Corrupt business practices

An ethical problem is ubiquitous to all construction areas. To get a positive self-result for the contractor, they should not hire a professional lobbyist with money and valuables. Civil infrastructure should be constructed under the ethic range. Figure 80 presents possible consideration facts.

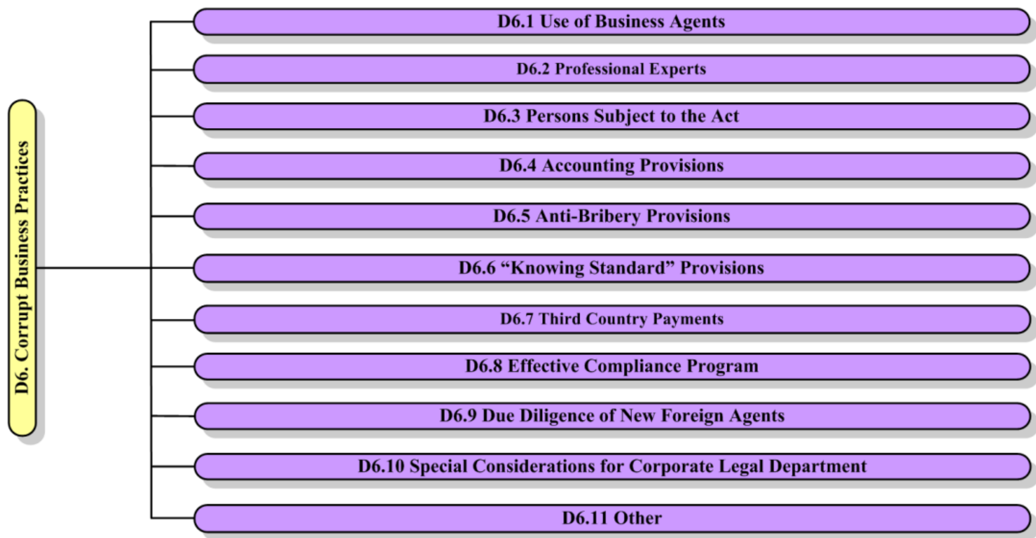

Figure 80 Risk elements of corrupt business practices (Walewski, International Project Risk Assessment, 2005)

Section III – Facilities

Facilities need adequate resources such as materials, mechanics, manpower, money, and minutes. For the successful delivery of international projects, monitoring is essential to fulfill the project requirements. This section deals with the overall project life cycle from the scope development to the start-up project as shown in Figure 81.

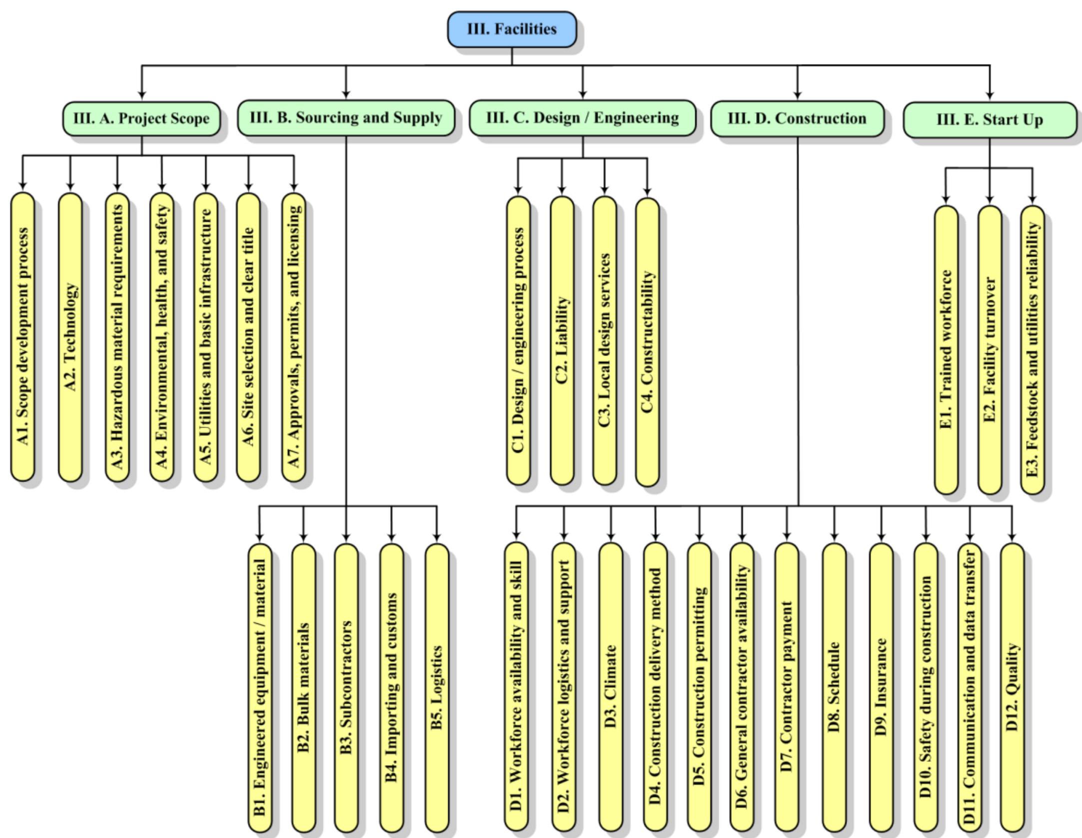

Figure 81 International project risk frame of facilities section (Walewski, International Project Risk Assessment, 2005)

Category III. A. Project scope

Element III. A1. Scope development process

For fewer trials and errors, the experiences and proper resources are significant to determine the scope of project. Historical similar projects can be a good model to determine the optimized project. Through Figure 82, project scope development process can be determined.

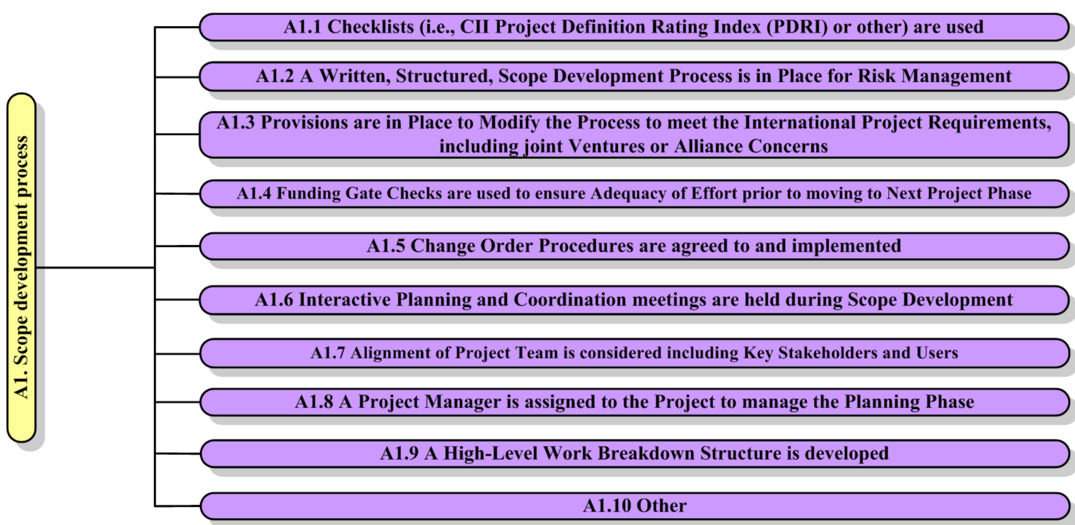

Figure 82 Risk elements of scope development process (Walewski, International Project Risk Assessment, 2005)

Element III. A2. Technology

As long as progressing technology enhances construction, smarter constructions will develop. Certain technologies should be under the new law to protect the exposure of original technologies and to respect the developers' efforts. The new technologies include the uncertainty of whether those skills are adequate or not. However, proved technologies can accelerate the project to be completed as soon as possible. An elaborate work is possible with the technologies. Figure 83 shows consideration factors for technologies.

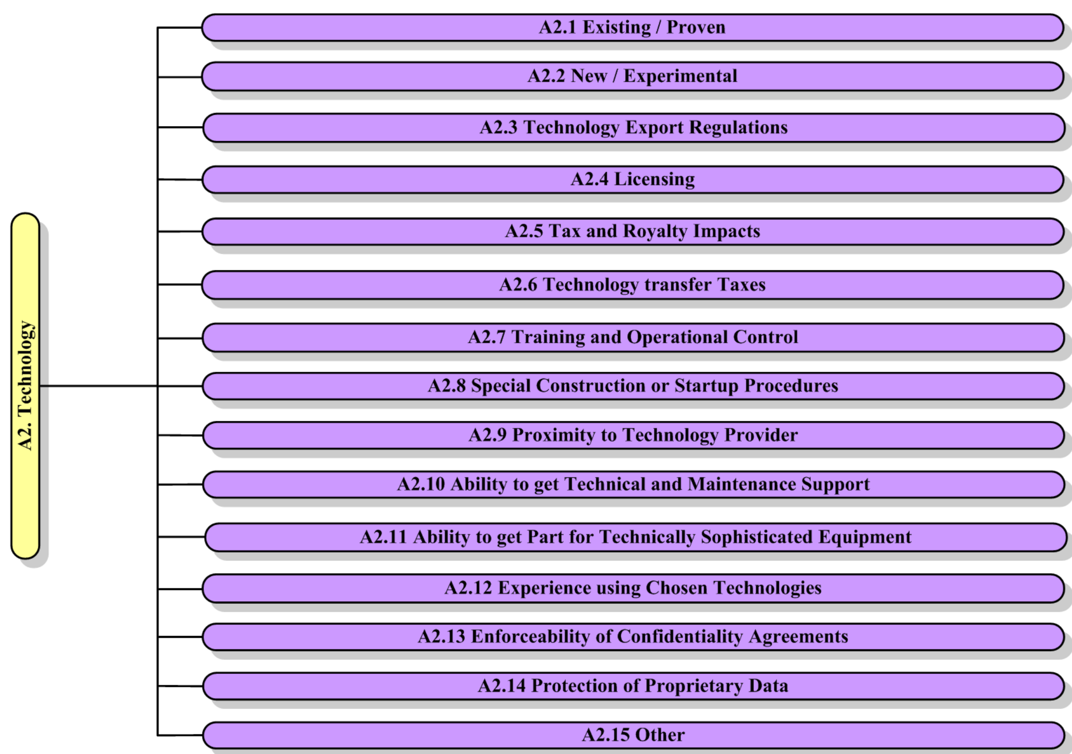

Figure 83 Risk elements of technology (Walewski, International Project Risk Assessment, 2005)

Element III. A3. Hazardous material requirements

Heavy industry projects or infrastructural projects often require hazardous materials. Thus, safety regulations should be kept by the laborers. Potential risks should be determined by the elements as shown in Figure 84.

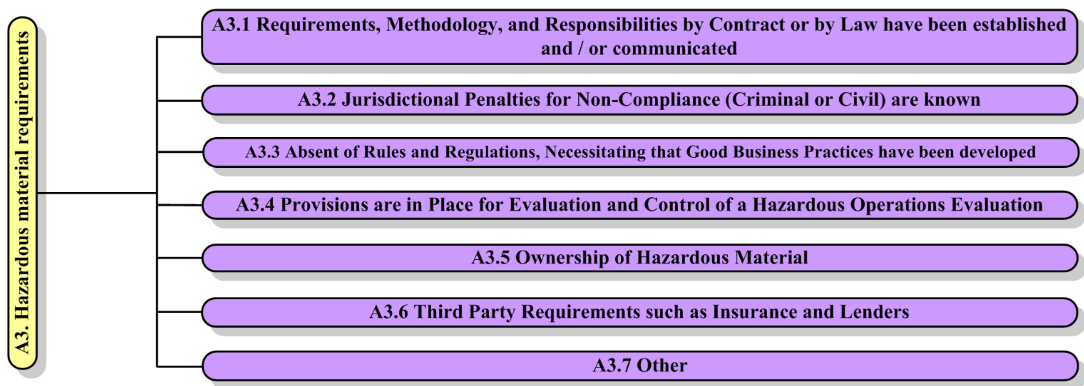

Figure 84 Risk elements of hazardous material requirements (Walewski, International Project Risk Assessment, 2005)

Element III. A4. Environmental, health, and safety

Protection of the environment and of laborers is the target of all projects. However, climates of protection issues are different in each country. The general perspective is shown by the Figure 85.

Figure 85 Risk elements of environmental, health, and safety (Walewski, International Project Risk Assessment, 2005)

Element III. A5. Utilities and basic infrastructure

To lead a basic life, fundamental infrastructures and basic utility system should exist. Specifically, the majority of underdevelopment countries do not prepare these basic infrastructures. To establish the project, an infrastructure construction should be accompanied by basic utilities. Water supply is needed to support society as basic infrastructure, as well. Figure 86 clearly shows elements of utilities and basic infrastructure.

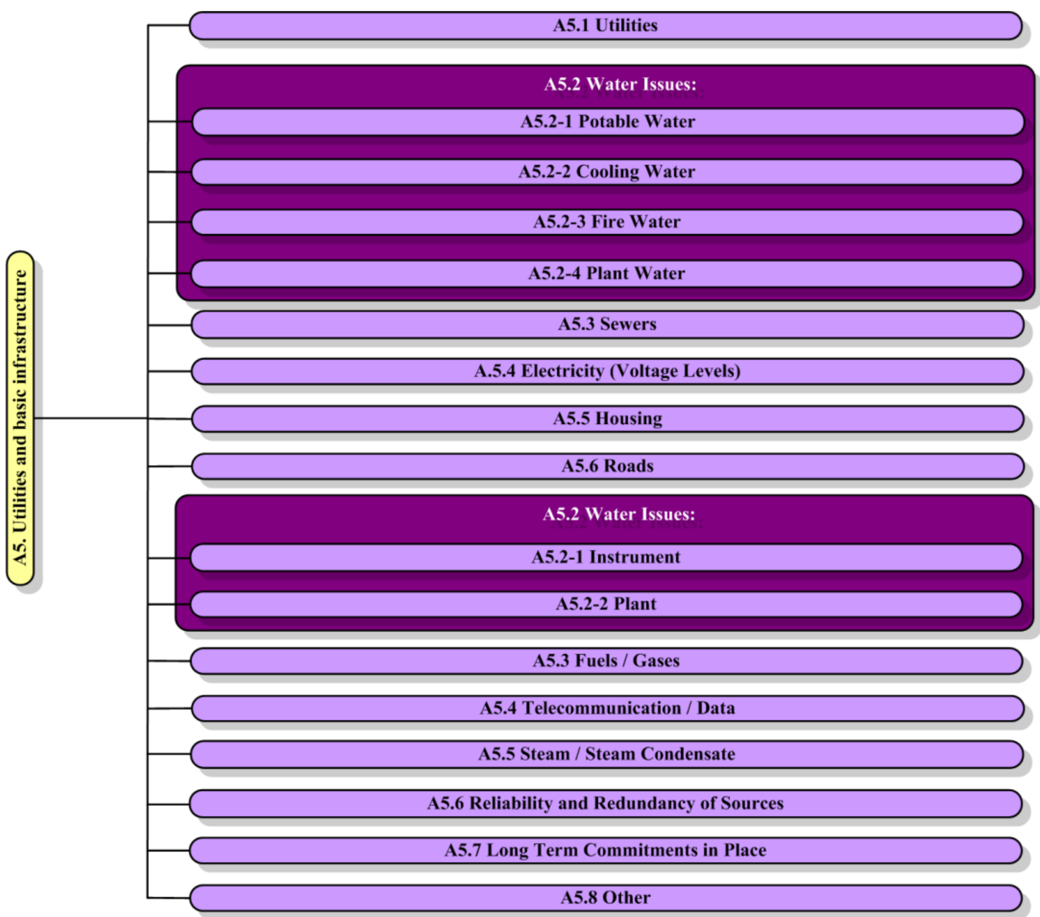

Figure 86 Risk elements of utilities and basic infrastructure (Walewski, International Project Risk Assessment, 2005)

Element III. A6. Site selection and clear title

An international project has two approaches. One is that the project works for the domestic area. The other is that the project works for the international deal. For the latter, the project site location is very important for convenience and accessibility. A major transportation point needs to be determined for the site location. Clear titles such as licenses, permits and experiences should provide support for the construction site. Elements of Figure 87 should be considered.

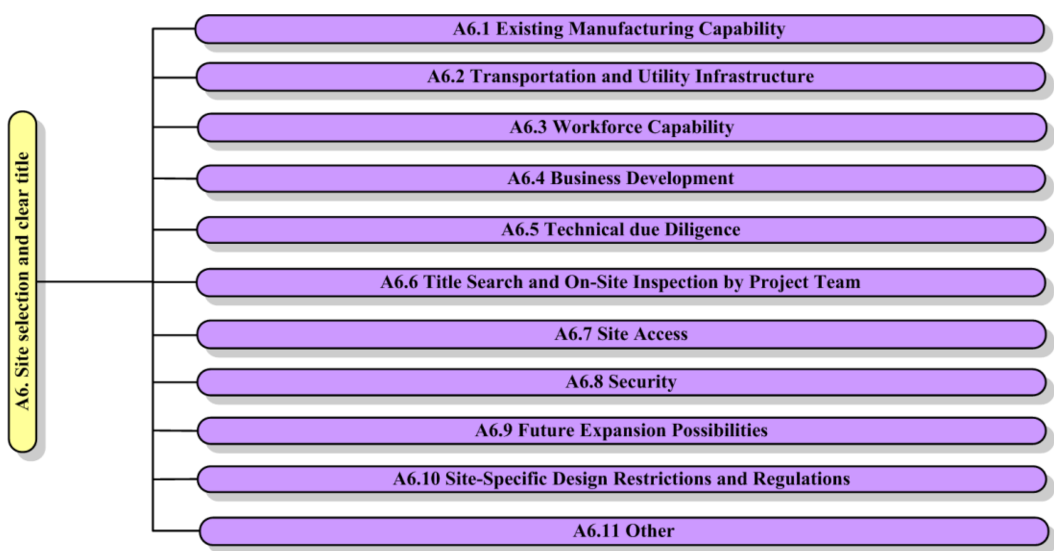

Figure 87 Risk elements of site selection and clear title (Walewski, International Project Risk Assessment, 2005)

Element III. A7. Approvals, permits, and licensing

A thorough understanding of the document's progress is necessary to cover the extra payments, preparation, submitting, and monitoring, etc. Figure 88 clearly appears arrangements of approvals, permits, and licensing.

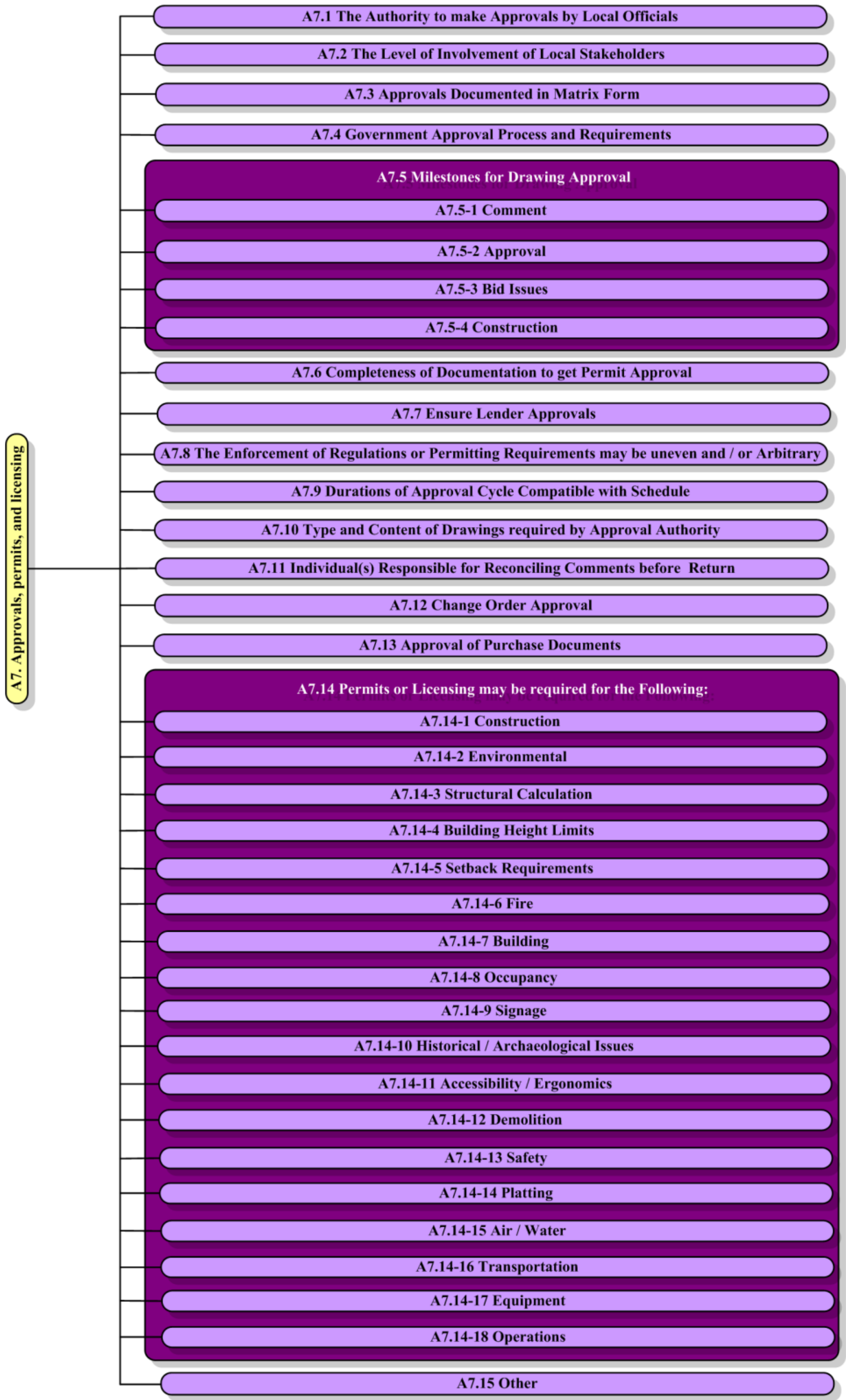

Figure 88 Risk elements of approvals, permits and licensing (Walewski, International Project Risk Assessment, 2005)

Category III. B. Sourcing and supply

Element III. B1. Engineered equipment / material

Success and failure of a long lead project depends on the assignment of resources. Specifically, equipment and material have a big portion of budget. A heavy equipment budget is a vital part of the total budget. Additionally, materials are consumable and can be depleted. If a material is used in an improper place, a reorder is unavoidable. Hence, the previous material costs will be wasted and a budget will be doubled by an additional order. A schedule will be delayed by shipping duration, as well. Therefore, an arrangement of sourcing should be considered by Figure 89.

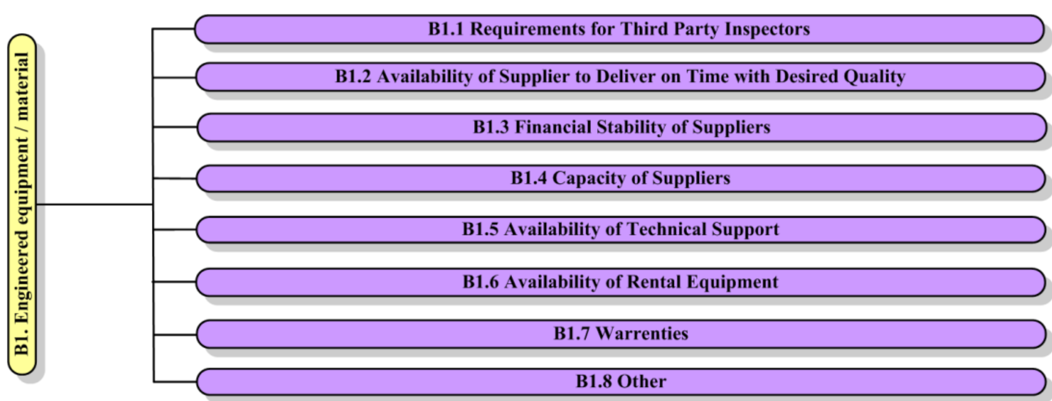

Figure 89 Risk elements of engineered equipment / material (Walewski, International Project Risk Assessment, 2005)

Element III. B2. Bulk materials

Usually, bulk materials are supplied by local areas. It is more convenient to delivery and the project budget can be saved. Figure 90 shows the elements of bulk materials.

Figure 90 Risk elements of bulk materials (Walewski, International Project Risk Assessment, 2005)

Element III. B3. Subcontractors

The biggest advantage of subcontractor is that they know the detail circumstances of small region construction firms. If a large international company just conducts everything, the project budget may be increased and does not account for the local atmosphere. Subcontractors' general considerations can be found by Figure 91.

Figure 91 Risk elements of subcontractors (Walewski, International Project Risk Assessment, 2005)

Element III. B4. Importing and customs

Compatibility and vague knowledge about the regional perspective or atmosphere negatively impacts on over cost and pushes a project behind schedule. Therefore, risk factors of importing and customs are shown by Figure 92.

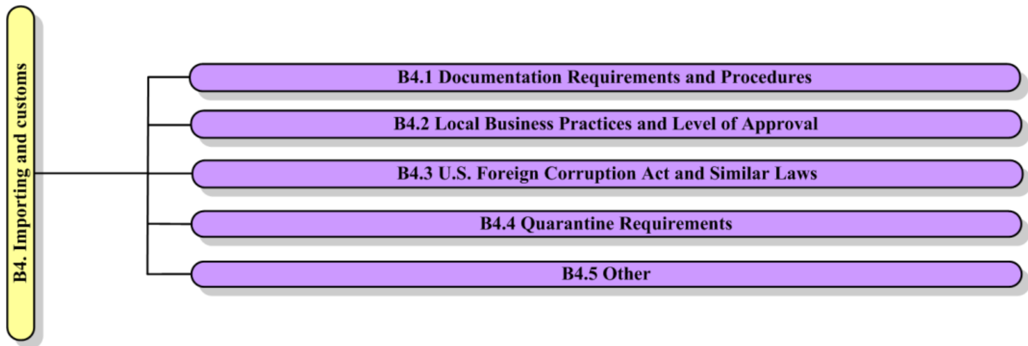

Figure 92 Risk elements of importing and customs (Walewski, International Project Risk Assessment, 2005)

Element III. B5. Logistics

The construction site location and type of project with expectations lead to logistics factors as bad influences of projects. International logistics can be considered by Figure 93.

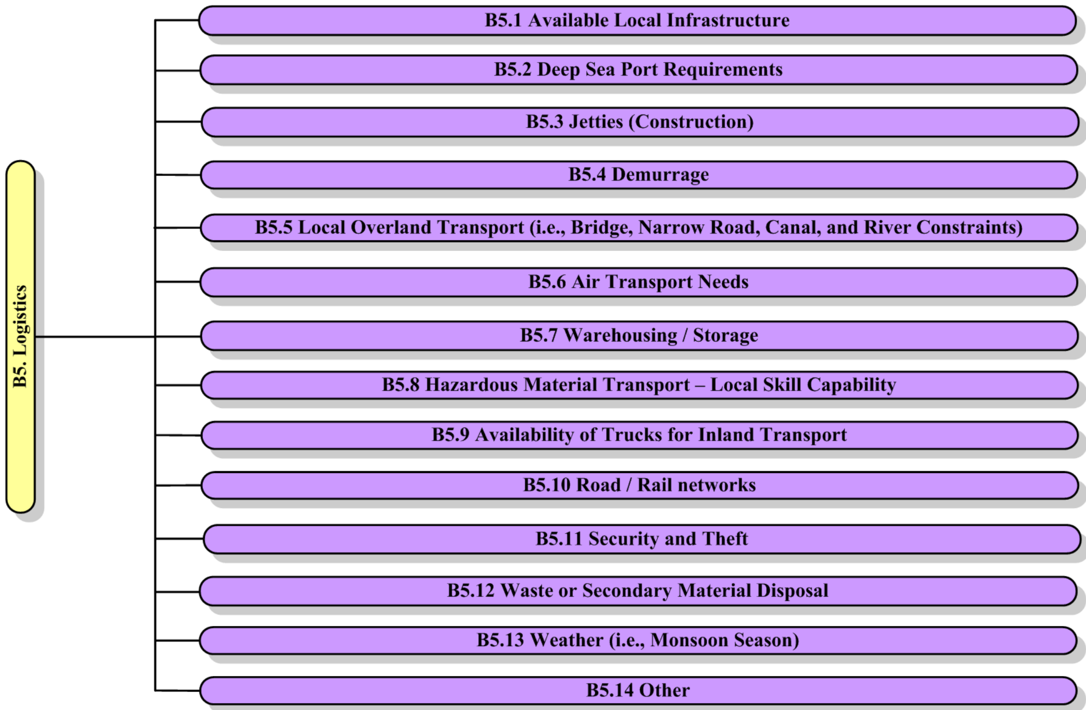

Figure 93 Risk elements of logistics (Walewski, International Project Risk Assessment, 2005)

Category III.C. Design / engineering

Element III. C1. Design / engineering process

A design of international projects accompanies an understanding of the local inhabitant's thoughts and opinions for effective and efficient design as shown in Figure 94.

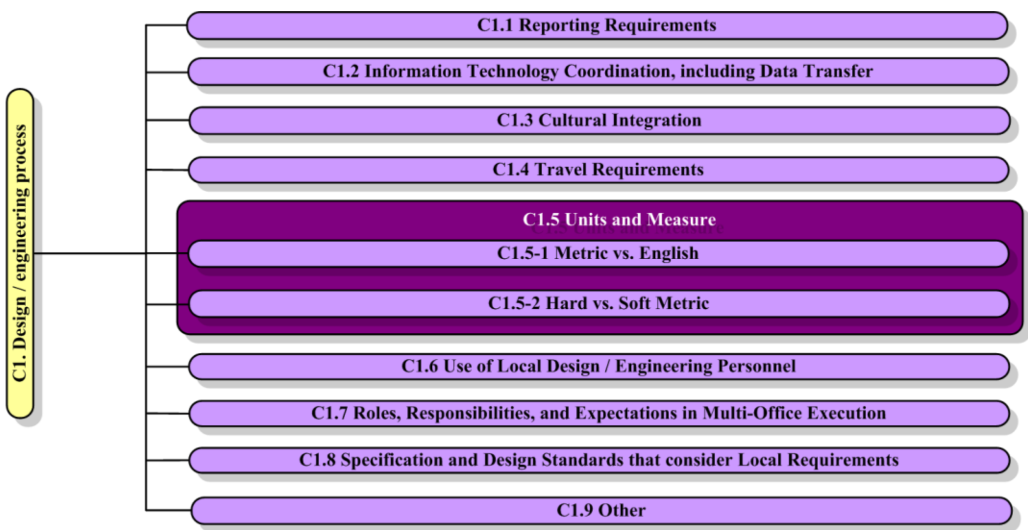

Figure 94 Risk elements of design / engineering process (Walewski, International Project Risk Assessment, 2005)

Element III. C2. Liability

The responsibility of error design falls upon certain organizations or positions and may be taken by a civil prosecution or a corresponding organization for design errors and beyond performances. Liability will be taken as shown in Figure 95.

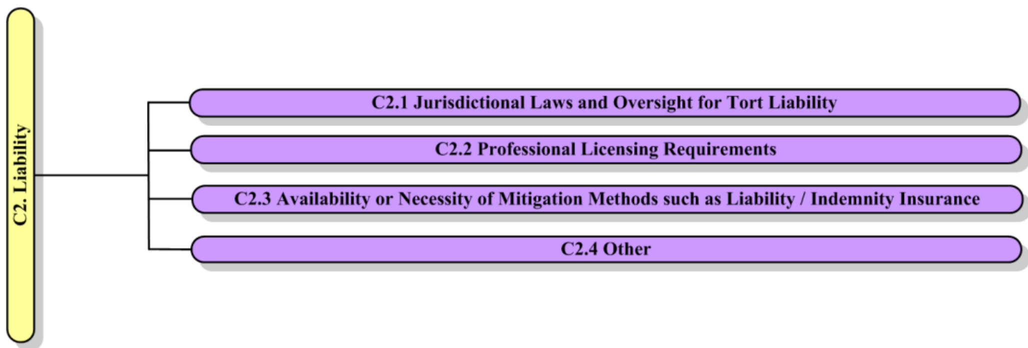

Figure 95 Risk elements of liability (Walewski, International Project Risk Assessment, 2005)

Element III. C3. Local design services

Saving cost and schedule can be possible by committing local design services. Also, the design can take regional characteristics. But the quality of design and safety cannot be guaranteed. The local design issues are surveyed by Figure 96.

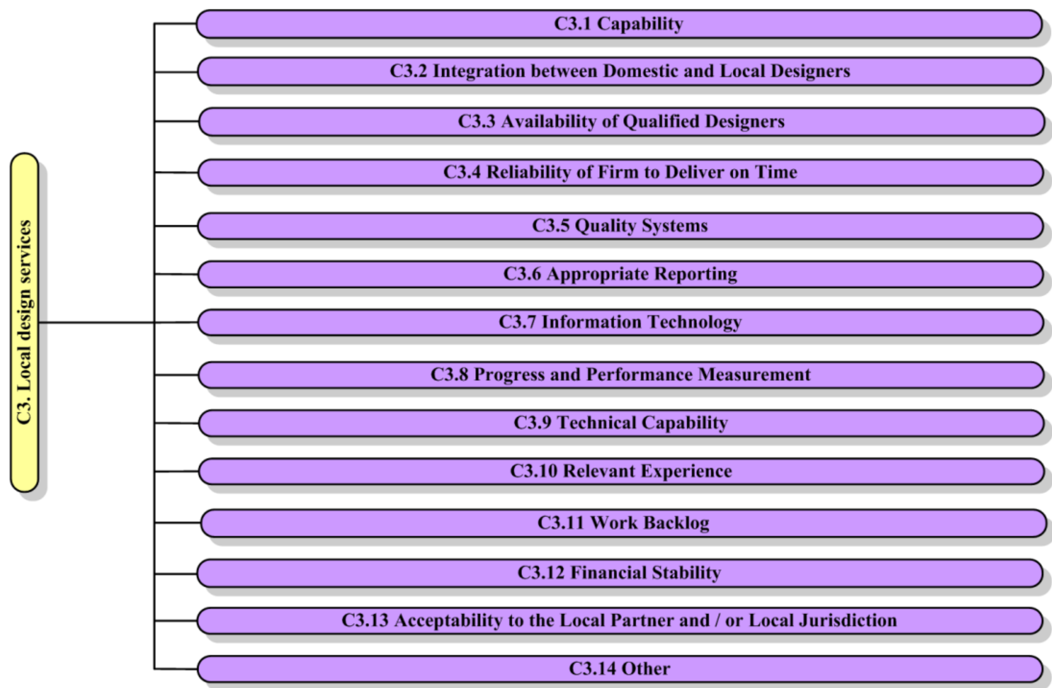

Figure 96 Risk elements of local design services (Walewski, International Project Risk Assessment, 2005)

Element III. C4. Constructability

To conduct a project from beginning to maintenance, a construction company needs to participate from the very first phase of a project. Maximum benefits can be earned by knowing construction history. Specifically, international projects are sensitive with constructability for cost-down, reduced schedule, and safety etc. Constructability is considered by Figure 97.

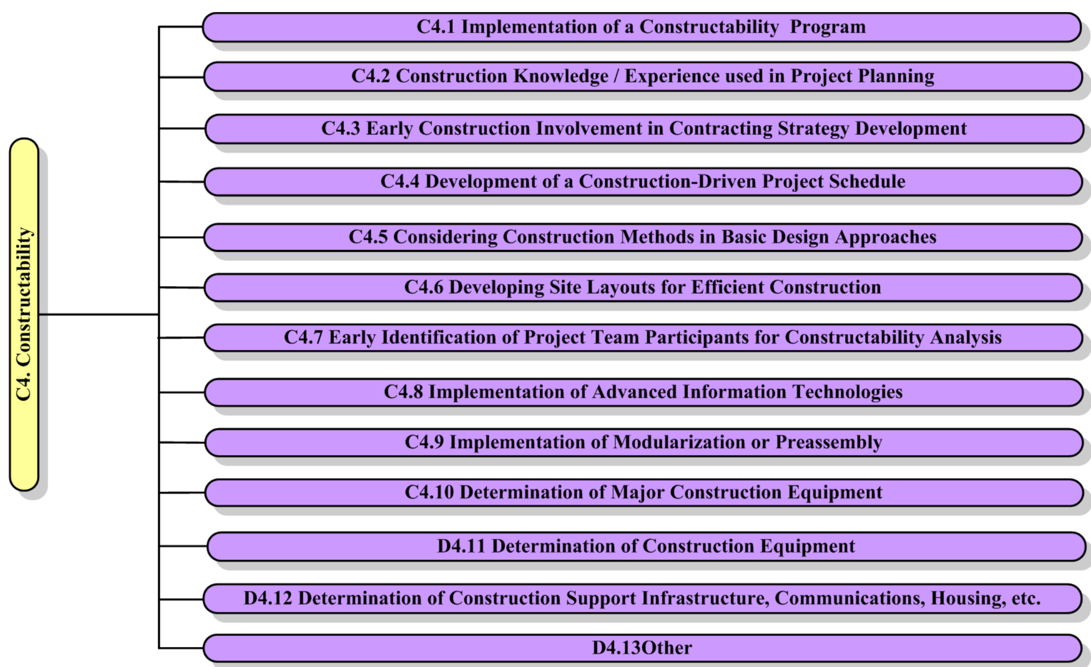

Figure 97 Risk elements of constructability (Walewski, International Project Risk Assessment, 2005)

Category III.D. Construction

Element III. D1. Workforce availability and skill

Progress of a project depends on the workforce availability and skill. Also, a regional difference exists. But the local skillful workers need to be hired to save cost and reduce the project duration. Workforce availability and skill can be considered by Figure 98.

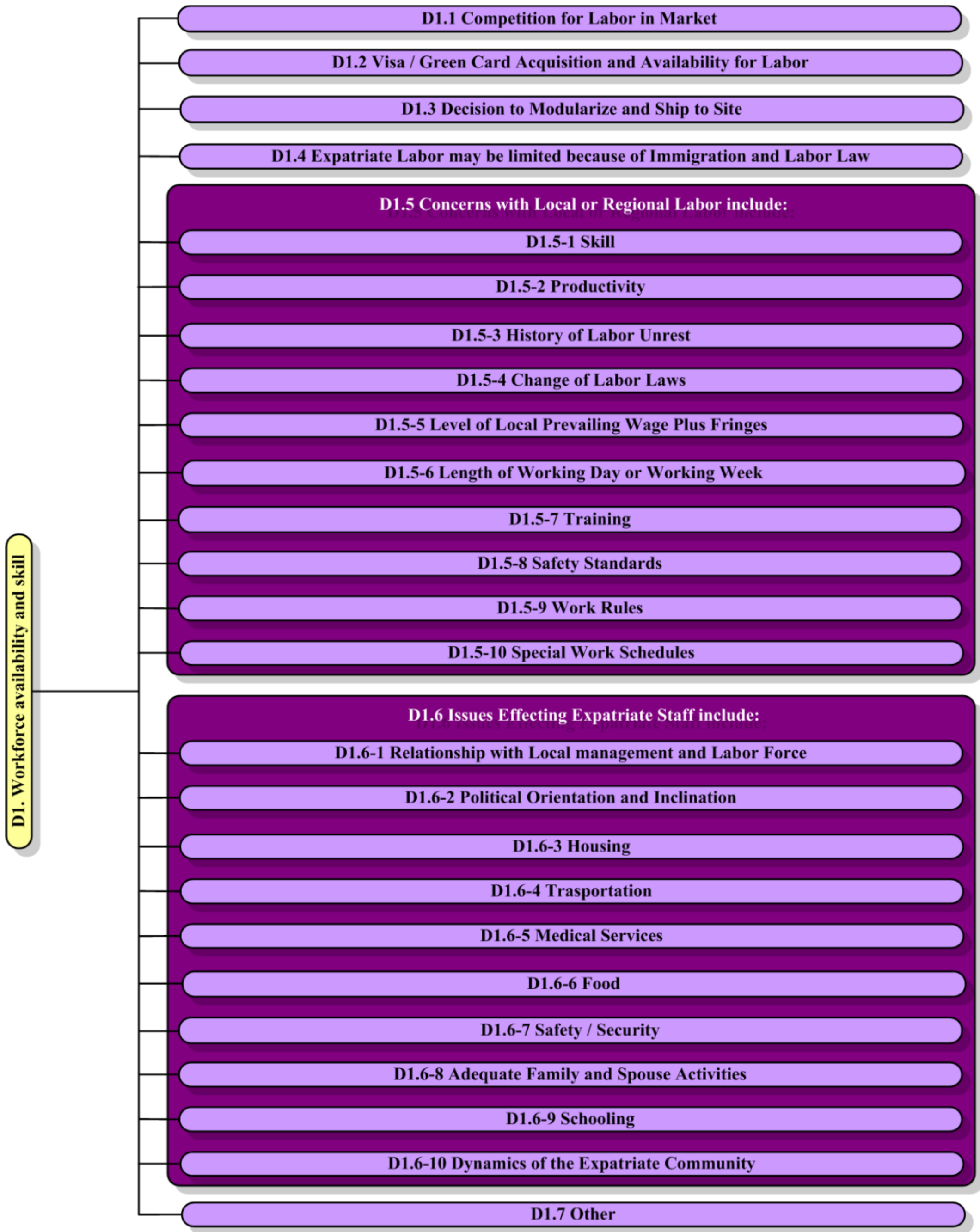

Figure 98 Risk elements of workforce availability and skill (Walewski, International Project Risk Assessment, 2005)

Element III. D2. Workforce logistics and support

The plans such as proper assignments, reasonable schedules, and smooth services for workforce are required for the adequate progress of project. Figure 99 shows the possible elements of workforce logistics and support.

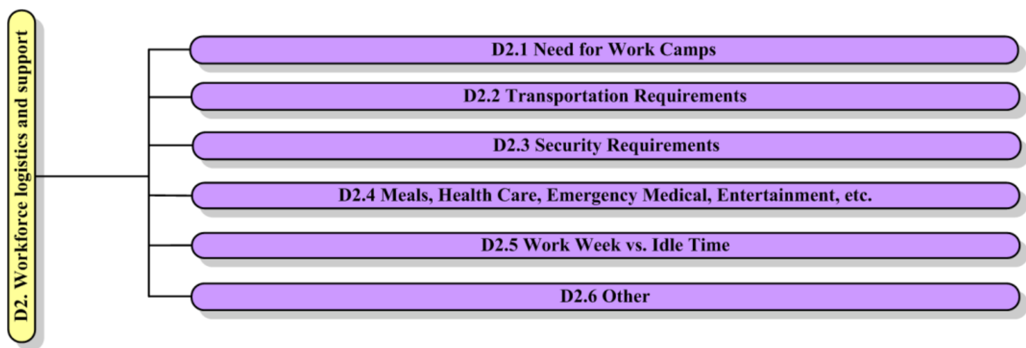

Figure 99 Risk elements of workforce logistics and support (Walewski, International Project Risk Assessment, 2005)

Element III. D3. Climate

Climate impacts construction projects. But natural occurrences and "acts of God" cannot be controlled by men. A list of consideration facts is Figure 100.

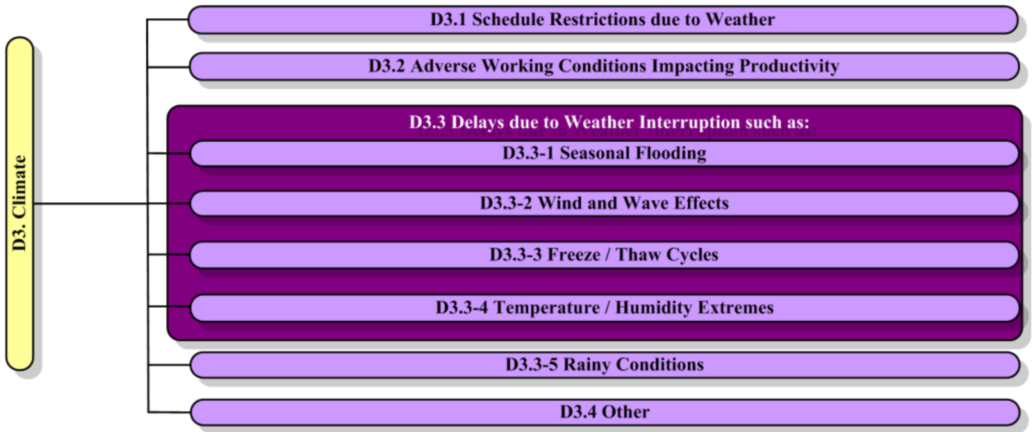

Figure 100 Risk elements of climate (Walewski, International Project Risk Assessment, 2005)

Element III. D4. Construction delivery method

A flexible project delivery system impacts the project to be ahead and economically sound. An international construction delivery method can be identified and assessed by Figure 101 elements.

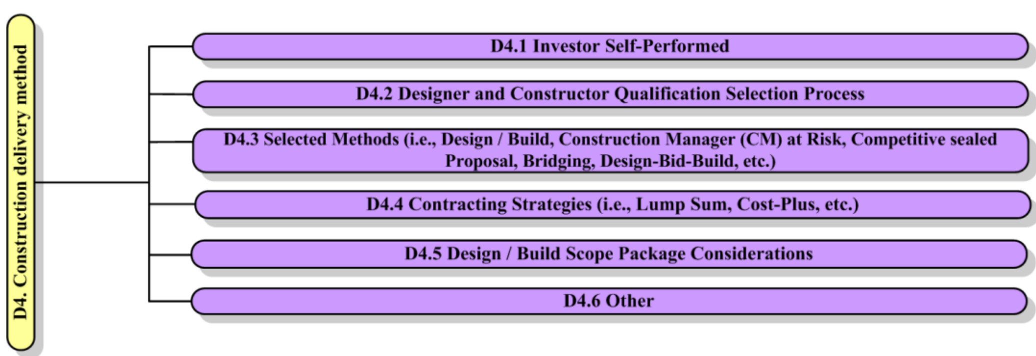

Figure 101 Risk elements of construction delivery method (Walewski, International Project Risk Assessment, 2005)

Element III. D5. Construction permitting

Every construction project should be accompanied permission to progress for construction and operation. Many obstacles exist for furthering progress when there is no permission granted. For the construction permitting, Figure 102 can be considered.

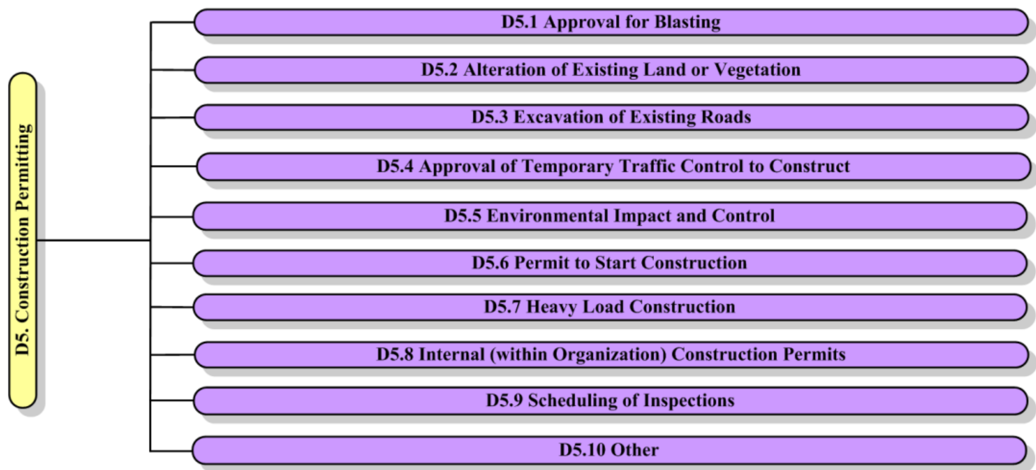

Figure 102 Risk elements of construction permitting (Walewski, International Project Risk Assessment, 2005)

Element III. D6. General contractor availability

Sometimes, international general contractors have difficulty understanding qualified local customs. It is possible that an international general contractor spends unreasonable money for the local customs because they are unfamiliar with the real state of things in the locale. The budget can be influenced by this fact. Figure 103 shows the possible elements of general contractor availability.

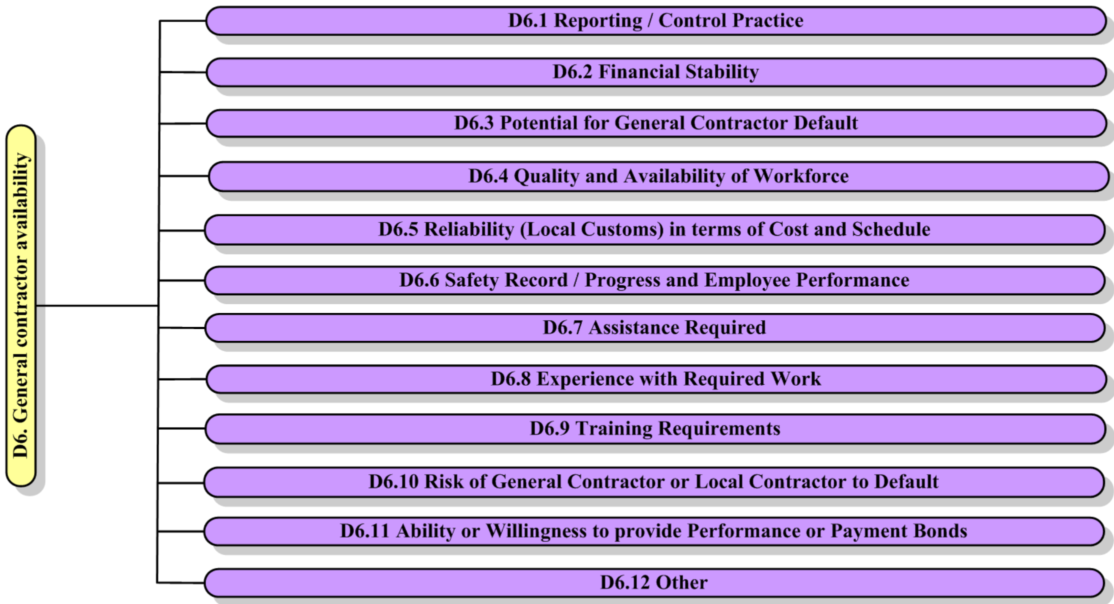

Figure 103 Risk elements of general contractor availability (Walewski, International Project Risk Assessment, 2005)

Element III. D7. Contractor payment

The owner should be paid on time or earlier to avoid a late payment. A late payment is a high risk factor for an international project. Contractor payment can be considered by Figure 104.

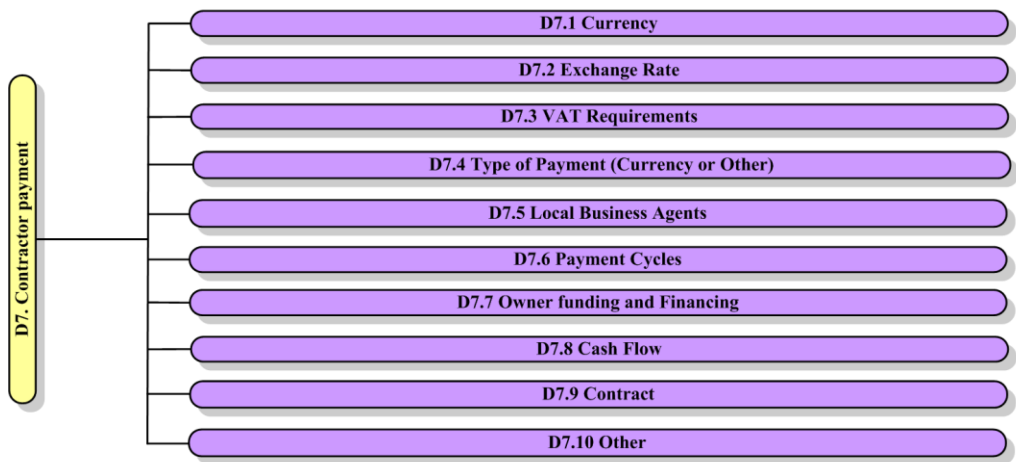

Figure 104 Risk elements of contractor payment (Walewski, International Project Risk Assessment, 2005)

Element III. D8. Schedule

Scheduling should be accompanied with the critical path, milestones, resources assignments, and cumulative project life cycle etc. Scheduling is one of the most important factors for a successful project. The convincing and optimized schedule can be considered by Figure 105.

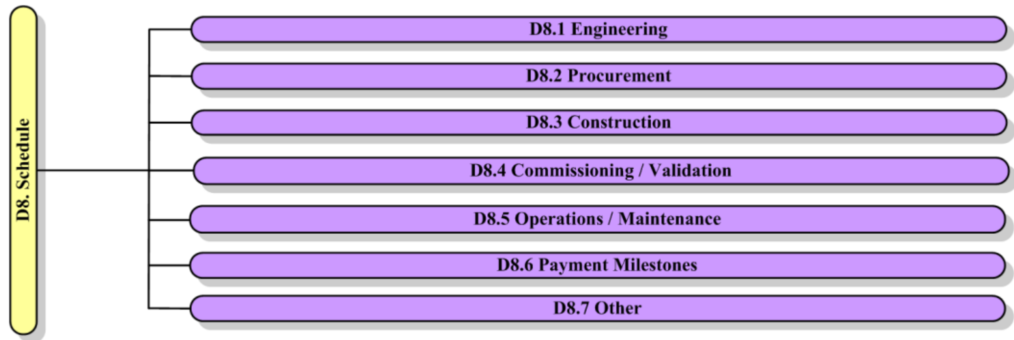

Figure 105 Risk elements of schedule (Walewski, International Project Risk Assessment, 2005)

Element III. D9. Insurance

Risk exists for all projects. Most especially, international project risks are bigger and complicated than domestic project risks. Hence, international projects need to be covered by insurances. Typical insurances are enough to cover the project risks. But the unique project risks can be covered by particular specific insurances. Consideration of insurance facts is as shown in Figure 106.

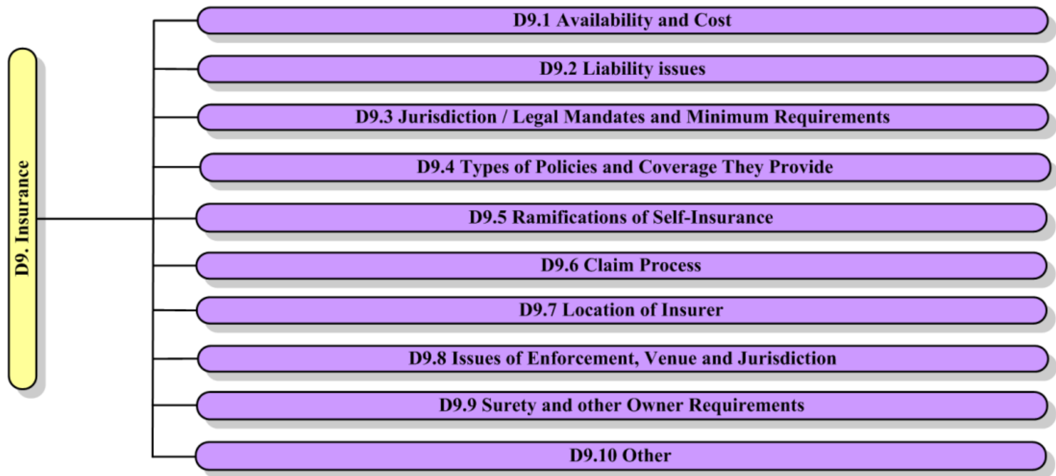

Figure 106 Risk elements of insurance (Walewski, International Project Risk Assessment, 2005)

Element III. D10. Safety during construction

Labors' safety issues are important. International projects need to be determined in detail risk factors at the very first part of the project lifecycle. To handle the risk factors, Figure 107 will be helpful.

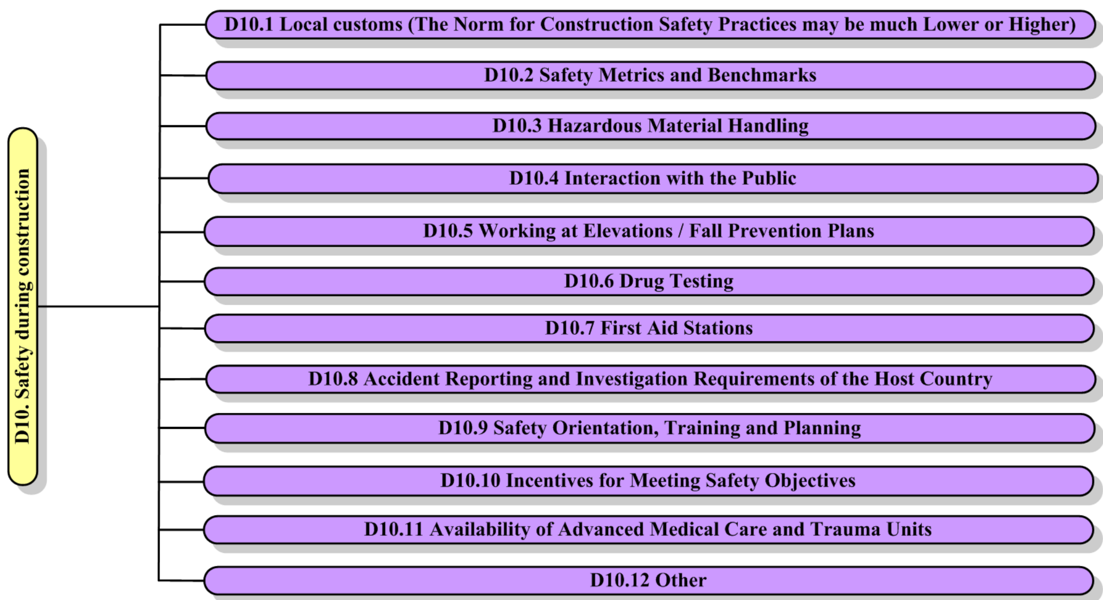

Figure 107 Risk elements of safety during construction (Walewski, International Project Risk Assessment, 2005)

Element III. D11. Communication and data transfer

All concerned parties need to set up a communication system for communication and data transfer. Nowadays, smart systems make a better atmosphere to communicate each other. These systems can make a reduced schedule. However, often times workers panic when system does not work because the level of dependence becomes too high. The level of reliance can be a risk factor for the project. Consideration factors for communication and data transfer risk are as shown in Figure 108.

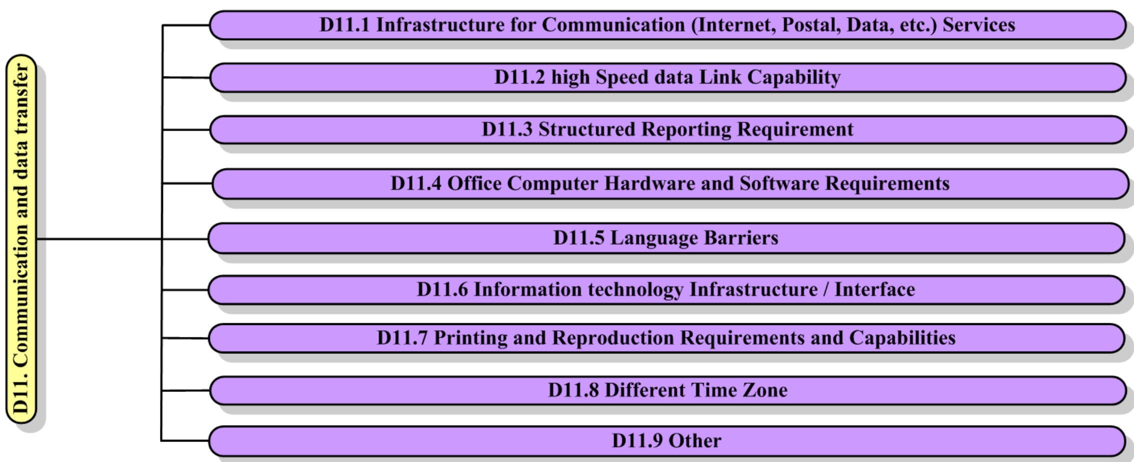

Figure 108 Risk elements of communication and data transfer (Walewski, International Project Risk Assessment, 2005)

Element III. D12. Quality

Clearly difference of expected quality exists in each country. But overall project quality can be set at a general level. Specific project quality can be covered by detail strategies as well. To meet the planned quality of a project, materials and equipment should be checked when they are delivered to the site. Quality can be considered by Figure 109.

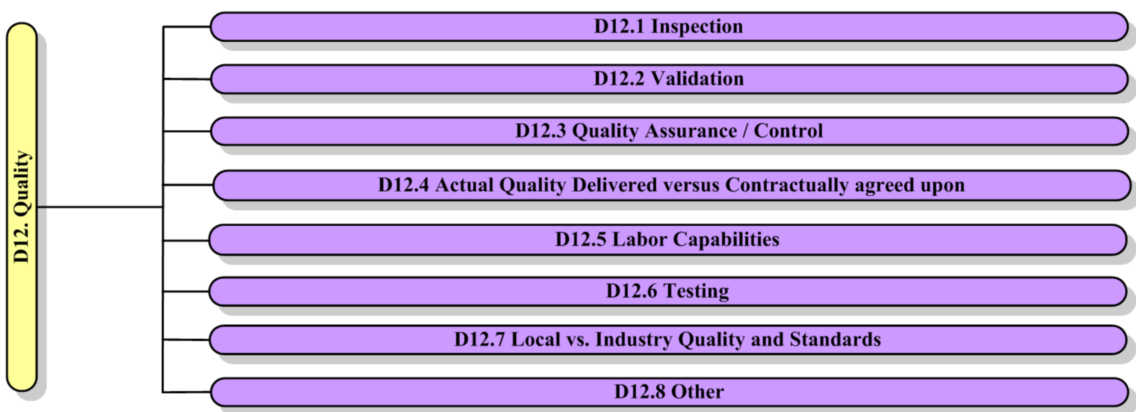

Figure 109 Risk elements of quality (Walewski, International Project Risk Assessment, 2005)

Category III.E. Start up

Element III. E1. Trained workforce

Some construction parts require some professional skills. In this case, hiring skillful manpower is the best solution for the project to go as planned and to meet the project quality. Therefore, the project can be delayed by putting unskillful workers with a low quality meeting. Thus, committing trained workers can provide a huge help eventually. Possible elements of risk are shown in Figure 110.

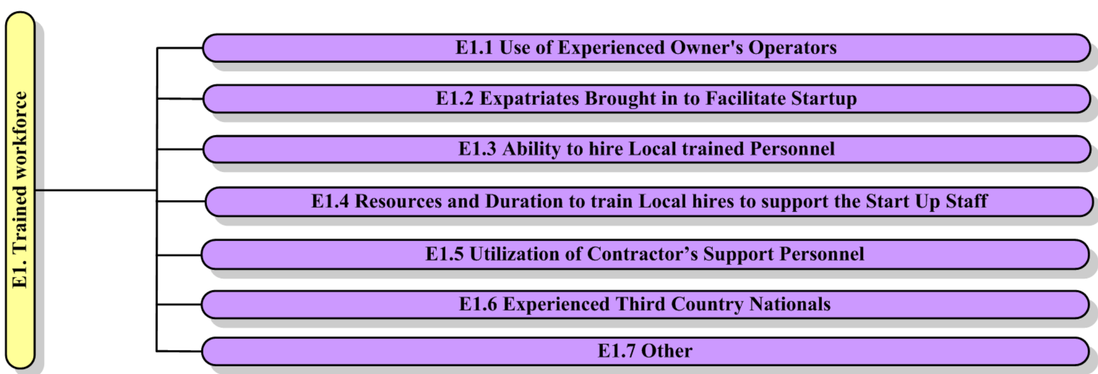

Figure 110 Risk elements of trained workforce (Walewski, International Project Risk Assessment, 2005)

Element III. E2. Facility turnover

After the project is completed, the contractor or a project manager gives a key to the owner for start-up. Before start-up, testing, checking every construction project should be evaluated by a project manager and the owner. Figure 111 can be consideration elements for facility turnover.

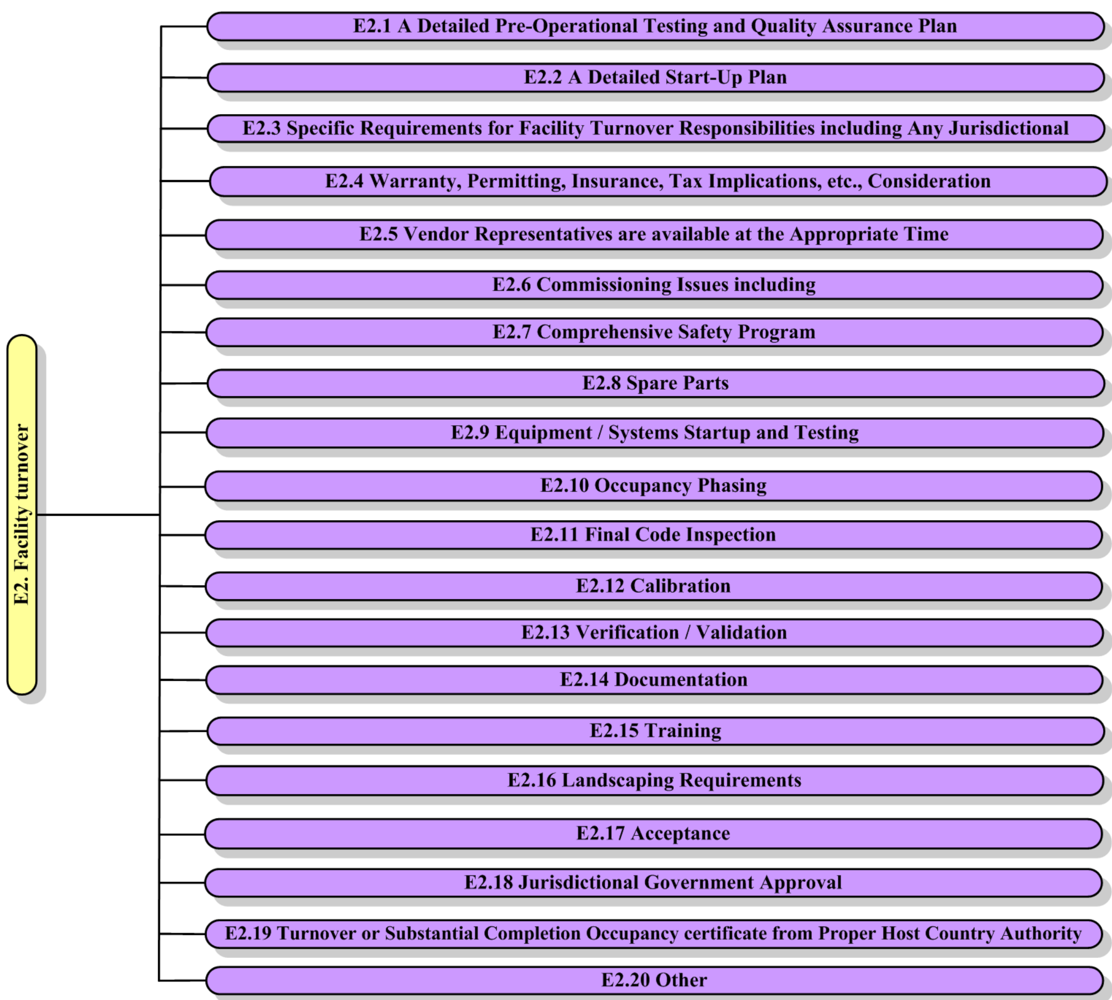

Figure 111 Risk elements of facility turnover (Walewski, International Project Risk Assessment, 2005)

Element III. E3. Feedstock and utilities reliability

To make a profit through a completed project, reliable feedback and utilities need to be checked before the project begins. Elements of Figure 112 are required for the project start-up.

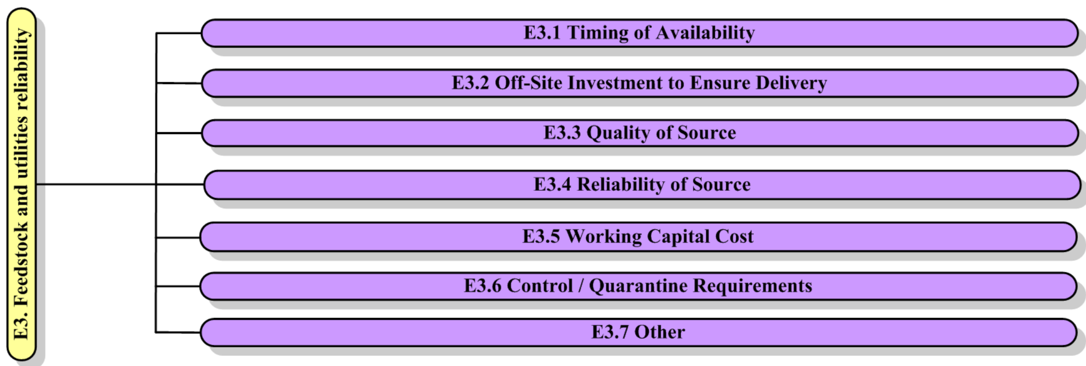

Figure 112 Risk elements of feedstock and utilities reliability (Walewski, International Project Risk Assessment, 2005)

Section IV – Production / operations

The section of production and operations deals with the decline period of the project performance. The covered parts are manpower, legal, and technical domains as shown in Figure 113.

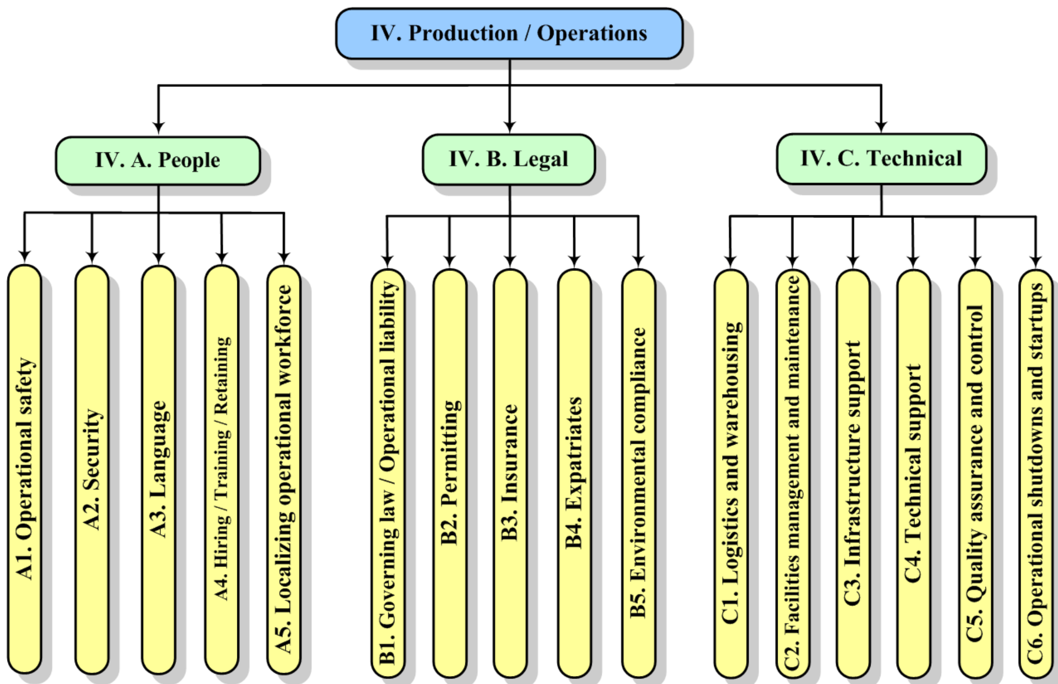

Figure 113 International project risk frame of production / operations section (Walewski, International Project Risk Assessment, 2005)

Category IV.A. People

Element IV. A1. Operational safety

Cultural differences occur within the wide disparity between a country and another country concerning incidents, loss of lives, and property loss etc. To consider different perspectives, Figure 114 provides operational safety elements.

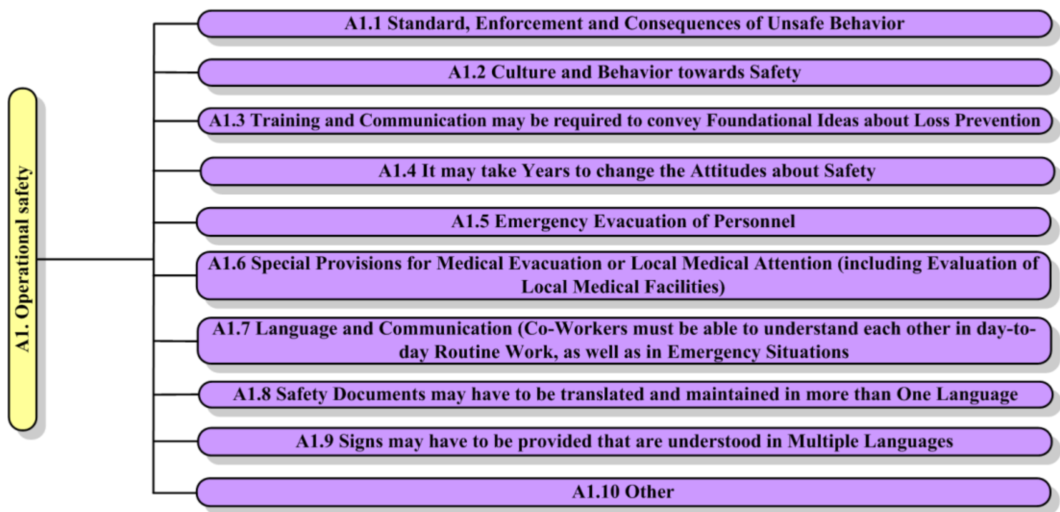

Figure 114 Risk elements of operational safety (Walewski, International Project Risk Assessment, 2005)

Element IV. A2. Security

Security is significant for the overall capital facility. Security systems need to be established to avoid unexpected situations. Project security issues can be considered by Figure 115.

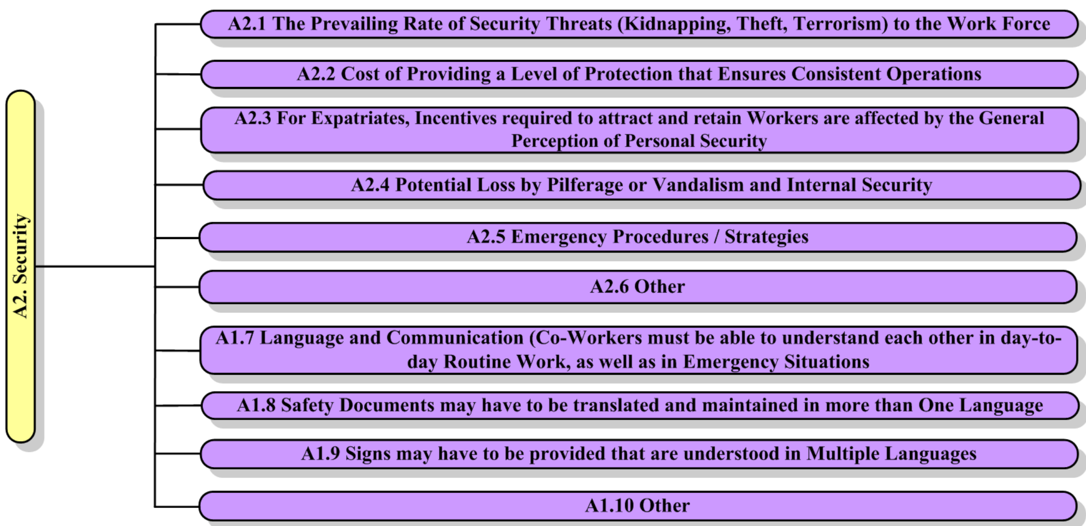

Figure 115 Risk elements of security (Walewski, International Project Risk Assessment, 2005)

Element IV. A3. Language

Even though the project is not a living being, language proficiency is very important because the project is conducted by people. If the organization of the project cannot communicate briskly, the project cannot operate well and detailed operations may take a lot of time. For better interaction, hiring a translator who is proficient with the local language and global languages, such as English, is important. Language elements are shown in Figure 116.

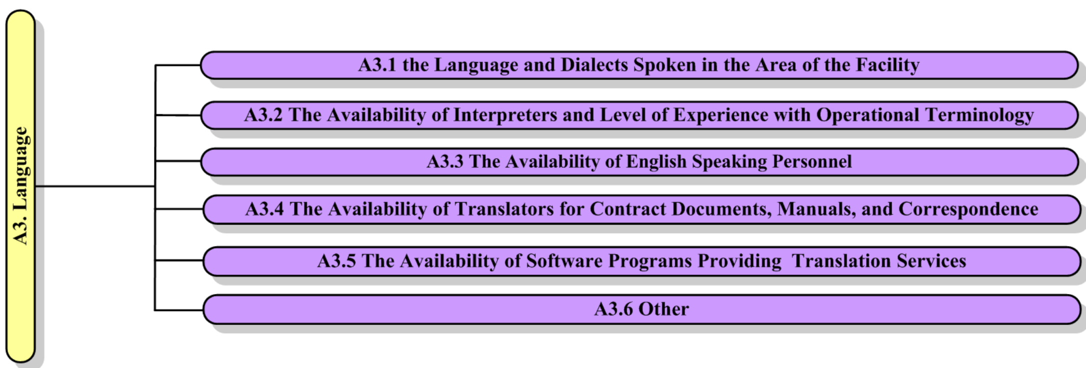

Figure 116 Risk elements of language (Walewski, International Project Risk Assessment, 2005)

Element IV. A4. Hiring / training / retaining

Training, educating, and retaining are some of the most essential parts for a strong organization and helps avoid incidents. Qualified training should be accompanied by well-trained instructors. Also, a local instructor can be helpful to understand the local atmosphere. Figure 117 shows the list of consideration for elements.

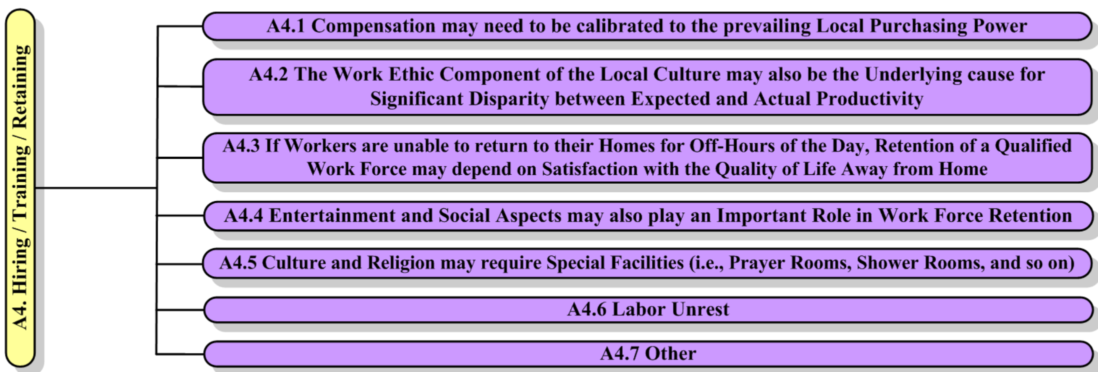

Figure 117 Risk elements of hiring / training / retaining (Walewski, International Project Risk Assessment, 2005)

Element IV. A5. Localizing operational workforce

The governments of some countries often request to hire a certain level of local workers for the regions' economic activities. Localization operational workforce can be considered by Figure 118.

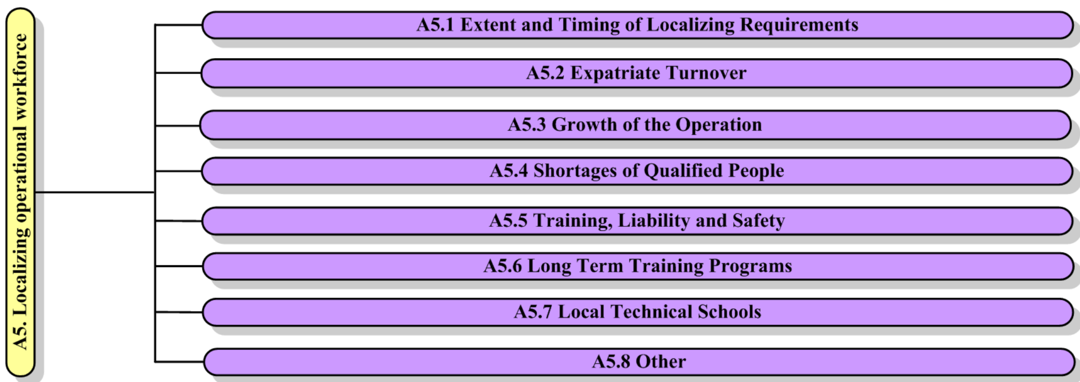

Figure 118 Risk elements of localizing operational workforce (Walewski, International Project Risk Assessment, 2005)

Category IV.B. Legal

Element IV. B1. Governing law / operational liability

To cover the overall project with contracts, two contracts are required at the minimum. The governing contract can cover the majority of project. Unique and detailed parts of each country can be filled by the local contract. Governing law and operational liability can be considered by Figure 119.

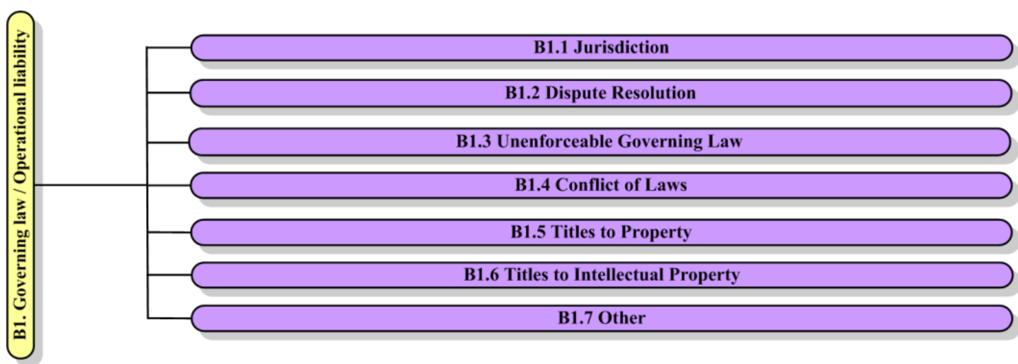

Figure 119 Risk elements of governing law / operational liability (Walewski, International Project Risk Assessment, 2005)

Element IV. B2. Permitting

In some countries, legal allowances are difficult to obtain for continuous work progress. To work officially and to protect with law, a permit should be provided under the local law. Figure 120 shows elements for permitting.

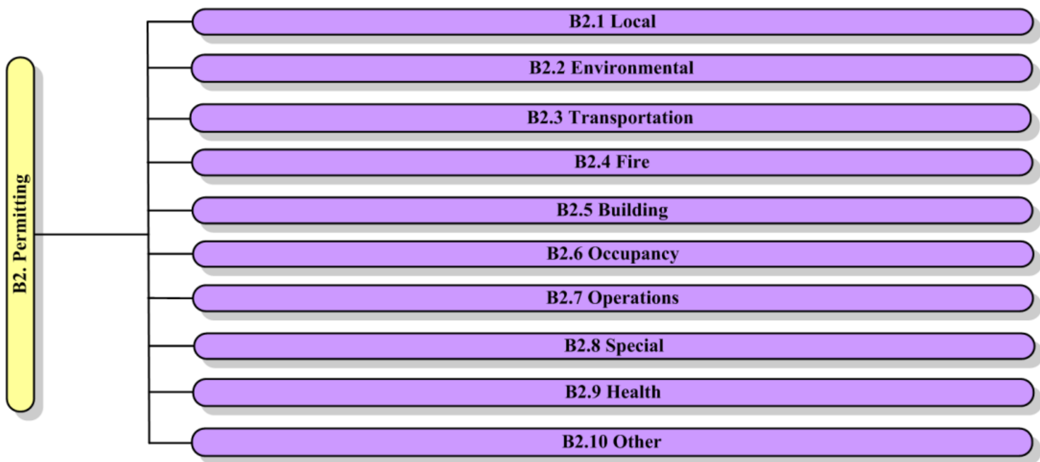

Figure 120 Risk elements of permitting (Walewski, International Project Risk Assessment, 2005)

Element IV. B3. Insurance

The majority of uncertainty can be covered by insurance as an adequate protection tool. Some jurisdictions do not allow insurance of their sides. To cover the unexpected situations, these kinds of jurisdictions desire to import insurance from the other countries. Insurance elements are as shown in Figure 121.

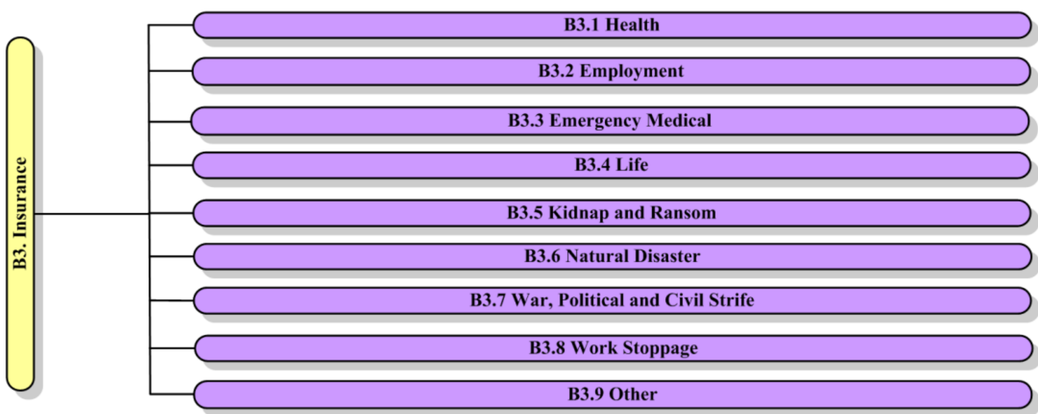

Figure 121 Risk elements of insurance (Walewski, International Project Risk Assessment, 2005)

Element IV. B4. Expatriates

Some experts and specialists are hired by the project manpower management team to cover the part that needs professional skills. In these cases, these people can be included as expatriates. Immigration offices need to protect them with law. Elements of expatriates can be covered by Figure 122.

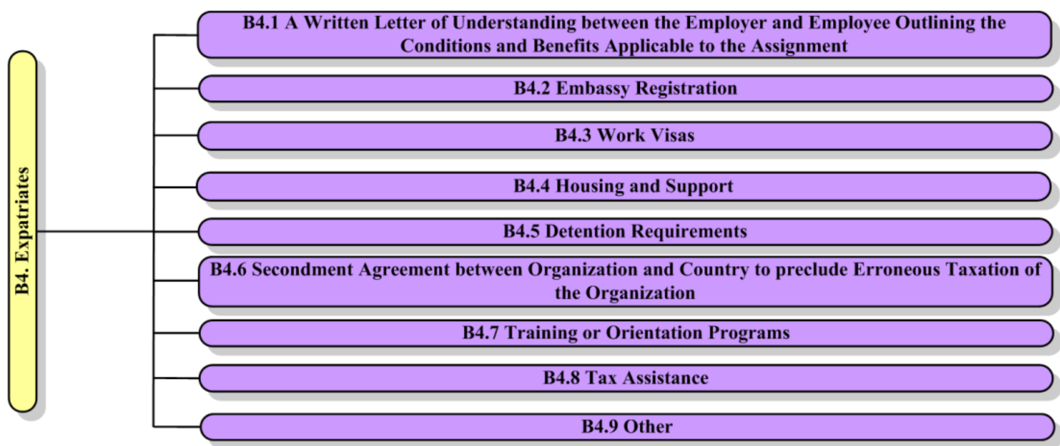

Figure 122 Risk elements of expatriates (Walewski, International Project Risk Assessment, 2005)

Element IV. B5. Environmental compliance

Civil and infrastructure projects are faced with environmental organizations easily because environmental groups believe that the protection of environment is the only way to keep the environment viable. But the eco-friendly heavy industry projects ubiquities nowadays. This problem can be connected with a project economic loss. Environmental compliance of international projects is as shown in Figure 123.

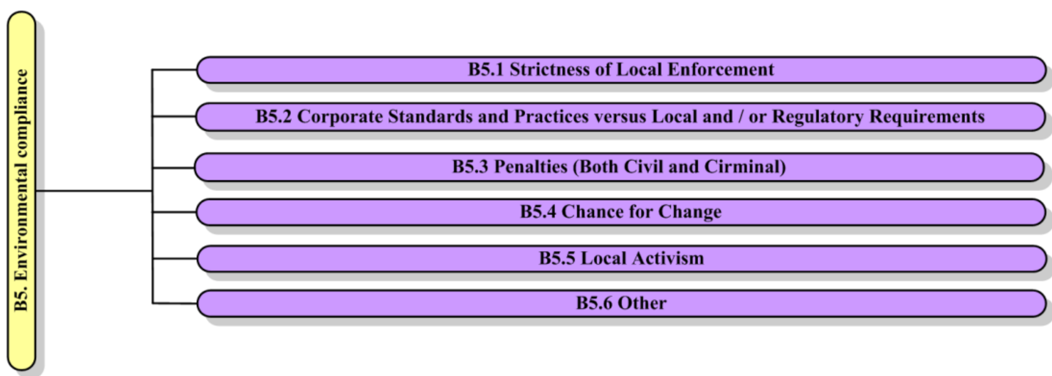

Figure 123 Risk elements of environmental compliance (Walewski, International Project Risk Assessment, 2005)

Category IV.C. Technical

Element IV. C1. Logistics and warehousing

To provide and supply right materials in the right places on time, storage units should be located on the near site. Also, the conditions of storages should be kept for adequate conditions. Figure 124 shows the elements of logistics and warehousing.

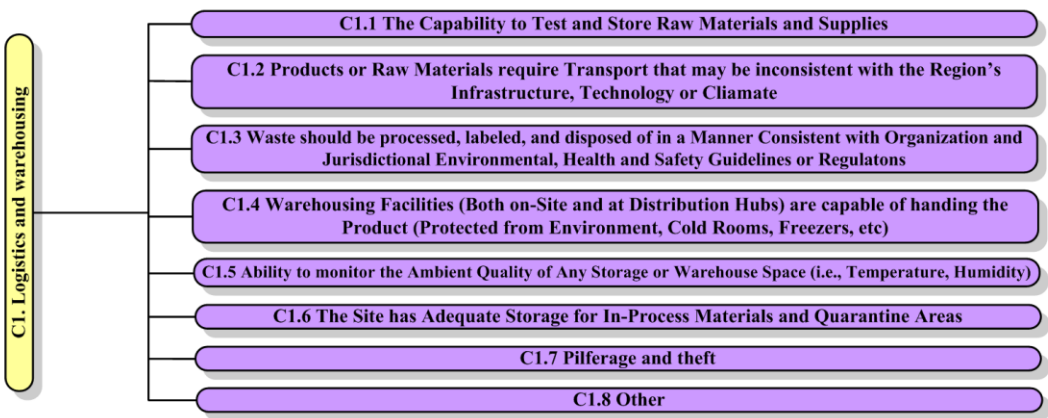

Figure 124 Risk elements of logistics and warehousing (Walewski, International Project Risk Assessment, 2005)

Element IV. C2. Facilities management and maintenance

To maintain the exact quality and performance of facilities, local site workers need to be hired and dealt by the management. Potential facilities management and maintenance are shown in Figure 125.

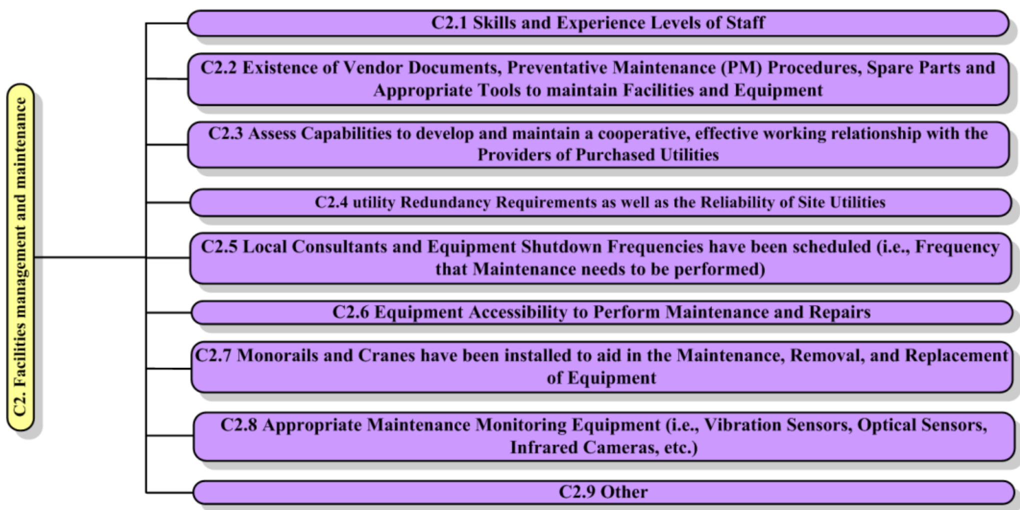

Figure 125 Risk elements of facilities management and maintenance (Walewski, International Project Risk Assessment, 2005)

Element IV. C3. Infrastructure support

Professional experts require maintaining infrastructure. Most especially, local maintain firms or experts are hired by the company. Creating funds will be helpful for long-term maintenance. Consideration elements of infrastructure support are shown in Figure 126.

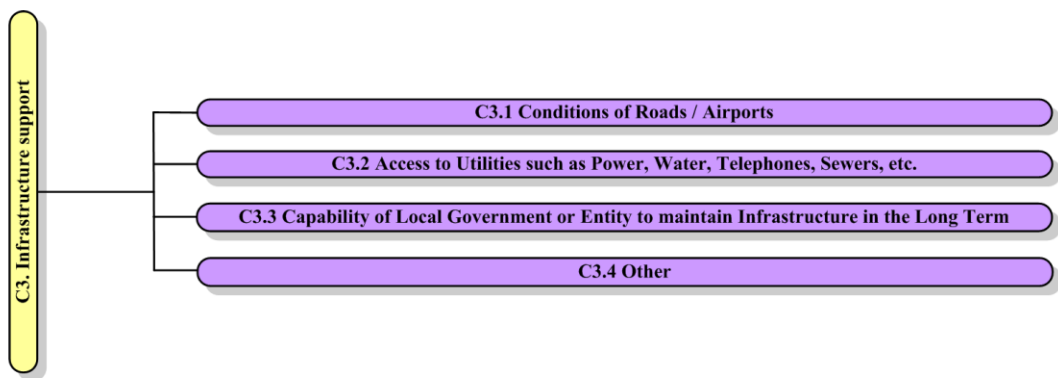

Figure 126 Risk elements of infrastructure support (Walewski, International Project Risk Assessment, 2005)

Element IV. C4. Technical support

Qualified and cutting-edge technical products support international projects. Using the right products is very significant and should be accompanied with the maintenance plans. As the level of dependence about technical supports increases, an adequate back-up plan should be prepared. Figure 127 shows risk elements of technical supports.

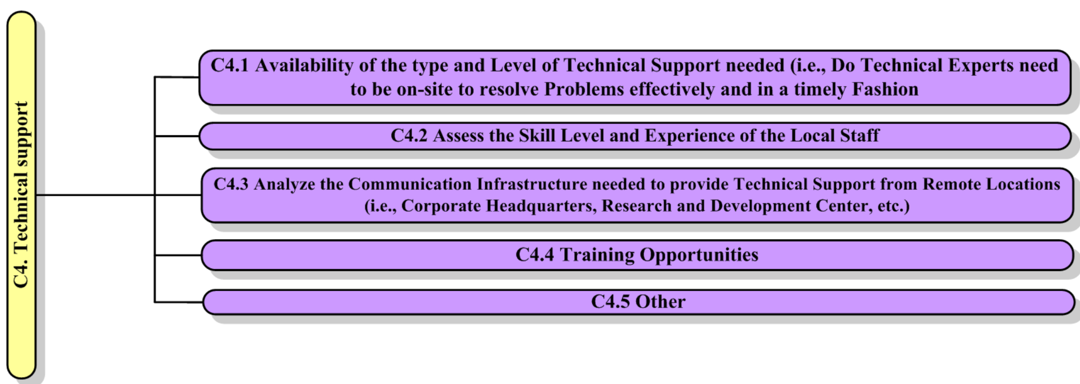

Figure 127 Risk elements of technical support (Walewski, International Project Risk Assessment, 2005)

Element IV. C5. Quality assurance and control

Quality assurance is significant because it directly connects with project life or sometimes it connects with laborers' safety. Furthermore, sometimes quality and control issues can be linked with ethic problems. In some countries, the project management team and the suppliers deal with each other illegally. Thus, quality assurance must be opened and kept by certain standards. Figure 128 is potential quality assurance and control elements.

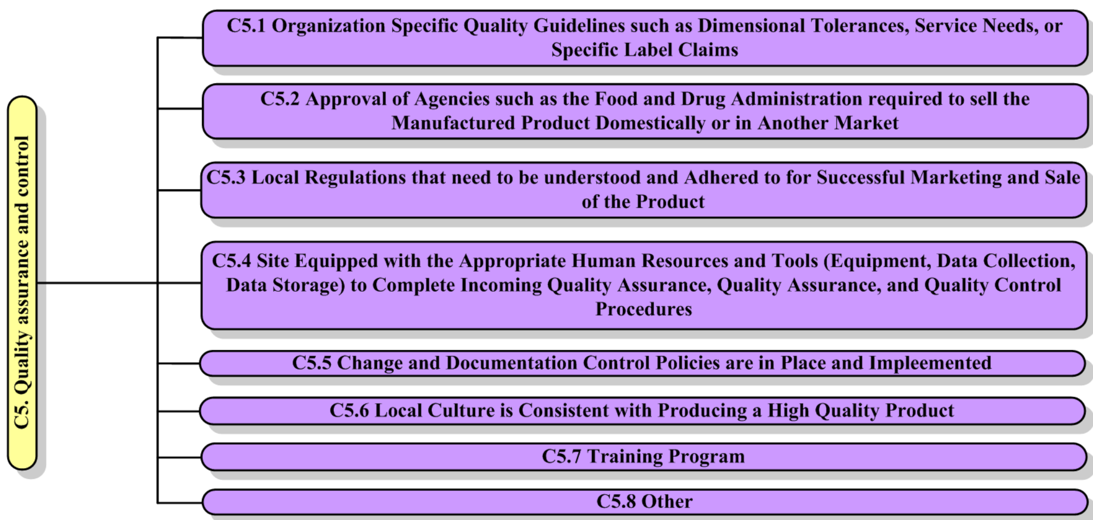

Figure 128 Risk elements of quality assurance and control (Walewski, International Project Risk Assessment, 2005)

Element IV. C6. Operational shutdowns and startups

An operational shutdowns and startups plan should be created by local site staff. Since regional works that are well-known in that place, they can make an optimized routine for operational shutdowns and startups. Thus, the management team recruits local crews as a helper. Operational shutdown and startups plan can be planned by the elements of Figure 129.

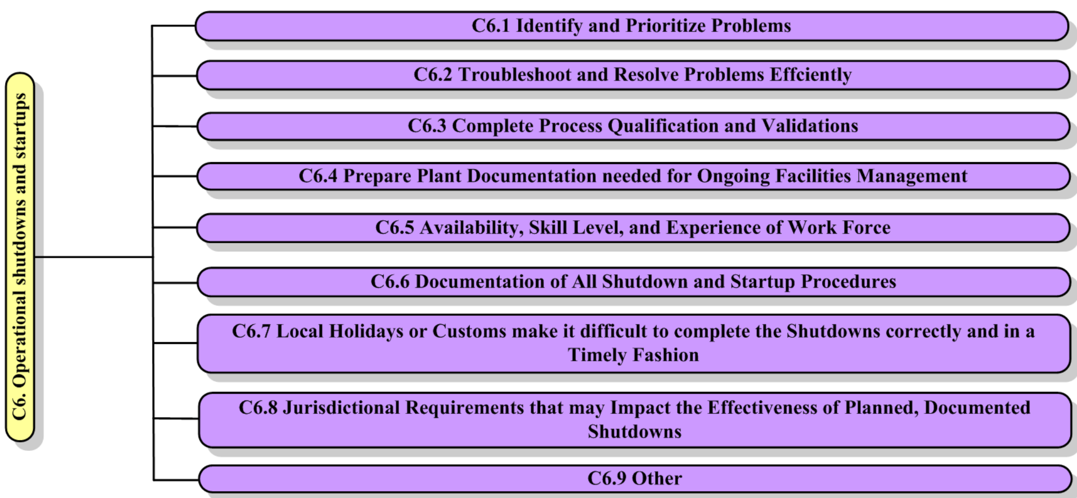

Figure 129 Risk elements of operational shutdowns and startup (Walewski, International Project Risk Assessment, 2005)

Composition of Relative Impact Value Component sheet and matrix

To get a credible result, Relative Impact Value Components should be surveyed by many experts of various construction areas through many conferences or professional meetings to avoid a bias of risk scoring with a survey form as shown in Figure 130 (Walewski, International Project Risk Assessment, 2005). For this thesis, the research will be stopped at the proposed level of the slightly modified IPRA tool for NPP. To verify the modified IPRA for NPP, risk ranking will be entered in by the author manually based on the previous practical nuclear power plant examples as a secondary survey way.

Category	Likelihood of Occurrence (L)						Relative Impact (I)					Baseline	Coordinate L, I	Comments
	Very Low → Very High						Negligible → Extreme							
	NA	1	2	3	4	5	A	B	C	D	E			
II. C. CURTURAL														
II. C1. Traditions and Business Practices						√						E	5, E	
II. C2. Public Opinion			√						√			D	2, C	
II. C3. Religious Differences					√							B	4, B	

Figure 130 Partial Relative Impact Value Components sheet (Walewski, J., 2005)

To summarize the results of Relative Impact Value Components visually, the IPRA risk matrix is designed as shown in Figure 131. Through the matrix color coding, the level of risk magnitude is determined at once. Adequate countermeasures or appeasement policies can be prepared by the project management team based on the

IPRA matrix. After cumulating each risk matrix, the project risk as an overall perspective can be evaluated whether the project can proceed or cannot proceed. (Walewski, International Project Risk Assessment, 2005)

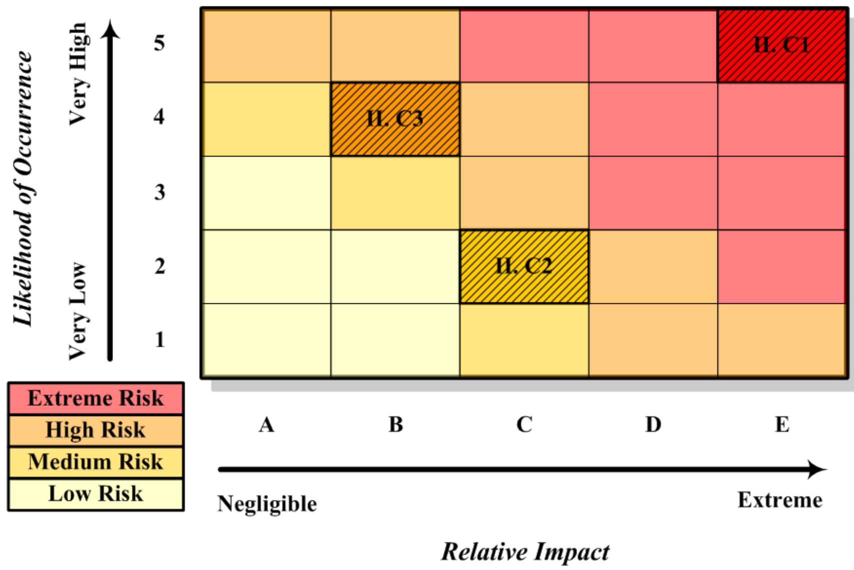

Figure 131 The IPRA risk matrix example (Walewski, International Project Risk Assessment, 2005)