

Risk Management and Safety Management Associated with the Safe Disposal of Nuclear Waste in the Gulf Countries

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Abstract

The countries of the Gulf region have the capacity to rapidly expand their economic growth and gross domestic product (GDP). To match this economic growth, they need an assured electricity supply. At present this is produced in oil fired power stations. In the early 21st century they now require a mix of energy sources because their own oil reserves are finite besides fossil fuels create carbon dioxide and this adds to the greenhouse gas emissions. So, nuclear power plants can have a significant role as an energy source for Gulf countries. Although, some gulf countries have now signed contracts to construct nuclear power plants, the use of nuclear energy remains a problem because it produces radioactive waste and that is dangerous to human life, health, safety and the environment. The objective of this paper is to explore the risks of operating nuclear power stations in the region. Then the paper discusses how to protect public health and save and the environment from the hazards of nuclear waste. There are a number of theories, strategies and tools which can be used to decrease the risks from nuclear waste and increase the opportunities for using nuclear energy by increasing human safety and the protection of the environment. However, this paper chiefly provides new risk and safety management methodologies. The new risk management methodology helps to illuminate the consequences of waste disposal in a nuclear power plant environment which might otherwise affect public health and safety. Furthermore, risk management can play a role in highlighting the consequences and the effects of the risks of using nuclear energy. In addition, it helps people to understand the potential risk implicit in nuclear waste disposal. Besides, it assists management and other stake holders to rate priorities for the risks and to determine the risk levels. The new risk management approach provides data, information, tools and strategies, which are potentially more appropriate for evaluating the risk. In addition, the new risk management methodology develops action plans that determine and implement the most appropriate tools for managing those risks. The new safety management methodology provides appropriate data and information to analyse these in order to formulate effective strategies. Furthermore, this helps stake holders to develop a proper design, ensure high quality construction, provide a safe operational approach and ensure the correct disposal of nuclear waste. This paper assists to

decrease risks in order to protect human health, the environment in the region and indeed beyond national borders and for future generations. It can increase an awareness of safety in the disposal of nuclear waste from nuclear sites in the Gulf countries as well as around the world.

Key Words: Risk management, safety management, nuclear waste disposal, environmental risks, Project management, Project Failure, Knowledge management and Strategic management.

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1. Introduction:

Today, the world needs more energy. In 2008, the World Energy Council (WEC) pointed out that the energy demand in 2020 will be 50-80% higher than 1990 levels [16]. Furthermore, the USA Department of Energy (DoE) reported that the world energy consumption will increase from 22 billion KWh in 2008 to 53 billion KWh by 2020[13]. The Gulf region has an increasing population, growing wealth and therefore, higher energy demands. The Gulf counties will need to generate and secure more energy, because of the growing population, increased high demand for energy and the growing economy and to secure and maintain sustainable development, decrease their consumption of fossil fuels and gas emissions, and to protect the environment in the region. They need to have a mixed energy strategy which includes generating electric power without increasing carbon emissions. The World Nuclear Association points out the six Gulf Cooperation Council (GCC) Countries are seriously concerned with building nuclear power plants [20]. The

Gulf region needs to transfer from electricity generating techniques that rely on fossil fuel to the use of nuclear power energy, because fossil fuel produces more waste than nuclear energy. Fossil fuel waste produces gas emissions such as carbon dioxide, carbon monoxide, sulphur dioxide and nitrogen oxides that have an effect on global warming. Nuclear power is free of these emissions into the environment. However nuclear energy entails different risks such as the creation of nuclear waste and questions relating to nuclear safety, nuclear proliferation, nuclear security, and nuclear financial cost risk.

Nuclear waste is categorised into three levels: low-level waste (LLW), intermediate-level waste (ILW), and high level waste (HLW). Potentially, nuclear waste can damage human health and the environment. To reduce risks from nuclear waste and ensure its safe disposal, it is necessary to carry out a risk and safety management process for the disposal of nuclear waste. This paper has proposed that the six GCC countries adopt the new risk and safety management proposals to reduce the risks, address the issues and increase the protection for humans and the environment.

2. People , Power , Waste

The Gulf countries need to build nuclear power plants for several key reasons. Firstly, they require a reliable energy source for their economic growth. The demand for electricity in the six Gulf Cooperation Council (GCC) countries is also high, because the population growth rate is predicted to more than double within the twenty five years (by 240%). Table 1 represents the expected population growth by 2030. Consequently, we can predict that these countries need to ensure a reliable source of electricity.

Table 1: Population of the six Gulf Cooperation Countries ('000)

	Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE	GCC
1990	493	2143	1843	467	16256	1867	23069
2000	650	2228	2402	617	20807	3247	29951

2010	799	3080	2791	891	26643	4770	38974
2020	951	3832	3473	1072	33332	5963	48623
2030	1095	4555	4137	1225	39950	7125	58087

Source: Cited of United Nations World Population Prospects 2006

In addition, their oil and gas supply in the future will decline. Currently, their economy, development and sustenance rely on oil and gas. Finally, the Gulf countries, in common with the rest of the world, need to reduce greenhouse emissions. Greenhouse gases are the prime contributors to global warming. The solution to all these issues could be the construction of nuclear power plants. A nuclear power station can provide 90,000Mw which will be sufficient for the growing population, without relying on fossil fuels, and in turn reducing the emission of greenhouse gases in the Gulf countries.

The impact of global climate change in the environment is a particularly notable risk. The GCC as industrial countries, have a responsibility to a help reduce carbon emissions throughout the world [18]. The Kyoto protocol requires all countries to decrease their emissions of greenhouse gases. Decreasing greenhouse gas emissions are needed to prevent dangerous climate change. This is because fossil fuel produces high levels of carbon dioxide in the environment [8, 1]. Consequently, by the construction of nuclear plants in the GCC countries, the rate of carbon dioxide emissions will decrease and help to avert catastrophic climate change in the world.

It is calculated that fossil fuel, as currently used, produces 40-100 times more carbon dioxide than nuclear power. Nuclear energy entails other dangers not directly related to power generation. The construction of nuclear power plants therefore poses opportunities and risks in the Gulf region.

3. Opportunities and Risks in the Construction of Nuclear Power plants

Construction of a nuclear power plant provides opportunities in the GCC to help get a diversification strategy for their energy resources. Similarly, over the next 10 years, Kuwait, Bahrain, Saudi Arabia, Qatar, Oman and The United Arab Emirates require 100,000 megawatts of electricity to meet their demand and this will increase to more than 200,000 Mw by 2030[3]. The construction of nuclear power plants in those countries can help their

economy grow. By this means, each year until 2016, the six Gulf cooperation council countries can start building a 1500 Mw nuclear power plant. Consequently, they need a mixed strategy for producing electricity.

Thirty one countries currently use nuclear power plants as a part of a mixed strategy of electricity generation. There are significant nuclear powers plants in America, Europe, Asia and Africa. Today, 440 nuclear power plants are active in comparison to a far greater number of standard power stations. The nuclear power plants reduce by nearly 3 billion tonnes the amount of carbon dioxide emissions annually. Fossil fuels generate electric power accounts for 34% of man-made carbon dioxide in the atmosphere. However, generating electric power by nuclear energy is virtually emission-free. Also, nuclear energy does not release greenhouse gases into the environment [11]. This is by comparison with a standard fossil fuel power plant that emits 2-6 grams of carbon per kilowatt hour of energy produced. If the 440 nuclear reactors in the world were shut down and replaced with fossil fuel, carbon emissions would increase to 600 million tonnes [14].

In fact, nuclear energy can be a proper alternative strategy which could effectively and efficiently replace fossil fuel in power stations. At this time, a further 31 nuclear power plants are under construction throughout the world. For example, China, India, Japan and South Korea are planning to construct a total of 8 nuclear power plants in their countries [4].

Table 2: Percentage of electricity generation from nuclear power plants by country [11]

Country	Percentage of total electricity produced
France	78
Lithuania	69
Slovakia	57
Belgium	54
Slovenia	48
South Korea	39
Hungary	38
Switzerland	37

Construction of nuclear power plants entail certain risks such as: the lack of safety and security procedures for dealing with nuclear waste may be dangerous for humans and cause

damage to the environment, the waste material can be targeted by terrorists and finally nuclear waste can be enriched to produce nuclear weapons. As a result, these risks have to be considered, when the Gulf countries express the desire to build nuclear power plants in their countries. Specific challenges in the disposal of nuclear waste include the following: lack of appropriate storage, lack of a nuclear safety regime, lack of proper funding and financing, lack of a proper legislative framework, lack of safeguards of the regulatory framework, effective radiation protection, lack of proper human resource development, stakeholders not being effectively involved in planning, lack of proper support facilities, environmental protection issues, emergency planning, security and physical protection [9]. Radiation pollution is also a remarkable risk to the environment. It can be released to the air, water, or the earth. Also, waste from the mining, processing and production of nuclear materials can be used in nuclear bombs. Furthermore there is the danger of accidental release of nuclear waste from stored nuclear weapons. The impact of radioactive pollution on the environment poses important and serious risks such as: harming reproduction of plants, humans and animals, increasing mortality, producing radioactive iodine within agricultural production and holding radioactive materials in water bodies and fish. There are real challenges that associated with nuclear power plants in the GCC region. Each challenge could be a concern for the Arab state countries and the rest of the world.

The Gulf countries need a new risk and safety management process to manage and mitigate those risks and challenges that nuclear waste entails. The new risk management and safety strategies will be discussed below.

4. Risk Management Process

The well known methodology of the risk management process is to identify, assess, manage and control risks which can occur in a project. The project Management Body of Knowledge (PMBOK) defines risk management as a process of implementing risk management planning, risk identification, qualitative risk analysis, and quantitative risk analysis, risk response planning, and risk monitoring and control [17]. According to Badr and Stephen [21], “risk identification, risk reduction, risk contingency plan and risk monitoring” are essential parts of the risk management process. Furthermore, Australian and New Zealand standards state [2] that risk management has the following steps: establish the context, identify the risks, analyse and evaluate the risks, treat the risks, monitor and review, and communicate and consult. However, those processes do not focus strongly on

the use of information and data in the project management methodology, because the disposal of nuclear waste is a sensitive, risky, large and complex project.

Consequently, a new process methodology for risk management is suggested. This new process helps to decrease the probability and impact of negative events and increases the probability and impact of positive events. The new risk management process includes [7, 8, 12]:

- Planning the risks: Define the main short-term and long-term objectives and outcomes required, select a proper approach and plans which are needed in risk management activities.
- Identifying the risks: Determine and define the nuclear risks that might affect the disposal of nuclear waste, particularly in the Gulf countries.
- Analysing the risks: Rank risks that are identified using both qualitative and quantitative methodologies. Qualitative methodology prioritizes the effects of nuclear waste on the environment and in the operation of the power station; quantitative methodology is used to measure the consequence of risks and their probability.
- Treating and responding to the risks: Plan and determine what should be carried out in reducing risks that have been recognized. In other words, options and actions will be developed and established.

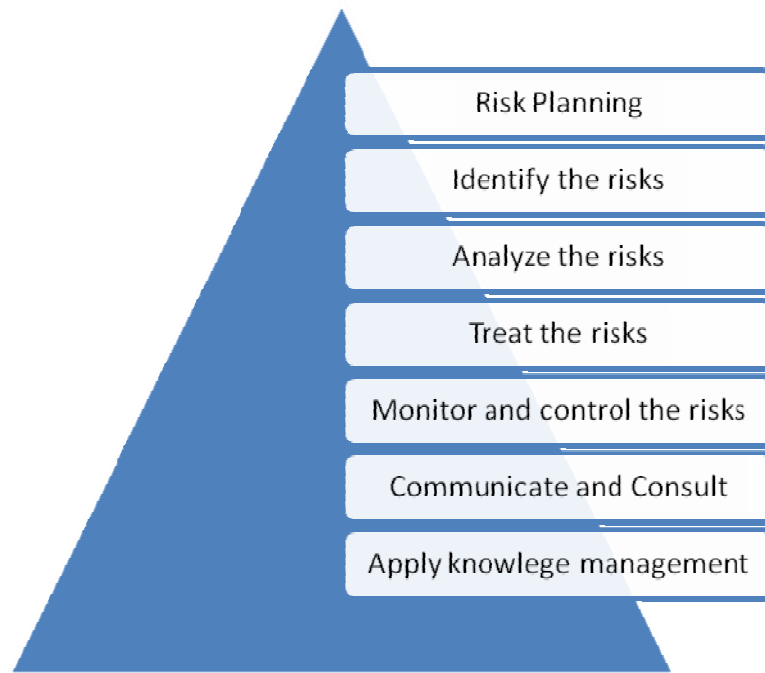


Figure 1 the Risk Management Process

- **Monitoring and controlling the risks:** Observe and compare planned and actual performance. Information on performance is provided by reports, briefings, and participation in review meetings, casual conversations, and observations and listening to employees who work in the disposal of nuclear waste. Monitoring and controlling means to replan and correct mistaken actions which have happened previously within project. All parameters, which should be considered in a project, are monitored and compared. Monitoring helps to evaluate and compare the planned performance against the actual performance. In this step, policies, strategies, objectives, goals, the process and methods are all assessed. Furthermore, teams which work in disposal of nuclear waste, the functional manager's level and the general manager's level should be evaluated in term of whether they meet planned levels of performance or not.
- **Communicating and consulting:** Provide and report risks which occur in a project and manage the project team. Project managers report their decisions about risks which affect the project team and the other stake holders [7, 8].
- **Applying knowledge management:** Initiate, plan and organize, implement, monitor and control information and data. This step helps to reduce risks and threats and increase opportunities.

This paper includes and emphasizes knowledge management within a risk management process. Knowledge management provides and selects proper information and data that help project managers improve and develop their ability to plan, identify, analyse, treat and respond, and monitor risks in a project. By applying knowledge management, project managers can generate proper strategies that provide more structure and formality to decrease the complexity and risks which may occur in a project [22].

The risk management process is discussed in this section. It process has a number of strategies to respond to the risk in the project. The safety management process is a strategy that reduces risks and issues which can occur in the disposal of nuclear waste and thus increase human safety and decrease risks to the environment.

5. The Safety Management Process

One of the main issues associated with the construction and operation of a nuclear power plant is nuclear waste, because it may affect humans and the environment. The disposal of nuclear waste needs special controls and safety processes [11]. A safety management process helps to minimize risks in the disposal of nuclear waste. In other words, it is a strategic plan to decrease hazards, issues and problems which can occur from the production and storage of nuclear waste [7]. The safety management process reduces risks that can harm persons or damage property and it protects the environment. Implementing a safety management process provides an acceptable and satisfactory level of attention through a systematic process of risk management and hazard identification [10].

The European Scale states that safety management includes: policy, plan, achievement, assurance and communication [20]. However, this paper provides new safety management processes that it includes the: policy, plan, implementation, assurance, promotion and application of knowledge management [6, 3].

- Policy: set out and identify strategic objectives and goals of safety. The world needs a proper policy for the safe disposal of nuclear waste. This is important for the long-term future, because nuclear waste has a long life. In the policy step, the objectives, goals and strategies necessary are thought through and defined explicitly, efficiently and effectively.

- Plan: define how to achieve the objectives and goals of safety in the disposal of nuclear waste.
- Implementation: implement both strategic objectives and goals in the project.
- Assurance: monitor safety features for humans, the environment, equipment, the disposal of nuclear waste and the continuing process of safety surveys and reviews.
- Communication: ensure communication of a safety culture, the distribution of data, information and lessons learned regarding risks that have happened.
- Knowledge management: put into operation tacit and explicit knowledge. Tacit knowledge is derived from understanding, values and experience of people in the organization. However, explicit knowledge is theoretical knowledge which is derived from documents, reports and information and data available inside or outside the organization [14].

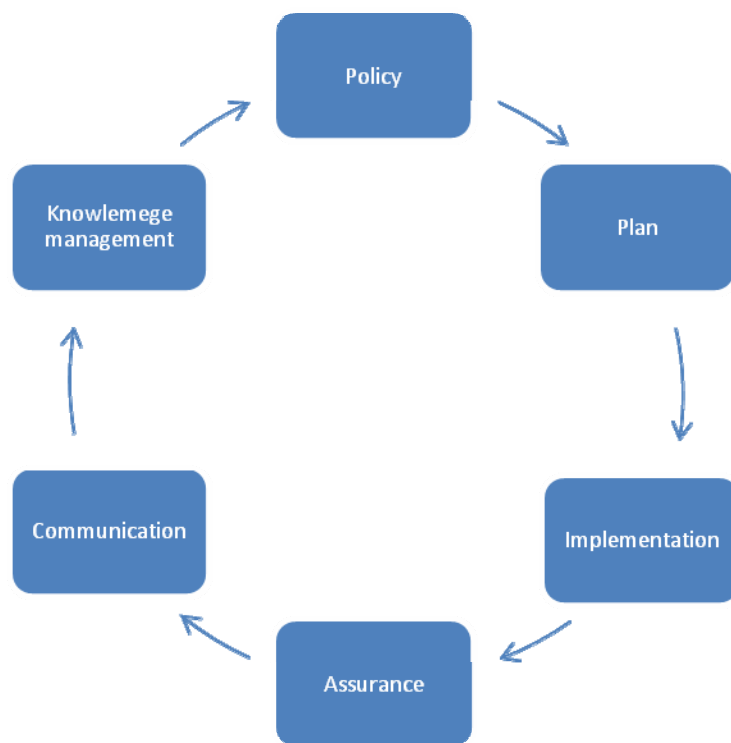


Figure 2 the safety management process

The successful strategy for disposal of nuclear waste in the Gulf Cooperation Countries is dependent on the conversion of tacit knowledge to explicit knowledge. Socialization, internalization, externalization and dissemination are methodologies which can be used to convert knowledge from tacit to explicit. Socialization is to share information and data by exchanging tacit knowledge between project managers who have experience in the operation and the disposal of nuclear waste facilities. The Gulf countries can develop risk and safety management knowledge from the experience of other countries which have dealt with decreasing the risks of nuclear waste and raising safety. It means nuclear knowledge can be transited to the Gulf Cooperation Countries (GCC). Internalization means that information and data can be employed in reducing risks and increasing safety factors that should be applied in the disposal of nuclear waste. Externalization is to convert information sourced from universities and reading documents. Dissemination is to combine and transit information and data; by training people involved in the storage and operation of nuclear waste disposal. These people can study to procedures and increase their knowledge of nuclear waste management.

6. Conclusions

The findings from this paper are that the Gulf Cooperation Countries will be faced with an increased population, accelerated economic growth, limited energy supply and inadequate fossil fuel supplies to meet their energy needs in the future. This leads to the need for the Gulf Countries to diversify their energy supply. Nuclear power can create such opportunities, because nuclear energy produces much less waste than fossil fuels. Emissions such as carbon dioxide, carbon monoxide, sulphur dioxide and nitrogen oxides that have an effect on global warming are produced by fossil fuel. The storage and disposal of nuclear waste has negative risks in Gulf countries such as high costs for disposal of nuclear waste and safety issues. Furthermore, there may be the potential for nuclear proliferation, terrorist attacks, theft of fissionable material, destruction of the plant or damage to infrastructure plus environmental impacts including radiation leaks and toxic pollution of the area.

In response to these potential threats, this paper has presented new risks and safety management processes that can be used to manage and mitigate risks in the disposal of nuclear waste. The risk management methodology includes: risk management planning, risk identification, risk analysis, risk response planning, risk monitoring and control, communication and consultation and knowledge management. This new methodology aims

to identify and analyse risks, respond, control and communicate and to effectively use knowledge management techniques, namely tacit and explicit knowledge. They can be converted into one another by socialization, internalization, externalization and combination. Furthermore, those conversions can be both useful and effective to help with managing and controlling risks in the disposal of nuclear waste in the Gulf countries.

Consequently, knowledge management could meet the Gulf Countries' needs for decreasing the risks, enhancing safety, reducing capital and operation costs, shortening construction schedules, decreasing and managing environmental risk and increasing the useful operational value of the nuclear fuel [15]. In addition, disposal of nuclear waste needs rigorous safety management. The new safety management includes policy, plan implementation, assurance, communication and knowledge management.

This paper has emphasised knowledge management, because it provides research and development programs to enable deeper penetration of nuclear power into the energy markets and reduces future emissions within the GCC. Knowledge management can provide technology that prevents nuclear radiation escaping from the nuclear reactor within the production process. In other words, the knowledge flows from science and technology to improve the elimination of waste products and increase safety in nuclear power plants [16]. Finally, knowledge management could provide short-term and long-term strategies for fuel procurement, fuel management and nuclear waste management. However, the researcher believes that there is still significant work needed to support and develop risk and safety management methodologies, to decrease risks and increase safety in the disposal of nuclear waste.

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