The Influence of Cost Incurred on the Critical Success Factors of SMRs in the UAE

تأثير التكاليف المتكبدة على عوامل النجاح الحاسمة للمفاعلات الصغيرة والمتوسطة في دولة الامارات العربية المتحدة

by

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ABSTRACT

The study began with the objective to understand the influence that the cost incurred has on the critical success factors of the SMRs. SMRs are a promising technology in the nuclear sector which can provide clean energy while being safer than the large reactors. Thus, to realize the study's objectives, the primary independent variable (Cost Incurred) and the primary dependent variable (Success Factors) were categorized into four sub-variables each. Cost incurred was measured via the four sub-variables: Higher Profit Margins, Low Cost Encourages Investment, Low Cost Encourages Economic Cost and Easy Impacts Projection on Costs. The critical success factors were categorized into the following sub-variables: Governments Regulatory Framework, Government Supporting in Grid Development, Geopolitical Collaborations and Large Space Availability. A questionnaire was developed and distributed to the employees of UAE's nuclear power plant. The results obtained were analysed through SPSS. It was found that there was a statistically significant correlation between Cost Incurred and Success factors. Subsequently, multiple regression was carried out and the regression was significant thereby a predictive model of the relationship between the cost incurred and the success factors was developed.

ملخص البحث

كان الهدف من الدراسة هو فهم تأثير التكاليف المتكبدة على عوامل النجاح الحاسمة للمفاعلات الصغيرة والمتوسطة. وتعد المفاعلات الصغيرة والمتوسطة تكنولوجيا واعدة في القطاع النووي ويمكنها أن توفر طاقة نظيفة في الوقت الذي تعد فيه أكثر أمانًا من المفاعلات الكبيرة.

ولتحقيق أهداف الدراسة، فقد صنف كل من المتغير المستقل الأساسي (التكلفة المتكبدة)، والمتغير التابع الأولي إلى أربعة متغيرات فرعية لكل منهما. فقد تم قياس التكلفة المتكبدة من خلال المتغيرات الفرعية الأربعة التالية: ارتفاع هوامش الربح، والتكلفة المنخفضة تشجع الاستثمار، والتكلفة المنخفضة تشجع التكلفة الاقتصادية، والسهولة تؤثر على توقعات التكاليف.

وقد تم تصنيف عوامل النجاح الحاسمة إلى المتغيرات الفرعية التالية: الإطار التنظيمي للحكومات، ودعم الحكومة في تطوير الشبكات، والتعاون الجيوسياسي، وتوافر المساحات الشاسعة. وقد تم تطوير استبيان وتوزيعه على موظفي محطة الطاقة النووية في الإمارات العربية المتحدة. وقد تم تحليل النتائج التي تم الحصول عليها عبر برنامج (SPSS).

وتوصلنا إلى وجود ارتباط دلالة إحصائية بين التكلفة المتكبدة وعوامل النجاح. وبناء على ذلك، تم إجراء عدد من الانحدارات الخطية وكان الانحدار الخطي كبيرا مما أدى إلى تطوير نموذج تنبؤي للعلاقة بين التكلفة المتكبدة وعوامل النجاح.

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Contents

Chapter 1: Introduction

1.1 Study Background and Research Context

Currently, there has been an increase in the demand for electricity, and the rate of demand is expected to double in the next 25 years (Locatelli & Mancini, 2010). When this problem is combined with the case of international global warming we establish that the demand is likely to increase at a higher level. Today, the electricity that is provided by the nuclear industry accounts for almost 11% of the total electricity that is found across the globe. Even though large nuclear reactors can fulfill the demand for a high level of electricity by people across the world, they are still faced by some challenges as a result of the financial and economic costs. Thus, the most suitable alternative to such a case is the adoption of the SMRs as they can be used in different countries and locations where the large reactors are not applicable.

The idea for the usage of small-medium reactors is not an idea that is new to most countries. In the early, 1940's, there was the establishment of the SMRs that were made up of about 10's of megawatts. The primary purpose for which the SMRs were built was to be used in the process of research demonstration, testing, and propulsion. There was the development of the first commercial reactors in the form of scaled-up versions for the small power plants in the late 1950s's and 1960's. The increase in the demand for the SMR follows the principle of economies of scale that a more significant quantity is better as compared to the small quantity. As a result of the principle, it pushed up the size of the reactors to1300 MWe (Kuznetsov & Barkatullah, 2009). From the 1970s, the mainstay in the nuclear industry has been the focus of the large generation reactors (Gen II). The generation that followed relating to light water reactors, continue with the trend for the development of new power reactor designs including the

AREVA's European Pressurized water Reactor (EPR") a that is almost 1650 MWe, Westinghouse Advanced Passive reactor (AP1000") at 1154 MWe, General Electric-Hitachi Advanced Boiling Water Reactor (ABWR) at 1350e1460 MWe, and lastly Mitsubishi Nuclear Energy.

Researchers indicate that the levelized costs that relate to the big plants are higher as compared to those of the small plants. Besides the large power plants having multiple uses, they have increased the substantial upfront costs that are being evidenced in the liberalized markets. Most of the customers across the world are not in a position to obtain the €3 to €5 billion that is needed to cater for the full start-up, construction and the design of the massive nuclear power plants (Kuznetsov, 2008).

Various definitions have been posited by researchers of Small Modular Reactors (SMR). In the case of this study, they refer to the type of reactors that have a capacity that is below 300 MWe. In most cases, these type of nuclear reactors is produced in different factories before being transferred to different locations where they are installed and are required to perform the tasks that they are supposed to do (Lokhov & Sozoniuk, 2016). In UAE, the government aims at decreasing the level of dependence on gas for generation of electricity. This has been done through an increase in the use of nuclear reactors and solar energies in the process of generating electricity. The decision for UAE to undertake the above step was as a result of 2009 that indicated the state to be the sixth among the countries causing high levels of revelation in 2009 carbon dioxide emissions (The Guardian, 2011). By 2020, the government of UAE aims at producing at least 7% of the overall electricity produced within the country from the renewable sources. Thus, in this paper, a study is made on establishing the financial and economic viability of small modular reactor in UAE.

Furthermore, SMRs are highly reliant on serials; these are the factory-based production of reactor modules. Due to the characteristics that are portrayed by the SMRs, it makes them be suitable for adoption in the niche markets such as in islands and areas that are isolated. This is because in such areas it is difficult to implement an option of power generation as it will be costly for any entity. However, a problem may occur in the process of implementation of such type of nuclear reactors especially in the case of an island as they are specific in nature and may contradict the requirements for standardization. Furthermore, the SMRs could be deployed in regions that re on-grid whereby the NPPs and the conventional plants compete with each other. In such a case, the SMRs benefit highly as they are able to use a lower number of systems, structures, and components as compared to the large-scale NPPs that are deployed in factories.

The increased interest in SMRs is a result of the low level of carbon, job creation, economics and the emerging job opportunities in the international market. In the European Union (EU), a number of efforts have been dedicated towards the creation of carbon technologies that are low and affordable to all people in the member countries. Furthermore, efforts have been dedicated to making the carbon technologies within the union to be more competitive. This is an idea is the main reason behind the European Strategic Energy Technology Plan (SET-Plan). In the US, the main reason behind the development of technology is to ensure that they are competitive and the creation of employment for the people in the region.

Across the globe, the potential customers for the SMRs include the small utilities, countries that experience constraints of infrastructure and financing problems, non-electrical customers and the distributed power markets. SMRs have a wide range of concepts, and the applications that are related to the technologies are also diverse. Vendors from different countries across the globe including those from China, South Africa, Argentina, South Korea, France, India, Japan and the

International Atomic Energy Agency (IAEA) have taken steps in the process of development of various designs for the liquid metal-cooled systems, gas cooled and the water cooled systems (Locatelli, Bingham & Mancini, 2014). There may be the deployment of some of the reactors in 10 years to come since there have been same designs in the previous years through of the Nuclear Regulatory Commission license process. Among these types, there are some designs that are exotic so as to increase on the period of refueling.

Primarily, plant economics in the future will be used as the critical determinant of the viability of the SMRS thus in this paper focus is made on two aspects of plant economics including financial and infrastructure as the main aspects of establishing the viability of SMRS. Studies that will be conducted in the future are meant to broaden the view above through usage of more measures on the environment, infrastructure, financial viability, social impact and many other factors. Most countries prefer SMRs as compared to the current NPPs since they are less expensive to build, have an enhanced construction and fabrication logistics, improved level of plant safety and proliferation resistance and further they have a high level of operational flexibility.

1.2 Differences between SMRs and large reactors

The main difference that occurs in the SMRs as compared to the ALWRs is the aspect of their level of modularity. Even though some of the ALWRs that are being produced current depend on the modular construction, in the SMRs, the module is at times entirely a module reactor with all the parts of the primary circuit. Due to this reason, the stand-alone module can be transferred to the site of construction where installment of the reactor is done. This could be inclusive of the structures that are factory-produced also.

In the SMRs units, the equipment that is shared always varies according to the design of the system. Thus, most of the vendors of SMR tend to make the installment of their factory-built models in containments individuals; this is a similar case to the ALWR. A good example is the barge-mounted KLT-40 that share only a specific type of equipment, but the vessel in such a case is not shared. SMRs vendors reveal that their knowledge of various concepts of such reactors increase on the nuclear safety and at the same time allowing the use of passive features that are unique. In the case of the advanced designs, there is always no parts of the reactor pressure vessel that keeps on rotating due to the natural circulation. However, there are some types of ALWR that also depend on the principle of natural circulation.

According to the estimates of SMR designers, the total assemblage of the factory units allows for a high amount of savings being made on the costs incurred in the process of manufacturing. In the construction of some SMR design, there is a need for the establishment of five to seven plants, and from the supply chain learning and establishment, the most vital is selected. Therefore, most of the SMRs depend on serial production that occurs in the factory as they could make up for the diseconomies of scale that may occur in the industry. In theory, in a case that involves a large number of production series, overnight investment costs that are incurred may incur per kWe relating to SMRs are smaller as compared to that of the ALWRs. Furthermore, under terms that are absolute, the cost of SMRs is always cheaper as compared to those of the ALWRs

Plants that always use a group of SMR units have a flexibility that is better for the utilities that operate in a small number of grids. In the aspect of the transmission infrastructure, the requirements for the SMRs may be smaller as compared to that of the ALWRs due to the low level of electricity that the reactors produce. Due to this advantage, their deployment is more

natural in a number of locations. Most of the designs of SMRs offer a high degree of operation in the load-following regimes such as in Germany and France (NEA, 2011.). For the case of the massive nuclear reactors, the load-following is inefficient as the power generation process is mainly made up of costs that are fixed. Thus, the lower rate of power output does not result in a reduction in the generating costs. The most suitable solution to such a case is to ensure that the primary circuit is maintained at a level of full power and there is the usage of more power in the process of cogeneration.

In relation to the process of operation of the reactors, there are benefits that may arise as a result of the adoption of several SMRs as compared to a single large unit. This is because, in the operation process, the team for maintenance and refueling of the system is employed by only one operator. Furthermore, the use of a multi-unit configuration results in the prevention of the long outage periods as compared to the ALWRs that is done by use of a unit-by-unit refueling and maintenance process. According to Holtec (2011), the process of refueling might only take once a week in a period of 42 months. Thus, the process of decommissioning might be more accessible as a result of the use of modules that are less costly as compared to any other form of nuclear reactor.

The only available licensed SMRs is the Korean Atomic Energy Research Institute's (KAERI) SMART (System-Integrated Modular Advanced Reactor) (Keung et al., 2014). This type of reactor is characterized by safety features and is made up of 330 MWth. The unit is majorly designed for purposes of generation of electricity and the thermal applications. In addition, this type of design is made up of a 60-year life with a three-year cycle of refueling. This type of design received its Standard Design Approval (SDA) in the year 2012 from

Nuclear Safety and Security Commission (NSSC) that is a Korean regulator. In the month of March 2015, a Memorandum of Understanding was signed between KAERI and King Abdullah City, Saudi Arabia's president for the Atomic and Renewable Energy (KA-CARE). The supply chain and the various successes of SMARTis comparable to successes and the supply chain of the four Korean Electric Power Company in the UAE (NEA, 2015: 97-104).

1.3 Research Objectives

This research study aims at establishing three research objectives. These include:

- To establish the background information of SMRs.
- To identify the cost incurred in the development of SMRs.
- To outline the critical success factors of SMRs in UAE.

Research Questions

The research study aims at answering three research questions including:

- What are the benefits of using SMRs in comparison to large reactors?
- What are the factors which comprised the cost incurred variable of SMRs?
- What are the critical success factors of SMRs?

1.4 Significance/ Rationale

In the past few decades, there have been a number of studies conducted on the issue of SMRs across the globe. In order to be able to determine the different risks and benefits that result from the deployment of SMRs, there was a need for carrying out this study. There are few studies that have been conducted with respect to the establishment of SMRs. Furthermore, the studies carried out have been done to serve various purposes, and in different regions, thus the

findings established from such studies cannot be applied to the case of the United Arab Emirates. There is little information concerning the SMRs in UAE. Thus, in this paper, a study is made on establishing the financial and economic viability of small modular reactor to understand the influence of cost incurred on the critical success factors of SMRs. The developed study findings are expected to yield value both theoretically and practically. On the one hand, the value of the study findings is in the existing literature. In developing the study proposal, an in-depth pre-analysis literature evaluation and critique were developed. It is this literature analysis that guided in the formulation of the conceptual study framework. In a review of the existing literature, a number of literature gaps were established. The literature evaluated was mainly on the process of installation and usage of SMRs in the market. In this case, the studies are mainly developed on the technical part of the projects and plants development, installation, and management.

As such, this could be summarised as more of an engineering perception on the SMR plants in terms of designs and their installation. However, there is a literature gap on the financial aspects of these projects. These are projects mainly rolled out and funded through government budget. This means that their funding is from public finances. Thus, it is imperative for reviews to evaluate the economic and financial implications of the use of these projects. The key areas requiring focus and additional literature are on the financial implications of such projects in terms of the project investment costs, the rate of returns for the investments and the approximate periods it takes for the projects to break even. This is a financial basis through which the development of the SMR project would be based over the other reactor projects in the nation.

Unfortunately, this is literature that is rarely available and needs developing/. Although the study findings do not cover all the required areas on finances, it covers areas on the financial benefits and implications of starting such SMR projects. This is literature backed by empirical; findings

expected to play as a first step toward bridging the existing gap. Nevertheless, the study is cognizant of the need for further future studies to support the findings as a way for creating the findings reliability in literature use.

On the other hand, the obtained study findings have a direct impact on the UAE nuclear energy industry. In this regard, the study is developed in the UAE context's This means that the findings obtained, even without the need for generalization are directly applicable and usable in the UAE market. In particular, the study findings are projected to establish the real financial implications and benefits of developing SMR projects. In addition, besides the financial implications, the study findings demonstrate the real economic value for such projects. As such, this forms the basis through which the government could base its justification for investing in such findings. Additionally, the findings help compare SMR to other reactors. The need for any government is to invest in projects that have the highest value and result in sustainable economic growth and development in the country. Therefore, rationale based decisions on whether to support or not to support SMR plants in the UAE are supported by the study findings. It is additionally imperative to note that the findings practical implications are not only applicable in the UAE. Instead, they are applicable in the entire Middle East, the MENA region and the global market at large.

1.5 Structure of the research paper

- ***Chapter 1:*** Introduction- This study is comprised of five chapters beginning with an introduction to the topic under study. This involves the financial and the economic aspects of SMRs across the globe and UAE being used as a case study.

- ***Chapter 2:*** Literature review- The second chapter gives a literature review of the various studies that have been conducted in the past with respect to the objectives that the study intends to establish.
- ***Chapter 3:*** Research Methodology The chapter indicates the techniques that the researcher uses in the collection of data for the research process. In the case of this study, the investigator will use questionnaires and the interview guides in the collection of data
- ***Chapter 4:*** The chapters offers a summary of the obtained findings and interprets the findings in relation to existing literature outlined in chapter 2 of the study.
- ***Chapter 5:*** Conclusions and recommendations. The chapter details the general conclusion on the findings. The conclusions give way for the formulation of recommendations both practical and theoretical on areas for further studies development in the future.

Chapter 2: Literature Review

2.1 Introduction

The literature review section is made up of various studies that have been conducted by the scholars in the past concerning the topic under study. In this paper, past studies that have been reviewed have been done with respect to the research objectives that the researcher aimed at establishing. The section is further on divided into various sub-sections including background information of the SMRs, financial elements, and the economic elements

2.2 Background information on SMRs.

SMRs are considered a type of nuclear reactors that have an electric power that is either 300 MWeother nuclear reactors are termed as being medium sized reactors if their level of electric power ranges from 300 to 700 MWe (IEIA, 2007). However, I most cases the two are always combined into SMRs to represent the nuclear reactors that have an electrical output of not more than 700 MWe. On the other hand, the large reactors are assumed to have an electrical power output of more than 700 MWe. SMRs includes different nuclear options along with the remainder of the plant support infrastructure and equipment, namely the steam generator, turbine, and fuel storage facilities, if necessary, and can be deployed as multiple units on the same site to increase total power output. According to Khan et al. (2010) in their study, they established that there are different types of SMRs designs that are being developed and are currently at different stages across the globe. Ingersoll (2009) postulated that the features of these types of SMRs designs include: them being deliberately small.

SMRs are attractive in nature, and that's why most of the people are aiming at adopting as compared to the large reactors. The attractiveness of this kind of reactors is attributed to its characteristics such as the enhanced level of safety, limited usage of financial resources and their simplicity characteristics. Despite the high number of advantages that come along with the SMRS, they are always considered as not being economically competitive, and this is due to the misapplication of the principle of the economy. From the principle of economy scale, the capital cost of a given nuclear reactor reduces with an upsurge in the size of the reactor and this is attributed to the investment costs and the different setup costs that are related to the plant. The investment costs, in this case, include sitting activities, licensing, civil works that are carried out so as to access the transmission network. Hence, if there is an increase in the size and the power that is produced by a nuclear plant, it results in the increase of the given capital cost of the plant. In the past four decades, the size of reactors has been increasing from a few hundreds to almost 1500 MWe and upsurging more today.

Across the world, nuclear power has had a great debate in relation to the global climate change. This is because the nuclear power is the only type of energy that is carbon-free and is the one that is responsible for the generation of large scale. Furthermore, the source of energy has a room of expansion if efforts are made to reduce the challenges that are brought about by nonproliferation, safety, economic competitiveness and waste management. If such activities are improved, then it may result to an improvement in the overall performance of the SMRs and the financial resources that are spent by the government of UAE on the energy sector will decline eventually.

2.3 Opportunities and Advantages of SMRs

There are a number of opportunities that the UAE has to take advantage and the challenges that the government is supposed to overcome so as to become one of the leading countries in terms of SMR technology. As discussed earlier, it is evidenced that the SMRS have chances of resulting in the reduction of the amount of greenhouse gas emissions. The SMRs have an advantage of being able to serve as an alternative to power generation so as to facilitate the retirement of the smaller, older and the less efficient plants that are used in the generation of coal.

In the US, the nuclear reactors for decades have been responsible for the generation of almost 20% of the total nation's electricity level, this almost two-thirds of the country's total carbon-free electricity. Around the clock, the vast quantities of electricity that is produced are as a result of nuclear power plants. They are able to operate without depending on either wind or sunshine. Also, fuel is not necessary for the nuclear reactors to perform its tasks. The SMRs have an advantage in that they bring about price stability and if there was no nuclear generation, then the retail rates would be over 6% higher as compared to the average percent that is expected.

In addition, SMR designers emphasize that the concepts related to the SMRs allow for the enhancement of nuclear safety and the process of implementation of features that are passive nature. As a result, it results in an increase in the level of security of the nuclear energy that is produced by the SMRs. Due to the concepts related to the SMRs being simplified, most of the designs of SMR benefit from the reduction of the number of systems, structures, components and the conversion systems that have been simplified. The upfront investment that is needed for purposes of investment of one unit is smaller and hence making the process of financing the plants that use SMR to be cheaper as compared to the plants that use the NPP(NEA, 2015).

In support with the above ideas, it is reported that plants that use multiple numbers of SMR units give a higher level of flexibility for the various types of utilities that operate in markets that are

made of large shares and at the same time having a diversified number of renewable generating resources. This is advantageous to the SMR designers as most of the SMR designs are able to operate in the regimes that are load-following such as in Germany and France (NEA, 2011). The transmission infrastructure that is needed in the SMRs is smaller as compared to those of the advanced light-water reactors (ALWRs) due to the low electricity output level that is provided by these type of nuclear reactors (NEA, 2013). This advantage of the SMRs makes the deployment of this kind of reactors to be made in a wide range of locations.

In relation to the management of human resource of the team that is concerned with the operation of the SMR and the outage management, there are always advantages that come along with the act of having more similar SMR units as compared to only one large plant. This also helps in avoiding of the extended outage period either adoption of unit-by-unit maintenance or refueling (NEA, 2012). These advantages make the SMR be more suitable towards the goal of increasing electricity generation as compared to the large reactors.

2.4 Challenges of SMRs

The process of licensing, design and the engineering activities of the SMRs are in the early stages. Thus, the process of enhancement of the SMRs across the globe has become a difficult task for many countries. The design and the licensing of the documents for the SMRs are supposed to be ready for the NRC with a stipulated time frame, and it first requires detailed engineering that ranges from 10% to be 20% to be complete. Furthermore, there are limited cost data that is always available for the public and the estimates that are made at the current period are always comprised of a significant amount of uncertainty levels in it. Lastly, the enormous amount of investment that is required to be made towards the manufacturing of SMRs is high as

the SMR manufacturing process is still in its process of planning and thus, poses a significant challenge to governments that have put their efforts towards the manufacture of such plants.

Apart from the disadvantages of the SMRs that are mainly dependent of the development of the SMRs, there are other challenges that may arise that are not dependent on the attractiveness of the SMR technology or the willingness that the buyer has for purchasing of the SMRs. This includes the regulatory barriers that may come along with the development and the implementation of the SMRs. The features that are offered by most of the SMRs designs are innovative in nature such as an increased level of multi-modular deployment and the improved passive safety systems. Including the NuScale. According to Rothwell (2016), most the SMRs vendors posit that the passive features that are found in the SMRs may result in the reduction of the staffing requirements that are needed in the process of operation of the system.

Regardless of technology that is needed for a specific SMR, the process of deployment and manufacturing of the SMR vary significantly from the techniques that were adopted traditionally in the construction of the large NPPs. For purposes of attaining the economic competitiveness, some of the SMRS opt for reliance on a group of most SMRs rely on series of factory-modules that are standardized.

In addition, the attitude of the public towards the nuclear project that is supposed to be implemented is a critical issue in the success of the nuclear project. The public acceptance of the type of nuclear technologies that is comprised of the innovative technologies is dependent on the expertise that the independent safety authorities is made up of. However, the adoption of SMRs that use the passive safety features and massive deployment of the systems could result in an improvement in the attitude that the public has towards the nuclear reactors. This is mainly when

the management that is responsible for the construction of the nuclear project put into consideration the needs of the public where the nuclear project is supposed to be implemented. Moreover, infrastructure development that exists in the host country is another challenge that is faced by the process of development of the SMRs. The importance of the SMRs become a vital issue especially when the SMRs are being exported to other developing countries (IAEA, 2007). The nuclear power that is obtained is also made up of stringent requirements that are related to the reliability and the quality of the power grid. Despite the fact that the SMR always have small levels of power output, some level of grid reinforcement is always required so as to ensure that a given of reliability and the quality this needed for safe operation of the system is achieved. In relation to the localization of the production process, infrastructure development is dependent on the level of industrial and economic development of the host country. Even though a host country may aim at maximization of the localization of the nuclear power plant production, the idea may contradict with the requirements of the business of any given SMR since the factory units are usually factory assembled. However, on the other hand, the hand the reactors that are non-nuclear are supposed to be manufactured locally.

2.5 Financial elements of SMRs

Nelson (2010) carried out a study out on the main elements that were required for future nuclear energy. From the assessment, it was established that most of the projections are in support of the idea that the number of SMRs that are in existence are higher as compared to the more or fewer reactors that have capacities amounting to 1000 Megawatts-electric (EC, 2014). Besides, the closures that have scheduled on a number of power plants existing in some of the states that are made to be closed tend to run counter to projections. The main reason behind the scheduled

closure of some of the reactors in their respective states is due to some of them lacking the necessary financial resources to ensure that the reactors are successful in producing the required by the people within the state energy.

Furthermore, Lokhov et al., (2016) assessed on SMRs focusing on the market potential of the nuclear energy for the deployment in the near term. In their case, there has been progressing in the construction of the SMRS in the past few years. The reason behind the improvement is due to the need to reduce on the capital costs that are related to power plants and ensure that power is provided to the small grid systems. As a result of this, efforts have been made so as to ensure that there is an improvement in the SMRs and hence leading to the development of the advanced SMRs. The study employed data that was obtained through the use of questionnaires and the interview guides that were issued to the potential customers and the SMR vendors. The participants were used so as to be able to determine the potential for the deployment of the SMR commercially across the globe. It was determined that despite the fact that the cost of financial resources that are needed in electricity generation, the floating NPP tends to be the most suitable alternative to this process as it can be able to provide power to remote regions such as those in Russia as compared to the cost of alternatives such as the power grid extension whose cost is also high (EMWG, 2007).

In the United Arab Emirates, the main reason behind the government increase of the policies relating to the use of the low carbon technologies is to ensure that there is an increase in the delivery of the energy requirements. Also, in the US in 2008, concerning the climate change Act enshrined in the law aimed at reducing the level of gas that is eliminated from the greenhouse by the year 2050. So as to attain this strategy, there is a need for the use of a diversified number of technologies inclusive of the nuclear technology. Furthermore, the US has a policy of ensuring

that there is diversification of the different types of nuclear technologies and the vendors that are found within the region. This is mainly aimed at ensuring that there is an increase in the amount of electricity that is generated from the nuclear reactors.

There is a chance for the SMRs to be made the central part of a generation of nuclear energy and the low carbon technologies in the US. However, so as to be able to ensure that the SMRs are able to perform their functions there is need to ensure that the SMRs make sense in the conservative perspective (Rosner & Goldberg, 2011). Thus, the price of the SMRs needs to be competitive as compared to those of the massive nuclear reactors. The two central costs that are related to the SMRs include the Overnight Capital Cost and Levelised Cost of Energy ("LCOE"). The two metrics are the primary standards that are used by industries in establishing and benchmarking project economics as well as assets that generate electricity. The earlier cost refers to the charges that are incurred when building a nuclear reactor overnight while the latter refers to the costs incurred in the process of economic assessment of the unit cost of generating electricity over the economic life of a generation asset in net present value terms. The Overnight Capital Cost is not good at establishing the construction cost of the nuclear reactors since it ignores the financing cost but makes a comparison of building different types of power plants through their economic feasibility. Thus, in the case of this study, the OVC will be expressed in terms of £/kWe.

2.6 Economic Viability of SMRs in UAE

According to Locatelli, Bingham, and Mancini (2014), the main challenges that face the scientists and the engineers is to be able to develop and deploy power plants that have the ability and capacity to meet the growing demands of energy across the globe. Their main aim in

conducting their study was to be able to review the SMRs and mainly focusing on the Light Water Reactor (LWR). From the results, it was determined that the most suitable type of nuclear reactors be adopted if the power to be installed range between 1 and 3 GWe. This applies when the primary aim of the policymakers is to ensure that there is an increase in the cost of investment through activities such as an improvement in the employment opportunities of the people within the country.

The nuclear industry always classifies the economic costs related to the NPP projects as operating, fuel, maintenance, decommissioning and the capital costs. The main techniques that are employed in the computation of such costs that are related to the development of the SMRs include the top approach and the bottom-up technique. When the first method is employed, scholars argue that there is always a need for one to merge together the different escalation coefficients and the cost drivers. In respect to the power plant, the main aspects of cost driver that are looked at include the size, location and the technology that is used on the power plant. On the contrary, when the bottom up analysis technique is used, the level of resources is used in the determination of the unitary and the quantity cost.

Furthermore, the key indicator that is used by the policy maker in the determination of such costs is the use of levelised costs that are related to the cost of electricity that is generated by the power plant. In most cases, the indicator is always denoted by the term “LevelisedUnit Electricity Cost(LUEC). The costs that are included in this type of indicator are made up of all the life cycle costs that are incurred in the process of development of the SMRs are denoted by use of the energy currency [$/KWh].

For purposes of investigating on the profitability that is attained by investing in a power plant for different utilities, different utilities are always adopted with the main ones being the Internal

Rate Return (IRR) and the Present Net Value (NPV). In such a case, the latter is used in the measurement of the absolute profitability [$] that in most cases is affected by the value that is discounted. In this case, the discounted value refers to the factor that is used in the weighing of the present costs that are incurred versus the revenue that may be generated in the future. The indicator is dependent on the source of financing and is forecasted as the Weighted Average Cost of Capital (WACC). If the WACC obtained is low then it gives a present value that has a similar weighing to the revenues that are expected in the future. On the other hand, if WACC is high, then the present costs are weighted towards the revenues expected in the future.

IRR refers to a specific indicator that is always dimensionless. In most cases, the IRR is always represented as a percentage of the rate of return. If the value of IRR obtained is higher, it implies that there is a high level of profit that is obtained from the utility. An increase in the level of IRR is as a result of an increase in the profitability that is obtained from the upsurge of utility. Thus, so as to ensure that there is an increase in the SMRs IRRR, there is always need for minimization of the various indicators that included in the process of computation of either the present costs or the future revenues.

2.7 Economies of scale

Across the globe, economies of scale are usually employed to facilitate the process of production of the cost structure of the LWR. From the traditional techno-economic analysis, it is established that with the increase in the plant size that is evidenced across the world, it has resulted to a reduction in the overall operating and investment costs that incurred on every unit of electricity produced. However, the above argument cannot be applied to the case whereby an analysis made on the investment decision that involves the comparison of the LR and the SMRs since the

argument is based on the notion that other things that are involved in the computation are equal. Thus, this gives an implication that all aspects of SMRs are similar to those of the LR with the exception of the size. In a situation whereby the design of an SMR is marginally different from that of the LR, it leads to the price of the LR to be lower than that of the SMR. The reasons behind such occurrence are either geometrical or economical. Geometrical reasons include the increase of the volumes of the SMRs to the powers of 3 and a similar case to the areas. On the other hand, the economic costs that may result in such a situation include a point whereby the semi-fix such as licensing is increased or decreased on the amounts that are more than MWe.

On the contrary, SMRs have some benefits that are only evidenced on the small innovative reactors, and if there need for them to be replicated on the LRs, then it will only be to the extent that is very limited. In this case, the main factors that are considered include modularization. Modularization refers to the act of conversion of the construction and the design of a plant that is monopolistic so as to enhance factory fabrication of various modules due to the need for installation and shipment in the field as assemblies that are complete. In relation to fabrication, it has been determined that site fabrication is always expensive as compared to the factory fabrication.

There are two advantages that are exploited by the SMRs that are synergic. These included the amount of time that is spent on the construction and learning. In respect to learning, there are two main issues that are addressed in the economy of any given nation including the mass of economies and modularity learning economies. In modularity, it is revealed that SMRs depend on a specific technical concept that involves supplying of standardized components, maintenance, and their assemblage within at the plant site. The main aim of all these activities is to ensure that there is a reduction in the level of operating and investment costs. There is a need

for standardization of the components of SMR together with some size of units as the condition allows a supplier to replicate in the factory the production of units of SMR and ensure reaping of the learning economies.

For purposes of achievement of mass production economies, more SMRs are required to be used for any plant that has been installed as compared to LRs since the power that is always provided by the SMRs is a fraction of the one that is generated by LRs. Thus, there is a possibility that in the usage of SMRs a number of ordering processes of components such as the valves to be included. Such a process allows the SMRs to be able to exploit the issue of economies of scale production and the procurement process that is more standardized. A critical aspect that is needed in the industrial learning is the stability of a regulatory environment that allows the utilities to be able to standardize on the various design. It is indicated by NOAK that the costs that are incurred for the next plant are always attained after a period of 8 gigawatts (GWe) power installed, but before that, there is a decrease in costs with every cost having a doubling experience.

Learning is majorly an advantage to the SMRs in the early stages of the market but at the end is equalized to market for both types of market designs. Besides the global learning, there is also an additional type of learning that is on site and obtained through the process of successive construction of SMR units on a similar site. This results in a significant part of total learning that may be used when making a comparison of a site that uses LR to that makes use of the SMRs.

Economics of SMRs vs. Other Sources

According to OECD [2011], usage of nuclear power in the market is highly competitive with other energy sources including the coal plants, renewable fired pants, and the gas-fired plants. This has been adopted across the world in countries such as Japan, Brazil, Republic of Korea,

Russia and the United States though in China it has not been adopted by most companies. Generally, SMRs including those that are either multi-module or the twin-unit have an advanced level of LUEC as compared to the NPPs that are made up of the large reactors. In agreement with this argument Locatelli and Mancini (2010) posit that as compared to the NPPs, there is need for a number of SMRs to be partly competitive to the different types of gas-fired, coal-fired and the renewable plant projects of different types including those that belong to the class of the small to medium-sized that have a capacity that is less than 700MWe.

Furthermore, Locatelli and Mancini (2010) in their assessment discuss on a Montecarlo analysis that is used in the comparison of the SMRs to the fired plants that are mainly made up of gas and coal. In this, a great emphasis is made on the function that is majorly played by the carbon tax or sequestration cost. If there is no accommodation of this kind of cost, then there will be a clear picture of how the Combined Cycle Gas Turbine (CCGT) and coal will look like. For example, if there is a 335 MWe Power plant, then it will be more attractive to the purchasers of the nuclear reactors as compared to other forms that produce energy. It has been determined that coal has the lowest level of LUEC but the NPV is higher as compared to other forms that are used in the generation of electricity. However, this type of nuclear reactors follows the principle that postulates that the IRR increases with an increase in the CCGT. In such scenarios whereby the SMRs are not attractive to most of the shareholders due to the low level of NPV and the high chances of uncertainty that is involved with the ultimate output. The situation is consistent with the type of policy that has been adopted in the US and EU. In such countries, the most common type of base load power that has been installed in the last few decades is the installed CCGT. These type of plants are so reliable, and their upfront costs are meager as compared to other forms of plants. Hence, their adoption has been facilitated by the low level of risk that is

involved in the investment process and due to the low payback period time. Due to such reasons, it has led to them being adopted even in the markets that are liberalized.

According to the report of EPIC, Rosner, and Goldberg (2011) that focused on making a comparison between the NGCC and the SMRs. The results of their findings indicated that the costs related to the SMRs are higher as compared to those of the NGCC. However, the long-term competitiveness of the market for the SMR market is measured by the LCOE. Thus, there is a need for the exploitation of the mass production economies and the learning as they are a crucial aspect of the SMRs.

2.8 Financial and economic factors that influence SMRs markets

In the case of economic factors, there are similar issues that affect a vendor in the choosing of either the large nuclear reactors or the SMRs. Although the economic factors being similar in both the nuclear reactors, SMRs have been established to have a higher level of flexibility and also is ease on some of the regulatory requirements. Irrespective of the size of the economy of any country, the construction of nuclear reactors always takes place in states where there is a program of nuclear power, or the country is in the process of developing one of the nuclear power programmes. Thus, this analysis is only limited to markets that have made efforts towards the development of a nuclear programme.

In this section, a discussion is made on the various factors that influence the SMRs vendors and potential customers in the selection of SMRs technology and market. Furthermore, a discussion is made on the global factors including the challenges that are faced by different factories in the process of deployment of SMRs and the competitiveness issues. Such factors arise as a result of

either the economic factors or financial elements that occur in the country. The constraints may make an individual to choose either the SMR technology or opt for the massive nuclear reactors.

SMR customers:

The factors that may influence the choice of a customer of a specific technology of SMR or market can be grouped at either the national level or the utility level. At the national level, there is a need for ensuring that a nuclear programme within the country. Thus, the existence of a nuclear programme in any state may influence a country to engage in either the construction of the SMRs or the large reactors. According to the IAEA (2007) the necessary steps that a newcomer country that wishes to engage in the developing of a nuclear reactor include ensuring that there is establishing of a national nuclear reactor that is independent and has sufficient resources and the base being scientific. The resources required in this perspective are inclusive of both the financial and the human resources. In the past, the process was seen as a difficult task, but recently the newcomers including the United Arab Emirates have shown that the process of development of a nuclear reactor is fast as long as the country considers it as an issue of priority and at the same time having sufficient financial capabilities.

An important aspect that may influence any country to engage in the process of deployment of the nuclear reactors is the need for electricity within the country. This need may be as a result of a low proportion of the population within the country lacking the accessibility to electricity. Thus, the development of a nuclear reactor may result in the curbing of such a situation. Also, the growth in the economy leading to an increase in the consumption of electricity per capita may result in a country choose a specific SMR technology. If it is a new country, it will be forced to come up with a nuclear reactor programme so as to be able to meet the increasing consumption of electricity level per capita.

Furthermore, due to the need for meeting the demands for energy supply and the production of electricity for domestic use leads a country to engage in the construction of SMRs and the large nuclear plants. The most commonly adopted indicated of energy supply of any economy is the use of the ratio of energy production/overall primary energy supply. Depending on the increase in the size of any economy or the rates of demand for electricity, a nation may opt for making an analyzing of choosing either an NPP or SMR.

Factors influencing SMRs at the Utility level

The most common factor that may influence SMR customer's choice of SMR units as compared is the financial capabilities that one holds ad the credit capability. In the case of utilities, SMRs are used as a presentation of a new form of the financial model for deployment of the NPP. This is one that has an allowance for building and installing of more generating assets on the basis that is predictable. SMRs in most cases act as a significant source of investment for the investment of utilities where there are not enough resources for the construction of the ALWRs. Also, utilities are attracted by the idea of the SMRs having the ability to be installed on a one by one basis as compared to the ALWRs that require a high amount of upfront costs being required in the process of implementation and installment of the reactors. This also helps in the avoidance of additional costs that may arise due to the risk premiums on the units that are subsequent.

Level of electricity prices

In the deployment of SMRs, the prevailing prices of electricity are crucial. So as to be able to recoup the investment at the end of the process, there is always a need for ensuring that the long-term prices of electricity are higher as compared to the levelised costs.

Chapter 3: Research Methodology

3.1 Introduction

This chapter gives the various methods, philosophies and the strategies that the researcher so as to ensure that the objectives that the study to establish were determined. The methods, philosophies and the strategies used were as per the objectives that the study aimed at establishing. Moreover, the various approaches that the researcher intended to use for the purpose of this study are discussed in this chapter. Under pilot testing, the reliability and the validity of the research instruments are also discussed as the researcher used questionnaires for purposes of collection of data. Lastly, the ethical considerations which the researcher in the process of collection of data is discussed. The section gives essential insight into various approaches, philosophies and approaches and their importance in the case of this study.

Furthermore, this section of research serves as a guideline for the data gathering process, analysis and how conclusions are drawn from the data gathered in the process. The chapter gives a justification for reasons as to why the various philosophies and strategies are adopted instead of others in the case of this research. In the figure below, a research onion is depicted that shows the steps that the researcher used in the collection of data (Saunders 2012). A further discussion of the various aspects of the research onion is discussed in the chapter.

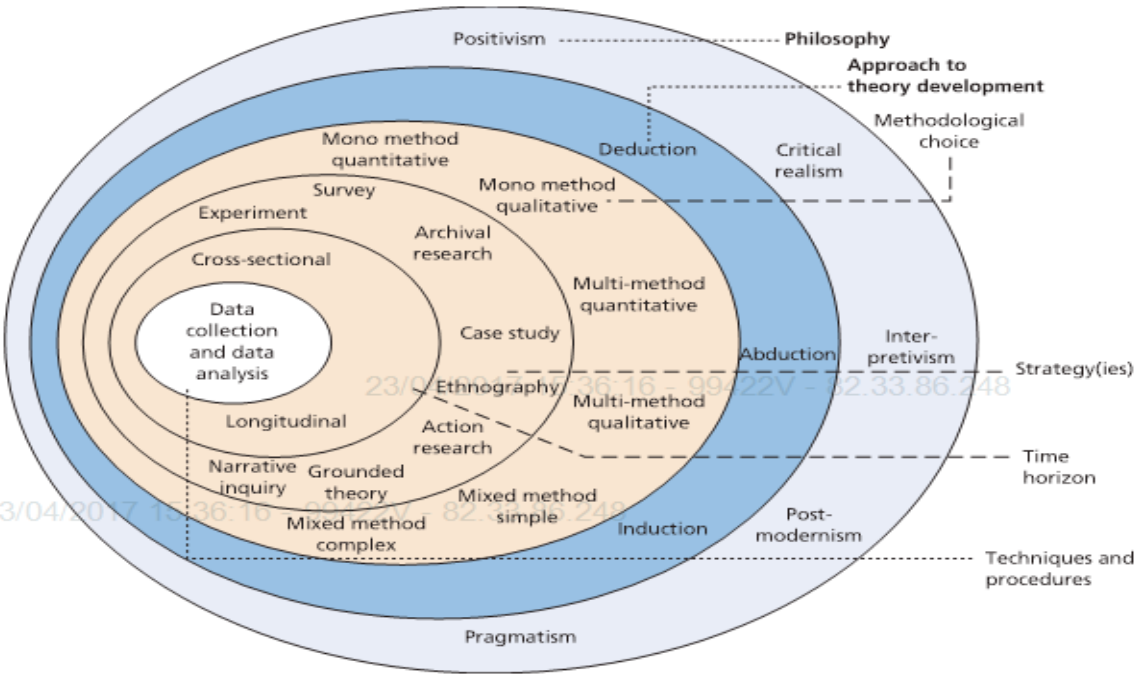

Figure 1.0: Research onion (Saunders 2012*)*

The link between the various philosophies, strategies and the methods that a researcher uses in the study are described through the use of a research onion. In the ring that is outermost, there are various philosophies that are used as guidelines for the entire research process. In the next ring are the types of strategies that are used along with the various philosophies that one may intend to use in the research process. From the ring of the research strategy is the research design or method. There are three types of research designs that are used in a research process inclusive of the qualitative, quantitative and the mixed research techniques. The research design that is adapted for a specific study in most cases is dependent on the type of research philosophy that is selected in that case of study. Moreover, the various philosophies and research designs are linked in a way that they form theories that they used to inform on the research process (Saunders 2012).

3.2 Research Philosophy

A research philosophy refers to a set of assumptions that are held by the researcher in the process of gaining of some knowledge regarding a specific aspect (Creswell, 2013). The main aim of one using a research philosophy in the process of carrying out a study is to ensure that the data collected at a specific place and for a specific period is through a process that is scientific. Scholars indicate that there are various types of research philosophies that an investigator while conducting a study. However, among the various philosophies, the four that are mainly used include pragmatism, realism, interpretivism, realism, and positivism.

In the case of this study, a positivism research philosophy will be used in the process of establishing the financial and economic viability of SMRs in UAE. Through the adoption of this type of research, it will be possible for the research study to justify the adoption of quantitative methods in the process of collecting data. Furthermore, the philosophy allows the researcher to collect data in a manner that is objective and unbiased. As a result, leading to one being able to determine the objectives that the study sought to establish (Chambliss & Schutt 2012). Through the use of the positivist approach, it implies that the researcher will be required to determine the correlations and regressions between the data. In this case, the philosophy used allows the research study to use statistically quantifiable data. This is a data source and set that allows for objectivity in the evaluation and analysis as the researcher is viewed as independent and not directly involved in the analysis and collection evaluation process.

3.3 Research Strategy

A research strategy has been defined by scholars as the method using which a scientist goes about to answer the questions that the research intends to answer (Saunders 2012). In a research study, the data collection process and scrutiny of data is always related to the strategy and the

philosophy that has been chosen for that study (Denzin and Lincoln 2011). In this case, the researcher will collect data through both the qualitative and quantitative means. The quantitative data will be obtained by the use of questionnaires. Creswell (2013) posits that the adoption of a case study in a research process along with other typological studies gives one a chance to be able to determine the financial elements and economic viability of SMRs.

Case studies are used as a representation of different aspects of a given time period in history that is well defined and hence, it is of great importance in the process of answering the research questions. Besides, the use of case studies results to the generation of perceptions concerning a specific activity that are intensive and in-depth and thus, leading to a theory being developed. In cases where there is the use of more than one case studies, a comparison of the collection from the various case studies can be made on the financial and economic viability of the SMRs in different regions. The result obtained from the process provides a basis on which conclusions can be drawn concerning the various aspects of the financial and economic viability of SMRs in UAE. The adoption of a case study of the UAE market allows for the narrowing down on specific industry features. The use of a case study allows for the specific evaluation of variables that are unique to the case study, and that could not be adequately explored if a broader population base was used. In the case of the UAE energy industry and the country at large, the culture, leadership, and public finance management unique practice across the Emirates are considered. This would be impossible if a broader industrial base such as the regional or the global armlet would have been used.

3.4 Research Design

In this study, a quantitative design is used in the collection of data. Furthermore, the study makes use of both the inductive and the deductive methods. When inductive methods are used in a research study, it leads to the integration of the secondary sources and academic theories in the research process. Thus, allowing for conclusions to be drawn from the research process.

An inductive method in research allows one to explore a given phenomenon and at the same time look at the patterns and the themes that are exploited by the phenomena. In addition, the researcher is able to determine the independent variables (cost incurred) affecting the dependent variable (critical success factors) of SMRs. On the contrary, the deductive methods are employed so as to ensure that the data that is collected is as per the objectives of the study (Bryman 2015). Thus, the deductive methods in the case of this research will enable the investigator the relationship that exists between the primary independent variables and the dependent variable that is SMRs. In a case where deductive methods are employed in a study, it makes the use of quantitative data thereby allowing the researcher to draw out a relationship between the independent and dependent variable.

3.5 Data Collection

Primary and secondary sources are used for the data collection to establish the relationship between the cost incurred and the critical success factors of SMRs. Saunders (2012) has stated that a primary source of data is when the data is collected for the very first time during a research. This is the data that is collected via questionnaires and surveys from the respondents of a study. Secondary data, on the other hand, has been defined by Saunders (2012) as data which is available to be referenced. This means that secondary data refers to data from scholarly

journals, books, etc. This helps the researcher ground the research into a particular theoretical area and also lend validity to the research.

In this study, the researcher employs the use of both data sources (primary and secondary). Questionnaires are developed for as part of the quantitative primary data collection. The primary data which is obtained through this means quantitative in nature as it makes uses of statistical procedures.

Questionnaires' distribution is a challenging aspect of this process. Thus, to ease the process and streamline the collection of the data in an efficient manner, the survey monkey platform was used. The questionnaire was formatted properly and sent to the potential respondents using the unique URL that Survey Monkey Creates. This allowed the respondents to answer at their own pace and eased the data consolidation process.

3.6 Data Sources

In this study, to sufficiently reach the research objective, primary and secondary data sources are used. The secondary sources of data on the financial and economic viability are reputable sources. Questionnaires are used for the collection of data from participants in factories that use SMRs and have in-depth knowledge on the financial and the economic elements of SMRs in UAE.

3.7 Sample size and sampling technique

In the research process, a sample size defines a unit that is as a representation of an entire population while sampling technique denotes the approach that is used in the selection of the sample size. This study will involve a sample size of 45 SMRs vendors that will be selected by

the use of purposive sampling. The main reason for the use of purposive sampling was due to the need for determining the appreciation of the financial and economic viability of SMRs that are situated in the UAE. Thus, there was a need for selection of the 45 respondents that had knowledge of the SMRs existing in UAE. Due to the sample size not being too large, the researcher was able to cope with the constraints that may have arisen as a result of time and other economic resources (Saunders, Lewis & Thornhill 2009).

3.8 Data Validity and Reliability

Cresswell (2013) states that validity of a research is how credible the data is; meaning if the test was repeated under similar conditions, would it yield the same results.

To ensure the soundness of the research process, there was a need for issuance of letters of consent to the SMRs vendors before the research process. The main aim of letters of consent was to ensure that the respondents took part in the research process at their own willingness. However, the participants that were not willing to take part in the research process were not forced to take part in the research. For purposes of obtaining accurate information, the researcher ensured that the respondents were conversant with the topic under study.

In the aspect of the validity of the data collected, the researcher was able to improve on content validity of the data by seeking of opinions from individuals that had expertise on the performance of SMRs. In such a case, content validity will be improved through the opinions of the management of SMRs in UAE.As a result, this improves on the data that is collected from the field and those from the secondary sources. Besides, content validity results in an increase in the modification that is needed on the questionnaires thus an improvement on the validity of the questionnaires.

Reliability is the measure of whether the research instrument is measuring the intended aspect it is supposed to measure. According to Bhattacherjee (2012), the research instrument, which is the quantitative questionnaire in this study, needs to measure the research question no matter how many times the research has been repeated. The most common measure of reliability is the Cronbach's Alpha which is measured using the SPSS tool. The ideal Cronbach's Alpha value is supposed to be greater than 0.7, however, a value in between 0.6 and 0.7 is also accepted. This value measure the internal consistency of the research instrument and the higher the value of the Alpha greater than 0.7, the greater is its internal consistency. A higher alpha value removes any doubt of the data being incorrect.

3.9 Data Analysis

The data was collected on a Likert-Scale questionnaire. This data was first codified into numbers from text. For example, if the individual answered Strongly Agree, the response will be codified as 1and if the individual responds as Strongly disagree, then the response will be codified as 5. This data will then be run through the SPSS software. Common pre-tests such as Cronbach's Alpha will be carried out in addition to the Normality testing to ensure that the data is internally consistent. Subsequently, the data will be analysed using the Correlation test (Pearson's two-tailed significance) and Multiple Regression Analysis to identify the relationship between the independent and dependent variables.

3.11 Ethical Issues

In order to ensure ethical research and data collection, the participants' names or contact information was not collected through the questionnaires. This ensured that there was absolute

confidentiality which was maintained. The study conducted will not and did no cause any adverse effects to the individuals involved. Wherever secondary data has been used, the researcher has made use of appropriate referencing to ensure standardized used of data. This was because there was a wide range of past studies that were used in the research in the process of carrying out the study on the financial and economic viability of the SMRs.

Chapter 4: Results and Analysis

4.1. Introduction

The study began with the objective of understanding the influence of the cost incurred on the critical success factors of SMR's. To meet this objective, a questionnaire was developed as well as distributed to the employees of Nawah Energy Company. Nawah Energy Company is one of the Government entities responsible for the ownership as well as operation of UAE's nuclear power plants. The company was founded in 2016 and will manage the reactor sites 1 to 4. The sample population consisted of Industry Consultant, Executive, Middle Level as well as Supervisor all working in the Nawah Energy Company. There is only one reactor site in the UAE as the nuclear energy industry is just emerging in the UAE. This not only makes it a novel study, but also adds a limitation to it. The questionnaire was circulated to around 50 individuals and 49 of them responded. All of the questions were answered and there were no missing values.

As part of the investigation, one independent variable as well as one dependent variable were identified. Cost incurred was the primary independent variable which was further divided into several independent sub-variables. The sub-variables are: Higher Profit Margins (HPM), Low Cost Encourages Investment (LCEI), Low Cost Encourages Economic Growth (LCEEG), as well as Easy Impacts Projections on Costs (EIPC). For each of the sub-independent variable, the participants were requested to answer the three questions which were in the form of a Likert scale from Strongly Agree to Strongly Disagree. The primary dependent variable, on the other hand, was identified as the Critical Success factors of the SMR's. The following sub-variables were identified: Governments Regulatory Framework (GRF), Government Supporting in Grid

Development (GSGD), Geopolitical Collaborations (GC), as well as Large Space Availability (LSA).

A conceptual model that was developed is presented in the below figure.

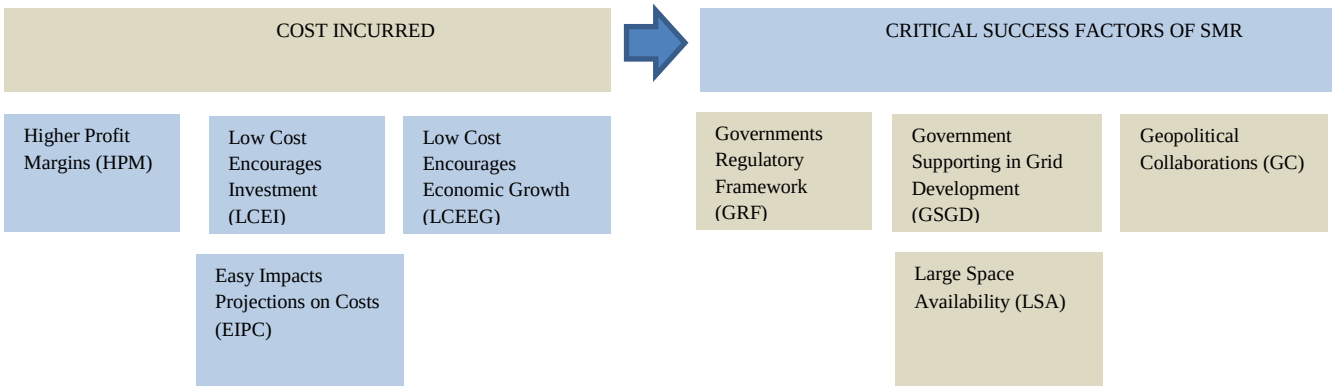

Figure 1: Conceptual Model

Once the results were obtained, the same was transferred into the SPSS software as well as data analysis was carried out.

4.1. Reliability Testing

Reliability testing is important due to the fact that there needs to be an internal consistency in the results. Internal consistency is the measure of how closely an item on a scale or questionnaire measures what it is intended to measure. To identify the reliability of the research instrument, which is the questionnaire based on a Likert scale, Cronbach's Alpha test was carried out.

The alpha value was identified at 0.75 which is the acceptable value. Once the reliability was tested, further tests were run on using the SPSS.

4.2. Correlation

Pearson's Correlation test identifies the correlation between any two variables. Correlation is the measure of the relationship between any two defined variables in a study. The statistical significance of the correlation can be measured using one-tailed test or two-tailed test. In simple terms, the one-tailed test measures the correlation's statistical significance in one direction whereas the two-tailed test measures the correlation's statistical significance in both directions of the two variables. It's important to note that the correlation is measured linearly between the two variables.

In accordance with the above, the two-tailed test was carried out on the Pearson's Correlation and the results are tabulated below. The below table represents the results for the overall primary independent (Cost Incurred) as well as the dependent (Success Factors) of the study.

Table 1: Correlation between the Cost Incurred and Success Factors

Correlations

		Cost_Global	Success_Factors
Cost_Global	Pearson Correlation	1	.528**
	Sig. (2-tailed)		.000
	N	49	49
Success_Factors	Pearson Correlation	.528**	1
	Sig. (2-tailed)	.000	
	N	49	49

**. Correlation is significant at the 0.01 level (2-tailed).

From the above correlation table that was generated for Cost Incurred as well as Success Factors, it can be seen that there is a statistically significant strong correlation between Cost Incurred as well as Critical success factors with the p value = 0.000.

A deeper analysis of correlation into the dependent sub-variables as well as the independent sub-variables is presented below.

Table 2: Correlation between the independent and dependent sub-variable

Correlations

		GRF	GSGD	GC	LSA
HPM	Pearson Correlation	.023	.315*	.464**	.202
	Sig. (2-tailed)	.878	.028	.001	.164
	N	49	49	49	49
LCEI	Pearson Correlation	-.068	.301*	.333*	.352*
	Sig. (2-tailed)	.643	.036	.020	.013
	N	49	49	49	49
LCEEG	Pearson Correlation	.057	.322*	.784**	.293*
	Sig. (2-tailed)	.698	.024	.000	.041
	N	49	49	49	49
EIPC	Pearson Correlation	-.066	.226	.493**	.145
	Sig. (2-tailed)	.652	.118	.000	.320
	N	49	49	49	49

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

As can be seen from the above table of the correlations between the sub-variables of the primary independent as well as dependent sub-variable, HPM shows a statistically significant correlation on GSGD ($p = 0.028$ which is $p < 0.05$), as well as a highly statistical significance on GC ($p = 0.001$ which is $p < 0.05$). However, there is a non-significant correlation between the HPM as well as GRF ($p = 0.164$ which is $p > 0.05$) as well as LSA (($p = 0.878$ which is $p > 0.05$).

Looking at the independent sub-variable LCEI, it can be seen that there is a statistically significant correlation with GSGD ($p = 0.036$ which is $p < 0.05$), GC ($p = 0.020$ which is $p < 0.05$), as well as LSA ($p = 0.013$ which is $p < 0.05$). However, the correlation between LCEI as well as GRF can be seen to be statistically non-significant ($p = 0.643$ which is $p > 0.05$).

Furthermore, the correlation between LCEEG is statistically significant for GSDG ($p = 0.024$ which is $p < 0.05$), highly significant for GC ($p = 0.000$ which is $p < 0.05$), as well as for LSA ($p = 0.041$ which is $p < 0.05$). The correlation between LCEEG as well as GRF was non-significant at $p = 0.698$ which is $p > 0.05$.

EIPC, on the other hand, showed statistically significant correlation with only GC which was highly significant at $p = 0.000$ which is $p < 0.05$. For all the other variables, the value of correlation was statistically non-significant which is at $p > 0.05$.

It was found that financial elements are one of the major factors influencing the success of the SMR by Nelson (2010). The lack of financial resources is one of the primary reasons for the closures of SMR's. The purpose of the SMR is to generate the energy that is needed by the

people of the particular country or state as well as in the absence of that, the SMR cannot generate enough returns on the cost incurred in the operations of the SMR as well as hence, the plants need to be shut of due to a lack of financial resources to keep the running costs.

In addition, the market potential of the SMR's is also an important aspect that governs the success of the SMR's. The market potential can also cause a reduction in the capital costs of the SMR, thereby increasing its potential for success. In essence, the higher the profit margins, the greater the success of the SMR. There are two costs that need to be accounted for in the building as well as operation of an SMR. The first cost is related to the capital costs of building the investment. This is also measured via the investments that are required to carry out the construction of the SMR as well as the set up.

While the good market position is given by the sub-variable High Profit Margin (HPM) as well as the capital cost of set up and construction is given by the sub-variable Low Cost Encourages Investment (LCEI).

The economic costs of the NPP are classified as those required to produce one unit of electricity. Factors that influence the economic costs of a SMR are the operations cost in terms of manpower, fuel, maintenance, decommissioning, as well as various other costs. In addition, the profitability is also an important consideration.

From the above correlation results it can be stated that there is a relationship between HPM as well as GSGD. What this means is that with a higher HPM we can see a higher support by the Government for the grid development. In addition, there was also a correlation between the HPM as well as the Geopolitical collaborations. A higher profit margin means that in the case of an SMR, there can be an increased collaboration across countries in terms of investments, sharing of

knowledge as well as infrastructure. From here, it can be stated that there is a greater impact of the relationship between the higher profit margin as well as government's support for grid development. A better grid infrastructure can mean there is a better power transmission and increased access of clean energy to a wide population. Even in geopolitical collaborations, the influx of international funds, technology, human capital as well as knowledge can lead to a better operating capacity of the SMR which will create a positive feedback cycle. Thereafter, it can also lead to the increase in the country's economic growth as well as development as well as reduced reliance on hydrocarbon energy sources which creates a better environment. Hence, it can be stated this is will create a positive impact on the success of the SMR as well as add to the environment as well as the economy of the country as a whole.

When analyzing the Low Cost Encourages Investment (LCEI) factor, it can be seen that there is a strong correlation between the GSGD, GD as well as LSA. In essence, a lower capital and operating cost increases the investment value and hence, can lead to the government supporting the grid development, which like stated above, can lead more people to have access to clean energy as well as development of a better grid infrastructure. In addition, the low cost as well as high investment factor will increase the cross national collaboration between countries as well as bring in the influx of international manpower, develop a culture of sharing between two nations, as well as increase the accountability in the case of a failure or breakdown. Furthermore, if there is more investment vis-à-vis the cost, then there is a greater availability of space which can lead to better operating capabilities and hence increase the profit margin.

Looking at the impact of the LCEEG on the success factors of the SMR's, it becomes evident that LCEEG also has correlations with GSGD, GC, as well as LSA. Low Cost Encourages Economic Growth has an influence on the grid development support that can be provided by the

government. Naturally, as the cost reduces, the grid development will increase which will in turn lead the development of the economic growth of the organization as well as the country. In essence, the success of the SMR is correlated to having a lower cost and having a higher investment value because it will influence the government's decision to create an increased grid that will supply power to as much of the population as possible. There is in fact a higher correlation of LCEEG to the GC as well. What this means is that there is a relationship between the low cost which facilitates higher investment to the geopolitical collaborations. That is, the geopolitical collaboration will likely increase in the increase of lower costing and an increased investment. Once the international collaboration will increase it can also bring in more investment and further reduce the cost operating and setting up the SMR due to a higher and better knowledge transfer as well as technology transfer in the country. The LCEEG also showed a strong correlation to the LSA. The larger the space availability, the greater the performance of the SMR. Therefore, with an increase in the LCEEG, there could be an increased value of the space that is made available for the operations of the SMR. This will improve the success factor of the SMR at a substantial rate.

Finally, we will analyse the EPIC which is the Easy Projection on Costs. This is a critical factor of the Costs Incurred but it only has a string positive correlation to the GC of the Critical Success Factor of the SMR. In essence, international collaborations on any projects or works are highly complicated. Therefore, wherever there is ease it is highly welcomed. The fact that there is a positive correlation on this sub-factor speaks to possible reduction of the complexity of calculating the cost projections and hence, there is an overall benefit that can be observed. Where there is success for the SMR, there is a better and cleaner energy production as well as less reliance on the hydrocarbon fuel.

Because of the fact that there was significant correlation between the primary independent as well as the primary dependent variable, as well as there was significant correlation between most of the sub-variables, the next test that was carried out was Multiple Regression Analysis.

In addition, the regression analysis was also carried out due to the fact that correlation does not represent causation. What this means is that while there is correlation, it cannot be said that one variable will cause another variable. There are also several limitations to the correlation coefficient. The major limitation as mentioned above is that causation cannot be estimated. This means that even though the two or more variables behave similarly, there cannot be conclusively stated that one variable is causing the change in the other variable or if the two are even related to one another. In addition, it is not possible to go beyond the data that is collected in a correlation. Furthermore, correlation analysis can only be carried out in the case where the measurements were carried out on a scale. Thus, due to the above stated limitations of the correlation method, regression analysis was carried out. However, for the regression to show any statistically significant value, it needs to have correlation.

Since there was a correlation, the regression will allow the study to gain a deeper insight into the nature of the relationship between the two variables as well as the subsequent sub-variables. Furthermore, the regression can also allow the study to be predictive and lend robustness to the analysis.

4.3. Multiple Regression Analysis

Multiple regression analysis is an important test which allows us to establish the nature of the relationship between one dependent fixed variable as well as two or more independent variables. In other words, the multiple regression analysis will allow us to identify how much change is

caused in the dependent variable with a unit change in the independent variable. In addition, it can also help us identify the direction of change, that is, whether it is positive or negative.

Since the correlation test revealed significant correlation, regression was carried out on primary dependent variable and the primary independent variable. The results of the same are tabulated below:

Table 3: Model Summary of Regression between Cost Incurred and Success Factors

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.528[a]	.279	.264	3.76795	.279	18.197	1	47	.000

a. Predictors: (Constant), Cost_Global

b. Dependent Variable: Success_Factors

From the above Table 3, it can be seen that there is an overall goodness of fit measured by R at 0.528. This can also be represented by R = 52.8% thereby showing a strong relationship between the variables. The values of R represent the strength of the relationship between the independent as well as the dependent variable and as such this results show that the relationship is strong at 52.8%. In addition, the R^2 = 27.9% which means that around 27.9% of the variances in this model can be explained by the independent variable.

Following this, the attention was turned to the Analysis of Variance table which is presented below:

Table 4: ANOVA Success factors and Cost Incurred

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	258.352	1	258.352	18.197	.000[b]
	Residual	667.280	47	14.197		
	Total	925.633	48			

a. Dependent Variable: Success_Factors

b. Predictors: (Constant), Cost_Global

From the above table, it can be seen that the regression is highly significant at p = 0.000. This stated that the outcome of the dependent variable can be successfully predicted by this mode. Therefore, it can be said that the regression model significantly predicts the Success Factors at F (1, 47) = 18.197, p = 0.000.

Further analysis should be conducted to develop the predictive model. Therefore, the coefficients table presented below identifies the same:

Table 5: Coefficients for Success Factors and Cost Incurred

Coefficients[a]

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B

		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	31.302	3.809		8.218	.000	23.639	38.965
	Cost_Global	.360	.084	.528	4.266	.000	.190	.530

a. Dependent Variable: Success_Factors

From the above Table 5, it can be seen that Cost Incurred significantly contributes to the model (B = 0.36, p = .000). Using these results, a predictive model can be generated which is represented by the below equation:

Success Factors = 31.302 + (0.360) * Cost Global

The above equation is derived from the standard regression equation that is provided below:

X = a + b * Y; where X stands for the dependent variable that is being measured, a stands for the constant coefficient, Y stands for the Independent variable and b stands for the coefficient that corresponds to the variable.

Therefore, the equation: **Success Factors = 31.302 + (0.360) * Cost Global,** represents the below points:

1. For zero change in the Cost Incurred factor, the critical success factor of the SMR will be at an average of 31.302.
2. For every unit increase in the Cost Incurred factor, there will be an increase by 0.360 in the critical success factors of SMRs.

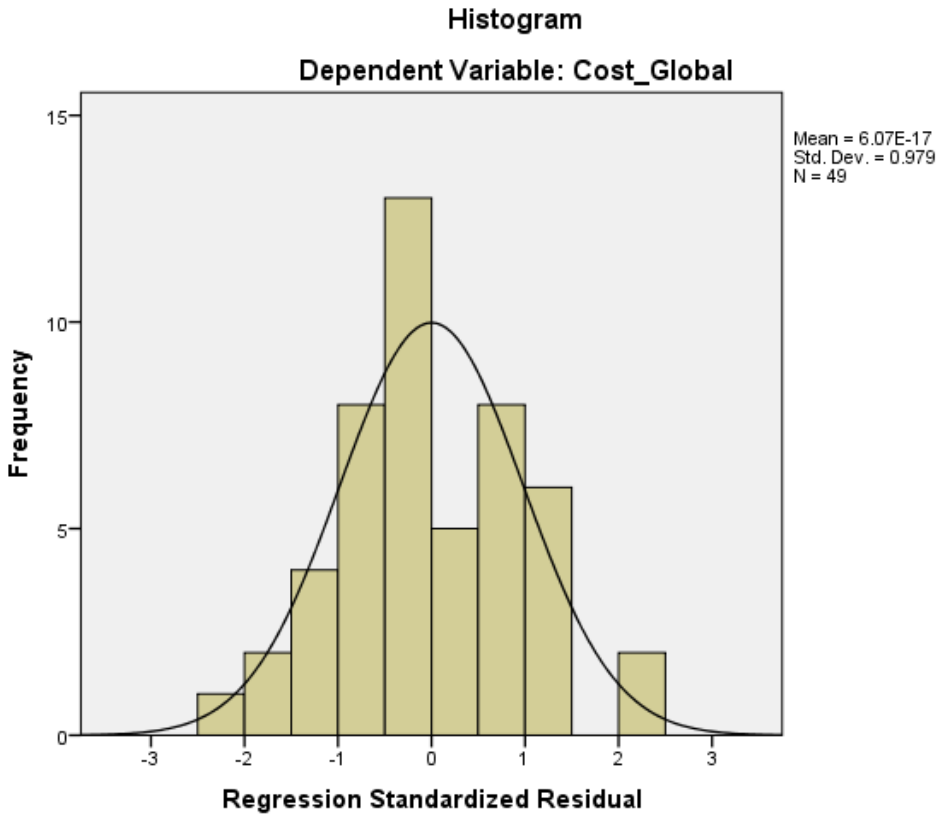

Figure 2: Regression Standardized Residual Histogram Plot of the Dependent Variable

The above figure 2 shows that the data shows that the data follows generally a linear relationship. Therefore, it can be assumed that the linear regression model that has been developed is accurate.

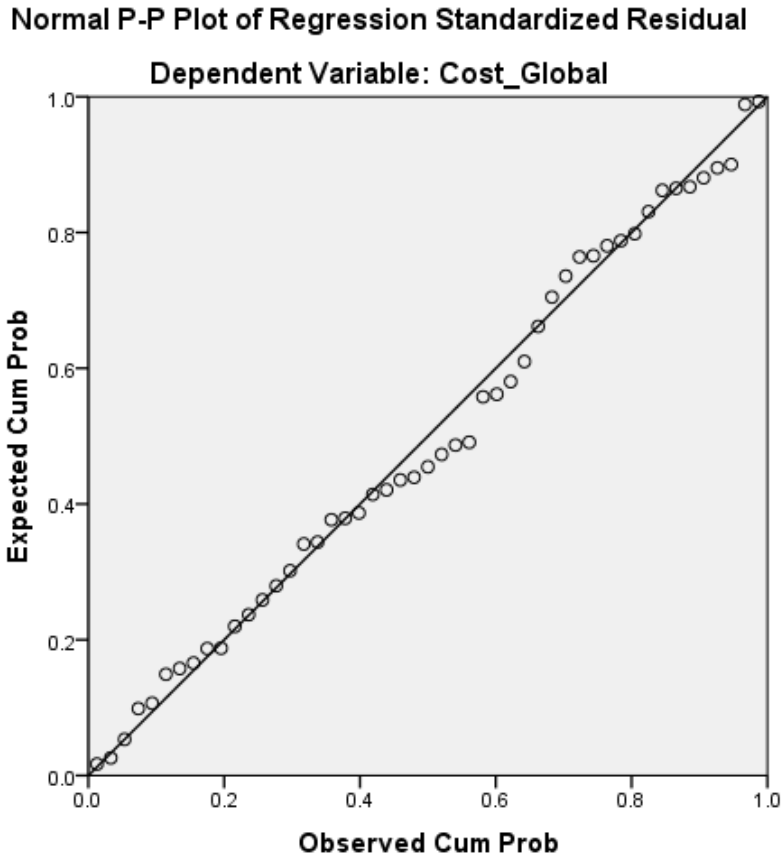

Figure 3: Normal P - P Plot of the Regression Standardized Residual of Variable Cost Incurred

Figure 3 represents the Normal Probability - Probability Plot of the Regression Standardized Residual of Variable Cost Incurred. The observed data generally follows the straight line. This represents the linearity of the regression model that was developed. Figure 3 is in accordance with the above discussed figure 2. This adds robustness to the regression model which displays the relationship between the independent and dependent variable.

There are several limitations to the Multiple Regression Analysis as well. First, there are several assumptions that the test makes and that the data needs to follow. If the data violates any of the assumptions, then the test results cannot be valid. One of the assumptions of the data is that it is

normally distributed. Any data is normally distributed when the values are surrounding the mean as well as when the mean, median and mode are equal. Therefore, in the case of outliers, that means when there is a value that does not follow the usual pattern of the data, the data set will not be normally distributed. SPSS allows data to be checked for normality. The normality test was performed and the following results were generated:

Table 6: Normality test for Cost Incurred

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Cost_Global	.090	49	.200*	.968	49	.199

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The significance p = 0.199 for the Shapiro-Wilk Test states that the data is normally distributed. The Kolmogrov-Smirnov shows a significance p = 0.200, which is greater than the typical p = 0.05. in these normality tests, the null hypothesis is that the data is not normally distributed. Therefore, a high p value that shows statistical non-significance allows us to reject the null hypothesis. In this case, the null hypothesis can be rejected and the data can be considered to be normally distributed.

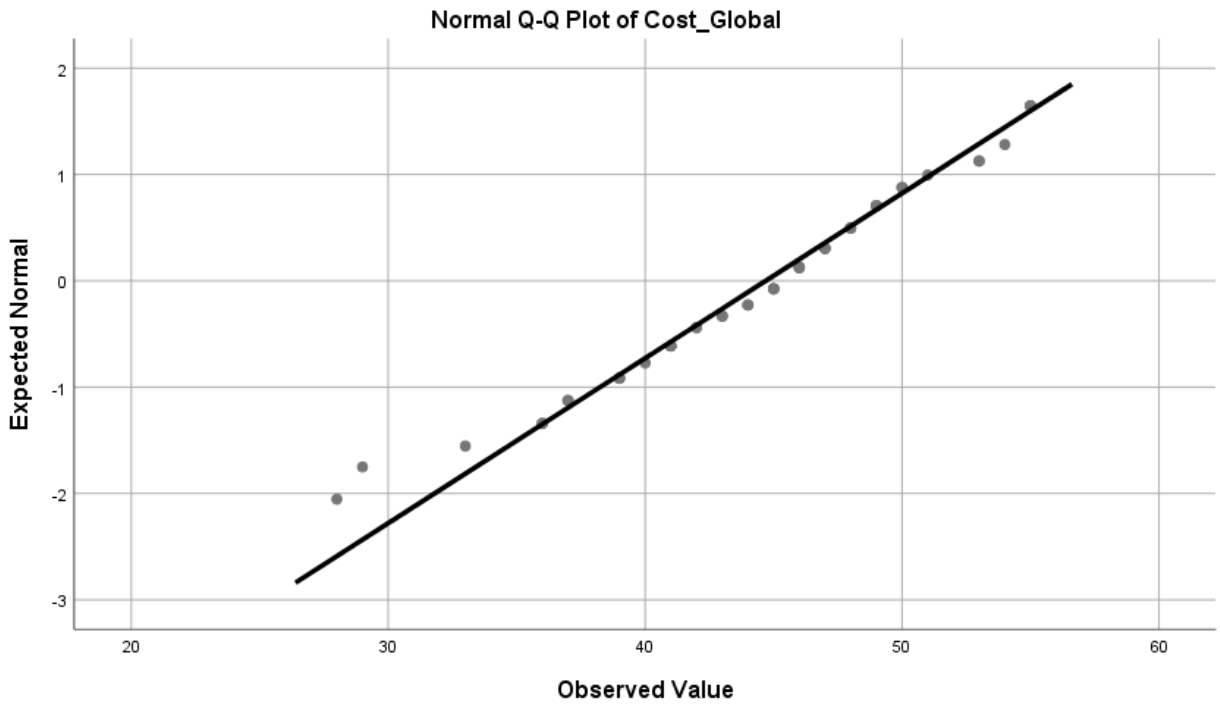

Figure 4: Normal Q-Q Plot of Cost Incurred

The above Figure 4 shows that data generally follows the straight line and can be thus assumed to be normally distributed.

The Tests of Normality was also carried out for Success Factors and the following result was generated.

Table 7: Tests of Normality for Success Factors

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Success_Factors	.077	49	.200*	.961	49	.105

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

As can be seen from the above table, the significance value is greater than the standard p = 0.005, the data can be considered to be normally distributed. The following figure was generated and can be seen to generally follow the straight line of.

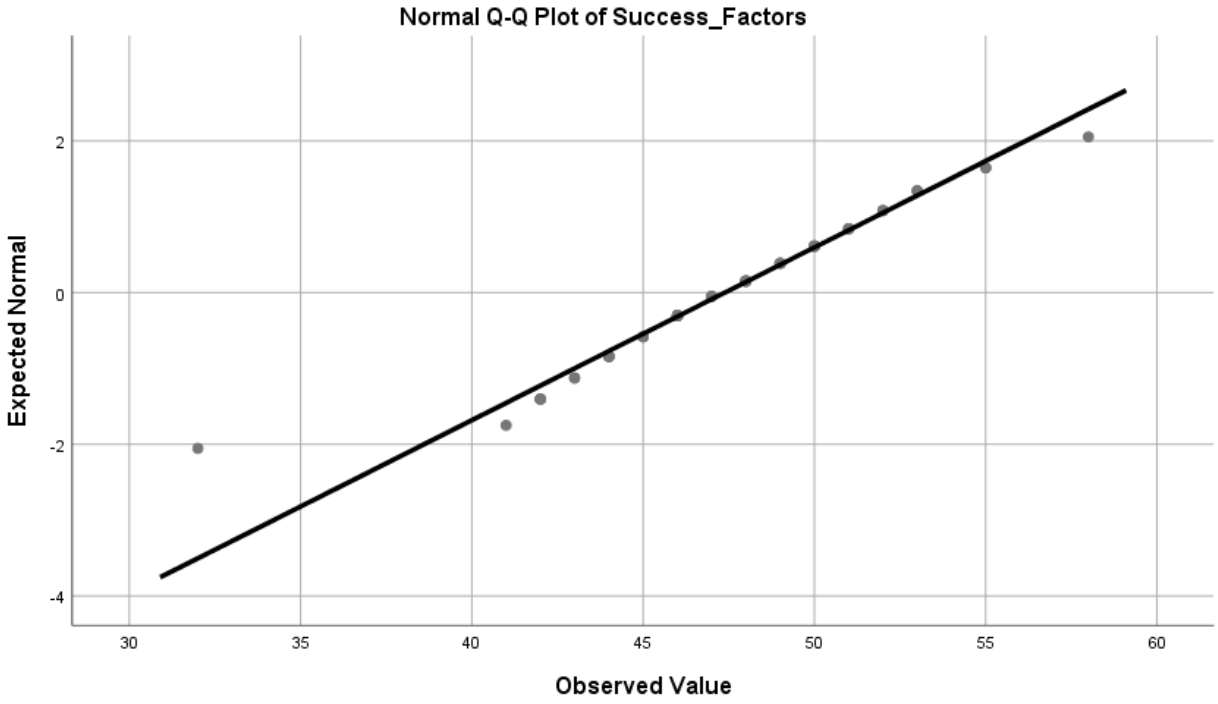

Figure 5: Normal Q-Q Plot of Success Factors

Following the above tests of normality, the data can be considered to be normally distributed and hence, the regression analysis can be considered to be valid.

The other limitation is that the regression model identifies any linear relationship between the variables. However, if there are any non-linear parameters that are present, then the regression model cannot provide a true picture of the relationship between the variables and the model will be hence, invalid. Additionally, the data size also matters. If there is sufficient data that is used

for developing the model, then the model will generate a good fit. However, in the presence of a lack of sufficient data, the model cannot be completely accurate.

4.4. Conclusion

This chapter presents and analyses the data that was obtained through quantitative enquiry. The data was collected through questionnaire that was distributed to a purposively selected sample. The data was processed through the SPSS software for data analysis. Tests such as Correlation, Multiple Regression Analysis were carried out. The linearity and the normal distribution (normality) were analysed through SPSS.

The data satisfied the linearity and normality. Thus, Correlation analysis was carried out and revealed significant relationships between the variables. However, correlation only shows a linear relationships between the independent and dependent variables but does not show causation. Therefore, in order to establish the nature of the relationship between the independent and dependent variable Multiple Regression Analysis were carried out. The regression analysis allowed us to quantify how much change in the independent variable can cause a change in the dependent variable. The following regression model was generated:

Success Factors = 31.302 + (0.360) * Cost Global

This equation states that with an increase of one unit in the study's independent variable (cost incurred) there will be an increase in the dependent variable (critical success factors of SMR) by a factor of 0.360. This is a signifiv=cant finding that can have a great potential to help the UAE'S emerging nuclear power industry. The next chapter covers this study's contribution, limitation and recommendation.

Chapter 5: Conclusion

5.1. Conclusion

The research began with the aim of developing a comprehensive understanding of the influence of the cost incurred on the critical success factors of the SMRs. As Global warming and its related environmental impact increases, there is increased focus on the obtaining energy that is free of carbon emissions and other greenhouse gases. Several renewable sources of energy are available such as solar, wind, geothermal and others. Energy generated from nuclear power, however, is more beneficial as energy can be generated for 24 hours in a day which can also result in better electrical planning and supply of power to the city. Regardless of the benefits of clean energy, the current world does not rely on the nuclear power as much as it should. Apart from the negative environmental concerns that a nuclear incident can cause, the financial viability of generating nuclear energy is also important to be understood. Many countries, for example, need to rely on international support for the successful generation of nuclear power due to lack of uranium mines and human capital. This has potentials on the cost increase which can increase the cost of energy to the people.

To that respect, SMRs can become an attractive option as they appear to be more economically feasible than large reactors. The key benefit of the SMR is that various units which comprise the structural aspects of the reactor can be manufactured in a separate location and brought together to be assembled. In addition, there are inherent safety features in an SMR that are not present in large nuclear reactors. This means that while large reactors require human input for some of the safety features, SMRs have an inherent system that relies on physical laws. In addition to the safety considerations, there is a cist benefit as well to the SMRs. Since they are deliberately

smaller in size, they are cheaper to make in comparison to the large reactors. The investment that is needed for the development of an SMR is relatively lower. However, another aspect needs to be considered regarding the SMRs which is that since the size is smaller, the power generation will be smaller too in comparison to the large reactors. Whereas, whatever power that is generated in the SMR can be transmitted easily due to the low energy output and an SMR can be installed in many locations rather than being concentrated in one large location.

In keeping with the benefits of SMRs, this study was conducted to understand the influence of cost incurred for the development of the SMR and its operations on the critical success factors of the SMRs. A conceptual model for this was developed with one primary independent and one primary dependent variable. The influence of the primary independent variable was measured by four sub-variables: Higher Profit Margins, Low Cost Encourages Investment, Low Cost Encourages Economic Cost and Easy Impacts Projection on Costs. The impact on the dependent variable was measured using four sub-variables: Governments Regulatory Framework, Government Supporting in Grid Development, Geopolitical Collaborations and Large Space Availability.

Keeping in mind the above variables and sub-variables, this study was conducted using a quantitative approach and questionnaires were distributed to experts working in the Nawah Energy Company which is tasked with managing the operations of the nuclear power plants 1 through 4. 60 potential participants were requested to fill the survey and 49 participants responded making the response rate at 81.67%.

The data obtained was run through the SPSS software and several tests were run on the data. Reliability testing revealed that the Cronbach's Alpha value was higher than the required 70%

and hence, the research instrument was validated. The first test that was run on the data was the Pearson's Correlation. The variables and sub-variables were compared and there were significant correlations on various items.

It was found that the correlation between the Cost Incurred independent variable and the Critical Success Factors dependent variable was highly significant at p = 0.000. This is a highly significant correlation but correlation does not mean causation. Therefore, in order to establish if any change in the Cost Incurred will lead to a change in the Success Factors of the SMRs, a Multiple Regression Analysis was carried out.

Once the regression was found to be highly significant with p = 0.000, a predictive regression model was developed: **Success Factors = 31.302 + (0.360) * Cost Incurred**

The above model shows that with one unit change in the Cost Incurred, there will be a change in the Success Factors by a factor of 0.360.

Thus, it can be said that with an increase in the Higher Profit Margins, and lowering the cost of investment, developing better impacts projections, there can be a positive change in the success factors. This actively illustrates that the Governments support for grid development, the geopolitical collaboration, the space availability, and Government's regulatory framework will also increase when there is a positive increase in the Cost Incurred.

In addition, in order to lend the study and the data some credibility, standard SPSS tests such as Normality tests for checking the normality of the data. It was identified that the data is normally distributed. The Normal P-P Plot and the Normal Q-Q Plot has also been presented.

5.2. Limitations

No study can be conducted without limitations. One of the primary limitations of this study is the small size of the sample. The data was collected from only 49 respondents, which makes it difficult to generalize the findings from the data. While the respondents were subject matter experts, there is an inherent difficulty in the generalizing of the results and applying them to other geographical areas. Furthermore, the nuclear industry of the UAE has only been just established. Therefore, it is emerging and is in its infancy. There is only one reactor site in the UAE and the plant is not operational. Thus, it is worth considering that the results generated in this study could vary if the study was conducted in an operational plant. This research only provides a preliminary investigation of if there is any influence of cost incurred on the success factors of the SMRs but does not delve into the reasons for the influence. Thus, the view it provides is only an initial inquiry in a field where there is not much research available. This study was exploratory in nature.

5.3. Recommendation

From a practical standpoint, this study has several recommendations. SMRs are small reactors and have inherent safety features which make them safer than the large reactors. In addition, while the output of power is lower in an SMR than the power output of large reactors, the capital cost that is incurred in the development of an SMR is substantially lower than that of the large reactor. As the nuclear industry is regulated by the government, the country can begin considering the SMR's to be one of the potential solutions to generating clean energy. In particular, because the cost incurred to develop, install and operate an SMR, impacts the success factors of the SMR, power generation using an SMR will pave the way for a cost efficient energy production. Since the lower cost of an SMR encourages investment as well as economic growth, it also leads to better geopolitical collaborations, better grid development and space availabilities.

Thus the Government of UAE can consider the development of SMRs as a potential energy generation tool. Another practical recommendation that can come out of this study is that an SMR can be developed to supply energy for a desalination plant in the UAE as that is one of the primary sources of energy consumption in the UAE. As UAE heavily relies on desalination as its drinking water source, the energy generated from an SMR can be used for this which will result in an environment friendly and cost efficient desalination process.

In terms of academic recommendations, the future research must use a larger sample size to conduct the research. In addition, once a robust research using quantitative methodology has been established, a comprehensive qualitative inquiry needs to be conducted in order to develop an understanding of why the cost incurred impacts the success factors of the SMRs and in what way. Furthermore, the conceptual model which has been developed can be expanded upon after a more detailed literature review. Finally, once the nuclear industry is booming in the UAE, this research can be replicated to see if the results of this study are any different in an operational plant as opposed to in a non-operational plant.

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Appendix A - Questionnaire

Questionnaire

Section A: Background Information

Kindly respond to the following background information questions. They are not meant to profile you but to ensure that we sued the right sample for our study.

Background Information	**Element**	**Tick here(Only one per variable**
Gender	Male	
	Female	
Age Group	Up to 25 years	
	26-35 years	
	36-45 years	
	Over 45 years	
Management level	Supervisor	
	Middle level manager	
	Executive manager	
	Renewable energy industry consultant	

Section B: Costs Incurred in developing and Operating SMRs

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Kindly indicate the extent to which you agree that the following costs statements are true and apply with respect to the development, running, and the operationalisation of the SMRs energy plants

Variable	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
Low cost Factor ***Financial factor questions*** Low input costs and a high output costs lead to higher profitability margins					
Low entry costs allow for increased profitability margins for investors					
Low cost of entry in SMR can encourage new business to invest in the nuclear reactors (financial factor question)					

Economic factor questions Low cost of entry in SMR can improve the economic situation of the country (economic factor question)					
Low cost of inputs and high outputs reduce the product breakeven period required					
Low operational costs increase the economic gains to the SMR host nation					
Ease of Cost Projections ***Financial factor questions*** Ease of cost projections increases the investors investments confidence					
Ease of cost projections makes SMR marketing to potential investors easy					
Ease of cost projections makes the feasibility of cost projections easy					
Economic factor Questions Ease of cost projections makes the project economically viable and feasible					

Ease of cost projections makes the project budgeting easier (possible to work out cost reduction strategies at the planning stage					
Ease of cost projections help in identify the economic costs (financial expected to be incurred) in the project lifecycle (allowing for sustainability planning)					

Section C: SMRs Success Factors

References

1. Shropshire, D. (2011). Economic viability of small to medium-sized reactors deployed in future European energy markets. *Progress in Nuclear Energy*, *53*(4), 299-307.
2. Carelli, M. D., Garrone, P., Locatelli, G., Mancini, M., Mycoff, C., Trucco, P., & Ricotti, M. E. (2010). Economic features of integral, modular, small-to-medium size reactors. *Progress in Nuclear Energy*, *52*(4), 403-414.

Kindly indicate the extent to which you agree that the following success factors statements are true and apply with respect to the development, running, and the operationalisation of the SMRs energy plants. The success factors variables are the conditions both in the plant's operations and in the external immediate environment that must and should be present to aid in the projects development success.

Variable	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Has the potential for supply of energy to the neighbouring counties adding economic value to the host nation					
Has the potential to allowing for high output low cost production-reducing energy costs in the host nation					
The installation process is easier and cheaper –allowing for a short project breakdown period					
High and quick returns to investors—encourages investors to offer financing for SMR projects					
Has the potential for reduced pollution- adding value to the environmental conservations in a host nation					

A supportive national legal framework for renewable energy use					
Requires large space and such space away from residential areas must be available for installations					
Regional and geopolitical collaborations for the sharing and distribution of excess produced energy					
Government support in the energy distribution and market monitoring process					
Regional political stability is imperative to support SMR success in the region					
UAE government political goodwill is imperative to enhance the project's success					
The projects value in the long run period have a social improvement value					