BUILDING DISASTER RESILIENCE WITHIN THE EMIRATI ENERGY SECTOR AND ITS INFRASTRUETURE THROUGH A COMPREHENSIVE STRATEGIC MITIGATION PLAN

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DEDICATION

With All My Heart, I thank my God (Allah), Because Without his blessing, support, Guidance and Love, This Work Would Not Have Been Possible.

This piece of work is especially dedicated to my mother for her love and encouragement; she has never ceased praying for me.

ACKNOWLEDGEMENTS

Also I dedicate this work to the UAE government and the Abu Dubai Police Department for allowing me this opportunity to study a PhD. I can only hope and pray that Allah gives me an opportunity to use the findings to benefit to my country, its institutions and its people.

I am heartily thankful to my supervisor Dr Chaminda Pathirage, for his continuous support, encouragement and follow up. I owe him lots of gratitude for giving me the means and ways to improve the lives of the Emirati citizens; including those I love the most.

I want to express my thanks and appreciation to the academic staff and administrative employees in the University of Salford, for their help and encouragement.

I feel a deep sense of gratitude towards my family: my father, my wife Mariam and my three young children who have all sacrificed so much in order to make this thesis possible; may Allah fully reward them, also my sisters and brothers. They all gave me the full support and encouragement which have influenced my success.

It is with extreme appreciation I thank Manager Mr Saud Abdul Aziz M.jassim and staff of Layyah Electric Station for the material and data provided to me.

DECLARATION

I declare that this thesis has been composed by myself, that it has not been accepted in any previous application for a higher degree, that the work of which it is a record has been performed by myself, and that all sources of information have been specifically acknowledge.

Khalifa Alkhaili

ABBREVIATIONS

APA	American Planning Association
CIA	Central Intelligence Agency (US)
COAG	Council of Australian Governments
DMIB	Disaster Management Institute Bhopal
EAD	Environmental Agency Abu Dhabi
EIA	US Energy Information Administration
ENEC	Emirates Nuclear Energy Corporation
EM-DAT	Emergency Events Database
EUAEW	Embassy of the United Arab Emirates in Washington DC
FDEM	Florida Development of Emergency Management
FEMA	Federal Emergency Management Agency
GDP	Gross domestic product
GHG	Greenhouse gas
ICEM	International Conference on Evacuation Modelling and Management
ICOA	Insurance Council of Australia
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
NCEMA	National Crisis and Emergency Management Authority
TOSE	Technical, organisational, social and economic resilience
UAE	United Arab Emirates
UNHSP	United Nations Human Settlement Programme
UNISDR	United Nations Office for Disaster Reduction
UNV	United Nations Volunteers
WHO	World Health Organisation
WNA	World Nuclear Association

ABSTRACT

The energy sector dominates in the United Arab Emirates (UAE) and consists of various assets - electricity, oil and natural gas - that are geographically dispersed and connected by systems and networks. The protection of these systems and assets within the energy sector, especially the safeguarding of the oil and gas infrastructure from any internal and external threats, should become a top priority in the UAE. Threats to geopolitical and economic stability that need to be considered and prepared for include tectonic activity, climate change, nuclear energy, terrorism and war. The aim of this research is to develop a framework to enhance the resilience of the UAE's critical energy infrastructure facilities through a strategic disaster mitigation plan.

The philosophy of this research is interpretivism. The research approach is inductive, whilst the research strategy is case study. The secondary data was taken from various academic and professional sources whilst the primary data collection included questionnaires and semi-structured interviews. Three facilities were selected for this research and they were electricity generating plants using gas - one in Abu Dhabi, one in Dubai and one in Sharjah. In total 100 questionnaires were distributed, out of which 42 were answered by energy sector workers (20 from Abu Dhabi, 15 from Dubai and 7 from Sharjah). Respondents of the questionnaire discussed issues such as energy sector preparedness, vulnerability and barriers to be overcome. Respondents believed that while the energy sector is best prepared for terrorism, extreme heat, and health and safety related accidents, it is ill prepared when it comes to facing natural hazards. The risk of terrorism was thought to be the greatest vulnerability. In addition, a total of 9 semi-structured interviews were conducted with Emirati energy sector managers who discussed the questionnaire responses and proposed further solutions to the concerns raised.

This thesis provides important practical knowledge and makes a contribution to the provision of advice and methodological steps, derived from fieldwork, when it comes to developing a strategic mitigation plan and communicating it to the energy sector. It provides key information that could be used to improve the design and structure of current educational and professional programmes undertaken by individuals in the

disaster sector. The thesis provides tools for qualitatively evaluating the various threats and vulnerabilities faced by the UAE and acts as a platform for change.

In terms of theoretical contributions, this research represents the first of its kind that engages both workers and managers in the Emirati energy sector. This gives academics and professionals unique insights into some of the significant problems that have become latent and perhaps would have continued unnoticed but require more comprehensive investigation. The study has specific implications for policy and practices within energy organisations operating in such settings, not to mention the way disaster is viewed.

CHAPTER 1: INTRODUCTION TO THE RESEARCH

1.0 Introduction

The purpose of this introductory chapter is to establish the background to the research, its rationale and justification, its aim, objectives and underlying research questions. It also highlights contributions to knowledge that could emerge, then provides a brief overview of the research methodology and the overall layout and structure of the thesis.

1.1 Background

Hazards, either natural or anthropogenic in origin, are converted into disasters by a complex mix of the overall environment and other interacting external factors. In the period 2000 to 2011, disasters affected 2.7 billion people, 1.1 million of whom were killed. The financial cost of disaster recuperation was estimated at $1.3 trillion (UNISDR, 2012). The cost in 2011 was the highest on record and since 1973 disaster statistics have seen a rising trend (UNISDR, 2012; Guha-Sapir et al, 2003). Developing nations, in particular, are vulnerable to natural hazards and ill-prepared for terrorist threats and activity (Naudé et al. 2009). Any disaster they experience is likely to have grievous consequences, in terms of loss of life and infrastructural damage (Petley et al., 2012). It is important that any potential disaster or threat of disaster is managed appropriately, in order to protect the increasing numbers of those who may have to suffer it. A pattern is emerging whereby recent developments in the field of disaster management have progressed towards the concept of disaster resilience and resilient communities. Disaster mitigation and strategic planning can shorten the recovery period and protect infrastructure, particularly critical infrastructure, such as that utilised by the energy sector, including power stations, transformers and oil pipelines; this is defined more elaborately in section 2.2. Both can be made effective by improving the disaster resilience measures required in the disaster management cycle (please refer to Section 2.13 in Chapter 2). This research specifically focuses on the disasters that have frequented the United Arab Emirates (UAE), or have the potential to do so. A special emphasis is placed on the effects disasters have on the energy sector, its personnel and infrastructure. The range of disasters that the UAE could face is appreciable given that

they could stem from tectonic activity, climatic change and even terrorism. These threats are as complex and diverse in origin as they are in effect. Having outlined the background to the research, this introduction turns now to its justification.

1.2 Justification of the Research

According to the Global Facility for Disaster Reduction and Recovery (2012), disasters are increasingly threatening sustainable development. Indeed, evidence suggests that disaster risks are rising at a rate faster than affected communities can build resilience. The increase in the number of disasters and the number of people affected by such disasters in the last thirty years (1974-2003) is shown in Figure 1.1.

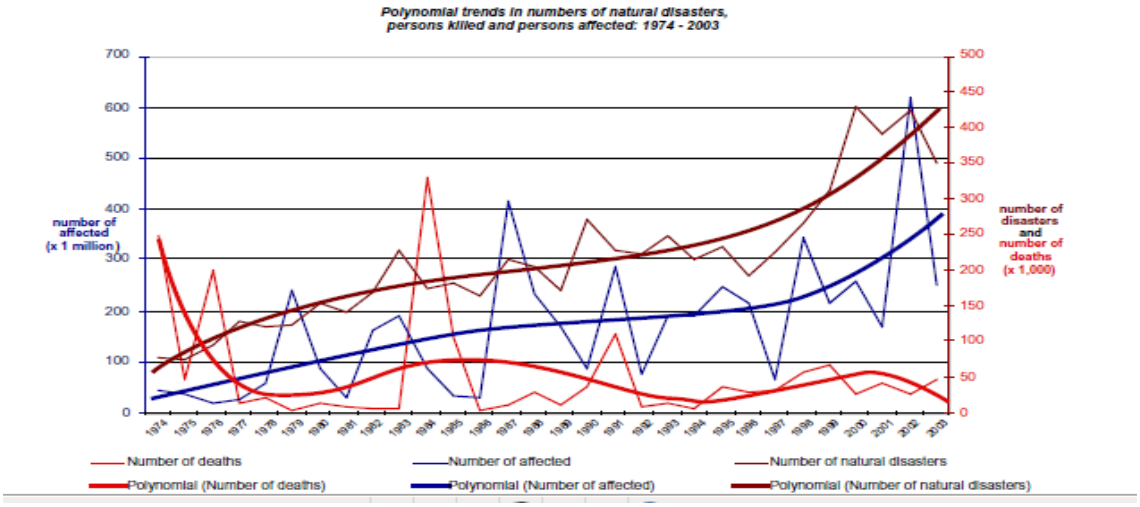

Figure 1.1: Trends in numbers of natural disasters, of persons affected and of deaths. Source: Guha-Sapir *et al.*(2003)

The increase in disasters since the 1970s has been linked to various factors. One such factor is the rise in national gross domestic product (GDP). This is for two reasons: One is that wealth generally improves the capacity of individuals and national research institutes to collect, process and publish data on disasters. The other reason is that with increased GDP comes increased infrastructure and thus a greater exposure of potential human populations and services to a natural or man-made hazard (Gonzalez-Diez *et al.*, 2012). Another factor put forward by the Intergovernmental Panel on Climate Change (IPCC) (2012) is that of climate change and the increased frequency of climate based

disasters such as floods and droughts. Cities, where more than 50% of the global population resides and where most economic assets can be found (WHO, 2014), are very much the epicentres of the destruction and loss brought about by natural and manmade disasters. Cities experiencing rapid but often poorly planned growth are among the most vulnerable. Africa and Asia have experienced the fastest rate of increase in the number of disasters recorded (Guha-Sapir et al., 2003). They have also experienced the most accelerated economic growth and urban development. That said, the highest economic losses, in absolute terms, are those experienced in the high income regions of Europe, North America and Australia.

Table 1.1: Number of Disasters by type (1900-2006). ***Source: Smith and Petley (2009)***

Disaster type	*Number of fatalities*	*Percentage of fatalities*	*Number of events*	*Percentage of events*
Drought	11,707,946	52.5	533	5.9
Flood	6,898,950	31.0	3,179	35.0
Earthquake	1,962,119	8.8	1,041	11.4
Windstorm	1,209,116	5.4	2,883	31.7
Wave/surge	241,441	1.1	61	0.7
Extreme temperature	106,311	0.5	353	3.9
Volcano	95,958	0.4	201	2.2
Slide	56,965	0.3	517	5.7
Wildfire	2,723	0.0	327	3.6
Total	**22,281,529**	**100**	**9,095**	**100**

Table 1.1 lists the number of fatalities according to disaster type. The type of disaster is a significant consideration; drought, a potential problem in the UAE, claims half of the recorded fatalities. Indeed, as Dilley *et al.* (2005) state, 50 percent of the world's population is exposed to one or more natural hazard. Figure 1.2 illustrates the cost from 2000-2011; 2011 is the costliest year on record, given the number of people affected and killed by natural disasters, largely due to the tectonic disasters in Japan. Also, as indicated in Figure 1.2, in the last few years there have been a significant number of disasters with some of the worst recorded involving tectonic activity. The Indian Ocean Tsunami (2004), triggered by an earthquake measuring between 9.1 and 9.3 on the Richter Scale (Walton, 2005), left approximately 180,000 dead and half a million displaced in Indonesia alone (Meisl *et al.*, 2006). The Chilean Earthquake in 2010 left

over 8 percent of the total population without shelter (Larrañaga and Herrera, 2010), whilst the Japanese Tsunami in 2011 crippled the economy and sent one of the world's most developed country into meltdown (The Economist, 2011).

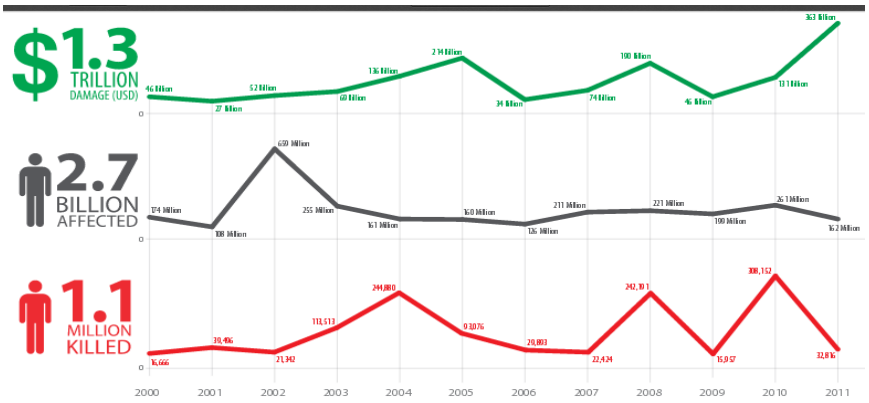

Figure 1.2: Financial cost, numbers affected and killed by natural hazards. Source: UNISDR (2012)

Given such events, it is important to build disaster resilience, especially in the energy sector. The energy sector is a strategic component of any modern society. As the demand for electricity and thermal energy grows, so do the complexity of the system and the need to protect it. The significant increase in consumer demand and population generally in both developed and emerging countries means that not only is society dependent upon the energy sector, but also that more people and businesses require an increasing energy supply, in order to operate normally (US EIA, 2013). Failure to protect the energy system and build resilience into the infrastructure could have catastrophic affects, should a nation or region experience a natural or manmade disaster. A country without power is one that is severely weakened in its ability to defend itself. Communication systems, transport links, hospitals and the emergency services all depend on a stable and constant energy supply, no more so than in the aftermath. A loss of power will most likely have longer impacts on the economy and geopolitical position. It will also affect social cohesion and individuals' ability to rebuild their lives and the communities in which they live.

The UAE holds a very important global position in the world's economy because of its natural resources. As a country it is also very important politically; it is seen as an ally

by the West and has a political stability that is currently not readily found in the Islamic world, following the Arab Spring revolutions in Egypt, Tunisia, Libya etc.). The UAE should have strong national interests in protecting its assets and security from any natural or terrorism based threat (Black, 2008). It is important to explore the key concepts of disaster resilience for future planning in urban development, in order to minimise the impact of natural disasters such as earthquakes, of terrorist activity, of climatic phenomena linked to global warming, etc. In Emirati cities such as Abu Dhabi and Dubai, it is also important to identify key issues such as formal training, which will improve the competence of employees in the energy sector and their ability to react in a more coherent manner during a disaster event and its immediate aftermath. The UAE should also improve the long-term planning and procedures that contribute to the overall wellbeing of the energy sector, and of the nation as a whole, by reducing the time needed to recover from an event. In short, this research addresses the need to provide the cement for the five pillars of resilience: preparedness; protection; early warning; emergency response and recovery; and reconstruction (please refer to section 2.3 in Chapter 2 for a detailed discussion) within the energy sector.

Another reason why this thesis is justified is its potential contribution to academia and to the field of disaster theory. Limited literature exists which directly relates to the culture and practices of the Middle East in relation to disaster theory. Furthermore, any literature in this area that pertains to an Islamic nation is even more scarce. This thesis has a responsibility to provide data and accessible information, as to the reality experienced in the Gulf Region, and specifically for those energy organisations operating there. It is justified because it builds on previous studies regarding disaster phenomena and corroborates such information. This undoubtedly makes subsequent research easier, as the obtaining of reliable secondary sources presented one of the more difficult challenges. In many cases, Chapter 2 updates information which has not been generally available since 2007. This research potentially represents the first of its kind in that it asks energy sector workers and managers about the issues that concern them. This gives a unique insight into some of big problems that have become latent ones.

The thesis serves to highlight some issues of perception and challenges in the UAE and calls disaster practitioners to use their knowledge and expertise to help the Emirati

government disseminate information such as that relating to renewable energy or disaster management programmes, in a more efficient way. Finally, it deserves attention because it ensures that the voices of those operating day to day in the energy sector are heard by sector professionals, by Emirati government ministries and by the wider academic community. This should result in increased resilience as those in a position of power and responsibility become more acutely aware of the reality on the ground and can thus use their expertise to help find solutions.

1.2.1 Emirati Energy Sector and Vulnerability

Prior to the onset of the economic crisis, the Gulf region witnessed an extensive and phenomenal rate of urbanisation and development (Shanableh *et al.,* 2005) with the greatest proportion of such activity occurring in the UAE. Since then, the crisis has hit the country hard, leaving the oil sector largely responsible for the UAE's federal finances (Emirates 24/7, 2011; Augustine, 2010). In other words, energy dominates the UAE, especially in terms of its production and supply. Indeed, future energy requirements are expected to grow at a rate of 9 percent per year - three times the global average (Gulfnews, 2013a). Unlike other countries, the UAE does not need to be overly concerned about where its energy comes from, given its substantial oil reserves. Rising natural gas demand nationally has however turned the UAE into a net gas importer, despite its relatively plentiful reserves. Furthermore, the country does need to consider the wider issues that could threaten or damage energy security and subsequently its financial recovery and growth. One can only imagine the disastrous effect on the local and global financial and political security should the 4th largest exporter of oil suddenly be unable to provide to the export market (CIA, 2011). Any cuts of natural gas or electricity supply in an increasingly energy hungry nation would also spell certain disaster. The electricity infrastructure is already strained by a lack of spare capacity at peak seasonal times due to the lack of natural gas. Figure 1.3 illustrates the sudden increase in gas imports post 2006, as demand soared.

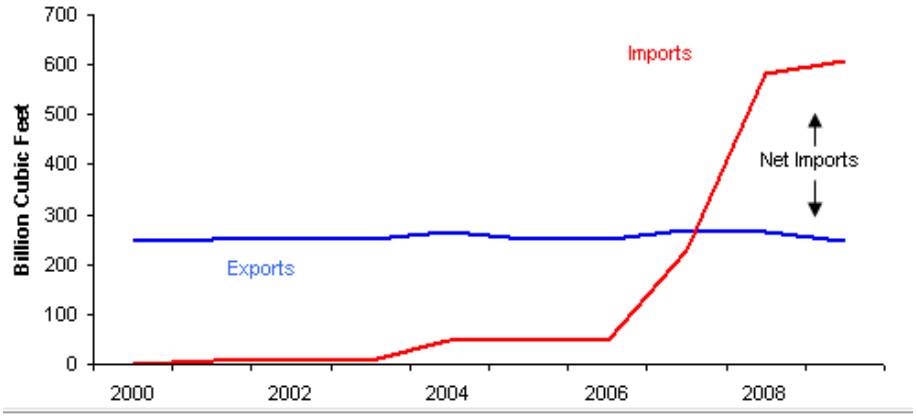

Figure 1.3: UAE Natural Gas Trade Balance 2000-2009. Source: http://www.eia.gov/cabs/UAE/Full.html

Service disruption is a real possibility, given the country´s vulnerability to various man-made and natural hazards. Preparations for any potential disaster have been slow and have featured on the national scene, at an appropriate scale, only recently. In short, it has only been part of the UAE's political focus and policy within the last few years.

There are 25 seismogenic source zones in the Arabian Peninsula (Al-Amri, 2005) including the Zagros Thrust Fault which defines the western coastline, running from Abu Dhabi through Dubai and Sharjah to Al Khaimah (Rogers *et al.*, 2006; Wyss and Al-Homoud, 2004). Yet despite this, there is little in the form of seismic detection, protection, resistance or design for some of the newest and tallest structures in the world (Petrovski, 2005; Shanableh *et al.*, 2005). In fact, the seismic risk is increasing as dramatically as the UAE skyline with the strong wind, known locally as *shamal*, thought to be a concern to the UAE's super tall structures (Samarai and Quadah, 2007; Wyss and Al-Houmoud, 2004). Extensive coastal development is particularly ill-considered and Emirati strategic planning (or lack of) has amplified rather than diminished the likelihood of disaster. Reclaimed land is potentially more susceptible to liquefaction and slope failure (Williams, 2005), whilst building on the salt flats, or sabkha, apart from the obvious ecological degradation, intensifies extreme and flash flooding events (Aspinall, 2006). The annual *shamal* combining with sea surges also

contribute to this problem (Gulfnews, 2005; Jordan *et al.*, 2005) and such threats are expected to increase with the likelihood of climate change.

Despite the fact that in the last decade and a half only the UAE and Oman have been free of terrorist incidents, threats remain a possibility (Clark, 2010; Shaheen and Dajani, 2010). The cause for concern is increased in light of the lack of national preparation for man-made disasters (Swan, 2011). The UK Foreign and Commonwealth Office webpage states (October, 2012) that the threat of terrorism is "high" and that "terrorists may be planning to carry out attacks" (FCO, 2012). The US also remains concerned about the close proximity of Iran (Katzman, 2012). Potential threats to national stability stemming from regional uprisings since the Arab Spring, from terrorist activity and from nuclear reactor-associated issues are also a national concern. The last of these is particularly important in light of the new nuclear development at Braqa, which according to Al Farra and Abu-Jijleh (2012), is planned to consist of four APR1400 reactor units designed to produce up to 1400 MWe each, for a total capacity of 5600 MWe.

Therefore, this research examines the application of disaster resilience and investigates how planning can be applied to the UAE, a country of considerable geopolitical importance and economic position as a major conventional fuel provider of the Gulf Region. Specific focus is given to the UAE energy sector and its vulnerability to natural and man-made hazards. The results can help to build resilience in the energy sector, in order to improve the overall quality and speed of the national response, should disaster strike.

1.3 Research Questions

A number of questions that emerge from the discussion above are given below:

- What are the current disaster management practices and their relation to those infrastructures deemed critical within the energy sector?
- How and to what extent are the Emirati critical energy infrastructure facilities vulnerable to hazards?

- What are the barriers that affect the application of disaster management practices on critical energy facilities in UAE?
- How could these barriers be reduced?
- Why does the Emirati energy sector not adopt a strategic disaster mitigation plan?

1.4 Research Aim and Objectives

1.4.1 Aim of the Research

The aim of this research is to develop a framework to enhance the resilience of the UAE´s critical energy infrastructure facilities through a strategic disaster mitigation plan.

1.4.2 Research Objectives

In order to achieve the research aim, a number of objectives have been identified.

1. To identify Emirati critical energy infrastructure facilities and their vulnerabilities to hazards.
2. To examine current disaster management practices and their relation to those infrastructures deemed critical within the energy sector.
3. To comprehensively evaluate existing barriers to the application of disaster management practices on critical energy facilities in the UAE.
4. To contextualise and define the concepts of disaster resilience and strategic mitigation planning within the UAE.
5. To develop a framework through a strategic disaster mitigation plan for critical energy infrastructure.

1.5 Research Scope

This research focuses on the disaster management efforts of the UAE. Specifically, it investigates the impact of natural and manmade events/hazards on the energy sector and its infrastructure. Although regional events such as the *shamal* are considered, the investigation is limited geographically to the confines of the borders of the UAE. The disasters assessed are both natural and manmade in origin. The former is however

considered in more depth with the impact of climate change, which has both natural and anthropogenic elements.

The research is focused on the energy sector, which is understood to be those components relating to the electricity network and the oil and gas sector, because, as Table 1.2 indicates, the primary and secondary energy consumption in the country has increased by 41.8 and 69.5 per cent respectively. It is thus an increasingly important component of the economy and national development. It is also therefore a sector which must increase in resilience, for the stability of the nation and its population.

Table 1.2: Energy Consumption in the UAE 2004-2010. Source: Various IEA statistics.

	Capita	Prim. energy	Production	Export	Electricity	CO_2-emission
	Million	TWh	TWh	TWh	TWh	Mt
2004	4.32	510	1,907	1,273	49.0	103
2007	4.37	601	2,074	1,267	70.5	131
2008	4.48	680	2,100	1,196	75.8	147
2009	4.60	693	1,963	1,084	79.5	147
2010	7.51	723	2,050	1,129	83.0	154
2012	7.89	769	2,211	1,246	83.8	166
Change 2004-10	73.8 %	41.8 %	7.5 %	11.3 %	69.5 %	49.4 %
Mtoe = 11.63 TWh, Prim. energy includes energy losses						

In addition, this study focuses on the pre-disaster phase, particularly disaster mitigation and strategic planning for the building of resilience. The term ‘pre-disaster’ refers in this thesis to extensive data collection, maintaining directories of resources, the development of action plans, capacity building, and training and community awareness activities, undertaken to prevent, prepare for and mitigate potential disasters (Sundar and Sezhiyan, 2007).

1.6 Research Methodology

Methodology is viewed as an established, habitual, logical or prescribed practice or systematic process of achieving certain ends with accuracy and efficiency, usually in an ordered sequence of fixed steps. In order to address the research aim and objectives and to answer the research questions, the researcher adopted a qualitative approach, while a

quantitative approach was also used to supplement research findings as well as to enhance the research quality.

The research onion introduced by Saunders et al. (2009) is adopted as the methodological framework. An interpretivist stance has been selected as the main research philosophy for the following reasons: this research falls within the remit of social sciences, as it deals with the beliefs, perceptions of reality, attitudes and experience of people involved with the Emirati energy sector, in the event of disaster. This orientation is supported by researchers such as Hussey and Hussey (1997); and Collis and Hussey (2009). Secondly the subject under investigation is not supported by an extensive theoretical background because of the lack of previous research on this subject, as highlighted by Creswell (2003).

The research approach is inductive, whilst the research strategy is case study. The secondary data was taken from various academic and professional sources whilst the primary data collection included questionnaires and semi-structured interviews. Three case studies were carried out for this research and they were electricity generating plants using gas - one in Abu Dhabi, one in Dubai and one in Sharjah. In total 100 questionnaires were distributed, out of which 42 were answered by energy sector workers (20 in Abu Dhabi, 15 in Dubai and 7 in Sharjah). The research methodology is discussed in more detail in Chapter 4.

1.7 Structure of the thesis

The thesis is organised as follows.

Chapter 1: Introduction to the Research. This chapter introduces the main focus of this thesis: building disaster resilience within the Emirati energy sector and its infrastructure through comprehensive strategic mitigation plans. It provides the background to the study with information on the Emirati energy sector and its vulnerabilities. This section then presents the justification of the research. It also sets out the research aim, objectives, questions and scope. The chapter concludes with a brief overview on research methodology adopted for this study.

Chapter 2: Literature review. This chapter looks at existing literature (books, journal articles and reports) on the key concepts explored in this thesis. Specifically, it looks at disaster theory and management, resilience and strategic planning, critical infrastructure and energy facilities. All these aspects are discussed in the UAE context.

Chapter 3: Conceptual Framework. This chapter sets out the content and structure of the draft disaster mitigation framework and strategy, along with the need for its communication and development via a tripartite committee. It forms the basis of the final framework presented in Chapter 6.

Chapter 4: Methodology. This chapter discusses at length the research philosophy, approach, strategy and the methodology employed to achieve the aim and objectives.

Chapter 5: Results and Analysis. At this point in the thesis, the results of the 42 answered questionnaires and 9 semi-structured interviews are presented and analysed through statistical analysis and the drawing of graphs. Respondents of the questionnaire discussed issues such as energy sector preparedness, vulnerability and barriers to be overcome.

Chapter 6: Discussion. This chapter evaluates in a comprehensive manner the fifth research objective. It looks in depth at what a strategic mitigation plan is by definition, what it should contain, how it should be developed and by whom. The communication of such a plan is also discussed. Chapter 6 also evaluates the significance of the results presented in Chapter 5 in the context of the Gulf Region and the United Arab Emirates, discussing how these results could contribute to the development of a disaster mitigation process. In light of this, the contributions of the thesis to theoretical and practical knowledge are presented and its limitations are considered. Amendments to the draft disaster mitigation framework found in Chapter 3 are highlighted and explained. Finally, proposals are made for future research which could serve to enhance the work presented here.

Chapter 7: Conclusion. This chapter provides a synthesis of the new findings and their significance in both the Emirati energy centre and disaster theory. The successes and limitations of the thesis are also reflected upon here.

1.8 Chapter Summary

This chapter introduces the concept of disaster, both natural and manmade, vulnerability and resilience. It outlines the aim and objectives of this thesis by preliminarily investigating disaster management practices and the significant infrastructure of the Emirati energy sector. Global disaster trends are evaluated, as are recent disaster events in the UAE, within their regional and cultural context. This information is built upon in the following chapter, in the form of a literature review, and thus provides the basis of the strategic disaster mitigation. An indication of the methodology to be adopted and of the scope of the research has been provided. Finally, an outline of the structure of the thesis has been identified.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

A literature review is an important component of a thesis. It gives an overview of the field of inquiry: what has been previously discussed on the topic, who the key contributors are, what prevailing theories and hypotheses are being developed, what questions have been and continue to be relevant, and what methodology or methods are appropriate and useful for continued research. The literature review here is split into four parts, due to the multi-disciplinary approach undertaken in this research. The first part is disaster theory and management, whereby the concept and nature of disaster and the scope of the discipline is defined. Disasters are classified and the disaster cycle, its stages and its significance are introduced. Following these are the general definition of energy facilities and critical infrastructure and the concepts of resilience, strategy and strategic planning. Finally all these issues are placed in the Emirati context, with a focus on the energy sector.

2.1 Disaster Theory

Disaster theory and research affects how national, regional and even sectoral or corporate policy are undertaken in writing and practice, including in training. In order to understand the nature of "disaster theory" two things must be defined; the term "disaster" and what constitutes a theory. A simple explanation is that a theory is based on rigorous scientific study and rationality. This has been widely accepted as a valid explanation of a given phenomenon (Zimerman, 2012). A scientific theory follows a hypothesis that has been supported by sufficient evidence, following testing. A theory may also relate to the "entire body of knowledge available in the given discipline" (McEntire, 2004; p.2).

Long (2009) states that disaster theory deals with the maintenance of the ideal conditions that society desires, not only to function, but to prosper. In other words, humans do not want to experience devastating disasters and expect policy and practice, typically directed by the government, to mitigate any potential disaster, via a managed

response and recovery effort. The following sub-section examines definitions of disaster.

2.1.1 Definition of Disaster

When defining "disaster" one is rapidly reminded that the term is a semantic construction, like any other label which is used to explain and characterise an event or occurrence (Boin and Hart, 2007). *This is because not every windstorm, earth-tremor or rush of water is a catastrophe* (Carr, 1932, p211). In fact, a "disaster" may enter the Emergency Events database (also known as EM-DAT) only if one of the following has occurred: ten or more people are reported to have been killed; one hundred people are reported to have been affected; a state of emergency has been declared; or a call for international assistance has been made (CRED-OFDA, 2004). However, an event need not necessarily be considered a disaster or crisis by those experiencing it. Put simply, objective indicators, whilst important, are not decisive (Boin and Hart, 2007). Indeed even if one were to define a "disaster" within strict numerical parameters, consensus is by no means guaranteed. A flood that kills two hundred people in two topographically flat and vulnerable countries such as Bangladesh and the Netherlands will undoubtedly generate different types of response and consequences. The former's emergency may be regarded as somewhat routine whilst the latter's may be declared an absolute tragedy. If this is the case, a "disaster" or a "catastrophe" is what the individuals affected, either directly or indirectly, make of it (Boin and Hart, 2007). Such observations lend support to the argument of Horlick-Jones (1995) that catastrophe actually originates in the cultural disruptions of a modern society that cause a loss of faith in the institutions that are supposed to keep hazards under control. For some, disasters are simply one of the prices societies must pay for the gains they reap in discovering cultural inadequacies, resulting in advanced knowledge and protection from risk (Williams, 1958). Meanwhile Kreps (1982) regards the true nature of disaster as a social construction that does not exist in and of itself. Such definitions suggest disasters, although concerning the physical, built and social environment, are primarily social in nature (Mileti, 1999).

Defining disaster is a strongly contested and congested discourse, with conflicting voices across a range of disciplines fighting for space within a crowded paradigm. The core dispute in the "hazard paradigm" began in the 1970s and involved relocating the

perception of hazards and disasters as arising from the impact of the environment on humans, to the reverse view i.e. that they are the impact of humans on the environment (Marten, 2001). This debate continues as researchers still piece together the what-why/effect-cause question and decide whether the defining task is to clarify what a disaster is or what a disaster does or to explain why a disaster takes place (Oliver-Smith and Hoffman, 1999). Dombrowsky (1998) argues that the widely accepted paradigm results in a misdiagnosis that freezes a complex social process into a static event – that there is no separation between a disaster and "its" effect and that disasters do not cause effects, because the effects are what society calls disaster**.**

It is this tension of the value-laden term, coupled with the conflict between objective desirability and the subjectivity of the cultural and political spheres, which shape disaster's reality and manipulate human responses (Zane, 2009). The traditional modes of explaining and coping with disasters become meaningless and insufficient as "modern" societies, characterised by perpetual social change and cultural development, face the need for new modes of explanation and better ways of coping with disasters (Dombrowsky, 1981).There is no basis in logic and little hope in practice, that a single definition can be devised that is universally accepted and useful (Quarantelli, 1987); hence the complication.

2.1.2 Classification of Disasters

Classification is a critical tool used for the organising or ordering phenomena on the basis of their inter-relationships (Bailey, 1973) and the construction of paradigms within a discipline (Kreps, 1989). Kreps (1985) refers to it as a key to the "scientific" goal of content-driven qualitative description – an essential element of the theory of disaster, its knowledge production and development. Drabek (1986) first called attention to this area, stating it as the most pressing issue confronting the field at that time. Quarantelli (1987) similarly asserted the need for a system of classification capable of distinguishing the varying disaster agents, including those that fall within the same category through, for example, the dimensions (scope of impact, speed of onset, duration of impact, social preparedness) introduced by Barton (1969). Quarantelli (1987) further argues for consensus in typologies, not just the definition of disaster. There is also a need for the disaster community to engage on the subject and scrutinise

the rationality underpinning a classification, such as the choice of taxonomic procedures and criteria when creating classifications (Kreps, 1989).

Classifying disasters and their causation is by no means easy, but it is vital because any discussion of disasters depends on, and often references, a common understanding of disaster taxonomy (Green and McGinnis, 2002). Indeed many disasters and their causes may defy simplistic classification (Alexander, 1993) and may require a growth in understanding (Perry, 2005) and an appreciation of the epistemology of disaster theory.

Some may be far easier to distinguish as simple or compound, "natural" or "manmade" (refer to Figure 2.1; Gad-el-Hak, 2008). They may even be classified relative to the anticipated response such as the manner developed by Gunn (1990) which subsequently divides into the level of support required to effectively deal with a disaster and its aftermath, or that proposed by Burton *et al.* (1978) which considers timescales involved in adequately managing a given natural hazard (refer to Figure 2.2). Other basic distinctions as stated by Alexander (1993) could involve "duration or frequency of event."

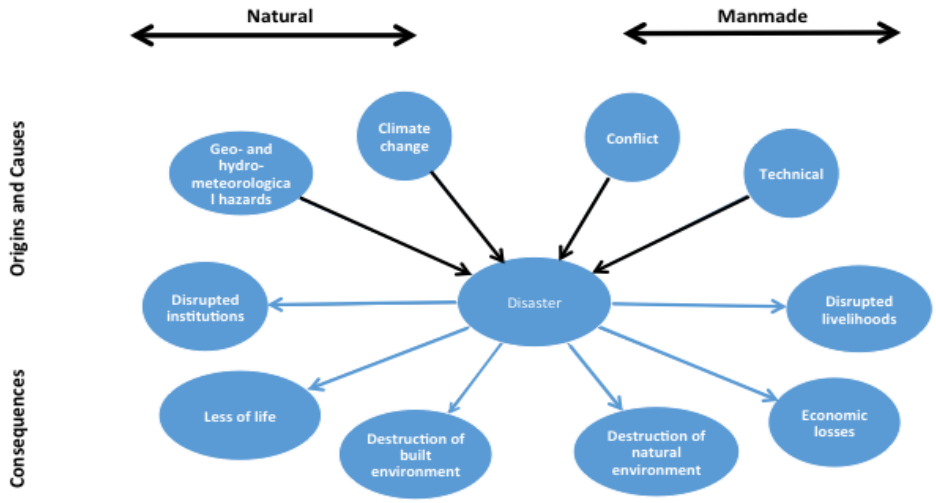

Figure 2.1: Classification of the Constituents of Disaster. Adapted from Gad-El-Hak (2008)

Additional and easily recognisable systematic classifications involve the intensity of a hazardous event such as that of Saffir and Simpson (1974), which relates to hurricane wind speed and pressure, the Richter Scale for earthquakes, the Soloviev-Imamura for *tsunamis* and the Fujita Scale for tornadoes. The significance of having a universal scheme is that it gives officials an informative, quantitative measure of the magnitude of the disaster, so that proper response can be mobilised and adjusted as warranted. It applies to all types of disaster, putting them on a common scale (Gad-El-Hak, 2008). Not all such hazards (floods are an example of this exception), are however amenable to the classification of the intensity of their physical impact or human effects (Alexander, 1993). In answer to this, Fischer (2003) developed a quantitative measure based on the level of social disturbance a hazard could create to classify flash floods of mountain rivers as either extreme emergencies or small-town disasters. Other increasingly important issues such as terrorism and climate change induced drought have no form of intensity measure (Gad-El-Hak, 2008). Causation of disaster is also an important way of categorising.

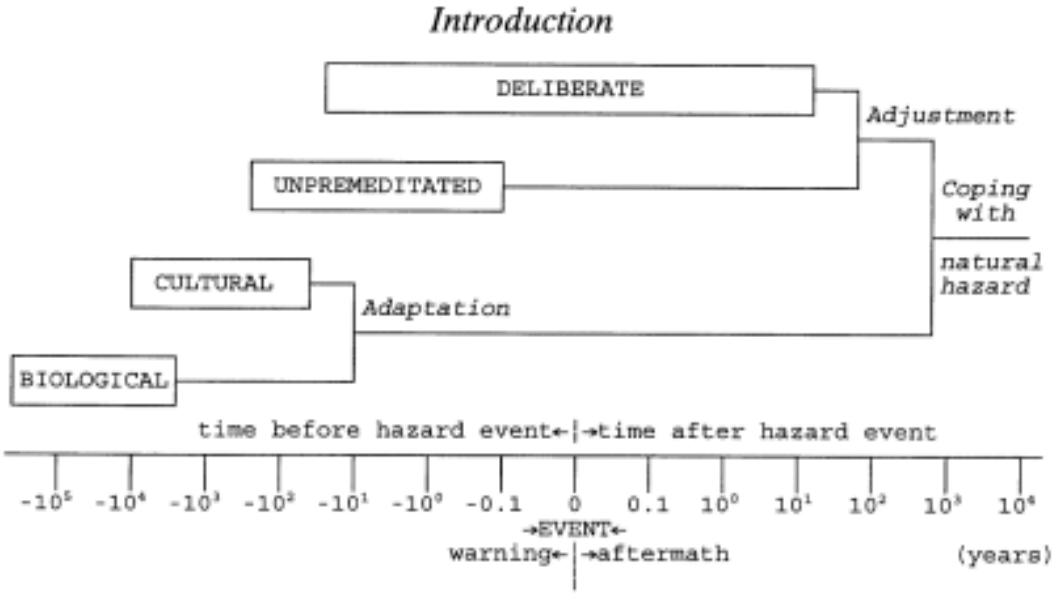

Figure 2.2: Timescale for Dealing with Hazards. Source: Burton *et al.* (1978)

Distinctions between causation can however be blurred, as a natural disaster or phenomenon can trigger a secondary disaster which results from the weaknesses of human elements (Veenema, 2007). The 2011 Tsunami in Japan provides a timely

reminder of the vulnerability of even the best prepared population as it struggled to prevent a nuclear incident triggered by a magnitude 8.9 earthquake (Reuters, 2011; Spiegelhalter, 2011). Disaster management for the Japan tsunami and any other relief efforts and recovery relies on reliable classification to identify the significance and value of the most relevant factors. Rigorous classification may however actually serve to inhibit rescue and relief teams trying to respond with already limited resources and manpower (Verma, 1998). Therefore, classification systems despite this criticism, remain an excellent tool for making comparisons and developing suitable solutions for disasters of the same genotype (Perry, 2005). The importance of this cannot be over-stressed (Drabek, 1986) or undervalued. This study classifies disaster as natural or manmade, based on origins and causes of hazard as illustrated in Figure 2.1. Geological, hydrological and meteorological hazards and some aspects of climate change are examples of disasters with a natural origin whilst manmade disasters are those linked to conflict and technical issues. Natural disasters which affect the UAE include earthquakes, droughts and floods whilst manmade disasters are often linked to terrorism.

2.1.3 Disaster Management Cycle

Risk can be defined as the objective (mathematical) or subjective (inductive) probability that something negative will occur. The probability of an earthquake occurring in the UK is quite low compared to that same hazard happening in say California or Turkey. The possibility of the event occurring plays an important role in determining how important it is that a community is prepared to face it. Certain natural hazards and their risk factors can be modified by a good working knowledge of the phenomenon and disaster risk management.

The ultimate goal of disaster risk management is to break the disaster life cycle (Frumkin, 2010), but this can be challenging, as a major issue relating to the concept is the identification of stages. All disasters are said to follow a cyclical pattern (refer to Figures 2.3 and 2.4) termed the disaster cycle (Hogan and Burstein, 2007) or disaster continuum (Novick and Marr, 2003). The cycle is an overall view of stages within a continual loop (Forsman, 2007) such as that described by Ciottonne (2006), who states that it includes prevention, mitigation, preparedness, response and recovery. The first

term, prevention, typically refers to those actions taken to prevent a potential hazard from occurring, if it can be avoided. Should that not be possible, preventative steps would prevent or diminish any potentially harmful effects from on human life or financial assets. According to Sena (2006), "prevention" involves hazard identification and vulnerability assessments. The former identifies the actual threats facing a community, the latter is an evaluation of community risk and capacity. Mitigation refers to the effort required to reduce loss of human life, wildlife or financial assets in the event of foreseeable disaster. An effective mitigation, according to the US Federal Emergency Management Agency (FEMA, 2014), requires that all involved understand risks, address the hard choices and invest in long-term community wellbeing. Planning involves the continuous cycle of organising, training, equipping, exercising, evaluating and taking corrective action so as to ensure effective coordination during incident response (Department of Homeland Security, 2013). According to the UK Government guidance accompanying the *Civil Contingencies Act 2004* (p10):

Response encompasses the decisions and actions taken to deal with the immediate effects of an emergency. It is the decisions and actions taken in accordance with the strategic, tactical and operational objectives defined by emergency responders. At a high level these will be to protect life, contain and mitigate the impacts of the emergency and create the conditions for a return to normality... Response encompasses the effort to deal not only with the direct effects of the emergency itself (e.g. fighting fires, rescuing individuals) but also the indirect effects (e.g. disruption, media interest).

Recovery is defined as the process of rebuilding, restoring and rehabilitating the community following an emergency. Although distinct from the response phase, recovery should be an integral part of the response from the very beginning, as actions taken during the response phase can influence the longer-term outcomes for a community.

All these form components or stages of the disaster cycle, as shown in Figure 2.3.

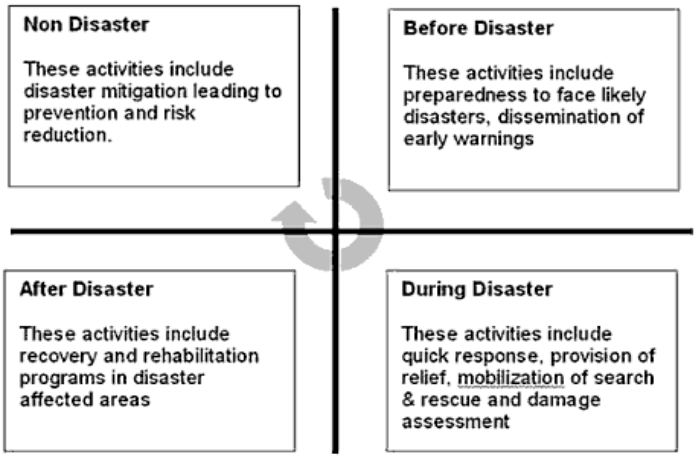

Figure 2.3: A Four Stage Disaster Cycle. Source: *Shaw et al., 2009*

The ultimate goal of disaster risk management is to break the disaster life cycle (Frumkin, 2010) or as Lewis (1999) believes, to break the dual disaster cycle. His dual cycle stems from the idea that some events invoked in a disaster result not from the natural hazard itself but from the context in which it happens, e.g. the level of development. "*Individuals and communities progress through phases at different rates depending on the type of disaster and the degree and nature of disaster… this progression may not be linear or sequential"* (Roberts and Ashley, 2008, p4). It is argued that any false separation between the different aspects makes the society in question all the more vulnerable and susceptible to disasters (Satendra and Sharma, 2004). The process of dividing the disaster process into various, albeit overlapping, stages is a useful heuristic device driving better understanding (Levinson and Granot, 2002) from which a disaster management plan can be implemented. This can be quite difficult, however, because they are not necessarily mutually exclusive (Latfifi, 2010).

A major challenge associated with disaster cycles is the identification of stages. Ciottonne (2006) recognises five; the International Union for Conservation of Nature and Natural Resources (Miththapala, 2008) considers six steps within two phases (refer to Figure 2.4); FEMA lists four; and the United Nations lists eight: *prevention, preparedness, early warning, impact and immediate needs assessment, relief or emergency response, rehabilitation, reconstruction and sustainable recovery* (Westlund, 2007, p.24).

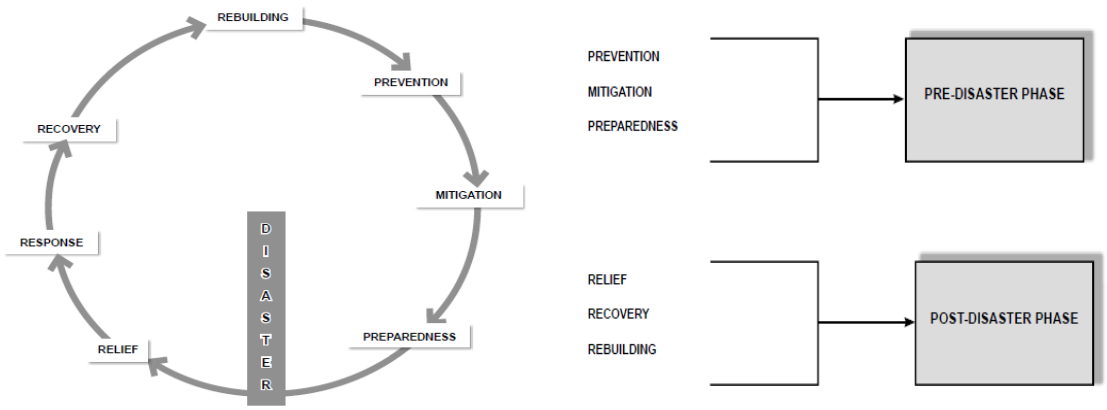

Figure 2.4: The Disaster Management Cycle and Phases Source: *IUCN* (2008)

2.1.3.1 Pre-Disaster Phase

The three components of the pre-disaster phase, i.e. prevention, mitigation and preparedness, which were explained comprehensively in the previous section, involve extensive data collection, maintaining directories of resources, the development of action plans, capacity building, training and community awareness activities (Sundar and Sezhiyan, 2007). Policy decisions and actions during the prevention and mitigation stages have enormous and far reaching consequences with the success of post-disaster management largely dependent on pre-disaster steps. It is essential that all natural and socio-economic resources are mapped in order to ascertain resource dependence and it is important to fully understand their function from an infrastructural and ecosystem service perspective (Miththapala, 2008). This community profiling is particularly useful when outside agencies join the project or when it is necessary to build rapport and develop dynamic interactions with a local group. This information then facilitates the community risk assessment identifying vulnerabilities and issues of the disaster specific to the context (Yodmani, 2001). In this way, disaster preparedness and the other elements of this phase are guided in a manner which adequately protects communities in its comprehensive, multi/inter sector, community based and cultural sensitive/specific approach (Cittone, 2006), a key approach for the research presented here.

2.1.3.2 Post-Disaster Phase

In the period following disaster, confusion abounds and many people working on the immediate response are under huge pressure and stress to make the right choices and take the right action. Their decisions must be quick and decisive. In many respects, such decisions and actions carry a high level of intuition, in addition to those issues based on a strategic disaster mitigation plan. The latter must provide some practical vision and stability in the chaos. In short, it must help guide decision makers in selecting the right course of action within a rigid framework which is strong enough to direct resources and people in a way that builds resilience and confidence in the government's response, its systems and the government *per se*. The initial relief stage after a disaster tends to attract the highest level of media response and it is here that the humanitarian agencies and volunteer groups play the most significant role. This is where agencies address the basic human needs of food, clean water, sanitation and shelter (Penuel *et al.*, 2011). Communities that have developed their own contingency plans can support the work of those involved in the immediate response and in doing so can greatly reduce the time lag between the immediate aftermath and post-disaster recovery (APA, 2005).

The recovery phase begins after the immediate emergency relief has ended (Penuel *et al.*, 2011) and *lasts as long as the effects of the incident can be expected to persist* and *can be described as the coordinated efforts and processes to effect the immediate, medium and long-term holistic regeneration* (Cole, 2006, p.7). This stage creates a sense of normality and is often identified as a "window of opportunity" because it is here that corrective actions can be implemented regarding recovery planning, urban planning and other national/regional policies which will serve to benefit the totality of the community in the re-building (Penuel *et al.*, 2011; Birch and Wachter, 2006) and potentially in the restructuring.

When considering this stage, the term "post-disaster recovery planning" needs to be defined in order to optimise the process. It can be defined as the development of a strategy or various strategies which serve to assist an affected community in its rebuilding following disaster. In this respect, it can be thought of as a community blueprint for reconstruction. It helps communities engage in post-disaster activities and address the failings that led to the disaster, or the difficulty in managing it in the first

place. According to the *Partnership for Disaster Alliance* (2007) there are a number of activities that can be applied:

- Post disaster recovery plans
- Recovery ordinances
- Business and government continuity plans
- Post-disaster buildable land inventories
- Utility recovery and reconstruction plans
- Temporary shelter and housing plans
- The establishment of a coordinating organisation and guiding principles for reconstruction

There are also the long term considerations that come with the need to identify critical issues and the establishment of a framework with which to assign personnel and resources for their management. This requires local, regional and national input and expertise and is, in many ways, the first step involved in the developing of a long term recovery plan. Such a plan will identify policies, operational strategies, roles and responsibilities for implementation that will, when necessary, guide decisions that affect long-term recovery and post-disaster community redevelopment. It places the emphasis on the need to seize opportunities for hazard mitigation and to maintain community improvement which is consistent with the goals of the local comprehensive plan. This is something which by its very nature involves full community participation. According to FDEM (2011, p.9) recovery issues considered typically include:

"Sustainable land use, housing repair and reconstruction, business resumption and economic redevelopment, infrastructure restoration and mitigation, long-term health and social services support, environmental restoration, financial considerations, and short-term recovery actions that affect long-term redevelopment as well as other long-term recovery issues identified by the community".

This thesis focuses on the pre-disaster phase in its in depth investigation on disaster mitigation and strategic planning in order to build resilience. Pre-disaster, when used in this research, refers to extensive data collection, maintaining directories of resources, development of action plans, capacity building, and training and community awareness

activities required to prevent, prepare and mitigate (Sundar and Sezhiyan, 2007). This information facilitates the community risk assessment identifying vulnerabilities and issues of the disaster specific to the context (Yodmani, 2001). In this way, disaster preparedness and the other elements of this phase are guided in a manner which adequately protects communities due to its comprehensive, multi-sector, community based and culturally sensitive approach (Cittone, 2006), hence the need to employ strategic planning and resilience enhancement in such communities.

2.2 Critical Infrastructure

Undoubtedly, national security, economic prosperity and quality of life for most people in modern society depends on continuous and reliable national public infrastructures – most of which are interdependent (Al Khaili *et al*, 2014). The protection of infrastructure is thus one of the most important and difficult tasks for any government and for national security. This is because it is so large that it is logistically and economically impossible to protect absolutely everything from a potential attack or natural event. Therefore one of the highest priorities for state authorities is to shield *critical* infrastructure, and not just infrastructure *per se,* from any detrimental occurrences and minimise serious impacts on the health, safety, security or economic wellbeing of citizens (Wuchte, 2012). In this study, critical infrastructure, according to the definition adopted by the US Patriot Act 2001, is considered to be not only physical assets but also virtual systems so vital to the State that the incapacity or destruction of such systems would have a debilitating impact on international security, national economic security, national and/or public health or safety. It is thus taken to embody components that contribute to the wellbeing of a nation and essential to the chemical sector, transportation network, defence security, telecommunications, banking and finance, water utilities, public health system, emergency services and the energy sector (*i.e.* electricity network, power plants etc.). The identification and designation of criticality is discussed in *Directive 2008/114/EC*, which looks at how vulnerabilities in the transport and energy sector (production and transmission) impact the EU as a whole. One should not look at critical infrastructure as a collection of geographically defined objects but rather see it as a network which goes beyond and is not confined by

the boundaries. Neither is critical infrastructure necessarily confined to one particular sector, as there are in fact many potential overlaps.

The greatest challenge for policymakers, managers and engineers, when it comes to critical infrastructure, is the vastness of size and the complexity of identification and prioritisation. That is perhaps why governments try to group them into some sort of taxonomy (as with the above examples of the US Patriot Act), which reflects a provision of a good or service. According to Macaulay (2008), this taxonomic style grouping is not without its problems, given the lack of the consensus between different administrations (or even nations) as definitions morph and evolve, and the tendency to assign arbitrary meanings with no agreed methodology.

Another key consideration is whether a failure or loss of infrastructure is caused by a primary, secondary or tertiary order impact. A first order impact would be a direct impact caused by an earthquake such as a fire. A second order one would then be the effect of that fire on an entity which did not experience that fire. A third order would be the cascading effect of the second order impact. The concept is best explained by the domino effect.

The need to face the challenges of critical infrastructure is recognised in the 2003 *U.S. National Strategy for the Physical Protection of Critical Infrastructure and Key Assets*. The first objective of this strategy centres on the identification and protection of assets, systems and functions that the U.S. Government deems to be critical for public health, governance, economic security, national security and public confidence.

According to Flammini (2012), little progress has been made towards a unified approach to critical infrastructure protection, even though more than 250 tools and methods currently exist for evaluating criticality in infrastructure. Identification and prioritisation of the most critical components of critical infrastructure remain a challenging intellectual problem.

The assigning of criticality levels, despite the lack of consensus, can be said to be associated with the contribution (real or perceived) that a given infrastructure has in maintaining the dependent society at a minimal level of national, regional and

international law and order. This level will in turn relate to aspects of public safety and health, the state of the economy and the environment.

According to *2008/114/EC*, there are three cross-examined aspects involved in any assignation of criticality:

- The number of casualties
- The economic impact (including potential environmental effects)
- Public impact (psychological and political)

All infrastructures, particularly that of the highest criticality, need to become more resilient through vulnerability assessments, continuity of operations planning, and deliberate investment in cost-effective technologies which improve the capacity of service providers and public authorities to maintain those critical functions (Auerswald *et al.,* 2005). The protection of these systems and assets and within the energy sector, especially the safeguarding of oil and gas infrastructure from any and all internal and external threats, should become the top priority of the UAE and other oil-providing nations against all forms of threat.

2.2.1 Critical Energy Infrastructure

Infrastructure in all its forms is a valuable asset and vulnerable to many natural and manmade hazards. The protection of infrastructure is thus one of the most important and difficult tasks for any government. The energy sector, which dominates the UAE economy, consists of various assets—related to electricity, oil and natural gas—that are geographically dispersed and connected by systems and networks (Al Khaili *et al*, 2014). The term "energy sector" is not easily defined, nor is the concept of critical energy infrastructure. That said, given that the energy sector of any nation or region provides fuel for and to its people via its infrastructure, in a process that depends on the existing transportation, communications, finance and government infrastructures (Kolevar, 2007), it is important to find an accepted understanding of these terms. The Energy Charter Treaty, signed by 51 countries, establishes in Article 1, paragraph 5, that energy sector investment is "an economic activity concerning the exploration, extraction, refining, production, storage, land transport, transmission, distribution, trade,

marketing or sale of Energy Materials or Products", these last two terms referring to coal, natural gas, petroleum and petroleum products, and electricity (De Brabandere and Gazzini, 2014, p69). The UAE became an observer to the Energy Charter in 1991.

The Australian Government (2010) states that critical energy infrastructure includes physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact on the nation or affect its ability to ensure national security. When critical energy infrastructure is damaged, transportation may also be affected; for example, electricity lines may block roads and other routes, making transportation difficult or dangerous.

One important (if not the most important) issue related to the long-term security of a national or even a regional energy system is the failure of international supply, whether on technical or political grounds. Any resilient energy network requires cooperation and the shared interests of all involved to work towards protection from "shocks". This is especially the case if long term resilience is regarded as a secure supply. Resilient critical infrastructure, based on Olinsky-Paul (2013), is defined in this thesis as that which has the self-sustaining ability to supply emergency electricity during outages where normal operations are absent or disrupted.

Finally, natural disasters which destroy energy supply infrastructure are equally hazardous or threatening to suppliers and consumers alike. It is thus important that both forge a strong relationship which recognises the symmetrical nature of the risks which may later lead to disaster. In short, they must be adequately addressed in the planning, mitigation and preparation stages of pre-disaster phase (Minullin and Schrattenholzer, 2011). A weak management team and poor planning throughout the process would arguably only serve to amplify any failures during the immediate and longer term post disaster period. It would almost certainly make a community less disaster resilient. The next section discusses in more detail the concepts of resilience and vulnerability.

2.3 Disaster Resilience and Vulnerability

The term 'vulnerability' inherently involves various other somewhat complex ones such as resilience, marginality, susceptibility, adaptability, fragility and risk. It can also

involve issues such as exposure, sensitivity, coping capacity, robustness and criticality, hence the need for in-depth discussion of such terms in this chapter (Liverman, 1990; Fussel 2006). Perhaps the easiest way to understand it is to clearly describe a vulnerable situation and distinguish it from the vulnerability, or risk, factors that could be considered in such situations. A useful example of this is vulnerability to climate change.

Moss *et al.* (2001) identify three aspects of climate change vulnerability. The first is what they refer to as the physical-environmental dimension, which they state "accounts for the harm caused by climate". It includes biophysical impacts such as agricultural productivity and the distribution of disease vectors. The second aspect is that of socioeconomics, which refers to a given society's or region's economic and social capacity to recover from extreme events and the use of wealth and financial institutions to adapt over the longer term. Their third dimension, external assistance, is defined as "the degree to which a region may be assisted in attempts to adapt to climate change through its allies and trading partners, diasporic communities in other regions, and international arrangements to provide aid".

The United Nations (2004), meanwhile, identifies four groups of vulnerability factors that are relevant in the context of disaster reduction: physical factors, i.e. those that describe the exposure of vulnerable elements; economic factors, affecting the economic resources of individuals, population groups and communities; social factors, i.e. non-economic factors that determine wellbeing, such as the quality of education, security, access to basic human rights, and good governance; and environmental factors.

A related concept which it is equally important to define is that of disaster resilience. The present study adopts the definition coined by researchers at the Multidisciplinary Center for Earthquake Engineering in Buffalo, New York, for whom disaster resilience is *the ability of social units (e.g. organisations, communities) to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimise social disruption and mitigate the effects of future disasters* (Fitzgerland and Fitzgerald, 2005, p5). These effects can be related to the acronym TOSE, which stands for the four measures of resilience listed by Chang and Shinozuka (2004):

- **Technical** resilience refers to how well physical systems perform.
- **Organisational** resilience refers to the ability of organisations to respond to emergencies and carry out critical functions.
- **Social** resilience refers to the capacity to reduce the negative societal consequences of loss of critical services.
- **Economic** resilience refers to the capacity to reduce both direct and indirect economic losses.

Each must be managed in a way which builds what Hays (2013a; 2013b) terms the "Five Pillars of Resilience":

- **Preparedness**: This involves identification of potential hazards and vulnerabilities through risk assessments, the development of forecast and warning systems, modelling and training for a number of disaster scenarios of different hazards and at different magnitudes, the development of insurance infrastructure and the growth of an intelligent community more capable of dealing with incidents.
- **Protection**: This can be done through the implementation of improved building codes and standards, site-specific design and performance norms for critical and essential facilities and infrastructures such as the power plants considered in this report.
- **Early Warning**: A provision of advance warning: models, sensors, communication networks and protocols, evacuation protocols and the assignation of "safe havens" and transportation/ road network tests. This assignation must ensure that these havens really are safe and are accessible before, during and after an emergency, i.e. logistic evaluation of the journey to and from homes or temporary constructions, in the event that homes have been destroyed. Such systems reduce recovery time, as less infrastructure is damaged in the first place.
- **Emergency response**: The development of an emergency evacuation programme, training and tests of a "search and rescue" operation for those individuals who were unable to reach the safe zone. Provision of emergency personnel and medical assistance, investigation of road network under an

emergency scenario (before during and after). Testing and creation of networks to support the affected area in obtaining local, regional and international assistance is also necessary.

- **Recovery and reconstruction**: The development of insurance and indemnification to facilitate the re-initiation of "business as usual" in terms of commerce and day-to-day operations improves the ability of the affected society or community to recover. This would typically involve undertaking post-disaster studies to improve pre-disaster preparedness in a similar event.

The success in building these pillars can be better represented and evaluated by the resilience triangle (Figure 2.5) whereby the quality of performance is plotted against the time period needed to restore and recover, following a 50 percent loss of infrastructure. Disaster mitigation and good strategic planning can reduce this period.

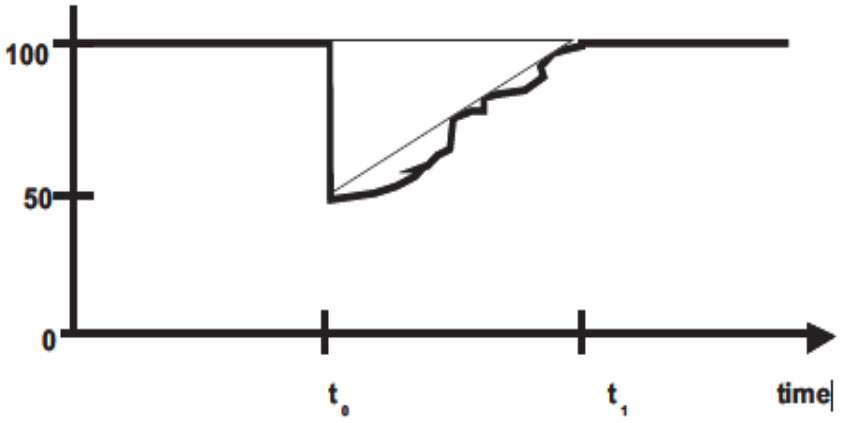

Figure 2.5: The Resilience Triangle. Source: Tierney and Bruneau (2007)

The recovery period can be shortened by improving the disaster resilience measures required in the disaster management cycle to restore and replace damaged infrastructure. This in turn increases the resilience of a given community. The better a community is able to withstand a crisis event and recover quickly from its impacts, the more resilient it is considered to be. Communities that are most resilient would (in the figure above) produce only an almost imperceptible resilience triangle when faced with the exact same disaster circumstances (ICOA, 2008).

Decision makers can alter the size of the triangle with an effective disaster management strategy and resilience building programme. Jha and Stanton-Geddes (2013) propose education and communication, higher levels of preparedness and investments, better urban planning, coordination and development as the main tools with which to address the risks that a vulnerable community might face in the event of disaster. The Commonwealth Office of the Australian Government (2011) add another dimension to disaster management – increasing awareness of the local community regarding the threats directly relating to them and of what can be done on an individual (household) level to actively plan and prepare for the protection of life and property.

To increase disaster resilience, emergency management planning should also be based on risk and be integrated with strategic planning of government and communities. It should consider risks and risk treatments across the social, built, economic and natural environments (COAG, 2011, p2).

One of the keystone features of strategic planning and community resilience is public participation, because it can strengthen the interface between government and the people. Participation, as part of strategic planning, also reduces the likelihood of assumptions, miscommunications and the margin of error that could lead to failure in the most disastrous of circumstances (Borodzicz and van Haperen, 2002). Thus, such planning should find a place as part of disaster mitigation, in the overall urban planning framework for resilience (Byahut and Parikh, 2006). A limited, or absent, national strategy and its resulting plan will inhibit a country's ability to cope with disaster (Penuel *et al.,* 2011) and any ad-hoc intervention without comprehensive and fundamental planning at the post-disaster phase of the cycle will have unpredictable, random, unexpected and subsequently unacceptable consequences, with service disruptions such as electricity cuts right at the time when such services are most needed (Chiba, 2011). This could mean, for example, that lights go out during evacuation, making searches within the disaster zone all the more difficult. This must be avoided through strong contingency or strategic planning, as discussed in the next section.

2.4 Strategic Planning

Planning, by its very nature, deals with the future and how current decisions are taken and expected to affect that future. Strategic planning, for its part, is a process or a series of steps that look at the chain of cause and effect over time for a decision that either has been taken or is yet to be taken (Barksdale and Lund, 2006). Strategic planning is a thus way of identifying *A*, *B* and *C* and the links between them – whereby *A* is representative of where an organisation is, *B* where it wants to go and *C* how to get there. In order to be effective, this requires efficient data gathering, analysis and synthesis, in addition to the clarification of goals and the development and exploration of rational alternatives. It can amongst other things support:

Communication, participation and judgement, accommodate divergent interests and values, foster wise decision making informed by reasonable analysis, promote successful implementation and accountability and enhance ongoing learning (Bryson, 2011, p10).

Strategic planning is therefore a useful management tool to help an organisation improve by focusing its energy and ensuring that all members involved are working towards the same goal and are able to contribute to the agreed aims (Doherty, 2008). It is fundamental to and intertwined with strategic management precisely because it looks at the alternatives of a particular decision over others and evaluates the relevance and benefits of each in turn. Once a course of action is selected, it becomes the subsequent basis for current decisions and operations.

All managers within an organisation will need to plan to ensure smooth running operations which, for the long term, require strategy. Strategic planning is central to supporting managers in delegating strategic management responsibilities to other members of staff involved in operations and day to day running of the organisation. In this respect, it is vital to the success of the goals of both the public and private sector. That said, and according to Steiner (2010), strategic planning is not an attempt to force a blueprint, nor something set in stone and inflexible to the need for periodic revision as dictated by the corporate world, the public, government policies or global events. Good strategic planning is open to changes and is readily modified to take advantage of

developments. It is also flexible enough to be easily used by the various departments and individuals who need to apply it in their own field and activities. It should never be used to undermine those who use it; neither should it replace managerial intuition and judgement. It is instead a systems approach which allows room for manoeuvre and can help an organisation navigate within uncertainties to achieve previously determined aims. This is effectively why the wrong strategy can lead to serious negative implications, regardless of how efficient or competent employees and management may be. Chandler (1962) defined "strategy" as the formulation of long term goals followed by the marshalling and allocation of resources to achieve those goals (Goodstein *et al.*1993) developed the idea further by stating that it is a coherent unifying and integrative pattern of decisions with the means of establishing an organisation's or nation's long-term objectives, action plans and allocation of resources. Minzberg (1987) stated that strategy is a position – that is to say a mediating force – between an organisation and the environment. Figure 2.6 illustrates a generic strategic process model introduced by Rea and Kerzner (1997) that helps an individual or group to focus on their external and internal issues that affect and/or influence their operations. Strategic planning is the basic direction and rationale for determining where an organisation should head, providing that there are specifications against which any organisation may best decide what to do and how to do it. It is the basis for creating and describing a better future in measurable terms and the selection of the best means to achieve the results desired (Kaufman, 2003).

Put simply, strategic planning is a disciplined, deliberative approach to help key decision makers in organisations figure out what they think they should be doing, how and why (Bryson, 2011).

Figure 2.6: Traditional Strategic Planning Model. Source: Rea and Kerzner (1997)

One must remember that strategic planning is the process by which one develops a strategy to achieve a certain purpose (Abraham, 2012). In the case of disaster management, this purpose is to reduce the possibility of the impact of a natural event or a manmade hazard, on a given community, and to increase the resilience of that said community. "Strategy" is thus a key component of building disaster resilience, as also seen in the extended strategies of the five pillars proposed by Hays (2013a; 2013b). This is because the strategic planning process assumes a critical situation and seeks an effective and direct solution. It defines directions and plays an integral role in making decisions for the allocation of the necessary resources (human and monetary capital) with which to pursue its strategy (Doherty, 2008). Such planning also identifies strengths, weaknesses, opportunities and threats as in a SWOT analysis, so as to increase the likelihood of achieving success in tackling disaster (or any other) phenomenon. Arnold (2006), in a *World Bank* publication, provides an example of how a SWOT analysis, falling under strategic planning, can bring benefits to a community affected by disaster.

Successful strategic thinking, planning and action lead to various benefits, including improved organisational performance, the development of teamwork and expertise, the amendment of inherent organisational issues and the establishment of clarified norms

and priorities - all of which clearly serve to advance disaster management and resilience (Bryson and Delbecq, 1979). According to Sadeghi (2006, p.22):

Strategic planning [thus] provides the appropriate infrastructure for integrated, coordinated decision making following natural disasters such as earthquakes. Hence, applying strategic planning to disaster management can reduce the impact of catastrophe on the community which results in reducing the number of casualties.

According to Doherty (2008, p.33), there are five steps in putting together a strategic plan for disaster management:

1. Identify the targets – who they are and who they are not.
2. Type of help – Who needs assistance and who does not?
3. Timing – When will the assistance be most useful and when will circumstances and the situation allow such assistance?
4. Theme – What are the themes, issues, concerns and threats that should be considered in order to build and plan the right invention package? What has already happened and what will happen in connection to the incident?
5. Team and Resources – What resources will it take in order to provide the right interventions at the right time(s)?

In order to answer these questions one must consider the threats through an in depth analysis and assessment; one must then develop and implement alternative responses and decide how any information should be communicated to all those involved. Any decisions arrived at need a procedure stating how they should be taken and in which circumstance. Finally one should state how a return to normal operations, once the threat or crisis has subsided, should be coordinated.

A comprehensive plan will consequently formulate the implementation, monitoring and evaluation stages and will form the basis of enriched and improved communication and coordination among the different parties for the various different scenarios.

2.5 United Arab Emirates in Context

The UAE is located between latitudes 22.0º and 26.5º N and 51º and 56.5º E. Collectively, the Emirates and its archipelago that extends over the Arabian Gulf cover 83,600 sq km. The Emirati coastline extends approximately 700 km. The country shares land borders with Qatar to the west, Saudi Arabia to the south and west and Oman to the east and south.

Four-fifths of the UAE's land mass is desert. The highest altitude is 1,500 m in the Hajar Mountain range which extends into the northeast region and into Oman. Other land forms occur along the extremely shallow and gently sloping continental shelf of the Arabian Gulf where there are various offshore islands, salt marshes and coral reefs. The littoral zone of the UAE is characterised by active coastal sabkhas, or salt flats (Doherty, 2009).

The climate is arid and subject to ocean effects due to the proximity of the Arabian Gulf and the Gulf of Oman. The coast brings humidity along with very high temperatures during the summer months. The Al Hajar al Gharbi Mountains, due to their high altitudes, create generally cooler weather conditions. There are two seasons: winter, from November to March and summer, which is from April to September. During winter, temperatures are generally mild, given that it is rare that they ever fall below 6ºC (Ministry of Energy, 2006). In summer, conditions can be extreme, reaching 48ºC and 90% humidity at the coast, but normally oscillating between 50-60%. Inland humidity is lower at around 45% but temperatures are known to climb to 50ºC. As one might expect, rainfall is few and far between. Any abnormally high rainfall, which is usually tied to the combination of winter *shamal* wind and atmospheric depressions, makes headline news. In November 2013, heavy flooding caused a number of minor injuries and one fatality when a man was swept from his vehicle. Medical staff stated the need for careful and considerate driving (Hasan, 2013). Likewise, in February 2014 heavy rainfall and unusually cold conditions made headlines with traffic generated and drivers urged to exercise caution (Kazmi, 2014). Summer rainfall is infrequent outside of the mountainous and south eastern regions (which experience 140-200 mm/yr). Whilst rainfall is typically low, even in the wettest months of February and March, evaporation is considerable, averaging 8 mm daily (Ministry of Energy, 2006).

Politically, the country is a federation of seven Emirates – Abu Dhabi Ajman, Dubai, Fujairah, Ras Al Khaimah, Sharjah and Umm al Quwain. In terms of population, the UAE is experiencing one of the fastest growth rates in the world. Most of this influx can be linked to the arrival of working age immigrants (Figure 2.7), typically from India, Bangladesh and Pakistan (who account for 90% of the nation's workforce) but also the United States and Western Europe. In fact, the 2013 estimated figure for the migrant population was 7.8 million, which equated to 84% of the total. It also means that the UAE has the fifth largest immigrant working stock in the world (Malit and Al Youha, 2013).

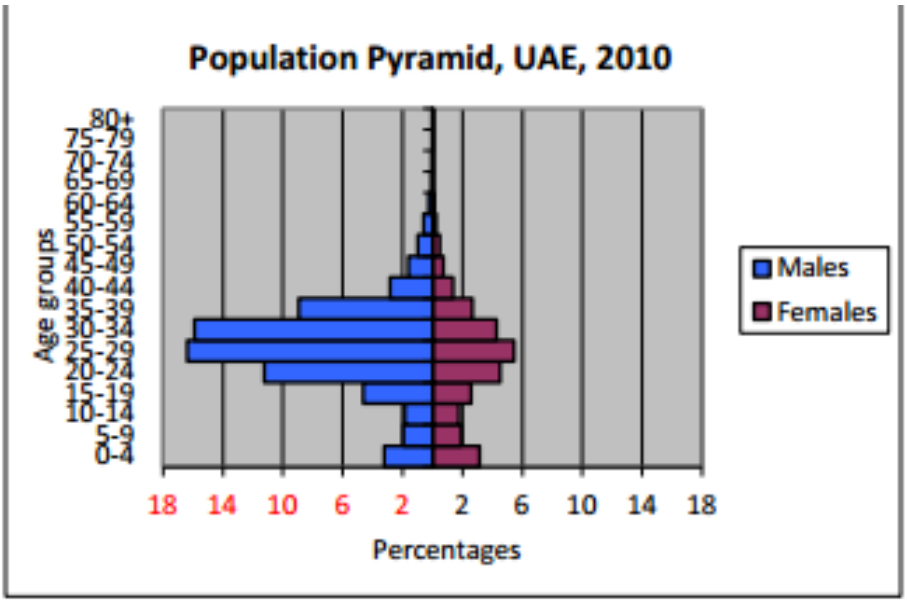

Figure 2.7: UAE Population Pyramid, 2010. Source: ESCWA (2010)

In 1980 the total population was 1 million. It increased to 8.4 million only 30 years later. The UN expects this figure to reach 15.5 million by 2050 (ESCWA, 2010). This is a huge growth rate on the 287,000 present in 1971. In 2004, the three most populous Emirates were Abu Dhabi, Dubai, and Sharjah. Collectively, they accounted for roughly 85% percent of the total population. The overwhelming majority of the population lives in urban areas in coastal zones, which are also prone to a vast number of natural hazards and manmade threats (Ministry of Energy, 2006). These are discussed in the following sections.

2.5.1 Natural and Manmade Hazards of the UAE

2.5.1.1 Natural Hazards

The term "natural hazard" includes all atmospheric, hydrological, seismic and volcanic and wildfire phenomena that, because of their location, severity, and frequency, have the potential to affect humanity, the wellbeing of their society and the effectiveness of their activities. If a hazard is described as “natural”, it does not relate to any manmade phenomenon such as war, pollution, or chemical contamination. These are discussed in Section 2.5.1.2**.**

The natural hazards considered include those relating to tectonic activity (earthquake, tsunami) and atmospheric phenomena (*shamal*, climate change).

2.5.1.1.1 Earthquakes

There are 25 seismogenic source zones in the Arabian Peninsula (Al-Amri, 2005), including the Zagros Thrust fault which readily generates earthquakes measuring 5 on the Richter Scale, such as the Masafi Earthquake (magnitude ~5) whose accompanying shocks were felt throughout the northern Emirates (Rogers *et al,* 2006). This fault defines the western coastline, running from Abu Dhabi through Dubai and Sharjah to Al Khaimah (Wyss and Al-Homoud, 2004). Other potential threats come from the Hurmuz Straits, north of which is one of the most seismically active zones in the world (Shanableh *et al.*, 2005; Figures 2.8 and 2.9).

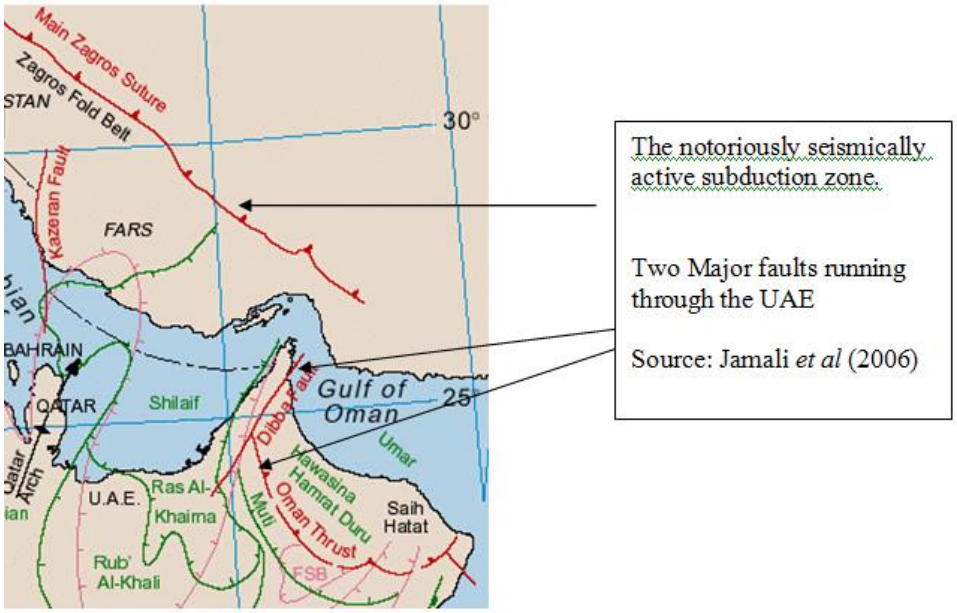

Figure 2.8: Fault line in the Gulf Region (Jamali *et al*., 2006)

Evidently, the UAE is exposed and vulnerable to tectonic activity from a number of sources, and yet there is little in the form of seismic detection, protection, resistance or design for some of the newest and tallest structures in the world (Petrovski, 2005; Shanableh *et al.*, 2005). In fact, it is clear that with its rapid progress, the UAE's seismic risk is rising as dramatically as its skyline (Wyss and Al-Houmoud, 2004). This danger is particularly acute for tall buildings located on reclaimed land because little is known about the underlying or nearby fracture zones, whilst such land is potentially more susceptible to liquefaction and slope failure (Williams, 2005). Two earthquakes in quick succession (9th April and 16th April, 2013), measuring 6.3 and 7.2 respectively on the Richter Scale, forced residents in Abu Dhabi, Dubai and Sharjah and some 500 km across the Arabian Gulf to rush out from high raise buildings (Kazmi *et al.*, 2013). Whilst no casualties or property damage was reported, the lead national authority responsible for managing and coordinating emergencies and crises in the UAE, NCEMA, were forced to react quickly to the rapid panic and the publishing of misinformation (Al Hoscini, 2013). Other incidents of recent tectonic activity experienced in the UAE are shown in Figure 2.9.

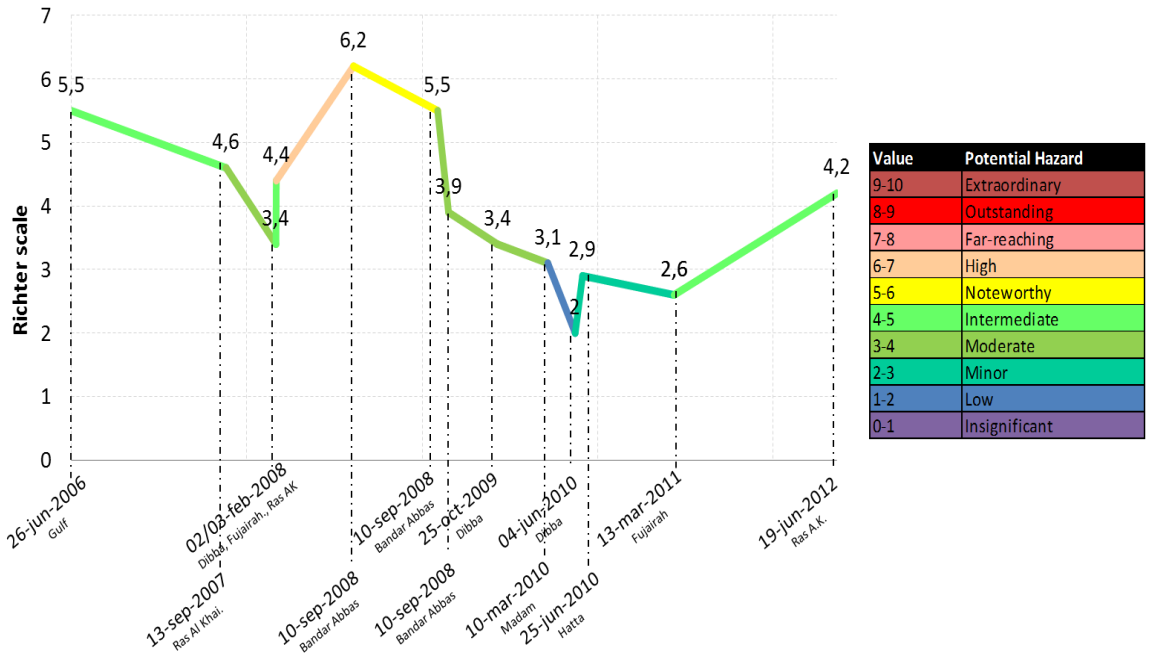

Figure 2.9: UAE Earthquakes experienced in the last 8 years: Magnitude and Place. *Source: Author (Al Khaili) Data taken from Gulf News* (*2013c*).

2.5.1.1.2 Tsunami

Tsunamis are gravity water waves and typically occur following a large and relatively shallow underwater earthquake in coastal regions. They are generated by a sudden vertical motion of the ocean floor due to earthquakes, landslides, volcano eruptions or asteroid impacts (Heidarzadeh *et al* 2007). The main tsunami source in the region is the seismic activity of the Makran subduction zone (Rodriguez *et al* 2013). The 1945 Makran earthquake generated a tsunami of 11.5-17 metres in height (Murty *et al*, 1999; Pararas-Carayan, 2006), killing four thousand people and affecting not only the South Asian region but also the Arabian Gulf, including Iran and the UAE's large sand bar at Ras al-Khaimah (Chadha, 2007; Jordan, 2008). In 2012, the Pacific Tsunami Warning Centre initially forecast that a Tsunami could reach Fujairah in the UAE, following an earthquake in Sumatra, Indonesia. The threat did not however materialise (Shane, 2012). In 2015, Abu Dhabi, Dubai and Sharjah were all vulnerable to the possibility of tsunami activity (Kumar, 2009). Such activity also needs to be considered in light of the nuclear development which will bring four reactors (of combined capacity 5600 MWe) to the coastal site of Barakah (WNA, 2011) – (see in section 2.5.1.2.1 Nucleur Energy for more details).

2.5.1.1.3 Shamal and Dust Storms

Shamal is an Arabic word that can be translated into English as "north." It refers to the above normal northerly to north-westerly wind that blows in the Gulf. As of 2010, there is still no universal consensus as to what exactly defines a shamal. The UK Meteorological Office (1991, page unknown) states that it *is a hot, dry north-westerly wind which blows with special persistence in summer over Iraq and the Persian Gulf" and that it is "often strong during the daytime but decreases at night*. Others such as Rao *et al.* (2001) define it according to its speed and duration, given that it must register a mean hourly speed of 17 knots and last for at least 3 hours in any given day. It is the only persistent strong wind in the region that can last for several days. It routinely produces gale force winds and 3–4 m (10-12 ft) high sea waves (de Villiers, 2010).

There are two distinct *shamal* seasonal patterns, one in the summer and the other in the winter due to the specific dynamic processes. The winter one is the most intense in its horizontal and vertical extent (Perrone, 1979; Safar, 1980). It can, as a result of the turbulent mix of the cold frontal boundary with high wind speeds, throw up dust as high as 5 km. This carrying of dust combined with speeds of 8-15 m/s (up to 25 m/s for gusts) is known to significantly impact visibility, which can fall even to 0 m (Wilkerson, 1991).

The summer *shamal* meanwhile results from the interaction of the high pressure from the Mediterranean with that of the summer monsoon as it flows out of southwest Asia and into Saudi Arabia and Kuwait (Bartlett, 2004). Daily summer *shamal* winds, although longer lasting, are at a slightly lower velocity than their winter counterparts and average 7-13 m/s. Dust particulates reach slightly lesser heights too – approaching 3 km (Wilkerson, 1991).

As an atmospheric phenomenon, the summer *shamal* brings with it a wave of high pressure lasting from three to forty days, when passing through the UAE. It is thought to be, amongst over things, a concern to the UAE's super tall structures as its velocity differs at heights surpassing 400 m (Samarai and Quadah, 2007). As a yearly recurrent storm event (Hellebrand *et al.*, 2004), it also presents a major and frequent disaster risk

to the coastal region (Jordan *et al.,* 2005), which is also the most heavily populated area, where incidentally most of the construction and oil production occurs.

The true impact of the winter *shamal* winds on the coastal region and construction industry were evidenced on 11th January, 2005 when the *shamal*, combined with a high tide and storm surge, led to wave heights of four metres and the loss of a construction worker as he was swept out to sea (Gulfnews, 2005). In 2008, the *shamal* once more caused flooding in Ajman (Khaleej Times, 2008). In February 2014, *shamal* winds helped contribute to unstable cool weather and strong offshore waves that led to shipping warnings. Small inland dust storms were also reported (Kazmi, 2014).

Dust storms are also common and may cause a variety of problems. The reduction of visibility increases traffic accidents, and may increase the occurrence of vertigo in aircraft pilots. Meanwhile the environmental impacts include reduced soil fertility and crop damage, damage to telecommunications and mechanical systems, dirt and air pollution which lead to an increase in the incidences of respiratory diseases (Furman, 2003).

The UAE is one of the places in the world which suffer increasingly from dust storms (Al Mandoos, 2013). Between 2007 and 2011, dust events in the UAE occurred somewhere in the atmosphere for 239 days. The highest number of dust storms which affected terrestrial activity directly was in 2008 (68 days), the lowest number was 32 days in 2010 (Todorova, 2014). In 2013, sand and dust storms caused various low visibility issues leading to widespread warnings for drivers (Ruiz, 2013).

2.5.1.1.4 Climate Change

Fighting climate change should be a priority for the Emirati government, since 85% of the UAE population inhabits a thin strip of land along the coastline. The biggest city, Abu Dhabi, which lies practically at sea level, consists largely of reclaimed land. Furthermore, by 2050 the sea level increase could engulf 722 km^2. This anticipated rise, resulting from global warming, is expected to increase the severity and frequency of natural and manmade disasters resulting from oceanic and coastal hazards. Environmental catastrophes off the coast of the UAE were registered in 1996 and 1998, when a mass coral bleaching and mortality episode occurred due to seawater

temperature anomalies. This fact was published by the IPCC (2007) in their *Third Assessment Report.* The IPCC, in the same report, also highlighted concerns that climate change in the region could alter patterns of erosions and accretion.

According to Kumar (2009), the expected sea level augmentation of 5mm/yr is expected to seriously impact low-lying coastlines, which due to the high degree of infrastructural development, poses a serious concern for cities such as Abu Dhabi. Indeed between one and three percent of the land mass will be affected in the event of just a one metre sea level rise (Tolba and Saab, 2009). In addition, it can be argued that such offshore townships built on reclaimed islands could also be affected by inundation and erosion, due to that same sea-level rise and the related increase in storm surge events. If the sea rises not by one but by three metres, the UAE coastline is expected to shift 35 km towards the south-east, leading to a loss of around 80 percent of its mangroves, spelling ecological catastrophe for many of the coastal fauna and flora (Chowdhury, 2010; Oxford Business Group, 2010).

Apart from those complications associated with a sea level rise, climate change is also likely to exacerbate heat waves. They are forecast to become not only more frequent, but also more intense and prolonged. Heat waves, most certainly a health risk, are consistently linked to higher mortality rates. Other health issues set to rise in the UAE are those relating to an increase in the seasonal concentrations of allergens in the atmosphere. These allergens can cause severe allergic reactions and increase proneness to pulmonary disease. Malaria may also become prevalent (Tolba and Saab, 2009).

The UAE, in the face of such events, has however tried to mitigate the impact of global warming and associated disasters through various initiatives including the establishment of the *Green Arab Council*, the construction of Masdar—the first zero carbon city—and a mass afforestation programme. Masdar, in particular, is seen globally as an innovation in the fight against climate change, with its emphasis on new clean tech and technology transfers so as to remain in the vanguard. Solutions include concentrated solar power, waste-to-energy technology, geothermal solutions, power distribution, water management, desalination, cooling technology, grey water recycling, light rail and logistical platforms (Oxford Business Group, 2010).

New more demanding building codes are also being incorporated outside of Masdar to cut down carbon emissions (Bodart and Evrard, 2012). That said, general environmental concerns remain as do concerns about nuclear energy, given that this type of energy is being cited as a solution to the country's growing carbon footprint (see Section 2.5.1.2.1).

2.5.1.1.5 General Environmental Concerns

The enormous demand for aggregate, stone and cement has led to very extensive quarrying in the mountains and gravel extraction on the outwash plains, resulting in the loss of pristine mountain habitat and extensive dust pollution, whilst the development of artificial islands, ports, marinas and coastal residential areas has brought alteration and degradation of marine habitats through pollution and dredging (Gardner and Howarth, 2009).

Uncontrolled and uncoordinated urban growth has been shown to cause a lot of different ecological and socio-economic issues and risks in the UAE. The *Dubai World Centre*, for example, has already impacted the pre-existing 140 km^2 sand dune and *sabkha* ecosystem and has threatened nine species of mammals, diverse resident and visiting bird species, seventeen reptile species, a wide range of invertebrates and 43 species of plants (Gardner and Aspinall, 2006). This could lead to an environmental disaster with the full scale of its effects as of yet unknown. The same is true for Abu Dhabi as coastal development increasingly comes into conflict with the region's ecological and geomorphic systems and processes (Al-Harthi, 2008). This is largely due to the temporal inadequacy of a contractor's Environmental Impact Assessment which does not consider transient species or seasonal variation (Gardner and Howarth, 2009). In addition, the increasing demand for potable water and human land reclamation coupled with microclimatic change is expected to destroy the halophytic cover of the coastal dunes (Kendell *et al.,* 2000). Extensive oil production is also known to take its toll with 31 percent of the world's barrels passing through the Strait of Hormuz daily and threatening marine life in multiple ways: from oil pollution to thermal discharges (Doughty *et al.,* 2009).

2.5.1.2 Manmade Hazards

A manmade hazard is one which is caused directly or predominately by identifiable human actions, either deliberate or accidental. In this section, the thesis discusses war, terrorism and nuclear activity.

2.5.1.2.1 Nuclear Energy

Electricity for heating and cooling is the highest greenhouse gas (GHG)-emitting sector, accounting for 25 percent of global GHG emissions (Al Hammadi, 2013). Every year the UAE's global contribution of carbon is increasing because the Emirati energy demand has risen in the 21st century by nine percent per annum. This percentage is three times the growth of most other countries. The electricity usage per capita in the UAE is also notably high. To address this footprint, the country has increasingly committed to diversifying its energy generation technology and adopting cleaner technologies and practices, through the *Peaceful Energy Programme.* Nuclear energy forms an integral part of the programme and is expected to help reduce Emirati GHG emissions by around 12 million tonnes (Al Mazroui, 2013).

Nuclear energy is, however, very controversial. The 1986 Chernobyl accident and that of Fukushima Daiichi in 2011 are two important disasters that have highlighted the public to the particularly catastrophic consequences of failure. Risks relating to nuclear waste disposal are also known and have been well documented (Murray *et al.,* 1982).

The Emirates Nuclear Energy Corporation (ENEC) has set the target of delivering electricity to the UAE grid by 2017. It is projected that by 2020 nuclear energy will satisfy nearly a quarter of the nation's electricity needs (ENEC, 2013). In April 2010, Emirates Nuclear Energy Corporation lodged license applications and an environmental assessment for its preferred site at Barakah, which is situated on the coast 53 km west of Ruwais and 300 km west of Abu Dhabi city. It is planned to consist of four APR1400 reactor units designed to produce up to 1400 MWe each for a total capacity of 5600 MWe (Al Farra and Abu-Jijleh, 2012).

The applications were assessed by the Federal Authority of Nuclear Regulation (FANR). This assessment was subsequently re-written following the tsunami in Japan.

The building of the second of four reactors was made publically known in 2013 (WNA, 2013; Gulf News, 2013a). This made the country the first since China in 1985 to construct a nuclear plant where none had existed previously (Quevenco *et al.,* 2012). Safety and public perception is thus of paramount concern.

2.5.1.2.2 Terrorism

The UAE's main association with global terrorist activity is through its financial institutions. Illicit cash is also said to be responsible for the continuation of international crime and the continued support of terrorist groups (Mathiason, 2010). This has been blamed on a lack of border controls due to inadequate police funds and on the finance of many involved in illegal activity, including the Taliban, which render the anti-terrorist legislation useless (The Guardian, 2010; Cartwright *et al.*, 2007). In 2014, a new anti-terrorist law was passed in an attempt to severely curb any form of terrorist activity by (or perceived leniency shown towards) such groups or individuals within the country's border.

Terrorism is a difficult concept to define. It has arguably become increasingly difficult to do so as the methods and networks used to conduct terrorism have become increasingly complex. It is a term which is contested and intensely political in nature (Der Derian, 2005) with as yet no true consensus (Laqueur, 2003). Schmidt and Jongman (1988) compared some 109 different definitions and found that the most commonly occurring words were "violence, force", "political" and "fear", which were found in 83.5, 65 and 51 percent respectively of them. The most complete definition and the one used in this thesis when referring to either "terrorism" or "terrorist activity" is that provided by Hoffman (2006, p 40):

"The deliberate creation and exploitation of fear through violence or the threat of violence in the pursuit of political change... it is specifically designed to have far-reaching psychological effects beyond the immediate victim(s) or object of the terrorist attack. It is meant to instil fear within and thereby intimidate a wider "target audience".

The UK Foreign and Commonwealth Office states that the threat of terrorism in the UAE is "high" and that "terrorists may be planning to carry out attacks there" (FCO, 2012).

In addition, Australia, as of March 2013, states on its government webpage that:

We advise you to exercise a high degree of caution in the UAE because of the threat of terrorist attack. We have in the past received reports that terrorists are planning attacks against Western interests in the UAE. – Australian Government, DFAT (2013)

The US also remains concerned about the close proximity of Iran with regard to both nuclear and terrorist activity (Katzman, 2012). It also associates the UAE's large expatriate population, which includes several million Indian and Pakistani nationals, with a potential increase in terrorist activities, given that there have been incidents and terrorist groups in their native countries, which could have an impact on Emirati national security and stability (Overseas Security Advisory Council, 2013). That said, initiatives such as Dubai's *Al Ameen*, first launched in September 2013, provides a service whereby its citizens can communicate confidentially with the authorities via social media when there is a potential threat to the stability, safety and security of the UAE (Al Ameen, 2013; Kantaria, 2012).

UAE nationals also are shown to worry about terrorism. Research undertaken by Alomash and Al Khattar (2013), as shown in Table 2.1, indicates that the highest percentage of respondents, students of the University of Sharjah, saw terrorism as the "source most threatening to stability, societal and individual security". At 32 percent, the perceived possibility of high level threat is significantly higher than for natural hazards and still more than for war.

Table 2.1: Perception of Security Risk and Threats, according to a student population *Source:* Alomash and Al Khattar (2013).

Source	Frequency	%
Terrorism	135	32.5
Organized Crime	20	4.8
Poverty	69	16.6
Unemployment	58	13.9
Illiteracy	27	6.5
Natural Disasters	10	2.4
Disease and Epidemics	20	4.8
War and Armed Conflict	55	13.2
Other	22	5.3
TOTAL	416	100

Potential threats to national stability, stemming from regional uprisings since the Arab Spring in 2011, include terrorist activity and nuclear power-associated issues. The sudden explosion of extremist pseudo-religious groups, such as Islamic State in 2014, prompted the development of stringent national anti-terrorist legislation and penalties, some as harsh as capital punishment for the taking of female hostages and prison sentences for the carrying of mock bombs and other explosive devices in public (Dajani, 2014). The rationale behind this is to prevent the country becoming a fertile ground for terrorist organisations and training. Referred to as the strictest anti-terrorist law in the history of the UAE, terrorist activities were established as those acts:

..which result in the death of a victim, including attacks on a head of state or his family or a representative or officer of a state; coerced recruitment of individuals into a "terrorist" organisation; hijacking; hostage-taking; infringement of diplomatic or consular premises in committing a "terrorist" act; use of nuclear, chemical or biological weapons and assaulting security forces. (Salama, 2014)

As of late-2014, 83 organisations are listed in the UAE as terrorist groups (WAM, 2014). Some of them have obvious connections to terrorist activities due to their use of violent and criminal means to dictate their ideology. Obvious examples of this are Islamic State and al Nusra Front (an offshoot of Al-Qaeda). The designation of "terrorism" for others is less clear and even subject to criticism. The UK based charity Islamic Relief and the US based Council on American-Islamic Relations are two such organisations whose charity work, legal advice and fund raising is far from the terrorist activities the anti-terrorist law was designed to prevent (Bayoumy, 2014) The cause for concern and the heightened sensitivity surrounding terrorism have increased in light of

the lack of national preparation for manmade disasters (Swan, 2011). As of April 2013, some 97 people are on trial for local terrorism and trying to "overthrow the government." Western media has, as with the designation of western European headquartered Islamic charities, however questioned the legitimacy of this action, especially as the nation is yet to face any terrorist incident (Law, 2013).

In December 2012, the world's first-ever International Center of Excellence for Countering Violent Extremism (CVE) was inaugurated in Abu Dhabi. The centre, which is still in its embryonic stages, will be proactively engaged in three programme areas: research, dialogue and cooperation, and training (Gulf News, 2013). In June 2013, a national law was passed which meant that the centre became part of the private sector. Hedayah was established *due to the strategic challenge and widespread agreement on the need to prevent individuals from starting down the paths toward radicalisation, the embrace of violence, and support for terrorism, as well as to divert those already on that path before they are fully committed and mobilised* (Hedayah, 2013).

2.5.1.2.3 War

There are as many points of convergence as there are of divergence, when it comes to the similarities between war and terrorism. Both are clearly violent acts with instigators using them as an ultimate "solution" to complex problems which, they believe, cannot be fixed through more peaceful means. In many cases, both will stem from resource conflict. This could be in the form of high value minerals, such as gold and oil, or land and ancestral land rights. According to Tahmisoglu and Özen (2009), the major difference between war and terrorism is the way that capital (human, monetary, natural resource) is employed. Wars often have a legal element and may be defined as legalised attacks on one State from another, or in the case of a civil war, one group of identified people on another. Terrorism meanwhile is typically performed by a small group of individuals with the ultimate aim of changing a nation's or region's policy in a way that benefits the aggressors. Not all terrorist activity is perceived as "bad", especially if the ruling party is seen as oppressive or corrupt. It is often about wanting to see change and forcing that change. Terrorism in the 21st century has been heavily linked to the Middle

East region and the rise of Islamist ideology, meaning that the UAE does occupy a vulnerable position socially and geographically (Mallat, 2015).

The UAE is a stable country politically with good relationships with the West. It is however situated in a volatile region and, like many of its Gulf neighbours, worries about the impact of the previous conflict in Iraq (Terrill, 2005). Relations with Iran, due to the UAE's strong relationship outside of the Islamic states, particularly with the US, is also seen as a threat to national security and trade. In 2012, there were fears that Iranian-Emirati tension could cause the breakdown of maritime activities (Badih, 2012). National concerns surrounding the ownership the three islands of Abu Musa, Greater Tunb, and the Lesser Tunb have also proven detrimental to Iran-UAE relations (Assl, 2012). Many among the Emirati population are sensitive to the issue and believe that it is a cause of concern which could generate conflict, as shown by the primary questionnaire data reported in this thesis.

The regional conflict in Syria has not affected the stability of the UAE. The UAE does however participate in war zones and is the only Arab nation frequently involved in coalitions with the US, including in Afghanistan, Libya, Somalia, Bosnia-Kosovo, and the 1990 Gulf War, where it has either deployed force or provided assistance (EUAEW, 2012).

2.5.1.2.4 Crime

The general crime rate in the UAE is relatively low. Dubai residents, for instance, have a 0.00085 percent chance of being involved in a crime such as murder, assault, robbery or theft (Kantaria, 2012). According to a survey conducted in 2010 by the Emirati newspaper, *The National*, over 97 percent of the population (nationals and expats) felt safe. In 2014 an updated survey was undertaken by The National (2014) which suggested once more that neither Emirati nationals nor expatriates felt particularly unsafe or affected by crime. The number of concerned individuals did however rise. One third felt that crime represented some kind of an issue whilst 15 percent said that there was no issue at all. Where it was a problem, respondents believed the main causes of crime were alcohol (39 percent), drugs (37 percent), unemployment (32 percent) and a lack of discipline from parents (32 percent). Some researchers believe that this low

level of crime (or at least low perceived crime rates) results from the fact that 80 percent of the total population are immigrant workers who fear that illegal activity would result in their deportation (Gornall and Hassan, 2010).

2.5.2 Critical Emirati Energy Infrastructure: Resilience and Vulnerability

The Arabian Gulf is shallow, about 200 meters or less in most areas. The Gulf water moves slowly and has limited tidal waves. That said, the terrain, as observed by Hafez and Halim (2007), is flat, which plays a role in flooding risk and frequency. Most of the oil installations are either on the shore or in shallow water areas and major oil fields are either in the shallow area of the Gulf or in the desert adjacent to the Gulf shores. Severe weather, though infrequent, can include large tidal waves or sea storms. Terrorism presents a key issue which could easily affect the geopolitical stability of the region, if not the entire globe (given the number of energy installations), in addition to the impact on global trade, economy and operations (refer to Figure 2.10).

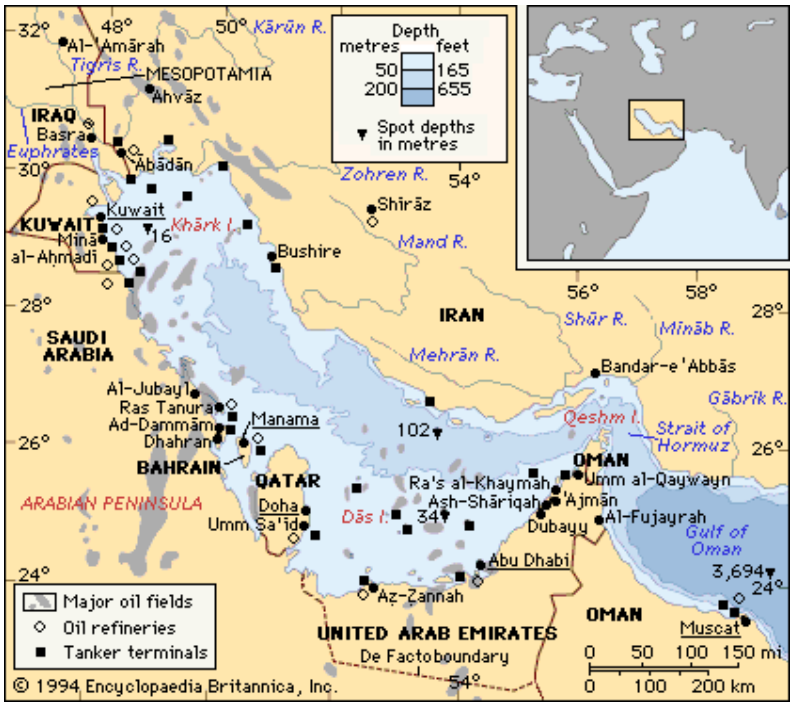

Figure 2.10: Key oil infrastructure as of 1994. Source; Encyclopedia Britannica [within] Hafez and Halim (2007)

As discussed elsewhere, the energy sector dominates the UAE and the Gulf region generally. The Emirati economy is the second biggest in the region, after Saudi Arabia (Kawach, 2011). The energy sector is therefore very much an economic powerhouse

responsible for the positive development of the nation. Some OPEC nations and many non-OPEC nations have seen production decline over the last five years, but the UAE has increased its total production of crude oil by approximately 31 percent and thus plays a highly significant role in global energy markets (EUAEW, 2011). Energy security and supply are equally a priority for a country that has built its reputation as the region's most stable country, both politically and economically, with attractive business opportunities that are not found elsewhere (Dalli and Wilcox, 2006a). The new development of nuclear power at Braqa, 33 miles from the coast, provides another prime reason for comprehensive strategic planning in the mitigation of disaster. The technological choice of *Generation III APR1400* which has enhanced safety features such as longer plant life (normally 60 years), enhanced user-friendliness, and burn-up rates ,and reduced fuel consumption and waste production (Al Farra and Abu-Jijleh, 2012), is a good example of manmade prevention (as opposed to hazard preparation).

It is irresponsible to ignore the UAE's vulnerability to various natural hazards. As development continues, the country and its people become even more vulnerable to the effects of those hazards. The issue of disaster is particularly acute on the coast where the highest population densities, the large number of high-rise buildings and commercial/residential structures are located. Ill-planned urban development has intensified, rather than abated, disaster. Preparations for any impending disaster have been slow and in fact, due to the country's recent legal establishment as a nation, large scale disaster preparation has featured on a national scene at an appropriate scale only recently. Every year brings more encompassing disaster management legislation and initiatives (Al Ghanim, 2010). In 2007, for example, a national emergency strategy was set-up to ensure a prompt, coordinated and efficient response to any potential disaster (Al Kindi, 2007). This is particularly important because of the four-fold nuclear reactor development at the coast of Barakah and the crippling effect of the Japanese Tsunami (WNA, 2011). The UAE must act in a proactive manner and must subsequently develop an appropriate disaster management strategy before any disaster event occurs.

2.5.3 Current Disaster Practices in UAE

The National Crisis and Emergency Management Authority (NCEMA) established in 2007 is the key government body for disaster and its management within the UAE's

borders. It comes under the Higher National Security Council and has the primary objective of ensuring the safety of the lives of all citizens and residents in the territory of the United Arab Emirates and to preserve the property of the country (NCEMA, 2014). It is responsible for the regulation and coordination of all matters related to emergency and crisis management, as well as for the development of a national plan for responding to emergencies. Its mission is:

To enhance the UAE's capabilities in managing crisis and emergencies by setting the requirements of business continuity, enabling quick recovery through joint planning, and coordinating communication both at the national and local level (Ibid, 2014).

NCEMA work on the principle of using an extended network to advise on the scale and the nature of a registered disaster, considering all its contributing factors. This obtaining of information is then followed by an "escalation procedure." This procedure has four categories of seriousness with four being the lowest and one the highest. Any escalation must be well-documented in any crisis/emergency plan and top management must be provided with a copy of the typical protocol. The steps for notifying NCEMA are the following (NCEMA, 2012, p.22):

NCEMA becomes aware of the event and declares it to be an 'emergency', formally notifying the NCTE Chairman, identifying the requirement to activate the NCTE team and /or government representatives; *NCTE formally notifies Licensee(s)*

A critical component of worldwide disaster management in 2015 is the use and control of social media. Social media is a rapidly growing global phenomenon and a tool for the mass and rapid dissemination of information. In the UAE, the spreading of information regarding two earthquakes, which occurred in quick succession on 9th and 16th April 2013, was almost as instantaneous as the earthquakes themselves. According to Al Holsini (2013), much of this information was misinformation, a situation which forced the NCEMA to appear on national television and various press conferences in order to calm the public after exaggeration led to widespread panic. This was despite the fact that no fatalities or physical injuries were recorded and no single building nor any form of infrastructure had collapsed. The threat of panic due to incorrect and/or unsubstantiated information entering the public realm has also meant that NCEMA must

maintain a constant presence on social media platforms, which it does through its YouTube, Twitter and Facebook accounts, giving members of the public the facts about disasters, the information necessary for their prevention, and advice during and immediately after their occurrence.

NCEMA also produces quarterly internet-based magazines in Arabic and English to keep the public informed as to disaster management practices, legislation and activity. Important developments which will shape disaster management in 2015 and beyond include *Law No. 7 of 2013*, which centres on the establishment of an independent and distinguished national academy for the training and development of young members of staff in the fields of safety, security, defence, emergency preparedness and crisis management, with the ultimate aim of achieving a standardised, integrated and efficient response to all types of threats, risks, incidents and crises. It is also expected to offer specialised conferences, forums and workshops to foster academic, scientific and professional partnerships in cooperation with relevant local and foreign authorities and agencies to exchange expertise and to establish and develop a modern database that would serve as reference to professionals and specialists (NCEMA, 2014).

Furthermore, and in line with the UAE's strategy for emergency preparedness, the Environment Agency - Abu Dhabi (EAD) inaugurated its Emergency Operations Centre (EOC) in 2013. The EOC collaborates with NCEMA and in many respects strengthens its position and expertise. It is thus heavily involved with risk analysis, scenario planning, provision of advice to executive emergency authorities, potential on-site crisis inspection, and direct line communication with key stakeholders. It does, however, work predominately on Abu Dhabi crisis issues and serves as a training centre to build emergency response capacities among the EAD staff (EAD, 2013). Dubai, meanwhile, was the venue for the 2014 *International Emergency and Catastrophe Management Conference & Exhibition* (IECM). The objective of the event was to support capacity building during an emergency situation. Through new practices, methodologies and case studies, it focused on issues faced by, and trending topics within, the Emergency Management Sector extending across the community (IECM, 2014). For the energy sector, specifically, another key organisation is the International Renewable Energy Agency (IRENA). It is headquartered in the UAE and is tasked with supporting the

building of resilience by diversifying the national energy matrix. The problem with these practices is that such conferences or international bodies have limited reach behind a small number of professionals, many of whom are international figures, in the industrial and the academic sphere. It is not enough to stage events or build headquarters. The government needs to work harder in ensuring that expert information is passed down to national actors for the benefit of Emirati development. It must facilitate communication and committees that serve to break down, not act as barriers.

2.5.4 Existing Barriers to Emirati Disaster Preparation and Resilience

The barriers in the UAE to disaster preparation and resilience are influenced, as in the case of any country, by a multitude of factors including external and internal influences on personal behaviour.

Specific to the UAE, Jones (2011) talks about one key attitude of entitlement rather than responsibility, which could affect the level of disaster preparation and resilience. Many Emirati citizens look to the State to deal with disaster and many other related aspects and do little in the way to proactively manage their own personal level of risk to a particular threat. In short, people either blame somebody else or feel there is nothing they can do. They do not assume personal responsibility (Bohm and Pfister, 2001). As Ayubi (1995, p319) asserts, *instead of the State taxing the citizen, then, the citizen is seen as taxing the State.* This barrier is one of expectation and a lack of participation from the grassroots level, given that everything is expected from the top down.

2.5.4.1 Disaster Education

To raise the skill base of Emirati society and to advance in the general direction of public policy, student and school performance and quality must be raised to international standards (Asimakopoulou, 2010). The first national media reporting of the Dubai Health Authority's Disaster Management Committee's call for disaster education, with emphasis on mitigation, at the school level was in 2010 (Saseendran, 2010). Yet by 2015, there had been no reported progress outside conferences and small meetings. Literature in English and in Arabic relating to education and disaster is notable by its absence.

2.5.4.2 Awareness

According to ACNielson (2007), only 16 percent of Emirate nationals are aware of climate change and global warming and even fewer are concerned. This statistic is perhaps not surprising, given the distinct lack of scientific literature and knowledge concerning the UAE climate. *ScienceDirect* and other academic databases indicate that the few English journals available on the subject arguably remain as limited, incomplete and scattered as they were in the 1990s (Boer, 1997). The availability of Arabic literature is considerably lower. This does not reflect the fact that the region is extremely susceptible to mass scale lifestyle changes in addition to economic and ecological devastation due to its geographical position, high levels of consumerism, unsustainable primary energy consumption (Kazim, 2007) and reliance on the energy market, as the reader has seen throughout.

The issue of limited education having a detrimental effect on disaster preparation and management is something which extends to the professional sphere. Loney *et al.* (2012) use the example of cement workers provided with masks to protect themselves from dust, only 12 percent of whom are trained in when and how to use them. Many third world expatriate workers have reported *(i) a lack awareness of the negative health consequences of specific occupational hazards; and/or (ii) not having been trained in, or not perceiving the benefits of adhering to specific health and safety requirements, such as the use of appropriate personal protective equipment* (Loney *et al.*, 2012, p.299).

A further issue related to disaster management is that many people in the Middle East, as followers of Islam, believe in the idea that life events (i.e. one's destiny) are written in advance (Aw, 2010) as reflected by the commonly used term "inshallah" or "if God wills". The concept of God's Will means that directing people to take precautions when working in occupations which demand health, safety, environmental or disaster management has cultural and religious sensitivities that do not generally apply to the Western world (Loney *et al.*, 2012).

Finally, a major consideration in terms of energy sector resilience is the limited application of renewable energy solutions, with the exception of the concentrated solar panel.

2.5.4.3 Renewable Energy Integration within the National Grid

Renewable energy has an important role in the development of a more secure energy sector, sustainable economy and resilient community. When larger conventional power plants fail, following an earthquake for example, the distributed form of energy that comes from solar and wind farms *etc* can play a part in keeping the lights on in those urban areas affected by a disaster. The ability to keep important facilities such as hospitals or emergency service locations working then further reduces the risk of indirect casualties or fatalities. Urban energy networks are particularly vulnerable during and after a disaster due to their geographic density and interconnectivity. Power outages caused in the U.S. by hurricanes Katrina and Sandy contaminated local water supplies, stopped telecommunications, and disrupted the availability of petrol and diesel, which then had an impact on the transportation of further goods and services (Leavitt and Keifet, 2006). Alternative energy options could have reduced the size of the resilience triangle in these communities.

Renewable energy is an important alternative in the energy matrix because it does not require the transport of fuels to generate electricity. During an earthquake it is not just roads but gas/oil pipelines that can become damaged or ruptured. This means that even if a centralised oil power plant has not been directly affected, it will not, after a disaster, be able to support the system. In fact, it will simply become another problem to solve. A dip in power due to the inability of a plant to stay online can cause immediate issues, given that it is a time consuming and costly procedure to bring base load installations back into working condition. Further blackouts can then occur creating further implications throughout the grid. More people are likely to be affected by a lack of electricity. As Panfil (2014) states, renewable energy does not only feed into the grid. It can also operate independently as a micro-grid and continue to supply electricity even when the rest of the system is down. This autonomous energy is then used locally. This is why further coverage of wind, solar and waste to energy technologies should become a priority for a well-developed and resilient disaster mitigation strategy, policy and plan.

The UAE has a strong potential to capture energy from renewable technologies. The most important resource is solar. The country has an average horizontal irradiance of 2100-2300 kWh/m^2, and clear skies some 80-90 percent of the time (ReCREMA, 2013). Despite this, in 2010 renewable energy did not contribute at all to the UAE's primary energy mix and was almost negligible in the secondary (Matsumoto, 2013). Abu Dhabi chose subsequently to make important and highly publicised investments into renewable energy technology in order to tackle natural gas shortages and issues surrounding the underproduction of electricity on the domestic front. The city's overall goal is to produce 2.5% of its total power by renewable means. Such a percentage is not particularly notable on a global scale. Austria, for instance, produces 78% of its electricity via clean energies (Krane, 2014). It is however notable in the Middle East, especially in the case of a country that is not obligated by United Nations to cut carbon emissions. The UAE government plans to cut the latter, via renewables, by 30 percent (Abu Ali, 2012). Shams 1, the world largest concentrated solar project, at 100 MW, is located in Abu Dhabi and is expected to power 20,000 homes (Saadi, 2014). Shams 2 and Shams 3 are two future projects that are to add a further 150 MW to installed capacity. Other solar projects involving rooftops are also key aspects of the government's goal to build upon the previously installed 10 MW solar photovoltaic project at Masdar (ReCREMA, 2013). Apart from Masdar, the fact that IRENA is headquartered in the UAE shows that the government is moving in the right direction.

Despite these obvious benefits, renewable energy alternatives must overcome various barriers. One of them is the question of directives, legislation, regulatory and financial systems that have evolved to promote, or at least facilitate, the development of the conventional energy options at the detriment to renewable innovation and adoption. Another issue, and perhaps interconnected, is the evident confusion over and lack of understanding when it comes to renewable energy options for electricity and/or heat production. Lack of training opportunities, even for energy sector workers, sector and public awareness and day to day dealings with renewables also means that the benefits of such technologies are not fully realised or even that they remain unknown. This, then in turn, increases the perceived risks of replacing or supporting oil and gas with solar panels, wind turbines etc. Media miscommunication, inaccuracy of information and lobbying have also slowed the uptake of renewable energy and created, in some cases,

public or sector apathy for alternative technologies. Political/economic strategy and limited transparency has also not helped matters, particularly in the UAE (Kumetat, 2014; UK House of Commons 2005; Assmann, 2012).

2.5.5 Strategic Mitigation Planning in UAE

The first of ten defined objectives for NCEMA (2007) on its establishment as a federal entity under the jurisdiction of the Supreme National Security, the lead national authority responsible for managing and coordinating emergencies and crises in the UAE, as stated on the organisation's webpage, was the following,:

Participating in, and supervising the preparation and coordination of, strategic plans to manage emergencies and crises and take all necessary measures in order to implement these plans in cooperation with organizations that have key responsibilities – NCEMA (2007)

In addition, the UAE Government (2011) stated the need for a national government strategy and direction to:

Respond effectively to climate change and environmental hazards by mitigating and adapting to the impact of climate change, ensuring compliance with the UAE's international environmental obligations, ensuring an effective response to UAE-specific environmental challenges, and improving food security (UAE Government Strategy, 2011-2013, p.15)

Strategic mitigation planning has therefore been at the forefront of Emirati politics and actions since 2007, and is something which is continuing into 2020. Whilst there appears to be both policy and political support for strategic planning for disaster mitigation, there is very little in the way of detailed information or practical steps which could make this policy drive a practical reality on the ground. There is also, apart from the author's own publications (Al Khaili and Pathirage, 2014), no updated information post the 2011-2013 Government Strategy. This is why, as discussed in depth in Chapter 5 and 6, this thesis plays a key role in enhancing disaster management and strategic planning for the Emirati energy sector.

2.6 Chapter Summary

This section states the issues of disaster management and the building of resilience within the context of the Emirati energy sector. It first involves a discussion on the theory, concepts and tools used, including how a disaster is defined and classified and how different disasters can be collectively classified into phases which can be managed according to the disaster management cycle. The literature review then becomes more specific, developing a discussion on resilience, strategic management, and critical infrastructure and energy facilities within the Emirati context. The review then turns to those phenomena, both natural and manmade, which cause vulnerability within the national (and regional) energy sector infrastructure including tectonic activity, climate change, nuclear energy, terrorism and war. The literature review finally looks at the barriers to disaster preparation and resilience, such as a lack of understanding of renewable technologies, through the lens of cultural and religious sensitivities and expectations. This review feeds into the framework development of Chapter 3.

CHAPTER 3: CONCEPTUAL FRAMEWORK

This chapter uses the information presented in the previous chapter to put forward a conceptual framework that would help to mitigate disasters within the Emirati energy sector. This will subsequently be modified in line with the results reported in Chapter 5 and converted into a final framework in Chapter 6.

The purpose of a framework for disaster risk management and mitigation is to reduce the underlying risk factors and to prepare for and respond to a disaster event, when and if it should occur. The focus of this framework, as with the literature review, is the pre-disaster phase. Actions in this phase aim to improve community capacity and disaster resilience through prevention, i.e. avoidance, or where this is not possible, mitigation, i.e. limiting the impact of adverse effects and providing timely and reliable hazard forecasts. As one moves on to the response phase, the focus changes to one of saving lives and property. In the post-disaster phase, the focus changes once more to recovery and rehabilitation.

This chapter should therefore form the basis of a public and institutional commitment, including organisational capacities, policy and legislative development and community action, as well as environmental management, land-use, urban planning, protection of critical energy facilities, research and development, and partnership and networking, through a tripartite committee. The framework, through that committee, should have the scope to provide space for traditional communities to be involved constructively and to take ownership of the strategic disaster mitigation plan, thus diminishing excessive or unnecessary dependency generated by relief offered by those from outside the community or even outside the UAE.

The data analysis presented in Chapter 5 will allow this draft framework to be amended and support the development of a final strategic disaster mitigation plan (Figure 6.1) to be presented to the Ministry of Energy, amongst others.

3.1 Constructing a Strategic Disaster Framework

Sekaran (2003) defines a strategic framework as "*a conceptual model of logical sense of the relationships among the several factors that have been identified as important to the*

problem". Fisher (2007) mentions that the relationship between a literature review and a framework is that the former provides the raw materials from which the latter is built or developed (as in the case of this research). Saunders *et al.* (2009) indicate that a framework helps organise and direct data collection and analysis (as this research does). Furthermore, Fisher (2007) points out that a framework prepares and helps undertake research findings, and gives a sense of control over the research.

The United Nations Office for Disaster Risk Reduction (2014), in a press release entitled *Towards a Post-2015 Framework for Disaster Risk Reduction,* discusses the need to improve conceptual disaster frameworks in order to enhance disaster risk management. One of the key considerations is how disaster risk management, particularly full risk assessments, can contribute to national (and regional) development. Risk reduction and resilience building must come from integrated development mechanisms that include all societal members. Any real tackling of disaster, from its roots, must "*incorporate national public investment planning systems, social protection, and national and local infrastructure investments"* (UNISDR, 2014, clause no. 14). The design and answering of the questionnaires and interviews should identify where there are weaknesses in planning and local infrastructure investments, so that resilience in all its forms—technical, organisational, social and economic—can be enhanced.

3.1.1 How should strategic planning be considered in a framework to develop a plan for the mitigation of disaster in the Emirati energy sector?

In Chapter 2, the terms "strategy" and "strategic planning" and their application within a disaster management context are evaluated. The purpose of strategic planning is to reduce the possibility of a natural event or manmade hazards impacting the Emirati energy sector. It defines directions and plays an integral role in the making of decisions for the allocation of the necessary resources (human and monetary capital). This type of planning also identifies strengths, weaknesses, opportunities and threats, leading to various benefits, including improved organisational performance, the development of teamwork and expertise, the amendment of inherent organisational issues and the establishment of clarified norms and priorities - all of which clearly serve to advance disaster management and emergency response (Bryson and Delbecq, 1979). Doherty

(2008, p33) identified five steps in putting together a strategic plan for disaster management:

1. Identify the targets – Who might be affected and who might not?
2. Type of help – What assistance do they need?
3. Timing – When will assistance be most useful and when will circumstances allow assistance?
4. Theme – What are the themes, issues, concerns and threats that should be considered in order to build and plan the right intervention package? What has already happened and what will happen in connection with the incident?
5. Team and Resources – What resources will it take to provide the right interventions at the right time(s)?

In a conceptual disaster framework, and in order to answer the above questions, it is important to clarify the definitions of those terms that are used in the disaster discipline. In the previous chapter, the literature review, the reader was introduced to the concepts of hazards (manmade and natural), risk, vulnerability and disaster resilience. These interrelated—and perhaps even competing—conceptualisations and terminologies are particularly problematic in a discipline such as disaster theory, which incorporates various other sub-disciplines and is characterised by considerable collaboration between scholars from many different research traditions, including risk assessment, climate science, sustainable development, economics and policy (Fussel, 2006). It is thus of the utmost importance that these practitioners (frequently exposed to disaster theory) and the general public (ignorant of it) understand a common language, so as not to create general tensions and cause communication breakdown. Once a common language has been decided, those involved in disaster management can operate more effectively and efficiently.

3.2 Key Components of the Framework

A solid disaster framework will need to consider the exact nature, not just the definition, of hazards and vulnerabilities, critical energy infrastructure, barriers as discovered in the data analysis and latent issues that can affect the four measures of resilience, as listed by Chang and Shinozuka (2004):

- **Technical** resilience refers to how well physical systems perform.
- **Organisational** resilience refers to the ability of organisations to respond to emergencies and carry out critical functions.
- **Social** resilience refers to the capacity to reduce the negative societal consequences of loss of critical services.
- **Economic** resilience refers to the capacity to reduce both direct and indirect economic losses.

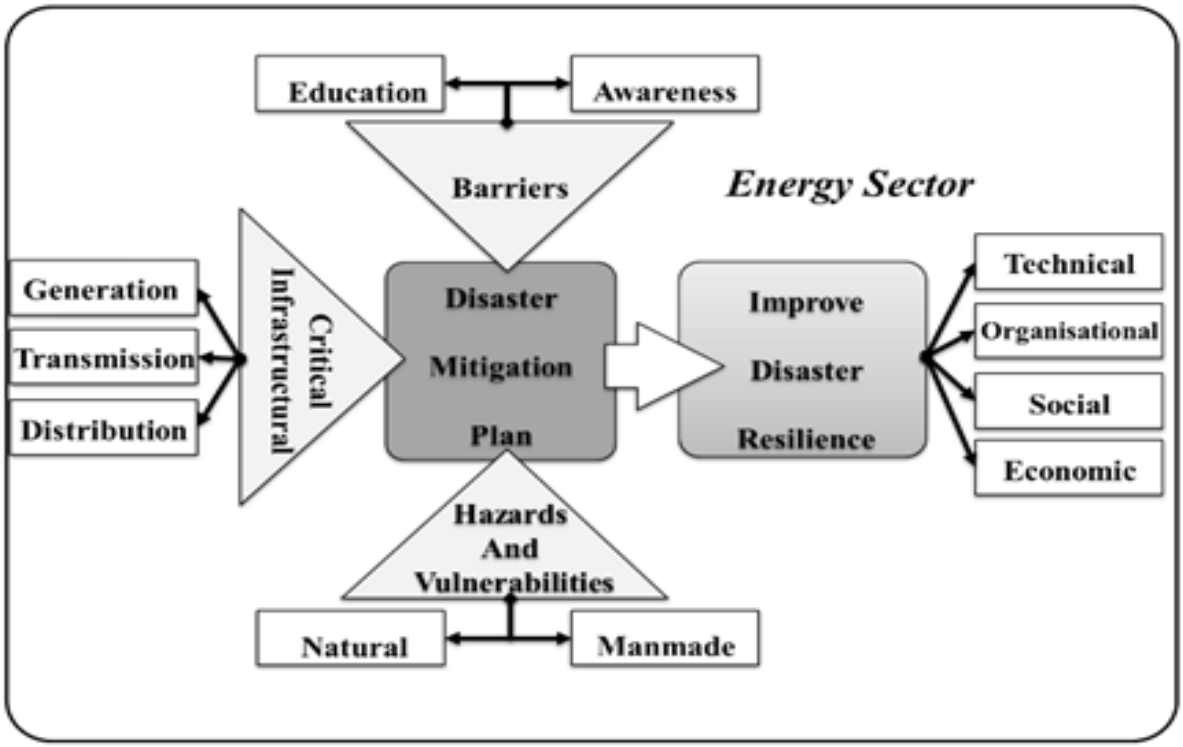

Figure 3.1: Conceptual framework for improving energy sector disaster resilience.

3.2.1 Hazards and Vulnerabilities

Any conceptual framework must introduce the natural and manmade hazards likely to be faced by a given community. In this thesis, most of this information will come from the secondary sources included in Chapter 2. Any primary information will come from the carefully selected members of a tripartite committee. This committee should include members of civil society as well as established members of the government and key individuals within the energy and associated industries. A productive and ultimately successful tripartite body will convene when necessary. Fundamentally, it is established

to provide actors from each of the three positions who can contribute to a national forum, that is to say, a platform upon which the country can solve or at least mitigate a given set of problems that have been identified in areas from policy to social action (Casale, 1999). All of those involved must agree clear definitions of the terms used within the discipline, as has been explained in Chapter 2 and then in this one.

Probability calculations and past occurrences should be discussed, along with current and future concerns such as those linked with anthropogenic global warming. The framework and the subsequent final disaster mitigation plan will direct the tripartite committee to look at all such hazards, natural and manmade, and the interactions between them. It will also look at the geographical dimension of hazards, recognising that they can occur on an international, national, sub-national or local scale.

3.2.2 Critical Infrastructure

Any disaster framework for the energy sector must identify the critical infrastructure. These considerations can be amended in the final strategic mitigation plan, as key information from the data collection and analysis comes to light (please refer to Chapter 6).

In Chapter 2, critical energy infrastructure was shown to have a broad definition. It was said to include any:

"*… physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact on the nation or affect its ability to ensure national security" [p30]*.

Critical infrastructure is not an easily definable physical object but rather an indefinable network, not confined to boundaries. This lack of boundaries means that critical energy infrastructure should not be seen only as that which exists within the conceptual walls of "energy generation". There can be no true sense of ownership when the "parts" of a network often, if not always, constitute more than one sector and are critical to many societal functions, not just those related to power production. All parts make up the whole and it takes a holistic perspective to fully immerse oneself in the real concept of

critical infrastructure. That said, whilst an infrastructural network may be neither definable nor confined, a thesis is by definition bound by a scope that takes into consideration the researcher's and participants' resources and time. Here in this framework, it will be the energy sector managers who identify the most critical aspects of infrastructure, their jobs and functions.

If the idea that no single part is more important than any other - given that the failure of one will still affect the whole system- is the one that most readily resonates with disaster theorists and those involved in energy production management, any strategy and mitigation plan must likewise construct all future contingencies on that basis. That is not to say, however, that more resources should not be in place to protect the most expensive, delicate or complex installations. It would be counterproductive or even impossible, to afford the same level of protection and financial input one gives to a gas turbine, to the safeguarding of a single cable. In a disaster mitigation framework there should be a weighted comparison provided as to the importance of each part and a cost-benefit analysis undertaken to evaluate the most appropriate division of resources (human, financial, *etc*) so as to best support optimal performance of the electricity grid and the energy sector.

A cost-benefit analysis is a planning process most readily associated with the decision to commit (or not commit) funds or assets. According to Bennett (2007, p.323), it is *a systematic attempt to measure or analyse the value of all the benefits that would be achieved from a particular expenditure*. This expenditure can take various forms. In any case, it typically involves three steps – 1) the identification of all direct and indirect consequences of a given expenditure, 2) the assignation of a price (monetary value) to all costs and benefits resulting from that expenditure and 3) the discounting of potential costs and savings that have occurred as a result of that expenditure.

A cost-benefit analysis should be combined with a more quantitative model based approach for risk analysis. The latter is comprised of risk assessment and risk management. The former refers to the measuring of risk, taking into account probabilities, system vulnerability and expected damage. The latter involves the process of selecting counter measures and modelling their impact on risk reduction (Setola and Geretshuber, 2009).

An interpretation of a risk model would still have to occur but value judgements are, following a modelling procedure, more likely to be uniform and perhaps even better understood and replicable at other sites. For example, in taking into consideration data relating to historical records, and in analytically determining measurable consequences such as time of service interruption and the number of people injured, decisions are more likely to reflect the seriousness of any given implication and not excessive individual concern or whim. Modelling has the added benefit of fine tuning and relatively "easy" updates and amendments as more data becomes available.

A lack of data makes it more difficult not only to model the effects of disaster but also account for losses and investment decisions. Energy sector management can defend with vigour their investment decisions if they can show some logic. Governments and private sector actors can only show a logical chain of decisions once they are able to take ownership of their assets and identify through a suitable form of risk analysis that which is most vulnerable.

According to Butts and Shenoi (2014), a good risk analysis should be able to show any professional exposed to a hazard, the current risk levels, how and why the cost-benefit analysis decisions have been taken, their effect on risk reduction across multiple assets and at multiple hierarchal levels, including management and the changes in resilience over time. Most of the information required to do this is generically available, in any number of case studies from across the globe. After determining the definition of critical energy sector, one must consider the role of disaster risk management and how this supports sustainable development.

3.2.3 Barriers to Improving Disaster Resilience

The section on barriers and the TOSE measures of resilience will discuss disasters of all types, both natural and manmade. The former are classified as those linked to tectonic activity (earthquake, tsunami) and to atmospheric phenomena (*shamal*, climate change, dust storms), while the latter are those associated with environmental concerns, nuclear energy, war and crime. More specifically, this section will consider the following points, which could affect the level of disaster preparation and resilience:

- The fact that many Emirati citizens look to the State to deal with disasters and many other related matters, while doing little to proactively manage their own personal levels of risk to particular threats;
- Disaster education and training;
- Disaster awareness;
- Renewable energy integration within the national grid.

This discussion will be developed further in light of the data presented and analysed in Chapters 5 and 6 respectively.

3.3 High Level Community-Based Dialogue: First Priority, Three Way Process

The first step in a comprehensive disaster framework should be the development of a dialogue. For high level communications to be successful, all the important actors in the public and private sector must be invited to participate and the logistics of this must be considered at this stage of the draft framework so that decisions are not restricted to those solely in the energy sector, given that its infrastructure and energy provision do not operate in isolation. In fact, as aforementioned, any structures involved in electricity generation constitute more of a network than a physically defined boundary. Thus, for resilience to be built, cooperation must be prioritised at all government levels and across company policies. Meetings need to be scheduled in order to create dialogue and trust. The issues presented in Chapter 2, along those which will become clear following the data presented and analysed in Chapters 5 and 6 respectively, must be shared if one is to bring about real change.

For a tripartite council to function "properly" and to ensure all voices are heard, all three components must be equally represented. This may, but does not have to necessarily, mean that if there are three government members, there are also three from the private sector and three from civil society. Tripartite cooperation is not however a "numbers game". All parties must be strong enough to carry out their functions and roles effectively and decisively. There needs to be structure, and representatives must have not only technical capacity and theoretical knowledge, but also the commitment to drive the process forward (ILO, 2000). It is also about finding a balance and common ground between the interests and needs of all the representatives involved.

To take two of the three parties of a tripartite body thus formed - civil society and the government - both the State and its citizens can benefit from the construction of a network connecting them and a series of mediating steps. Government programmes, including but not limited to disaster mitigation, are enhanced when the government interacts with organised groups of people. Civil society also benefits as it finds power and when it acts as a means to mobilise social capital and meet development objectives (Krishna, 2001). As the reader has seen, sustainable development and good disaster management policies and practices go hand in hand. A working relationship between the two concepts relies on strong bonds of trust and dialogue, and these in turn create and maintain social capital. According to Krishna and Prewitt (2000, p4):

Social capital in this reckoning has both a cognitive dimension - consisting of norms, values, attitudes and beliefs that predispose people toward collective action - and a structural dimension, composed of formal or informal organizations that facilitate collective action for achieving some common objective.

An important common objective would be the safety and prosperity of a community well-rehearsed, informed and subsequently resilient when it comes to facing disaster. Some authors, such as Hamada (2014), argue that for the effective reduction of natural disasters, tripartite elements are indispensable. The author is not surprised by this view. After all, industry is an important partner given that its designs, innovations and implementations are just as responsible for a building *not* falling in the event of an earthquake, as a government is when it puts into place policies to protect its citizens and infrastructure. Academics, themselves part of civil society, who advise on policymaking also have their role and responsibility. Therefore quite clearly:

The task of mitigating the effects of natural disasters is not restricted to the fields of science such as seismology, geology and engineering… to effectively confront this challenge, those working in the fields of sociology, economics, humanities, information science and medical science must also be involved – Hamada (2014, p xiii).

An Emirati tripartite council for disaster management must include government representatives and must not be limited to those working in the planning departments (national and local). This council should include the Critical National Infrastructure

Authority, the National Emergency Crisis and Disaster Management Authority, members of the Ministry of Energy, Ministry of Environment and Water, Ministry of Education especially the Minister of Higher Education and Scientific Research, Ministry of Culture, Youth and Community Development and the national and local environmental authorities and law enforcement members. Industry associations and affiliations and key constructors already in the UAE, along with manufacturers of key energy generating equipment are members of the industrial sector. Inviting important innovators and providers in renewable energy technologies is also advisable, given the points discussed in this chapter. As for civil society members, there is the need to invite key community members, academics across the disciplines and institutions and non-governmental organisations (NGOs) normally involved in disaster relief operations. NGOs should be a combination of both international and national actors. All should be encouraged to share advice and build capacities. National examples include the Khalifa Bin Zayed Foundation, Zayed Bin Sultan Foundation, Dubai Cares, Dubai Charity Association, Human Appeal, and Fujairah Welfare Association. International options may include organisations such as the Red Crescent and the United Nations.

Themes that need to be discussed and the rationales behind them, as supported by the collected data in the literature review and the primary data from the field, are presented in Table 3.1. The column “urgency” is a transitional concept whereby the tripartite council should not merely prioritise those elements considered highly urgent but go on to address those less urgent through them.

Table 3.1: Themes to be discussed in a tripartite disaster community in preparation for a final strategic disaster mitigation plan. Source: Author

Themes	Urgency	Rationale
Leadership in Disasters: Measuring Effectiveness and Strategies	High	Disaster management must be integrated into mainstream government operations if it is to be successful. A leader's capacity to collaborate effectively with disaster networks is essential. Frequent interaction, including participation in planning and training exercises, builds capacity and enables those in the highest positions to measure the effectiveness of strategies and actions (Waugh and Streib, 2008).
Risk Management, Reduction and Mass Communication	High	Information and Communication Technologies (ICTs), for example, can be used to support the practice of disaster risk management. They can be mass utilised in times of crisis, planning and reconstruction. Their potential stems from their ability to instantaneously connect vast networks of individuals and organisations across great geographic distances. This facilitates fast flows of information, capital, ideas, people and products (Crane and Phillips, 2014). All these are extremely necessary if a community is to become more resilient.
Recovery: Defining, Planning, Measuring and Financing	High	Long term recovery from disastrous events is more of a central concern than ever before. Pre-disaster recovery planning is likewise important. There is also the added pressure to combine recovery with economic development. It is also seen as a catalyst for the tackling of social and environmental issues, especially if they exacerbate or are exacerbated by a potential hazard.

Themes	Urgency	Rationale
Disaster Law and Policies	High	Policies and legal frameworks are indispensable tools in addressing the threat of disaster. According to the collaborative effort by the Red Cross and Red Crescent (2011), empirical evidence has shown that, when well designed and adhered to, laws can focus and strengthen State efforts to prevent and respond to disasters. They can also empower communities and civil society organisations to contribute effectively to disaster management and resilience. On the other hand, when poorly prepared, legal and regulatory regimes can block and frustrate progress, contributing to, rather than reducing, the impact of disaster.
Identification of Risk Groups: The vulnerable elements of society	Medium	Prioritising of resources and providing of support to those that are considered to be the most at risk ensures that disaster management is optimised through a well-coordinated programme which minimises, monitors and controls the probability and/or impact of unfortunate events or maximises the realisation of opportunities.
Community Resilience: Initiatives, engagement and recovery	Medium	Managing disasters efficiently and effectively begins and ends with communities. Those located in hazardous areas are not helpless victims of events outside their control. They may have limited options but if given opportunities, they can engage in initiatives that build resilience (UNV, 2011).

Themes	Urgency	Rationale
Behaviour change: Cultural, public and organizational	Medium	A good disaster risk reduction framework is composed of public commitment and institutional frameworks, including organisational policy, legislation and community action, along with public awareness, provides a good structure for behavioural change. Public awareness activities foster changes in behaviour, leading towards a culture of risk reduction. This typically involves public information, dissemination, education, radio or television broadcasts, use of print media, as well as the establishment of information centres and networks and community and participation actions (DMIB, 2015).
Resilience in Infrastructure	Medium	A discourse in resilience needs to be developed and defined for critical infrastructures (such as the supply of basic services like water, food, energy, transport, housing/ shelter, communications, finance, health). The wider public should be integrated into the process to better address human and social dynamics in crises and disaster situations. Resilience concepts must lead to the anticipation, planning and the implementation of key strategies and processes throughout the disaster cycle.

Themes	Urgency	Rationale
Local Government Initiatives	Medium	Virtually all disasters are experienced at the local level. In many cases any affected community will be isolated for up to 72 hours after the original impact. Thus, and although all levels of government are involved in disaster management, the role and actions of the local government is perhaps the most critical (Col, 2007). Empowering local governments and communities enables them to bring their skills, knowledge and experience to the forefront of disaster preparedness, response and recovery efforts (Queensland, 2013).
Volunteers: Engagement, training and support	Low	Volunteers provide essential surge capacity and links to community resources (Waugh and Streib, 2008). During disaster, there is a heightened need for manpower. The planning of the recruitment and retaining of volunteers is essential. Better preparation results in a more effective response. A comprehensive volunteer management system must be developed. It must include a volunteer needs assessment, and a way to recruit, match, train, supervise and give recognition to volunteers (Wong, 2006).
Innovation in Disaster Management and Governance	Low	Innovative thinking in risk, crisis, and disaster management provides more successful ideas and action plans for dealing with these. Approaches could include delegated authority and exploitation of 'lay' knowledge (Bennett, 2012).

Themes	Urgency	Rationale
New Technology and Social Media	Low	The advent and establishment of social media and networks, particularly in the Middle East, has led to progressively more freedoms, ill-afforded by the mainstream media. According to Jamali (2014), it has become an important and active means to express opinion and share knowledge among the general population. This can as, Potts (2013) points out, be an important tool in disaster management. Technological advances with good governance saves lives and limits destruction. Innovative options that the tripartite council may consider include early detection, warning, notification and command and control systems, erosion and other disaster prevention and control technologies, new roads and evacuation vehicles. According to Sutton (2013), drawing up an effective social media strategy and tweaking it to fit an emergency is a crucial part of preparedness planning. In addition, the public must be taught how to use social media effectively, how to get information from the Internet and to put out useful information.

In addition to permanent members of the committee, there should also be expert consultants who join proceedings when it is necessary or when what they have to say is of added significance. Some of these experts may be international and well-known in their field. The input of a geotechnical expert would be valuable when a tectonic disaster has affected a power plant or when one is being designed and built to withstand such an event. Other important consultants may include PR leaders and those who work in the media. Citizens and newspaper reporters and informers have insight into a whole range of issues and typically have access to a wider social network. This is useful when

the committee needs to engage with a specific community. It may also be of value when there is a desire to disseminate information or even prepare a press release or initiate a social media campaign. This can be done in the form of a roster whereby key and *trusted* members of the local, national and international press operate as dual communication channels. They provide information to the committee, regarding conditions on the ground in the aftermath of a particular disaster and feed advice that reduces the immediate impact or helps build resilience in the long term.

The initial five-year plan, say for 2016-2020, should form the baseline of a disaster mitigation programme. It should also be treated as a working document that is subject to updates as more information becomes available, according to a clearly stated and proactive timetable or Gantt chart. All stakeholders, i.e. those who are required to read and act on the plan or are simply affected by it, should be notified when it is revisited and reviewed. They must be informed as to who reviewed it, where exactly and for what purpose. Any major changes, substitutions or additions of sections and/or content must be made clear and communicated efficiently (Todaro, 2009). Such updates can be emailed, posted or presented in person as amendments or annexes. The exact means of communication will depend on the group or individual and should have been identified in the communication chapter or in a more comprehensive sister document.

3.4 Chapter Summary

This chapter has outlined the practical knowledge needed to develop a draft strategic mitigation plan. This draft will be consolidated by the findings elaborated in Chapter 5 and discussed in Chapter 6. The final strategic disaster mitigation plan will be elaborated on in Section 6.7. The present chapter has discussed some of its key elements, such as how it will be constructed and which content is significant. The latter includes the definition, explanation and typology of hazards and vulnerabilities, critical infrastructure and barriers to resilience in technical, organisational and economic terms. Finally, this chapter has looked at how high-level dialogue might occur, its mechanisms and the personnel needed to support it.

CHAPTER 4: RESEARCH METHODOLOGY

4.0 Introduction

Research methodology is considered as a key element in any thesis. It refers to the selection and use of a certain philosophy, strategy and techniques for data collection and analysis (Collis and Hussey, 2009; Chandler, 2006).The research aim and objectives are the main issues that determine a suitable research methodology (Saunders, *et al*., 2009).

The uniqueness of disaster theory and its methodology is not the knowledge obtained in the research, or even the instrumentation of methodology, but rather the unique set of circumstances in which otherwise conventional methods are applied. Any disaster researcher must consider not only research methods but also how the circumstances surrounding disaster affect the implementation of these methods (Stallings, 1997).

This chapter investigates the types of philosophies, approaches, strategies and techniques of data collection used in this present research. Subsequently, this part of the thesis describes the interview protocol and the validity and reliability of the analysis employed in achieving the aims and objectives set out in the first chapter.

4.1 Research Methodology

According to Connaway and Powell (2010, p1), research methodology is a "method of study by which, through the careful and exhaustive investigation of all ascertainable evidence bearing upon a definable problem, one can reach a solution to that problem".

Methodology is an established logical and systematic process of achieving certain ends with exactness and efficacy, commonly in an ordered sequence of fixed steps (Business Dictionary, 2014). Likewise, Hanze University (2014) defines research as the purposeful and methodological search of new knowledge and practical solutions in the form of answers to questions formulated beforehand.

Saunders *et al.* (2009) describe research methodology as an 'onion' with six layers, as shown in Table 4.1 and Figure 4.1. The external layer is the research philosophy, the second layer is the research approach, the third is the research strategy, the fourth the choices made, the fifth the time horizons and the sixth data collection and analysis

(Figure 4.1). It is one of the widely accepted frameworks that can be used to clarify a methodological position. Its multiple layers become progressively more detailed as one moves from the outer to the inner layer. Wedawatta (2011) affirms that it is important to consider these layers in determining what methodology to adopt for a particular study. Subsequent sections describe these layers and their relevance to this research.

Table 4.1: The breakdown of the research onion. Source Saunders *et al.* (2009)

Layer	Approaches
1.Research Philosophy	Positivism ,Interpretivism (Or Phenomenology), Realism
2.Research Approach	Deductive , Inductive
3.Research Strategy	Experiment, Survey, Case Study, Ground Theory, Ethnography, Action Research
4.Time Horizons	Cross Section, Longitudinal
5.Data Collection Methods	Sampling, Secondary Data, Observation ,Interviews, Questionnaires
6.Research Choice	Mono-Method, Multi-Method, Mixed Method

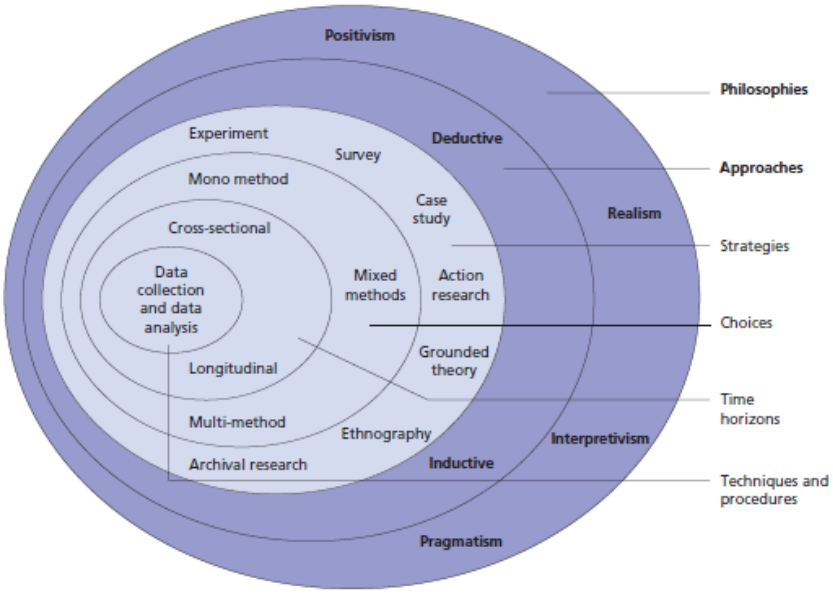

Figure 4.1: The research onion Source: Saunders *et al.* (2009)

This research examines the resilience of UAE's energy sector, and aims to develop a framework to facilitate the improved resilience of its energy infrastructure facilities by developing a strategic disaster mitigation plan. In order to understand the components of

the energy sector (from key electricity plants, network equipment and final users) of key Emirate states, it needs a research methodology to describe the overall approach used to generate new knowledge, based on the appropriate philosophy. The next section sets out the research philosophy adopted here.

4.2 Research Philosophy

Saunders *et al.* (2009) argue that research philosophy reflects the way the researcher thinks about the development of knowledge. Likewise, Yin (2009) and Collis and Hussey (2009) state that there is no definite rule of which philosophy to select when doing research. It all depends on the nature and scope of the thesis, research aim, objectives, research questions and source of data collection.

Saunders *et al*. (2009), Collis and Hussey (2009), Easterby-Smith *et al*. (2004) and Hussey and Hussey (1997) attest that there are two main research philosophies in social sciences: positivism and interpretivism. However, before defining theses stances, an author must know the philosophy behind it; that is to say, its ontology, epistemology and axiology.

4.2.1 Ontology

Ontology is concerned with the nature of reality. It is a general set of assumptions about what is reality (knowledge) (Aouad, 2011). It is a concept concerned with the existence of, and relationship between, different aspects of social actors, cultural norms and social structures (Jupp, 2006).

In a philosophical sense, it is the study of the nature of being, becoming, existence and the concept of "reality". Audi (1995) refers to ontology, as the study of explaining reality by breaking it down into concepts, relations and rules. In positivist philosophy the reality is objective, structured and external to the researcher, as in the field of natural sciences, consequently, there is only one reality experienced by us all (Collis and Hussey, 2009; Sutrisna, 2009). However, Sutrisna (2009) and Collis and Hussey (2009) argue that interpretivism states that the world holds an unknowable reality, as in the field of social sciences, where every person has his/her own sense of reality. Therefore,

interpretivists believe that there are multiple realities because reality is socially constructed by people differently (Aouad, 2010).

In the context of knowledge sharing, which is one of the fundamental pillars of successful disaster management, ontology according to Grolinger *et al.* (2011, p2) is: *A formal, explicit specification of a shared conceptualisation that provides a common understanding of information. They also provide a way of representing human knowledge, making it readable and understandable. This, in turn, represents the basis for achieving semantic interoperability.*

In other words, and according to Gruber (1992), ontology is a description of the concepts and relationships that can exist for an actor or a community of actors. Pragmatically, a common ontology defines the vocabulary with which queries and assertions are exchanged among actors. Ontological commitments are thus agreements made, so those involved use shared terms in a coherent and consistent manner. Ontology can thus, as stated by Wache *et al.* (2001), be used to reveal both implicit and hidden knowledge. Understanding and constructing a consensus ontological stance has its obvious benefits in disaster management. Confusions leading to hesitations or even prevention of a given action may hold grave consequences including fatalities.

The ontology followed in this thesis is interpretivism: the world is produced and reinforced by humans through their actions and interactions, which are observed in their true settings, in this case in energy-generating plants in the UAE.

4.2.2 Epistemology

Epistemological assumptions are a general set of assumptions about how researchers obtain and accept knowledge (reality) about the world (Sexton, 2008). This involves the theory of knowledge, especially with regard to its methods, the validity of that knowledge and the possible ways of gaining it (Sutrisna, 2009). Thus, epistemology involves the ways in which knowledge is generated, taught, learnt and assimilated by those who operate on the ground (McEntire and Marshall, 2003).

Epistemology concerns the nature, definition and limitations of that knowledge with concepts such as belief, memory, certainty, justification and evidence (Cooper, 1999;

Floridi, 1996). It considers the creation and dissemination of knowledge within a certain context or discourse. It is therefore the study of knowledge and justified belief. Consequently, epistemology is concerned with the following types of questions (Stanford University 2005):

What are the necessary and sufficient conditions of knowledge? What are its sources? What is its structure, and what are its limits? How are we to understand the concept of justification? What makes justified beliefs justified? Is justification internal or external to one's own mind?

In other words, epistemology uncovers the strengths and weaknesses of values, assumptions and methods relied upon for theory development (McEntire and Marshall 2003).

The paradigm adhered to in this thesis is interpretivism, with a strong focus on social actor-constructed meaning and methodologies that yield qualitative data. There is however mixed methodologies applied with lean interpretivists not ruling out the use of surveys and Likert scales within the questionnaire. The strengths of quantitative and qualitative methods can be combined to bring synergy and robustness to the work presented.

Both the survey and the interview will pose qualitative and quantitative questions. As the aim of research is to enhance resilience within the UAE's critical energy infrastructure, and given that individuals give their externality meaning in the specific context where they are found, it is more appropriate to lean towards interpretivism for the ontological and epistemological framework. The qualitative responses will however be quantitatively "coded" and grouped together, according to the similarity of responses. Such data is validated through the positivistic style line of questioning. Table 3.2 shows the distinctions between qualitative and quantitative methods which are also detailed below.

4.2.3 Axiological assumptions

Axiological assumption is concerned with the role of values. Value, or the concepts of "good" or "bad", implies the assignation of a social definition which itself is subject to

the surrounding phenomena. Such phenomena will be deemed to be either beneficial, neutral or detrimental to Man and the society that mankind has created. To any given individual or group of individuals, "value" serves a given interest. That is to say if someone has no interest in something, that same something will be of no value. Subsequently the attitude expressed will also depend on that value.

In short, according to Permilovskiy (2012), a value always exists and depends on the subject. Furthermore, an axiological assessment will measure the quality of an "evaluative judgment" or the idea that in judging something one also expresses a feeling of "like" or "dislike", "importance" or "unimportance".

In positivist research, the researcher declares that research is value-free from any influences from society, ethics, and politics and unbiased, because positivists consider that they are independent from what they are researching (Collis and Hussey, 2009). On the other hand, interpretivists believe that the process of research is value laden, which means that the researcher is involved with that which is being researched (Collis and Hussey, 2009).

The application of axiology in disaster management lends itself to a paper by Hartman (1967) where he took the classic study of axiology and developed the branch "formal axiology". This branch uses mathematical tools – calculus to measure how judgments are made and gives a quantitative aspect to the otherwise subjective term "good". According to the CAVS (2014) (Centre of Applied Valued Science) there are three dimensions of value that are:

Intrinsic: These values are unique to each conscious being and are linked to that given being's individual feelings and character.

Extrinsic: Refers to the everyday physical world of functions, processes, activities and objects that can be compared to each other, like houses, sports or jobs – those that exist outside of the "self".

Systemic: This dimension is for complete concepts that exist as a whole *i.e.* Systems of thought, ideologies and philosophies. Systemic concepts include things like ideas,

music, mathematics, plans, organisation, statements, structure, graphs, judgments and propositions.

These three components of "value" will determine what a government or organisation sees, in the words of Immanuel Kant, as its moral "sense of duty" or ethical code. This, in turn, will dictate how a country or public/private entity responds to a disaster and how the consequences of that disaster are to be managed. Subsequently the axiology followed here in this thesis is that of formal axiology.

Furthermore, one cannot deny that the researcher's own values are present in the choice of research area, formulation of research questions, selection of methods and techniques, implementation of data collection, the analysis and interpretation of data and conclusions (Bryman, 2008). It is therefore reasonable to state that the research presented in this thesis is value-laden.

4.2.4 Positivism and Interpretivism

Sutrisna (2009) declares that positivists support the application of methods of natural science to the study of reality and beyond, as the 'truth' is out there to be discovered (by the researcher). Positivists desire the use of statistical analysis of data collected by large-scale empirical surveys and controlled experiments and formulating hypotheses and then testing them (Amaratunga *et al.*, 2002). It maintains an independent and objective stance (Table 4.2). These assumptions are commonly found in research studies in the natural sciences (Collis and Hussey, 2009).

In contrast, interpretivists concentrate on the meaning rather than the measurement of social reality, because they focus on understanding the phenomena (reality) in depth to find out answers to the questions such as why, what and how (Collis and Hussey, 2009). Besides, under the philosophy of interpretivism, the researcher is a part of what is being researched and is not independent of it (Sutrisna, 2009; Remenyi *et al*., 1998). Consequently, interpretivists consider that reality can only be interpreted. These assumptions are commonly found in the field of social sciences, which is concerned with the activities and behaviour of people (Table 4.2). Also, the process of inquiry in the social sciences can influence both researchers and those participating in the research (Collis and Hussey, 2009).

Collis and Hussey (2009) provide a summary description of the philosophical assumptions under the two main philosophies.

Table 4.2: Assumptions of the main philosophies. Source: Collis and Hussey (2009)

Philosophical assumption	Positivism	Interpretivism
Ontological assumption (the nature of reality)	Reality is objective and singular, separate from the research	Reality is subjective and multiple, as seen by the participants
Epistemological assumption (what constitutes valid knowledge)	Researcher is independent of that being researched	Researcher interacts with that being researched
Axiological assumption (the role of values)	Research is value-free and unbiased	Researcher acknowledges that research is value laden and biases are present

The nature of the disaster theory field and its application means that various research approaches can be applied – ranging from strongly positivist which entails disaster statistics and a quantitative universal measure of disaster, as discussed by Gad-El-Hak (2008), to a more interpretivists view of disaster as a semantic construction (Boin and Hart, 2007) requiring qualitative analysis. The qualitative sociological connection to disaster is explained by Mileti (1987, p69): 'from a methodological point of view, disaster research is hardly distinguishable from the general sociological enterprise'.

However, the positive approach to disaster management is not frequently used, as disaster management is political in nature and issues of these types interfere with positivistic approaches. Consequently, one has no choice but to reject its use in the disaster (Shrader-Frechette, 1991).

Positivists believe that there is a truth or objective reality waiting to be discovered by social scientists and that researchers discover this reality by staying detached, neutral and objective throughout the research. They concentrate directly on relationships among variables, especially those of cause and effect (Denzin and Lincoln, 2003). In other words, they do not pay much attention to people's inner mental states, but seek to develop causal explanations for phenomena and in doing so try to reduce the whole into

its simplest components in order to simplify its further analysis (Hussey and Hussey, 1997; Sekaran, 2003). Such an attitude is clearly inappropriate for the fulfilment of the aim of this research, which is to develop an in-depth understanding of the phenomena under investigation within the three case studies, as discussed later in sections 4.4.1 and 4.4.2.

Furthermore, this research will be exploratory and explanatory. Such research is conducted when little information is available, as is the case for those issues involved in improving resilience and enhancing the disaster management practices in the UAE energy sector. Thus, adopting a qualitative methodology within the interpretivist research paradigm is a way to become familiar with the phenomena so that more rigorous research can progress (Sekaran, 2003). It seems clear that Hussey and Hussey (1997), Sekaran (2003), Denzin and Lincoln (2003) and Silverman (2003) provide views that support the adoption for this study of a qualitative interpretivist approach rather a quantitative positivist one.

Disaster practice built on interpretivism concepts focuses on the meaning of policies, on the values, feelings, or beliefs they express, and even on the processes by which those meanings are communicated to, and understood by various audiences (Yanow, 2000).

Based on the above discussion, this research is positioned as broadly interpretivist in philosophy. However, some aspects of the positivist approach, in terms of collecting quantitative data, are incorporated into the research design, which was adopted following a review of literature and the development of the research questions.

4.2.5 Quantitative and Qualitative Methods

Interpretivism and positivism are represented by two main types of social science research, namely qualitative and quantitative (Yin, 2009; Hussey and Hussey, 1997). Qualitative research is found under the philosophy of interpretivism and consequently includes the study of a given phenomenon in its natural site. The methodology applied includes case studies, questionnaires, interviews, and observations. Quantitative approach is supported by the positivist philosophy which concerns with observable measurable facts (Collis and Hussey 2003). Research, according to this perception, requires the use of numbers and statistical methods and tends to be based on numerical

measurements of specific aspects and the testing of replicable hypotheses (Thomas, 2003).

In practice, most research does not fit neatly into one category; instead, much of it combines both. Some data may be collected that lends itself to statistical analysis, whilst other data, which is equally important, does not. This is why King *et al.* (1994) state that neither qualitative nor quantitative research is superior to the other or more scientific than the other. The differences between qualitative and quantitative methods are identified in Table 4.3. That said, most researchers place emphasis on one form or the other. Strauss and Corbin (1990) state that these emphases relate to the researchers' own beliefs and training and to the nature of the problems studied.

Table 4.3: The main differences between qualitative and quantitative methods. Source: Ghauri and Gronhaug, 2005.

Qualitative	Quantitative
Emphasis on understanding	Emphasis on testing and verification
Focus on understanding from respondent's/informant's point of view	Focus on facts and/or reasons of social events
Interpretation and rational approach	Logical and critical approach
Observations and measurements in natural settings	Controlled measurement
Subjective 'insider view' and closeness to data	Objective 'outsider view', distant from data
Explorative orientation	Hypothetical-deductive; focus on hypothesis testing
Holistic perspective	Particularistic and analytical
Generalisation by comparison of properties and contexts of individual organism	Generalisation by population membership

Hussey & Hussey (1997) indicate that the main reasons for taking a qualitative approach relate to the nature of the research and its philosophy. The nature of the present research is shown by its aim to undertake theory building rather than theory testing and the fact that the researcher intends to make generalisations to theory rather than about a population. Its philosophy, as noted above, is interpretivism, carrying the assumption that reality is constructed by the participants in this research (Sekaran, 2003). Besides, this research focuses on meaning rather than quantities and it seeks a

deep understanding of the factors that enhance the resilience of the critical energy infrastructure in the UAE. This is an exploratory study investigating the process of meaning and experience that people bring, which requires the researcher to examine real-life events in order to explain why and how certain obstacles arise to the implementation of a strategic disaster mitigation plan, in the three electricity generating plants taken as case studies, in Abu Dhabi, Dubai and Sharjah. In doing so, this study seeks to make inferences and to draw conclusions. It can be concluded that a qualitative approach is most appropriate when selecting the methods to be used in this study, a conclusion which is supported by the work of many researchers.

4.3 Research Approach

The research questions, along with the aim and objectives, play an important role in the selection of the research approach. Accordingly, Oppenheim (2005) argues that choosing the best approach is a matter of appropriateness. According to Saunders *et al.* (2009), there are two general approaches to the reasoning of the research in the literature, deductive and inductive approaches. Table 4.4 compares the deductive and inductive reasoning.

Table 4.4: Differences between deductive and inductive Approaches (source: Pathirage, *et al.*, 2008).

Deduction	Induction
Moving from theory to data	Moving from data to theory
Common with natural sciences	Common with social sciences
A highly structured approach	Flexible structure to permit changes
Explain causal relationships between variables	Understanding of meanings humans attach to events
Select samples of sufficient size to generalise conclusions	Less concern with the need to generalise

Deductive reasoning is a theory testing process which starts with a theory or hypothesis from the literature and seeks to observe whether the theory applies to specific instances. It goes from the general to the specific. Typically, this involves a literature review, which is then used to generate a conceptual framework and develop a hypothesis. The hypothesis is then tested, affirmed or rejected, through the gathering of data. Such activity is most intrinsically connected with quantitative research, due to the large quantities of data used to verify hypotheses or find patterns.

Inductive reasoning is generally an inquiry to understand a social or human problem from multiple perspectives (Yin, 2009). It is a theory building approach used when a researcher collects data and develops a theory as a result of data analysis (Saunders *et al.,* 2009). In other words, it goes from the specific to the general, starting with observation, then the identification of patterns, followed by the creation of a hypothesis, its exploration/validation and lastly the development or formation of a theory. Deductive reasoning, conversely, involves theory testing and goes from the general to the specific. Deductive reasoning in research has become synonymous with positivism, inductive reasoning with interpretivism (Pathirage *et al.,* 2008; Saunders *et al.,* 2009).

Collis and Hussey (2003) and Saunders *et al.* (2008) encourage the combining of deductive and inductive approaches within the same piece of research. According to Yin (2009), some element of inductive research is very likely where a case study strategy is used, due to its necessary qualitative elements which help the development of the formation of the "how" and "why" questions. Semi-structured interviews, which can be simple conversations, can help provide the meaning to the action observed as it has both quantitative and qualitative aspects.

Accordingly, it was decided that the most appropriate design for the present research was for it to start with a literature review, to aid an understanding of the phenomenon from a theoretical perspective, followed by field research to deal with it from the empirical viewpoint. Therefore, the researcher has chosen to combine the deductive and inductive approaches: a list of key components of the resilience and vulnerability within the context of the Emirati energy sector were derived from the literature and then investigated within the case study settings (deductive). After that, the findings from the fieldwork will be incorporated into the existing theory (inductive).

4.4 Research Strategy

Saunders *et al.* (2009) define the research strategy as the general plan of how the researcher will go about answering the research questions in order to satisfy the research objectives, whereas Remenyi *et al.* (2003) state that it provides the overall direction of the research, including the process by which that same research is conducted. Yin (2009) lists five different research strategies, as summarised in Table 4.5.

Table 4.5: Different Research Strategies. Source: Yin, 2009.

Strategy	Form of Research Question	Requires control of Behavioural Events?	Focus on Contemporary Events?
Experiment	How, Why?	Yes	Yes
Survey	Who, What, Where, How many, How much?	No	Yes
Archival analysis	Who, What, Where, How many, How much?	No	Yes/No
Historical	How, Why?	No	No
Case study	How, Why?	No	Yes

Yin (2009) identifies three conditions which can be used to select the appropriate strategy for the research:

- The type of research question;
- The control of the researcher over behavioural events;
- The degree of focus on contemporary as opposed to historical events.

Yin (2003; 2009) indicates that the case study is a particularly appropriate strategy when 'how' or 'why' questions are being posed. This allows the researcher to determine not only what happened but also how it happened or why it happened. He also recommends a case study strategy when the researcher has little control over the events and when the focus is on contemporary events. Yin (2009, p18) defines a case study as "*an empirical inquiry that investigates a contemporary phenomenon in depth and within*

its real-life context, especially when the boundaries between phenomenon and context are not clearly evident".

Furthermore, many scholars including Saunders *et al.* (2009), Amaratunga (2002) and Velde et *al.* (2004) affirm that the case study is suitable if the researcher needs to gain rich descriptions and deep understanding of the context; it is a valuable way of exploring existing theory and will enable the researcher to investigate real life, which can provide powerful insights. Besides, one of the strengths of the case study strategy is that it allows the researcher to use a variety of sources and a variety of types of data as part of the investigation (Denscombe, 2003). Also, the case study is a favourite strategy for research that has a qualitative orientation (Amaratunga, 2002).

However, Yin (2009) notes that the case study is far from perfect and could lead to a lack of rigour with too specific results that take a long time to obtain. One problem that must be considered carefully is that the conclusions drawn may be specific to the particular organisations studied and may not be generalisable (Gable, 1994).

Another possible strategy for this type of research is that of the survey. The survey technique relates to a group of methods which emphasise a quantitative analysis for a larger group of organisations, than that which is considered by the case study. The typical methodology in survey strategy is that of questionnaires, telephone interviews or even structured face-to-face questionnaires/interviews, via the appropriate selection of a representative sample. This would then enable the researcher to make generalised statements regarding the objective and value of the study. One of the difficulties of this strategy is its snapshot nature, which provides a wide angle lens but a poor focus on some of the in-depth information and meanings that the researcher is ultimately interested in. It is therefore helpful to combine the survey and case study strategies in some form.

Based on the above discussions, the method with the strongest potential application to the topic of this study, i.e. resilience and vulnerability within the context of the Emirati energy sector, is the case study. Archival and historical strategies can be dismissed because of their focus on past events, whilst the experimental strategy can be rejected because of the inherent need to control behavioural factors.

4.4.1 Single Case or Multiple Cases

A case study can be conducted within one organisation (a single case study) or more than one organisation (multiple case studies). The main distinction to make when implementing a case study design is between single case and multiple case designs (Yin, 2009). Perry (1998) mentioned that there are no specific guides for the number of cases to be incorporated. However, this research will adopt a multiple case studies design as illustrated in Figure 3.2.

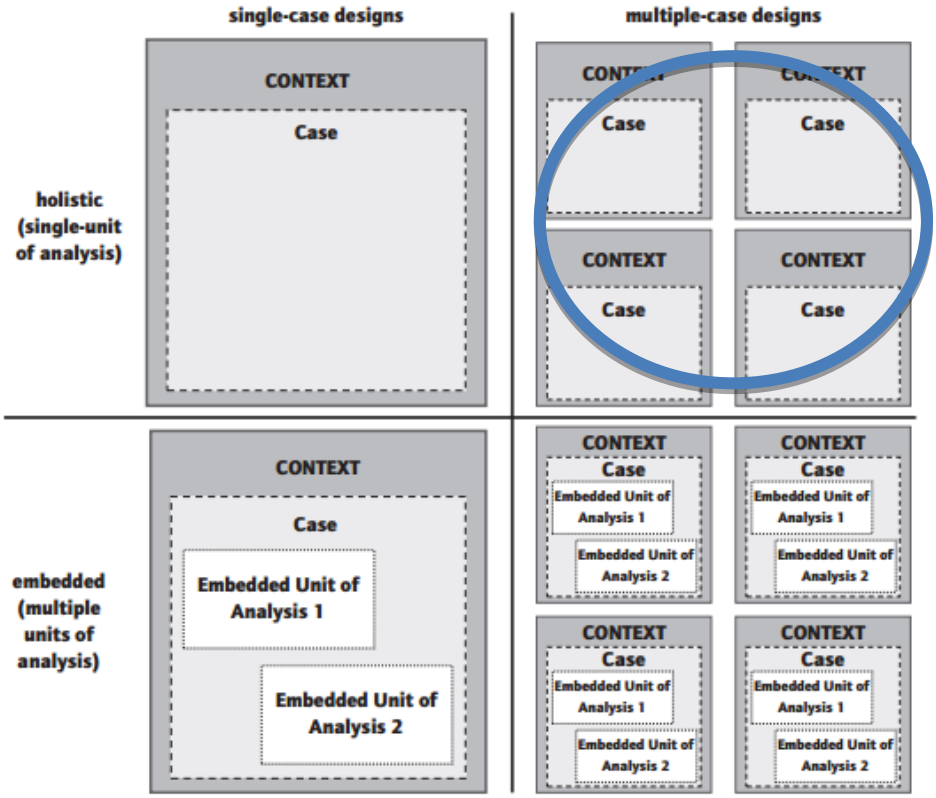

Figure 4.2: Single, multiple, holistic and embedded case study designs, including that selected by the author for this research. Source: Yin, 2009.

Yin (2003) argues that multiple case studies may be preferable to a single case study and that any researcher who elects to use a single case study needs to have a strong justification for this choice. Indeed, Yin (2009) observes that multiple case studies are more common and are generally used to replicate findings or support theoretical generalisations. Multiple case study research increases external validity and it helps to protect against the observer bias (Voss *et al.*, 2002). By studying multiple cases which

cover several key components of the energy sector (from key electricity plants, network equipment and final users) in the main Emirate states, the present researcher will be better equipped to gather sufficiently rich data to address the research questions.

It will also guarantee the best sources of data relevant to the current research. The use of multiple cases would strengthen the research, as there is a higher probability of triangulating findings and so of identifying any information that is erroneous or exceptional.

It is important that suitable case studies are selected. Evidently, a national grid depends on the reliability of its service and equipment in its entirety, which can affect the quality of electricity delivered. Any malfunctioning, poor coordination or indeed mismanagement by any number of parties can lead to power surges or power dips, whilst excessive use of reactive power can multiply the power losses experienced. If inappropriate or insufficient case studies are taken, then an unrealistic and potentially damaging conclusion (for political or technical reasons) could be reached.

A holistic multiple case study design was chosen because the study required a holistic perspective, involved one bounded case, qualified as being both explanatory and exploratory in approach and sought to understand the level of resilience in the current disaster management strategy for the Emirati energy sector.

Based on the above considerations, three case study organisations were selected: three electricity generating plants, in Abu Dhabi, Dubai and Sharjah.

4.4.2 Justification of the Choice of Case Study Organisations

It is important that suitable case studies are selected, because of the nature of the electrical grid and the need for reliability of the service and the equipment in its entirety.

Three electricity generating plants, in Abu Dhabi, Dubai and Sharjah are used as case studies and have sufficient scope for the study as they are the largest plants within the context of the Emirati energy sector.

Furthermore, the cities of Abu Dhabi, Dubai and Sharjah can be considered the most sophisticated of Emirati cities. Their location means that their services are provided to

large numbers of consumers. To this researcher's knowledge, no other researchers have had this level of access in the past to investigate issues relating to the UAE's energy infrastructure. These plants will become typical, as they represent the future of other UAE's critical energy infrastructure via the development of strategic disaster mitigation planning, since they will carry the same structure and administration systems. Thus, the lessons and knowledge that could be obtained from these case studies would be vital and significant for other Emirati energy sector infrastructures currently being planned in the UAE.

4.5 Research Time Horizon

The research onion by Saunders *et al.* (2009) shows two principal time horizons. The first is longitudinal and the second is cross-sectional. The former involves longer term research by having an extensive timeframe involved (typically years) or various points of measure at more than one point of time. This kind of research sketches out the effect or dynamics of an observed phenomenon, providing a "why" it occurs. This "why" can be discovered, precisely because a chain of repeating studies can be built, which a researcher can examine and re-examine, as time proceeds and as they become more intimately aware of the complexity of the issue being studied (Jueterbock, 2012). Longitudinal studies, whilst providing a clearer picture of the reality on the ground, are by their nature time consuming. This is one of the main reasons that they fall beyond the scope of this thesis.

In the work reported in this thesis, the time horizon reflects that of cross-sectional studies with a small sample, to allow for a more qualitative approach. That is to say, that all variables studied are considered at the same specific point of time. Cross-sectional studies emphasise observation and come under the category of descriptive research.

According to Jueterbock (2012), there are some issues that need to be overcome in this time horizon. First, the sample may not reflect or represent the true nature of the total population. This is not a significant concern, however, if it involves a smaller sample. This sample was purposely selected so as to maintain a more qualitative dataset and an interpretivist philosophy. The second disadvantage is that information can be skewed as one does not have the advantage of time to isolate factors that may influence

correlations and observations. The third is that there is simply no answer as to "why" that which is observed occurs.

Thus, whilst this type of research can describe the characteristics of the phenomenon being studied, a researcher using it cannot determine cause and effect relationships. One typically uses this research as a preliminary test, which would then lead on to a further study (Cherry, 2014). Even if no further research is undertaken, this perspective allows a researcher insight into performance paradoxes, know-doing gaps and the role of employees in the event of a specific disaster at a specific point of time (Roettgers, 2011).

Cross-sectional studies, meanwhile, may be so vast that the variables of interest may be overlooked or scarcely measured with very weak evidence of cause and effect. If a survey is to successfully elucidate causal relationships it must contain all the right questions asked in the right way (Gable, 1994). As a result it can be quite inflexible with limited robustness - there is little one can do upon realizing that some crucial item was omitted from the questionnaire, or upon discovering that a question is ambiguous or is being misunderstood by respondents. It is therefore helpful to combine the survey and case study strategies, as has been done in this study.

4.6 Data Collection Techniques

There are numerous ways to obtain primary data, such as interviews, questionnaires, observations or archival material (collie and Hussey, 2009; Easterby-Smith *et al.*, 2004). In fact there is no method fits all studies. The specific requirements, the research philosophy, research approach, research strategy, and objectives of research will usually dictate the appropriate method to use (Yin, 2009). According to Hussey and Hussey (1997), there are two major types of data collection; primary data and secondary data.

Primary data is information collected specially for the purpose of this study. Secondary data is information collected for another purpose but related to the subject of the study, and which the researcher has gathered to build the theoretical base for this study. The sources of these data include mainly: articles, papers, research, reference books, theses, magazines and the internet.

In this research both primary and secondary data were used. In general, questionnaires and documentation were used to collect data, along with interviews as support technique to gather in-depth information from case studies.

Based on the above, triangulation has been employed, as one method is not sufficient to solve the problem of various factors under study. Also, data triangulation enhances the reliability and validation of collected data. It also increases the opportunity to generalise results; thus addressing the criticism of qualitative research.

4.6.1 Questionnaire

The questionnaire is a multipurpose instrument that combines various aspects of the investigation, from the evaluation of people through to the processes and training. It can provide both qualitative as well as quantitative data. Saunders *et al.* (2009) argue that the questionnaire survey is often the only available way to develop of a representative picture of the attitudes and characteristics of a large population, while Bell (1993) points out that when using a large sample, it is important to ensure that data can be gathered and reliably processed. Moreover, measures of statistical significance are easy to calculate with questionnaire data. According to Oppenheim (2000) and Saunders *et al.* (2009), there are several advantages gained in adopting questionnaires, the most important being the straightforwardness, speed, economy and efficiency with which data can be collected from a large sample.

However, Hussey and Hussey (1997) identify many disadvantages, such as:

- The typically low response rates;
- The difficulty of designing questions;
- The participant may not be the intended recipient and hence, may not have the required expertise.

The development of a questionnaire, based on qualitative data (as in this research) generated from field observations and interviews, may also contribute to greater confidence in the generalisability of the in-depth results found. It is thought that this should provide objective data which can be more easily evaluated in light of the national

nature of the Emirati energy sector. In terms of exact methodology, the questionnaire consists of a collection of questions of various types which have been carefully and systematically prepared according to the interest and values of the investigator (Garcia, 2003). The success of a good questionnaire is based on the strength of the questions it asks, as illustrated in Figure 4.3.

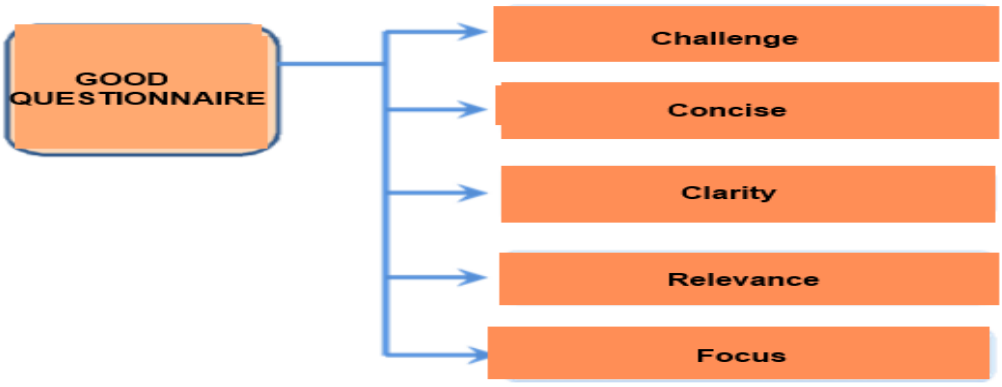

Figure 4.3: The five factors involved in asking a good question. Source: Fonseca, 2012.

According to Garcia (2003), closed questions are principally used to clarify the facts concerning previously stated information. They must not be overused, however, as the investigator will otherwise substantially reduce the information available and may cause the respondent to feel cross-examined. Typical closed questions include the answers "yes", "no" or "maybe". To open them up a subsequent (open) question could be: *Why do you think that?*

Closed questions can also be used in the way where the respondent is asked to choose from a set of potential answers such as: *Never; occasionally; frequently or Always.* Closed questions could also represent as they do in this investigation a scale or a matrix numbered 1 to 10 (refer to Table 4.6).

Table 4.6: A matrix table taken from the questionnaire. *Source*: Al Khaili (2013)

#	Questions	1	2	3	4	5	6	7	8	9	10
1	Tectonic activity – Earthquake	○	○	○	○	○	○	○	○	○	○
2	Tectonic activity – Tsunami	○	○	○	○	○	○	○	○	○	○
3	Climatic activity – Flooding caused by wave surges	○	○	○	○	○	○	○	○	○	○
4	Climatic activity – Flash floods	○	○	○	○	○	○	○	○	○	○
5	Climatic activity – *Shamal*	○	○	○	○	○	○	○	○	○	○
6	Climatic activity – Extreme heat (above recorded mean)	○	○	○	○	○	○	○	○	○	○
7	Climatic activity – Other extreme meteorological conditions (hurricane, dust storm etc)	○	○	○	○	○	○	○	○	○	○
8	Landslides, liquefaction and slope failure	○	○	○	○	○	○	○	○	○	○
9	Manmade disaster – Terrorism	○	○	○	○	○	○	○	○	○	○
10	Manmade disaster - Chemical spill and/or explosions	○	○	○	○	○	○	○	○	○	○
11	Manmade disaster - Health and safety related accidents *etc*)	○	○	○	○	○	○	○	○	○	○

The difficulty in preparing a well written questionnaire is the issue of exhaustively covering all possible answers. This may be a very complex task, at least in the beginning, because the subject is an unknown, meaning that the writer needs to think before time about all or any of the possible answers (opinions) provided by the respondents. The inclusion of the category "other" can help, but it does have the disadvantage that it has the effect of converting the closed question to an open one. Nonetheless, this tactic is particularly useful in the early pilot stage, as it allows one to explore all possible answers that the investigator was unable to envision when the questions were first set. After this stage Garcia (2003) believes that they should become an obsolete feature, given that the investigator should have sufficient information through triangulation, to ask the "right" question.

The open questions meanwhile offer a greater opportunity to obtain information that could be used subsequently. Such questions are generally as follows: What? Who? Where? When? How? Why? How much or how many? Such questions will thus

generally involve the terms “would” and “could” as they are conditional and serve to express an idea or clarify it.

4.6.1.1 Questionnaire Design

The questionnaire was selected in this research to obtain data about attitudes and perceptions towards Emirati energy sector infrastructures. It was issued to workforces in order to acquire a descriptive and general picture. The questionnaire was designed and processed in accordance with the following conditions:

- A formal description agreement of the research was signed by respondents before starting;
- Qualitative and quantitative-style questions were designed, most offering multiple choices or with responses structured in a matrix (Appendix 1);
- Written in the official language of the UAE, Arabic;
- Any potential disruption to the electricity generating plants of Abu Dhabi, Dubai and Sharjah was minimised;
- The confidentiality and anonymity of the responses were guaranteed in advance;
- Respondents were given the right to ask questions about the project and if unsatisfied, they were able to freely withdraw from it at any stage, without having to provide a reason;
- Respondents were assured that their participation was voluntary in nature;
- To understand the questionnaire and the purpose behind it, an information session and introduction by the researcher and informative written information were given on site;
- The respondents were instructed to put their questionnaire in a sealed envelope.
- On refusal, the individuals were personally thanked and simply asked to put their blank questionnaire in the designated area.

- Respondents who filled in the questionnaire and signed their consent form (Appendix 3) were given the author's contact details and invited to ask further questions.

One hundred questionnaires were distributed in the three energy generating sites (Abu Dhabi, Dubai and Sharjah), of which 42 were answered. Given the cultural sensitivity of the Emirati workplace and the limited interest of Emirati women in working outside the office environment, all non-management respondents were male. All were aged between 30 and 40 years. The mean number of years that respondents had been employed at the Abu Dhabi, Dubai and Sharjah plants were 4.5, 4.2 and 4.1 respectively, while their respective length of experience was 4.4, 3.8 and 7.1 years. All respondents worked in either the operational, administrative or technical areas.

The questionnaire was divided into three sections, each using close-ended, open-ended and leading questions on the following topics:

- Preparation of the Emirati energy sector for natural and man-made hazards
- Perceived state of preparedness
- Barriers to be overcome so as to reduce vulnerability and increase preparedness.

4.6.2 The Interviews

To conduct a case study, the researcher has to identify the sources of evidence, as explained by Yin (2009). This research used multiple sources, as mentioned in section 3.6.

Interviews are one of the methods that allow a researcher to gather valid and reliable data, which is associated with the research question(s) or objectives. Fonseca (2012) argues that one must prepare the interview by always keeping the principal objective in mind. This involves careful selection of the interviewees, because the sample should cover all of the hierarchy, from the typical manual worker to the director. Furthermore, the researcher must ensure that each interviewee understands what the interviewer is really asking – thus improving the final quality of information (Carmona, 2013).

According to Vincoli (1993), the success of an interview depends on the interviewer's professionalism, objectivity and ability to evaluate the information given in an appropriate manner, which is also friendly enough for people to provide information. In an interview one must express empathy but avoid sympathy to demonstrate that whilst they may not agree with everything said, they are able to understand the situation from a view different from their own (UN, 2003).

According to Saunders *et al.* (2009), interviews can be classified into three categories:

- Unstructured interviews;
- Semi-structured interviews;
- Structured interviews.

Structured interviews are characterised by the use of a set of questions with the same wording, asked in the same order. This type of interviews could contribute to obtaining uniform information, which assures the comparability of data (Oppenheim, 2005).

In unstructured interviews the interviewer formulates questions unexpectedly during an interview (Sekaran, 2003). The interviewees in this type of interview feel free to talk about their points of view, opinions and attitudes related to the topic of the research. In this situation, the interviewer needs to have a clear idea about the aspects that are wanted to be explored, since there are no determined questions to work through (Saunders *et al.,* 2009). Regardless of the possible fluency that both structured and unstructured interviews offer, the semi-structured interview contains numerous advantages of both methods (Yates, 2004). In general, the semi-structured interview has many advantages, such as:

- Flexibility in providing rich and in-depth information;
- Giving sufficient freedom to the interviewer;
- Allowing for changes in the questions based on the experience gained by the researcher during the interviews. Hence the type of information obtained from those who are interviewed earlier may be different from that obtained from those interviewed later (Oppenheim, 2005);

- Delivering uniform information similar to that provided by structured interviews without losing the flexibility and freedom of unstructured interviews;
- Allowing the researcher to explore complexity, ambiguity, or incompleteness in the responses that interviewees may give.

However, there are some disadvantages in the interview method. The whole process can be expensive and time-consuming, especially if there are a large number of respondents to be interviewed. Furthermore, the interviewer may affect the validity and reliability of the questions by something as simple as his or her mood. This could influence the interaction with the interviewee and thus the interview process and the data.

4.6.2.1 Justification of Choosing Semi-structured Interview in Data Collection

The semi-structured face-to-face interview method was chosen in this study because of the advantages mentioned above. This method is described by Easterby-Smith *et al*. (2004) as being the most principled of all qualitative methods. It was also chosen because of the necessity to understand the basis for the interviewees' views, beliefs and attitudes, as well as to develop an understanding of each respondent's own point of view regarding disaster situations.

Additionally, it is important to note that some Arab researchers, for example Al-Bahussain (2000) and Al-Faleh (1987), have used semi-structured interviews to conduct empirical work. These researchers found that such interviews were a very successful approach in Arab organisations, where people prefer to talk rather than to complete a questionnaire. Furthermore, the response rate from questionnaires is very low when compared with direct interviews. Therefore, the interview tool was designed to give interviewees every opportunity to explain their own experiences from their own perspective, in that way supporting the inductive nature of the study.

In this research semi-structured interviews enriched the results of the questionnaire. It was a way to cross-examine the reliability of the questionnaire and served to ensure that workers' concerns were heard. All interviews were conducted face to face at the workplace, to facilitate the process. In compliance with the ethical approval for this research (Appendix 4) all interviewees were given anonymity.

Saunders *et al.* (2009) claim that the reliability and internal validity of the data depend on the design of questions and the strictness of the pilot testing section (4.8). Thus, with the above mentioned facts in mind, the questions were developed in accordance with the following techniques:

- Creation of the initial draft of the interview questions from a literature review;
- Modification of the questions following a pilot study;
- Administration of the final revised questions.

4.6.2.2 The Interviewees (Research Sample)

Interviews are methods of collecting data in which selected participants are asked questions in order to find out what they do, think or feel (Hussey and Hussey, 1997).

Taylor and Bogdan (1984) define qualitative interviewing as flexible, as there is no need to be specific as to the number or the type of participants before embarking on the research. Based on this principle the researcher started interviewing without knowing how many participants would be interviewed and continued until most answers had become repetitive and he judged that the data gathered was sufficient to achieve the research aim and objectives.

For this research, the interviewees were carefully selected managers who were thought to have sufficient working knowledge of the plants in their current state and of any future plans, etc. A total of nine logistics, finance and project managers were interviewed at the three sites. The inclusion of the different managerial levels enhanced validity through the triangulation of data by gathering different points of view.

4.6.3 Documentation

Mason (2004) states that documentation is a technique used in qualitative research. It was used in this research to overcome the potential low reliability of the data produced from the questionnaire and interviews. Authors including Silverman (1997), Denzin and Lincoln (2000) and Yin (2009) have asserted that a documentation review is one of the most important ways of supporting evidence gathered by other methods of data collection. According to Mason (2004) and Yin (2009), documentation review has many

advantages, such as reducing researcher bias, but it also has disadvantages; for example, the documents studied may not be representative and may not allow generalisation. In addition, some documents, such as personal diaries and private letters, are not easily accessible.

Related documents used in this research were: annual reports from the Emirati energy sector; government legislation (federal and/or state); regulations and training files; financial reports and company policy.

4.6.3.1 Pilot Study

Many authors including Sekaran (2003) and Yin (2009) believe that the questions asked by the researcher in interviews or questionnaires should be subject to a preliminary test or pilot study. A pilot study is advantageous in filtering the questions to clarify wording and design. In this research, a pilot questionnaire was administered to four Emirati PhD students at Salford University. By this means, the researcher ensured that the questionnaire was clearly designed and simply understood by respondents. This was accomplished by asking the four participants to complete a feedback form about the simplicity, layout, ambiguity and clarity of the questionnaire items.

A similar pilot study was conducted to elicit feedback in order to redraft and improve the interview questions. As a result the language of some questions was modified to make them clearer, that is, unambiguous and more understandable.

4.7 Data Analysis

In this thesis, descriptive statistics and content analysis were undertaken for the questions presented in the surveys. When the answers were in a numerical form, descriptive statistics were used to summarise tendencies (patterns). Central tendency is a particularly important consideration. This involves working out the mean, median, range etc. It also typically involves the creation of graphics to enable a clear visual representation of the phenomena being investigated. Briefly, according to Thompson (2009), descriptive statistics are typically used to compare results from one study with another and this can help researchers detect sample characteristics that may influence their conclusions.

The data obtained in this study, however, was not always provided in numerical or quantitative form. In this case, content analysis was undertaken. This is typically used when qualitative information needs to be reduced to numerical terms, as was the case for the questionnaire surveys and interviews. It is a way of trying to analyse the content of qualitative material (data) by quantifying it (Browne, 2011). It is summarises, rather than reports. It thus seeks to generate conclusions which are generalisable, meaning in this case that they can be applied to the whole Emirati energy sector, rather than being limited to a full and precise statement of the sentiments of one particular group or individual (Neuendorf, 2002).

Content analysis has various advantages, such as being relatively cheap, and if done properly, it is a reliable method that can be easily checked by other researchers. However, it also holds various disadvantages that must be neutralised as much as is practicably possible. These include selection of appropriate categories and the researcher's intrinsic bias, which will affect data interpretation; in addition, it is mainly concerned with what is being studied and not so good at explaining it (Browne, 2011).

In general, content analysis involves multiple stages, where the answers provided are first read and categorised by some criterion such as an underlying theme, level of emotion, favourability or key term. This process is repeated, creating sub-groupings, until there are no more categories left to allocate. Each sub-group is then reviewed so as to reduce the overall number of categories. In its simplest form, content analysis allocates a value to each of the groups; which are then tabulated and presented as either a cross-tab report or rudimentary frequency distribution (SSU, 2014).

In this thesis, the combination of the two data analysis techniques means that once survey data is collected from respondents, the next step is to input the data into an appropriate programme for the statistical analysis of data and its interpretation.

Steps in data analysis include: editing and coding survey data; processing them using appropriate software; providing a descriptive statistical analysis for all the questions to generate insights. In order to give some quantitative indication of the results, such as relative preparation for example, an index using the mean is to be constructed for each situation.

For a comprehensive analysis of the data, the researcher breaks it down into the following sections:

- Preparation of the Emirati energy sector
- Level of preparedness of energy sector workers in Abu Dhabi vs Dubai
- Potential barriers and solutions.

4.8 Relation between data collection tools and research objectives

The aim of this section is to map the research objectives against how they were achieved through the various research techniques discussed in Sections 4.6.1 and 4.6.2. Table 4.7 summarises the research objectives and the corresponding data collection techniques.

Table 4.7: Research objectives and corresponding data collection methods

Research objectives	Data collection technique/s used			
	Literature review	Questionnaire	Interviews	Documentation
To identify Emirati critical energy infrastructure facilities and their vulnerabilities to hazards	✓			
To examine current disaster management practices and their relation to those infrastructures deemed critical within the energy sector.		✓	✓	✓
To critically evaluate existing barriers to application of disaster management practices on critical energy facilities in UAE.		✓	✓	✓
To contextualise and define the concepts of disaster resilience and strategic mitigation planning within the UAE.	✓	✓	✓	
To develop a framework for a strategic disaster mitigation plan for critical energy infrastructure.	✓	✓	✓	

4.9 Reliability, Validity and the Ability to Generalise

Validity and reliability for qualitative research means that data collection can be repeated, with the same findings (Yin, 2009). To achieve validity and reliability, this researcher has tried to be consistent at all times, so that if another researcher followed the same processes similar results could be produced. The researcher has built a clear research design and has adopted appropriate methods that give high internal reliability. In collecting the data, consideration was given to the most proper strategy for the specific investigation. Yin (2009) states that the common way of approaching the reliability problem is to make as many steps as operational as possible and then to conduct the research. This means that the research procedures and methods used in a study should be properly documented.

Saunders *et al.* (2009) note that the reliability of interviews is also related to bias. In this research, the researcher tried to avoid bias through improving the perceptions of respondents by building a good relationship or trust with the participants, providing a good introduction to the study, giving emphasis to the confidentiality, and finally leaving respondents to talk as they felt inclined.

4.10 Ethical Approval

Ethics in the context of research refers to the suitability of the researcher's behaviour in regard to the rights of those who become a part of the research, or are influenced by it (Saunders *et al.*, 2009). It is the ideology of behaviour that guides honest choices about behaviour and relationships with others (Saunders *et al.*, 2009). In this respect, the policy of the University of Salford obligates researchers to apply for ethical approval before conducting field studies.

Professional ethics are core to the undertaking of good and sound scientific investigation. The researcher must ensure that a person's dignity, integrity and sense of self-worth are maintained. The importance of human relationships should not be underestimated and certainly not sacrificed for the benefit of the research.

According to Adams and Callahan (2013, p17):

"*The primary concern of the investigator should be the safety of the research participant. The scientific investigator must obtain informed consent from each research participant. This should be obtained in writing after the participant has had the opportunity to carefully consider the risks and benefits and to ask any pertinent questions. Informed consent should be seen as an ongoing process, not a single event or a mere formality. The investigator must protect the subjects' privacy and confidentiality. Researchers must have mechanisms in place to prevent the disclosure of, or unauthorized access to, data that can be linked to a subject's individual identity".*

The difficulty of creating an ethical framework within disaster theory is that disasters are, more often than not, chaotic and destructive, making human subjects vulnerable and subject to unforeseen risks or levels of discomfort. Participants must thus be protected and fully aware of potential risks and of any effects, negative or positive, that could result from the research or the researcher's activities.

Disaster research requires the collection of evidence and the identification of the absence of any factor that could serve to reduce the impact that a natural event or manmade activity has on an individual, community, physical infrastructure or social structure. This evidence, through the identification of latent failures, should drive both corporate and governmental policy and practice in a safer direction, i.e. proactive instead of reactive.

The weighting of proof due to the sensitivity of the disaster discipline, given that failure in the disaster mitigation plan and strategy may result in deaths or other forms of catastrophic losses (monetary, political power, etc.), means that research participants are particularly vulnerable to emotional or physical repercussions and/or burdens. Disaster research draws attention to where a person or team have or are likely to fail in the event of any given number of scenarios. It heightens the sense of urgency to act and rectify policies or procedures (Mathuna, 2010).

If issues are identified but cannot be readily solved, respondents may feel helpless and become despondent. It would be unethical for a researcher to put a participant in this position. The problem is that whilst such issues can be anticipated there may be little that a researcher can do given that he or she has only limited power to influence those

who make wide reaching decisions to make them correctly, according to the facts presented by a thesis. Researchers can advise and may to some extent facilitate, but ultimately they cannot force a decision.

The researcher applied for ethical approval prior to conducting the field study. The Research Governance and Ethics Committee (RGEC) subsequently granted the researcher the ethical approval to conduct the data collection (Appendix 4).

4.11 Chapter Summary

To achieve the aim and objectives of this study, the research philosophies, approaches strategies and data collection methods have been identified and their selection justified.

This chapter has explained that deductive and inductive methods were selected and has justified these choices. The research strategy was to collect data in multiple case studies set in Abu Dhabi, Dubai and Sharjah. The decision to use a qualitative methodology approach and the use of questionnaires and semi-structured interview technique as the main sources of evidence has been fully rationalised.

Finally, the chapter has explained how the data was collected and analysed. The following chapter discusses the findings that emerged from the collected data.

CHAPTER 5: RESULTS AND ANALYSIS

5.0 Introduction

This chapter presents and analyses the questionnaire and interview results from the three electricity generation sites of Abu Dhabi, Dubai and Sharjah. The limitations of the results and the two tools used are also considered. All data and data analysis subsequently informs the discussion and the answering of each research objective and question, as discussed in Chapters 6 and 7.

5.1 Survey and Interview Description: Methodology, Site Location and Respondents

The primary data collection research of this study involved a combination of semi-structured questionnaires and opened-ended face to face interviews. The language was the official language of the UAE, Arabic. One hundred questionnaires were distributed, of which 42 were answered (20 Abu Dhabi, 15 Dubai and 7 Sharjah) with various refusals. All questionnaire participants were male energy sector professionals and most were aged between 30 and 40 years. The individuals were selected for their position and willingness to participate, but given the high number of refusals, particularly in Sharjah, this was not as selective as originally intended. The three power plants, and thus the potential participants, were themselves selected according to the strategic importance of the plants, in terms of number of customers and the significance of the business districts and urban areas served. Consequently, the study covers a substantial proportion (around 65%) of domestic and industrial energy users in the UAE. The mean length of time that participating energy sector workers had been employed at the Abu Dhabi plant was 4.5 years, slightly longer than the mean of 4.4 years that they had served in their current positions. The equivalent figures for Dubai were a little lower, at 4.2 and 3.8 years respectively, while in the Sharjah case, average length of employment was much greater at 7.1 years, with a mean of 4.1 years in current position. Figure 5.1 shows the work position of the respondents: all worked in either the operational or technical areas, those having the most direct contact with any threats in the field. Overall, most participants (81%) were either foremen or electrical technicians/engineers. Given this predominance, overall as well as at each site, it is perhaps not surprising that the

responses were similar for the three companies, despite their administrative and geographic differences.

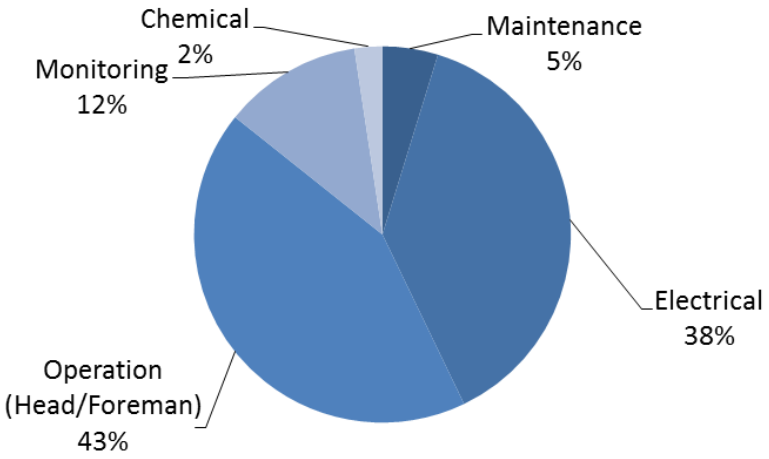

Figure 5.1: Work position of the respondents

The interviews were undertaken with the management of each plant (see Table 5.9 for details) and were used to obtain further information, in order to validate the questionnaires.

5.2 Site Location

The locations were three electricity generating plants: one in Abu Dhabi, one in Dubai and one in Sharjah. Both the questionnaires and interviews were conducted in these three locations. The exact locations are shown in Figure 5.2.

Figure 5.2: Power station locations. Source: Author, adapted from Google Maps (2014)

5.3 Questionnaire Format

The questionnaires contained a set of eight questions with various sub-sections (refer to the Appendix). There were both qualitative and quantitative questions, and most were multiple choice or structured in a matrix. In the latter, the respondent was given a scale of 1 to 10 on which to make his choice. In addition, "yes/no" answer options were used. In order to ensure a collective understanding of the questionnaire and the purpose behind it, an introduction and information session was given by the researcher. At this point, respondents were given the right to ask questions and to withdraw from the process. Respondents were also told that their participation was voluntary in nature and that their anonymity and data protection were assured. They were given the option to withdraw at any stage, without having to provide a reason.

The questionnaire contained questions on the following topics:

- Preparation of the Emirati energy sector with regard to natural and man-made hazards
- Perceived state of preparedness

- Vulnerability and resilience
- Significance of climate change or other hazards which may alter the vulnerability of the energy sector and that of the general public.
- Barriers to be overcome to reduce vulnerability and increase preparedness.

5.4 Analysis

Once survey data was collected from respondents, the next step was to input the data into an appropriate programme for statistical analysis and interpretation. The analysis comprised three steps: (i) editing and coding survey data, (ii) processing it in Microsoft Excel (iii) providing a descriptive statistical analysis for all the questions to generate insights. There are three basic measures of central tendency: mean, median and mode. In order to give some quantitative indication of the results, such as relative preparation, an index was constructed for each situation.

For a comprehensive analysis of the data, sections are broken down as follows:

- Preparation of the Emirati energy sector
- Level of preparedness of the Emirati public
- Level of preparedness of Abu Dhabi, Dubai and Sharjah
- Energy infrastructure vulnerability
- The role of climate change
- The greatest vulnerability
- Potential barriers.

The findings for each of these themes is presented in the following sections.

5.4.1 Preparation of the Emirati energy sector

Question 1a explored which hazards the Emirati energy sector was best prepared for. Tables 5.1, 5.2 and 5.3 provide a descriptive statistical analysis of the perceptions of the employees of the three companies, while Figure 5.3 is a graph of the overall results for this item.

Regarding preparation, in terms of the overall results, respondents stated that the Emirati energy sector was best prepared for two categories of manmade disasters, i.e.

health and safety issues or accidents and terrorist activity, along with extreme heat (Figure 5.3). Respondents located in Abu Dhabi and Dubai believed that the sector was most prepared against terrorism, extreme heat and health and safety-related accidents. In general, with the exception of terrorism, where the mean score was 6, respondents appeared to believe that the energy sector was ill-prepared to face natural disasters, since state of preparation scores were rarely above 5. It can be stated, based on the maximum values of Dubai, that workers felt more prepared for disasters in Dubai than in Abu Dhabi. This result is reinforced in Tables 5.1 and 5.2. Sharjah's results, as Table 5.3 shows, were very different from those of Dubai and Abu Dhabi. The modal value is 5, which is higher than that for most of the answers given in Abu Dhabi and Dubai. Tectonic activity and terrorism were said to be the least prepared for. The latter, in contrast to the other results, is perhaps due to the substantially lower resources provided in Sharjah to fight terrorism. This in turn is likely to relate to the lower terrorism risk faced compared to the arguably more important cities of Dubai and Abu Dhabi. Sharjah respondents stated that climatic activity was the least significant issue. The perceived resilience to flooding may result from their recent experience with flooding events and the changes introduced to improve emergency response and mitigation.

Table 5.1: Descriptive statistical analysis for Question 1 in Abu Dhabi

Parameter	*Mean*	*Standard Error*	*Median*	*Mode*	*Standard Deviation*	*Variance*	*Kurtosis*	*Asymmetric Coefficient*	*Range*	*Min*	*Max*	*Sum*	*Count*
Tectonic activity – Earthquake	3.06	0.15	3	3	0.64	0.41	6.55	-1.56	3	1	4	55	18
Tectonic activity – Tsunami	2.89	0.08	3	3	0.32	0.10	5.98	-2.71	1	2	3	52	18
Climatic activity – Flooding caused by wave surges	2.83	0.12	3	3	0.51	0.26	10.4	-3.24	2	1	3	51	18
Climatic activity – Flash floods	3.28	0.19	3	3	0.83	0.68	7.85	2.92	3	3	6	59	18
Climatic activity – *shamal*	3.72	0.30	3	3	1.27	1.62	1.28	1.55	4	3	7	67	18
Climatic activity – Extreme Heat	5.78	0.39	6	6	1.66	2.77	-0.56	-0.29	5	3	8	104	18
Climatic activity – other extreme meteorological conditions	3.78	0.31	3	3	1.31	1.71	1.05	1.52	4	3	7	68	18
Landslides, liquefaction and slope failure	2.89	0.11	3	3	0.47	0.22	18.00	-4.24	2	1	3	52	18
Man-made Disaster – Terrorism	6.06	0.42	6	6	1.76	3.11	0.45	0.12	7	3	10	109	18
Man-made Disaster - chemical spill and/or explosions	3.67	0.28	3	3	1.19	1.41	2.22	1.68	4	3	7	66	18
Man-made Disaster - health and safety related accidents	5.56	0.41	6	6	1.72	2.97	-0.47	0.09	6	3	9	100	18

Table 5.2: Descriptive statistical analysis for Question 1 in Dubai

Parameter	*Mean*	*Standard Error*	*Median*	*Mode*	*Standard Deviation*	*Variance*	*Kurtosis*	*Asymmetric Coefficient*	*Range*	*Min*	*Max*	*Sum*	*Count*
Tectonic activity – Earthquake	3.13	0.17	3	3	0.64	0.41	-0.13	-0.10	2	2	4	47	15
Tectonic activity – Tsunami	2.93	0.18	3	3	0.70	0.50	3.99	-1.33	3	1	4	44	15
Climatic activity – Flooding caused by wave surges	3.13	0.17	3	3	0.64	0.41	5.64	1.78	3	2	5	47	15
Climatic activity – Flash floods	3.33	0.16	3	3	0.62	0.38	2.62	1.79	2	3	5	50	15
Climatic activity – *Shamal*	3.67	0.23	3	3	0.90	0.81	-1.35	0.78	2	3	5	55	15
Climatic activity – Extreme Heat	6.40	0.29	6	6	1.12	1.26	-1.12	0.46	3	5	8	96	15
Climatic activity – other extreme meteorological conditions	3.60	0.34	3	3	1.30	1.69	2.89	2.01	4	3	7	54	15
Landslides, liquefaction and slope failure	2.87	0.09	3	3	0.35	0.12	4.35	-2.40	1	2	3	43	15
Man-made Disaster – Terrorism	6.33	0.46	6	8	1.80	3.24	0.08	0.10	7	3	10	95	15
Man-made Disaster - chemical spill and/or explosions	3.80	0.31	3	3	1.21	1.46	2.17	1.56	4	3	7	57	15
Man-made Disaster - health and safety related accidents	5.67	0.47	6	6	1.84	3.38	-0.67	-0.07	6	3	9	85	15

Table 5.3: Descriptive statistical analysis for Question 1 in Sharjah

Parameter	*Mean*	*Standard Error*	*Median*	*Mode*	*Standard Deviation*	*Variance*	*Kurtosis*	*Asymmetric Coefficient*	*Range*	*Min*	*Max*	*Sum*	*Count*
Tectonic activity – Earthquake	4.71	1.06	4	4	2.81	7.90	-0.52	0.60	8	1	9	33	7
Tectonic activity – Tsunami	5.00	1.13	4	3	3.00	9.00	-1.70	0.16	8	1	9	35	7
Climatic activity – Flooding caused by wave surges	7.29	0.42	8	8	1.11	1.24	3.23	-1.78	3	5	8	51	7
Climatic activity – Flash floods	6.43	0.69	7	7	1.81	3.29	1.29	-1.37	5	3	8	45	7
Climatic activity – Shamal	5.71	0.89	6	8	2.36	5.57	-2.41	-0.16	5	3	8	40	7
Climatic activity – Extreme Heat (above recorded mean)	7.43	0.57	8	8	1.51	2.29	-0.81	-0.62	4	5	9	52	7
Climatic activity – other extreme meteorological conditions (hurricane, dust storm etc)	5.57	0.78	6	8	2.07	4.29	-1.41	-0.14	5	3	8	39	7
Landslides, liquefaction and slope failure	5.14	0.63	5	3	1.68	2.81	-1.47	-0.31	4	3	7	36	7
Manmade Disaster – Terrorism	4.57	1.00	4	3	2.64	6.95	0.08	0.50	8	1	9	32	7
Manmade Disaster - chemical spill and/or explosions	5.57	0.65	5	4	1.72	2.95	-2.11	0.38	4	4	8	39	7
Manmade Disaster - health and safety related accidents	5.57	0.53	5	7	1.40	1.95	-2.35	0.05	3	4	7	39	7

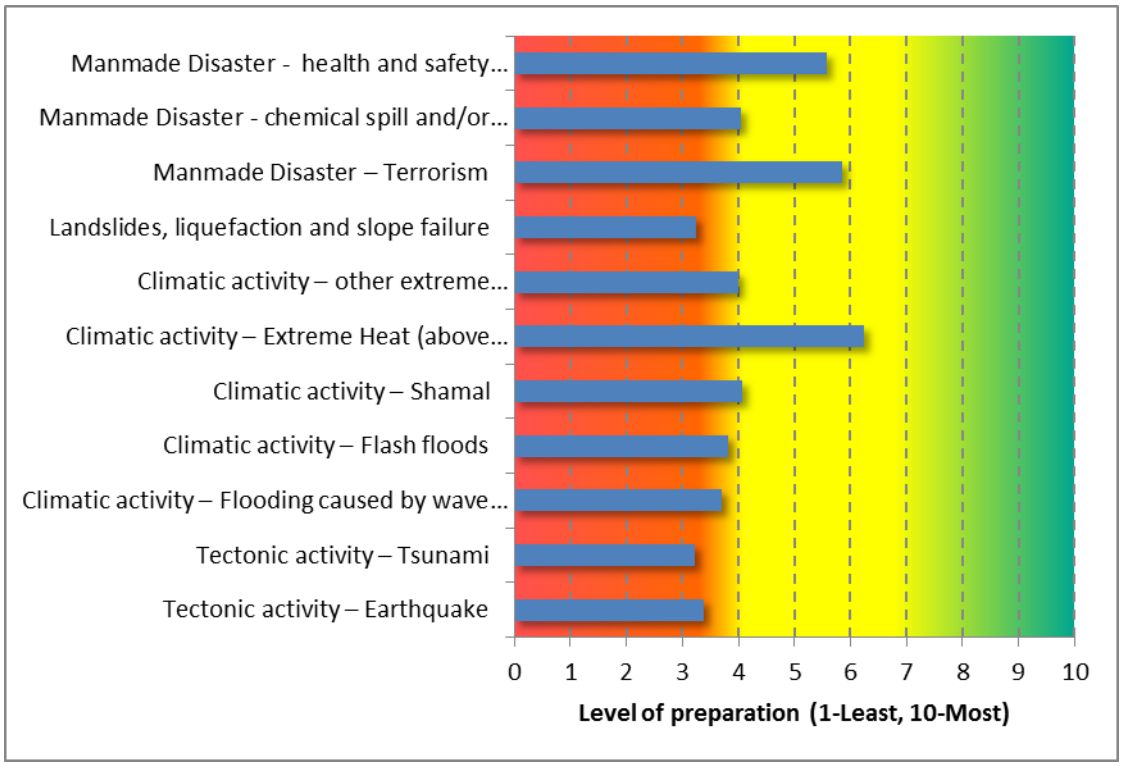

Figure 5.3: Level of preparation of the Emirati energy sector by hazard. Overall graph.

Across all three sites, as noted above, health and safety, terrorism and extreme heat were considered the least problematic due to the high levels of preparation. Conversely, tsunamis and landslides, liquefaction and slope failure presented the lowest levels of preparation. Scores for some 73% of the hazards listed were below 4 (high vulnerability).

The same three issues, health and safety, terrorism and extreme heat, registered as highly prepared for in the overall graph (Figure 5.3), albeit with different proportions, were also considered to be well prepared for in Abu Dhabi and Dubai. For Sharjah, the values differ substantially from those of the other two cities, demonstrating a perceived safety, greater than elsewhere. Their greatest level of preparation related to climatic phenomena. In section *b* and *c* of question 1, respondents were asked to provide reasons as to why hazards scored highly (i.e. > 8). Although not all respondents scored any hazard greater than 7, and given that the highest mode for Abu Dhabi was 6, they nevertheless attributed reasons to the greater state of preparedness (refer to Table 5.1). Again, there is a strong degree of consistency between the three datasets.

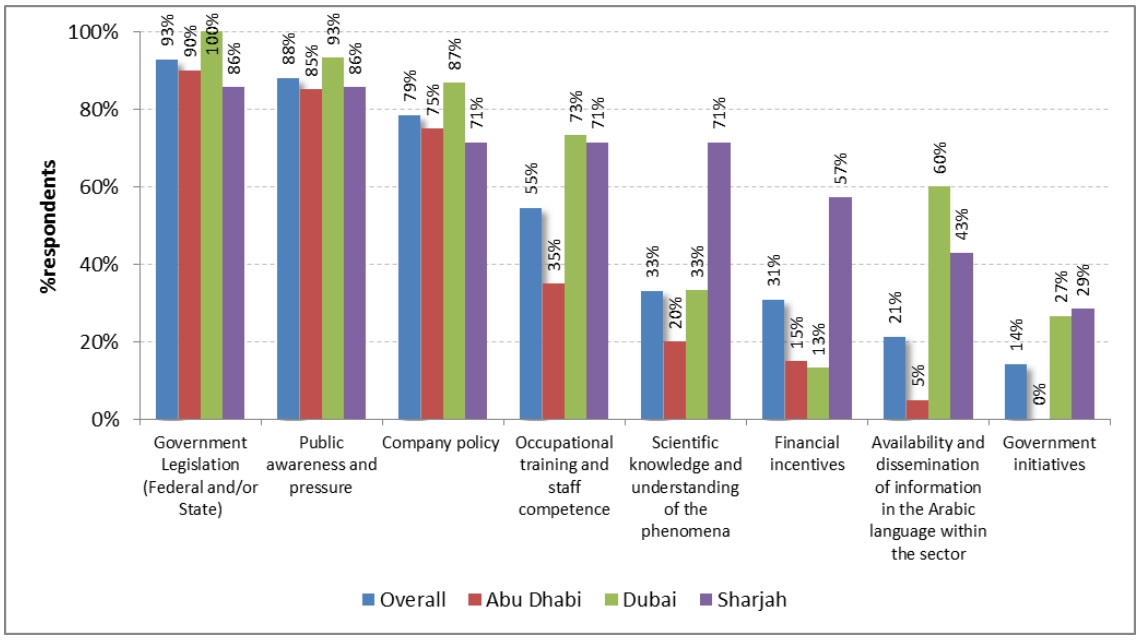

Figure 5.4: Reasons behind greater preparedness for the phenomena that scored highly across the Emirati energy sector

All three sites, Abu Dhabi, Dubai and Sharjah, registered similar answers and proportions for the three most registered answers.

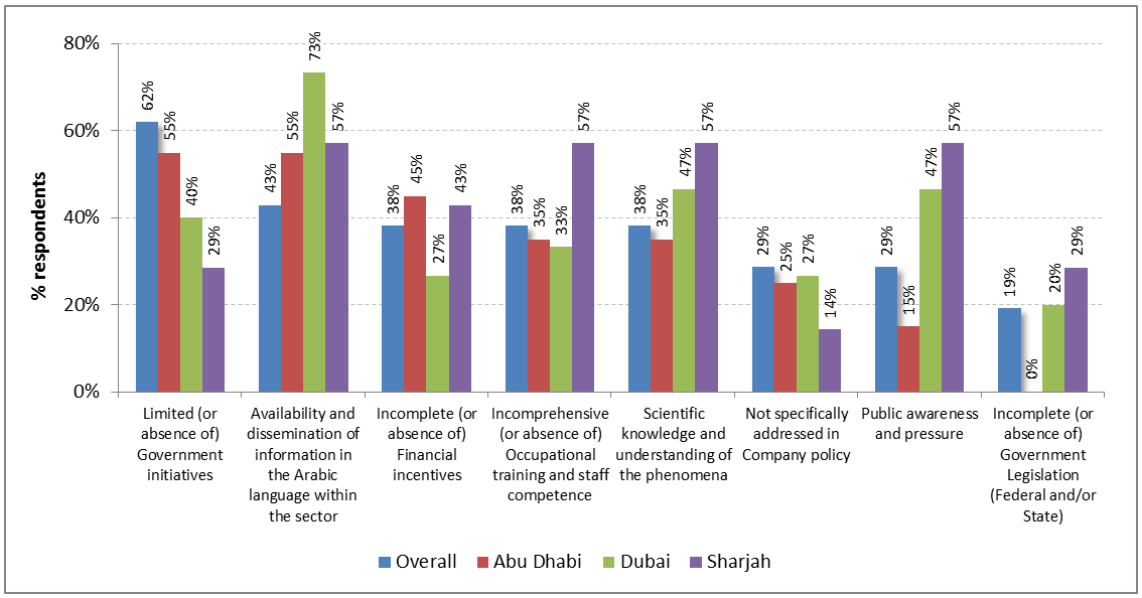

Figure 5.5: Reasons for lack of preparedness of the Emirati energy sector for those phenomena that scored the least

The three main reasons for a lack of preparation when it came to say landslides or Tsunamis are "Limited or absence of government initiatives", the "availability and

dissemination of information in Arabic" and the "incomplete or absence of financial incentives".

Results were similar to the overall picture in both Dubai and Abu Dhabi. In Sharjah (Figure 5.5), opinion was more divided, with four categories identified, each scoring 57%.

After having established the preparedness of the Emirati energy sector, the participants were asked their opinion on the Emirati public's level of preparedness, as presented in the following section.

5.4.2 Level of Preparedness of the Emirati public

Question 2 examined which of a list of hazards respondents thought that the Emirati public was best prepared for. Using the mean, Tables 5.4 and 5.5 and 5.6 indicate how the respondents viewed the situation. One of the most noticeable observations is that in comparing the level of preparedness of the energy sector (question 1) with that of the Emirati public, the mean drops further by an average of 0.3, with the exception of terrorism for the power plants of Abu Dhabi and Dubai. Similar to the energy sector, the public were said to be best prepared for terrorism (Figure 5.6), even more so than the energy sector. It is not clear why this occurred, but perhaps a lower level of understanding was ascribed to the public because they know less about the nature and impact of terrorist activity. The changes between sector and public perception of disaster preparation were most noticeable for Sharjah, with a mean drop of 0.63. Respondents in Sharjah stated that the energy sector was least prepared for terrorism but that the public felt that it was most prepared for terrorist acts, with a score of 7.0. This may be due to the higher level of national confidence, when it comes to preventing terrorism, rather than the Sharjah region's real ability to deal with it.

Table 5.4: Descriptive statistical analysis for Question 2 in Abu Dhabi

Parameter	*Mean*	*Standard Error*	*Median*	*Mode*	*Standard Deviation*	*Variance*	*Kurtosis*	*Asymmetric Coefficient*	*Range*	*Min*	*Max*	*Sum*	*Count*
Tectonic activity – Earthquake	3,00	0,21	3	3	0,91	0,82	7,02	2,13	4	2	6	54	18
Tectonic activity – Tsunami	2,83	0,09	3	3	0,38	0,15	2,04	-1,96	1	2	3	51	18
Climatic activity – Flooding caused by wave surges	2,94	0,06	3	3	0,24	0,06	18,00	-4,24	1	2	3	53	18
Climatic activity – Flash floods	3,17	0,12	3	3	0,51	0,26	10,49	3,24	2	3	5	57	18
Climatic activity – *Shamal*	3,17	0,12	3	3	0,51	0,26	10,49	3,24	2	3	5	57	18
Climatic activity – Extreme Heat	4,11	0,39	3,5	3	1,64	2,69	3,98	1,96	6	3	9	74	18
Climatic activity – other extreme meteorological cond	3,22	0,13	3	3	0,55	0,30	6,36	2,57	2	3	5	58	18
Landslides, liquefaction and slope failure	3,06	0,06	3	3	0,24	0,06	18,00	4,24	1	3	4	55	18
Man-made Disaster – Terrorism	7,11	0,29	7	8	1,23	1,52	-0,88	-0,23	4	5	9	128	18
Man-made Disaster - chemical spill and/or explosions	4,06	0,34	3	3	1,43	2,06	-0,05	1,10	4	3	7	73	18
Man-made Disaster - health and safety related accidents	4,39	0,40	3,5	3	1,69	2,84	-0,45	0,88	5	3	8	79	18

Table 5.5: Descriptive statistical analysis for Question 2 in Dubai

Parameter	*Mean*	*Standard Error*	*Median*	*Mode*	*Standard Deviation*	*Variance*	*Kurtosis*	*Asymmetric Coefficient*	*Range*	*Min*	*Max*	*Sum*	*Count*
Tectonic activity – Earthquake	2,73	0,18	3	3	0,70	0,50	-0,67	0,43	2	2	4	41	15
Tectonic activity – Tsunami	2,73	0,12	3	3	0,46	0,21	-0,73	-1,18	1	2	3	41	15
Climatic activity – Flooding caused by wave surges	2,87	0,13	3	3	0,52	0,27	1,40	-0,28	2	2	4	43	15
Climatic activity – Flash floods	2,93	0,15	3	3	0,59	0,35	9,74	-2,37	3	1	4	44	15
Climatic activity – *Shamal*	3,13	0,17	3	3	0,64	0,41	5,64	1,78	3	2	5	47	15
Climatic activity – Extreme Heat	3,53	0,19	3	3	0,74	0,55	-0,11	1,07	2	3	5	53	15
Climatic activity – other extreme meteorological cond	3,53	0,19	3	3	0,74	0,55	-0,11	1,07	2	3	5	53	15
Landslides, liquefaction and slope failure	2,87	0,17	3	3	0,64	0,41	5,64	-1,78	3	1	4	43	15
Man-made Disaster – Terrorism	7,13	0,31	7	6	1,19	1,41	-0,79	0,00	4	5	9	107	15
Man-made Disaster - chemical spill and/or explosions	4,00	0,39	3	3	1,51	2,29	0,19	1,29	4	3	7	60	15
Man-made Disaster - health and safety related accidents	4,73	0,41	5	5	1,58	2,50	-0,40	0,51	5	3	8	71	15

Table 5.6: Descriptive statistical analysis for Question 2 in Sharjah

Parameter	*Mean*	*Standard Error*	*Median*	*Mode*	*Standard Deviation*	*Variance*	*Kurtosis*	*Asymmetric Coefficient*	*Range*	*Min*	*Max*	*Sum*	*Count*
Tectonic activity – Earthquake	*4.3*	*1.1*	*3*	*2*	*2.98*	*8.90*	*-0.87*	*1.04*	*7*	*2*	*9*	*30*	*7*
Tectonic activity – Tsunami	*4.0*	*0.9*	*3*	*3*	*2.45*	*6.00*	*-0.58*	*1.14*	*6*	*2*	*8*	*28*	*7*
Climatic activity – Flooding caused by wave surges	*4.6*	*0.6*	*5*	*6*	*1.62*	*2.62*	*-1.15*	*-0.67*	*4*	*2*	*6*	*32*	*7*
Climatic activity – Flash floods	*4.6*	*0.6*	*4*	*4*	*1.51*	*2.29*	*-0.81*	*0.62*	*4*	*3*	*7*	*32*	*7*
Climatic activity – Shamal	*5.4*	*0.7*	*6*	*6*	*1.81*	*3.29*	*-0.48*	*-0.43*	*5*	*3*	*8*	*38*	*7*
Climatic activity – Extreme Heat (above recorded mean)	*5.6*	*1.0*	*5*	*3*	*2.70*	*7.29*	*-2.42*	*0.21*	*6*	*3*	*9*	*39*	*7*
Climatic activity – other extreme meteorological conditions (hurricane, dust storm etc)	*5.3*	*0.9*	*4*	*4*	*2.29*	*5.24*	*-2.39*	*0.33*	*5*	*3*	*8*	*37*	*7*
Landslides, liquefaction and slope failure	*5.1*	*0.6*	*5*	*5*	*1.46*	*2.14*	*-0.67*	*0.11*	*4*	*3*	*7*	*36*	*7*
Manmade Disaster – Terrorism	*7.0*	*1.1*	*8*	*9*	*2.89*	*8.33*	*3.65*	*-1.86*	*8*	*1*	*9*	*49*	*7*
Manmade Disaster - chemical spill and/or explosions	*5.4*	*0.9*	*4*	*4*	*2.30*	*5.29*	*-1.16*	*0.76*	*6*	*3*	*9*	*38*	*7*
Manmade Disaster - health and safety related accidents etc)	*4.7*	*0.6*	*5*	*5*	*1.50*	*2.24*	*-0.97*	*0.26*	*4*	*3*	*7*	*33*	*7*

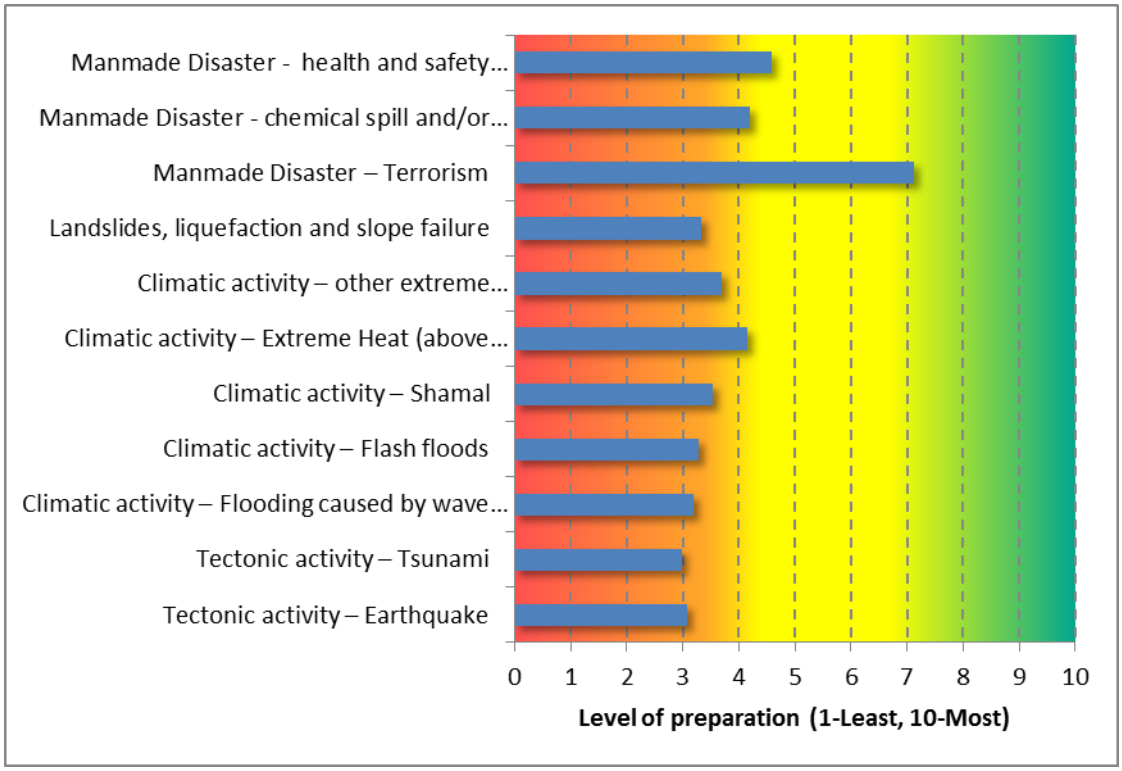

Figure 5.6: Perceived level of preparedness of the Emirati public by hazard

Energy sector workers considered that the public thought that the sector was best prepared for terrorist threats and least prepared for tectonic activity such as Tsunamis and earthquakes.

Results from Abu Dhabi and Dubai were similar. Terrorism was by far the threat which was "best prepared" for. In Sharjah this was also the case, although general preparedness was perceived to be greater.

Finally, it is difficult to say how relevant the information given is regarding members of the energy sector's perspective on public opinion. It is, however, useful to know their perceptions if the energy sector is to form part of educational initiatives or the drawing up of a legal framework to protect public interests. This is because if they are challenged to think of the public, they are more likely to involve and/or represent them in disaster policy for the energy sector. The questionnaire subsequently considered which of the three sites was best prepared to deal with a disaster.

5.4.3 Opinion as to the Best Prepared Site

Figure 5.7 shows that Abu Dhabi and Dubai respondents viewed Dubai as the Emirate best prepared for natural disaster. Indeed, more energy sector workers in Abu Dhabi than in Dubai itself thought that Dubai was better prepared. All participants in Sharjah likewise perceived Abu Dhabi as well prepared. Table 5.7 presents the reasons provided.

Table 5.7: Reasons given in each Emirate as to the best prepared Emirate

Opinions	Abu Dhabi	Dubai	Sharjah
Better corporate policy for preparedness and response to disaster	25%	7%	14%
Better planning standard for energy distribution and preparation against hazardous events	25%	33%	29%
Being a more organised and disciplined company	20%	7%	-
Human development e.g. through training, motivation and salary	15%	33%	29%
Creation of a specialised area for disaster management	15%	-	-
Being pioneers in the field via innovation including better working and operating practices	10%	27%	-
More resources for work equipment	-	7%	29%

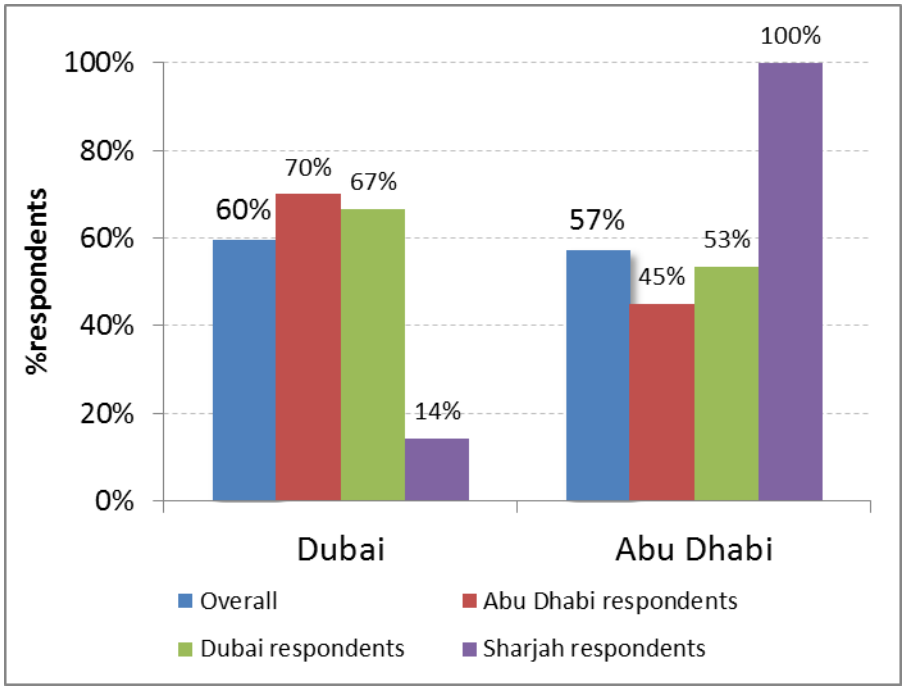

Figure 5.7: Emirates perceived as well prepared for hazards in the energy sector

When asked which Emirate was the worst prepared, few people answered the question, as shown in Figure 5.8. Most who answered named Abu Dhabi and very few Sharjah, attributing the limited preparation to corporate human resource policies, particularly in training and development, and to poor operation planning. The absence of response may relate to social desirability bias. Social desirability, a problematic bias recognised as early as 1954 by Maccoby and Maccoby, is a social phenomenon which can be considered as the common courtesy and acceptability shown to strangers or acquaintances (or researchers) before they penetrate the circle of friends or enemies. Social desirability is best described as:

The basic human tendency to present oneself in the best possible light. A light which can unfortunately *significantly distort the information* because *respondents are often unwilling or unable to report accurately on sensitive topics… for impression management reasons* (Fisher, 1993, p303).

Social desirability can occur in research due to issues of trust as respondents may not truly believe or understand what the researcher will really use the information for.

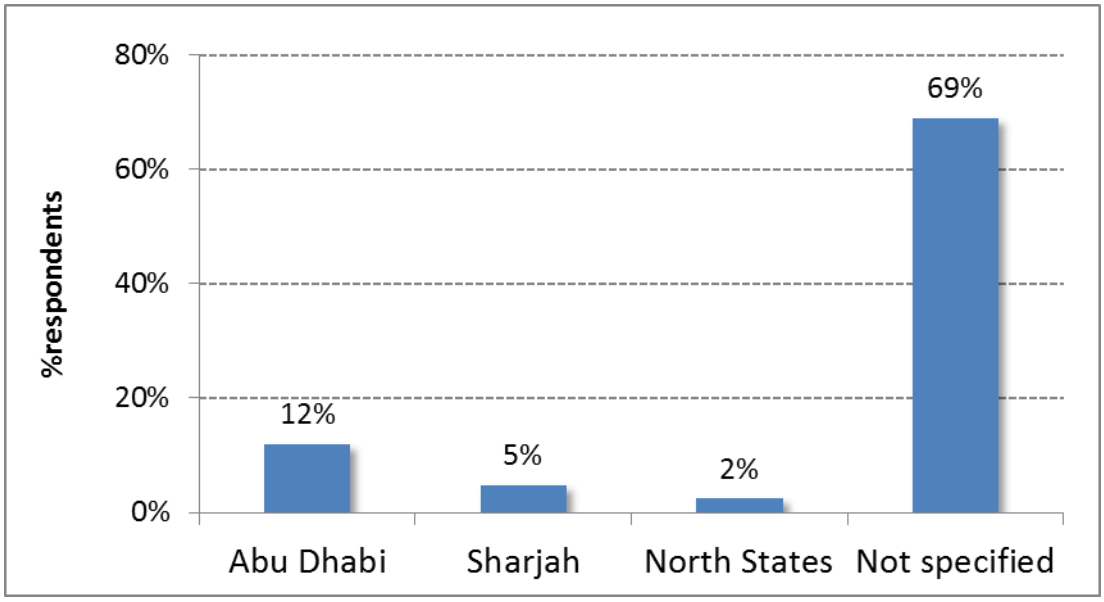

Figure 5.8: Emirates perceived by respondents overall as ill prepared for natural hazards in the energy sector

Given this issue of social desirability and the 69% refusal rate, it is difficult to state how valid these set of responses are, when comes to ill-preparation. It is clear however that Dubai is perceived to be the best prepared Emirate. Unfortunately, these answers were not expanded upon in the questionnaire, nor in the subsequent interviews with management. Following the question regarding state vulnerability, the questionnaire moved on to infrastructural specifics.

5.4.4 Energy Infrastructure Vulnerability

Question 3 broke down the energy sector into its constituting components and asked respondents to identify which were the most vulnerable. Abu Dhabi and Dubai selected fuel exploration and supply (oil, gas) as the most vulnerable, as shown in Figure 5.9. Sharjah differed from the other two sites, perhaps because of its less modern facilities and recent flooding event. That said, all respondents attributed high risk to the following:

- Mechanical or electrical risk (up to 80% of respondents), which is related to the complexity of the equipment and techniques, high voltage, probability, of failure *etc*.
- Chemical risk (up to 60%), - mainly associated with the use of substances, flammability and the risk of leakages.

- Explosions (up to 50%)
- Oceanic exploration risk (up to 27%), as operations out to sea are more complicated and riskier than their terrestrial counterparts
- Social risk (up to 20%), due to the potential of the energy sector forming a terrorist target.

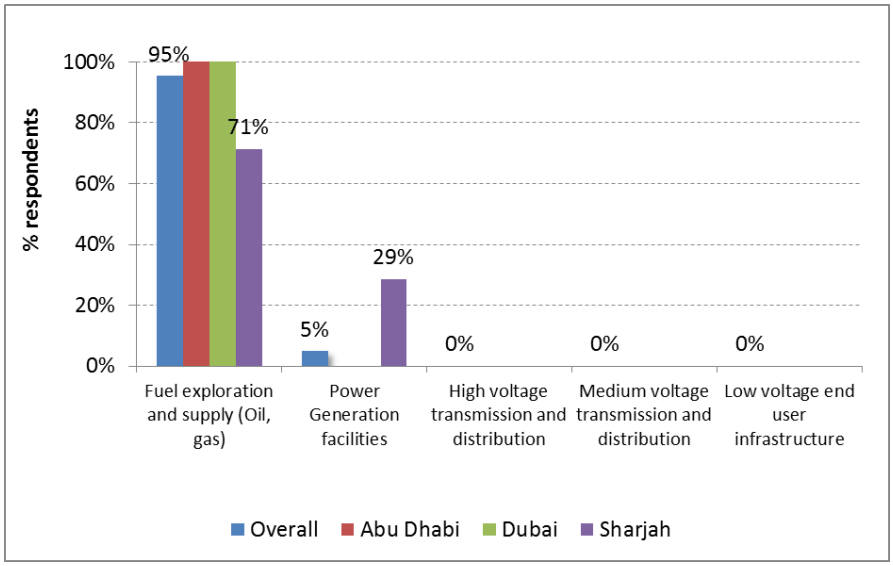

Figure 5.9: Most vulnerable section in the energy sector

Despite the hazards associated with fossil fuel exploration, renewable energies, along with nuclear, were chosen as the energy sources least resilient to natural, social or technological hazards (except Sharjah) (Figure 5.10). This may be due to their limited influence in the current energy provision. The nuclear plant at Brakah is still being built and is not expected to produce electricity until 2017. Likewise no wind power is established and remains in the planning stage (Al Mazrouei, 2013).

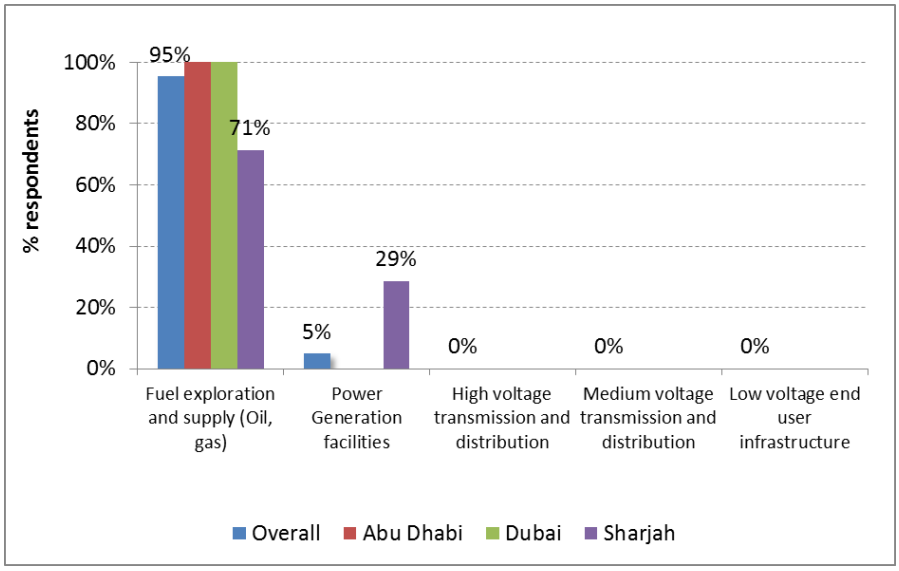

Figure 5.10: Energy sources most resilient to natural and man-made hazards

Limited strength in renewable provision may also relate to the limited attention on renewable policy until after the undertaking of the questionnaire. Indeed, following the appointment of Al Mazrouei as Energy Minister and the subsequent commitment to renewable options, there has been an increased interest in renewable energy solutions.

Under Al Mazrourei, Abu Dhabi, with its investments in Masdar, aims to get seven percent of its power from renewable sources by 2030. Neighbouring Dubai meanwhile is building a 1 GW concentrated solar array that will be the largest in the world helping Dubai reach five percent of renewable sourced electricity supply by 2030 (Dreazen and Belogolova, 2013).

Should coverage of renewable energy be increased further it is likely that renewable energy will become the most resilient option for the energy sector, given that there was widespread recognition among respondents of the benefits of renewable energy sources:

- Clean energy (85% of the respondents), meaning no physico-chemical risk of flammability or explosions.
- Renewable energies at the moment are not currently considered to be a terrorist target (55%).

- Operation is less risky, mechanically and electrically, and because renewable options on land only were considered, participants felt that any negative issues would be less severe (50%)
- Consequently, operation and equipment were perceived as less complex (35%).

Subsequently, 100% of respondents said that renewables were safer and more environmentally friendly than the other categories. Many do see it, however as a simple technology from an economic and technical point of view. However their opinion is not supported by literature on the subject. Whilst it is true, compared with other conventional options, that the impact of renewables is negligible (Kaldellis *et al,* 2013), the extent of impact from renewable energy sources on the environment is still far from certain (Moriarty and Honnery, 2012). Furthermore, despite 35% asserting the simplicity of renewable energy, it is by no means a "simple" technology (Kunze and Busch, 2011; Outhred *et al,* 2007). In addition, the IEA (2012) speaks about the following barriers that must be overcome when implementing them:

- Cost: Most renewable technologies are not yet competitive with fossil fuel-based technologies
- Subsidy: To foster the deployment of renewable energy, governments use subsidies to lower the cost of renewables or raise their revenues, helping them compete with fossil fuel technologies. The justification is that imperfections in the market fail to factor in externalities (such as environmental costs attributable to other fuels) or deny nascent technologies the opportunity to mature without support.

Clearly, the national and regional governments need to do more to communicate to energy sector workers the benefits of diversifying the energy matrix with alternative energies, including renewables. There seem to be contradictions and misunderstandings regarding their use, strengths and weaknesses, especially when it comes to combating climate change and growing carbon emissions. These issues are discussed in the following section.

5.4.5 The Role of Climate Change

Question 4 examined the role of climate change as a significant cause of vulnerability within the energy sector and general public in the future. On the scale of one to ten, 1 = 'not at all significant' and 10 = 'extremely significant'.

Table 5.8 shows a descriptive statistical analysis of the perceptions of respondents. The histograms (Figures 5.11, 5.12 and 5.13) show strong similarities in the set of answers given by all sets of respondents. Answers were strongly concentrated around the average value of 4 or 5, meaning there was general consensus that climate change was not a very important consideration challenging the resilience of the UAE energy infrastructure or that of Emirati society in the future. This is despite the fact that 85% of the population and > 90% of the nation's infrastructure is located within several meters of sea level in low-lying coastal areas (Dougherty *et al*, 2009). The public was perceived to see climate change as an even lesser concern, which is in line with previous unpublished research by the author, which showed that most schoolchildren in their final year did not worry about climate change and few saw it as a concern until after a presentation was given (Al Khaili, 2008). The highest level of concern was registered in Sharjah, probably resulting from the flooding events they have experienced recently. It is surprising, however, that the level of concern attributed to the Sharjah public with regard to climate change was much less than that for the energy sector.

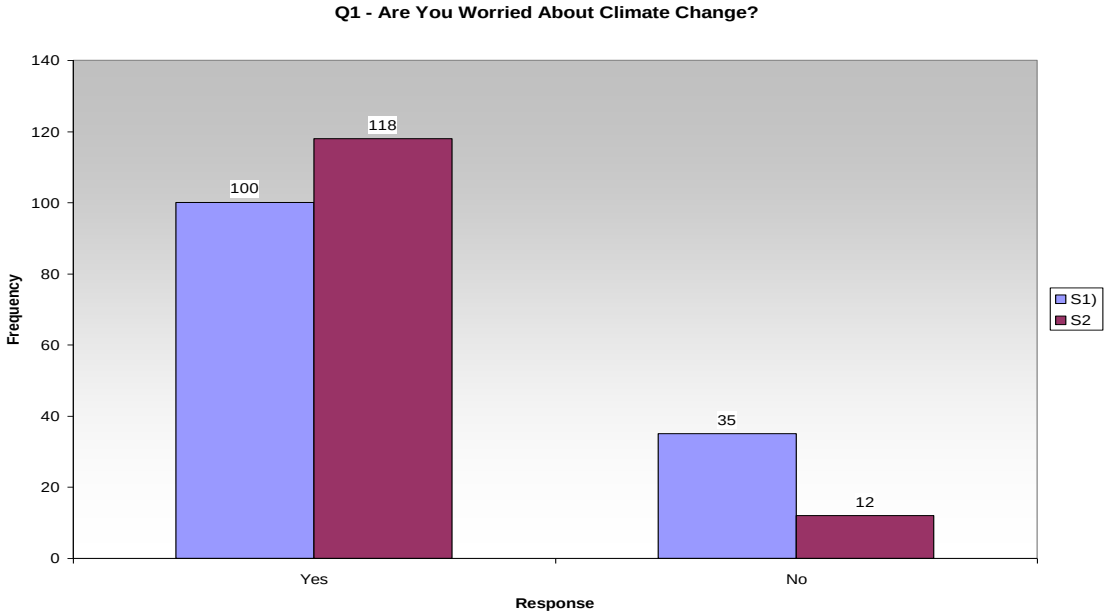

Figure 5.11: Results from the author's unpublished research on climate change in 2008. The values represent the number of students. S1 was before the presentation and S2 after.

Table 5.8: Statistical parameters for Question 4

Parameter	*Energy sector*	*General public*
Mean	5.5	4.0
Standard Error	0.1	0.1
Median	5	4
Mode	5	4
Standard Deviation	0.89	0.73
Sample Variance	0.79	0.53
Kurtosis	1.48	1.31
Skewness	0.18	0.07
Range	5	4
Minimum	3	2
Maximum	8	6
Sum	233	166
Count	42	42
Confidence Level(95.0%)	0.28	0.23

Figures 5.12 and 5.13, meanwhile, show the tendency for both sectors.

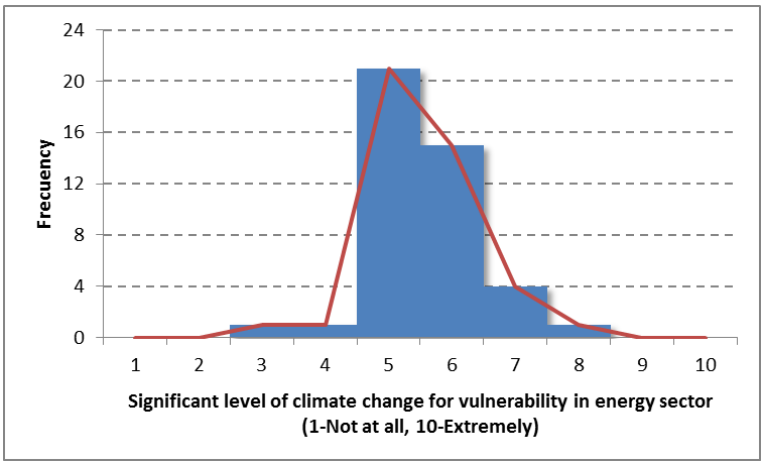

Figure 5.12: Perception of the significance of climate change for vulnerability in the energy sector, by overall respondents

In general, the impact of climate change for the energy sector was seen neither as significant nor insignificant (Figure 5.12). Energy sector workers felt that climate change had a less of significant impact for the general public than for the energy sector. Opinion was not widely divided.

Once more, answers from Abu Dhabi and Dubai were similar. Sharjah had a wider spread from the mean, in the direction of higher vulnerability. This may be at odds with their previous answers that the region was best prepared for climatic phenomena (Figure 5.3). It could suggest that they do not understand the implications, hence their concern, or it could mean that because they feel vulnerable to the threat of climate change, they also feel the need to prepare well for it, in the event of a potential climate-related disaster.

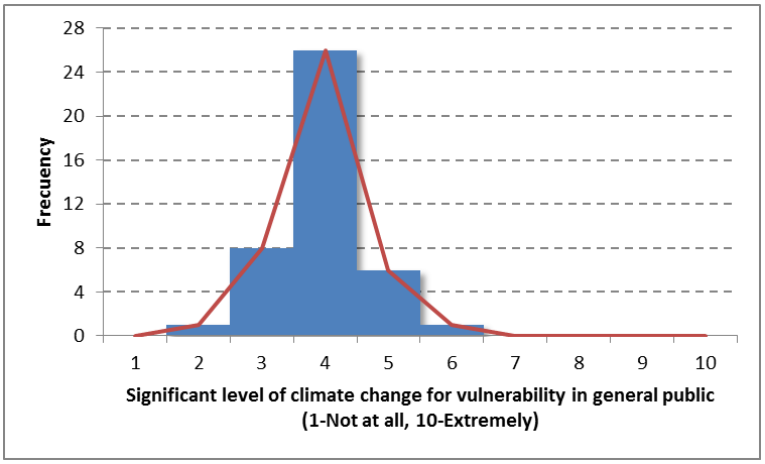

Figure 5.13: Perception of climate change vulnerability among the general public, by overall respondents

Workers overall perceived that the public would be less concerned and view climate change as a less significant threat to the energy sector than the energy sector workers themselves. This sentiment was mirrored across all sites, but most noticeably at Sharjah.

Respondents considered that the difference between the energy sector's and the public's perceived vulnerability stemmed from the following:

- Awareness and knowledge regarding disaster prevention and the phenomena at hand is higher in the energy sector than for the general public (65% of the respondents). This is because the energy sector is facing situations continuously.
- Competence, in terms of education, experience or skills, is more developed for those working in the energy sector (34%). Also, it has developed more training actions in the energy sector (37%)
- It is still necessary to develop skills for assessing risks, especially in the public sector (20%)
- Planning for vulnerability management is better in the energy sector (11%)

Climate change did not appear to be of great concern, so the next question asked respondents what was the greatest vulnerability of the energy sector, if not climate change.

5.4.6 The Greatest Vulnerability

Question 5 looked at which phenomena were significant causes of vulnerability within the energy sector, apart from climate change. Risk to terrorism was thought to be the greatest vulnerability, with every single respondent choosing it in Abu Dhabi and Dubai. The overall the figure was 98% (Figure 5.14). This was despite the fact that respondents had previously stated that it was the threat that the energy sector was best prepared for (Figure 5.3). The "other" category included war as the highest level of concern. War, which is related to threats of a social origin, was placed under "other" because it was mentioned by respondents despite not being part of the questionnaire. Half of the respondents, regardless of location, selected "terrorism" as a threat. In Sharjah, the greatest vulnerability was considered to be atmospheric, unsurprisingly perhaps, following the flooding events. It is perhaps a little contradictory that this, the greatest vulnerability, was also considered to be the best prepared for.

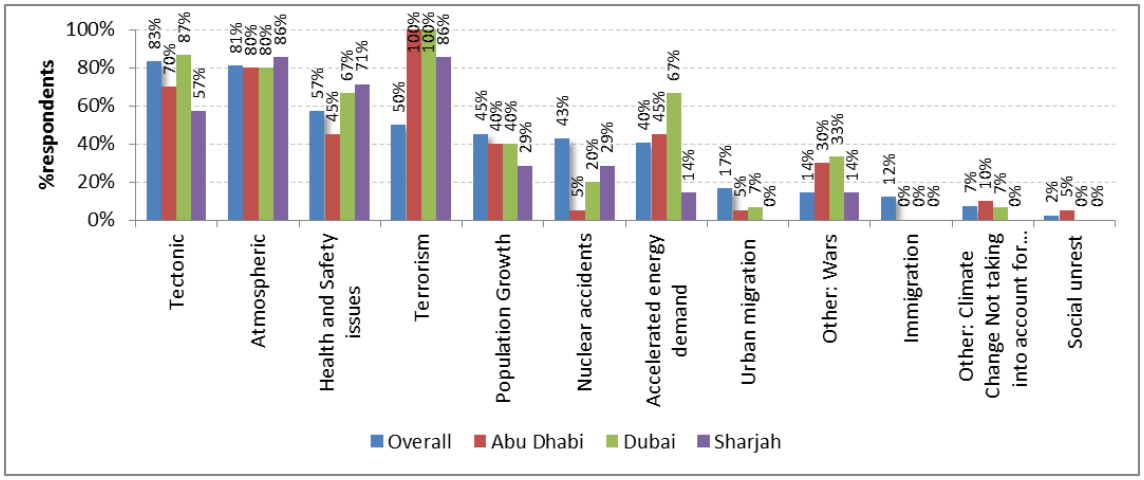

Figure 5.14: Coverage of the causes of vulnerability in the energy sector

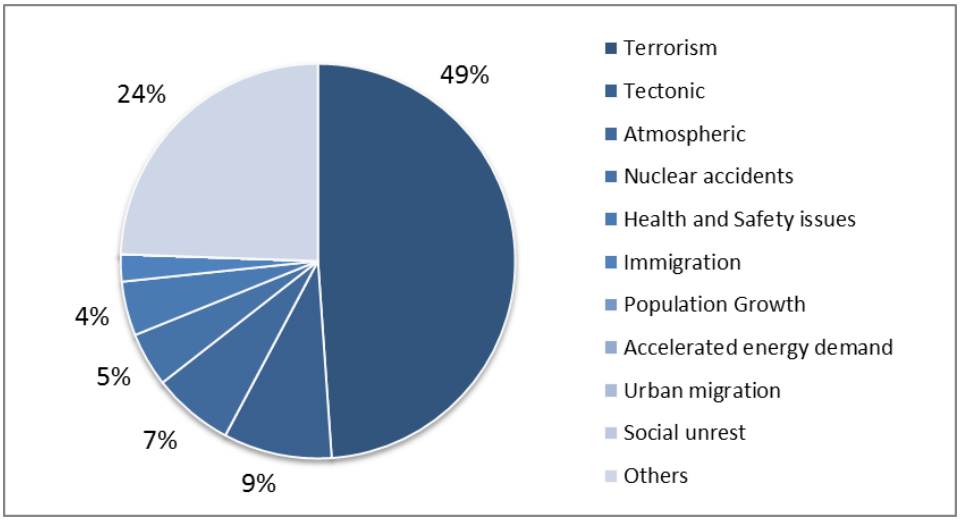

Figure 5.15: Distribution of the causes of vulnerability within the energy sector, apart from climate change

Terrorism, atmospheric and tectonic threats were the three main causes of vulnerability. The next section looks at how the barriers to good disaster management practices may have contributed to these three and other threats as perceived by participants.

5.4.7 Potential Barriers

Question 6 queried if there were any existing or potential barriers which served to prevent the energy sector from dealing with the causes of vulnerability. Some 90% of the respondents in Abu Dhabi said that "public awareness and education" was the biggest barrier. In the case of Dubai, the figure was 100%. In Sharjah, this figure was the lowest of all at 86%. In fact the biggest barrier for Sharjah was "additional occupational staff training." That said, the greatest barrier overall was the lack of or absence of national government legislation.

For the open ended questions, participants stated that in addition to those issues listed:

- Disaster management training in the energy sector remains to be addressed (71% of the respondents)
- Staff competences, especially through education, to support the understanding of climate change and its related disasters (31%)

To complement the above, they argued that is necessary to:

- Undertake verification simulations to assess the stage of personnel preparation, organisational structure in disaster response and resource capacity installed (31%)
- Develop a better planning stage for disaster preparation (26%)
- Achieve greater awareness, which means to give more priority to the issue (23%)
- Improve the human management policies in companies, such as safe working practices, especially when it comes to time pressures (6%)
- Set more regulations in line with sound disaster management practice (3%)

It is notable that the majority of responses were aimed at human resource improvements, more so than other variables, including technical or financial resources, policies or research.

Considering the importance given to training by respondents, relevant courses should be designed to develop skills and awareness using effective and participatory methodologies. Such an approach could be an effective way to improve safety measures that may lead to prevention. Also, a revised training program assures the effectiveness of training.

Question 7 asked what was required to enhance resilience in the energy sector. The following suggestions were made by three-quarters of the respondents as ways to develop a sound disaster management plan for hazards affecting the sector (refer to Figure 5.16):

- More public awareness and education
- Increased research
- More comprehensive government legislation
- Additional occupational staff training.

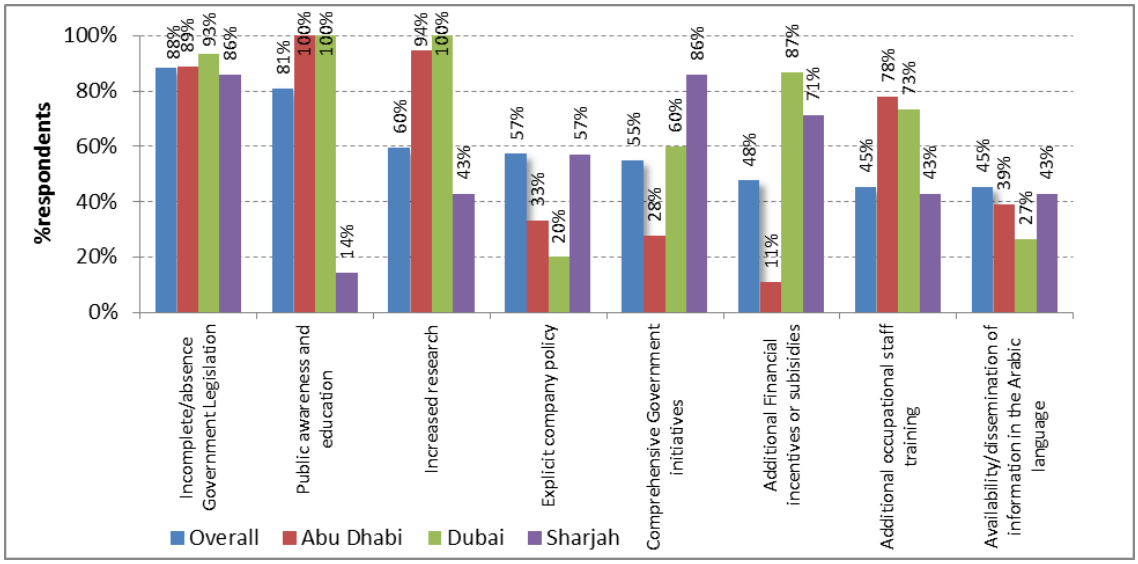

Figure 5.16: Ways to enhance resilience in the energy sector

Despite having highlighted training as the main means to reduce vulnerability in question 6, only Sharjah designated it as the most important factor. Abu Dhabi and Dubai respondents gave higher priority to other factors when proposing ways to increase the level of preparedness:

- Public awareness and education
- Government legislation (at federal and/or state level)
- Increased research to enhance scientific knowledge and understanding of the phenomena.

There are various barriers to the success of current disaster management and mitigation practices. These were subsequently discussed with the management staff in their interviews, as elaborated upon in the next section.

5.5 Interviewing of Management Staff

With the aim of validating the information obtained from the questionnaires, distributed to energy professionals in three power plants across the UAE, the researcher undertook a series of interviews with six management staff at various sites. As part of the interview process those involved were shown some of the key questionnaire results. Those interviewed included male and female managers, employed in different professions such as finance or project management. The experience of such individuals

in the sector was between 7 and 21 years. Details of the interviewees are presented in Table 5.9.

Table 5.9: Details of the interviewees

Interviewee	Gender	Position	Experience (years)	Location
1	Male	Head of department	10	Abu Dhabi
2	Male	Assistant manager	12	Abu Dhabi
3	Female	Head of planning department	7	Abu Dhabi
4	Male	Assistant manager	8	Dubai
5	Female	Head of department	10	Dubai
6	Female	Director of incoming and outgoing managers	14	Dubai
7	Male	Head of department	13	Sharjah
8	Male	Project manager	9	Sharjah
9	Female	Secretary	5	Sharjah

The objective of the semi-structured interview was the identification of the strengths, weaknesses and knowledge gaps perceived by those members of staff in direct contact with the phenomena discussed. It was hoped that this action would help support an effective management of those vulnerabilities within the energy sector. It addressed the following three objectives:

- Identify Emirati critical energy infrastructure facilities and their vulnerabilities to hazards
- Examine current disaster management practices and their relation to those infrastructures deemed critical within the energy sector
- To critically evaluate existing barriers to application of disaster management practices on critical energy facilities in UAE

Recommendations were made in line with the results to increase resilience and to deal better with some of the risks experienced in the Emirati energy sector. In the next few sections, each of these three objectives is discussed in turn.

5.5.1 Energy infrastructure facilities identified as critically vulnerable

Table 5.10 lists those aspects of infrastructure that managers in each of the three sites deemed critical to energy production. The basis of this criticality is linked to the severity of impact they would have upon an electricity generating service and supply in the event of a hazard or disaster.

Table 5.10: Infrastructural aspects that managers deemed most vulnerable

Aspect	Abu Dhabi	Dubai	Sharjah
Critical energy infrastructure facilities	Generating stations, transformers and transmission lines	Generating station	Station distribution centres, which are responsible for the distribution of 30% of the city's power
Vulnerabilities to facilities	High cost of operation and maintenance	Complexity and expense of system maintenance and construction, machinery and technology	Dependence on others i.e. Abu Dhabi to generate any further requirements
Most significant vulnerabilities	Lack of alternative energy sources of energy Need to increase the efficiency of electricity generation and transport	Lack of resources Abu Dhabi must provide Dubai	In terms of own system, lack of security and protection leading to the possibility of overloading and blackouts
Least critical energy infrastructure	Distribution lines and cables	Transmission	Distribution lines and cables
Why is the above infrastructure resilient?	Limited effect elsewhere Cheap parts to replace or repair Less time is needed in their maintenance	Well structured system	Cheaper assets Replaced or repaired in less time
Strengths	An abundance in energy production Provides its excess energy to the others	Company policy which has a focus on health and safety.	Safe city Excellent police force both of which reduce the likelihood of terrorist attacks and vandalism

For management, “all infrastructural components are important given that they work collectively and none of them work in isolation”. Yet the most critical components, should they fail, are the generating stations and specifically, the larger pieces of generating equipment. Abu Dhabi holds particular strategic importance given that its generating system provides energy not just locally but for Dubai and Sharjah.

The specifics of each city, management procedures and practices, as one might expect, affect the level of vulnerability experienced by a site and their ability to generate electricity. To add resilience, it was suggested that the “Dubai government could provide more legislation than Abu Dhabi” and that “Abu Dhabi could give more financial initiatives than Dubai. Dubai established health and safety before Abu Dhabi and gave it more importance. The city also developed more advanced education and training for their staff. In Abu Dhabi government initiatives play an important role as they encourage renewable and alternative energy, not just conventional forms”.

Sharjah questionnaire results indicated that heightened levels of security and disaster preparation meant that Sharjah was less vulnerable to threats (Figure 5.4).

In light of the above answers, strategic planning and risk management must come hand in hand with a detailed analysis of the threats and vulnerabilities that correspond to the context under evaluation (area of influence, reality, operative processes, environmental zoning). In addition, the scope of governmental legislation, according to interviewee opinion, should be widened. Any amendments or new branches should cover risk management and the need to establish a plan that can be applied across the energy sector and all facilities. The latter should champion any movement in this direction. An organisational structure should be developed to facilitate information flows between key actors. Institutions such as the police force and transit authorities must be involved to integrate the disaster response and/or preparation and planning. Responsibility should also be shared to make disaster management and mitigation more effective. Inefficiency may occur, for instance, if a central generating station must take all the burden and make all the decisions. Synergy must be built by multiple members practicing emergency procedures and building policies before a potential disastrous event occurs so that in the event of a disaster, people’s roles are known and well-rehearsed and resilience assured.

One of the unexpected results is that the experts make no mention as to the need to diverse the energy matrix to include renewable energy. This was however a key aspect in the answers of the questionnaire participants. The only associated statement is that of nuclear energy whereby it is considered that it "may be an important issue in the future as it is being developed as the country's wealth and energy demand increases". Indeed, it was not until the researcher questioned them on the theme that there was some reflection: "to rely entirely on renewable energy is a strategic goal, where clean energy is available. An example of which is solar energy and I think that in the near future we will witness a major shift toward reliance on solar energy, both thermal and photovoltaic". Following the questioning regarding the infrastructural vulnerabilities, the author than asked how disaster management practices influenced them.

5.5.2 Current disaster management practices and their relation to energy infrastructure deemed critical

Table 5.11 lists those practices and processes that interviewees deemed to improve resilience.

Table 5.11: Aspects of resilience as perceived by interviewees

Aspect	Abu Dhabi	Dubai	Sharjah
Most important management practices in avoiding disaster and increasing resilience	Sufficient employee awareness Studying of risk more comprehensively	Strategic plan	Strategic plan, greater levels of awareness, education
Training and awareness level	Seen as having great importance. It contributes significantly to the ability to make the right decisions	Further education is highly beneficial and disaster theory should be explored in schools and university	Awareness should lead to improved strategic decisions and is thus a key component
Rehearsed processes and procedures	This occurs in periodic tests emergency planning	Undertaken in experimental training and professional education generally	By running scenarios to identify weak and strong points. Also amending and building on training and processes according to analysis.

In terms of education, "the training of employees, so they understand that disasters and hazards represent a serious problem, is important, as is explaining to them likely consequences of not doing their job properly. They will only know that and be able to act accordingly if they are well-trained, competent members of staff. Improved awareness and ability will also result. Subsequently, they should be more able to identify weak points and communicate them. Their added level of awareness should also lead to improved strategic decisions and consequently their support in the drawing up and enhancing of strategic plans and planning generally can be achieved".

Various answers speak of good practices supported by policies and defined processes. These are significant and necessary steps for consistent improvement in key disaster prevention protocol, such as evacuation and role play. Further developments are required with the focus needing to be more preventive than reactive. Having identified the disaster management practices, their strengths and weaknesses, the questionnaire focused on the exact boundaries that can prevent management practices from being successful in the mitigation of a given disaster.

5.5.3 Critical evaluation of existing barriers to the application of disaster management practices for critical energy facilities

For those interviewed on the management team, the greatest barriers to the reduction of vulnerability and disaster potentiality in the energy sector were the same as those identified by the workers during the questionnaires survey. Most, if not all, were related to education, training and increasing general awareness of energy personnel operating at all levels. This is most clearly seen in Table 5.12.

Accordingly, it was stated that "policy, specifically relating to education, must be improved. This will support disaster mitigation generally and increase resilience".

Educating people, supports the development of tools and values. Both of which are important when it comes to making judgement calls as to the severity of a given risk.

Table 5.12: Key barriers to disaster mitigation according to energy sector managers

Aspect	Abu Dhabi	Dubai	Sharjah
Most significant barriers in the application of the procedures, policies and practices	Time and the effective distribution of tasks	Policies which should be amended to include more educational development as a professional	Lack of professional training and education
Underlying cause of these barriers	Lack of sufficient awareness in the management team	Staff are unprepared or ill-prepared.	No one has looked sufficiently at the experiences of neighbouring countries to learn from them
Best position person or group for the removal of barriers	No one person or group. Rather it is an integrated role between the private and public sector	Heads of departments	All involved in energy generation, transmission and distribution.

The barriers identified in Table 5.12 and their underlying causes apply to the energy sector generally – not just the case studies represented directly in this research. All respondents conclude that responsibilities should be shared and integrated between all actors, public and private.

To overcome any kind of barrier, learning from relevant and valuable international and regional experiences, especially if a disaster was mitigated successfully, is considered highly important. There was also a call to nationally "share energy sector experiences, within the government ministries. In fact, government legislation needs to facilitate, if not force the sharing of experiences (i.e. there should be umbrella procedures).

The recommendations, for strategy building, that come out of the series of interviews are as follows:

- Build upon current knowledge and better analyse information on the nature of the energy sector to comprehensively understand risk and risk prevalence
- Upon deciding risk management planning, develop cost-benefit analysis in order to establish adaptation strategies that are not only efficient but also sustainability

- Strengthen policies for disaster management and incentivise the right type of investment opportunities to trigger various financially and technically viable solutions.
- Increase public awareness when it comes to those themes relating to disasters and hazards that may have a detrimental effect on the energy sector
- Generate networks of learning which facilitate the exchange of best practices and the sharing of resources between companies or across the various public bodies. The fundamental idea of any such network should be an improved level of resilience.
- Increase the quantity and quality of resources dedicated to research and innovation. This is particularly key when it comes to the diversification of energy resources and the development or renewable energy and clean tech.
- Focus on the concept of sustainability with regard to the corporate or residential consumer.

This section represents the last of any participant response. It is now important that the author considers any limitations which may have affected the quality of any of responses and/or analyses of the previous sections.

5.6 Limitations

It is important that the limitations of the results, in terms of their validity and representativeness, are reflected upon. One of the major issues is that only 42 of a possible 100 questionnaires were answered. The other respondents refused, as was permitted under the ethical framework developed in this thesis. These refusals mostly occurred in Sharjah, which although much smaller than the other two sites, was involved to a much lesser extent than originally anticipated. This meant that only seven employees responded. This number was less than half that of Dubai and almost two-thirds less than Abu Dhabi. It is thus difficult, with such a small number to know whether those seven persons represented the general employee population or were anomalies. It also means that the results of the overall graphs are more likely to represent Abu Dhabi or Dubai opinion, rather than be a representative depiction of the overall opinion. In hindsight, greater weighting should perhaps have been given to the

responses of Sharjah participants, so as to prevent the obscuring of their voice in the presentation of the overall results.

All questionnaire respondents were male, effectively silencing the woman's voice at the general worker level. This issue may be particularly problematic in questions where the workers must place a value on the public's perception of disaster – most of that population is either a woman or child, neither of which were represented in the questionnaire. It is however difficult to address this issue due to cultural sensitivities. Women are not frequently found in these types of working conditions outside the office environment. There are few in the energy sector generally. The author addressed the issue of representation by asking women, who occupied administrative roles such as Finance Manager for their participation in the interview. In fact half of the interviewees were female, in an attempt to reduce this problem.

Time was a major issue, especially in terms of that spent in collecting primary data in the UAE. Limited time was spent at each site and this may have affected rapport and to some extent the analysis presented in this chapter, given that primary knowledge was restricted to a few weeks each time in the field.

The interviews were limited in terms of number, due to time. Apart from that some the answers provided were vague and not particularly easy to analyse. In providing vague answers, respondents were able to answer the interviewer's question and move one step closer to finishing an undesired question and answer session whilst not being overly committed to one course of action or another. Vague answers may have resulted from vague questions despite the efforts made to avoid this possibility, as explained in Chapter 4.

Vagueness and time issues means that the views expressed may not be representative or reflect the reality on the ground. The limited information provided also meant that no statistical analysis was possible. Any analysis was strictly qualitative and thus subjective in nature. This, as discussed in Chapter 4, is a source of weakness, which is why quantitative analysis was used in the questionnaire survey and why methodological plurality was employed in this investigation.

5.7 Chapter Summary

The results from Abu Dhabi and Dubai were very similar. In terms of preparation, respondents believed that the sector was best prepared for terrorism, extreme heat and health and safety-related accidents. In general, with the exception of terrorism, with a mean of 6, limited error and a higher concentration to the right of the mean, respondents expressed the view that the energy sector was ill-prepared to face disaster. It can be said, based on the maximum values of Dubai, that workers feel more prepared for disaster than their Sharjah and Abu Dhabi counterparts. Shajah's results are very different. This may be due to the lower number of respondents- only seven- meaning less than half of that for either Abu Dhabi or Dubai. Representativeness may be a key issue, especially when it comes to the overall graphs, which more readily reflect Dubai or Abu Dhabi opinion due to the disparity in the number of participants. In hindsight the answers from Sharjah should have perhaps been weighted differently. There was a perception in Sharjah that the energy sector was more prepared, with a mean of 5.73. The lowest levels of preparation were considered to be for terrorism and tectonic activity. Terrorism is in direct contrast to that experienced by energy sector workers elsewhere. It is also surprising that Sharjah employees believed that the public perceived the sector to be best prepared for terrorist acts. This may reflect national rather than regional resilience.

All respondents identified renewable energy as safer than either nuclear or conventional options. However, 35% see it as a simple technology from an economic and technical point of view, a fact not supported by literature on the subject. Thirdly, war and terrorism were seen as key threats to the Emirati sector, despite not being specifically listed as possible answers. In fact 50% of respondents said that "terrorism" was the risk of number one concern. Climate change is also recognised as a problem, most acutely in Sharjah. The main barriers to resilience in the energy sector are said to be:

- Disaster management training in the energy sector remains to be addressed (71% of the respondents)
- Staff competences, especially through education, to support the understanding of climate change and its related disasters (31%)

The interview answers focused predominately on those issues brought up in the questionnaire. Emphasis was placed on the need for further education, awareness and training in order to build staff competence.

The wider repercussions of the results and recommendations presented in this chapter for the development of an appropriate disaster mitigation plan and strategy are discussed in Chapter 6.

CHAPTER 6: DISCUSSION

6.0 Introduction

This thesis states five objectives with which to achieve the aim of drafting a framework to support the development of resilience within the UAE's critical energy infrastructure facilities, through the introduction of a strategic disaster mitigation plan. The first four objectives have been dealt with in the previous chapters. The first, to identify Emirati critical energy infrastructure facilities and their vulnerabilities to hazards, was introduced in Chapter 1 and comprehensively evaluated in the literature review in Chapter 2. The second objective, to examine current disaster management practices and their relation to those infrastructures deemed critical within the energy sector, was discussed in Chapters 2 and 3 (in terms of secondary research) and in Chapter 5 (in terms of primary research). The third objective was achieved through Chapters 2 and 3. The fourth objective was considered in the literature review of Chapter 2. The fifth and last objective is to develop a framework for a strategic disaster mitigation plan for critical energy infrastructure. Chapter 3 provided a draft framework but without taking into account the findings, analysed in Chapter 5. Such data is evaluated in the wider context of the Emirati energy sector, in terms of what these findings might mean, their value and their contribution to the future. The limitations of the thesis in terms of the benefits it may bring to the disaster discipline, energy sector and the possibility of building resilience is also discussed. The shortcomings of the research and future research topics connected to those themes presented in the thesis are also elaborated on. The next section proposes what kind of strategy and disaster mitigation plan is needed to further protect critical energy infrastructure, and what the framework may look like.

In light of the empirical results analysed in Chapter 5, which supplement the provisional framework set out in Chapter 3, this chapter discusses in depth the various elements that constitute a well-developed strategic disaster mitigation plan for the UAE energy sector. The discussions range from what kind of strategic planning is required to best mitigate disaster in the Emirati energy sector (Section 6.1), effective forms of training and education (Section 6.4.1), critical energy infrastructure (Sections 6.3 and 6.5.2), the role of renewable energy in national development and its contribution to resilience through

the diversification of the energy matrix (Section 6.4.2), the importance of creating a platform for dialogue and the sharing of information within the government. The structure of the document (Section 6.6) and its communication (Section 6.2) are also discussed.

6.1 Proposed Strategic Disaster Mitigation Plan

Critical factors for a successful strategic disaster mitigation plan and disaster management, according to Moe and Pathranarakul (2006, p412), include effective organisational (or institutional) arrangements, coordination and collaboration, supportive laws and regulations, effective information systems and communication, managerial and team member competence, effective consultation with key stakeholders, clearly defined goals and commitments by all parties, effective logistics and sufficient mobilisation and disbursement management; in other words, a comprehensive set of measures across the entire disaster lifecycle. All of these need to be discussed and developed in the establishment of a multi-year plan.

The environment and ecological resilience should not be overlooked or downplayed. Any strategies must be anchored to national Emirati policies and legislation

Communication and dissemination plays an integral role in preventative disaster management. Measures and protocols for communication strategies should also be included. Finally a disaster mitigation plan may discuss relevant case studies and should include general recommendations, conclusion and future outlook, so that following data collection and analysis, the following issues, first highlighted in Chapter 3, can be discussed in more detail:

1. Identify the targets – who might be affected and who might not?
2. Type of help – "what assistance do they need?
3. Timing– When will assistance be most useful and when will circumstances allow assistance?
4. Theme– What are the themes, issues, concerns and threats that should be considered in order to build and plan the right intervention package? What has already happened and what will happen in connection with the incident?

5. Team and Resources– What resources will it take to provide the right interventions at the right time(s)?

Based on the data analysis of Chapter 5, the first question has a simple answer. Those that were predominately identified as key actors were the workers directly affected by hazards, latent failures and disastrous events. The next question also is associated with the same theme, i.e. issues, concerns and threats. The literature review and the responses to the questionnaires showed that key potential hazards included tectonic activity such as earthquakes and tsunamis, climatic activity such as *shamal* and flooding, landslides and a host of manmade disasters such as war, terrorism and chemical spills and/or explosions. Most respondents in their questionnaires and all those interviewed (management staff) stated that education and training were among the most important interventions when it came to developing a strategic plan for disaster mitigation. Further assistance, in terms of training and personal development, is crucial, given that the workers identified the main barrier as:

- Disaster management training (71% of respondents felt that it remained to be addressed)
- Staff competences (31% thought that the lack of education on climate change and its related disasters was a problem and required attention)

To complement the above, questionnaire respondents stated that it was necessary to:

- Undertake simulations that assess and verify the level of personnel preparation, organisational structure in disaster response and resource capacity installed
- Develop a better planning stage for disaster preparation
- Achieve greater awareness, which means giving higher priority to the issue.

In terms of timing, the third question on Doherty's list, all these issues are proactive responses to disaster management. That is to say that they must occur before a disaster strikes. Given the long term nature of a training and development programme, it is in the Emirati energy sector's best interest to launch it as soon as practicably possible. Before any launch however, and based on the literature reviewed in Chapter 2 and the

data analysed in Chapter 5, the Ministry of Energy needs to ascertain in greater detail the exact type and level of disaster preparation training, education and awareness. Interviews undertaken with management across the three sites, Abu Dhabi, Dubai and Sharjah, particularly emphasised the role of professional training and further education to combat disaster. Such initiatives proposed to go beyond those individuals working in the energy sector and into the reach of schoolchildren and university students. The level of training and general awareness was seen as having great importance, contributing significantly to the ability to make the right strategic decisions for sustainable development.

For disaster mitigation to support development, any strategic plan must be undertaken in a way which optimises resources, thus reducing the duplication of effort. It should also initiate, or improve upon, the possibility of constructing collaborations, shared responsibilities and joint actions across the science-policy interface. This should in turn support the writing of guidance for policymakers and professional practitioners (such as those participants in the questionnaires and interviews) in and beyond the energy sector. Management representatives must therefore come together and meet with those politicians best placed to amend policy and practices. Any changes in terms of procedures and strategies must be integrated across the spectrum of installations associated with the energy sector, if training and development is to be truly successful. Committees and dialogues must occur first (See Section 6.2). They should also be accompanied by the closure of knowledge gaps and the re-examination of how things are currently being done. Pilot studies can then follow, followed by more widespread innovation in disaster management. This task requires multiple experts and a considerable amount of time. This leads to the discussion of the final question in Doherty's (2008) list: *What resources will it take in order to provide the right interventions at the right time(s)?*

In the interviews it was stated that resources that add to the overall level of awareness in the construction of improved strategic decisions and the drawing up of plans were much needed. The possibility of enhancing energy sector resilience was frequently linked to research and an investment in the right personnel to achieve resilience. Specifically, one

of the respondents, highlighted the importance on risk knowledge, identification of risks and ways of dealing with it:

"…*Focus on this aspect and the rewriting of key risk concepts related to the energy sector in a simple and understandable way, in order to raise the level of scientific knowledge and understanding of disaster phenomena".*

There was a notable consensus that any resource investment and utilisation should focus on preventative measures rather than reactive actions. There was however limited solution provision with many respondents identifying key issues and what any future resources would need to achieve, but not providing much input as to *which* resources would be most useful. There was no talk of timeframe or personnel assignation, in terms of the number of hours needed to attain what was being asked for etc. Regional and international experiences were said to be key, but again nothing detailed was mentioned as to what exactly would contribute to the resilience of the Emirati energy sector. National government ministries and legislation were seen as important to encourage experience sharing and umbrella procedures, but no information was provided to direct the researcher more precisely towards what exactly should be shared or which procedures were useful. There seemed to be an overriding reluctance to provide real solutions with strategic actions that could be followed up. This may be to do with the desire to look knowledgeable in front of the researcher and not suggest ideas that may indicate otherwise. It may also be a way to minimise responsibility in the future, in the sense that if an individual identifies a possible solution he or she may then be put in charge of seeing it through.

Accountability is a key component of any strategic disaster mitigation plan which not only serves to reduce risk but also acts as a catalyst for development. National legislation and actors such as the *National Emergency Crisis and Disaster Management Authority* must ensure that any implementation of a disaster strategy and the actions that stem from it are monitored and audited independently to ensure not only legal compliance but also the establishment of the highest global standards. All information, apart from the most sensitive, should be made available on request to the general public, or least the community affected. Such information could include natural or man-made (terrorist) alerts, the official response, the consequences of an event and the key actions

put in place to reduce or prevent damage from its future recurrence. Preventive measures such as planning policy and urban and mains grid mapping should also be made public, where a clear societal interest has been identified.

To incorporate all the above into a strategic disaster mitigation plan, it is essential that a set of targets are established at every level of governance. Such aims should differ slightly according to the nature of the disasters faced and the capacity with which to meet the targets. There should be a supporting government drive to bring each level to a certain standard, so that cooperation can occur when it comes to trans-boundary issues such as tectonic activity. This can be done following the training and education.

As discussed in Chapters 3 and 5, training and education are two important tools to combat vulnerability and to build resilience. Both are integral components of a long-term disaster mitigation strategy. Despite the emphasis placed on the building of professional competencies, by those responding to the questionnaire as well as those interviewed, only an explanation as to *why* and for *whom* disaster education was necessary was given. No one stated *what* they needed to involve and *how* one might go about doing this, which is not helpful when it comes to strategic decision making. Section 6.4.1, according to the knowledge presented in this thesis, discusses what kind of educational development and training is needed and how it might contribute to the disaster discourse and the strategy for disaster mitigation. Such information should provide added value to those communities at risk, and to disaster and energy practitioners using this thesis to build resilience into the Emirati energy sector. Meanwhile, the next section considers the communication of the strategic plan.

6.2 Communicating a Strategic Disaster Mitigation Plan

One of the key issues revealed in the questionnaire and interview sessions was the role of the government and especially the need for the coordination and sharing of disaster policy and practices across energy generating sites. For resilience to be built and maintained, the Emirati Government (on a ministry level and below), in order to reach local level departments, must improve communication to ensure standardised and coherent operations in the running and protection of critical infrastructure. As first elaborated upon in Chapter 3, all communication processes should occur transparently

and involve multi-stakeholder input. An example of where such communication is beneficial is the holistic look at land use designation and policy, urban and spatial planning and construction/reconstruction, so as to address potential risks in a preventive and decisive manner. It is not sufficient to bring together a skilled and capable committee and external consultants to design and develop a disaster mitigation plan for a certain circumstance if no one knows the plan even exists. Even if one does know of their existence, the plan and protocol need to be accessible – both physically and conceptually. In other words, those who need to access it and train their staff, according to the information contained within a plan, should know where they can obtain a copy. It is best to have both a hard and an electronic copy. The latter is easier to share on mass but a physical copy is useful for reference and for training purposes. Furthermore, if a disaster results in the loss of power and/or data, a hard copy is the only copy a team may have available to them. Furthermore, any copy must be readable. In some cases, various translations of the master document may be required.

Any communication team must prioritise the timely delivery of information to target audiences. For example, whilst team leaders in energy generating plants need the plan in its entirety, a community leader will potentially only be interested in the section, plan and protocols that specifically relate to community resilience. In this case, it may be prudent to ensure that this section (or chapter) is simplified. This represents one way of using appropriate communication mechanisms to ensure that the message gets across.

According to Haddow and Haddow (2013), for the successful dissemination of a disaster mitigation plan, those responsible for writing it (in this case the tripartite committee) must consider the ultimate goal of the disaster mitigation plan, in measurable terms, and the objectives that one should establish in order to reach that goal. The audience, the messengers, the tools and the time allocated to communicate the plan should also be considered.

When considering the audience, a plan and the means of communicating that plan must identify the functional needs of those who will be using it. Perhaps the most complicated component is the community. The way to address elderly members of the Emirati community, some of whom are illiterate, is not the same as the way one addresses young and equally illiterate children. Tools should thus be used in

combination to get the attention of all involved. Older members may prefer the more traditional means of Bedouin communication, i.e. word of mouth, from community leaders to the wider group. Others still may use the television and radio. Younger generations may be more reachable via social networks and online streaming platforms. Equally important are those individuals selected to bear the message. For some, demographic groups elected and appointed government officials. His Royal Highness and UAE president Khalifa bin Zayed Al Nahyan is a good example of an official who is widely respected by the population. His intervention would have an extremely positive impact on the general population's adherence to the disaster mitigation plan. For children, the message could be more effective if given by animated characters. Finally, and like with any plan, there should be an evaluation phase with the goal of continual improvement. This should also be communicated so that there is informed forward progress, future collaboration and consensus.

The above paragraphs represent the details of a framework for a communication process for the dissemination of a strategic disaster plan. These are of course subject to change and depend very much on the nature and network of the tripartite members. It is thus poignant to remember, that the fundamental role and characteristics of communication in disaster planning lies in the detail. This is according to Luchini (2014, p.198):

… to be considered through resilience characteristics in terms of coherence of the message, robustness of the channel… subculture and those who send the messages.

In addition to a brief outline of a communicative process in the strategic disaster mitigation plan, the tripartite committee should also develop a far more detailed "National Emergency Communications Plan" for the four years that the mitigation plan operates. It should also be updated regularly, given the speed of progress in the telecommunications sector, technology and the way in which the general public choose to communicate. The rules and recommendations that apply on the update of the mitigation plan are also of relevance here.

6.3 What is Considered to be Critical Energy Infrastructure?

In Chapter 2, critical energy infrastructure was shown to have a broad definition. It was said to include any:

"*… physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact on the nation or affect its ability to ensure national security" [p30]*

Here in this study, it was however, ultimately the energy sector managers that identified the most critical aspects of infrastructure - their significance and function. Their decision, as is frequently the case, was performed using a qualitative approach, based on expert judgement, and a limited range of risk attributes, i.e. high, medium and low, as highlighted by Setola and Geretshuber (2009). In turn, the choice of range tended to be linked to economic costs, ease of replacement (should a unit fail) and overall impact on the electricity service in the region. Subsequently, the distribution lines and cables were seen as the least critical, and the most resilient. Most managers saw the generating stations as the most significant weakness due to the expense and complexity to bring them back on line. Others refused to break the system down into its individual structures, stating that it can only ever be seen as a whole.

6.4 Barriers and Ways of Improving Disaster Resilience

This section elaborates on the findings concerning disaster education, disaster training and awareness, along with a full and correct understanding of renewable energy and its potential integration in the energy sector. It will discuss, in depth, the mechanisms that can be put in place to address such issues.

As discussed in Chapters 2 and 3, the TOSE measures of resilience (Chang and Shinozuka, 2004) are these:

- **Technical** resilience refers to how well physical systems perform.
- **Organisational** resilience refers to the ability of organisations to respond to emergencies and carry out critical functions.
- **Social** resilience refers to the capacity to reduce the negative societal consequences of loss of critical services.
- **Economic** resilience refers to the capacity to reduce both direct and indirect economic losses.

The results reported in Chapter 5 are more focused on the organisational and social issues of resilience. Technical and economic resilience were not directly addressed, but rather provided some insights into how the draft strategic disaster mitigation plan should evolve into the final strategic plan. Limited disaster awareness and training were the main organisational problems, alongside staff competences and communications, as well as misunderstandings regarding renewable energy technologies. Social resilience was addressed via questions eliciting energy sector workers' perceptions of the general public's views on and readiness to cope with potential disaster events. This section takes each of these topics in turn and addresses the issues raised.

6.4.1 Effective forms of training and education

It is no secret that formal education and professional training on disaster mitigation and risk reduction are an integral part of a forward looking, longer-term strategy for anticipating risk.

Given the emphasis placed on training improvements, the recommendations made by the researcher at the end of Chapter 5 included the generation of networks of learning to facilitate the exchange of best practices and the sharing of resources between companies or across the various public bodies. The aim here would be to increase the quantity and quality of resources dedicated to research and innovation. Both are long-term strategies which require the integrated effort of various actors across the public and private sectors. Financial resources need to be set aside to develop an application system and regulations, either nationally or internationally, and to fund three or four-year research studentships. There also needs to be funding for those professionals charged with making the decisions on research priorities and the kinds of professional and/or academic candidates best placed to complete a doctorate degree and apply their knowledge to the Emirati energy sector on their return. Learning networks also take time to become established. Conferences and debates need to be offered to those actors in private companies and public bodies, in order to begin the process of knowledge sharing and building. One could begin, for example, by inviting those members who attended the 2015 World Future Energy Summit in Abu Dhabi. Another important consideration when it comes to building knowledge networks is Masdar City and the associated initiatives such as the Abu Dhabi Government-owned Mubadala

Development Company, with its mission to invest, incubate and advance the establishment of a clean energy industry in Abu Dhabi and around the world. This is especially true given its international status and credibility within clean tech and energy research. Groups such as those linked with Masdar also support the construction of knowledge and analysis of risk and risk prevalence. They may also help government ministries to achieve another recommendation for strengthening disaster management policies. It is equally likely that they could aid research programmes that investigate investment possibilities and various financially and technically viable solutions.

In short, long-term strategic planning is necessary to mitigate disaster. In the first instance, the government must ascertain which actors, both national and international, have the knowledge and capacity to research, more comprehensively, the issues presented here. Conferences and committees are a good first step in bringing competent individuals together to begin dialogue. Once capacity has been built and communication enhanced, strategic planning must focus on policy, legislation and practice. It is important to have a standard in the private and public sectors that applies across the board. The timeframe for attaining at least a platform from which a national strategy can be developed should be less than three years.

It is not however, a case of simply building knowledge and enhancing awareness, as Shaw and Oikawa (2014) point out, given that, in their experience, Japanese high school children are particularly aware and knowledgeable when it comes to a whole host of natural hazards, but are not able to translate theoretical lessons into practical action. For these authors, the most successful form of professional training and preparation for the reduction of risk has been the delivery of extremely realistic, action-oriented education in reducing disaster and risk; this then has to be linked to the roles and responsibilities of local government, schools, homes and the wider community. All such actors must have a basic level of disaster education. If one can remove, or at least reduce, some of the vulnerabilities that they face, resilience will be built – not just in the energy sector but generally. For example, should the emergency services have to focus their immediate efforts on digging trapped people out of the ground, considering that with the most basic disaster training, these people could have evacuated the building, it will take them longer to bring the energy installations and other forms of infrastructure back on

line. By taking such precautionary measures, the recovery period can be shortened and the resilience triangle can shrink to an almost unnoticeable size. As the Council of Australian Governments (COAG, 2011) states, increasing awareness of the local community, regarding the threats directly relating to them and what can be done on an individual (household) level to actively plan and prepare, can and does save lives and assets.

The kind of education that COAG refers to is that of frequent emergency drills and simulations, the re-evaluating of escape routes and behaviours that hinder good health and safety practice. It may also encompass the installation of domestic technologies such as evacuation alarms, in the event of fire or tectonic activity. Such devices act as early warning systems and increase the probability of survival. Training and education should take place in schools and higher education institutions, village meeting places, and in the offices/workplaces of key sectors or professions such as town planners. Rural (traditional Bedouin) Emirati women and other vulnerable individuals or groups should not only be included but encouraged to champion and hold a leading position in the development and operation of such initiatives. Traditional community values, such as those held by Bedouin, should be reinforced. Education and training programmes should not come at the expense of independence, resourcefulness and cooperation. The community receiving disaster and risk reduction training must be encouraged to make full use of their pre-existing managerial skills, creativity, and innovative and lateral thinking. In fact, and according to Fernandez *et al* (2012), the real and noticeable difference, following educational drives, must come from within the community which can then take ownership of it. If not, funding and material support may be wasted or mismanaged.

For energy sector professionals involved in disaster management and mitigation, such as those working in the public sector, any training or education must be focused on advanced planning and the mobilising of resources to combat disaster. It must also have motivational elements, not just education and theory. Any disaster management training must be offered at the beginning of any contractual appointment, and updated frequently, at least, on an annual basis, with refresher events. It is beneficial to use case study examples and practical actions, tailored to the needs of the organisation and the

level (capacity) of the group (Collins, 2000). Inviting disaster training professionals from recognised bodies is also beneficial. Education must, however, be directed towards key aspects of the energy sector such as the protection and the building resilience of critical energy infrastructure. In order to safeguard something however, one must identify its definition and scope, hence the importance of the next section.

6.4.2 Renewable Energy, Development and Disaster Resilience

One of the key aspects of the questionnaire and interviews was the possibility of utilising renewable energy to make the energy sector more resilient and ultimately less reliant on fossil fuels. The problem is however one of perception. All worker participants commented that renewable energy technologies were the weakest link in the chain. In fact, not a single participant felt that alternative energies were a real option to build resilience, contrary to research undertaken elsewhere and discussed above. Renewable energy may be seen as weak due to the limited attention given to these technologies prior to the appointment of Al Mazrouei as the Energy Minister, which happened subsequent to the questionnaire. There is certainly some recognition by questionnaire respondents as to the benefits that renewable energy may have on overall energy sector. This acknowledgement is somewhat contrary to the statement by respondents that renewable energy is not a technology capable of reducing vulnerability.

Renewable energy was also conspicuous by its absence, in interviews with management, when it came to identifying the need to diversify the energy matrix and to include alternative cleaner options. This limited awareness does not reflect the national policy to promote renewable technologies, in order to reduce the financial risk of what was then associated with a high oil price, established back in 2012. Both Abu Dhabi and Dubai promoted the generation of electricity by non-conventional energy, by setting targets of seven and five percent respectively of installed capacity by 2030. This is equal to 1.5 GW of a total 23 GW (Krane, 2014).

A key finding is thus the need to not only promote renewable energy, in terms of technical capability and installed capacity, but also to educate and build awareness about the benefits of its inclusion in the energy matrix as part of a disaster mitigation strategic plan.

Apart from that, a truly holistic mitigation plan for the UAE must incorporate personnel from various disciplines, including experts in the integration of renewable energy policy and practices. It must not take the traditional path of solely improving the existing large infrastructures via the reinforcing of transmission towers, the construction of sea defences around power plants, the stockpiling of larger amounts of fuel at plants *etc*. Instead, and as Evans and Fox-Penner (2014) indicate, disaster mitigation plans must encompass a combination of local generation and storage, increased procedural redundancy, conventional system hardening and stockpiling and smart grid functionality. Then and only then could an energy system be called resilient.

6.5 Amended Topics and Structure of Final Disaster Framework

Chapter 3 introduced the practical knowledge needed to develop a draft strategic mitigation plan. It discussed some of its key elements such as how it will be constructed and which content is significant. The latter included the definition, explanation and typology of hazards and vulnerabilities, critical infrastructure and barriers to resilience in technical, organisational and economic terms. The results presented in Chapter 5 will now be integrated into the draft framework to create the final strategic disaster mitigation framework.

6.5.1 Amendments to Hazards and Vulnerabilities

This section remains largely unchanged from the material presented in Chapter 2 and consolidated in Chapter 3. The major exception is a greater level of detail that will be provided for those manmade disasters and vulnerabilities such as social unrest, war and terrorism, which were identified as key concerns by the participants.

6.5.2 Amendments to Critical Infrastructure

The information provided in Chapter 2 will be supplemented by the responses of those participating in the interviews. Examples of key case studies and infrastructures, using the three power plants, will be included. A semi-quantitative cost-benefit evaluation of key infrastructure, as part of a risk assessment, will build on the qualitative analysis provided by the management staff in their respective interviews so that financial and human resources can be properly assigned, managed and directed to the most critical components of the energy sector.

6.5.3 Structure of the final disaster mitigation plan document

Figure 6.1 shows a chapter-by-chapter structure of what the founding strategic disaster mitigation framework document could look like, taking as its basis the themes explained in this chapter and publishing them in a precise manner, to aid those who will make the plan a reality within Emirati disaster policy and practice.

The first chapters of a disaster mitigation plan, as discussed in Chapter 3, must include the national, regional and global context, i.e. the current state of disaster theory, key definitions and data and key concepts regarding the UAE in terms of legal, environmental, social and economic aspects and the potential disaster that could serve to disrupt them. Much of this context can be found in Chapter 2 of this thesis. It will also integrate the primary questionnaire and interview data when it comes to concerns such as barriers. The third chapter of the disaster mitigation plan could include information pertaining to the document itself. In other words, it could point to how it was constructed and by whom. The scope, objectives and rationale behind the plan and the risk assessment should be explained. This helps to support future continuity, and to answer questions about validity, representativeness and reliability. The following chapters will follow the disaster management cycle, first introduced in Chapter 2. It is worth reiterating, as stated in the literature review, that the process of dividing the disaster process into various, albeit overlapping, stages is a useful heuristic device driving better understanding (Levinson and Granot, 2002) from which a disaster management plan can be implemented. It is, however, quite difficult because they are not necessarily mutually exclusive of each other (Latfifi, 2010). This difficulty is another reason why a tripartite committee should be engaged in the establishment and communication of a strategic mitigation plan. There needs to be a consensus between all parties (government, industry and civil society) as to the exact structure and content of each chapter in the disaster plan so that all components are fairly and equally considered. Chapter 6 of the plan, monitoring and evaluation, will act as a feedback loop to the participants of this thesis. Having identified their concerns this part will act as a plan-do-check-act method.

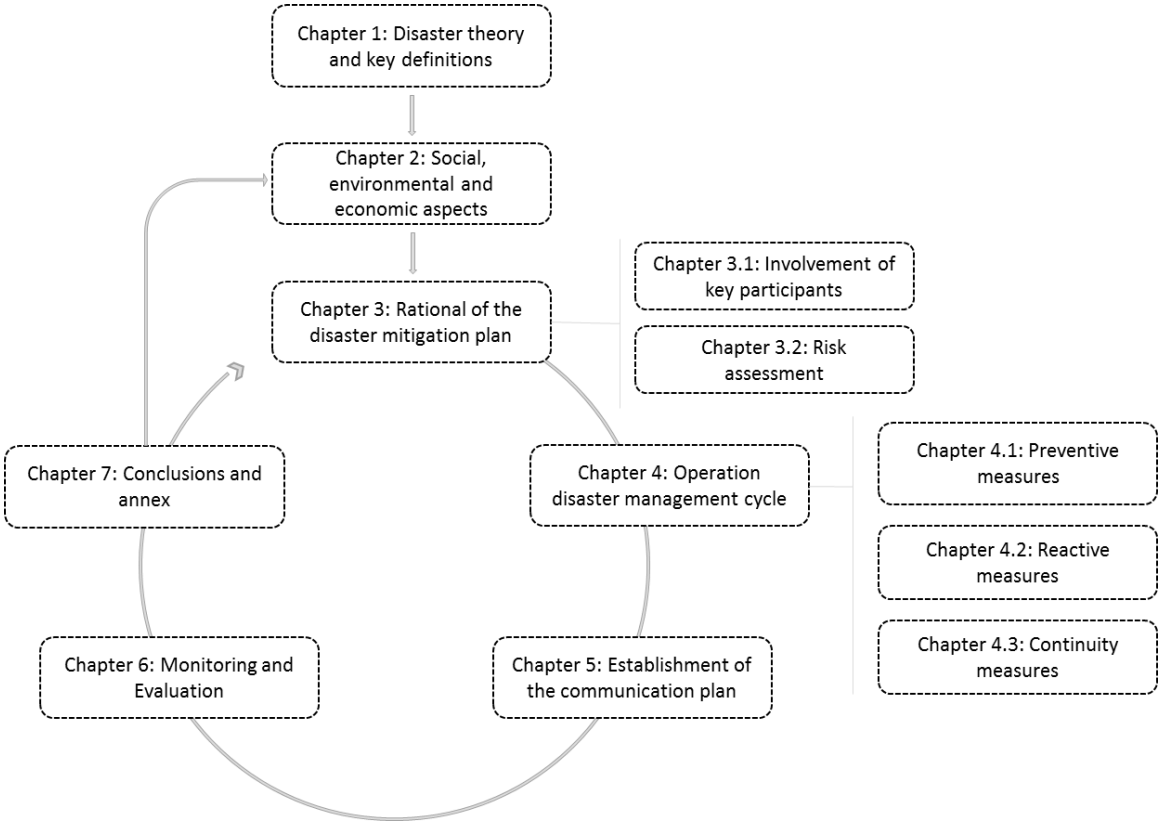

Figure 6.1: Strategic Disaster Mitigation Plan, chapter by chapter

6.6 Chapter Summary

This chapter has evaluated the importance of the results presented in Chapter 5 and supported by the literature review (Chapter 2) and the draft disaster framework (Chapter 3). It has discussed the content and communication of a strategic disaster mitigation plan, including the important barriers that need to be considered. The amendments to the draft plan have been highlighted.

The final chapter discusses the important practical and theoretical contributions of the thesis to knowledge in the energy sector and the wider academic world and explains how such knowledge would be integrated into the final strategic disaster mitigation plan. It also considers the limitations of this study and makes some suggestions for further research.

CHAPTER 7: CONCLUSION

7.0 Introduction

This research aimed to develop a framework to enhance the resilience of the UAE's critical energy infrastructure facilities through a strategic disaster mitigation plan. This principal purpose was subsequently broken down into five research objectives and their accompanying research question, which were addressed throughout and discussed comprehensively. In this concluding chapter, the most important findings are synthesised. Before going through each objective and question, it is worth reiterating the importance of this study.

Firstly, it is recognised on a global scale that population increases combined with an ever more complex society and economic and geopolitical systems means that more people and assets are vulnerable to hazards than ever before. In Chapter 1, it was noted that since 1973 disaster statistics have seen a rising trend (UNISDR, 2012; Guha-Sapir *et al,* 2003). Such statistics report that between 2000 and 2011, 2.7 billion people have been affected by hazards, 1.1 million of whom lost their lives as a result (UNISDR, 2012). The financial cost is also escalating. This means that developing and emerging nations are particularly vulnerable to natural hazards and ill-prepared for terrorist threats and activity. For the UAE specifically, the range of disasters that the nation could face is appreciable, given that they could stem from tectonic activity, climate change and even terrorism, as explained in the literature review in Chapter 2. Given the numerous types of hazards that could impact the UAE, the energy sector in particular must reduce vulnerability and build resilience both in the infrastructure and in the communities threatened by a potential disaster. Failure to protect the Emirati energy system and prepare it for future hazards, regardless of their specific origin, means that the country as a whole will be severely weakened in its ability to defend and govern during and following a catastrophe. Communication systems, transport links, hospitals and the emergency services, for instance, all depend on a stable and constant energy supply, no more so than in the aftermath. A loss of power will most likely have longer-lasting impacts on the economy and geopolitical status. It will also affect social cohesion and individuals' ability to rebuild their lives and the community which they inhabit.

This research represents one of many efforts helping direct the UAE into a more resilient and sustainable future. It provided a means to explore key concepts of disaster resilience for future planning in urban development and in the prevention of terrorism, the understanding of climatic phenomena linked to the exacerbation of global warming and some of the consequences linked to natural phenomena. It identified weaknesses in key issues such as education and training, including latent failures. It thus provides a platform for enhancing the competence of employees in the energy sector. In turn, their ability to react and communicate in a more efficient manner during a disaster event and its immediate aftermath could save lives and protect assets (financial, social or environmental). This research also supports long-term planning and the procedures that contribute to the overall wellbeing of the energy sector and the nation as a whole by reducing the time needed to recover from an event. In short, this research cements the five pillars of resilience: preparedness; protection, early warning, emergency response and recovery, by giving key actors in civil society, industry and the public sector the means with which to discuss disaster issues and to develop strategic mitigation plans, as elaborated in Chapters 3 and 6 of this thesis.

7.1 Research Objectives Revisited

Apart from the contributions of this thesis to the energy sector and their impact on it, there are also contributions that are beneficial to academia and specifically to disaster theory. First and foremost, this thesis serves to highlight some issues of perception and challenges in the UAE and calls disaster practitioners to use their knowledge and expertise to help the Emirati government disseminate information such as that relating to renewable energy or disaster management programmes, in a more efficient way. In many cases, this thesis, especially in Chapter 2, updates country specific information, which has not been generally available post 2007. This research arguably represents the first of its kind in its seeking to understand the issues that concern energy sector workers and managers in the field, by directly soliciting this information from them. This gives a unique insight into some major problems, either latent or experienced on the ground. That said, to truly understand the importance of the findings for both the Emirati energy sector and disaster theory, the objectives and questions were considered previously, but now warrant a more precise answer.

Research Objective 1: "*To identify Emirati critical energy infrastructure facilities and their vulnerabilities to hazards".*

Associated research question: "*How and to what extent is the state of the Emirati critical energy infrastructure facilities vulnerable to hazards?"*

Chapter 2 of the thesis discussed certain aspects of the multiple and diverse hazards, both natural and manmade, that could potentially affect the energy sector and the Emirati society. These include those relating to tectonic activity, climatic phenomenon, accidents and terrorism. The complication in answering this question comes not in the identification of the hazard but rather in the identification of the infrastructure deemed critical. In the first instance, the identification of criticality, by both energy sector workers in their questionnaire and management in their interviews, was subjective. The identification was based not on quantitative modelling or semi-quantitative scenarios but rather on intuition, built on experience. Their decision, as is frequently the case, was performed using a qualitative approach, based on expert judgement, and a limited range of risk attributes *i.e.* high, medium and low, an approached critiqued by Setola and Geretshuber (2009). It is not the most appropriate form of decision making and in the absence of a logical chain derived from a suitable form of risk analysis, it is difficult to say with any degree of certainty which infrastructure is the most vulnerable and warrants investment (financial or otherwise). A lack of quantitative data can also result in a loss in perspective and makes standardised policy and practices all the more difficult to achieve. A deeper discussion of the need for more quantitative measurements can be found in Chapter 6 of this thesis.

Another problem encountered is the fact that critical infrastructure is not necessarily an easily definable physical object but rather an indefinable network. Its 'parts' often, if not always, constitute more than one sector and are critical to many societal functions, not just those isolated to power production. All parts make up the whole and it takes a holistic perspective to fully immerse oneself in the real concept of critical infrastructure. While some energy facility managers identified in their interviews physical components as "resilient" or "vulnerable", others refused to break the system down into its individual structures, stating that it can only ever be seen as a whole. At some point, however, one has to try to separate components in order to enhance the resilience of the

whole. After all, it would be counterproductive, if not impossible, to afford the same level of protection and financial input to the safeguarding of a single cable as for a gas turbine. The need to manage vulnerability more intelligently leads naturally to the second objective.

Research Objective 2: "*To examine current disaster management practices and their relation to those infrastructures deemed critical within the energy sector".*

Associated research question: "*What are the current disaster management practices and what is their relation to those infrastructures deemed critical within the energy sector?"*

Participants shared little information as to the exact nature of disaster practices and what could be done to solve any underlying issues. Whilst there was a notable consensus that any improvement measures needed to be focused on preventative measures rather than reactive actions, there was no talk of timeframe, of personnel assignation in terms of hours or indeed of other resources required to improve disaster practices. It is difficult to provide an exact description, given the absence of answers regarding current activities. There seemed to be an overriding reluctance to provide real solutions with follow-up actions. This may be to do with the desire to appear knowledgeable to the researcher by refraining from suggesting anything that may indicate otherwise. It may also be a way to minimise responsibility in the future, in the sense that if an individual identifies a possible solution he or she may then be put in charge of seeing it through.

Regardless, the current Emirati disaster management practices in the energy sector need to be enhanced and modified to reflect the reality of an energy network as opposed to physical isolated installations. The final framework for a strategic disaster mitigation plan as a platform has its basis in increased dialogue and tripartite solutions between civil society, the State and industrial actors. It is not the ideal scenario, but it does provide a means to answer this question satisfactorily in the near future. The ultimate aim of this thesis, which is also its general contribution, is the improvement of operations, policies and practices of the Emirati energy practitioners and the community through a strategic plan. This plan must support the sustainable development of a UAE that is better and more proactive in its preparation for any potential hazard (manmade or

natural) that could temporarily or permanently affect the sovereignty and functionality of the country and its population, particularly when it comes to those matters associated with energy.

Research Objective 3: "*Critically evaluating existing barriers to the application of disaster management practices on critical energy facilities in UAE".*

Associated research questions: "*What are the barriers that affect the application of disaster management practices on critical energy facilities in UAE"* and *"How can these barriers be reduced?"*

Answers to these questions were provided in the primary research by both general workers and site managers. Data analysis in Chapter 4 identified the main barriers as:

- *Disaster management training, 71% of respondents felt that it remains to be addressed*
- *Staff competences, 31% thought that the lack of education on climate change and its related disasters was a problem and required attention*

To complement the above, respondents of the questionnaire stated that it was necessary to:

- *Undertake simulations to assess and verify the state of personnel preparation, organisational structure in disaster response and resource capacity installed*
- *Develop a better planning stage for disaster preparation*
- *Achieve greater awareness, which means to give more priority to the issue*

Given the consensus that training and general awareness level are of great importance and that they contribute significantly to the ability to make the right strategic decisions, the implications of this research are highly relevant. If education, training and elevated staff competences are considered important by management, then one must further question why employees feel that the current level of training is not sufficient. Quite clearly therefore, management staff representatives need to come together and meet with those policymakers best placed to amend energy sector policy and practices. Any changes in terms of procedures and strategies must be integrated across the spectrum of

installations associated with the energy sector, if training and development are to be truly successful. Committees and dialogues must be established first (see Chapter 3). They should also be accompanied by the closure of knowledge gaps and the re-examination of how things are currently being done. Pilot studies could be conducted, followed by widespread innovation in disaster management. This task requires multiple experts and a considerable amount of time. Such efforts will be better programmed if undertaken as part of a strategic disaster mitigation plan developed within the national context. Hence the inclusion of the fourth objective.

Research Objective 4: "*To contextualise and define the concepts of disaster resilience and strategic mitigation planning within the UAE".*

The discussion of this objective is well developed in the literature review of Chapter 2. Consequently, only two relevant points will be highlighted. In 2015, social media, for example, plays a key role in strategic mitigation and communications before, during and following the aftermath of a disaster. In 2013, the National Crisis and Emergency Management Authority (NCEMA) were taken by surprise by the rapid spread of misinformation following two earthquakes. The situation forced NCEMA to appear on national television and various press conferences in order to calm the public after exaggeration led to widespread panic. The threat of panic due to incorrect and/or unsubstantiated information entering the public realm means that NCEMA, and various other institutions must maintain a constant presence on social media platforms (YouTube, Twitter and Facebook accounts), so as to alert members of the public with disaster facts and the necessary information for the prevention of disaster and advice during and immediately after it.

Another key point worthy of comment, specifically for the energy sector, is the wider recognition in 2015 of the need to diversify the energy matrix with renewable/alternative energies. Renewable energy can play a key role in the development of a more resilient energy sector, sustainable economy and community. When larger conventional power plants fail to operate, following tectonic movement for example, the distributed form of energy that comes from solar and wind farms etc can play a part in keeping the lights on in those urban areas affected by a disaster. The possibility of keeping important facilities such as hospitals or emergency service

locations working then further reduces the risk of indirect casualties or fatalities. IRENA is headquartered in the UAE and should support strategic disaster mitigation planning and policy via the diversification of the national energy matrix and the reinforcing of strategic technologies such as concentrated solar power, which would make the country less vulnerable to natural hazards, social unrest and terrorism. The government needs to work harder to ensure that expert information is passed down to national actors for the benefit of Emirati development. It must facilitate communication and the establishment of committees that serve as bridges, not as barriers (see Section 2.5.4). Existing barriers can be removed through the development of a framework, as proposed in the answer to objective 5.

Research Objective 5: ***"To develop a framework through a strategic disaster mitigation plan for critical energy infrastructure".***

Associated research question: "*Why does the Emirati energy sector has not adopted a strategic disaster mitigation plan?"*

Based on the evidence presented in this thesis, the adoption of a strategic disaster mitigation plan has not occurred for various reasons. One of the most important ones is the evident lack of communication, particularly apparent in the drive for renewable energy from high ranking officials (and from those lower down) that has simply not reached those working on the frontline of energy generation. Furthermore, if training and education programmes are noticeable by their absence, it is unlikely that communication between managers and employees is optimal. Training and education play a key role in ensuring safety, good working practices and resilience. They can also provide a platform for the voicing of concerns. Another reason for the lack of a strategic disaster plan is the cultural reluctance to find solutions to identified problems, as has been discussed previously.

The thesis should thus contribute to the development and dissemination of a comprehensively written framework to build resilience and sounder practices in the energy sector. Ultimately, the success and limitations of this study in facilitating better disaster management practices in the energy sector depends on the practitioners and policymakers themselves. This research calls for standardised practices and protocols

within the energy sector. It calls for greater awareness in terms of theoretical knowledge among sector workers and key members of society and government. It demonstrates the need for dialogue and for inviting industrial leaders and high level academics from other countries to participate in building a more resilient UAE. It is perhaps wise to use the annual renewable energy conferences in Abu Dhabi in a more constructive way than as a "showcase of talents." Indeed, such professionals could help in diversifying the energy matrix via clean technology. This is one example of how a proactive vision and policy, rather than a reactive stance, can support communities, industry and the government to deal with vulnerabilities prior to a state of emergency.

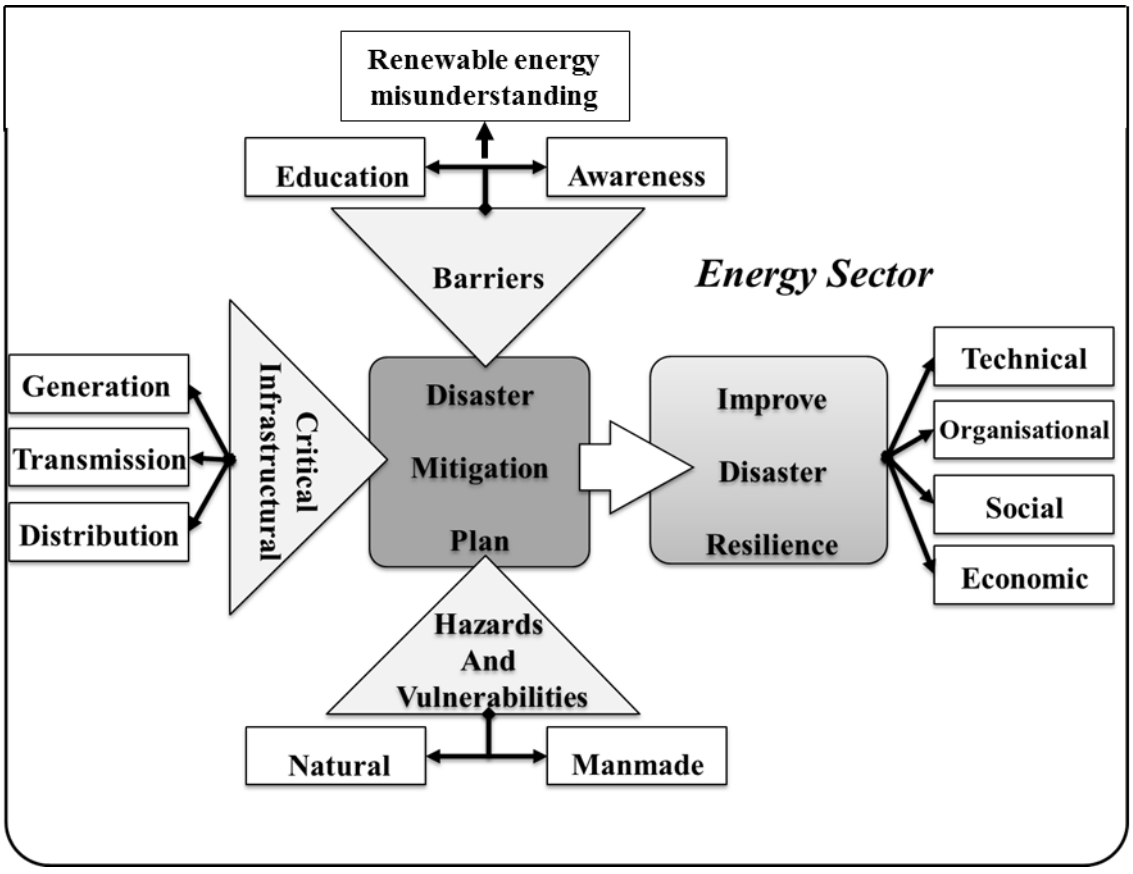

Figure 7.1: Framework for critical energy infrastructure based on a strategic disaster mitigation plan

Natural and manmade disasters were identified during questionnaires survey and critical infrastructure components were also identified during both the survey and interviews. Barriers were highlighted during question survey and interview components of the

disaster mitigation plan were discussed in Chapter 6. These are highlighted in the framework presented in Figure 6.1.

7.2 Limitations of this Study

In this section two main limitations are considered. The first relates to the limitations of the thesis for the academic community; the second to limitations with respect to with the Emirati energy sector.

In both cases, a thesis, is limited by the number of people who read it and act accordingly. If this thesis remains on a shelf, it will be ineffectual and its value questionable. To support proactive development, meetings, following the completion of this study, are also necessary to ensure that the results and key findings of this investigation are communicated to the energy sector workers at the three sites visited, regardless of whether they participated or not. Any follow-up actions, such as an amended training schedule, should also be clearly planned, with fixed dates for the accomplishment of their objectives.

7.2.1 Academia and Disaster Theory

Of course, there are various limitations, when one thinks of the usefulness of this thesis for the research community. Given the case study approach, it may be difficult for other investigators to apply the findings to their own work. That is not to say that the results presented here are invalid but rather that they are specific to the situation found in three Emirati power plants. Therefore, it is necessary, for the satisfaction of academic curiosity to undertake further research in the Emirati energy sector. In to discover just how representative that which is presented here is. It is worth noting that part of the problem may be that most of the current theories on disaster are either European or North American. Limited literature exists which directly relates to the culture and practices of the Middle East. The application of disaster theory in the UAE, at least within this research, seems to show the difficulty Emirati based respondents have in communicating in relation to disaster. By its very definition, disaster invokes feelings of discomfort, negativity and anxiety. Judging from the results and their analysis, Emirati energy managers do not appear to focus on such issues and prefer to “save face” rather than solve them. Disaster theory must help researchers deal with such tension and

cultural conflicts between an academic framework and the reality on the ground. This latter point is however a limit of the theory rather than of the thesis *per se*.

7.2.2 Emirati Energy Sector

There are three limitations of this work as far as the Emirati energy sector is concerned. The first, and perhaps the most obvious, is the small sample of participants, particularly in Sharjah (due to high refusal rate). It could be argued, for example, that the results presented here are not representative and that further research needs to be done. The second is the fact that this work is presented in English rather than in Arabic. This could present some barriers to the efficient development of a plan. Nevertheless, every effort must be made to present this work, and if necessary translate the major findings into the readers' mother tongue. This is not so difficult given that all fieldwork and much of the notes supporting the construction of this thesis exist in Arabic. The third limitation is that for those working in the energy sector, the scope of this thesis is more broad than deep. Many of the terms presented in Chapter 3 will be completely new to them. In addition, some of their technical or engineering preoccupations are unlikely to have been addressed. This is because whilst renewable energy integration may be important, the research participants failed to understand the nature of the technology and subsequently were unable to explain how this might be achieved. That said this broad basis is useful for the tripartite council as a multidisciplinary body with a mixture of interests, skills and abilities. This thesis can act as a starting point for this committee which can, via its members, address some of the specific concerns that are identified here; however, a further explanation would fall beyond the scope of this thesis.

7.3 Contributions of the Study

The thesis serves to highlight some issues of perception and challenges in the UAE and calls disaster practitioners to use their knowledge and expertise to help the Emirati government disseminate information, such as that relating to renewable energy or disaster management programmes, in a more efficient way. It has makes theoretical contributions, such as the participation and voice of women in the interviews, that are useful to academics operating in the field of disaster and supporting efforts to improve disaster preparation and resilience.

7.3.1 Practical Contributions

Practical knowledge helps in the deep understanding of the concepts along with the origin and the importance of the facts learned through theoretical knowledge. Sometimes there are obscure lessons which are not so easy to communicate from a theoretical stance but which gain value once they can be practically demonstrated in a way that aids proper understanding. This thesis gives important advice and methodological steps, derived from fieldwork, when it comes to developing a strategic mitigation plan and communicating it for the building of disaster resilience in the energy sector. It provides key information that could be used to improve the design and structure of current educational and professional programmes undertaken by individuals in the sector. The same information can be used for the mid- to long-term strategic planning for the diagnosis and building of resilience, through strategic planning when it comes to adapting to the threat of climate change. The thesis provides tools for qualitatively evaluating the various threats and vulnerabilities faced by the UAE and acts as a platform for change.

The framework of the strategic disaster mitigation plan has been developed comprehensively (Chapters 3 and 6), going beyond the document and content to the identification of key actors required for the construction and dissemination of a useful tool and/or instrument that can be used to build resilience into the Emirati energy sector. In addition, the plan is a new variant of the plan-check-act methodology frequently used worldwide in the industrial sectors.

The identification of misconceptions regarding renewable energy should be used by the Ministry of Energy to better communicate alternative technologies and their integration within the energy sector. The thesis contains useful information which can be easily transformed into practical knowledge via the various social actors participating in the tripartite committee.

7.3.2 Theoretical Contributions

In terms of its contribution to theoretic knowledge, this research represents the first of its kind in that it asks energy sector workers and managers in the field which issues concern them. This gives academics and professionals alike a unique insight into some

major latent problems that would perhaps have remained unnoticed but require more comprehensive investigation. Furthermore, in the literature review, it was shown that there was a distinct lack of academic research into disaster theory and management as applied to the UAE. This thesis provides data and accessible information as to the reality experienced in the Gulf region and in predominately Arab and/or Islamic cultures that have the concept of *inshallah* (God willing), whereby a risk may be taken because any negative impact is expected to occur if only God allows it to. This has specific implications for policy and practice within energy organisations operating in such settings, and for the way disaster is viewed. The number and variation of potential disasters ranging from atmospheric and tectonic to terrorist-related means that the energy sector in vulnerable zones and developing countries elsewhere can apply the lessons learned to their specific locations. This would not have been the case for the UK energy sector, which is mature and which does not face this combination of threats.

The inclusion of women as interviewees has ensured that disaster was also considered from the female perspective. This is important because most disaster victims are among the most vulnerable and thus likely to be women and children, who are not well represented in the Emirati workplace. Furthermore, the identification of social desirability bias when it comes to response validity and the high refusal rate, particularly in Sharjah, gives any subsequent researcher empirical knowledge that should serve to support future field investigations.

The theoretical knowledge contained within this thesis builds on the information gained from previous studies of disaster phenomena, corroborates such information and puts it in one place. This undoubtedly eases subsequent research, as the obtaining of reliable secondary sources represented one of the more difficult issues. Finally, the possibility of identifying cultural concerns means that there is a platform for communication between energy sector workers and the wider academic world, as addressed in Section 7.3.4. Meanwhile, the next subsection considers the contribution to the Emirati energy sector.

7.3.3 Contributions to the Emirati Energy Sector

The contributions of this thesis to the Emirati energy sector are more tangible than those for academia. Specifically, the feedback from the members of the Emirati energy sector

is indicative of the latent failures and urgent issues in this sector, predominately those of training, education and communication relating to the potential integration or use of renewable energy as part of a resilient energy matrix. The Ministry of Energy must ensure that top-down orders and initiatives reach those directly working day-to-day in electricity generation. Targets publicised from the highest government offices mean little if those operating in the sector remain unaware. For clean energy targets to be achieved there needs to be a buy-in by the whole Emirati population, otherwise these findings represent nothing more than wishful thinking and lip service to sustainability, as opposed to real and powerful sustainable development. Perhaps IRENA could help with this, given that it is headquartered in the UAE and has access to many world experts on clean and renewable policies.

The widely held consensus that the major issues relate to absent or insufficient education, training and personal development is worrying, but the *raison d'être* of this kind of investigation is to highlight the latent failures *before* a disaster inevitably uncovers them in less desirable or even catastrophic circumstances. The discussion points in Chapter 6 provide a draft sketch of those steps required to improve training and renewable technology integration. Although nothing is set in stone, Chapter 6 provides a good basis with which to start collaborative discussions between interested parties. One can subsequently begin drafting both the mitigation plan and the communication plan for its successful dissemination and uptake by members of national and local government, industry members and communities across the UAE. Some of these findings presented here are likely to be of use to those individuals constructing strategic disaster mitigation plans for neighbouring countries such as Oman.

7.3.4 Academic and Disaster Theory Contributions

Academics have a role when it comes to the development of a strategic disaster mitigation plan. In the literature review, it was shown that there was a distinct lack of academic research for disaster theory and management applied to the UAE. The publication of this thesis thus provides data and accessible information as to the reality experienced in the Gulf region, specifically within the energy sector, for both academic and energy professionals (Al Khaili and Patirage, 2014). It builds on previous studies regarding disaster phenomena and corroborates such information, and puts it into to

once place. This undoubtedly eases subsequent research, as the obtaining of reliable secondary sources represented one of the more difficult issues. In many cases, Chapter 2 updates such information, which has not been generally available since 2007. This research represents the first of its kind in that it asks energy sector workers and managers in the field which issues concern them. This gives a unique insight into some of big problems that have become latent ones. It is not a case of looking in on those working in the energy sector in order to "help" them, but rather, a way ensuring that their voices are heard in the wider academic community.

The exact contributions of thesis to disaster theory are more difficult to affirm. Part of the problem, as aforementioned, may be that most of the current theories on disaster are either European or North American in origin. Such issues do provide a much needed platform for further dialogue and problem solving within the discipline.

The questionnaire and interview results identify the most significant barriers to resilience, such as education and cultural problems, which have since converted into latent problems and have slowed the process of finding optimal solutions within the sector. The possibility of identifying cultural concerns means that instead of being a problem they can in fact act as a platform for communication and continuous improvement. The framework of the strategic disaster mitigation plan has been developed comprehensively (Chapters 3 and 6), going beyond the document and content and onto who are key actors required for the construction and dissemination of a useful tool that can be used to build resilience into the Emirati energy sector. Subsequently, this thesis can catalyse a tripartite community to take action and improve the overall performance of energy sector workers and a whole host of associated professions – government officials, town planners, academics and industry leaders.

7.4 Further Research and New Directions

Further research needs to indicate the representativeness of the findings presented. This could be undertaken in a post-doctoral study, as it is simply a matter of taking the theoretical basis and premise and applying the method elsewhere. It would be beneficial for an Emirati student to work alongside the tripartite committee as they develop the

plan. They could assess how well such undertakings address the disaster cycle and build resilience in the energy sector.

As elaborated in Chapters 3 and 6, a tripartite committee needs to be established to make sure that this framework becomes a working document and a reality which makes a difference to how disaster is mitigated and managed in the UAE.

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APPENDICES

Appendix 1: Questionnaire

Building Disaster Resilience within the Emirati Energy Sector through a Comprehensive Strategic Mitigation Plan

Name of Company _____

Years employed at Company _____

Position _____

Years of Experience in current position _____

1a) Out of the following options, which of these hazards do you think the Emirati energy sector is best prepared for? ***Scale each one 1-10. 1 LEAST prepared, 10 MOST prepared.***

#	Questions	1	2	3	4	5	6	7	8	9	10
1	Tectonic activity – Earthquake	○	○	○	○	○	○	○	○	○	○
2	Tectonic activity - Tsunami	○	○	○	○	○	○	○	○	○	○
3	Climatic activity – Flooding caused by wave surges	○	○	○	○	○	○	○	○	○	○
4	Climatic activity – Flash floods	○	○	○	○	○	○	○	○	○	○
5	Climatic activity – *shamal*	○	○	○	○	○	○	○	○	○	○
6	Climatic activity – Extreme Heat (above recorded mean)	○	○	○	○	○	○	○	○	○	○
7	Climatic activity – other extreme meteorological conditions (hurricane, dust storm etc)	○	○	○	○	○	○	○	○	○	○
8	Landslides, liquefaction and slope failure	○	○	○	○	○	○	○	○	○	○
9	Manmade Disaster – Terrorism	○	○	○	○	○	○	○	○	○	○
10	Manmade Disaster - chemical spill and/or explosions	○	○	○	○	○	○	○	○	○	○
11	Manmade Disaster - health and safety related accidents *etc*)	○	○	○	○	○	○	○	○	○	○

- Any other (Please explain _____-

1b) For the hazards you scored the most highly (i.e. > 8) which of the following reasons do you attribute to the greater state of preparedness?

- Government legislation (Federal and/or State)
- Government initiatives (*Please state which)* _____
- Financial incentives (*Please state which)* _____
- Company policy
- Occupational training and staff competence
- Scientific knowledge and understanding of the phenomena
- Availability and dissemination of information in the Arabic language within the sector
- Public awareness and pressure
- Other (*Please explain)*
-

1c) For the hazards you scored the lowest (i.e. < 4) which of the following reasons do you attribute to the lack of state of preparedness? Please cross out should it not apply

- Incomplete (or absence of) Government legislation (Federal and/or State)
- Limited (or absence of) Government initiatives
- Incomplete (or absence of) financial incentives (Please state which) _____
- Not specifically addressed in company policy
- Incomprehensive (or absence of) occupational training and staff competence
- Scientific knowledge and understanding of the phenomena
- Availability and dissemination of information in the Arabic language within the sector
- Public awareness and pressure
- Other (*Please explain)* _____

2a) Out of the following options which of these natural hazards do you think the Emirati public are best prepared for? Scale each one 1-10. 1 LEAST prepared, 10 MOST prepared.

#	Questions	1	2	3	4	5	6	7	8	9	10
1	Tectonic activity – Earthquake	○	○	○	○	○	○	○	○	○	○
2	Tectonic activity - Tsunami	○	○	○	○	○	○	○	○	○	○
3	Climatic activity – Flooding caused by wave surges	○	○	○	○	○	○	○	○	○	○
4	Climatic activity – Flash floods	○	○	○	○	○	○	○	○	○	○
5	Climatic activity – *shamal*	○	○	○	○	○	○	○	○	○	○
6	Climatic activity – Extreme Heat (above recorded mean)	○	○	○	○	○	○	○	○	○	○
7	Climatic activity – other extreme meteorological conditions (hurricane, dust storm etc)	○	○	○	○	○	○	○	○	○	○
8	Landslides, liquefaction and slope failure	○	○	○	○	○	○	○	○	○	○
9	Manmade Disaster – Terrorism	○	○	○	○	○	○	○	○	○	○
10	Manmade Disaster - chemical spill and/or explosions	○	○	○	○	○	○	○	○	○	○
11	Manmade Disaster - health and safety related accidents	○	○	○	○	○	○	○	○	○	○

Any other (Please explain) _____

2b) In relation to the energy sector, are there any particular STATES (Emirates) that you believe to be extremely well or ill prepared for natural hazards? *Please, if appropriate, indicate which Emirate and provide an explanation*

WELL PREPARED

_____(EMIRATE(S)

_____

(REASON PROVIDED)

ILL PREPARED

_____(EMIRATE(S)

_____

(REASON PROVIDED)

3) For any of the hazards you highlighted in the above questions, which sections of the energy sector do you consider to be the most vulnerable?

- Fuel exploration and supply (oil, gas)
- Power generation facilities
- High voltage transmission and distribution
- Medium voltage transmission and distribution
- Low voltage end user infrastructure

3b) Please could you list three reasons as to why you believe this to be the case?

3c) Which type of energy source do you consider to be the most resilient should a natural hazard occur?

- Oil
- Gas
- Nuclear
- Renewable

3d) Which do you consider the least resilient should a natural hazard occur?

- Oil
- Gas
- Nuclear
- Renewable

3e) Could you briefly explain the reasons behind your selection?

4a) In the future, do you see the role of climate change as a significant cause of vulnerability within the energy sector? ***Please circle as appropriate, where 1 is not at all significant, 10 is extremely significant.***

1	2	3	4	5	6	7	8	9	10

4b) In the future, do you see the role of climate change as a significant cause of vulnerability within the general public? ***Please circle as appropriate, where 1 is not at all significant, 10 is extremely significant.***

1	2	3	4	5	6	7	8	9	10

4c) In which ways are the vulnerabilities different?

S

Different

1) _____

2) _____

3) _____

5) Apart from climate change, is there any other natural or manmade phenomenon which is a significant cause of vulnerability within the energy sector? *Please Circle all which could apply.*

- Tectonic (earthquake, tsunami)
- Atmospheric (severe storms, shamal, dust storms, extreme heat)
- Nuclear accidents
- Health and safety issues
- Population growth
- Accelerated energy demand
- Urban migration (national)
- Immigration
- Terrorism
- Social unrest
- Other, please explain_____

5b) Which of the above are of the highest concern?

_____

_____

6a) Do you consider there to be any existing or potential barriers which serve to prevent the energy sector from dealing with the aspects of *Question 4 & 5?*

- Yes - No - Don´t know

6b) Can you please explain your answer?

_____

_____

7) Could you propose any improvement to the energy sector which would serve to enhance resilience?

- Incomplete (or absence of) Government legislation (Federal and/or State)
- More comprehensive Government initiatives (Please state which) _____
- Additional financial incentives or subsidies (Please state which) _____
- More explicit company policy which deals with energy, environment and conservation issues
- Additional occupational training to build staff competence
- Increased research to enhance scientific knowledge and understanding of the phenomena
- More availability and dissemination of information in the Arabic language within the sector
- More public awareness and education
- Other, p*lease explain* _____

Thank you for your time. Finally…

8a) Is there any question(s) here that you consider either ambiguous or inappropriate?

Ambiguous _____

Inappropriate _____

8b) Did you at any point ask the researcher to clarify a question(s)?

Which? _____

8c) Did the researcher respond satisfactorily to any queries you may have had?
Please Circle

- Yes - No - N/A

8d) Are you fully aware of the researcher's intentions and the reasons why you have been asked to complete this questionnaire?

- Yes - No

8e) Are you unhappy with any part of the questionnaire or the way in which it was conducted?

- Yes - No

Please explain _____

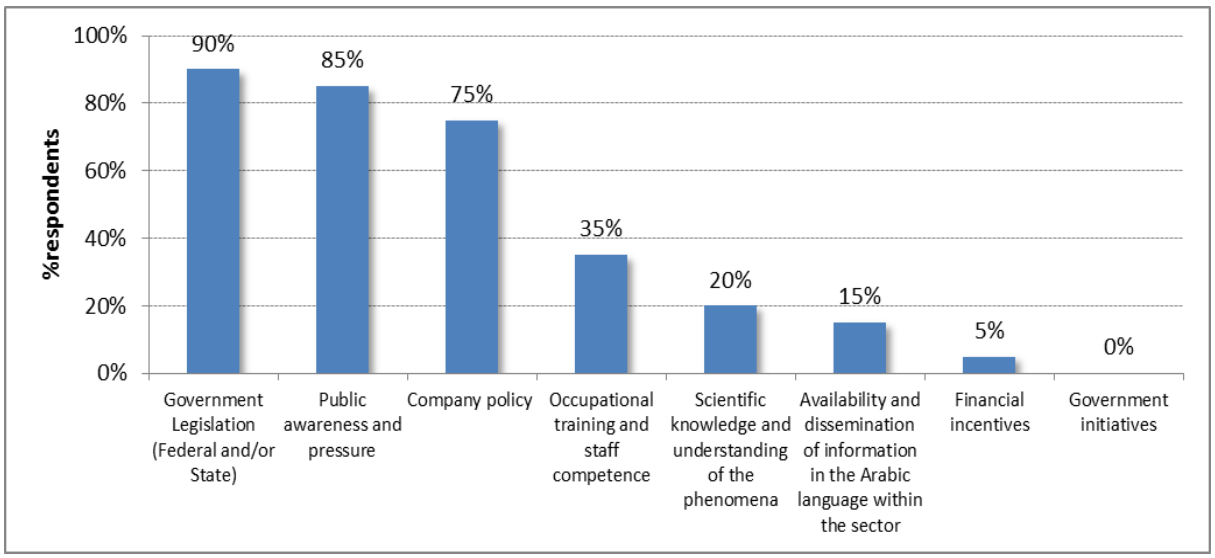
9) Do you have any other additional comments or suggestions?

Name: ……., PhD Candidate
Address: Room 413, School of the Built Environment, 4th Floor, Maxwell Building, The University of Salford, M5 4WT, Manchester, United Kingdom
Tel: +44 (0) 7……..
E-mail: (….. @edu.salford.ac.uk)

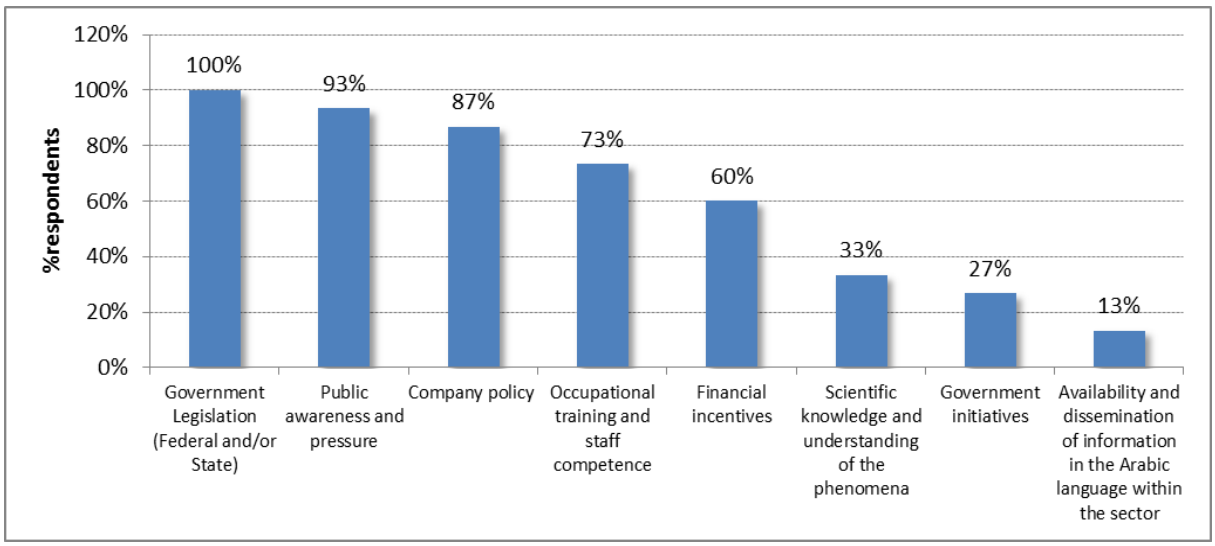
Appendix 2: Interview questions (1)

1. How many years do you have in the energy sector? How many in your current place of work? How many in your current position?
2. Do you have experience abroad or only locally? If you went abroad, for how many long did you go?

3. Do you have any comments in respect to the following graphs?:



(a) Company 1



(b) Company 2

Greater state of preparedness of the Emirati energy sector

4. Given that respondents identify a “lack of scientific knowledge and understanding of the phenomena”, as a key weakness in the preparation against threats, what could the energy sector and the government do to reduce this vulnerability?
5. What do you think about the workers perceptions that a greater training and development programme is needed for the preparation and response to threats? How do you feel knowing that they listed it as the greatest barrier to a resilient energy sector?

6. Apart from the fact that the UAE has never been subject to terrorist attacks or war, could you provide a reason as to why you think respondents believe that it are either one of these two which present the greatest threat and require the greatest level of protection?

7. Workers in both companies (in Abu Dhabi and Dubai) have stated that Dubai is the best prepared to affront the threats of natural hazards. What could be their reason(s) for arriving to this conclusion?

8. Which strategies could Abu Dhabi develop to reach the same (real or perceived) level as Dubai in terms of pre-emergency preparation?

9. What perspectives are there for the integration of renewable energy in the energy sector, taking into account that they are perceived to be the most secure forms of the future?

10. What is your opinion on developing the 3 suggestions below, in order to build resilience in the energy sector and disaster management?

Interview questions (2)

Objective 1

Identify Emirati critical energy infrastructure facilities and their vulnerabilities to hazards.

1) What do you consider to be the MOST critical energy infrastructure in the UAE energy sector? In terms of generation, transmission and distribution…

2) Why do you think that?

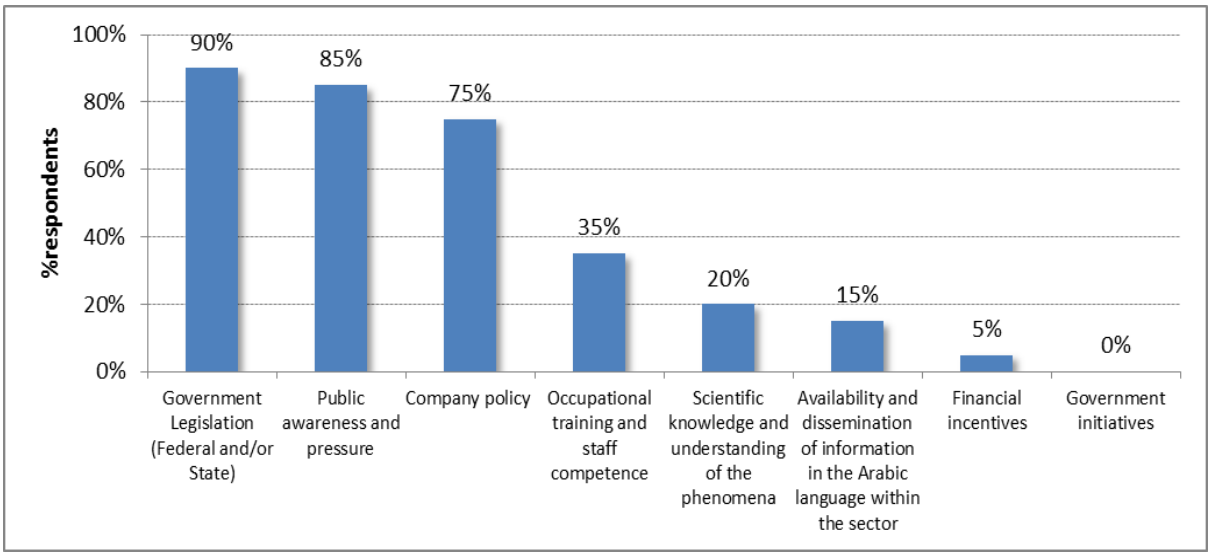
3) What are their most significant vulnerabilities? Technologically, politically, resources… etc

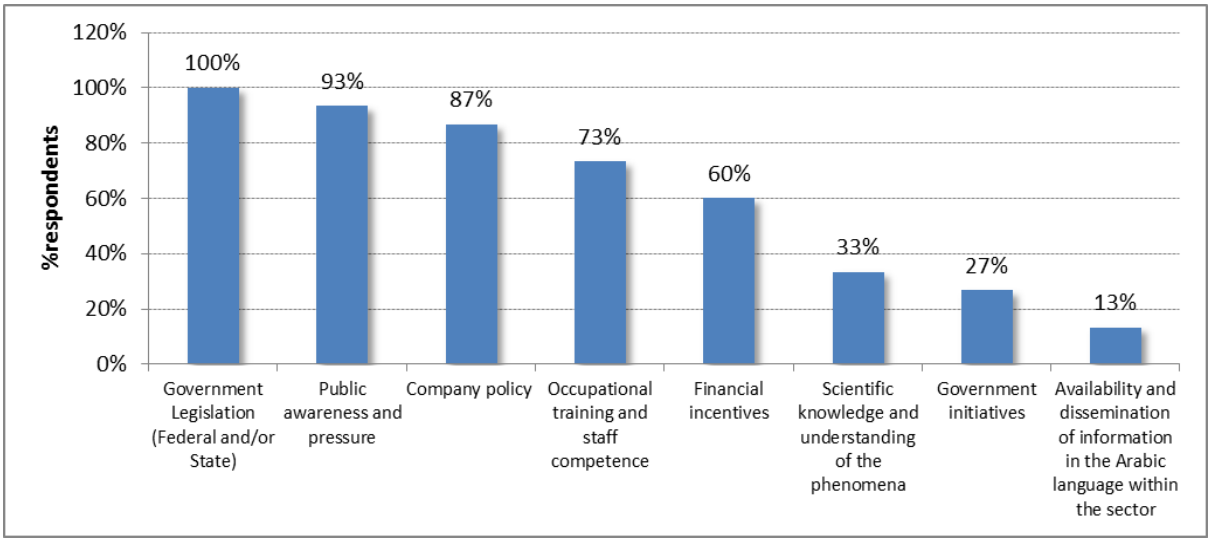
4) What do you consider to be the LEAST critical energy infrastructure in the UAE energy sector? In terms of generation, transmission and distribution…

5) Why do you think that?

6) What are the greatest strengths…?

7) Do you have any comments in respect to the following graphs?:





7) the question based on the answers to the questionnaires, e.g. in the questionnaire the respondents answered “x”, why do you think their response differs to your own?

8) Is there anything you would like to add regarding infrastructure and/or vulnerability?

Objective 2

To examine current disaster management practices and their relation to those infrastructures deemed critical within the energy sector.

How would you define the terms “disaster” and “resilience”?

2) What do you consider to be the most important management practices in avoiding disaster and increasing resilience?

3) Is your answer to the previous question based on previous experience? If it is, what experience did you have? If not, what do you base it on?

4) To what extent do you believe training and awareness amongst your employees is important?

5) If they answer “very important”, ask them why members of staff believe that this is one area that could be improved…

6) Could you briefly go through your safety protocol and policy that is enacted in the event of an emergency?

7) What procedures do you have in place to ensure that every member of staff is rehearsed in that plan and would know what to do in such an event?

8) Is there anything you would like to add regarding management practices?

Objective 3

To critically evaluate existing barriers to application of disaster management practices on critical energy facilities in UAE.

1) What do you consider to be the most significant barriers in the application of the procedures, policies and practices, you mentioned above?

2) Why do you think they present a barrier?

3) What do you consider to be the underlying cause of these barriers?

4) Since occupying your current position, do you think the number and type of barriers have changed? Can you give me an example?

5) the question, in relation to the results i.e. if it the same answer:

The workers also mentioned this in the questionnaire, how do envision the control or diminishing of such barriers?

Or:

The answer differs to that of the workers. Why do you think that is? Do you think that both of you could be right? What do you think could be done?

6) Do you think that the aforementioned barriers apply only to this installation or the Emirati energy sector in general?

7) Who do you think is in the best position to remove or reduce the barriers? E.g. private sector, government, external agents (other countries)

8) Are they approachable? Do you think a person in your position could communicate and coordinate with them? If not, then who?

9) Do you have any other comment you would to add?

Appendix 3: Consent Form

PARTICIPANT CONSENT FORM

Title of Research Project: Building Disaster Resilience within the Emirati Energy Sector through a Comprehensive Strategic Mitigation Plan.

Name & address of researcher: ……..., School of the Built Environment, University of Salford, United Kingdom.

Tel: 004478…., 00971……

Sponsored: Ministry of Interior, United Arab Emirates.

Please use the check box to the right corner after the statements.

1. I confirm that I have read and understand the Participant Information Sheet explaining the above research study and that I have had the opportunity to ask questions about the project. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without providing a reason. ☐
3. I agree to take part in the above research study. ☐
4. I understand that if I decide to participate in this study, then the results obtained from this study may be kept for possible use in future studies. ☐
5. I understand that my anonymity is assured and that only the researcher involved in this study at the University of Salford, UK, will use the data. I thus give permission for this individual to use this information as they wish within academia. ☐

For researcher's use only:

	Y/N
I agree to the interview being audio recorded.	
I agree to the use of anonymous quotes in publications.	

_____	_____	_____
Participant's Name	Date	Signature
_____	_____	_____
Researcher's Name	Date	Signature

Appendix 4: Ethical Approval

Academic Audit and Governance Committee

College of Science and Technology Research Ethics Panel (CST)

To **Khalifa Al Khaili and Dr Chaminda Pathirage**

cc: **Prof Mike Kagioglou, Head of School of SOBE**

MEMORANDUM

From **Nathalie Audren Howarth, College Research Support Officer**

Date **9th July 2013**

Subject: **Approval of your Project by CST**

Project Title: Building Disaster Resilience within the Emirati Energy sector through a comprehensive strategic mitigation plan

REP Reference: **CST 13/60**

Following your responses to the Panel's queries, based on the information you provided, I can confirm that they have no objections on ethical grounds to your project.

If there are any changes to the project and/or its methodology, please inform the Panel as soon as possible.

Regards,

Nathalie Audren Howarth

College Research Support Officer

END OF THESIS