UNIVERSITY OF SALFORD , MANCHESTER

Building a disaster-resilient energy sector within the United Arab Emirates – a critical analysis of the approaches for mitigation, vulnerability reduction and preparedness

PhD Thesis

By Saqer Al Qassimi

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ABSTRACT

The purpose of this PhD work is to examine the vulnerability and resilience of the energy sector in the United Arab Emirates and shape the development of a strategic approach to build resilience against risks and disaster events in the future, as well as to identify the barriers this resilience building process could come up against. To reach this aim, a thorough examination of the literature on disaster risk reduction, vulnerability and resilience has been undertaken, with notable attention being given to risk management practices and resilience frameworks. The ISO 31000 standard provides an effective approach to enhancing resilience by reducing the possibility of risks occurring via several steps (risk identification, assessment, treatment) and tools (risk matrix, SWOT analysis, monitoring and evaluation). The most potent hazards to pose a danger to the Emirati critical infrastructure include natural threats (e.g. earthquakes, sand storms, fires, floods), and man-made risks (e.g. human error, terrorism via cyber and drone attacks).

The theoretical framework of this research is focused on resilience and delimits four (N=4) major dimensions and four (N=4) major capacities of resilience, namely the technical, organisational, social and economic dimensions, and the prevention, absorption, recovery and adaptation stages.

The research has implemented a multi-method qualitative approach, as primary data has been collected through semi-structured interviews with UAE energy sector experts and secondary data was collected from documents.

Notably, the primary data classified all themes into vulnerabilities and opportunities, with the main opportunities that the UAE energy sector excels in are related to its adaptive capacity, policy reform and capacity building (OR), to its buying power (ER), the ability to train its personnel (SR), as well as to the backup power deployment and redundancies (TR). The most concerning vulnerabilities are related to the infrastructure and system reliability (TR), with moderate concerns regarding the sector's technical progress and hardware hardening (TR), the adoption of risk management (OR), decision-making and coordination (OR), management training (SR), financial stability and investment opportunity (ER). Together, these show that while progress is made, it is done so at the cost of securing existing systems, notably the physical infrastructure (transmission and distribution specifically) is in dire need of refurbishment or replacement, as it is the most exposed to all types of risk, while the economic security of the entire sector cannot be guaranteed, due to the country's reliance on exports and the private sector's reliance on governmental support. Multi-

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agency collaboration efforts could also be improved, and this is indicative of another vulnerability, notably the training of upper managers who actively make decisions, and who lag behind the personnel in terms of expertise – which results in a slow adoption of certain practices. These may all be due to the lack of proper risk management policies and procedures, which could help identify and treat some of the other key vulnerabilities. Still, the UAE energy sector is rapidly progressing, diversifying its energy generation and adhering to the United Nations Sustainable Development Goals as part of the UAE national strategy to reach carbon neutrality by, 2050, however many of these issues need to be addressed in order for this strategy to be achieved.

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List of Abbreviations

ADGAS: Abu Dhabi Gas Liquefaction Limited

ADNOC: Abu Dhabi National Oil Company

ADWEA: Abu Dhabi Water and Electricity Authority

ADWEC: Abu Dhabi Water and Electricity Company

AED: United Arab Emirates Dirham

AI: Artificial Intelligence

BBC: British Broadcasting Corporation

BCM: Business Continuity Management

BP: British Petroleum Company

CBRN: Chemical, Biological, Radiological and Nuclear

CCGT: Combined Cycle Gas Turbine

CEPSA: Compañía Española de Petróleos S.A.U.

DEWA: Dubai Electricity and Water Authority

DROP: Disaster Resilience of Place

DRR: Disaster Risk Reduction

DUGAS: Dubai Natural Gas Company Limited

DUSUP: Dubai Supply Authority

EECSP: Electoral Empowerment of Civil Society

EIA: Energy Information Administration

ENEC: Emirates Nuclear Energy Corporation

ENG: Emirates National Grid

ENOC: Emirates National Oil Company

ERM: Enterprise Risk Management

EU: European Union

EWA: Etihad Water and Electricity

EWEC: Shuweihat Emirates Water and Electricity Company

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FEWA: Federal Electricity and Water Authority

GASCO: Abu Dhabi Gas Industries Limited Company

GCC: Gulf Cooperation Council

GDP: Gross Domestic Product

KEPCO: Korea Electric Power Corporation

KSA: Kingdom of Saudi Arabia

KWH: Kilowatt-hours

IAEA: International Atomic Energy Agency

IFRC: International Federation of Red Cross and Red Crescent Societies

IPCC: Intergovernmental Panel on Climate Change

ISO: International Organization for Standardization

IT: Information Technology

LNG: Liquefied Natural Gas

LPG: Liquefied Petroleum Gas

MCDM: Multi-Criteria Decision-Making

M&E: Monitoring and Evaluation

MoE: Ministry of Economy

NCEMA: National Emergency Crisis and Disaster Management Authority

NPP: Nuclear Power Plant

NRF: National Response Framework

OCGT: Open-Cycle Gas Turbine

OECD: Organisation for Economic Co-operation and Development

OHSMS: Occupational Health and Safety Management System

ONGC: Oil and Natural Gas Corporation

OPEC: Organization of the Petroleum Exporting Countries

P: Participant

PDCA: Plan-Do-Check-Act

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PESTLE: Political, Economic, Social, Technical, Legal, Environmental

RCA: Root Cause Analysis

RM: Risk Matrix

SDGs: Sustainable Development Goals

SES: Socio-ecological Systems

SEWGA: Sharjah Electricity, Water and Gas Authority

SEWA: Sharjah Electricity and Water Authority

SPC: Supreme Petroleum Council

SWOT: Strengths, Weaknesses, Threats & Opportunities

TAKREER: Abu Dhabi Oil Refining Company

TAQA: Abu Dhabi National Energy Company

TES: Total Energy Supply

UAE: United Arab Emirates

UK: United Kingdom

UN: United Nations

UNISDR: United Nations Office for Disaster Risk Reduction

USA (US): United States of America / The United States

USD: United States Dollar

UNSDGs: United Nations Sustainable Development Goals

CHAPTER I: INTRODUCTION

1.1. Research Justification

The booming economy of the UAE has been historically founded upon its energy sector, and to this day, the country relies on this industry, which contributed 26% to the state's annual GDP in, 2016, with oil activities increasing from, 2017 to, 2018 by 35.1% (Alareeni et al., 2019). However, many of the Emirati energy production facilities are located either in terrain where natural disasters are prone to occur or close to border areas where terrorists or adversarial foreign actors could attempt to deliberately sabotage them and thus threaten both the security and economy of the country (Paul at al., 2016). The extent and complexity of this wide production and distribution energy network demonstrate the complexity surrounding the Emirati energy sector task in relation to building resilience and reducing disaster risks.

In addition, a series of hostile events (with potentially Iranian origin) took place in the Strait of Hormuz, off the port of Fujairah, that resulted in the decommissioning of four oil tankers in, 2019, which suggest that energy production and transportation infrastructure might be at risk in case the tensions in the Gulf escalate (Wintour, 2019). In light of the growing volatility in the Strait of Hormuz, undertaking an extensive assessment of the degrees of risks and the level of resilience of the Emirati energy infrastructure is a priority for researchers and for the Emirati government. Energy sector resilience is not an issue that has been widely explored in the Emirati context, let alone in the light of the recent troubling developments which suggest that the energy sector will be a primary target of hostile foreign attacks even if there is no direct confrontation between the Gulf States, the USA and Iran (Wintour, 2019).

Furthermore, a, 2013 survey noted the stark number of fatal injuries which have occurred within the Emirati industry (where the energy sector comprises a critical part) – and the percentage out of all such damages in the country is no less than 40% (Statistics Centre Abu Dhabi, 2013). Although the Emirati authorities have not neglected the various risks the energy sector needs to

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address, its legislative framework and resilience-building practices lack sufficient scope, practical results, and advancements (Al-Kaili et al., 2014). It can also be argued that Developing responses to the challenges to emergency management and business continuity in the UAE must be built on scholarly evaluation and analysis. Without independent assessments of the risk factors and the industry's barriers to managing and mitigating risks, disaster and resilience (like the current project), advancements in the area can hardly be made.

1.2. Research Aims and Objectives

The overall purpose of this project is to examine the existing resilience-building capacity of the Emirati energy sector to assess whether this can and should be improved, as well as to establish viable means through which resilience in the UAE's energy sector can be enhanced during all stages of the disaster cycle, within all industries and at all levels, as well as for all stakeholders.

To achieve this goal, the study first identifies and examines disaster management concepts, theories, frameworks, policies and practices from a general and specific (UAE) perspective, focusing on exploring the importance and implementation of resilient measures in the energy sector. Afterwards, the research explores the contextual factors, vulnerabilities and specific risks facing the Emirati energy industry. In addition, the current practices used for risk management, disaster response and recovery, and resilience building in the Emirati energy industry are critically explored and compared with the best practices in the field based on a framework designed specifically for this thesis by the researcher, presented in Chapter III. In doing so, the researcher strived to develop recommendations for future strategic disaster management and mitigation plans focusing on building resilience.

Therefore, the study seeks to address the following research questions:

- What strategies are there for improving resilience within the energy sector and which of these strategies can be applied to the UAE?

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- What is the current capacity for resilience building for UAE energy facilities, and what factors influence it?

- What are the measures that the Emirati energy sector can adopt to increase its overall resilience?

The research has therefore set the following objectives:

- To identify and explain essential disaster management concepts, theories and frameworks
- To analyse disaster management policies and practices and their suitability for the energy industry and in the UAE context
- To explore the importance of resilience within the energy sector, particularly for the UAE.
- To design a framework for assessing the resilient capacity of the energy sector in general and as a means of exploring the disaster management and resilience practices of the UAE energy sector in particular.
- To evaluate the framework for assessing the resilient capacity of the energy sector in the UAE context.
- To identify the opportunities and barriers that influence resilience-building within energy facilities in the UAE
- To formulate a set of recommendations for the UAE energy sector aimed at increasing resilience and mitigating potential future disasters.
- To assess the validity and relevance of the recommendations.

1.3. Background

The quantity, origin, type and scale of disasters over the past few decades have increased in proportion due to the industrialisation of modern societies and the wide-reaching effects of climate change (O'Malley et al., 2016). Apart from natural disasters, which were exacerbated as a consequence of climate change, the increased number and severity of socio-political conflicts have brought about their risks and vulnerabilities, especially taking into consideration issues such as international terrorist activity, military sabotage and the growing prominence of hybrid warfare for which advanced military technology that poses

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a critical threat to energy infrastructure (Luciani, 2011). In addition to this, the increased industrial and societal demand for energy, coupled with fears of the unsustainable use of non-renewable energy sources, forced many states to seek alternative sources of energy as well as practices that can ensure the uninterrupted supply of energy in the event of a disaster (Sorrell, 2015). Nevertheless, despite recent developments that encourage advancements in disaster resilience and international cooperation in the sphere, the delicate issue of handling disasters, especially when they concern critical structures or industries such as the energy sector, has, for the most part, remained within the jurisdiction of the state, albeit yielding varying success (Papadopoulou et al., 2013).

Energy has become a critical asset for states and societies as it contributes to economic power and performs vital social functions (O'Malley et al., 2016). Consequently, an entirely new branch of security studies emerged, called energy security, which stands for the "ability of an energy system to function optimally and sustainably, freely from any threats" (Azzuni and Breyer, 2018: 268). Thus, Energy security represents a broad but interrelated inter-disciplinary field covering economics, international relations, history, public policy design and geology. However, it often signifies only the sub-concept of energy supply security (Bahgat ,2011). Yet, energy security is much more than safeguarding the uninterrupted supply of energy, and the debates surrounding energy security have also emphasised the need to ensure the sustainably of energy resources through switching to renewable energy sources (Bahgat, 2011). In this sense, the concept of resilience has also come into play as it is believed to represent the future of a more sustainable international energy security framework (Johansson, 2011). In fact, resilience is key in energy security because it is impossible to avoid the risks to the sector completely but only to minimise their threat and effects, thus resulting in "low vulnerability of vital energy systems" (Cherp and Jewell, 2014; Gasser et al., 2019; Jesse, Heinrichs and Kuckshinrichs, 2019).

Yet, every region faces unique geopolitical, socio-economic, regulatory and environmental factors, which have historically shaped the energy sector. With

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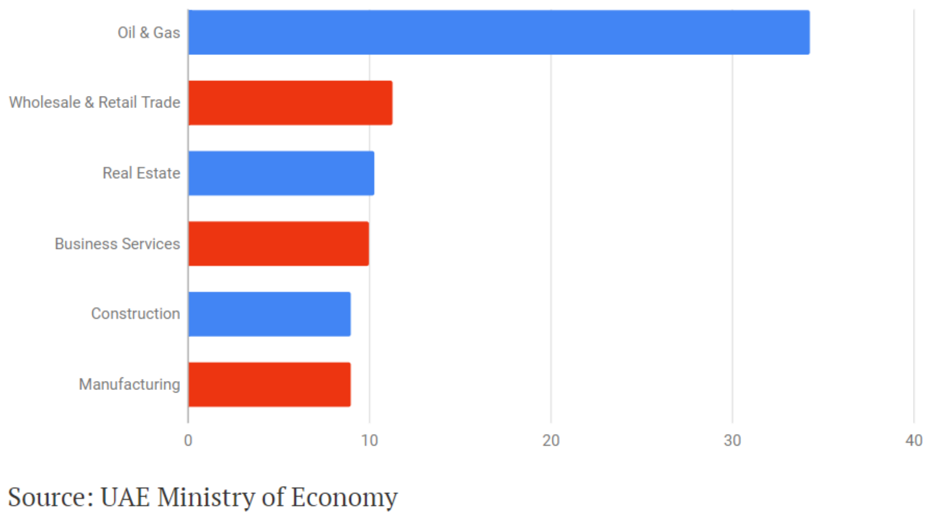
respect to the United Arab Emirates (UAE), and similar to its neighbours with an abundance of oil reserves, the energy sector has remained a crucial cornerstone of the Emirati economy up to the present day. In fact, the country is categorised as having “one of the most advanced power sectors in the region, with distinct structure and government policy that are favourable” (Mordor Intelligence, 2019: n.p.). Figure 1 shows that the share of the oil and natural gas sectors to the UAE GDP and economy is approximately a third of the total, whereas the percentages are much smaller and more evenly distributed among the other sectors in the country:

Figure 1: UAE GDP Contribution by Sector -, 2015



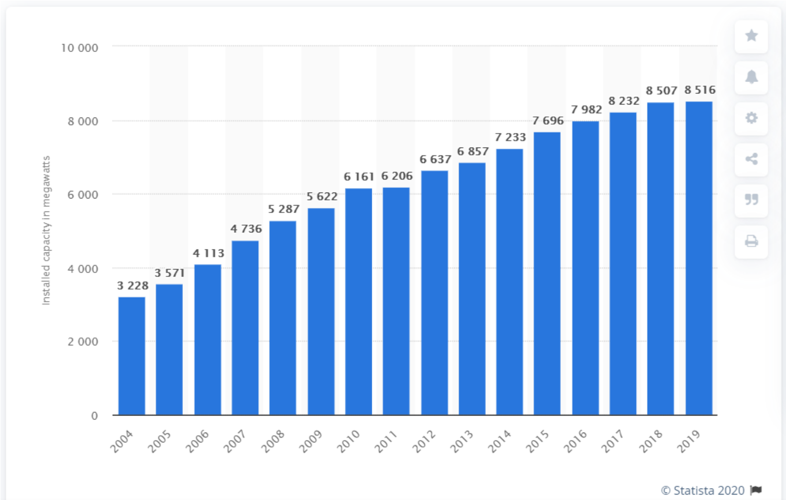
Source: Invest in Group (n.d.)

Figure 1 has remained relatively stable across the years, with the share of the oil and gas output equalling approximately 30% in, 2020 as well (OPEC, 2020). The total generation capability of the UAE energy facilities is estimated at 134.6 TWh (terawatt-hours) derived from a combination of natural gas sources (132.2 TWh), which equals 98% of the total output, and of oil (1.5 TWh), which contributes a mere1% to the total energy capability framework (World Nuclear Association, 2020).

Over the past two decades, the oil production rate in the UAE has been increasing; in, 2019 it reached 4 million barrels of oil daily (Garside, 2020). Figure 1 includes “crude oil, shale oil, oil sands and NGLs (natural gas liquids)” but “excludes liquid fuels from other sources such as biomass and coal derivatives” (Garside, 2020: n.p.). The total value of, 2019 petroleum exports was calculated at 49,636 (million USD), with crude oil reserves marked at 97,800 million barrels and natural gas reserves at 97,8000 billion cubic meters (OPEC, 2020). The marketed natural gas production (in million cubic meters) was 55,096.5 million cubic meters (OPEC, 2020).

The ever-increasing international demand has resulted in an increased oil production output whereas rising domestic demand for power has resulted in expanded gas production and utilisation (EIA, 2017), and as Figure 2 shows, the energy supply demand in the DEWA-covered (Dubai Electricity and Water Authority) region has been rising by more than a per cent each year since, 2004, which is due to the rapidly expanding economic activity in the emirate of Dubai and the growing population.

Figure 2: Peak power demand in Dubai (2004-2019)



Source: Statista (2020)

In addition, the UAE has historically imported natural gas (close to a third of its aggregate gas needs for the year, 2010) to meet domestic demand, see Figure 3 (El-Katiri, 2013). As a result, the emirate of Dubai relies primarily on imports as it has insignificant oil and gas supplies of its own, whereas the emirate of Abu Dhabi has managed to leverage some of the costs of imports through the utilisation of its more abundant oil supplies (El-Katiri, 2013: 13). Figure 3 and Figure 4 portray the rising trend of domestic oil and natural consumption habits

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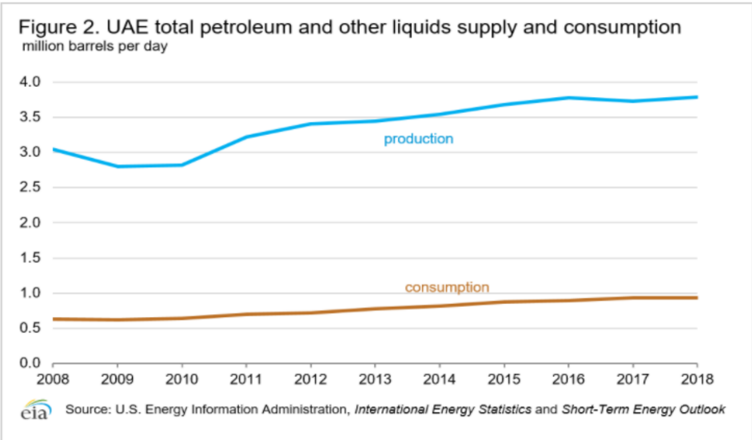
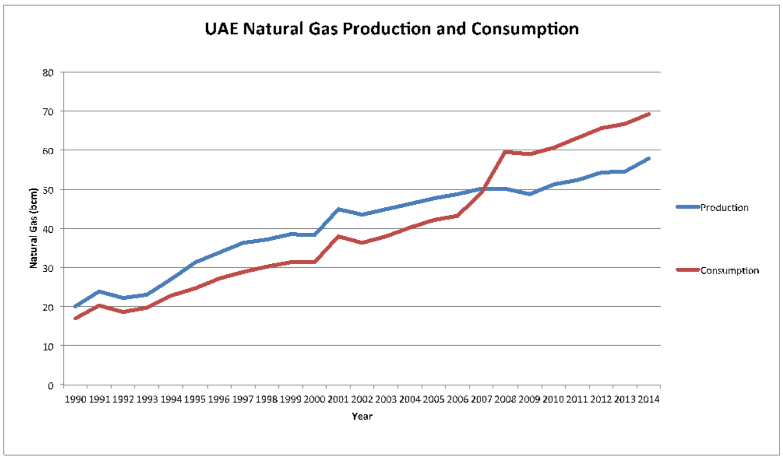
in the past few decades, and the attempt to match these changes with a respective increase of production of both natural resources. While the consumption of natural gas outweighs its production, the production of oil products far outweighs its consumption (see Figure, 4), this, of course, being because the UAE is an international supplier of both crude oil and petroleum products, such as lubricants, as such the efforts dedicated to extracting and manufacturing of oil are understandable.

Figure 3: UAE Oil Production and Consumption, 2008-2018



Source: Nakhle (2019)

Figure 4: UAE Natural Gas Production and Consumption, 1990-2014



Source: Cedigaz (2015)

Under its, 2030 strategic framework announced in, 2016, Abu Dhabi National Oil Company ADNOC was unified into a single entity and comprised 14 subsidiaries. ADNOC Onshore and ADNOC Offshore represent the two largest companies, which naturally hold the most significant share of the gas

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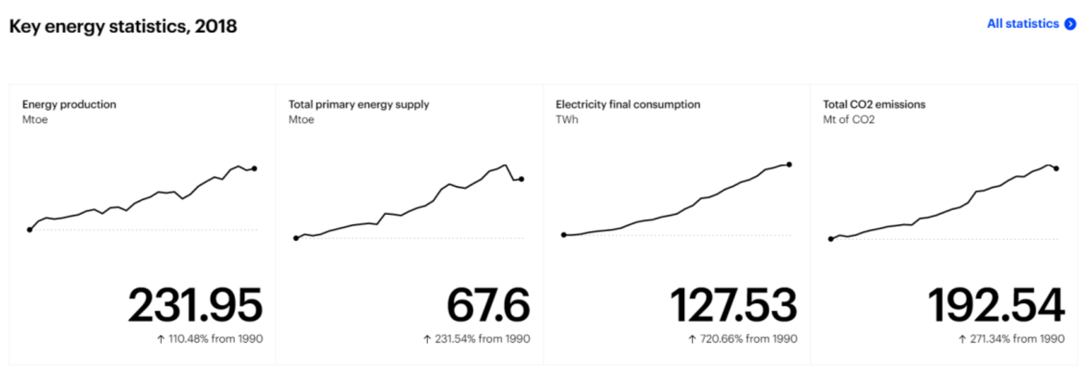
production market (International Trade Administration, 2020). The Abu Dhabi Emirate is also the leading player in this market in the country, and it mandates the future direction and reforms in the sector, and consequently for ADNOC, under the guidance of the Supreme Petroleum Council (SPC) (International Trade Administration, 2020), which is responsible for the creation, implementation and review of petroleum policies in the emirate and the formulation and tracking of petroleum industry goals (ADNOC, 2016). The, 2030 strategy, in particular, revolves around three key concepts: “more profitable upstream”, “more profitable downstream”, and “more sustainable and economic gas supply” (ADNOC n.d.). Some of the milestones included in the, 2030 ADNOC strategic report are the following: increasing crude oil production to 3.5m bpd (barrels per day) in, 2018, which target was almost reached in that year (El Gamal, 2020); increasing gasoline production to 10.2 mtpa (million metric tonnes per year) by, 2022; and increasing petrochemical production to 11.4 mtpa by, 2025 (ADNOC n.d.). In addition, the strategy outlines five core shifts in global markets as the raison d'être for its strategic direction – an increase in global demand “projected to rise by 10 million barrels a day by, 2040”; a 60% rise in global demand in the, 2016-2040 period; novel sources and markets of demand, especially non-OECD countries; an expected 45% increase in global natural gas demand in the, 2016-2040 period; and expanding digitalisation across upstream and downstream chains, which is expected to increase efficiency gains by 5-10% (U.S.-U.A.E. Business Council, 2019: 6-7).

In fact, towards the goals of more profitability, effectiveness and sustainability, the UAE has pledged to cover and reduce the “transmission and distribution losses by improving the efficiency of the [power] grid”, but these efforts have remained hindered, especially in the northern regions, due to the lack of private competition as the energy sector is state-controlled (Mordor Intelligence, 2019: n.p.). However, other challenges loom ahead of the energy diversification strategy (Matsuo, 2015). These include improving energy security for all types of energy production facilities and increasing the ratio of solar power in the overall power production metrics. Yet, the state of the non-renewable energy sector in the UAE remains underdeveloped and cannot effectively substitute traditional energy sources. What this means is that if the traditional energy industry suffers damage as the result of a natural or man-made disaster, the energy supply of both the domestic and international markets would invariably suffer as the overall energy sector is not resilient enough to switch to renewable energy in such a disaster scenario and to continue functioning properly. In addition, the problem becomes even more exacerbated by the ever-growing demand for Emirati energy supplies, making disruptions an even greater threat to the sector. Figure 5 presented below represents the key energy statistics from, 2018, which clearly display the constantly and rapidly rising demand for fuel and the respective drive to increase energy production to meet this increasing demand. This tendency has naturally skyrocketed in the past decades as a result of the UAE's rapid development; as it can be seen the consumption has risen since 1990 by more than 700%, while the production has only doubled in the same time:

Figure 5: Key UAE energy metrics -, 2018



Source: IEA (2020)

The current energy infrastructure in the UAE is comprised of four governmental authorities called ADWEA (the Abu Dhabi Water and Electricity Authority), DEWA (Dubai Electricity and Water Authority), SEWA (Sharjah Electricity and Water Authority) and FEWA (Federal Electricity and Water Authority) (UAE, 2020b). Out of these, ADWEA contributes the greatest share to the national electricity capacity, or 53%, whereas DEWA is responsible for the provision of 29%, SEWA contributes 11% and FEWA only 7% of the electricity capacity (IAEA, 2013). ADWEA provides power to the whole western region of the UAE, which includes the cities of Abu Dhabi and Al Ain, whereas DEWA, as the name shows, covers the city of Dubai, SEWA and FEWA own the energy output

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channels to the city of Sharjah, (the third most populous city after Dubai and Abu Dhabi respectively) Fujairah et al., (IAEA, 2013). The UAE aims to unite all of these into the national electricity power grid as the current fossil fuel generating capacity reached 27 gigawatts in, 2013, and industrialisation and urbanisation rates have led to skyrocketing demand (UAE, 2020b). Thus, the so-called Emirates National Grid (ENG) project intends to interconnect all four state-led authorities that currently manage the energy supply output in the country – FEWA, the Department of Energy (previously ADWEA), DEWA and what is now called SEWGA, or the Sharjah Electricity, Water and Gas Authority (UAE, 2020b). The overarching goal of this project is not only targeted optimising cost but also focuses upon the provision of “a stronger capacity to withstand major or sudden disturbances, such as the loss of production units and failure of grid elements, whether due to outages or natural catastrophes, as well as several types of crises” (UAE, 2020b: n.p.). There are also plans set into motion concerning the connection of the ENG to the power infrastructure of its close neighbours from the Gulf Cooperation Council (IAEA, 2013). Figure 6 and Figure 7 display maps of the energy infrastructure channels and point to the interconnected nature of these channels, both on-shore and off-shore. As seen, most of the oil and natural gas fields are found either within the Abu Dhabi Emirate or near it at off-shore locations, which explains the Emirate’s preponderance for manufacturing compared to the other Emirates, as previously mentioned. However, the pipelines run throughout the high-population Emirati locations to ensure easy access to these resources.

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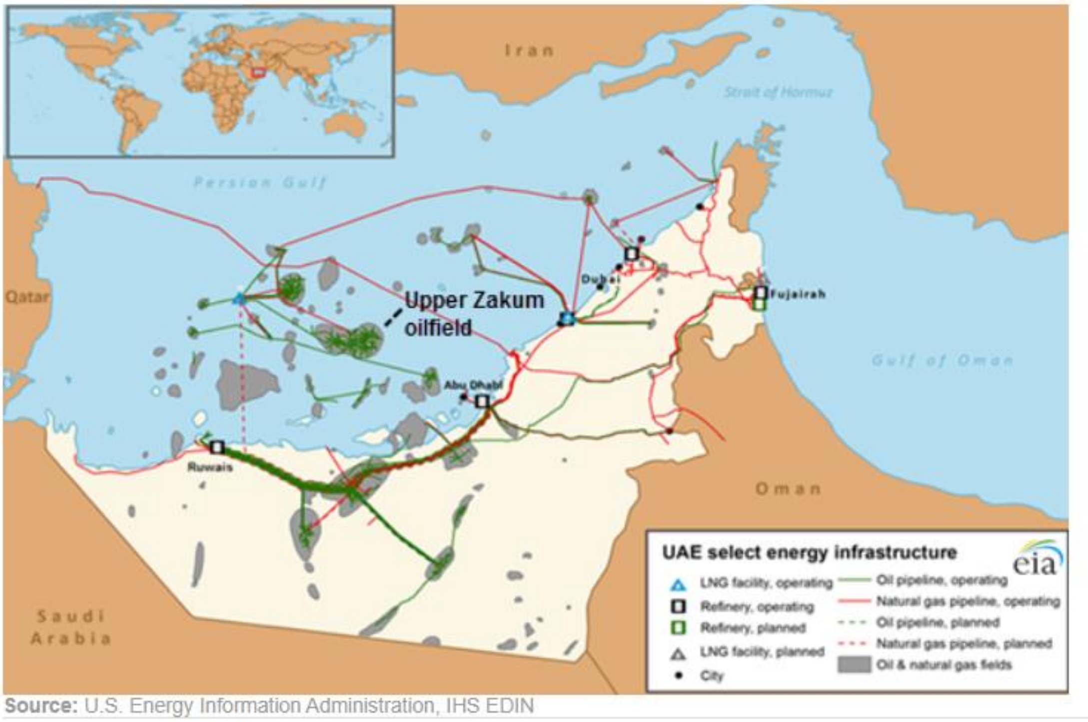
Figure 6: UAE select energy infrastructure



Source: EIA (2015)

The UAE has around 15 major gas turbine power plants, most of which produce power and water in a combined cycle (Global Energy Observatory, 2017). The major currently operational facilities include the Taweelah B Cogen CCGT Power Plant (2,266 MW), the Dubai Aluminium CCGT Power Plant (2,000 MW), Ameer OCGT Power Station near Dubai (1,844 MW) (Global Energy Observatory, 2017). Figure 7 and Figure 8 list the major production companies and their power output capacity in the UAE as well as the main locations of the facilities, which are involved in a combined cycle of power and water production.

In terms of sector structuring, each Emirate is responsible for regulating the production of natural gas and power supplies as well as the production of oil. ADNOC remains the leading organisation in the Emirate of Abu Dhabi, where it is responsible for regulating the natural gas and oil industries and producing natural gas and oil supplies, which it does through the use of its subsidiaries in the region (EIA, 2017). For instance, the Abu Dhabi Gas Industries Limited Company (GASCO) was founded as a collaborative project led by ADNOC, including foreign actors (namely, Shell, Total and Partex). Its primary

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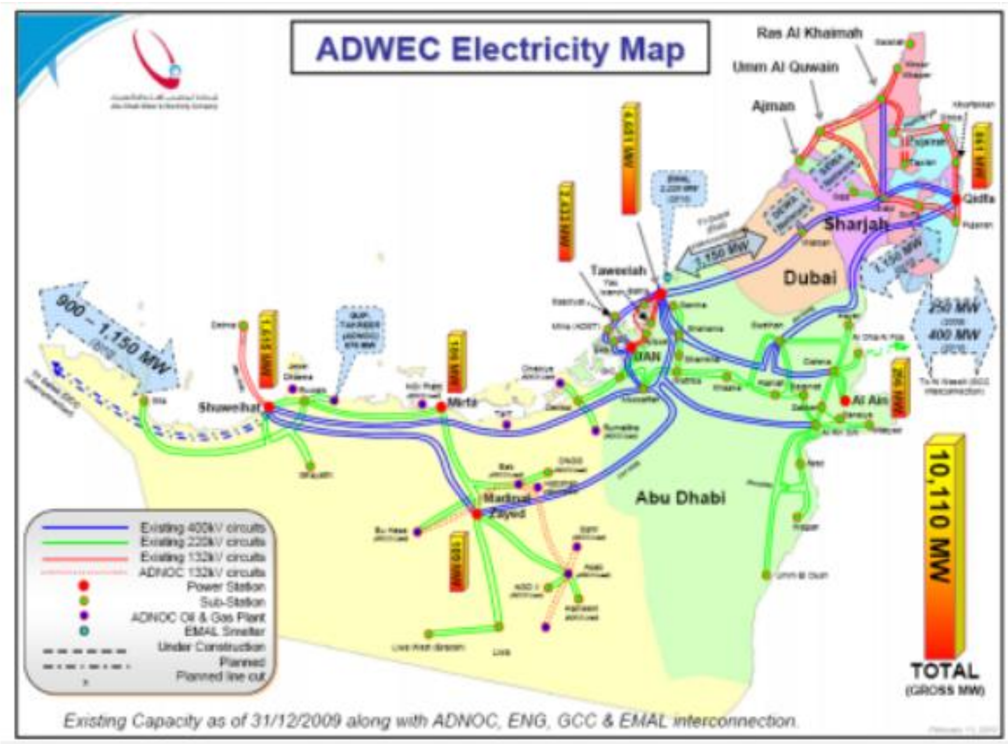
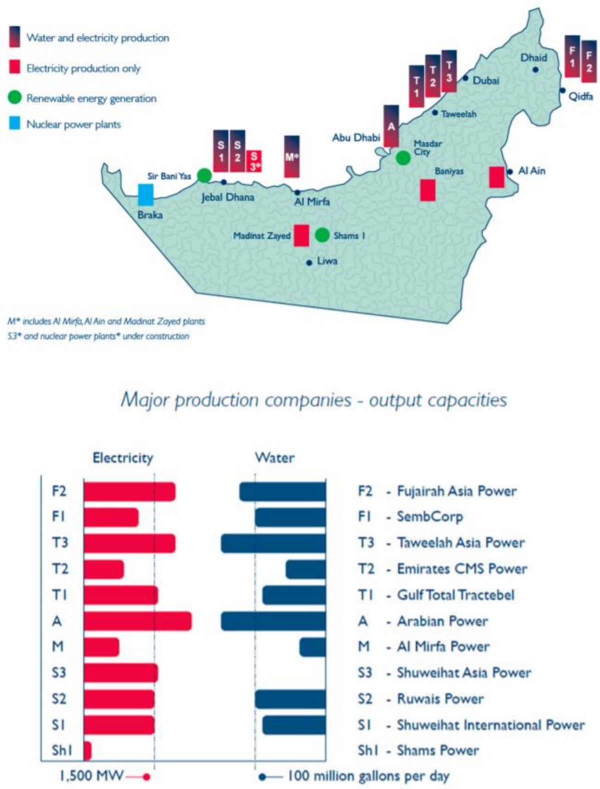
Figure 7: ADWEC Electricity Map



Source: Abu Dhabi Water and Electric Company (IAEA, 2013)

Figure 8: ADWEA power and water generation plants location map and capacity



Source: Paul, Tenaiji and Braimah (2016)

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responsibilities cover utilising and producing natural gas liquids (LNG) in the Emirate. Similarly, the regulation of the LNG (i.e. natural gas) and LPG (i.e. petroleum) products – which also includes producing and exporting the supplies – in the Emirate of Abu Dhabi is handled by the Abu Dhabi Gas Liquefaction Limited (ADGAS) (EIA, 2017). Another key player in the same Emirate is the Abu Dhabi Gas Development Company Limited (Al Hosn Gas), another collaborative project founded by ADNOC and the Occidental Petroleum Company, whose main goal is to exploit the abundant gas reserves that are to be found in the vast Shah field located within the Emirate of Abu Dhabi (EIA, 2017). The counterpart to ADNOC in the Emirate of Dubai is the Dubai Natural Gas Company Limited (DUGAS), which in turn handles the Emirate's natural gas infrastructure (EIA, 2017). Thus, the regulation of the wide-reaching gas infrastructure in the UAE is controlled by several strategic actors, who are also interconnected with smaller parties and subsidiaries, making the natural gas sector and power generation sector closely intertwined and heavily reliant upon a wide array of stakeholders – state authorities, state-owned organisations, investors, subsidiary organisations, and naturally, the communities and markets affected by these sectors.

Other energy companies operating across the country include the Abu Dhabi National Energy Company (TAQA), the Emirates National Oil Company (ENOC), EMDAD Services LLC, Emarat, Dubai Petroleum Establishment, Al Masadood Oil & Gas, Sharjah National Oil Corporation, Dana Gas, Crescent Petroleum Company, Dragon Oil Plc and Lootah BC (Bayut, 2020). A number of international energy players have also established their bases in the country and have forged close links with Emirati companies in the hydrocarbon value chain infrastructure. These global companies include such names as Occidental Petroleum, BP, Eni, ExxonMobil, Royal Dutch Shell and Total, all of which focus on the exploration and production activities in the Emirati sector, and Chevron, which specialises in the storage of hydrocarbon production as well as aviation fuel and lubricants distribution (U.S.-U.A.E. Business Council, 2019: 4). More recently, other companies have also started to gain a foothold on Emirati soil, and these include OMV and Compañía Española de Petróleos S.A.U. (CEPSA), India's Oil and Natural Gas Corporation (ONGC) and Chinese

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international players like the China National Petroleum Corporation and China ZhenHua Oil Company (U.S.-U.A.E. Business Council, 2019: 4).

The UAE is also currently engaged in the construction and completion of its first nuclear power - Barakah nuclear power plant; it is expected to yield 5.6 gigawatts (GW) per year (Power Technology, 2020). The plant represents a joint venture by ENEC, the Emirates Nuclear Energy Corporation, which was founded in, 2009, and the Korea Electric Power Corporation. It will be operated by their joint venture called the Nawah Energy Company (Power Technology, 2020). The power plant is set to include four generating units, and the first unit was completed and fully operational in, 2020, as it was connected in August to the national energy grid (Turak, 2020). The goal being to have the completed power plant meet a quarter of the national energy demand and thus “offset approximately 21 million tonnes of greenhouse gas emissions a year” (Power Technology, 2020: n.p.; Turak, 2020).

Nevertheless, the drive for diversification has prompted the UAE to focus on expanding its solar power potential, which is inherently vast, and upon expanding upon its nuclear energy projects and other “waste-to-energy” initiatives (Mordor Intellignece, 2019). In reality, the country is consistently one of the most promising solar energy producers owing to its favourable state regulations and economic initiatives to invest in clean energy (Mokri et al., 2013). Financial incentives have been granted to renewable energy projects, and one such example is the AED100 billion Dubai Green Fund, which aims to provide funding for the installation of solar panels on the high rooftops of the city of Dubai (Mordor Intelligence, 2018). One of the advantages of diversifying the power mix in the country with a greater share of renewable energy, such as solar energy, is that it is much less prone to potential disruptions and can recover somewhat quickly if disasters occur. In addition to this, diversification would inherently make the energy sector more resilient to disasters (although no energy strategy can completely obviate the risks and vulnerabilities of the industry) because if one source of energy suffers damage or an interrupted supply, the market can temporarily rely upon another, which has not been affected by a disaster. Figure 9 portrays the slow but steady rise of non-gas

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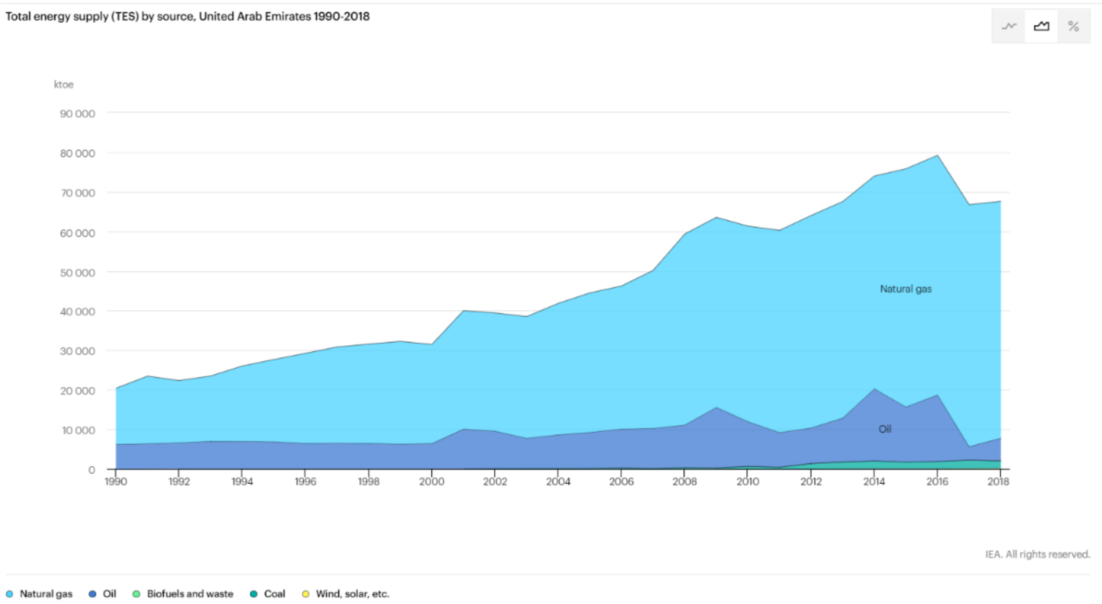
and non-oil resource production in the country as it strives to reduce its import amounts and become more self-reliant, however despite the country's arid environment and vast stretches of desert plains with low vegetation. Still, solar energy has yet to become a contingency energy source, even if the UAE has the financial capacity for investing in the development of such a reliable, environmental-friendly and inexhaustible solution (however a new solar farm is under construction so it is expected the reliance solely on fossil fuels will most likely be on the decline in the upcoming decades), yet up to now coal-based options were on the rise, as illustrated in the image below:

Figure 9: Total energy supply (TES) by source, UAE 1990-2018



Source: IEA (2020)

The "UAE Energy Strategy, 2050" posited that one of the goals for the year, 2050 would be the diversification of the energy mix in the UAE by expanding the percentage of clean energy up to 50% (UAE, 2020a). Thus, the framework prides itself on being grounded in the supply and demand dynamics of the Emirati state and national energy market, and as such, includes the investment of AED 600 billion by the end of the framework period to meet its set targets (UAE, 2020a). These statistics and goals only further reinforce the argument that the energy sector of the UAE forms the backbone of its economy and is critical in its relation to national security, economic goals and the interrelated political and social stability that come from these.

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1.4. Contribution of the Study

Past research studies that examined the approaches to disaster management in the UAE do not provide comprehensive guidance for the vulnerabilities and possible steps for improvement that the energy sector could adopt to address the current challenges. For instance, AlShamsi and Parthirage (2015) examined mitigation strategies in the UAE, but they did not apply their framework and findings exclusively to the energy sector, which carries its specific risks and vulnerabilities. Similarly, Dubey and Krarti (2017) have studied mitigation practices as well, with a focus on the Emirati context, but their findings are more concerned with gathering and analysing quantitative data and fail to incorporate the human factor into the discussion. The more practical and relevant proposals made by Al-Khaili (2015) can be considered as being overly generic and not applicable to the broader Emirati context per se since the research focuses on the barriers to resilience and mitigation in the UAE electricity sector, which constitutes a narrow segment of the overall framework for energy production in the UAE. Furthermore, the study by Al-Kaili et al., (2014) offers only a short and incomplete overview of the vulnerabilities of the Emirati energy sector without proposing any recommendations for addressing them. In general, most studies which have focused on the region of the Middle East focused on the energy security, politics and practices of the region in general or through a comparison format (Hertog and Luciani, 2009; Luciani, 2012), which does not allow for the detailed exploration of the energy industry and factors for the resilience of a particular country. Furthermore, scholars have focused on specific pertinent issues such as renewable energy sources and the search for sustainability in the GCC context (Griffiths, 2017) or the geopolitical, economic and disaster relevance of nuclear energy in the wider region (Hertog and Luciani, 2009) rather than providing a comprehensive overview of strategies for resilience and mitigation.

Therefore, the novelty and contribution of the current study relate to its focus, as first and foremost, the research expands upon the literature by conducting an in-depth investigation into the technological, organisational, economic and social factors that either challenge or improve the resilience of the Emirati energy sector. More specifically, the study incorporates a theoretical framework that develops a novel indicator library comprising condition-related and impact-related indicators for assessing resilience within organisations in the energy sector. Then the researcher applies this library to the primary data collected from Emirati energy experts. Furthermore, the thesis formulates a conceptual resilience-building framework based upon experts' direct contributions and the existing academic and specialised literature, which indicates the issues within the UAE energy sector and how they can be addressed. Thus, this thesis also provides recommendations suitable for future comprehensive and strategic resilience plans, which take into account all stages of the disaster management cycle and incorporate risk management procedures. Unlike the other mentioned studies, this study explores the identification of vulnerabilities and risks to propose practical and sustainable methods and strategies for addressing or minimising them.

1.5. Thesis Structure

This thesis is divided into seven chapters: Introduction, Literature Review, Theoretical Framework, Methodology, Primary Data Analysis, Discussion, and Conclusion.

This first introductory chapter provided the overall contextual basis of the research. Starting with the motivation and justification of the study, the discussion then explained the research aims, the research questions posed and the objectives that this research seeks to accomplish. Next, the discussion focused on offering a thorough presentation on the background of the research, which illustrates the importance of developing a resilient energy sector, emphasising the UAE’s reliance on this sector for both local development and international trade. This section also considers the recent green initiatives introduced by the UAE, which focus on renewable energy generation and diversification. Thus the section illustrates the current and future Emirati energy generation capacity based on current use and uses predictive metrics to assess the need to implement resilience standards and policies for the energy sector.

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The upcoming second chapter focuses on reviewing the relevant literature, namely the discussion will focus on the academic and expert knowledge regarding disaster management, risk management and resilience; the goal is to identify and critically examine key concepts, theories and frameworks. Thus, the discussion starts by exploring crucial notions such as hazard, risk, disaster, vulnerability, resilience and adaptability, as well as explaining why such notions should matter in every community. The main argument that emerged from this investigation is that each community should be aware of its own capacities and limitations as a means of achieving both stability and progress throughout each and every sector and industry, notably considering the energy industry, which is necessary for the proper function of all other societal elements. The discussion continues with a comprehensive investigation of disaster management in general – explaining the disaster cycle and its four stages (i.e. mitigation, preparation, response, recovery), but also in more depth as the discussion explains how a strategy focused on resilience-building may have a positive impact on the entire disaster cycle, with several disaster management models being considered. The chapter then focuses on risk management in general and the ISO 31000 standard in particular, as the thesis acknowledges that a proper risk reduction strategy can help diminish both the likelihood and impact of a potential disaster scenario. Thus, the discussion explains the importance of risk identification, risk assessment, risk treatment, and monitoring and evaluation procedures applied throughout the process as major steps towards reducing risk exposure. Several risk management frameworks and tools are explored throughout this process, and following this, the discussion then proceeds with the investigation of several resilience frameworks, and comparisons are drawn. Afterwards, the chapter explores how resilience is perceived within the energy sector, with the distinction being made between organisational and infrastructural resilience, as well as how it is possible to build resilience against natural and man-made disasters within the energy sector. This section is supplemented by an examination of the natural and man-made risks that the UAE energy sector is currently facing. The rest of the chapter explores the interconnected nature of disaster management, risk management and resilience in general and within the energy sector specifically, ending with a summary.

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Building upon the knowledge in Chapter II, the third chapter is dedicated to creating a unique theoretical framework for resilience building in the Emirati energy sector. The proposed framework includes a discussion on the dimensions of resilience chosen based on the resources employed in the energy sector (i.e. technical, organisational, social, economic), which were chosen based on existing literature to address the current needs of the UAE, as identified in the previous chapter. These dimensions are grouped into two major categories that showcase how resilience can strengthen the energy sector via interventions for enhancing existing resources and capabilities, and by implementing incident-focused and post-incident learning. The discussion then presents indicators of resilience identified for the proposed framework, explaining the logic, process and use of each of the sixteen indicators generated based on the impacted resources and the condition necessary to eliminate, reduce or mitigate the impact. A summary of the key principles of this framework ends the chapter.

The fourth chapter explores the methodological choices based on the available approaches and resources and the study's aims and objectives. Due to a lack of existing peer-reviewed data regarding the UAE energy sector's resilience, the inductive approach is employed in this research, to collect a wide array of data without relying on preconceived notions from international contexts that may not apply to the Emirati context. Even more so, given the phenomenon's dependence on its context, this research employs the case study strategy, seeking to investigate the resilience of the Emirati energy sector as a whole, thus acknowledging that the results will likely not be generalisable – even if they are replicable by other researchers seeking to explore this phenomenon in this unique context. Furthermore, the research employs a cross-sectional time horizon, collecting qualitative primary data by using semi-structured interviews that are analysed via coding, as well as qualitative secondary data to be examined using triangulation to increase the validity of the primary data gathered directly from experts. More specifically, the study employed a non-probability sampling method, namely purposive sampling, given that the data needed to be collected had to come from a limited number of local experts, including policy-makers and practitioners, who needed to be familiar with the

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topics explored throughout the thesis. The study established a sample size of twenty participants, and additional inclusion and exclusion criteria for their selection are presented. Additionally, the reliability, validity and generalisability of the research are individually examined, and the chapter also includes a hefty discussion on the research ethics and safety precautions taken before ending with a summary.

The fifth chapter is dedicated to organising and analysing the primary data from the interviews with the twenty experts, which were selected based on specific inclusion and exclusion criteria from private and public institutions currently operating in the UAE energy sector. The process of collecting the primary data is described in more detail, and the discussion moves to how the coding scheme was developed for the data set gathered for this research. The coding scheme is divided into four major codes (i.e. Technical & Technological Resilience; Organisational Resilience; Economic Resilience; Social Resilience), each organised into several themes catalogued as either vulnerabilities or opportunities. The resulting coding scheme mirrors the indicators identified in the theoretical framework developed in Chapter III. Each code and its specific themes are then explored separately, with both general (i.e. summative) and specific (i.e. quotes, presentation of incidents, experiences and opinions) data being offered to justify and clarify each code and theme. Each code also features a table with the main contributions from each participant. The chapter ends with a summary of the main findings and an analysis of how the participants perceive each issue, the overall goal is to identify the characteristics of the Emirati energy sector – presented via a SWOT analysis.

The sixth chapter, the discussion, considers each code separately and triangulates the primary data findings with the secondary data explored throughout this thesis, noting similarities and differences. These findings are then used to influence the recommendations offered in the last chapter.

Thus, the seventh and final chapter is dedicated to a final discussion that concludes this thesis and offers recommendations, taking into consideration the research purpose, questions and objectives. This chapter proposes a conceptual framework for improving resilience within the UAE energy sector to address issues raised by the participants, with recommendations based on both the participants' suggestions and the literary findings. To verify whether these policy suggestions could be successfully employed, a focus group interview with adequate experts was conducted, and unsurprisingly, the focus group raised similar issues to the Emirati experts and proposed similar solutions after open deliberations. The chapter and thesis end with a section that explores the problems encountered throughout this study, as future research could benefit from a more in-depth investigation of each Emirati energy sector industry, using a mixed-methods approach to reach more potential participants and to ultimately standardise the findings.

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CHAPTER II: LITERATURE REVIEW

2.1 Introduction

The first part of this chapter presents the concepts of disaster, resilience and vulnerability, focusing on their application in disaster management as outlined in the relevant literature. Then, the general aspects of resilience in the energy sector are identified. International best practices on developing resilience for the energy industry and critical infrastructure, in general, will be recognised primarily by looking at scholarly and practitioners' views.

While there is a literature gap regarding the vulnerability and protection of the energy industry in the UAE context, insight into the practices employed in other countries is valuable because they can be either directly transferrable or at least provide a basis for the UAE energy sector to develop its own mitigation strategies. In that respect, the chapter looks into the sector's vulnerabilities and barriers to resilience separately against both natural hazards and man-made disasters and critically evaluates the available resilience interventions in both cases. These insights helps discover ways to enhance the resilience of the UAE energy sector against hazards, as well as identify and anticipate the challenges disaster management practitioners face in implementing such interventions. To ensure the suggested resilience-enhancing measures are adequate to the UAE context, the subsequent material tries to identify the main threats facing the Emirati energy industry, natural and human induced.

2.2 Disaster, Vulnerability and Resilience

The investigation into the topics of disaster, vulnerability and resilience presupposes understanding the notions of hazard and risk, which are the pillars of disaster risk reduction. As such, these first need to be defined and differentiated between before a more comprehensive examination is developed. Firstly, a hazard can be defined as any perilous "phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage", and are typically related to environmental or technological contexts, for instance, "geological,

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meteorological, hydrological, oceanic, biological and technological” sources or settings (UNISDR, 2009: 17). In essence, a hazard refers to a dangerous element that carries the possibility of causing harm to someone or endangering something (Smith, 2001; Wells, 1996). Secondly, risk can be defined as “the combination of the probability of an event and its negative consequences” (UNISDR, 2009: 25). Simply put, a risk is the likelihood that a threat exploits any given vulnerability, regardless of intention or happenstance, and which as a result may cause harm or loss of life, or may damage an asset (Coppola, 2011; Cox, 2009; McKay, 2015).

Despite the commonality of the term, disaster is difficult to define with any degree of precision, as it is used for a wide range of adversities, which can have natural, technological or human causes (Burnham, 2008; UNISDR, 2009). What separates a large-scale accident from a disaster is sometimes decided merely by civil authorities or even the surrounding community and may depend on its effects (McFarlane and Norris, 2006; Lemyre et al., 2008). Indeed, within the field of emergency management, there have been attempts to identify the parameters that can potentially combine to form a disaster. For instance, organisations such as the Red Cross and Red Crescent societies designate whether an event constitutes a disaster based on its measurable impacts, such as number of human casualties or whether an appeal for international assistance and a declaration of national emergency have been made (McFarlane and Norris, 2006; Burnham, 2008). However, the severity of a disaster is measured in relation to local context and circumstance, meaning there is a limit to the applicability of common criteria across all societies. The same natural phenomenon can have much worse consequences for a society that lacks preparedness or has small response capabilities than a more developed one (UNISDR, 2015b). This context-based approach provides a threshold for researchers to differentiate disasters from other crises, as occasions when the demands exceed the capabilities (Quarantelli, 1986). Yet other researchers, like mental health professionals, prefer to put more emphasis on the effect such events have on individuals, thus defining disaster as a “potentially traumatic event that is collectively experienced, has an acute onset, and is time-delimited” (McFarlane and Norris, 2006). Considering all the

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above mentioned viewpoints, the UN has provided a general definition for disaster as a “sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material, and economic or environmental losses that exceed the community's or society's ability to cope using its own resources” (Siriwardena et al., 2011).

Due to their diverse nature and nebulous definition, the risk that disasters pose can sometimes only be recognised in hindsight (Bhamra et al., 2011). This means that a disaster is characterised by the interaction between a potentially harmful event – whether natural or man-made – and the weaknesses of the society it impacts, which are primarily determined largely by human actions and behaviour (Birkmann, 2006). While each community may have differing degrees or types of socially constructed vulnerabilities, there are also other ones, which are born by location (e.g. a region prone to earthquakes or a community close to a volcano) or by human activity in general, such as climate change (Lei et al., 2014).

These factors, which determine the susceptibility of infrastructure, lives, or other assets to damage and loss, constitute what is referred to as vulnerability (UNISDR, 2015b), although this concept can also be defined in a variety of ways (Lei et al., 2014; Zhou et al., 2010). As a general rule, vulnerability can be viewed as the “characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard” (UNISDR, 2009). For some purposes, hazard research can view vulnerability even more broadly as the ‘potential for loss’ (Cutter, 1996). For example, the IPCC (Intergovernmental Panel on Climate Change) refers to it as the degree of a system’s susceptibility to the effects of climate change in particular, while social scientists define it as the inability of people and societies to cope with the adverse impacts of multiple stressors (Kasperson and Kasperson, 2001; Lei et al., 2014; Birkmann, 2006). The progressive focus on the impact of human activities on the environment and climate and the subsequent consequences these activities have on communities has, in recent years, shifted the attention of researchers towards the vulnerability of human society (Lei et al., 2014). This is not simply caused by increased concern for the impact of disaster on humans but can also signal an approach that considers disasters to be generated by

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social systems through the production of vulnerabilities (Wisner et al., 2003) or failure to address them (UNISDR, 2015b).

Whatever their origin, being able to recognise a community's vulnerabilities, as well as the aspects that influence them, is key to the development of effective risk communication and reduction measures (Paton and Johnston, 2001). In very general terms, to reduce a system's vulnerability, disaster practitioners can limit its exposure to hazards (e.g. by building flood defences) and its sensitivity (e.g. by improving structural integrity or raising awareness) (Zhou et al., 2010). At the same time, when attempting to identify vulnerable groups, it is very important to keep in mind that a population characteristic can increase vulnerability under some circumstances but decrease it under others, meaning that constant and complex research is needed before attempting to formulate disaster management plans (Paton and Johnston, 2001). This task of measuring vulnerability is made even harder by the limited ability to properly evaluate the subjective aspects of disaster impacts, such as the cultural or psychosomatic effects (Wisner et al., 2003).

Whereas a society's vulnerability determines the magnitude of a disaster's impact upon it, resilience, in contrast, refers to the capacity of social, economic and other systems to anticipate, absorb and eventually recover from disaster in a timely and efficient manner (UNISDR, 2015b, Rehak et al., 2018). It is, therefore, inversely related to vulnerability, as vulnerable systems tend to lack resilience and vice versa (Rehak et al., 2018), to the point where some researchers may define one in relation to the other (Lei et al., 2014). However, while the aforementioned UNISDR definition offers a utilitarian and broad description, the concept of resilience has different nuances for each system – in the case of critical infrastructure for example, the ability to contain and reduce cascading effects of disasters is a further characteristic (Honfi and Lange, 2015). Because of the term's significance in the field of Disaster Risk Reduction (DRR), either for understanding the dynamic properties of natural disaster systems or for shaping policies, it is important to distinguish between the multitude of different definitions to comprehend the notion (Alexander, 2003, Zhou et al., 2010).

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As a concept, resilience can be traced back to the field of ecology, where it was first introduced by Holling (1973) to describe the amount of disturbance that an ecosystem can absorb without the relationship between its variables changing fundamentally. According to Holling (1973), systems that seek to achieve stability are more likely to encounter events than those that are unstable, with the latter being better equipped for handling sudden fluctuations than the former, which allow the accumulation of more risks before addressing them – thus resulting in overwhelming disasters. From ecology, the concept of resilience was transferred to a variety of fields that can be described by systems theory, from developmental psychology to sociology, medicine, and multidisciplinary approaches like DRR – the different ways each discipline views the same phenomena is the reason why resilience is hard to define, especially for overlapping fields (Alexander, 2003). Nevertheless, although the lack of a universally accepted definition is a cause of some confusion among scholars, being able to consider how resilience ties in with the examined system's dynamic attributes are more important (Walker et al., 2004), therefore, for scholars concerned with human societies, resilience may simply be the ability of communities to withstand external shocks and recover from them (Timmerman, 1981). For engineers, the key characteristic that defines resilience is the speed with which a system returns to equilibrium after a perturbation – this interpretation, though seemingly limited, is a useful metric used by researchers to assess how resilient a system is (Pimm, 1984). This sort of assessment is easier to perform on natural ecosystems since human societies each have a much wider set of factors which shape their resilience, such as technological capabilities, access to resources, wealth, organisational capacity, and others (Kasperson and Kasperson, 2005). Even though improving each of these factors should also reduce the recovery speed of the system, when dealing with complex systems, it is more prudent to address and evaluate each aspect separately (Ray-Bennett, 2018). While most researchers, whether dealing with natural or man-made systems, focus on the systemic ability to come back to a state of equilibrium, it is essential to point out that this process does not necessarily mean a return to the pre-disaster situation (Alexander, 2003).

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Indeed, in recent years many scholars have increasingly focused on the adaptation ability to absorb and recover from hazards (Zhou et al., 2010, Lei et al., 2014). Adaptation or adaptability, a term also borrowed from natural sciences, refers to an organism or system's ability to change, rather than simply withstand damage, to survive environmental stresses or disasters (Smit and Wandel, 2006). When dealing with socio-ecological systems (SES), adaptability amounts to the capacity of actors (humans) to influence and manage resilience (Walker et al., 2004). While this capacity is determined by the same community characteristics that shape vulnerability – and therefore resilience, the element of intentional management of these traits is what makes adaptive capacity an emerging key feature of DRR and emergency management (Walker et al., 2004, Meerow et al., 2016). This being said, the capacity to adapt may be influenced by either a sudden and urgent change of parameters, in which case adaptability is a response to emergent flaws or may emerge as a result of a critical examination of existing structures that find such structures to be lacking or obsolete (IPCC, 2014). Thus, an important feature of resilient systems is being capable of learning from past disasters. Such experience increases their capacity through adaptation (McLellan et al., 2012) and generally being flexible enough to adapt and change in response to new pressures (Bhamra et al., 2011). While adaptability is easier to manage and accomplish in SES through the actions of humans, efforts to increase the adaptive capacities of energy systems or of ecosystems to climate change are also possible (Meerow et al., 2016).

Organisations need to assess whether their adaptive capacity can be described as resistant to change, favouring incremental change or radical change, to determine what policies and procedures could be designed and implemented to encourage adaptability. Building adaptive capacities through gradual changes, rather than radical transition, may have opposite results than the ones expected or desired (Holling, 1973). In fact, slow and steady changes tend to provide a momentary alleviation of the experienced stressors rather than to encourage structural modifications, and as a result, the underlying vulnerabilities and issues are never addressed (Handmer and Dovers, 2007; Wise et al., 2014). Increasing the ability to adapt to new circumstances can be

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slowly achieved in a closed environment that is resistant to change. However, the over-reliance on existing structures tends to limit the adaptive capability in extreme cases with little or no precedent when adaptability is, arguably, needed the most (Holling, 1973; Wise et al., 2014). To combat the reliance on existing systems and thus increase adaptability, learning from minor emergencies is necessary to raise awareness of potential issues that would otherwise be ignored. Such interventions are also required to improve response and recovery practices, breeding a culture of faster adaptation to emergent hazards (Gunderson, 2010). At the opposing end, if organisations find that they favour radical changes, they also need to ensure that the modifications implemented are relevant and efficient, as the pitfall of encouraging building adaptive capacities through radical efforts may be maladaptation that stems from nefarious reasons, such as to reach financial, political or social gain (Wise et al., 2014).

Considering all of the above, resilience in the larger context of disaster management and DRR can be defined as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNISDR n.d.: 3). However, there is no single best practice approach to managing and implementing resilience practices, even though they all seek to attain three general goals, respectively to be capable of withstanding disasters, to be adaptive to new circumstances, as well as to recover from a disaster swiftly (Tiernan et al., 2018; Wise et al., 2014). In fact, a comprehensive mitigation plan requires more than just improving preparedness and response to emergencies – especially in the case of disasters affecting industries, like the energy sector, the indirect losses can significantly exceed the direct impact, making the aspects of recovery, impact absorption and adaptation critical (Hiete and Merz, 2009). This transforming process is a necessary developmental step towards reducing risk and empowering societies against future hazards, but is often overlooked due to an urge to view the recovery and reconstruction process as an effort to return to normality and the pre-disaster situation, rather than as an opportunity to improve and to decrease vulnerabilities (UNISDR,

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2015b). Other times, adaptation measures may have little practical effect due to a lack of representation of the affected group in the decision-making process or because the efforts are aimed at a specific vulnerability without considering broad community factors (Smit and Wandel, 2006). To make a difference, the incorporation of this concept of ‘build back better’ – as opposed to ‘business as usual’ – in the emergency management plan must go beyond building structural standards and infrastructure improvements in general and extend to addressing underlying factors that shape a society’s vulnerabilities, including economic discrepancies, political differences or gaps in regulation and policy (UNISDR, 2015b).

In the energy sector, resilience also refers to the capacity of the suppliers, manufacturers and distributors to continuously meet the demands of the consumers, affordably and equitably, by being able to endure, overcome or adapt to any disruptions in the supply chain (Silvast, 2017). Specifically, the supply chain of the energy sector includes everything from procuring materials from both conventional sources (e.g. coal, minerals, crude oil, natural gas, etc.) and renewable sources (e.g. solar, hydro, wind, etc.) to manufacturing and refining, from depositing to transportation, and from distribution and retailing to finally reaching the customer (Cucchiella and Koh, 2015). Therefore, resilient measures must be developed and implemented for all the supply chain elements. Ensuring the continuous flow of the energy sector’s supply chain is relevant not only to the direct stakeholders as enumerated above but also to all other sectors because the capability of all other local systems, organisations and actors to function is entirely dependent on the existent energy reserves (Gasser et al., 2019; Thomas and Kerner, 2010). it is important to keep in mind that:

> “Although owners/operators of privately owned critical infrastructure are ultimately concerned with the ‘bottom line’, there is nevertheless growing awareness in the business community that enhanced resilience is part of a well-designed strategy to enhance a business’s ability to withstand various shocks […] and thus enhance the business’s competitive position” (Carlson et al., 2012: 31).

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However, Carlson et al. (2012) also found that private companies tend to offer resilience strategies and support mainly to issues related to the resilience of the information technology (IT) infrastructure, which is also primarily provided to clients and not collaborators, to increase profits. A point often overlooked by non-specialised decision-makers is the fact that the policies and procedures devised to avoid, postpone, mitigate, respond to and recover from disasters are significantly more important than the cause of the disaster (Jesse et al.,2019). From this perspective, it can be argued that the energy sector – with particular attention being given to the extraction and manufacturing facilities that could be affected the most by a large-scale disaster – needs to devote specific attention to the development and implementation of resilient policies at all disaster stages and for the entirety of the supply chain, to bounce back from unforeseen disruptions quickly and thus to develop sustainable systems (Carlson et al., 2012; Gasser et al., 2019). While securing energy systems against the various vulnerabilities, threats and risks that arise could be a difficult and ever-expanding endeavour, developing resilient policies and procedures that prioritise system restoration regardless of the causal circumstance is a much more efficient approach to building resilience in the energy sector (Jesse et al., 2019; Silvast, 2017).

Considering all the various definitions explored throughout this subchapter, Table 1 summarises the different approaches to the key concepts of hazard, risk, disaster, resilience, vulnerability and adaptation.

2.3 Disaster and Risk Management: Policies, Practices and Tools

According to the UN (2020: n.p.), disaster management "aims to lessen the impacts of disasters, minimizing losses of life and property". As such, the practice of disaster management is reserved for practitioners who are tasked with the management and deployment of available resources, including the delegation of roles and responsibilities of the human capital of the organisation, with the goal being to minimise the effects of any disaster, be it natural or man-made (Subramanian, 2018).

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Table 1: An indicative summary of key concept definitions

	Definition(s) (organisation/field)
Hazard	dangerous circumstance that may result in harm, injury, loss or disruption of lives or assets (UNISDR, 2009)
Risk	the probability of an event with negative consequences occurring (Coppola, 2011; Cox, 2009; McKay, 2015; UNISDR, 2009)
Disaster	a sudden overwhelming, and unforeseen event leaving those affected unable to cope without outside assistance (Burnham, 2008; UNISDR, 2009)
	a potentially traumatic event, collectively experienced, with an acute onset and time-delimited (McFarlane and Norris, 2006)
	The sudden, calamitous event that disrupts community or society functions & causes human, material, economic or environmental losses exceeding the community's ability to cope using its own resources (Siriwardena et al., 2011)
Vulnerability	the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change (Kasperson and Kasperson, 2001; Let et al., 2014; Birkmann, 2006)
	Characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (UNISDR, 2009)
	a measure of both the sensitivity of a population to natural hazards and its ability to respond to and recover from the impacts of hazards (Zhou et al., 2010)
	Stress on the system's response to hazard or hazard potential, which determines the likelihood of loss from hazards (Zhou et al., 2010)
Resilience	the amount of disturbance that a system can sustain before a change in system control or structure occurs (Holling, 1973)
	the capacity of hazard-affected bodies to resist loss during a disaster and to regenerate and reorganize after a disaster in a specific area in a given period (Kasperson and Kasperson, 2005)
	The speed with which a system returns to equilibrium following a disruption (Alexander, 2003; Pimm, 1984; Ray-Bennett, 2018)
	the ability of human communities to withstand external shocks or perturbations to their infrastructure and to recover from such perturbations (Timmerman, 1981).
	the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner (UNISDR, 2015b; Rehak et al., 2018)
	the ability of a system to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner (IPCC, 2014; Lei et al., 2014; Zhou et al., 2010)
	the ability of a system to be restored after a disaster, regardless of the disaster (Smit and Wandel, 2006)
Adaptability	an organism or system's ability to change or adapt (Bhamra et al., 2011; Meerow et al., 2016; Smit and Wandel, 2006)
	the capacity of actors (humans) to influence and manage resilience in socio-ecological systems by learning from past experience (Gunderson, 2010; McLellan et al., 2012).

A most pertinent aspect of disaster management activity is risk management, which refers to the "complete process of risk assessment and risk reduction" to identify not only the possible risks and hazards that may affect an industry,

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business or system but also the means through which such risks may be averted or overcome (Svalova, 2018: X).

Of notable significance is the disaster cycle (Figure 10), which characterises the life of a disaster in four key stages, namely mitigation, preparation, response and recovery, each representing the actions taken by disaster practitioners prior to, during or after the onset of a disaster (Subramanian, 2018).

Figure 10: Disaster Cycle

Source: Pinimg (n.d.)

The first stage, mitigation, requires actions taken towards risk prevention or reduction and is the stage when practitioners not only assess the possibility and probability of a risk becoming a disaster but also identify and institutionalise preventative measures to minimise the occurrence of such incidents (Coppola, 2011). The measures implemented by disaster and risk management specialists during the mitigation phase are usually informed by one of five objectives, such as reducing the risk likelihood, diminishing the potential consequences of a risk, avoiding the risk altogether, accepting the risk and its impact, or sharing the risk – mainly referring to distributing the financial consequences of a given risk – with other actors or stakeholders, such as through groups of organisations or syndicates (Coppola, 2011).

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The second stage, preparation or preparedness, requires implementing the measures detected during the previous phase, which are carried out with the goal of minimising casualties and economic losses in case of a disaster (Satendra and Sharma, 2004). It is common for this stage to include awareness campaigns and training programmes. At the same time, structural and organisational changes are enacted to strengthen the reliability of the disaster response and relief teams (Khan et al., 2008). A point often overlooked by practitioners is that the first two stages may be swapped depending on the industry or company (Carlson et al., 2012), under special circumstances such as whether needed changes have been identified in a previous disaster cycle and not yet implemented; however, such a change usually depends on internal policies when these are not regulated by national or international legislation.

The third stage, response, is the phase that starts with disaster onset and includes the interventions of responders at all levels, including decision-makers, ground units and rescue teams (Phillips et al., 2012). Without a doubt, timely response and sound decision-making are the most important attributes of disaster responders, who also need to perform their duties under stress – and for this reason, the response is typically perceived as a crucial component of disaster management (Coppola, 2011). Nevertheless, it is important to keep in mind that the response capabilities of an organisation are heavily dependent on the policies and procedures implemented in the pre-disaster stages. As such, at the onset of the disaster, the response strategy needs to be clearly and efficiently planned out (McCreight, 2011). To ensure that the response is carried out well, both theoretical and practical exercises with all the relevant stakeholders (e.g. decision-makers, key disaster practitioners, facilitators, evaluators, first and second responders, volunteers, actors, media representatives, public figures, and so on) need to be carried out in advance (Coppola, 2011; Fagel, 2012; McCreight, 2011). Without the implementation of such training exercises in the pre-disaster stages, relevant evacuation risks might not be identified in advance, and as such, the response could suffer from policy-related and procedure-related failures that could have otherwise been averted (Coppola, 2011).

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The fourth and final stage, recovery, is a post-disaster period when the various restorative and resilient initiatives that have been developed are now implemented, with the main goals being the restoration of the affected community and the rehabilitation of the property that was damaged (Phillips et al., 2012). The recovery stage is significant due to the involvement of a wide variety of private and public institutions in interventions meant to return the community to normalcy or at the very least, to adapt and overcome the aftermath of the disaster (Coppola, 2011). As the disaster cycle repeats itself, disaster management experts should be able to draw relevant conclusions regarding policies, procedures and tools that were either successfully or unsuccessfully employed, and as such, to improve disaster management plans (Satendra and Sharma, 2004). Introducing resilience policies throughout all four stages of the disaster cycle (i.e. mitigation, preparedness, response and recovery) will ensure that each strategy is not only relevant to each risk but also that there is the capacity to learn and adapt based on the hazards and risks that appear throughout each stage.

Related to this, Carlson et al. (2012: 21-22) propose six characteristics of resilience that follow the disaster management cycle (Figure 10), respectively anticipation, resistance, absorption, response, adaptation and recovery (Table 2). These characteristics correspond to four major components: the ability to be prepared for a disaster by collecting and analysing data that is relevant to the environment and to the target (which could refer to a community, organisation, facility, process, and so on); the capacity to plan and enact mitigation measures that are capable of minimising the negative impact of the disaster; the responsive capacity of the overseeing body, of the affiliated organisations and of those directly impacted (i.e. stakeholders) to dedicate efforts towards actively halting or reducing the adverse impact of the disaster; together with the combined capability of the stakeholders to recover from said adverse effects, the goal being that of either returning to normalcy or focusing on improving the circumstances in order to further minimise vulnerabilities in the future – whichever option is more suitable in light of the disaster (Carlson et al., 2012). As it stands, planning for resilience is, much like disaster management, a process that needs to take into account the moments before, during and after

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the onset of a crisis, and this process thus requires a dedicated task force to ensure a lasting implementation of effective and relevant procedures (Carlson et al., 2012).

Table 2: Relationship between Characteristics of Resilience and the Disaster Cycle

Anticipate	**Resist**	**Absorb**	**Respond**	**Adapt**	**Recover**
Preparedness	**Mitigation**		**Response**		**Recovery**
Activities taken by an entity to define the hazardous environment to which it is subject	Activities taken before an event to reduce the severity or consequences of a hazard		Immediate and ongoing activities, tasks, programs, and systems that have been undertaken or developed to manage the adverse effects of an event		Activities and programs designed to effectively and efficiently return conditions to a level that is acceptable to the entity

Source: Carlson et al. (2012: 22)

Nevertheless, the disaster cycle is an idealised abstract model that offers a theoretical approximation of reality, wherein the process of managing disasters is simplified to fit the framework and thus suffers from some limitations. For instance, there has been an overwhelming tendency for private companies to prioritise response and recovery over the pre-disaster stages, thus possibly neglecting the development of key preventive or resilience measures (Twigg, 2004). This tendency may be rooted in the incipient aim of disaster management, which evolved as a response to disasters and initially tended to prioritise effective action during crises rather than to attempt to prevent and mitigate their occurrence (Lewis et al., 1976). However, the tendency to focus on prioritising the response phase is also characteristic of the other disaster management frameworks, for instance, the Kimberly (2003) model, the Gupta (2010) model or the Tuscaloosa (2003) model, all of which place an increased emphasis on the actions taken immediately after the disaster onset, and which generally tend to neglect pre-disaster stages. In fact, prioritising response over preparedness in resilience initiatives may result in situations where emergent risks are ignored until they grow into disasters, such as python-type crises

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(Evans and Elphick, 2005). According to Seymour and Moore's (1999) classification, such python crises are characterised by repeatable patterns and thus are recurring due to poor practices that slowly build up to a foreseeable disaster that could have otherwise been prevented. Although the return to normalcy or the pre-disaster stage is an inherent feature of resilient systems, resilience requires introducing strategies to avoid or minimise the reoccurrence of crises experienced in the past. Even though the procedures pertaining to the response and recovery phases can be aptly implemented, they alone cannot diminish a system's susceptibility or vulnerability to risks (McEntire et al., 2010).

By contrast, other disaster management models emphasise exploring and addressing said vulnerabilities; for instance, the McEntire, Crocker and Peters (2010) model considers factors such as the social environment, exposure, susceptibility, liabilities, capabilities, resistance and resilience (Figure 11). In addition, Lagadec et al. (2009) argue that the current disaster management cycle is linear and does not allow a more comprehensive insight into the greater context of the affected systems (i.e. community, organisation or facility), which tends to lead to a superficial understanding of the causes behind a disaster. This is particularly noteworthy when seeking to increase resilience in a community or zone that is either frequently affected by disasters, or within an industry prone to be disturbed by a wide array of external or internal forces (Foreman, 2019), such as the energy sector.

Hence, devoting efforts towards the investigation and identification of major vulnerabilities is not only advised but is, in fact, an ideal first step towards the introduction of effective resilience practices, which need not be restricted to previous iterations – but instead should seek to identify potential liabilities as well (McEntire et al., 2010: 51). However, the major issue of assessing hazards and vulnerability, is that the concept is socially-defined and thus ever-changing, with topics related to the political and economic spheres directly influencing the degree of vulnerability (McEntire et al., 2010: 53-54). Therefore, mapping vulnerability could be perceived to be dependent on the social context in which it exists, and is thus specific to the needs and the development of a community and the system (see Figure 11) (Hillhorst and Bankoff, 2004). At the same time,

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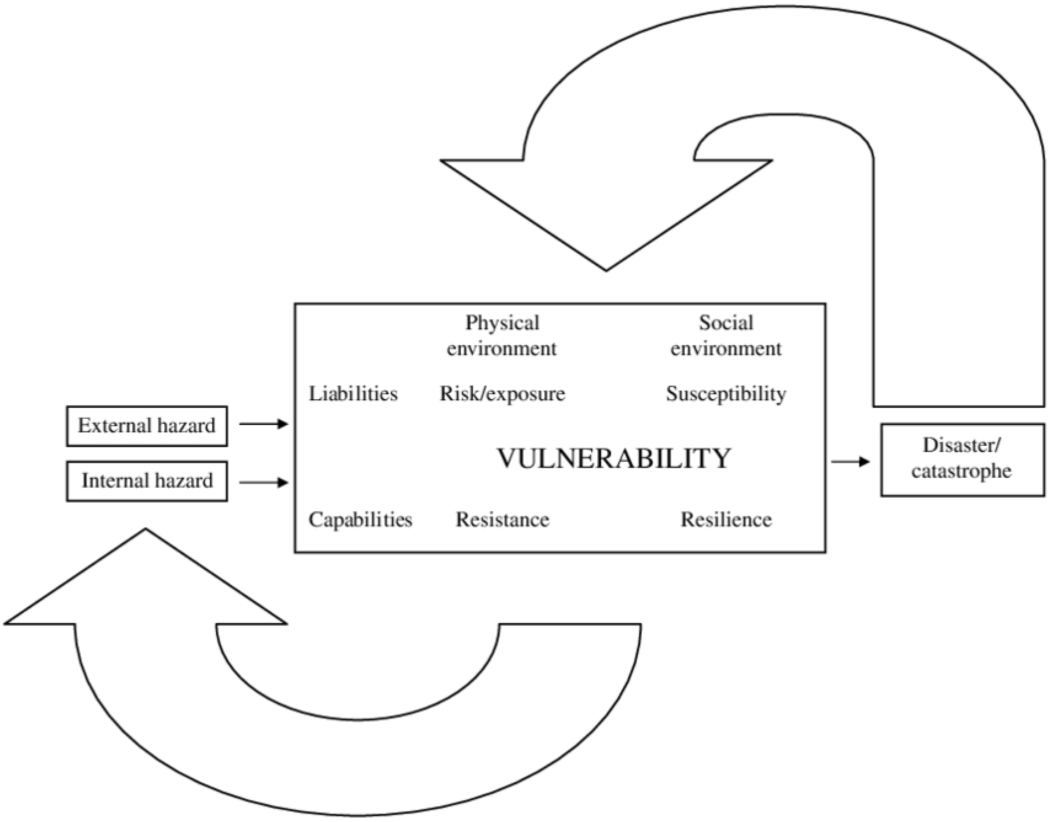
the major advantage of conducting vulnerability assessments based on dedicated vulnerability frameworks is that they are hazard-specific – and thus, several such investigations need to be performed to address all possible susceptibilities, liabilities and capabilities (Frerks and Bender, 2004). Furthermore, a singular framework, such as that proposed by McEntire et al. (2010), may be applied to various vulnerabilities, which helps simplify and streamline the process.

Figure 11: Relation of Hazards, Vulnerability and Disasters



Source: McEntire et al. 2010: 58)

Lastly, the disaster cycle has also been criticised for not directly addressing or including monitoring and evaluation practices, unlike Deming's Plan Do Check Act (PDCA) cycle (Charantimath, 2011; Figure 12), or the dedicated Monitoring and Evaluation model proposed by Scott et al. (2016), both of which seek to encourage organisations to verify the implementation of their disaster management and risk reduction plans, the overall goal being to address the issues that surfaced throughout all the stages of the crisis.

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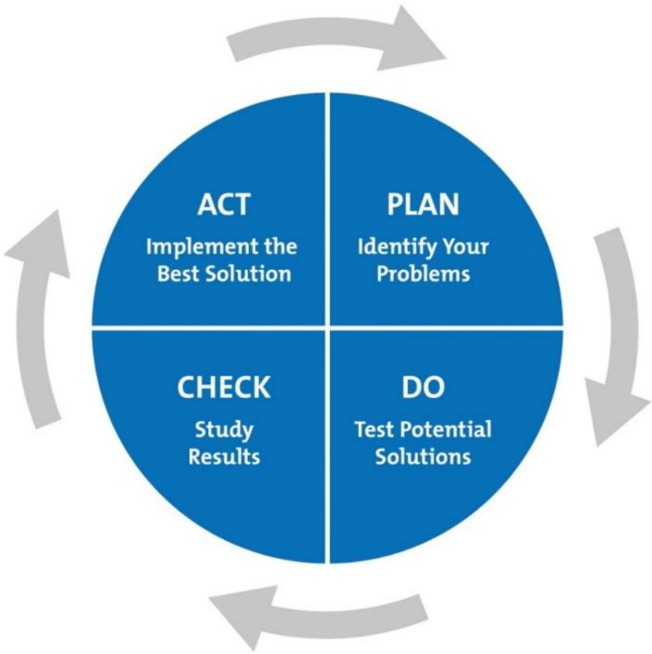
Figure 12: PDCA Cycle



Source: Mindtools (n.d.)

2.4 The ISO 31000 Risk Management Standard is a Tool for Managing Risk in Organisations

Before moving forward, it is important to consider the relationship between risk management and resilience and the role of risk management practices in building more resilient structures. Both risk management and resilience interventions focus on learning based on previous experience, as the emphasis is put not only on how to anticipate and adapt to adverse events but also on how to diminish the possibility of said events reoccurring by assessing vulnerabilities (Mitchell and Harris, 2012; Field et al., 2012). Furthermore, disaster and risk management teams can use various tools and techniques to ensure that preparedness levels are maintained at a high standard throughout all the stages of a disaster (Field et al., 2012). Thus, risk management practices can be employed to develop an effective resilience intervention (Mitchell and Harris, 2012).

A significant risk management tool that takes into account resilience building is the ISO 31000, a comprehensive standard that seeks to diminish the impact of

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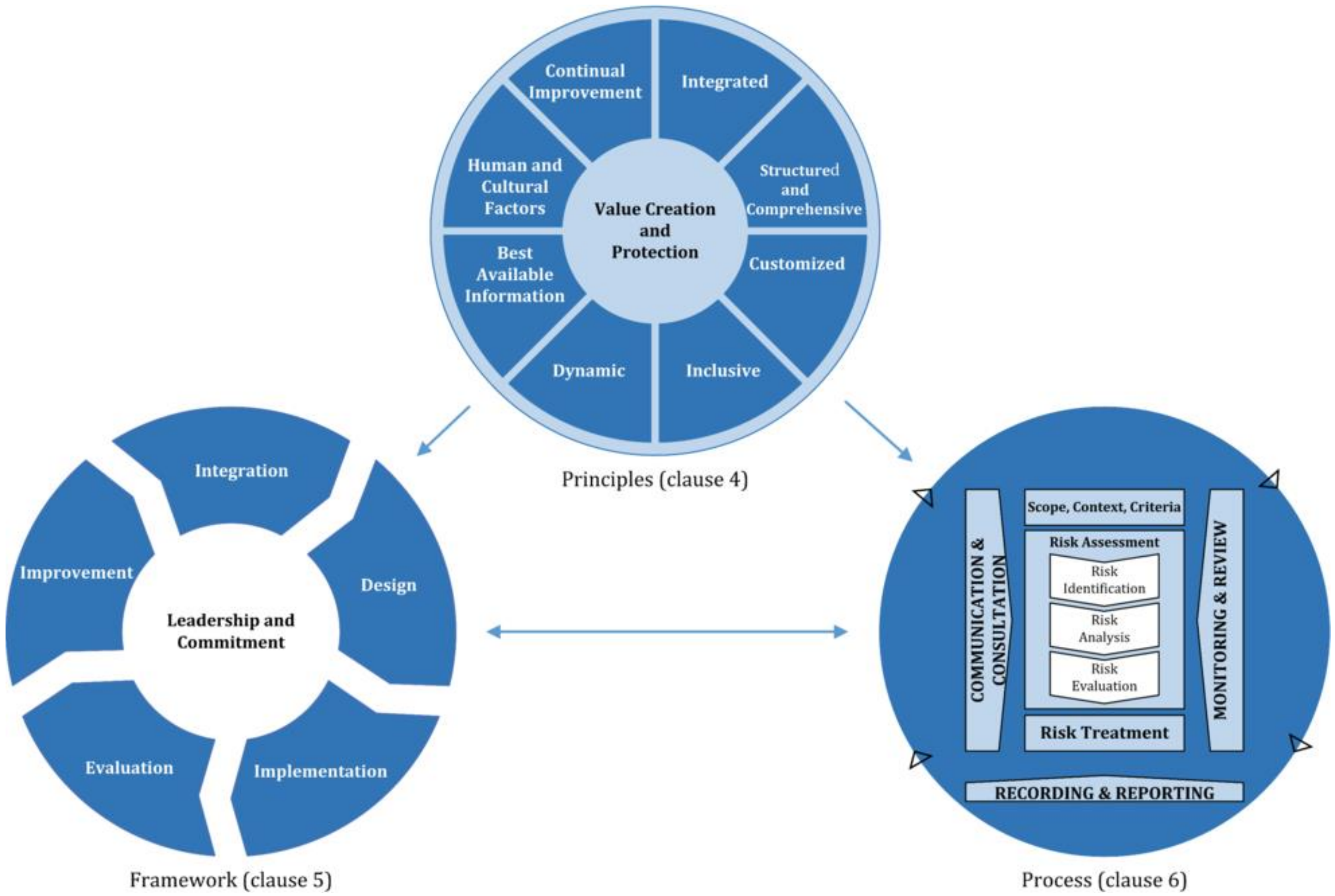
disasters by prescribing key principles and processes, along with a 5-step framework that centres on improving leadership through a commitment to continuous improvement (ISO, 2018; Figure 13). As the three components (i.e. principles, process, and framework) are interconnected and complementary, the standard manages to guide organisations regardless of sector, size or activity (Yilmaz and Flouris, 2019).

Taking into account the ISO 31000 standard (see Figure 13), the following practices are recommended for risk management specialists and resilience practitioners: risk assessment, risk identification, risk analysis, monitoring and evaluation, development of early warning systems, search and rescue, humanitarian aid and relief, damage assessment, rehabilitation, reconstruction (Coppola, 2011; Khan et al., 2008). Although many elements from the above list are self-explanatory, for instance, the need to develop early warning systems in cases where such tools do not yet exist, the need for launching search and rescue missions immediately after the disastrous event, or assessing the damage of the disaster at the start of the recovery phase or commencing the restoration of the affected structures (Kadri and Mei, 2018), some tools are more complex and need more clarification. Moving forward, the discussion will focus on examining crucial issues pertaining to the ISO 31000 standard and to risk management best practices in general, such as risk identification, risk assessment, risk analysis, risk evaluation, risk attitude, risk appetite, risk tolerance and risk treatment, as well as monitoring and evaluation policies and procedures.

Figure 13: ISO 31000 - Principles, Process, Framework



Source: ISO (2018)

2.4.1 Risk Identification

Risk identification refers to the process of discovering the risks or hazards that may have possible adverse repercussions for an industry, company or system (Loosemore et al., 2006). The main advantage of conducting risk identification is that it helps uncover the potential social and economic impacts of risks for a specific industry (Kreimer and Arnold, 2000). As such, while risks can be identified at the level of a sector or industry – such a task is more effective when it is employed at a company level, thus allowing disaster practitioners to pinpoint, based on internal and external factors, the same risks that an organisation is facing at (Coppola, 2011). The risks identified can be related to timing, budget and economy, but they can also be related to other types of resources (e.g. human competencies and availability, the available technology, equipment, materials and systems), to the scope and objectives set, to approaches in communication (be it intra-organisational or inter-organisational), and even to the environmental elements that may pose a threat (Loosemore et al., 2006). Fortunately, there is a wide array of tools and approaches that can be employed in the process of risk identification, from interviews of key stakeholders to paperwork reviews through audits and even to sessions of brainstorming in which known and common risks can be consulted to identify the potential risks (Coppola, 2011). However, some of the most popular tools for risk identification are the SWOT Analysis (Figure 14), which identifies both internal and external policies (Satendra, 2003), and the Root Cause Analysis, which is employed to seek out the underlying issues within a company, and which can be performed via different tools, for instance through a Fishbone diagram (Figure 15) or the 'Five Whys' approach (Figure 16), among others (Barsalou, 2015).

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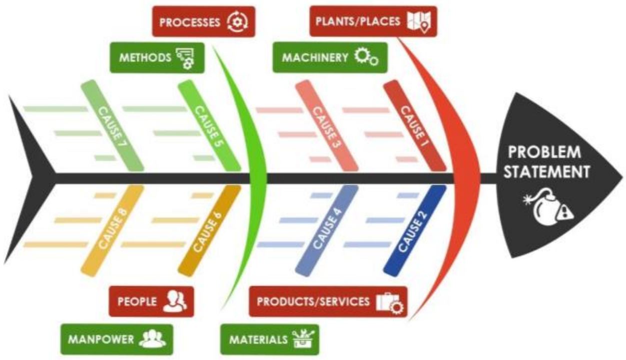
Figure 14: SWOT Analysis

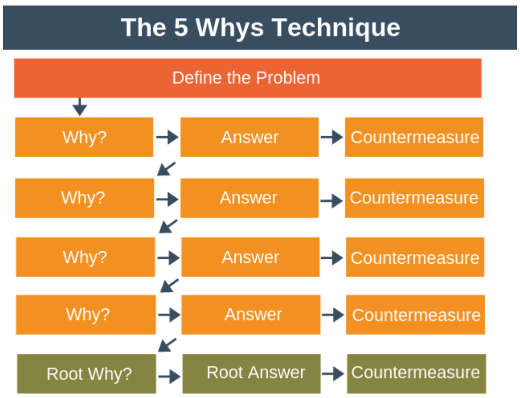
Source: Word Stream (n.d.)

Figure 15: Fishbone Analysis



Source: Analyst Zone (n.d.)

Figure 16: '5 Whys' Approach



Source: Expert Program Management (n.d.)

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It is without a doubt that risk identification is one of the most important practices for businesses and sectors. However, the process can be lengthy and costly, and it can be especially time and resource-consuming when employing various tools and techniques (Koirala, 2015). However, skipping this step can lead to severe repercussions, mainly caused by the lack of knowledge (Loosemore et al., 2006), which, through neglect and oversight, are very likely to lead to Python-type disasters that occur due to poor practices and which are very difficult to recover from (Ahman and Ahmad, 2019).

In the energy sector, risk identification is conducted via a wide array of tools and techniques to minimise the previously mentioned limitations. To illustrate, Correa-Henao et al., (2013), found that risk identification for the electricity sector is carried out through interconnected risk maps that offer clear visual representations of infrastructure-related risks (Figure 17). At the same time, Thangaiyan (2019) found that other preferred risk identification methods at a national or international level are: creating a merits and demerits table, employing surveys and interviews directed at key decision-makers within the industry, and afterwards triangulating the data. Furthermore, while Guerrero-Liquet et al. (2016) suggest that the direct approach via interviews has been preferred, nowadays, renewable energy stakeholders tend to employ the Fishbone analysis, the Delphi techniques (i.e. surveys), along with SWOT diagrams, the Multi-Criteria Decision-Making (MCDM) model, audits, simulations – notably following the Monte Carlo method, among many others to assess the risks and their probability. Similarly, Ioannou, Angus and Brennan (2017) found a preference for experts to use the MCDM model and employ scenario analysis to identify potential risks.

This being said, the above studies found both advantages and disadvantages to using the enumerated techniques, as there is no all-encompassing, comprehensive risk identification method to be employed in all situations – and neither should it be as a correct estimation needs to be calculated after the triangulated analysis of multiple sources, from various channels and by using several techniques – which increases the capacity to identify the existing risks (Coppola, 2011) correctly. Thus, the best practice is to employ several risk identification tools to ensure that the identified risks are not influenced by

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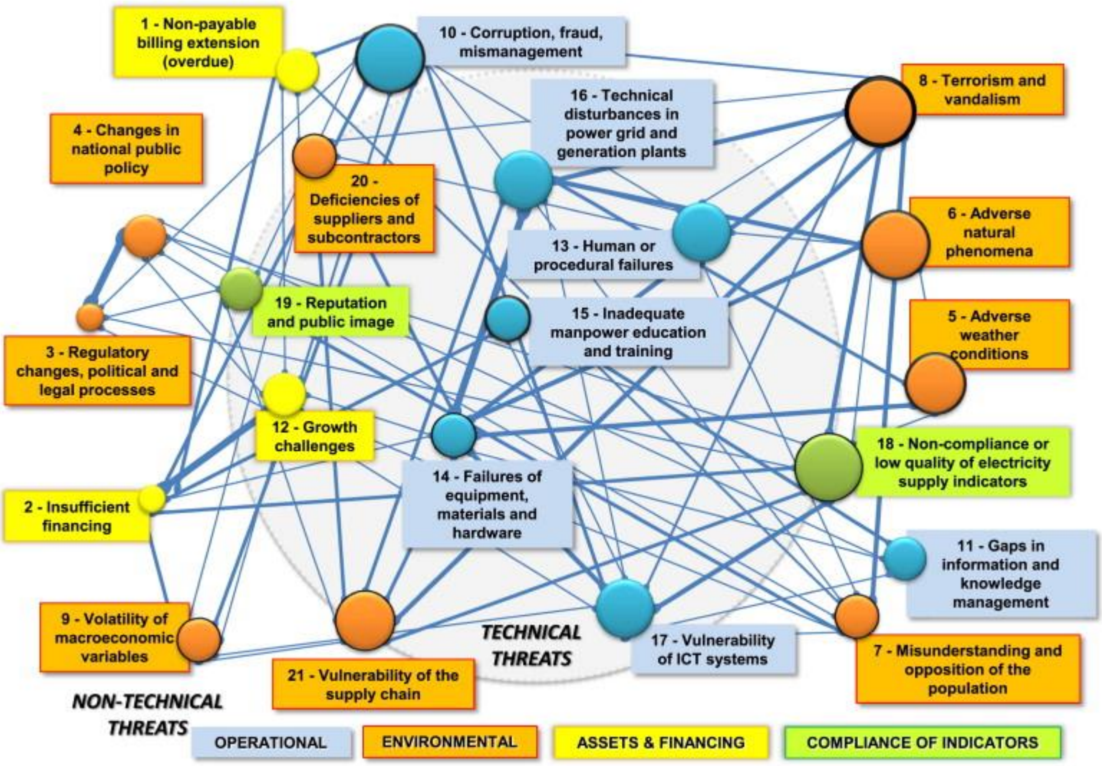
hindrances such as biased questions or deficient data analysis methods (Coppola, 2011). Furthermore, as Land (2014: 110) argues, risk prioritisation in the energy sector should constantly be changing, “dynamic” as opposed to “static” endeavour, as the latter may result in “critical decision making [being] based on outdated or erroneous asset information in efforts to direct scarce resources to those assets, systems, and networks that may be the most critical at any point in time”. Therefore, risk identification needs to be carried out continuously at various points in time for all critical infrastructure to pinpoint the areas that need improvement, such as through asset redistribution, additional training or the amendment of existing contingency plans (Land, 2014) as show on Figure 17.

Figure 17: Interconnected Risk Map in Energy Sector



Source: Correa-Henao, Yusta and Lacal-Arántegui (2013)

2.4.2 Risk Assessment

The concept of risk assessment has been debated since its inception. Even though there is a consensus that risk assessment is a process for analysing and evaluating risks, these two dimensions of risk analysis are rarely identified and explained individually. Instead, the emphasis is being placed on identified

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risks and calculating the potential impact of said risk. Gopinath et al.,2018: 175, define risk assessment as the "general methodology with the scope to analyse and evaluate risks associated with complex systems". For other researchers, risk assessment is synonymous solely to 'risk analysis'. It ignores 'risk evaluation' with the emphasis being placed on developing a systematic step-by-step approach and methodology for estimating risks (Ostrom and Wilhelmsen, 2019: 7). In Ostrom and Wilhelmsen's (2019) case, the process is being employed to ascertain the likelihood of a risk affecting an industry, company or programme, and to determine the probable outcomes if said risks would develop into disasters. However, best practices emphasise that risk assessment in the context of disaster risk management should refer to the application of two distinct, sequential and complementary processes, respectively, risk analysis and risk evaluation, where the former focuses on identifying the probability and consequences of a risk, while the latter seeks to ascertain the attitude, appetite and tolerance for each risk (Gopinath et al.,2018; Philipson, 1986; Rausand, 2011).

To emphasise the first part of the risk assessment, the risk analysis, may be done through the use of a risk matrix, the most commonly-used tool for risk analysis, which classifies risks based on two scales: the probability of occurring and the possible consequences to human lives, organisations, locations or the environment (Svalova, 2018). A risk matrix is a valuable tool that can be employed to ascertain the risk level, typically by colour-coding (Figure 18) or numerically (Figure 19). It can be beneficial when trying to increase awareness of the severity of a probable risk through a clear and direct illustration that informs decision-makers of what measures need to be prioritised – by them related to response and mitigation, by minimising consequences, or to prevention, by reducing the likelihood (Cox, 2009; Olson and Wu, 2015). Another benefit of conducting a risk analysis through risk matrices is that each risk is individually examined. As such, companies facing a wide array of risks, for instance, those in the energy sector, can accurately pinpoint the various risks faced and thus can subsequently plan for and dedicate resources to each and every probable crisis that reaches the risk level considered undesirable by the company, through a risk evaluation (Olson and Wu, 2015). Conducting a

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thorough risk analysis via risk matrices will thus allow decision makers to not only identify each risk that the company is facing but also to correctly pinpoint the level of impact of a given risk, which is necessary to inform the prioritisation of contingency planning for each risk (Rausand, 2011).

Figure 18: Colour-coded Risk Matrix

Likelihood		Very Likely	Likely	Unlikely	Highly Unlikely
Consequences	Fatality	High	High	High	Medium
	Major Injuries	High	High	Medium	Medium
	Minor Injuries	High	Medium	Medium	Low
	Negligible Injuries	Medium	Medium	Low	Low

Source: Public Library Safety Culture (n.d.)

Figure 19: Numerical Risk Matrix

	Likelihood of risk Low	**Likelihoodof risk** Medium	**Likelihood of risk** High
Level of risk high	3	6	9
Level of risk medium	2	4	6
Level of risk low	1	2	3

Source: Olson and Wu (2015: 82)

Although the risk matrix appears to be a simple tool, the final predictions need to employ probability calculations that risk specialists should determine (Cox, 2009: 104-110). Thus, creating risk matrices by unspecialised personnel may result in biased, incomplete or random data that lacks accurate information, which may nullify the benefits of this tool (Cox, 2009; McBean, 2019). Such issues are particularly relevant in the larger context of risk assessment, as the

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risk evaluation that informs risk tolerance needs to be developed based on the risk analysis, and thus an erroneous risk analysis may result in an inaccurate or incomplete rationalisation of the risk tolerance (McBean, 2019; Ostrom and Wilhelmsen, 2019).

All things considered, the risk matrix is one of the many tools that can be employed to assess risk, as organisations can choose between other standardised or non-standardised tools. For instance, among the standardised tools that can be utilised are the Delphi Technique which relies on external consultations, and the RCA (Root Cause Analysis), which seeks to investigate faults until the root cause of the disaster is found and addressed (Ostrom and Wilhelmsen, 2019), the Decision Tree that focuses on simulating disasters and thus investigation potential impact and responses to future events (Hsu, 2014), the SWOT analysis that was previously presented, and so on. Non-standardised tools may include data analysis if the organisation disposes of the necessary resources (e.g. time, funds, specialists) to carry out such investigations, for instance, through the review of documentation, qualitative or quantitative data (e.g. interviews or surveys), or even employing quicker methods such as brainstorming in a group meeting (Tiusanen, 2018; Vega et al., 2009).

The second part of an effective risk assessment is the risk evaluation, which according to Philipson (1986: 319), examines the “sociopolitical significance of an estimated risk”. More specifically, risk evaluations have the dual goal of determining the risk tolerance criteria and proposing feasible mitigation methods for each investigated risk (Rausand, 2011). Taking into account that risk evaluation is defined as the “process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude is acceptable or tolerable” (ISO, 2009: n.p.), for risk evaluations to benefit a company, issues such as exposure to the potential hazard, the possibility to avoid the risk, as well as the possible negative impact on human lives and property need to be taken into account (Gopinath et al., 2018). With this in mind, reliable risk evaluations make use of three crucial elements in the search for pertinent and efficient risk reduction approaches. These elements seek to assess the risk attitude, appetite, and risk tolerance of an organisation, each

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being employed to reveal unique details regarding a company's risk management strategy (Rausand, 2011; ISO, 2018).

Firstly, the *risk attitude*, according to the ISO 31000:2009 standard (ISO, 2009: n.p.), can be largely defined as the company's "approach to assess and eventually pursue, retain, take or turn away from risk". Thus, risk attitude refers to the overall stance that decision-makers adopt in relation to risks in general, and more specifically, it depicts the standard response that a company relies on when considering or reacting to various risks (Murray-Webster and Hillson, 2016). Given that each stakeholder has a unique perception regarding risks, the risk attitude – and as such, the willingness to accept various risks – may differ significantly from organisation to organisation, based on the inherent biases of each decision maker, based on the industry a company operates in and its related risks, but also based on precedent (Hopkin, 2014).

Taking into account the numerous risks that could disrupt critical infrastructure, and specifically the energy sector, it is important first to identify the vulnerabilities, the most probable risks and the impact of said risks (e.g. via a risk matrix) to determine which risks should be avoided and which should be set aside or retained (Olson and Wu, 2015; Ostrom and Wilhelmsen, 2019). This step then needs to be followed up by an investigation that takes into account both the stakeholders' perceptions and existing data of how the said risks can influence the organisation, for instance, from economic, political, socio-cultural, and environmental perspectives, or by examining the challenges and opportunities faced as a result of the potential disaster – which is why PESTLE or SWOT analyses can be employed during this step (Hillson and Murray-Webster, 2007; Perera, 2017). In essence, determining the organisation's risk attitude will not only increase the awareness of the stakeholders in relation to the existing risks but will also help identify the risks that the organisation as a whole is willing to oversee and which need to be addressed, thus allowing companies to develop and implement a strategy that prioritises urgent operations (Hillson and Murray-Webster, 2007).

Secondly, *risk appetite* can be defined in relation to the level of risk that a company deems acceptable when considering its objectives and overall

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capability of mitigating or responding to risk, regardless of structural, operational, financial or social impact (Hopkin, 2014). Similarly to risk attitude, the risk appetite differs from company to company, with some organisations leaning towards a more risk-averse approach and others towards one that is more risk-seeking (Vinnem, 2007). There is a tendency nowadays for companies to favour a risk-averse appetite. Still, it is crucial to remember that such cautious approaches may also be damaging to businesses, as risk aversion prevents them from pursuing emerging business opportunities (McKay, 2015). In fact, adopting a more risk-prone approach may be favourable in industries that are in constant need of innovation (Hillson and Murray-Webster, 2007). With this in mind, considering the new environmental-friendly mentality that is permeating today's society, the energy sector can be categorised as an industry that relies on continuous modernisation, and as such, a normal risk appetite could benefit companies that have the means to either mitigate or avoid certain risks.

However, the industry is not the sole factor that may influence the risk appetite of a company, with issues such as competition, the managerial approach, financial stability, resource diversity and personnel expertise, the existing company culture, the potential benefits and detriments, as well as the company's goals also need to be taken into account for an effective appraisal (Hillson and Murray-Webster, 2007; Hopkin, 2014; McKay, 2015; Murray-Webster and Hillson, 2016; Vinnem, 2007). Apart from being able to pinpoint the acceptable risk level, identifying a company's risk appetite based on these criteria over a longer time period will also allow companies to understand and determine what approaches have been beneficial or detrimental, and notably under what circumstances these effects occurred (Murray-Webster and Hillson, 2016). As such, conducting periodic reviews will allow companies to adjust their risk appetite frequently, based on the above-mentioned internal circumstances, but also as a response to the relevant external context, for instance, following market trends, social changes, technological developments, and so on (Hillson and Murray-Webster, 2007).

Thirdly, *risk tolerance* refers to the level of risk that a company is prepared to withstand (or tolerate) to attain specific organisational goals (McKay, 2015: 71).

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In that respect, risk tolerance and risk appetite are interconnected, as former showcases the variation between what a company considers to be an acceptable risk level (i.e. risk appetite) and what the company is capable and willing to endure, based on its capabilities (McKay, 2015). Conversely, while both the risk attitude and the risk appetite consider the entirety of potential risks as the subject in focus, risk tolerance is typically calculated for each risk separately. As such, the tolerance level will differ based on specific risks and contexts (Weber and Klement, 2018). Thus, examining a company's risk tolerance needs to consider the impact of a potential risk, the chance that said risk will materialise into a disaster, and the adequacy of existing prevention, mitigation and resilience strategies relevant to said risk (Hopkin, 2014). As such, risk tolerance can be defined as the "mediator that translates perceptions of risk and situational needs and constraints into decision and action" (Weber and Klement, 2018: n.p.). While through the lens of risk attitude and appetite, water may be viewed as a positive or low-level risk for hydroelectric power plants generally, a risk tolerance investigation would reveal that, for personnel, as well as for some equipment and machinery, the intrusion of a high water volume would become a severe, intolerable risk. Similarly, while strong air currents benefit wind turbines in the general sense, an examination from a risk tolerance perspective would show that strong air currents may pose a high risk for maintenance workers, and as such preventive measures must be enacted. This being said, it is important to also keep in mind the fact that while risk tolerance offers some "degree of flexibility", it is the risk appetite that "sets a limit beyond which additional risk should not be taken" (McKay, 2015: 71).

2.4.3 Risk Treatment

According to the ISO 31000 standard, the main objective of risk treatment is to be able to devise and enforce solutions for addressing risks (ISO, 2018). More specifically, this step involves a continuous investigation that needs to not only conceive and agree upon the solutions for treating risks but to develop and implement plans that take into account the efficiency of the identified solutions and the assessment regarding whether the risk that carries on after said solutions fit the organisation's attitude, appetite and tolerance (ISO, 2018). Overall, risk treatment aims to successfully raise the positive effects and

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minimise the negative repercussions of a given risk based on the organisational risk culture (Reason, 2008). As the nature of this process is repetitive, if, at the end of the investigation, the discovered effects do not have long-term positive outcomes, are not cost-effective or sustainable in any other way, the process is restarted, considering the newly-found discoveries (Yoe, 2019).

With this in mind, it is not uncommon that the immediate context of an organisation entirely influences risk, and thus, while a risk treatment strategy could work well under certain financial, social or environmental circumstances, the same strategy could be considered ineffective for similar companies exposed to different conditions (Del Bel Belluz, 2010). For this reason, each organisation needs to develop its own policies for treating various risks. Yet, at the same time, this process tends to be ignored or downplayed even by the big companies that choose to adopt a reactionary stance rather than a comprehensive, company-wide investigation (Yoe, 2019). The lack of funds and expertise may cause this or can be attributed to the tendency to overlook certain procedures and protocols when the existing practices have managed to prevent most losses (Del Bel Belluz, 2010; Reason, 2008). However, the tendency to ignore additional layers of defence, such as devoting effort towards developing a risk treatment strategy in favour of relying on tried and tested processes, can contribute to a disaster, as explained via the Swiss Cheese model (Reason, 1990; Figure, 20 below). Relying on existing strategies for risk mitigation and prevention may result in a false sense of security simply because emerging threats that do not have a precedent in the company or the sector are not considered and thus not addressed (Reason, 2008). An example of such emergent risks is the inability of significant companies to foresee the threat of cyber-terrorism in the early, 2000s, and as such many were unprepared for cyber-attacks, thus suffering both financial losses and major blows to their image and reputation (Elias, 2009; Manners-Bell, 2014). A more relevant example of disasters in the energy sector is those of Chernobyl or Fukushima Daiichi, which have resulted from hazards or vulnerabilities that could have been identified as high-impact risks – however, as the likelihood for these occurrences was significantly low, no preventive solutions had been established (Atsuji, 2016).

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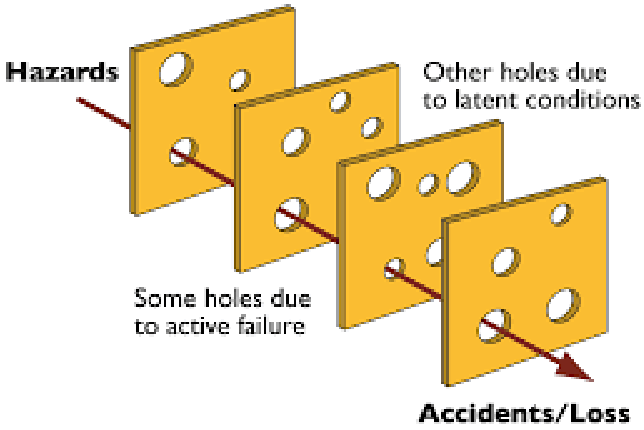
Figure 20: Swiss Cheese Model



Source: Core Safety (2015)

Nowadays, there are various tools to help guide organisations, and ISO 31000 suggests an array of potential strategies for risk treatment, which should be adopted based on the impact of the disaster (ISO, 2018). Among the options, two are the safest – yet at the same time the most drastic, respectively risk avoidance, which proposes the complete and definite elimination of the process, procedure, element or activity that allows a risk to exist, while a similar technique is the elimination of the risk source (ISO, 2018). Additional alternatives to mitigate disasters include trying to alter the likelihood for a risk to manifest or shaping the consequences of said risk to fit the stakeholders' perspectives, needs and priorities, or even "sharing the risk" by seeking out fruitful partnerships that could allow companies to diminish the possible repercussions (ISO, 2018: n.p.). Furthermore, another option is to keep the existing parameters of the known risk without modifying anything if the consequences of the onset of the crisis do not constitute a heavy burden on the organisation, the environment and the community at large (ISO, 2018). Finally, the last option considers risks that could result in positive effects or opportunities, in which case stakeholders could choose to increase the likelihood of the identified risk (ISO, 2018).

2.4.4 Monitoring and Evaluation Procedures

The main goal of introducing Monitoring and Evaluation (M&E) procedures is to assess, based on real data, the efficiency, relevance and quality of the risk management strategies, procedures and tools to allow for the periodic

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improvement of said elements (ISO, 2018). Therefore, from risk identification to risk assessment, risk treatment, implementation of the organisation's decisions and the outcomes of said decisions during all stages of the disaster (i.e. prior, during or after), these processes need to be – on the one hand, monitored continuously to collect performance data, and on the other hand, evaluated once to assess the strengths and weaknesses of the chosen strategies (Ankie, 2019; Gudda, 2011).

The act of monitoring refers to the dual process of collecting and examining data relevant to the subject's performance level, which may be a project, programme, or plan (Gudda, 2011). Monitoring procedures are exclusively implemented during the plan's duration and aim to inform the relevant stakeholders on how the project is being carried out, and notably seek to verify whether the established policies and practices are effectively delivered (De Connick et al., 2008). The main advantage of introducing monitoring activities is allowing the stakeholders to determine whether corrective action is required during the plan's implementation. As such, a well-enforced monitoring activity will quickly pinpoint any practical shortcomings or obstacles (Singh, Chandurkar and Dutt, 2017). While monitoring procedures might necessitate a large group of individuals tasked with gathering and analysing the data, nowadays, the advancements in the IT sector allow for a more affordable yet comprehensive insight into the plan's development (Gorgens and Kusek, 2009).

Evaluation, on the other hand, refers to the analysis of the data gathered during the monitoring process and is employed to assess the impact and efficiency of a plan by examining the management of resources and outcomes in relation to the objectives that were initially set (Gudda, 2011). The evaluation process is particularly important, as it allows stakeholders to acknowledge the successful measures that have been undertaken and understand the reasons for a possible departure from the intended objectives (De Connick et al., 2008). By evaluating a plan's implementation, the evaluators can inform the relevant stakeholders on why a task succeeded or failed, encouraging continuous adaptability and change towards better outcomes and improved performance (Singh et al., 2017).

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Overall, introducing M&E procedures will improve transparency and accountability, yet for these processes to be successful, they necessitate trained personnel and a dedicated budget, which may be costly (Gorgens and Kusek, 2009). However, there is a preconception that M&E must only be implemented in the post-disaster phases of the disaster cycle. On the one hand, monitoring should be initiated in the response stage, immediately after the disaster onset, to ensure that the first and second responder teams do not encounter any unexpected circumstances – and if they do, to ensure that they receive the necessary instructions on how to overcome the emergent risks (Gudda, 2011). On the other hand, monitoring and evaluation practices should be implemented in the recovery stage to ensure that the affected population and the damaged property are rehabilitated via already established resilience measures. Here, the goal is to verify if the resilience measures are apt and efficient and to ensure that they are implemented according to the guidance of the resilience plan (Singh et al., 2017). However, it is important to note that M&E procedures need to be planned and tested in the pre-disaster stage to ensure that at the disaster onset, the monitoring can commence without any delays (Gorgens and Kusek, 2009). An additional justification for ensuring that such procedures are set up in advance in the preparedness stage is to ensure that the response and recovery efforts and that even the preparedness measures are adequate, and that preparedness plans meet the stakeholders' needs and priorities (Ankie, 2019). This is because "disaster risk reduction and preparedness are far more effective and less costly than response, relief and recovery efforts" (Ankie, 2019: 50).

2.4.5 Sendai Framework for Disaster Risk Reduction

In recognition of the increased risk posed by disasters, the global community sought to develop a comprehensive framework that could apply to all nations, culminating in the Sendai Framework for Disaster Risk Reduction, 2015-2030 (UNISDR, 2015a). Building upon the previous Hyogo Framework for Action, 2005-2015, the Sendai Framework (Fugure 21) strongly emphasises the need for an increased focus on preparedness (UNISDR, 2015a). Understanding, managing, and eventually reducing disaster risk through focused preparedness, response, recovery, and resilience-building measures are the

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main priorities of the framework, achievable through a range of national, regional and global targets (UNISDR, 2015a, IFRC, 2016). Thus, the framework seeks to achieve seven global targets, particularly to reduce mortality rates, the number of people affected by disasters, economic losses as a direct consequence of disasters, and the damages to critical infrastructure and basic services, all the while enhancing countries' disaster risk reduction strategies, the accessibility to early warning systems, and international cooperation as a whole, with the focus being placed upon the developing countries (Figure 21).

Figure 21: Sendai Framework Global Targets

Source: Prevention Web (n.d.)

One of the major shifts from the Hyogo Framework for Action in the ongoing Sendai Framework is the significance placed on the potential scientific developments that could not only increase the detection of disasters and newly surfaced risks but which could provide solutions for reducing vulnerability and increasing resilience (Wannous and Velasquez, 2017). Thus, the Sendai framework calls to action the international scientific community to "focus on the disaster risk factors and scenarios, including emerging disaster risks, in the medium and long term", while local authorities are encouraged to "support the interface between policy and science for decision-making" (UNISDR, 2015a: 23). This being said, it should be mentioned that the Sendai Framework complements the existing disaster management plans, as it addresses emerging and

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problematic international issues and seeks to encourage communication and collaboration between nations, with the ultimate goal being the “exchange of good practice, knowledge, and information among governments and stakeholders” (Pal and Ghosh, 2018). This means that international cooperation is necessary to set common strategies and review results – in the Arab region, this has been forwarded through periodical summits summits (Acero, 2015, McClean, 2018).

However, even though communication and collaboration between critical infrastructure actors seem like an industry requirement, this is a difficult objective at an international level, especially between private entities (Gasper, 2010). As a matter of fact, in some cases, such cooperative measures are challenging to implement even at a local level, due to increased bureaucracy and top-down governance in the sector, due to internal and external company policies that do not always align, due to existing legislation that did not make multi-agency partnerships mandatory, due to actors’ inability to admit their own limitations and lack of willingness to comprehend their dependence on others, due to difficulties with planning that stem from the high number of stakeholders, due to the sheer amount of data that needs to be processed and distributed amongst all the actors, to name a few (Fagel, 2012; Gasper, 2010; National Academy of Sciences, 2011; Radvanovsky and McDougall, 2010; Ranade and Hudson, 2008; Snape and Taylor, 2004). Related to this, multiagency or interagency coordination has only recently started to become a good practice standard in disaster and risk management (Fagel, 2012; Cheminais, 2010), although the topic was introduced more than three decades ago (Byles, 1985) and despite the technological advancements that would permit agencies to more easily communicate with one another, the interagency collaboration continues to be a hurdle in most sectors to this day (Pereira et al., 2018). As such, the real solution that could improve disaster management and resilience efforts for practitioners is devoting significantly more effort to increasing collaboration between the critical infrastructure and other stakeholders while at the same time focusing on breeding an internal organisational culture that raises awareness of potential risks, hazards and vulnerabilities (Labaka et al., 2015a).

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2.4.6 Risk Management in the Energy Sector

The previous sections explored the utility and application of risk management for organisations and their stakeholders from a more general perspective to understand the best business practices that can be employed across all sectors and industries. As such, in seeking to demonstrate the importance of risk management in the energy sector specifically, it is important to remember that many of the principles and methods examined in the prior sections lend themselves to the energy sector, as well. Additionally, this section provides more insight into how the energy sector tends to identify, assess and treat industry-related risks.

Risk management in the energy sector involves the identification, evaluation, and analysis of one hand of the more general risks linked to the unpredictable and volatile nature of energy commodities and regulatory markets and, on the other hand, of the individual risks related to aligning the energy product choices with the operational strategies of each organisation (Burger et al., 2014; Global Association of Risk Professionals, 2009). In theory, by effectively managing these risks, the negative financial and operational consequences can be minimised, at the same time optimising performance and returns for energy conservation measures and distributed energy resources (Azzuni and Breyer, 2018; Hopkin, 2022; O'Malley et al., 2016). The control of risks may offer energy organisations increased market confidence, as risk management plays a crucial role in safeguarding the business reputation and longevity by increasing profits, protecting assets, and facilitating secure local and international trade at all levels (Eydeland and Wolyniec, 2003).

In order to understand how risk is addressed, it is important first to acknowledge that the list of risks facing the energy sector is hefty, given that it is a complex system comprised of several industries by energy source, all of which have their supply chain (Global Association of Risk Professionals, 2009; Jacoby, 2012). Thus, it is not uncommon that risks are grouped based on an industry's vulnerabilities and needs. The more commonly employed classification is found in disaster management, which separates risks by natural and man-made causes, with everything caused either by mistake or deliberately by humans

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falling into the latter category (Banet et al., 2022; Blazev, 2015; McDonald, 2003). Another encompassing approach that helps inform the stakeholders to what extent the identified risks can be tackled is to group risks based on whether the causes are exogenous (i.e. external) or endogenous (i.e. internal), and the approach largely depends on the experts conducting the risk evaluation (Blazev, 2016; Domnikov et al., 2015). Other perspectives for risk identification and assessment are much more focused, for instance, by considering how poor decision-making may give way to the rise of attitudes and decisions that corrupt energy systems' operations (Lu et al., 2019) by leveraging the expected outcomes with the expected outputs (Asian Development Bank, 2013), by investigating the underlying issues via a Root Cause Analysis (Barsalou, 2015; Ostrom and Wilhelmsen, 2019), and the list continues. A more complex distinction can be made by grouping risks based on what resources or assets they affect, and these may be technical and technological, organisational, economic, social, environmental, political or legal (Global Association of Risk Professionals, 2009). The main advantage of the latest frameworks is their versatility, as they consider an organisation's assets, needs and vulnerabilities, so experts conducting risk identification should select those that benefit their companies the most. As a result, scenario analysis tools (e.g. SWOT, PEST/EL analyses) have been commonly employed to simulate potential incidents based on specific circumstances or to stress-test the capacities of existing assets (Al-Kayiem, Brebbia and Zubir, 2015; Pollard, 2016; Shogren, 2013).

Even so, the sustainability of the organisation is paramount, and thus financial risks are given the most importance; however, it can be argued that most of the risks facing the energy sector also have an economic impact (Kersten et al., 2011; Kovacevic, Pflug and Vespucci, 2013). To identify and classify and assess these risks, experts in the energy sector rely on many theories, frameworks and tools to diminish potential losses. One approach is employing Prospect Theory, which assumes that investors are much more likely to be loss-averse and thus risk-averse, even if a riskier financial situation may result in higher profits (Kahneman and Tversky, 1979). Using this approach, experts may quickly identify high-risk, high-reward situations and propose solutions to diminish said risks (Wakker, 2010). Another tool for calculating financial risks

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and evaluating risks based on likelihood and impact is the Markowitz model, an investment technique employed to calculate the returns on investment compared to their associated risks (Markowitz and Blay, 2013). The key takeaway from Markowitz's model is the need to diversify investments to reduce the risk of financial loss, especially in volatile markets and industries (Fong, 2006). A similar framework is the Sharpe ratio, or the reward-to-variability ratio, a method commonly used to assess the volatility of an investment when compared to a risk-free asset (Pav, 2022). Thus, if a known risk's likelihood and potential impact render the score high, the investors are less likely to accept a proposal (Fong, 2006). However, it is important to remember that these frameworks are employed for assessing economic risks in various industries and fields, including in the energy sector, and additional models are utilised in tandem to represent this data. The risk analysis tool more commonly employed with such mathematical models is the Risk Matrix (Figure 18, Figure 19), which helps better illustrate the risk tolerance levels based on the likelihood and impact (Cox, 2009; McBean, 2019; Ostrom and Wilhelmsen, 2019).

However, a known caveat of risk management approaches and tools (including the above) is that they rely on data gathered from past events and projections, none of which can guarantee stability in more volatile sectors, such as the energy sector (Troccoli, 2008). To exemplify, the initial stages of the Covid-19 pandemic destabilised the energy sector, as the global supply chain was significantly affected after most countries introduced regulations to diminish human interaction and travel to halt the spread of the disease (Jiang et al., 2021; Olabi et al., 2022). This disaster indicated that the energy sector might be much more vulnerable to global risks and uncertainty than considered (Sczygielski et al., 2022). Thus, a better understanding of an organisation's risks should be gained by employing several risk identification and assessment tools, which ideally consider risks from several categories, before devising and implementing a risk treatment plan (Burger et al., 2014; Global Association of Risk Professionals, 2009; Kovacevic., 2013). To counteract this shortcoming, more specific frameworks have been devised to provide risk managers in the energy sector with an integrated approach to evaluating risks based on their organisations' characteristics. A commonly employed framework is Enterprise

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Risk Management (ERM), which takes into account an organisation's available resources and existing operations and sets objectives throughout all the risk management stages (i.e. identification, assessment, treatment) while incorporating monitoring and evaluation procedures to ensure operational stability (Burger et al., 2014; Global Association of Risk Professionals, 2009; Hopkin, 2022).

2.5 The Interconnected Nature of Disaster Management, Risk Management and Resilience Building

Disaster management, risk management and resilience are closely linked concepts that can be invaluable in the context of preparing for and responding to disasters (Coppola, 2011; Fagel, 2012; Land, 2014; Herwig and Simoncini, 2017; Pal et al., 2021; Santos et al., 2021; Serre, Barroca and Laganier, 2012; Yokomatsu and Hochrainer-Stigler, 2020). While they have distinct focuses, they all enhance the ability to cope with and recover from adverse events in different manners. This thesis proposes that resilience can and should be built during the entire disaster cycle by employing disaster management and risk management tools, as they complement each other.

To explain, disaster management has the general compound goal of reducing the vulnerability of communities and infrastructure to disasters on the one hand and enhancing their capacity to respond and recover on the other (Coppola, 2011; Fagel, 2012; McCreight, 2011; Subramanian, 2018; UN, 2020). By comparison, risk management is hyper-focused on understanding and mitigating the probability and severity of adverse events that can devolve into disasters (ISO, 2018; Mitchell and Harris, 2012; Field et al., 2012). Finally, resilience refers to the ability of individuals, communities, organizations, and systems to anticipate, adapt to, withstand, and recover from disasters or other shocks and stresses, and it involves building capacities and resources to absorb, respond to and bounce back from adversity (UNISDR, 2015b; Tiernan et al., 2018; Wise et al., 2014).

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The three areas complement each other in several ways. First and foremost, risk management plays a crucial role in disaster management by identifying and assessing potential hazards and vulnerabilities (Fagel, 2012; Pal et al., 2021). This data informs disaster preparedness and response planning, enabling targeted measures to mitigate risks and enhance resilience (Coppola, 2011; Serre et al., 2012). More specifically, risk management activities contribute to disaster preparedness by identifying potential hazards, analysing their potential consequences and by developing strategies to reduce their impacts (Yokomatsu and Hochrainer-Stigler, 2020), which are all requirements for enhancing resilience (Herwig and Simoncini, 2017; Pal et al., 2021; Santos et al., 2021). Furthermore, response and recovery may also benefit from all three capacities. To explain, disaster management involves coordinating and implementing response and recovery efforts when a disaster occurs (Cox, 2009; McCreight, 2011; McKay, 2015), and risk management principles may be employed to guide decision-making during these phases by considering the anticipated risks and potential impacts (Coppola, 2011; Herwig and Simoncini, 2017; Ostrom et al., 2011), while resilience strategies may support the recovery process by ensuring that the systems and the stakeholders can adapt quickly and bounce back to favourable conditions (Serre et al., 2012). Risk management and resilience considerations are increasingly integrated into long-term planning and development processes (Land, 2014; Santos et al., 2021; Serre et al., 2012). By identifying and addressing hazards, risks, vulnerabilities and opportunities, communities and organisations can make informed decisions that enhance resilience and reduce the likelihood and impact of future disasters (Coppola, 2011; Fagel, 2012; McCreight, 2011). All in all, disaster management, risk management and resilience are interconnected disciplines that may be applied together to reduce vulnerability further, enhance preparedness and improve the ability to respond to and recover from disasters.

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2.6 Resilience Frameworks

This section seeks to gain an understanding of how resilience frameworks are generally developed and implemented in order to identify the current best practices and international standards while at the same time assessing the specific challenges, requirements and contextual factors that need to be considered in developing an effective framework for the local energy landscape.

2.6.1. General Characteristics

From a general perspective, the investigation of the literature reveals that a disaster resilience framework typically encompasses several key characteristics and elements that are essential for enhancing the capacity of a system or community to withstand, adapt to and recover from disasters. These elements include, first and foremost, conducting a comprehensive risk assessment to identify potential hazards, vulnerabilities and exposure to various risks (Hollnagel et al., 2006; Ostrom and Wilhelmsen, 2019; Rausand and Haugen, 2020). Additionally, research suggests that effective governance structures and leadership play a vital role in implementing and coordinating resilience efforts when clear roles, responsibilities and accountability mechanisms are established among stakeholders (Coppola, 2011; Fagel, 2012; McCreight, 2011; Subramanian, 2018). Of course, planning and preparedness are crucial steps as they may significantly diminish the likelihood and impact of an incident, as they involve the development of emergency response plans, protocols and procedures to guide actions before, during and after a disaster (Alexander, 2003; Coppola, 2011; Fagel, 2012; Herwig and Simoncini, 2017; Pal et al., 2021; Santos et al., 2021; Serre et al., 2012; Yokomatsu and Hochrainer-Stigler, 2020). Many resilience frameworks also prioritise community engagement and education, as promoting collective responsibility, fostering local knowledge and cultivating a culture of preparedness helps addresses local vulnerabilities (Matin et al., 2018; Paton and Johnston, 2017; Shaw, 2012; Tariq et al., 2021). Even more so, adequate resource management, including resource mobilisation, logistics and supply chain coordination, is key to ensuring that effective response and recovery operations are carried out (Gudda, 2011; Tiernan et al., 2018; Tiusanen, 2018;

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Vega et al., 2009; Wise et al., 2014). Another key element is continuity planning, which focuses on strategies and mechanisms to maintain essential services, business operations and critical functions during and after a disaster (Engemann and Henderson, 2012; Fagel, 2012; Hiles, 2014). To help implement all of the above, monitoring and evaluation processes are crucial elements, as they assess the effectiveness of disaster resilience measures, evaluate the performance of stakeholders and processes, and as a result, they may help identify areas for improvement (Alexander, 2003; Ankie, 2019; Charantimath, 2011; Coppola, 2011). This continuous process commonly involves establishing indicators, collecting relevant data and implementing feedback mechanisms to help identify and address shortcomings (De Connick et al., 2008; Gudda, 2011; Singh et al., 2017). Related to this is the emphasis placed on learning and knowledge sharing as essential resilience aspects, provided that all stakeholders can access lessons learned, best practices and innovative approaches to assist with planning for the future (Alexander, 2003; Coppola, 2011; Enger et al., 2014; Fagel, 2012; Paton and Johnston, 2017; Toft and Reynolds, 2005). Of course, this cannot be achieved without a heightened commitment to collaboration among the various stakeholders, including government agencies, private sector organisations, non-governmental organisations and community groups, academia and the general public, which ideally should all foster a coordinated effort towards resource sharing and collective problem-solving (Alexander, 2003; Brandon., 2017; Fagel, 2012; Gasper, 2010; Labaka et al., 2015a; Tariq, Pathirage and Fernando, 2021). By integrating these key characteristics and elements into a disaster resilience framework tailored to the specific context and needs of the system or community, a comprehensive and effective approach to resilience can be established.

From a more specific perspective, while resilience frameworks tend to incorporate the same principles, the individual elements tend to differ, as many such frameworks are based upon different dimensions of resilience and typically include different conditions or capacities for building resilience. For instance, a recent study (Tariq et al., 2021), which comprehensively examines 36 of the most known disaster resilience frameworks, discovered that most

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such frameworks include a combination of six main dimensions of resilience. These six main dimensions refer to the physical (i.e. buildings, facilities, structures and any other palpable components), human/health (i.e. regarding individuals' competencies, knowledge and abilities to live and work safely), economic (i.e. the overall financial stability and any other economic factors), environmental (i.e. any event and action concerning the ecosystem), social (i.e. stakeholder collaboration) and governance (i.e. all international, national and organisational administrative decisions and duties) dimensions (Tariq et al., 2021: 13). However, it is important to keep in mind that not all of these need to be featured for a disaster resilience framework to be useful, while others may be introduced if they are more relevant to an organisation's mission or objectives (Tariq et al., 2021).

As an example of how specific and versatile a resilience framework may be, the IFRC's "Community Resilience Measurement Dashboard" (CRMD) identifies 11 resilience dimensions in no particular order and without additional classifications, as it considers them as equally important and necessary to ensure the resilience of a community (IFRC n.d.; UNDRR, 2022). These resilience dimensions are the following: disaster risk management; health; water and sanitation; shelter; food and nutrition; social cohesion; inclusion; economic opportunities; infrastructure and services; natural resource management, and connectedness (Figure 22). Communities may employ the framework to assess which dimensions need further improvement based on their resources and vulnerabilities to incorporate policies and practices that increase each indicator's score (IFRC n.d.).

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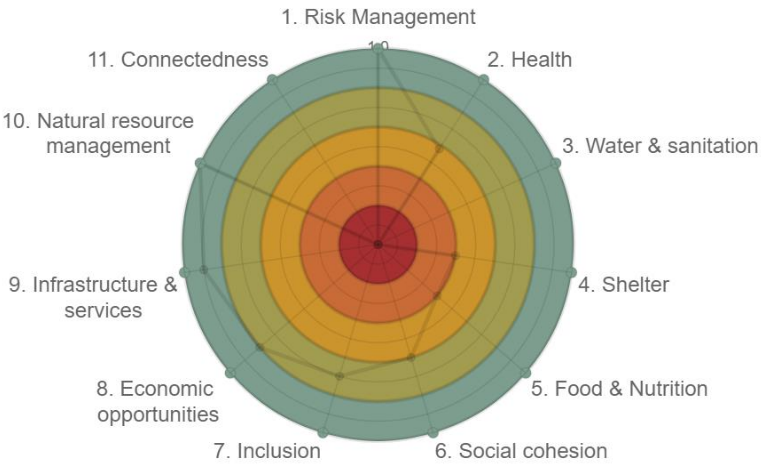
Figure 22: IFRC's Community Resilience Management Dashboard (CRMD)



Source: IFRC (n.d.)

In contrast to the IFRC's unstructured dimension classification is, for instance, the Disaster Resilience of Place (DROP) model that employs a firm classification of 4 dimensions, emphasising the inter-connected roles of the physical, social, economic and administrative characteristics of a community or organisation (Cutter et al., 2008). Succinctly, the physical dimension refers to a place's built environment, infrastructure and natural resources, including factors such as land use planning, structural design and security and the availability of critical services (Cutter et al., 2008; Jones, 2021). The social dimension encompasses the social capital, social networks and community characteristics that influence resilience, including social cohesion, community engagement, trust and transparency, and social support systems (Cutter et al., 2008; Fallah-Aliabadi et al., 2020). The third dimension focuses on the economic factors that contribute to resilience, considering economic diversification, employment opportunities, economic inequality, and the availability of financial resources for preparedness and recovery (Cutter et al., 2008; Laymon and Castro, 2020). Lastly, the governance dimension emphasises the role of institutions, policies and decision-making processes in enhancing resilience, including factors such as disaster management plans, regulatory frameworks, coordination mechanisms and community participation in the decision-making process (Cutter et al., 2008; Flores and Peralta, 2020). In addition to these dimensions, the DROP framework also considers that resilience is not solely dependent on

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the vulnerability or capacities of individuals but also the collective attributes of a community and its environment (Jones, 2021). By comparison to the IRFC's model that mainly targets community resilience, the DROP framework's structure is much more suited to organisations in the energy sector, as it offers a holistic approach to understanding the factors that contribute to or hinder resilience by considering a multitude of local dimensions and their interdependencies (Flores and Peralta, 2020; Laymon and Castro, 2020).

All in all, it is important to acknowledge that in some cases, the best approach proposed may be to design a resilience framework that targets the stakeholders' needs based on existing models, tools and resources. To explain, given the specific nature of vulnerability and resource availability, these are designed to enhance resilience in specific areas or for specific projects and components (e.g. power plants, transmission and distribution networks, cybersecurity and so on); as such, they tend to be based on an organisation's or a community's needs and thus commonly address highly specific objectives (Aldrich, 2012; Hamstead et al., 2021; Pearson et al., 2014; Walker and Salt, 2006; Zolli and Healy, 2012). This approach is particularly suited under distinct circumstances, for instance, to address unique organisational or industry needs, goals or processes, to consider unique societal norms and cultural values that characterise an organisation or community, or even to test cutting-edge technologies, newly-introduced local regulations or national strategies, organisational structures or processes for which the available data is limited, and usually not taken into account by existing frameworks (Eicholz, 2014; Hollnagel et al., 2006; Tariq, Pathirage and Fernando, 2021; Seville, 2017; Zolli and Healy, 2012). Considering the that this thesis examines the UAE energy sector, which has a distinct energy landscape characterised by its reliance on hydrocarbon resources, renewable energy investments and ambitious energy diversification goals to address the local socio-cultural context and to fit the recent adoption of the UN sustainable development goals (SDGs) at all levels and across all industries, the decision was made to design a unique resilience framework based on international standards, best practices and lessons learned from existing frameworks. Thus, by building on existing knowledge while tailoring the framework to its unique needs, the UAE energy sector could

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further enhance its resilience, mitigate risks and position itself as a global leader in the energy sector. This perspective will be further explored in Chapter III – Theoretical Framework.

2.6.2. Key Approaches to Enhancing Resilience

An investigation into resilience frameworks identifies two complementary approaches to enhancing resilience. The first approach seeks to improve resilience by strengthening elements of the crucial resources (i.e. technical, organisational, economic and social resources) that are vulnerable, while the second indicates the timing when vital operations need to be developed and implemented, as detailed below.

2.6.1.1 2.6.2.1. Improving resilience through interventions for enhancing resources and capabilities

A disturbance of the energy sector may have severe repercussions on other sectors, industries or even entire communities (McLellan et al., 2012); thus the first category of resilience dimensions is classified based on the resources that need to be strengthened: technical, organisational, economic, social, based on the type of impact (Bruneau et al., 2004; Labaka et al., 2015b).

To start, technical resilience designates the capacity of the entirety of the physical system or infrastructure (i.e. companies, facilities, utilities, tools, instruments, components, interoperability and connections) to continue functioning without interruptions, even when facing a crisis (Bruneau et al., 2004). As this dimension refers strictly to the existing technological, mechanical or industrial resources characterising the energy sector, it can be classified as an internal dimension (Labaka et al., 2015b). To determine whether an organisation is resilient from a technical perspective, it is important to assess the safety and security features of the physical infrastructure. This can be done by instituting several steps, for instance: ensuring the facilities are built with consideration to the environmental context and identified local vulnerabilities – with the added step of relocating facilities if such risks are considerable; upgrading all physical grid/network components to follow national and international standards of safety and practice, as well as the standards for use that the company sets and more importantly continuously ensuring these

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standards are upheld via monitoring and evaluation procedures; identifying and implementing means of minimising pollution of all types (e.g. greenhouse gas emissions, toxic and nuclear waste, oil spillage, waste, etc.); ensuring the availability of crisis response equipment; introducing redundancies at all levels; as well as working towards the goal of utilising the best available technology to increase efficiency in production, transmission and distribution.

Organisational resilience, on the other hand, refers to the ability of various organisations to ensure that the crisis and disaster management teams are not only capable of designing but of carrying out essential functions throughout the entire disaster cycle in order to ensure that the impact of a disaster on critical infrastructure and on other sectors is either avoided or mitigated (Bruneau et al., 2004). Specifically, organisational reliance is the internal capacity of an organisation to “make decisions and take actions that lead to a crisis being avoided or to at least reducing its impact” (Labaka et al., 2015b: 22). In order to ensure this type of resilience, organisations need to not only devise regulations, standards, guidelines, frameworks and plans for disaster and risk reduction practices but also to focus on training or hiring individuals in specialised roles to ensure that said parameters are carried out and modified when necessary (Labaka, 2013).

Furthermore, economic resilience strictly refers to the capability to endure the expenses caused by the disaster, regardless of whether they are directly or indirectly generated, and thus this dimension can be treated as both an internal and an external element (Labaka et al., 2015b). Specifically, this dimension refers to the financial capacity of all stakeholders to mitigate incidents occurring within critical infrastructure, and thus institutions need to dedicate a disaster management budget that includes steps such as planning and implementation before a disaster, as well as crisis response and alleviation after the onset of a disaster (Labaka, 2013).

Finally, social resilience is the capacity of a community to withstand and mitigate the negative impact of a disaster, considering that the personnel are, first and foremost, a part of society and are thus influenced by any disruptions in the energy sector, for these reasons, social resilience is considered an

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external dimension (Labaka, 2013). It can be achieved via preventive actions devised to diminish the societal consequences of critical services being severed – such as awareness campaigns and the continuous supply of critical information via various communication channels (Bruneau et al., 2004); however, it can also be reinforced via a strategy that encourages individuals to help first responders by volunteering, an approach that both helps increase awareness and mobilises the population to become proactively involved in disaster relief (Labaka et al., 2015b).

2.6.1.2 2.6.2.2. Improving resilience through incident-focused and post-incident-focused learning

Another means of conceptualising resilience is based on whether actions need to be taken before, during or after the disaster. Some resilience frameworks consider 3 capacities for resilience (i.e. anticipative, absorptive and restorative capacities), while others suggest that 4 conditions must be fulfilled (i.e. robustness, resourcefulness, rapid recovery, adaptability). It is important to note that both of these approaches offer valuable insights into resilience, but they differ in their level of granularity, focus and emphasis on different aspects of resilience; as such, the suitability of each approach may depend on the specific context and purpose of a resilience assessment.

The first approach considers the three capacities (i.e. anticipative, absorptive and restorative) and provides a straightforward framework that covers key aspects of resilience, offering a clear and concise structure to understand different phases of resilience, from preparedness to recovery (Rieger et al., 2022). More specifically, anticipation helps increase preparedness against potential incidents; absorptive capacity deals with response and coping during shocks, while restorative capacity focuses on recovery and rebuilding (Folke, 2006). However, the three capacities alone are somewhat limiting and may not fully capture the nuances and contextual differences within different systems, especially since resilience factors and requirements can vary significantly across domains and environments (Paton and Johnston, 2017). More importantly, this approach does not incorporate specific conditions for adapting

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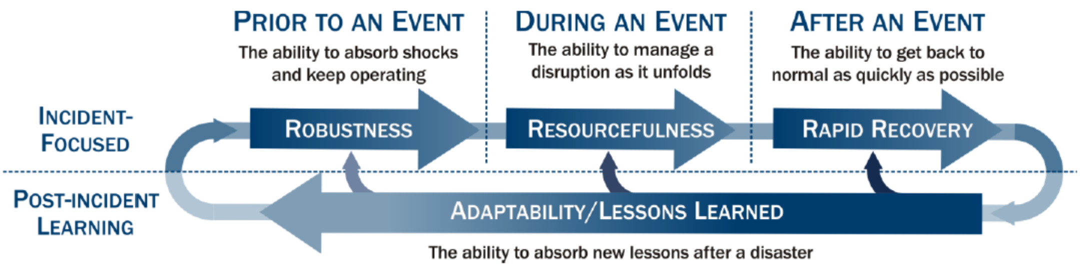
to emergent situations, even if such frameworks tend to emphasise the need for an adaptive approach to disaster management and resilience (Ungar, 2012).

The second approach considers a broader range of capacities or conditions necessary for resilience: robustness, resourcefulness, rapid recovery and adaptability (Berkeley and Wallace, 2010; Cutter et al., 2008; Flynn, 2008), which similarly follow the disaster cycle (Figure 23). The framework acknowledges that resilience is context-dependent, allowing for customisation based on specific environments and systems, as it emphasizes the need for adaptability and flexibility to suit diverse situations (Bhamra et al., 2011; Cutter et al., 2008; Meerow et al., 2016; Smit and Wandel, 2006). More importantly, the focus on adaptability as a condition highlights the importance of learning, innovation and flexibility in the face of uncertainty and evolving challenges, as it encourages proactive adjustments and continual improvement (Berkeley and Wallace, 2010; Flynn, 2008; O'Rourke, 2007).

Figure 23: Sequence of Resilience



Source: Berkeley and Wallace (2010: 17)

However, a known caveat of this approach is the lack of consensus, as the four conditions or capacities are neither universally adopted nor agreed upon, leading to variations in its interpretation and application. To illustrate, other such conceptualisations of resilience include elements such as absorption, adaptation (or adaptability), anticipation, resistance, robustness, recovery (or recoverability), response or redundancy, which have been used in a manner that closely mirrors the four dimensions of resilience initially identified in this section, namely robustness, resourcefulness, rapid recovery and adaptability (e.g. Carlson et al., 2012; Cepin and Bris, 2017). Nevertheless, all of the mentioned conceptualisations follow the disaster cycle by depicting various

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procedures that must be implemented throughout the four disaster stages (i.e. preparation, response, recovery, and mitigation). However, to streamline and ease the use of the framework, the proposed framework will instead use the typology proposed by Rehak et al. (2019: 127) to delimit the four stages of the resilience cycle in critical infrastructure, respectively prevention, absorption, recovery and adaptation. To explain, the terms used refer to the same phases: preparation or robustness is prevention, response or resourcefulness is absorption, recovery remains unchanged in all three instances, and mitigation or adaptability is adaptation (Rehak et al., 2019; Figure 23).

Thus, the first element, robustness, refers to the capacity of a system to “withstand external demands without degradation or loss of functionality” (O’Rourke, 2007: 25). It is thus concerned with maintaining operations should a vulnerability or risk develop into a crisis, and as such involves the creation of “sustainable or redundant systems that can be brought to bear should something important break or stop working” (Flynn, 2008: 6). For these reasons, robustness is characteristic of the pre-disaster stage and should thus focus on planning for an emergency (Berkeley and Wallace, 2010).

The second element, resourcefulness, is the ability to “skilfully manage a crisis as it unfolds” (Berkeley and Wallace, 2010: 5) by correctly deploying the necessary resources and adequate assistance during a disaster (O’Rourke, 2007). It thus involves procedures related to identifying and prioritising solutions based on capabilities and delegating tasks from the command centre to the responders (Carlson et al., 2012; Flynn, 2008). Resourcefulness is the dimension characterising the time when a disaster is actively occurring, and as such, urgency is the top priority, meaning that all actions are taken to ensure resourcefulness need to be planned for, evaluated and trained for in advance (Berkeley and Wallace, 2010).

Thirdly, rapid recovery is primarily concerned with returning to a state of normalcy as soon as possible after the crisis unfolded, where both the “speed with which disruption can be overcome” and the restoration of “safety, services, and financial stability” are equally important factors (O’Rourke, 2007: 25). The state of recoverability can only be achieved by planning for contingencies in

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advance (Berkeley and Wallace, 2010; Flynn, 2008). As such, rapid recovery focuses on the post-disaster stage and, therefore, also depends on previously identified and implemented procedures, practices and even external collaborations to mitigate the impact of the disaster on all other sectors and individuals (Berkeley and Wallace, 2010).

Lastly, adaptability can be defined as the ability of a system to identify "alternate options, choices, and substitutions under stress" (O'Rourke, 2007: 25). It, therefore, refers to the preventive capacity for all stakeholders to acknowledge, understand and include the lessons that were learnt during the crisis when preparing for future crises, the goal is an overall improvement in resilience practices (Flynn, 2008). Taking into account the fact that adaptability depends on learning lessons from all of the previously-mentioned stages, this step is the most difficult to implement – particularly in organisations that have not yet been exposed to certain emergencies – and as such, it is usually the most overlooked dimension, however, a good practice is to evaluate and incorporate industry standards and good international practices that have been developed after various disasters (Berkeley and Wallace, 2010).

2.7 General Aspects of Resilience in the Energy Sector

The energy sector includes all the industries involved in the production (i.e. fossil fuel, electrical power, nuclear power, renewable energy or traditional) and distribution of energy (e.g. transportation and storage, transmission, sales and consumption, even security). The increased dependency of societies on energy has expanded the industry from operating in simple individual systems to involving complex, interconnected ones, covering multiple regions, thus increasing the need to secure energy production and delivery (O'Malley et al., 2016). Aside from increased demand, political, economic and social conflicts and increased disaster risks have also brought attention to the concept of energy security (Azzuni and Breyer, 2018, O'Malley et al., 2016). For the purposes of this chapter, energy security refers to the ability of an energy system to "function optimally and sustainably, freely from any threats" (Azzuni

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and Breyer, 2018). As with other systems, building resilience and reducing vulnerability is paramount to disaster risk reduction in the energy sector (Azzuni and Breyer, 2018).

Considering the logistical components of the energy sector, as enumerated above, and considering that most critical infrastructure sectors in the modern world cannot function without the continuous and sustainable supply of energy, ensuring resilience in this sector is particularly important (Jefferson, 2013). In fact, ignoring or neglecting to maintain resilience in the energy sector may have significant negative repercussions for all other sectors. Therefore, considering the main attribute of a resilient system is to be able to return to a sustainable state of equilibrium after a disaster or, simply put, the ability bounce back (Brassett and Vaughan-Williams, 2016: 35), resilience in the energy sector can be described as the ability to continue generating and providing energy to all the other sectors, as well as to the consumers, by guaranteeing that the existing systems have built-in redundancies to withstand and recover from any potential disruption (McLellan et al., 2012). Therefore, in the case of centralised systems that aim for large-scale energy production, which is the case for the UAE, frequent maintenance and a higher level of skill are required to minimise the potential and endure the damage of a disaster (McLellan et al., 2012). Additionally, resilient energy systems must not only be robust in terms of limiting damage to their facilities and equipment but also remain operational throughout or immediately after a disaster (McLellan et al., 2012). In order to achieve this, they should not rely on outside intervention, meaning that on-site storage of fuel or other energy sources is recommended to support production during an emergency (McLellan et al., 2012).

According to Lin and Bie (2016: 174), resilience issues start to surface when a failure affects the following two aspects: “hardware hardening and operational resilience strategies”. Hardware hardening refers to the technical elements of the industry, including those mentioned above, but also the construction of factories based on the available resources, the management of facilities and distribution lines to ensure continued efficiency, the factories and tools used to extract or process the primary resources, and so on (Lin and Bie, 2016). Even more so, to ensure resilience in energy systems, several hardening measures

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can be implemented for all facilities, including ensuring the facility has safe and quick “black-start” capabilities (i.e. the capacity to restart a power station or a specific part of the grid following a shutdown using only internal resources), which can be achieved via the implementation of decentralised on-site generation units that act as a back-up, while another long-term solution for increasing resilience is making sure that no environmental damage occurs by managing the vegetation around the grid or distribution system, but also by reinforcing poles and substations, or even relocating facilities to minimise vulnerabilities to natural risks (Lin and Bie, 2016: 174). However, the resilience of the energy industry does not depend only on the technical aspects of robustness, such as the availability of resources or physical resistance of infrastructure (Rehak et al., 2018). Thus, practitioners look at organisational resilience, the environmental conditions of the built facilities, managing extraction and storage based on demand, instituting monitoring and evaluation strategies, and implementing disaster and risk management policies and procedures (Lin and Bie, 2016). Additionally, organisational resilience may also be ensured through the education and development of personnel, continuous reviewing and adaptation of safety standards and planning, and at a national level, through the development of a sufficient regulatory and legislative framework (Rehak et al., 2018).

Furthermore, the interconnection between organisational and infrastructural resilience has not been adequately investigated but is crucial for achieving better results in practice (Bhamra et al., 2011). For instance, competent leadership and management of information are also crucial components of the organisational aspect, while the overall resilience of critical infrastructure is also affected by the social and economic dimensions, as the community and the industry sectors are interconnected (Honfi and Lange, 2015). In order to achieve the level of interoperability necessary for organisational resilience, training and exercising plays a crucial role for responders, decision-makers and on-site personnel to become acquainted with the emergency plan and review it (Perry and Lindell, 2003). In the case of the energy sector, particularly the fossil fuel industry, the possibility of a disaster occurring in an isolated offshore platform means that the onsite manager should have the competence and

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leadership skills to oversee the immediate response or evacuation (Flin and Slaven, 1996). Therefore, specialised training, including personality assessment tests, is recommended for such critical positions (Flin and Slaven, 1996).

Given the various natural and man-made disasters that can affect the energy industry, this training needs to be done through various exercises and specific instructions based on the safety procedures that must be followed in case of each incident (McCreight, 2011). Fortunately, there is a wide array of training (e.g. seminars or workshops, tabletop exercises and role-playing games) and practical exercises (e.g. drills, functional exercises and full-scale exercises) that can be adopted and implemented to increase emergency preparedness of all the stakeholders (Green, 2000). In addition, the implementation of such operations can be costly or otherwise difficult to plan and oversee due to the large number of employees that would need to be trained and because each exercise needs to be tailored to respond to the needs of each organisation (McCreight, 2011). However, by developing training based on the areas that need to be improved, a company can thus ensure that the stakeholders are not only prepared to respond in case of a disaster but that they are also capable of identifying vulnerabilities, as well as proposing practical and sustainable solutions to improve resilience (Hollnagel, 2015; Ronan and Johnston, 2005).

2.8 Building Resilience against Natural Disasters for Energy Production Facilities and Distribution Networks

Natural threats against energy production facilities and distribution systems are related to the environmental and geological characteristics of the examined region. In general, they can include earthquakes, landslides or dust storms, volcanic explosions, flooding events, tropical cyclones or hurricanes, and the effects of extreme temperatures (Penna and Rivers, 2013). Moreover, climate change or atmospheric pollution can negatively affect sensitive systems (Audinet et al., 2014).

Energy production facilities built in tectonically active regions, such as the UAE, must take precautions to protect both buildings and transport networks against earthquakes and possible tsunamis in coastal areas (Kaili et al., 2014). While anti-seismic building construction regulations are generally embedded in the legislation of earthquake-prone countries, further measures are necessary to improve resilience – anchoring and securing sensitive equipment (e.g. batteries for emergency power, power transformers or turbines) is a relatively simple measure that can be critical to ensure a quick recovery and restoration of operations (Karagiannis et al., 2017). Earthquakes can also affect the transmission and distribution of electrical power by damaging transmission towers, which are vulnerable to seismic forces, but resilience can be achieved by the availability of equipment to support damaged towers until their eventual replacement (Karagiannis et al., 2017). Following an earthquake or other disaster that can cause damage to the infrastructure and considering the need for continuous operation, the availability of rapid response teams with access to data and information that will allow them to assess the damage to the facilities or equipment quickly is necessary (Honfi and Lange, 2015). Similarly, regular structural health monitoring to evaluate the state of a system compared to a known intact, safe state can help the energy industry be prepared to absorb the impact of a disaster (Honfi and Lange, 2015).

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Another risk for the energy sector is the occurrence of landslides, which can result from earthquakes, extreme rainfall or direct human interference (Herath and Wang, 2009). While critical infrastructure is constructed after an environmental analysis that includes hazard mapping (Liu et al., 2015), many energy production facilities worldwide were constructed at least a decade ago (Braun and Glidden, 2014; Freeman, 2007). Since then, weather patterns have changed significantly, and zones previously considered safe have suffered geological alterations in the meantime (McInnes et al., 2007). While it is common for the foundations of structures located in zones where landslides occur to be reinforced, for the soil to be nailed and for the subsurface to be drained to stabilise the area (Pun and Urchiuoli, 2009), landslides still pose a risk to land transportation of fossil fuels through rural areas – which are the most affected by such hazards (Herath and Wang, 2009). That being said the risk is not comparable to that posed by earthquakes, as nowadays, it is easy to verify and assess whether a power plant, for instance, is built on stable terrain (Liu et al., 2015; Pun and Urchiuoli, 2009). However, the investigation can be an issue in and of itself, as it may involve a large group of specialised individuals over a longer period – a condition that may be difficult to achieve, depending on the organisation’s funds, and especially when taking into account the potential corrective measures that would need to be implemented.

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Another emerging risk for the energy sector – particularly the renewable energy sector that focuses on solar energy – are sandstorms, which occur mostly in arid, hot climates where solar energy harvesting through solar panels is ideal (Wiesinger et al., 2020). Given that most solar panels are designed to be in direct contact with the sun’s electromagnetic radiation and are thus the cells are not covered by anything else that can offer protection against external force, the panels come in direct contact with sand particles and deteriorate in time (Wiesinger et al., 2020). Nevertheless, there are means of mitigating such damage, for instance, covering the panels or turning them to face the ground; however, depending on the personnel and the varying weather patterns, such practices may not be implemented in time (Kallos, 2013). Even so, power plants' energy production output can severely decrease during dust or sand storms, as visibility is reduced significantly even during milder weather (Kallos, 2013). Furthermore, this is not the only industry affected, as all other facilities involved in the production and distribution of energy (even non-renewable), located in countries that are characterised by an arid climate, are affected, to some degree, by sand and dust storms. For instance, Kuwait's oil and gas industries need to halt production and invest millions of USD per year into cleaning and maintenance costs due to sandstorms (Al-Hemoud et al., 2019).

Unlike the risks of earthquakes, landslides or sandstorms, which are known potential hazards in specific regions, climate change-induced risks can affect the energy industry worldwide in unexpected ways, requiring a multidisciplinary effort to achieve resilience (Audinet et al., 2014). Cooperation of the energy industry with climate scientists is necessary for effective risk assessment and preparedness, while authorities can raise awareness and incentivise the energy industry to adapt to climate change or to research new, resilient technologies (Audinet et al., 2014). Emergency response efficiency in a disaster also benefits from better knowledge of a changing risk environment, as new elements can be incorporated into planning and training exercises (Homeland Security, 2015). At the same time, awareness among stakeholders in the energy industry is crucial, as climate change and global warming are projected to cause a continuing increase in energy demands (Parry et al., 2012, Audinet et al., 2014). Therefore, the sector needs to be prepared and capable of increasing

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production to meet growing needs, both at the national level and, in the case of major energy-exporting countries like the UAE, at the international level. Investment in renewable energy sources is a way to supplement energy needs at the national level – the development of such additional energy production facilities decentralises the sector, making it more resilient by ensuring the continuity of operations in case of a disaster, as the system is less dependent on specific industries and increases its redundancy (Parry et al., 2012, McLellan et al., 2012).

Climate change could be linked to an increase in the frequency of flooding, which can be expected to grow further following the melting of polar ice and the subsequent rise of sea levels (IPCC, 2014). Tropical cyclones are also expected to lead to more frequent production interruptions, especially in the oil and gas industries, which rely on offshore infrastructure (Walsh et al., 2016). While such natural hazards are not new, their prospected amplified rate of occurrence will present new challenges for the energy sector both in production and delivery (IPCC, 2014). Pipelines and power lines face additional structural integrity risks that might occur during extreme weather or due to temperature increases (IPCC, 2014). Since these risks cannot be avoided altogether, regular risk assessment is necessary to prepare against them, while replacing equipment used in the energy industry that can be affected by increased precipitation, like cooling water pumps in power stations, is also recommended (Energy UK, 2015). Pipelines and other energy distribution networks will need structural upgrades and must employ risk-based design for future installations (IPCC, 2014). Awareness of these issues among the energy industry stakeholders is generally higher compared to other fields, but the interdependent business landscape means that vulnerabilities in cooperating sectors, for instance, problems with the transport infrastructure, can hinder continuous operation during crises (Energy UK, 2015).

Similarly, the impact of a disaster on the energy industry, especially the electricity network, causes cascading effects because of other systems' dependency on power (Haraguchi and Kim, 2014). Power substations are especially vulnerable to flooding and tropical storms or hurricanes; some recommended measures to increase their resilience include flood-proofing

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facilities, reinforcing and redesigning underground networks and tunnels and investing in new smart grid technologies to improve the system's reliability (Haraguchi and Kim, 2014). Meanwhile, ensuring there is availability of resources, up to date emergency planning and good flow of information among stakeholders, including customers, the government and emergency services, can help minimise recovery times (Haraguchi and Kim, 2014).

2.9 Building Resilience against Man-made Disasters in the Energy Sector

Man-made disasters can be the result of deliberate actions, such as terrorist attacks against facilities and attempts to steal oil from pipelines, as well as neglectful actions, such as accidents caused by human or organisational errors. Accidents are, to varying degrees, the result of human and organisational factors, a term which in recent years has expanded to include errors in decision-making, communication or resource allocation (Robertson et al., 2016). While up to 80% of man-made disasters are attributed to human (operator) error, these are, in turn, frequently caused by latent organisational failures that have accumulated through time, increasing the system's vulnerability (Robertson et al., 2016).

Numerous hazards may result in unintended failures; however, the energy sector's most common and significant risks are associated with fires and explosions, given the predisposition of energy production and distribution facilities to handle and manipulate flammable materials (Nolan, 2014). These risks are particularly relevant to the fossil fuel, electrical and wood-based industries; however fires and explosions have also occurred in the nuclear and renewable energy sectors (Nolan, 2011). The main issues related to these hazards include the urgency of putting out the fire as soon as possible, or at least ensuring that it does not spread to highly flammable or explosive materials, to reduce the disaster's negative consequences (Nolan, 2014). However, to ensure that a fire is contained, it is important to plan for such occasions in advance by introducing a fire safety plan that outlines the standardised response and the specific procedures that must be carried out during these crises (Nolan, 2011). Furthermore, the personnel must be aware

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of the instituted practices via tabletop training and practical exercises to ensure everyone knows their roles and responsibilities during the disaster (Coppola, 2011; McCreight, 2011). The main objective notably is mitigation with the overall purpose of returning to functionality as soon as possible, and with minimal damages and casualties, thus enhancing resilience (Fagel, 2012).

Another significant issue is the necessity to halt production, after which an inspection also needs to be carried out to determine the safety of the personnel, the equipment and the materials, as well as to verify the integrity of the installation itself by assessing the structural impact of the disaster (Erickson, 2006). A police investigation might follow, depending on the size of the incident and its impact – which puts an additional strain on the personnel and the system, and large fires or explosions may disrupt energy production facilities even to the point of destruction and significant loss of human lives and valuable resources, putting a large strain on entire communities as a result (Furness and Muckett, 2007). For these reasons, instituting fire prevention policies and practices needs to be among the top priorities for the energy industry, and training all the personnel on how to react to various types of fire hazards tends to be mandatory (Nolan, 2011). However, as previously mentioned, it is not uncommon that latent organisational failures – such as poor fire prevention strategies, a lack of safety equipment, minimal training for both personnel and decision-makers, a disregard for national regulations and international standards of best practice, or even neglecting to uphold fire safety norms (e.g. having working fire alarms, smoke detectors and emergency sprinklers, being equipped with sufficient and adequate fire extinguishers and water pumps, etc.) – may all add to increasing the risk of fires and explosions (Erickson, 2006; Furness and Muckett, 2007; Nolan, 2014).

Therefore, due to the complexity of systems such as those involving critical infrastructure, building organisational resilience is the key to limiting the likelihood of accidents (Ray-Bennett, 2018). In addition to training, developing and enforcing an adequate regulatory framework, organisational resilience can be bolstered by developing an organisational security and safety culture that advocates for communication, accountability and transparency in systemic functions (Ray-Bennett, 2018; Robertson et al., 2016). A security and safety

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culture can be defined as the desired “group values, attitudes, perceptions, competencies, and patterns of behaviour that determine commitment to, and the style and proficiency of, an organization’s security and safety management” (Johnsen et al., 2012: 261). In essence, defining and implementing such an organisational-wide culture will not only create a homogenous workplace that encourages the identification and minimisation of risks but will increase resilience by allowing individuals to understand how to overcome a disaster via the adoption of specific ‘safe’ patterns of thinking and acting, regardless of the position held – by them in leadership or followership roles (Johnsen, 2010; Wasilkiewicz et al., 2018).

At the same time, vulnerabilities start to emerge when the organisation does not support such an open environment and instead punishes or ignores the personnel who report faults with tools and machinery, protective equipment shortages or other unsafe working conditions such as bad on-site practices despite well-developed preventive measures on paper (Robertson et al., 2016). In a more trusting environment, individuals will be encouraged to report errors in time without fearing consequences, thus ensuring their timely resolution before they build up (Robertson et al., 2016). Unfortunately, corner-cutting to save funds is a reoccurring issue even in the energy sector, despite the potentially catastrophic repercussions, and this issue may indeed stem from a poor organisational culture that was not cultivated to emphasise resilience practices, sometimes not even ensuring that disaster risk reduction procedures are implemented (Hollnagel, 2015; Paton et al., 2017).

At the same time, the industry is vulnerable to external interference, notably to deliberate actions intended to cause harm. Because of the increased value of energy, deliberate attacks against energy distribution networks with the purpose of stealing resources (especially oil) are common, especially in developing countries (Ambituuni et al., 2015), although similar incidents occur in EU countries as well, albeit with less frequency and magnitude (Ralby et al., 2017). Such attacks may be carried out by organised crime, corrupted officials or people living below the poverty line with no other source of income (Ralby et al., 2017). The financial impact from such attacks can be very difficult to quantify since they involve not only direct losses but also indirect costs (compensations,

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litigation, environmental clean-ups) and long-term damage to the environment, which further impacts trade and the economy (Ralby et al., 2017; Ambituuni et al., 2015). They are, however, estimated to reach up to billions of dollars per year for heavily impacted countries (Obenade and Amangabara, 2012). It is important to note that such attacks have significant implications in the energy sector, notably to institute practices that increase security, which is commonly done by investing significant sums in personnel that provides security to the infrastructure (Katsouris and Sayne, 2013). In fact, intrusion and resource stealing come with the added risk of the intruders causing additional damage to the facility, be it intentional or unintentional, which may have a significantly more impact than the financial burden of stealing resources (Sun et al., 2016). For instance, in countries where such oil theft incidents are more common, like Nigeria, the spills caused by pipeline sabotage often cause fires or explosions, resulting in widespread disasters with multiple fatalities (Eboh, 2018; Zhang, 2006). In turn, large losses in resource-rich countries can have international consequences by impacting the global production and price of oil, meaning their effects are not limited to the country facing this threat (Nwachukwu, 2017). Proposed measures to mitigate the dangers of oil theft depend on the local context and can range from police crackdown against criminal organisations to more proactive actions, like improving the salaries and working conditions of security personnel to decrease corruption (Ralby et al., 2017). Legislative measures to fight corruption at the political level and fraud, such as fuel adulteration, are also necessary for countries that have extensive problems (Ralby et al., 2017). Another solution is to monitor the activity of employees, who in some cases, declare false oil volumes and who tend to collude with truck drivers for a small profit (Katsouris and Sayne, 2013; Sun et al., 2016). A more advanced yet more costly solution would be to dedicate a budget towards developing an anti-theft system that is incorporated in oil tank trucks, which would send an alarm if there are significant alterations in the volume of the oil or if the lid is opened without authorisation (Sun et al., 2016: 1584, Figure 24).

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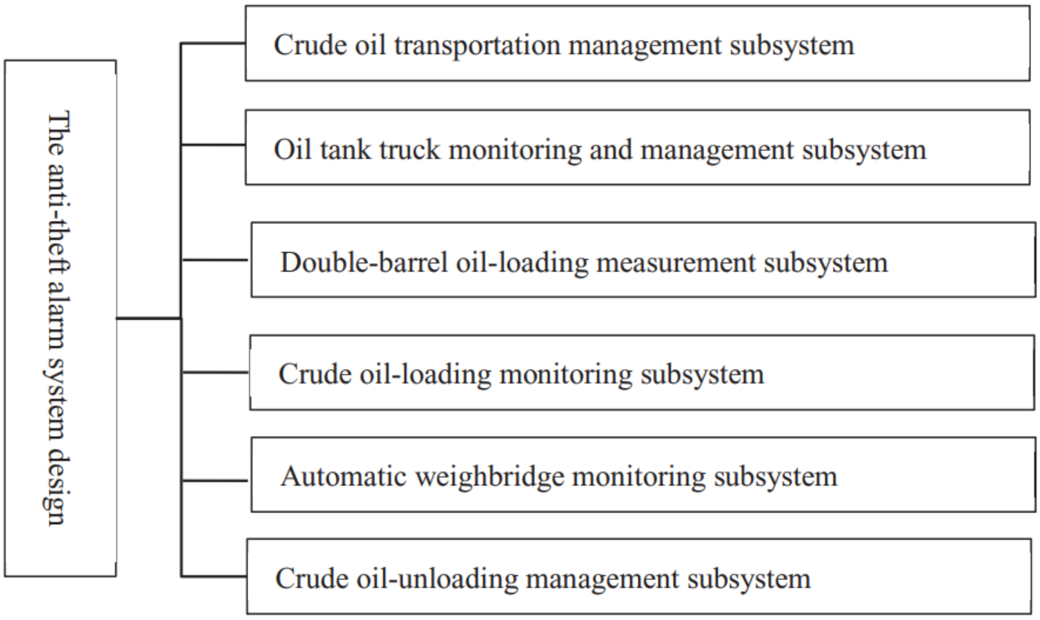
Figure 24: Subsystems of anti-theft alarm system



Source: Sun et al. (2016: 1584)

Terrorist attacks against the energy industry's infrastructure pose another hazard, notably considering the multitude of elements that can be tampered with – including facilities, installations, equipment, software, but also personnel – and also taking into account the costs associated with reducing the inherent risks of the energy sector, such as accidents and the wear of machinery (Beland, 2014). For instance, terrorist attacks can be aimed at power plants or distribution and transport systems, while transmission towers and transformer substations, for example, are also possible targets for terrorists. The former are too numerous to be protected. Still, they are not considered a high risk target, as they are easy to replace, and their destruction would cause a relatively small disturbance. However, it is advisable to maintain alternative paths of power delivery, as a strategic attack can cause significant outages (Abel et al., 2004).

Conversely, damage to transformer substations can have a greater impact, so some security measures, such as video surveillance, alarms, fencing and personnel identification, are recommended – moreover, the development of "recovery transformers" to be able to replace damaged ones rapidly would improve resilience by shortening the recovery time, making the impact of an attack against a substation negligible (Abel et al., 2004). It is important to mention that terrorist attacks may also refer to chemical, biological, radiological

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and nuclear (CBRN) incidents, which in this case refer to the intentional use of CBRN agents (e.g. weaponry, equipment or substances) with the specific aim of disrupting or destroying a facility or critical infrastructure general (Richardt and Sabath, 2013). Such attacks are considerably more dangerous, as they tend to target the human component in the energy sector, which is particularly vulnerable considering that facilities have not reached a level of automation that no longer requires human supervision, but also because working within the energy sector requires significant knowledge and training that cannot be quickly acquired, and as such the need to replace staff can have devastating short-term implications (Kaszeta, 2013). As such, critical infrastructure facilities need to develop contingency plans in case of CBRN incidents, particularly considering the fact that the critical infrastructure is both dependent on other sectors (e.g. technological, economic) and also influences all other sectors and businesses, terrorist attacks targeting the energy sector may result in cascading failures that disrupt society at large, causing tremendous damage (Kruszka and Kubikova, 2019).

Attacks against oil and gas pipelines form another risk. Globally, critical energy infrastructure is seldom the target of attack because the impact of such an attack is mostly economic, which is often unappealing for terrorists who prefer more symbolic targets and aim at a loss of life (Lilliestam, 2014). While in the case of the UAE, the country's status as a major energy exporter adds symbolic value to its energy sector, studies have shown that transfer systems for gas and oil are diversified enough that only a large-scale attack could have a severe impact (Lilliestam, 2014). However, the same systems are more susceptible to cyber-attacks, making them vulnerable to hybrid warfare (Lilliestam, 2014, Dancy and Dancy, 2017). Indeed, it has been speculated that the impact of a cyber-attack on energy infrastructure can bring about societal collapse, while the most serious attacks against pipelines have been achieved through cyber means (Dancy and Dancy, 2017). So far, cyber-attacks have typically been conducted by independent groups; however, critical infrastructure is started to be targeted by groups that are affiliated with governments (which happened to be the case with the, 2019 attack on Saudi oil facilities by Iran); thus it is not unlikely that energy grids and facilities could be breached via cybernetic means

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– particularly considering the generally poor cybersecurity practices within the energy sector (EECSP, 2017; Leszczyna, 2019; Niglia, 2016; Rundle and Nash, 2020).

Developing a regulatory framework to protect the energy industry against such attacks is challenging due to the evolving nature of the threat – it is therefore recommended that cyber-security standards are in the form of voluntary guidelines, drafted with the input of both regulating authorities and industry stakeholders to retain flexibility (Dancy and Dancy, 2017). Other than that, the gradual replacement of pipelines utilising dated technology is also suggested (Dancy and Dancy, 2017).

Equally important is the threat of attack against offshore oil platforms, as their isolation and position make them vulnerable and hard to protect (Harel, 2012, Jenkins, 1988). Designating a safety zone of 500m around the platform within which navigation is restricted – in international waters – is a common but not necessarily adequate measure, as countries have called for the extension of this buffer (Harel, 2012). Identifying and surveying any vessel in the area is another proposed measure, but its effect is uncertain, as international law does not force vessels in international waters to release such information (Harel, 2012). More traditional means of protection, such as deploying security forces quickly if suspicious approaches are detected, are viable alternatives to diplomatic solutions (Jenkins, 1988).

2.10 Risks faced by the UAE Energy Sector

Because the energy industry, and especially the production of electricity and fuel, is one of the key functions that maintain modern societies and economies, identifying and dealing with energy-associated risks has become a priority globally since the impact of a hazardous event can have far-reaching consequences (McLellan et al., 2012). In order to correctly identify the best approaches for building a resilient energy sector capable of managing and mitigating potential future disasters in the Emirati energy infrastructure and industry, it is first important to identify the various hazards, risks and vulnerabilities faced in the UAE local context.

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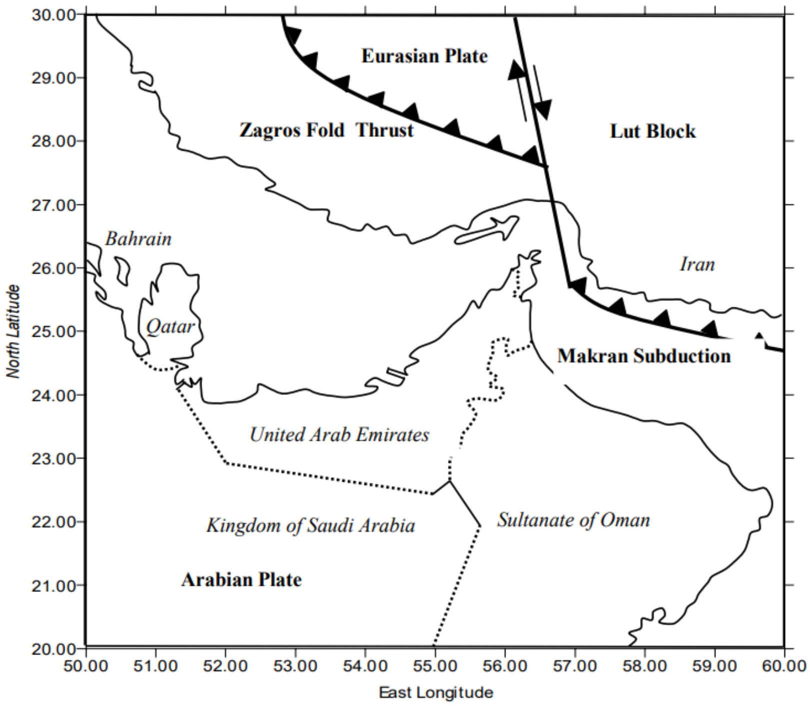
2.10.1 Natural Disasters

Among the most concerning natural hazards that could result in disasters are earthquakes; the UAE is situated on the Arabian Plate, yet the nearby Zagros Fold and Thrust Belt, as well as the Makran Subduction Zone (Figure 25), are “the only two fault systems that have a direct effect on the seismicity of UAE” (Abdalla and Al-Homoud, 2004: 2), their movement resulting in frequent earthquakes with a magnitude of over 4.0 on the Richter scale (Fnais, 2014; Figure 26).

Figure 25: UAE Tectonics



Source: Abdalla and Al-Homoud (2004: 3)

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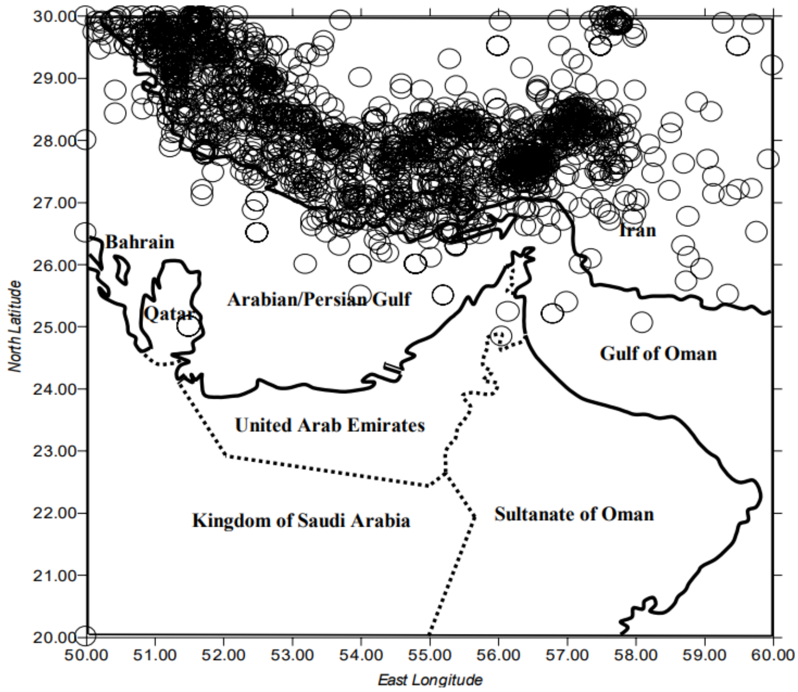
Figure 26: UAE Seismicity



Source: Abdalla and Al-Homoud (2004: 3)

Despite this, the UAE is insufficiently prepared to face the risks associated with high-magnitude earthquakes (Bardsley, 2018); the country introduced seismic detection systems only a few years ago in skyscrapers (Ciudad-Real et al., 2017; Webster, 2015). However, it is important to note that not all of the existing structures are designed to absorb the impact of a considerable earthquake, and local legislation is targeted towards buildings of over 10 floors, schools and hospitals withstanding up to 5.9 magnitude earthquakes, while buildings between 5 and 10 floors should withstand 5.5 magnitudes (Harnan, 2013). Of course, high-rise buildings are the most affected by this threat; however, the energy sector can be affected at both the production and distribution levels, especially considering liquefaction, which has been an issue ignored in the UAE (Bardsley, 2018). The remaining structures, including all in the energy sector, are not specifically designed to withstand high-intensity earthquakes by national legislation; instead, the UAE is divided into a seismic zoning map that informs the level of security concerning the Zagros Fold Thrust (Figure 27). For reference, buildings over 10 floors are qualified as part of Zone 2B, while buildings with 5 to 10 floors qualify as part of Zone 2A (Harnan, 2013), so

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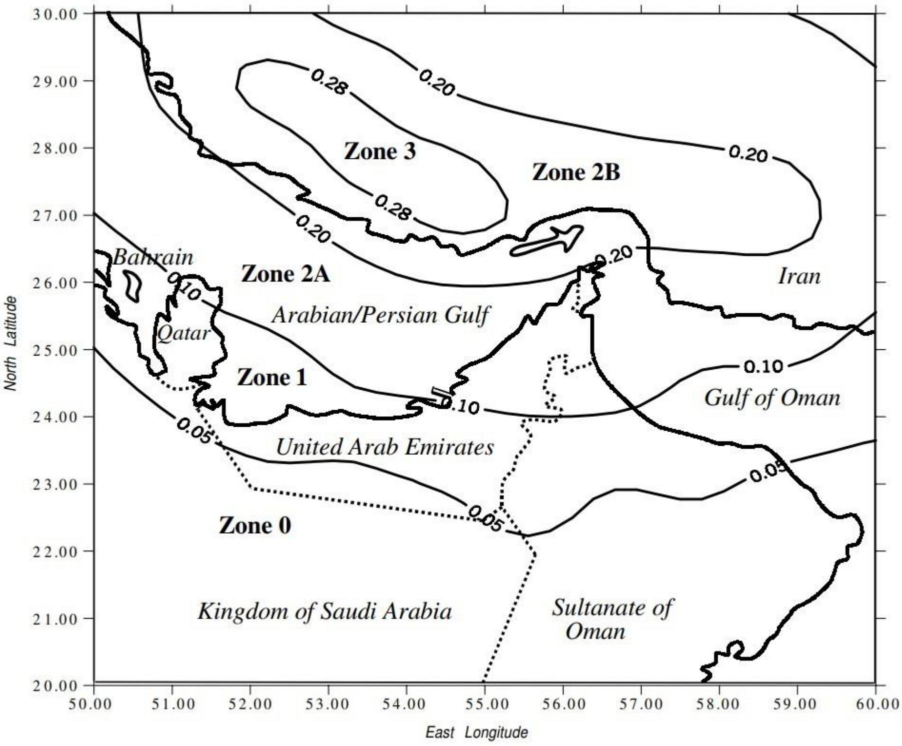
facilities in Zones 1 and 0 are required to withstand up to a 5.0 magnitude at most by law – however such specifications may be increased by private actors.

Figure 27: UAE Seismic Zoning Map



Source: Abdalla and Al-Homoud (2004: 833)

Aside from natural disasters that pose a risk to UAE's critical infrastructure because of local geological activity, respectively earthquakes (Pathirage and Al-Khaili, 2016), climate change impacts also cause new vulnerabilities to the energy systems. These include amplifying current hazards (e.g. more frequent and severe storms), negative effects on energy production, for instance, due to disruptions of the water cycle, or the need to consider additional criteria when deciding where to build or expand facilities (Schaeffer et al., 2012). Alterations in the tropical cyclones patterns affecting the Arabian Gulf, where the UAE is located, are another consequence of climate change-induced hazards – while such storms are not very common in the region, extreme occurrences have increased, while some models predict a large increase in their regularity (Walsh et al., 2016). In addition to the structural damage extreme winds can cause, tropical storms also increase the likelihood of tidal waves (Pathirage and Al-Khaili, 2016). Furthermore, and closely tied to the seismic risk is that of tsunamis, which have an increased chance of forming as a result of seismic

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activity (Joseph, 2011), for instance, due to the mentioned Zagros Fold Thrust, where earthquakes frequently occur (Figure 27). Even though the Gulf has been considered for a long time as a tsunami-safe zone (e.g. Kader, 2010), recent incidents such as the, 2017 Arabian Gulf Tsunami (Figure 28) and novel studies revealed that such a natural disaster to is more than plausible to occur within the region; however, it is currently considered unlikely (El-Hussain et al., 2017; Heidarzadeh et al., 2020; Jarvis, 2019). One of the reasons why the risk of tsunamis has not been properly investigated is also due to the fact that “the Gulf is shallow, does not have coastlines prone to landslides, and is without volcanoes”, and although there is a long history of tsunami events affecting the Arabian Peninsula, none have directly hit the UAE (Jordan, 2008: 40). However, the risk needs to be taken into account especially after the construction of the first Arabian nuclear power plant, the Barakah NPP, which is currently under construction and planned to fully open in, 2021 (BBC, 2020). As the plant will sustain up to a fourth of UAE’s energy demands (ENEC, 2020), the possibility of tsunamis needs to be considered and subsequent plans for protecting against such an event need to be implemented, particularly learning from the, 2011 Fukushima-Daiichi disaster. Even more so, a big majority of the country’s oil installations are built in coastal or shallow water areas; this increases the risk of flooding, especially since this is a hazard the UAE is ill-prepared for, as evidenced by the severe impact of flooding due to rare heavy rain falls (Pathirage and Al-Khaili, 2016). In general, however, adaptation decisions for coastal power stations can be taken with a sufficient level of certainty, as the impact of climate change on sea level rise and temperature is well-researched (Energy UK, 2015). Therefore, with proper risk assessment and informed decision-making processes and regulations, areas where the UAE still requires improvement, resilience against flooding can be achieved (Pathirage and Al-Khaili, 2016; AlShamsi and Pathirage, 2015).

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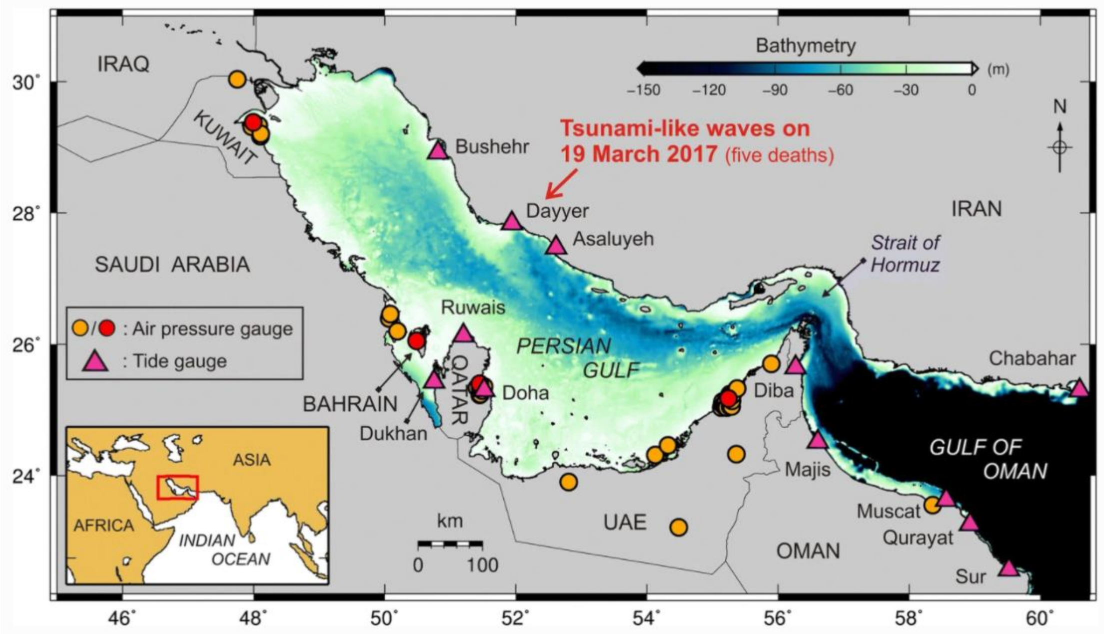
Figure 28: Regional tide gauges near UAE



Source: Heidarzadeh et al. (2020: 1232)

With this in mind, despite its status as a major oil and gas exporting country, the UAE has recognised the benefits of pursuing alternative energy production methods and initiated solar power projects in Abu Dhabi and Dubai to meet increasing demands (Dubey and Krarti, 2017). Having alternative energy production sources can act as a buffer to lessen the effects of large-scale disruption in production, but these initiatives should be extended to increase their potential, as so far, this sector is insufficiently explored. Nevertheless, Another significant natural hazard that influences the Emirati critical infrastructure is sandstorms and dust storms, as the solar power plants are affected by the massive amounts of sand, halting or reducing production somewhat frequently (Todorova, 2009). Although the necessity to stop the harvest of solar energy from allowing for cleaning after sandstorms has been a known issue ever since the plants in the Gulf were commissioned, so far, few other solutions than trying to maintain the solar panels' integrity via automated cleaners have been devised – the most technologically advanced being to coat the panels in a layer that minimises contact exposure and that reduces the accumulation of dust particles (Todorova, 2009).

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2.10.2 Man-made Disasters

When referring to man-made disasters, the UAE's critical infrastructure is vulnerable to human errors and malicious events. As previously noted, the energy sector is particularly vulnerable to events that result in fires or explosions (Nolan, 2014), and such incidents can be especially devastating when they occur within the nuclear energy division (Nolan, 2011). Such incidents tend to occur usually because of a series of unfortunate events that are a combination of corner-cutting, poor planning and poor execution, and commonly because the staff is not trained to respond to emergent hazards that have yet to be considered, the most notable being the Chernobyl and Fukushima-Daiichi disasters (Mahaffey, 2014).

Thus, of particular attention is the Barakah nuclear power plant, a project won by the Korea Electric Power Corporation (KEPCO), which has already been a subject of safety concerns as cracks were found in, 2017 in the containment buildings for all four reactors (Dorfman, 2019: 2-3; Hankyoreh, 2018a;, 2018b). As a result, both grease and water leaked when the reactors were tested, an issue that similarly occurred in South Korean nuclear reactors and which is difficult to fix as the concrete outer shell would need to be either fixed or re-poured (Dorfman, 2019; Hankyoreh, 2018a;, 2018b). Even more so, the structure does not feature a 'core-catcher' (Dorfman, 2019: 2), which is a special chamber designed to capture the molten core if a nuclear meltdown should occur for any reason and which should contain the nuclear debris within the containment building (Turinsky, 2010). These are significant vulnerabilities to the facility, which were allowed due to the UAE's inadequate regulations regarding nuclear facilities, and there is a lack of regional protocols for investigating and demonstrating liability in case of meltdown and contamination (Dorfman, 2019). The lack of adequate regulations is understandable, as no other nuclear power plant exists in the Gulf region; however, the UAE could have made better use of the international standards of best practice that have been continuously improved upon after decades of failures and successes – such as those imposed by the European Nuclear Safety Regulators Group – and which need to be taken as an example. These major vulnerabilities are of particular concern when considering the previously identified natural calamities

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that may befall the region and which may significantly affect the critical infrastructure in particular, and the livelihood of the population and neighbouring countries in general.

Aside from enhancing the sector's resilience in the event of an accident, planning has to include provisions against deliberate attacks, most prominently by terrorists, aimed either at physical structures and facilities (Abel et al., 2004) or at the technological support system that facilitates the industry's operation (Dancy and Dancy, 2017). While the threat of pipeline oil theft is practically non-existent, as there is no history of such crimes in the country, recent attacks on critical infrastructure facilities in the Gulf Region show that terrorism is a significant threat. For instance, in the past decade, nuclear facilities have been attacked via air strikes in Iran, Iraq, Israel and Syria (BBC, 2018; EurAsian Times, 2020; Sabga, 2020). Additionally, other energy production facilities in the region, namely in the Kingdom of Saudi Arabia, were attacked via drone and missiles, despite being protected by missile defence and despite the KSA being the third largest spender for national defence (Turak, 2019). In fact, the, 2019 attacks on the KSA oil facilities proved that the risk of drone strikes on the energy production infrastructure had never been considered by the KSA, which shows that the sector must engage in more profound investigation surrounding the risk of man-made threats (Chulov, 2019; Safi and Borger, 2019). Even more concerning is the fact that identification of the origin of the attacks was not possible, as the attackers utilised low-flying drones that could not be detected by the state-of-the-art anti-missile armament (Rogoway, 2019). The sophistication and the versatility of the new methods of terrorism also need to be taken into account by the UAE, not only because of the geographical proximity of KSA to the UAE but also because the UAE does not share KSA’s national defence capital. However, at this moment, this vulnerability has not been considered a significant threat to critical infrastructure, and so far, no research has been conducted to assess the steps taken by the Emirati energy sector in the aftermath of these attacks as a means of improving resilience to such terrorist attacks.

Similarly, cyber-security is another vulnerability that has yet to be seriously considered in the energy sector, with electricity grids being particularly

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vulnerable, as due to their coverage, they are very difficult to protect in their entirety (Desarnaud, 2017). Additionally, recent cyber-attacks via ransomware have been used on U.S. natural gas facilities after shutting down existing protocols to detect such malware (Buurma and Sebenius, 2020), and it is expected that similar attempts will be made in other countries, as well. Regarding this, recent history shows that Middle East critical infrastructure is also vulnerable to cyber risks, with cyber-attacks in the region already amassing more than $1 billion in losses as a result of disrupted operations or leaks of information, which shows that energy companies have yet to invest sufficiently into developing resilient cybersecurity preparedness, architecture and practices (Kamel and Gnana, 2018). Yet again, nuclear facilities are the most vulnerable to catastrophic disruptions, especially considering that state-of-the-art software is particularly vulnerable to digital interference (Brunt and Unal, 2019). However, by working towards improving the organisational culture in such a way that it is devoted to identifying and analysing these emerging risks, but also by introducing intensive training of all personnel to learn how to minimise the occurrence of such risks and even employing a specialised team to counteract potential cyber-attacks, while generally improving the cybersecurity capabilities of the critical infrastructure as a whole are major aspects of terrorism preparedness (Dancy and Dancy, 2017), and therefore need to be introduced in the energy sector to help prevent future attacks.

2.11 Summary

This chapter first focused on identifying and defining the crucial elements of disaster and risk management, vulnerability and resilience while also considering international best practices, the goal being to identify the connection between these issues and to assess their application within the energy sector. The literature review concluded that risks, hazards, vulnerability and resilience are indeed interconnected and that a deeper understanding of these issues would enhance resilience in critical infrastructure after a disaster. Additionally, the ISO 31000 standard showed that it is not only important to dedicate efforts towards identifying the various risks based on the larger socio-economic, political and environmental contexts of an industry and of a particular business, but that a risk assessment also needs to be conducted through a joint

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procedure of pinpointing the probability of occurrence and the impact of risk (i.e. risk analysis), along with diagnosing the company's attitude, appetite and tolerance for risk (i.e. risk evaluation). Even more so, to implement the findings from the identifying and assessing risks, these risks need to be treated based on their urgency and impact, in the sense that solutions need to be identified and implemented, and furthermore, these processes need and should be continuously monitored and evaluated for efficiency. For example, the Sendai Framework for Disaster Risk Reduction provided a suitably encompassing approach to increasing resilience based on seven major objectives and could easily be applied by companies working in critical infrastructure.

Additionally, the chapter explored the more commonly used principles, theories, models, frameworks and tools for both risk management and resilience in the energy sector. The investigation found that risk management experts operating in the sector tend to focus mostly on financial risks and commonly used tools such as the SWOT and PESTEL analyses to illustrate their findings to investors. The study also identified the most common elements of resilience frameworks and examined the current perspectives regarding the dimensions of resilience that can be considered and the capacities that can enhance resilience. A more in-depth discussion on the dimensions of resilience identified notes the existence of two major approaches to enhancing resilience: securing existing resources and capabilities based on the dimensions of resilience identified and increasing the capacities of the community by implementing incident-focused and post-incident learning. Given the unique features and context of the Emirati energy sector, the decision was made to create a resilience framework based on international best practices, which also considers the unique features of the studied phenomenon.

The second part of this chapter looked into the specific vulnerabilities, hazards and risks that typically characterise the energy sector, the objective being to identify means of increasing resilience based on the most common threats. The discussion took into account both natural hazards (e.g. earthquakes, landslides, dust storms, floods, hurricanes, etc.) and man-made disasters (i.e. accidents resulting in fires or explosions, and deliberate harmful actions, e.g. stealing resources, terrorism, hybrid warfare, etc.), identifying vulnerabilities

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and barriers to resilience for each group of risks. The main threats facing the Emirati energy sector were identified to ensure that proper resilience-enhancing measures are identified, with the UAE being more exposed to disasters caused by natural disasters (e.g. sandstorms, earthquakes, tsunamis), climate change, terrorism, as well as accidents that may cause fires or explosions.

The following chapter will analyse and outline the study's theoretical framework, which is designed based on similar, successful frameworks that prioritise improving resilience in critical infrastructure, with the assessment and evaluation of resilience interventions being the main goal of this tool.

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CHAPTER III: THEORETICAL FRAMEWORK

Given the unique energy landscape of the UAE, which on the one hand, depends financially on fossil fuels, but on the other, aims to achieve carbon neutrality by diversifying and investing in renewable energy, the thesis has chosen to develop a distinctive resilience framework. The designed framework draws upon international standards and best practices regarding disaster management, risk management and resilience, encompasses valuable insights from existing frameworks (as explored throughout Chapter II – Literature Review), and employs these lessons to address the local context that characterises the Emirati energy sector.

This chapter thus presents the theoretical framework that guides the primary data analysis, which has been developed in light of the fundamental concepts and principles identified in the literature review to operationalise resilience in critical infrastructure by identifying, understanding and appraising the actions that can enhance resilience for the UAE energy sector.

3.1 Proposed Framework for Resilience Building in the Energy Sector

As previously established, resilience can be characterised as the ability of a system to maintain stability in the event of a disaster or disturbance (Brassett and Vaughan-Williams, 2016), and thus in the energy sector, resilience generally refers to the capacity to ensure the uninterrupted supply of energy (McLellan et al., 2012). In order to ensure resilience within critical infrastructure, the systems need to include redundancies that can guarantee an acceptable level of functionality throughout various emergencies or disasters – and which are in effect even if fundamental features are disrupted, thus allowing a smooth and stable recovery for the stakeholders that operate within the energy generation, transmission or distribution industries (Flynn, 2008; McLellan et al., 2012). As such, the following Figure 29 portrays the critical infrastructure resilience cycle, a model designed to follow the stages determined in the classic disaster cycle (Rehak et al., 2019). The model thus includes a pre-disaster stage that seeks to minimise the potential of a disaster onset by considering the

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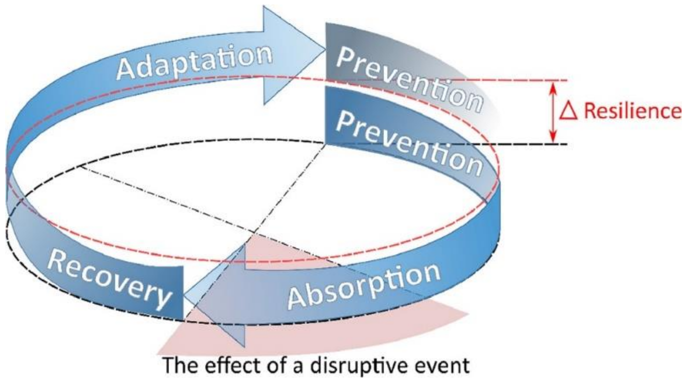
existing vulnerabilities and circumstances (i.e. prevention), a mid-disaster stage that attempts to mitigate the effects of an ongoing disaster by relying on the existing contingency measures and on the expertise of properly-trained personnel (i.e. absorption), a post-disaster stage that not only strives to return the system to normalcy, but which will seek to collect data and analyse it to evaluate this bounce-back capacity in order to make future amendments (i.e. recovery), and a post-incident stage that effectively relies on examining the previous stages and implementing additional prevention and mitigation measures based on the newly-identified needs, vulnerabilities, resources and capacities (i.e. adaptation), the goal being to increase resilience by strengthening the various elements that come into play at all stages of a disaster, with the emphasis being of course placed on minimising the potential onset from the beginning (Rehak et al., 2019).

Figure 29: Critical Infrastructure Resilience Cycle



Source: Rehak et al. (2019: 127)

Following the 4 major dimensions of resilience that represent the various resources characterising the energy sector (i.e. technical, organisational, social, and economic dimensions), the upcoming proposed framework also follows the 4 stages of the critical infrastructure resilience cycle portrayed above, including them as capacities or conditions for enhancing resilience.

The following resilience framework incorporates the best practices associated with disaster management, risk management and resilience explored throughout Chapter II – Literature Review. Considering the scope and goals of this thesis, the framework acknowledges the success of highly structured frameworks adapted to the unique context of a specific sector, industry or

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organisation to enhance resilience holistically. The elements identified in the proposed framework, comprising the technical, organisational, social and economic dimensions, including prevention, absorption, recovery and adaptation as capacities or conditions, play crucial roles in implementing disaster and risk management principles to foster resilience-building in the UAE energy sector. With this in mind, the dimensions and capacities/conditions identified specifically for this thesis address the following:

A. Dimensions

1. **The Technical dimension** involves employing appropriate infrastructure, technology and engineering practices to mitigate risks and enhance resilience for the physical system and its elements (Abel et al., 2004; Cutter et al., 2008; Dancy and Dancy, 2017; Jones, 2021). This includes designing or improving tangible structures and systems to withstand hazards and risks, diversifying energy generation and implementing other redundancies to mitigate the impact of a disaster, and establishing shared communication networks that monitor the infrastructure, all the while utilising advanced modelling and forecasting tools to assess risks and inform decision-making (Bruneau et al., 2004; Labaka et al., 2015b; Lin and Bie, 2016; Rehak et al., 2018).
2. **The Organisational dimension** is inspired by the governance dimension in academic literature. The organisational dimension of this framework focuses on establishing effective governance and administration structures, policies and procedures for enhancing resilience via disaster and risk management practices (Coppola, 2011; Fagel, 2012; McCreight, 2011; Subramanian, 2018). This involves the adoption of risk management practices, distributing resources and enhancing coordination and collaboration among relevant stakeholders, establishing regulatory frameworks and adopting an adaptive culture at all levels (Cutter et al., 2008; Flores and Peralta, 2020; Jones, 2021; Tariq, Pathirage and Fernando).
3. **The Economic dimension** addresses the financial aspects of resilience building, which is arguably the most important element of the energy sector (Coppola, 2011; Cutter et al., 2008; Laymon and Castro, 2020; Kreimer and

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Arnold, 2000). It involves integrating risk reduction measures into economic development planning and investment decisions, assessing the economic impact of disasters and adjusting the emergency budget accordingly, as well as developing sustainable financing strategies that ensure an organisation can be financially stable throughout the entire disaster cycle (Fagel, 2012; Kersten et al., 2011; Kovacevic et al., 2013; McEntire et al., 2010; Satendra and Sharma, 2004).

4. **Social:** emphasises the involvement and empowerment of all the stakeholders in disaster and risk management processes that aim to enhance resilience (Cutter et al., 2008; Fallah-Aliabadi et al., 2020; McEntire et al., 2010; Wise et al., 2014). This includes promoting awareness and education on hazards and preparedness measures, fostering community engagement in decision-making by strengthening social networks and cohesion and providing social support to affected individuals, but also encompasses the training of the energy sector's personnel (Birkmann, 2006; Hillhorst and Bankoff, 2004; Kasperson and Kasperson, 2001; Lei et al., 2014; Tariq et al., 2021; Wisner et al., 2003).

B. Capacities

5. **Prevention:** refers to the measures that can be taken to avoid or minimise the likelihood and potential impact of disasters (Coppola, 2011; Fagel, 2012; Hopkin, 2014; Reason, 2008; Rehak et al., 2019). This includes all the decisions that can be taken at the national, organisational and individual levels to reduce exposure to risks, and therefore assesses the regulations, laws, programmes, policies, procedures and practices that characterise the system (Alexander, 2013; Berkeley and Wallace, 2010; Bruneau et al., 2004; Flynn, 2008; O'Rourke, 2007).
6. **Absorption:** focuses on enhancing the sector's ability to absorb and mitigate the impacts of disasters when they occur (Carlson et al., 2012; Cepin and Bris, 2017; Rehak et al., 2019). The capacity involves developing robust emergency response systems that incorporate monitoring and evaluation, establish contingency plans, build redundancy and flexibility into

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systems, and ensure the continuous availability of critical resources to the population (Berkeley and Wallace, 2010; Carlson et al., 2012; Folke, 2006; Flynn, 2008; Hiete and Merz, 2009; Tariq et al., 2021).

7. **Recovery:** involves the process of restoring and rebuilding affected areas and processes after a disaster, based on existing plans (Cox, 2009; McKay, 2015; Rehak et al., 2019; Serre et al., 2012; Singh, Chandurkar and Dutt, 2017). This capacity encompasses efforts to repair infrastructure, provide humanitarian assistance, support livelihoods, and restore social and economic systems to their pre-disaster condition (Ankie, 2019; Carlson et al., 2012; Flynn, 2008; McCreight, 2011; O'Rourke, 2007). Effective recovery requires efficient coordination and resource mobilisation, and more importantly, it should address both short-term and long-term needs, as incorporating resilience considerations into recovery efforts helps reduce the chance of stacking vulnerabilities that may cause a cascading disaster (Gudda, 2011; Tiernan et al., 2018; Tiusanen, 2018; UNISDR, 2015a; Vega et al., 2009; Wise et al., 2014).
8. **Adaptation:** refers to the energy sector's aptitude to adjust and transform in response to changing risks and emerging uncertain conditions (Bhamra et al., 2011; Meerow et al., 2016; Rehak et al., 2019; Smit and Wandel, 2006; Singh et al., 2017). As such, it involves examining existing vulnerabilities and anticipating future risks via disaster and risk management practices, contingency and redundancy planning, and also by continuous monitoring and evaluation that should be followed up with proactive measures to adopt policies, procedures and practices based on the gathered data (Berkeley and Wallace, 2010; Carlson et al., 2012; Cepin and Bris, 2017; Flynn, 2008; Labaka et al., 2015b; O'Rourke, 2007).

By integrating these resilience dimensions and capacities, disaster and risk management principles are implemented holistically, fostering resilience building and enhancing energy organisations' ability to anticipate, avoid, mitigate and recover from disasters.

It is important to note that the upcoming suggested framework in Table 3 is an original design that has been specifically devised for this project by the

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researcher, based on the key elements, concepts, tools, issues, vulnerabilities, opportunities and risks identified and examined throughout the Literature Review Chapter, in essence creating a unique structure that incorporates various theoretical approaches and practical requirements that have been proved to be capable of increasing resilience within the energy sector at various stages, and for various elements, from both an internal and an external perspective. Having explored both the international best practices and the current vulnerabilities and opportunities related to the Emirati energy sector, the framework in Table 3 reflects the local realities and needs of the UAE.

Table 3: A four phased framework design covering prevention, absorption, recovery, and adapation strategies for both internal and external risk

	Prevention	Absorption	Recovery	Adaptation
Technical (Internal)	Evaluate designed plans to ensure their relevance and efficiency. Introduce and test crisis response equipment. Test physical resources (including redundancies) for safety and security via practical exercises. Make modifications to facilities, grids, networks to ensure a high degree of security and safety. Implement means of minimising pollution.	Monitor crisis preparedness procedures (including contingency and redundancy planning). Monitor responsiveness actions (regarding resources). Monitor the allocation and delivery of equipment and adapt, if necessary.	Evaluate the implementation of all plans, procedures, policies and practices immediately after the disaster onset. Monitor and evaluate the time when the system was unproductive and the time needed to restore operations to normalcy.	Investigate physical risks and vulnerabilities by ensuring ISO 31000 steps (risk identification, risk analysis, risk evaluation, risk treatment) via various tools (e.g. SWOT analyses, RCAs, Risk Matrix, etc.). Contingency planning: Plan for adequate capabilities & resources allocated in next stages. Redundancy planning: devise procedures capable of maintaining operations throughout disaster. Continuous evaluation of physical resources, enhancement when possible with best available technologies.

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	Prevention	Absorption	Recovery	Adaptation
Organisational (Internal)	Introduce 3rd party M&E to ensure industry standards are upheld. Implement training & exercises for all personnel and for affiliated stakeholders.	Monitor responsiveness actions (decision making and personnel capabilities). Monitor the delivery of the disaster relief in general. Provide continued supervisory support for all other dimensions (technical, economic, social) throughout the emergency.	Evaluate the delivery of the disaster relief at all levels of operation.	Investigate non-physical risks and vulnerabilities (following ISO 31000 steps). Devise regulations and standards for safety measures & guidelines in each industry. Devise disaster and risk management practices fit for industry. Plan for all risks, including emergent ones (e.g. terrorism, cyber-attacks).

	Prevention	Absorption	Recovery	Adaptation
Social (External)	Assess social vulnerability. Implement awareness campaigns on classic & social media on what to do in case of an emergency. Implement awareness campaigns to promote volunteering and ensure that community helps first responders.	Keep up-to-date via various channels (e.g. media, social media, internal communication channels) to inform community of the development of the crisis. Ensure availability of resources for disaster victims (e.g. shelter, food, medicine).	Keep up-to-date via various channels to inform community of the actions needed to be taken to ensure the return to normalcy. Monitor the capacity of meeting community needs post-disaster.	Evaluate the delivery of relief effort and modify plans for future relief, if necessary. Inform of changes to be made to technical, organisational, economic factors. Devise plan to promote volunteering.

	Prevention	Absorption	Recovery	Adaptation
Economic (Internal and External)	Planning, raising and evaluating budgets for disaster management departments and responders.	Implement and monitor the allocation of all disaster management budgets. Assist industry actors.	Calculate the overall financial burden of the disaster, including the time needed to regain lost revenue.	Evaluate the implementation of the disaster relief budget. Adjusting disaster management budgets to compensate for shortcomings and excess.

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Following the best practices identified throughout the literature review chapter, the proposed framework in Table 3 incorporates some of the foundational principles outlined by the ISO 31000 standard for managing risk, such as the need for continual improvement of risk management practices, the reliance on the best available information that is gathered from a variety of sources and via several tools or processes. However, each company implementing this framework would need to customise it based on its unique risks, vulnerabilities and capacities for risk reduction and disaster prevention (ISO, 2018); the identification of each is crucial to both industries in general and companies in particular (Coppola, 2011). Thus, the framework given above also introduces several processes identified in the ISO 31000 standard, namely risk identification, risk analysis, risk evaluation, risk treatment, as well as monitoring and evaluation practices (ISO, 2018), the goal being to mitigate risks at all operational levels.

Without identifying risks regularly, developing a relevant or efficient disaster management plan is impossible, and so is the adoption of preventive strategies crucial to enhancing resilience (Land, 2014). Once the risks have been identified, risk analysis must be conducted to assess the probability and impact of a potential disaster – which helps delegate resources (Olson and Wu, 2015). The process of risk assessment would not be complete without evaluating risk, which needs to be conducted via an assessment of the attitude, appetite and tolerance towards a given vulnerability (Rausand, 2011), and as such essential to identifying the most appropriate strategy for minimising risk to ensure the resilience of the facility and the impact of the potential risks on the community at large (Murray-Webster and Hillson, 2016). However, while the previous steps are vital, they mean little without risk treatment which implies solution development, a process requiring continuous monitoring and verification for applicability, effectiveness and feasibility (Del Bel Belluz, 2010; Yoe, 2019), as without M&E procedures, the improvements or drawbacks to the resilient capabilities could not be accurately identified and acted upon (Gudda, 2011; Singh et al., 2017).

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3.2 Indicators of Resilience

While the framework devised for this project is based on the needs and requirements of the Emirati energy sector (see Section 3.1) it is also important to identify clear indicators that help determine to what extent the UAE energy sector is resilient. Considering that this is a qualitative study, the indicators used for data gathering and analysis are explored qualitatively by employing a combined method of examining the language used to describe each factor (i.e. highlighting positive and negative words associated with each factor) together with identifying the frequency of such language use by the participants (e.g. X participants talked positively / negatively about Y factor) – the method also providing this otherwise qualitative study with a basic means for systematising the data simply and clearly. The process is explained more comprehensively in the coding scheme section of the data analysis (in the upcoming Chapter V).

In essence, the indicators of resilience that are used to assess the resilient capacity of the Emirati energy sector, which are presented in Table 4, are first and foremost relevant and applicable to the energy industry at large, as they refer to both internal and external factors, encompassing both the planning and the implementation stages, and also effectively representing repeatable actions that can be taken to increase resilience. Additionally, these indicators have also been carefully selected by the researcher based on the data gathered during the review of the literature, which has identified various gaps in the disaster management and resilience-building strategies implemented so far for the Emirati energy sector, but which has also discovered several opportunities that can be further strengthened to ensure resilience within the industry at large.

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Table 4: Intersection between Resilience Dimensions: Indicators of Resilience for Organisations in the Energy Sector

		CONDITION / CAPACITY			
		ROBUSTNESS	RESOURCEFULNESS	RAPID RECOVERY	ADAPTABILITY
IMPACT	TECHNICAL	Power Generation Diversity	Backup Power Deployment & Redundancies	Infrastructure & System Reliability	Technological Progress & Hardware Hardening
	ORGANISATIONAL	Adoption of Risk Management Practices	Decision-making & Coordination	Adaptive Capacity	Policy Reform & Capacity Building
	ECONOMIC	Buying Power	Availability of Emergency Funds	Financial Stability	Investment Opportunity
	SOCIAL	Personnel & Management Training	Multi-Agency Collaboration	Social Support	Sustainable Development

The indicators of resilience were, therefore, specifically and uniquely selected by the researcher following both international best practices and local Emirati needs; however, at their core, they have been created based on the impacts and conditions identified in the previous section and which characterise the dimensions of resilience, as follows:

A) <u>Based on resources affected</u> (IMPACTS)

→ Technical

→ Organisational

→ Economic

→ Social

B) <u>Based on actions required</u> (CONDITIONS / CAPACITIES)

→ Prevention: Robustness (before a disaster)

→ Absorption: Resourcefulness (during a disaster)

→ Recovery: Rapid Recovery (after a disaster)

→ Adaptation: Adaptability (post-incident)

Table 4 showcases the intersection between the two resilience dimension categories as previously determined (i.e. impacts and conditions/capacities) and creates a matrix based on the eight dimensions. By jointly examining each impact and capacity, the researcher identified sixteen (i.e. 16) indicators that can be used to assess whether Emirati companies and the energy sector at

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large are resilient or not, the goal being to not only facilitate the analysis of the primary data but pinpoint the additional improvements that the UAE can adopt based on the current realities of the sector.

Technical Impact:

Power Generation Diversity – investing in additional, alternative or renewable energy sources may help ease the pressure put on companies at all times, however having on-site generators independent of the main network will ensure that affected structures and networks can still operate at the necessary levels regardless of interference (Chowdhury, Chakrabarti and Chanda, 2021).

Backup Power Deployment and Redundancies – including black-start options for power stations after power outages, along with the continuous check-ups along the energy transmission network and distribution grids will ensure that the entire system may continue to function even during a disaster, therefore minimising potential vulnerabilities for all the stakeholders (Lin and Bie, 2016).

Infrastructure and System Reliability – monitoring and evaluating the condition and output of the energy system, in general, will allow companies to quickly identify vulnerabilities and find solutions for possible risks and hazards, thus increasing the short-term security and long-term resilience of the entire network (Chowdhury et al., 2021).

Technological Progress and Hardware Hardening – investing in addressing the issues related to the existing physical elements of the energy system (e.g. factories, machines, tools, equipment), companies may further harden their infrastructure by introducing reliable green technologies that are sustainable, all of which increase resilience at a local level (Lin and Bie, 2016).

Organisational Impact:

Adoption of Risk Management Practices – adopting risk management practices, such as the ISO 31000 framework, needs to be done in an applied manner that seeks to nurture a culture of risk identification, assessment and treatment throughout the entire company, at all levels and for all facilities, which will enhance resilience by minimising vulnerabilities and the exposure to hazards (Field et al., 2012).

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Decision-making and Coordination – ensuring that all of the available resources are well distributed while a disaster is unfolding is crucial to organisational stability and efficiency; thus companies in the energy sector need to invest in supervisors who possess the capacity to quickly and suitably respond to emergent situations (Ness, 2006).

Adaptive Capacity – seeking to return to the state before a disaster occurred is not always the best choice, and instead, companies need to be flexible in their policy-making and goal-setting, by identifying emergent setbacks and by taking advantage of new opportunities that will allow them to constantly prosper regardless of circumstances (Ebinger and Vergara, 2011).

Policy Reform and Capacity Building – making use of previously gathered information regarding what went wrong and what had good results will allow companies to reassess regulations and thus focus on the areas that need improvement, at the same time minimising the redundant allocation of resources, increasing both resilience and sustainability (Shukla and Sharma, 2017).

Economic Impact:

Buying Power – ensuring that a company can financially support itself is the first step towards increasing resilience throughout all systems (Labaka et al., 2015b). By conducting in-house audits, for instance, via Cost-Benefit and Cash Flow analyses, or by examining growth rates, profitability, efficiency and valuation, a company can optimise its budget and invest financially in long-term development that maximises profits and minimises losses (Lee et al., 2016).

Availability of Emergency Funds – as most disasters are associated with property damage and the deterioration of physical assets, having an emergency budget set aside to repair the damages done is crucial to ensuring business continuity in general, which translates to improved resilience for energy systems and facilities that can quickly recover and return to their state before a disaster (Labaka, 2013).

Financial Stability – while this can be perceived as a wider goal for companies, many fail to reach it following a disaster, as such the steps taken before to maximise profit also need to consider all possible risks that may result in unpredictable financial blows of catastrophic proportions, especially in the wake

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of a disaster that not only affects the entire infrastructure but which may also affect the entire community fuelled by the company's energy output (Ramlall, 2019).

Investment Opportunity – if and when the previous steps have been optimised, the company will be able to invest in additional technological, organisational and social policies and procedures that can help not only increase resilience at all levels by meeting the community demands and contributing to climate change action (Bohland et al., 2019).

Social Impact:

Personnel Training – building upon the competencies of the personnel, regardless of rank, roles and responsibilities, is a reliable approach to ensuring that vulnerabilities and risks associated with human error are diminished; companies need to introduce periodic training for their employees (Ness, 2006).

Multi-agency Collaboration – developing multi-agency plans that engage all the stakeholders in the decision-making process and investing in real-time communication solutions are crucial steps to reducing threats and vulnerabilities, which is needed to ensure the needs of the community are met even during times of hardship (Brandon et al., 2017).

Social Support – devising structures and providing solutions that alleviate the short-term and long-term impacts of disasters (e.g. specialised facilities and housing to reduce physical and mental trauma) helps build resilient communities that ultimately help a company grow by ensuring social stability through equitable actions (Institute of Medicine, 2015).

Sustainable Development – ensuring the long-term development of the community at large will allow companies to thrive despite the various emerging crises; in effect employing sustainability principles will ensure that future generations also prosper without compromising the company's success (Bridges and Eubank, 2021).

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3.3 Summary

This chapter employed the lessons learned in Chapter II (i.e. Literature Review) to develop a theoretical framework for enhancing resilience in the UAE energy sector. The framework was influenced by other resilience frameworks and models and is meant to follow the four-stage disaster cycle, given the importance of incorporating practices that can build resilience either passively or actively throughout the entire cycle of a potential incident. The resilience framework designates four major stages, namely prevention, absorption, recovery and adaptation, and four major dimensions, respectively technical, organisational, social and economic, each of which have been explained separately. Exploring the resilience stages and dimensions identified has led to the generation of sixteen indicators. Having been explored separately in the previous section, these are power generation diversity; backup power deployment and redundancies; infrastructure and system reliability; technological progress and hardware hardening; adoption of risk management practices; decision-making and coordination; adaptive capacity; policy reform and capacity building; buying power; availability of emergency funds; financial stability; investment opportunity; personnel and management training; multi-agency collaboration; social support; sustainable development.

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CHAPTER IV: METHODOLOGY

4.1 Introduction

The methodology chapter examines the various available research approaches and strategies for collecting, analysing and interpreting data and further justifies the particular techniques chosen for this project with the help of academic literature. These choices were made considering the study's research questions, explored phenomenon, the phenomenon's context and regional background, and the availability of existing data and practitioners. The chapter also argues for using qualitative data and examines additional parameters such as the research strategy and the time horizon. Additionally, the chapter offers a discussion of possible research instruments, substantiating the choice of conducting semi-structured interviews for the project and offering an account of how the interviews were set up. Moreover, the chapter presents details regarding the primary data collection method and showcases the final coding scheme formed after the data interpretation. Furthermore, this chapter examines the selection of the sampling procedures employed in relation to other available sampling frames and explores the inclusion and exclusion criteria used for sampling. The reliability, validity and generalisability of the selected methods, as well as of the collected material, is also examined. Lastly, as with any social science research, the study also raises a number of ethical issues that need to be considered, and special attention has been put to addressing the main ethical concerns along with measures taken to avoid or minimise their impact on the quality of the results.

4.2 Research Philosophy

The research philosophy is the theoretical perspective adopted by the researcher who is trying to understand the surrounding world, and the selection of philosophy influenced all of the other methodological choices (Crotty, 1998, Creswell, 2013), as shown in Saunders et al. (2009: 108) research onion, which is presented below (Figure 30). Two major philosophical paradigms were considered, specifically positivism and interpretivism (Saunders et al., 2009, Creswell, 2013, Crotty, 1998).

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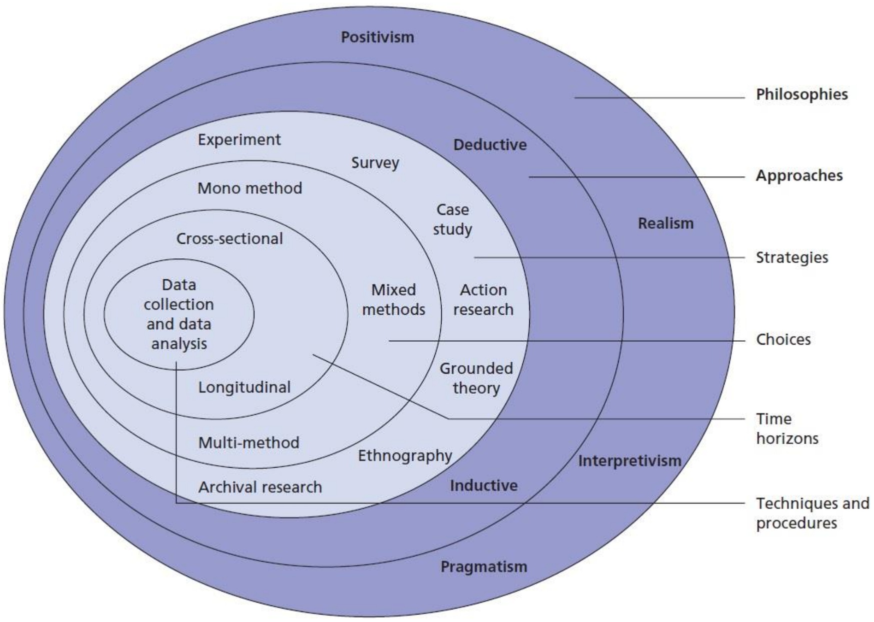
Figure 30: Research Onion



Source: Saunders et al. (2009: 108)

The epistemological position that ascribes to epistemological and ontological views of natural science stance is positivism and is generally thought to purport that there is a singular objective reality which can be measured by using the scientific method (Weber, 2004). The main means that positivism uses to discover this objective truth is by developing hypotheses, which can be tested to be confirmed or rejected, partially on in whole (Saunders et al., 2009). In order to test this reality, positivist studies mostly employ quantitative means of data collection and analysis, while the data itself is gathered from very large sample sizes (Cohen et al., 2011). These steps are crucial because the comprehension of a phenomenon in positivist studies must be measurable and, more importantly, validated independently (Hammersley, 2013). For these reasons, positivism is credited as being the core philosophy that argues for the existence of an objective truth, which is approachable by observation (Bryman, 2012). Positivist researchers thus focus on trying to explain the causality between several elements identified in advance and by exploring the relationship between said elements, as are able to pinpoint correlations and therefore identify predictable outcomes (Saunders et al., 2015). For the same reasons, positivist studies more aptly identify generalisable findings, making positivist methods less suited to the research on social realities that depends

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on individualised behaviours and perceptions, or where the findings heavily depend on the local political, cultural or economic context (Cohen et al., 2011).

Secondly, the epistemology that claims the social world cannot be adequately understood using the natural science model is called interpretivism (Bryman, 2012; Creswell, 2013). Interpretivism considers that the status of humans as social actors, who perceive social phenomena subjectively according to context and their individual values, means that reality is inseparable from people's interpretation of it (Saunders et al., 2009, Weber, 2004). Knowledge is, therefore, not objective but a social construct (Eisenhardt et al., 2016). This rejection of an objective truth leads interpretivists to seek to understand human behaviour rather than explain the external forces that shape it, as is the purpose of positivism (Bryman, 2012). For that reason, the researcher focuses not on the examined phenomenon but on human behaviour and interpretation of it (Pulla and Carter, 2018). This is helpful when studying complicated social phenomena with many contributing factors, which are affected by context and timing and thus cannot be described using law-like generalisations (Saunders et al., 2009). The emphasis on the affected subjects means it is easier for interpretivism to uncover findings that would be undetectable with an external stance that did not consider context or individual perceptions (Bryman, 2012). For these reasons, the data collected and examined in interpretivist studies needs to be highly detailed and typically descriptive in nature, encouraging the use of qualitative methods (Crotty, 1998). Of course, results from interpretivist studies are hard to replicate, and it is thus more difficult to apply the conclusions drawn under different circumstances (Saunders et al., 2009; Bryman, 2012).

The issue of the energy sector's security is heavily dependent on local context, as the risks faced by the industry are determined to a large degree by anthropogenic factors, such as political and economic stability, while even the impact and frequency of natural hazards are affected by human actions. Any risk assessment study requires bearing in mind that safety measures and plans are formulated and implemented by human actors and are thus susceptible to bias, omissions or poor execution. This realisation makes interpretivism more suitable for this research, when compared to positivism. At the same time, the limited literature on the topic of energy sector security in the UAE or even Arab

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countries in general (Dubey and Krarti, 2018; McClean, 2018) would make the development of a testable theory, as needed in positivism, a nearly impossible task as a careful review of an abundance of literature is a necessity for positivist researchers to develop a testable hypothesis (Saunders et al., 2009). As such, interacting with disaster or risk management specialists in the chosen context of the Emirati energy industry would greatly benefit the development of new theoretical and practical perspectives towards understanding the studied phenomenon. To emphasise, adopting an interpretivist perspective would allow the study participants to share their opinions, perspectives and experiences honestly and unrestrictedly, in a manner that would be difficult to quantify. Due to all of these, the reasearch developed in this thesis focused on developing new theories based on the insights and personal experiences of the expert who participated in the study, which is why the interpretivist approach was chosen.

4.3 Research Approach

The two main ways to develop a theory are deduction and induction, although alternatives exist (Bryman, 2012). On the one hand, deduction requires the a priori shaping of a theory based on existing knowledge and its subsequent testing, similar to the positivist paradigm, which is why deduction is often linked with positivist studies (Bryman, 2012; Saunders et al., 2009). Furthermore, deduction tends to rely on quantitative data that guarantees a more rigorous structure that allows the generation of measurable findings, compared to induction, which is more commonly dependent on qualitative data (Saunders et al., 2009). However, due to this, employing deduction does not allow the researcher to develop the research in directions different from the previously identified theories subjected to testing since the data being collected is only relevant to the pre-set research questions (Schutt, 2019). For these reasons, it is less well suited for research in novel areas with little existing data. Indeed, deduction relies on applying a known rule to the studied phenomenon. Still, in an under-researched field, the validity of such a general rule is difficult to ascertain. At the same time, initial assumptions or theories that apply to the studied reality are also difficult to conceive (Reichertz, 2004). Even more so, given the reliance on measurable data, a representative deductive study is

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considerably larger than that typically employed in inductive research (Schutt, 2019).

On the other side, induction does not apply an existing theory but relies on the collected data to construct one, which is why it is appropriate for developing original research topics (Saunders et al., 2009). However, constructing a theoretical framework from data requires deep investigation of the studied phenomena and rich data, preferably from a variety of different sources, to capture a multitude of aspects of the explored issue (Eisenhardt et al., 2016). This utilisation of multiple and sometimes unconventional sources, along with the flexible and non-dogmatic use of posterior ideas, means that the subject is examined from different perspectives compared to deductive techniques, which allows novel ideas to emerge (Eisenhardt et al., 2016). In fact, inductive research can offer several different but valid ways to understand the same phenomenon (Jebreen, 2012). Therefore, instead of constraining the research findings to test a limited number of assumptions which deductive approaches do, using induction allows researchers to directly gather and explore existing features of the explored phenomenon from various perspectives, and only after the data collection process would relevant theories be formed (Schutt, 2019). Consequently, the conclusions reached by induction are probable rather than true, as they tend to be applied under specific circumstances, which reduces their reliability – nevertheless, many scholars consider such results more realistic solutions to real-world problems that are currently developing (Copi and Cohen, 2007). Because of this, applying the inductive approach to examine a phenomenon with little or no theoretical background also necessitates considering the phenomenon's context (Saunders et al., 2009).

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phenomenon with little or no theoretical background also necessitates considering the phenomenon’s context (Saunders et al., 2009).

From the above, it is clear that for a subject without much research history, such as energy sector security in the UAE context, and given the complex and numerous factors that affect risk assessment and response, the inductive approach was the most fitting for the project. Considering the research topic, a large sample size would have been difficult to reach, as a limited number of Emirati energy sector experts are also familiar with disaster and risk management. At the same time, a deductive approach could not have been pursued as there are no unique, tested hypotheses, theories and approaches that can be applied to the study in order to achieve the research objectives. By comparison, the inductive approach allowed for a combined examination of all these aspects and approaches the issue without preconceptions, permitting novel insights and facilitating theory development.

4.4 Research Strategy

Social research can be conducted with a variety of different strategies, the main ones being the experimental, survey, grounded theory and case study strategies, although other forms are available, like archival or action research (Saunders et al., 2009). Although most of the above-mentioned strategies, or a combination of them, are possible when conducting social research, the objectives and aims of the project can show which one is most suitable for it (Yin, 1981). In addition, the overall purpose of the research should also inform the choice of strategy, for instance, exploratory studies that seek to determine the source of the phenomenon under investigation and tend to work best with surveys, case or field studies, descriptive studies that aim to offer an exhaustive perspective into a phenomenon could also employ ethnography in addition to the case study, explanatory studies that examine connections between variables are more likely to employ the strategies mentioned so far in addition to archival research, while predictive studies that intend to forecast outcomes will most likely employ experimental approaches (Saunders et al., 2009).

This being said, the links presented above are not set in stone, and, in theory, any strategy can be successfully employed regardless of the research purpose;

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however, each strategy is best employed under specific circumstances. For example, the experimental strategy is well suited for studies of causal relationships without examining context-specific factors (Saunders et al., 2009; Yin, 1981). Developing experiments via two observed groups (i.e. the control group and the experimental group) and by introducing distinct manipulations of the variables in question, a researcher may examine the causality between the said variables (Saunders et al., 2009: 142-143). While this approach can offer causal extrapolations, as the researcher controls the environment, such manipulation of the interactions might not be possible in a real-life environment. At the same time, the lack of pre-existing knowledge may result in the development of wrong assumptions based on unverifiable or flawed correlations, reducing the reliability and validity of the findings (Leavy, 2017).

Secondly, the survey is a good way to test a theory as it collects standardised quantitative data that increases the generalisability of the results, making it suitable for deductively approached research (Saunders et al., 2009). The survey strategy is versatile, as questionnaires can be delivered via many channels, such as face-to-face, via phone calls, through electronic means or even by delivering physical copies directly to the participant (Jones et al., 2013; Leavy, 2017). However, among the main limitations of this strategy are the considerable sample size needed, the tendency of individuals to either not respond or respond hastily to the questionnaires, especially if it is lengthy, as well as the fact that both the data collection and the data analysis processes take a considerable amount of time, given a large amount of information (Jones et al., 2013).

Thirdly, a strategy that seeks to evaluate a phenomenon under a specific context is action research; however, this strategy would not be suited for this project as the goal is to not only examine an issue but also to devise a working strategy towards addressing the underlying problems (McNiff, 2013). Since action research must be integral to the organisation under examination, the researcher being employed at or an affiliate of an organisation is a typical requirement for such research, as the researcher needs to foster development change within the company (Saunders et al., 2009). In a sector (such as the chosen energy sector) that relies on experts who are familiar with the

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company’s issues and who have experience in decision-making roles to employ the findings to benefit said organisation (McNiff, 2013), it would be challenging to conduct action research, at least when it comes to producing a verified roadmap for building resilience that in any company would require the input, active research and collaboration from different stakeholders.

Fourthly, ethnography is a research strategy that is more commonly employed in inductive studies, its purpose being the depiction of a phenomenon within its natural context, and as such, it seeks to identify the perceptions and opinions of individuals who experience both the studied phenomenon and its context first-hand (Leavy, 2017). From this perspective, ethnographic research could be employed for this research, however conducting such a study requires the direct and lengthy involvement of the researcher in the daily routine of various employees within a company, which would be difficult to attain as it also requires an extensive period allotted to data collection, as building rapport is significant for the observation of veridical daily interactions and scenarios (Saunders et al., 2019).

Bearing in mind the stated aims and purpose of this project and the adopted research philosophy of interpretivism, the strategy that emerged as most appropriate was the case study. This is because the case study is, by definition, concerned with studying a real-life phenomenon within its context, typically using multiple sources (Robson, 2002, Yin, 2009, Karlsson, 2016). Indeed, the research presented in this project is concerned with the current state and potential of the UAE’s energy sector security, fitting this definition and representing the case study of interest for this work. The subject's dependence on complex relationships between many variables (i.e. legislation, risk awareness, staff competence) also favoured the case study strategy since it requires using sources that can provide a wealth of information (Fidel, 1984). The fact that this information often comes directly from individuals with experience of the studied phenomenon means that, if done correctly, the case study offers results that are practical and easily acceptable by the reader since they reflect the complexity of real life (Cronin, 2014).

Another advantage of the case study as a strategy for this project is its flexibility, allowing the research to focus on different points of interest during data

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collection and analysis (Fidel, 1984). This is a valuable attribute when exploring new research areas without preconceived notions and theories as to what findings can be expected, while it also allows adjustments to data collected during the study since the theory, or explanation, is gradually built through the process (Cronin, 2014). Because of this, exploring a phenomenon via the case study strategy implies the collection of qualitative data from a variety of primary and secondary sources, for instance, from individuals or organisations through interviews or questionnaires, from events through observation, by doing documentary research and so on, the main goal being the study of authentic relationships (Yin, 2009, Saunders et al., 2009). Thus, as various perspectives are examined, these can be analysed comprehensively and comparatively, which allows the formulation of several possible explanations, which ultimately benefit the organisation and could also improve the understanding of the chosen phenomenon within the larger industry (Yin, 2009).

Weaknesses of this strategy are mainly related to the fact that by producing context-dependent conclusions, the findings cannot be replicated – since the context may have changed – or be validated accurately (Krusenvik, 2016; Karlsson, 2016). For this reason, they were seen as mostly useful for the initial exploratory phases of research, a notion that has changed (Yin, 2009). Modern proponents of the case study strategy point out that limited generalisation capability is not a drawback since general, context-independent knowledge is not necessarily more valuable than practical, contextual knowledge (Flyvbjerg, 2006). At the same time, if generalisation is desirable, it is in no way impossible to do it through case studies, especially if multiple cases are under scrutiny, as the phenomena will be difficult to replicate under different circumstances (Flyvbjerg, 2006, Karlsson, 2016). However, this also implies that while the findings are not absolute, the results of other case studies can, for instance, be of some value to this research, and similarly, the findings herein can be used in tandem with other case studies to improve understanding of energy sector security in a somewhat similar political, economic or cultural context. The upcoming sections provide further information on the specifics of the case study, including the chosen time horizon, the data collection and analysis methods employed, as well as details regaring sampling and participants.

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4.5 Research Time Horizon

Research can be cross-sectional and provide a snapshot of a phenomenon at a particular time, or it can be longitudinal and document its progress through a given period (Saunders et al., 2009). More importantly, the choice between conducting a longitudinal or a cross-sectional study needs to be informed by the study's overall purpose, particularly by the research questions and how these can be best addressed (Saunders et al., 2009).

First and foremost, conducting a longitudinal study allows the researcher to study the changes befalling a phenomenon during multiple key moments in time, thus requiring longer timescales to observe (Sekaran and Bougie, 2016). This time horizon thus focuses on the “study of change and development”; the issues under investigation are the changes in the phenomena, which can be examined by regularly reviewing the studied variables (Saunders et al., 2009: 155). For these reasons, the longitudinal data collection process consists of repeated interactions and observations, the data being afterwards analysed by comparing the same set of variables across time and space (Kalaian and Kasim, 2008). While longitudinal research can help the researcher comprehensively understand the topic, it should only be applied when studying phenomena that are prone to develop over time; if no changes are expected, the cross-sectional approach should be employed (Adams, 2007; Saunders et al., 2009).

At the same time, conducting a cross-sectional study is significantly swifter and less costly, as the data collection is limited to a rather short period, usually ranging from as few as days to months (Sekaran and Bougie, 2016). However, this does not mean that such research would result in a reduced amount of produced data, as researchers employing a cross-sectional approach commonly seek to acquire a wide array of information during the said time from a variety of perspectives in order to investigate the occurrence of the studied phenomenon or to explore the connection between certain variables (Saunders et al., 2009: 155). A major advantage of the cross-sectional time horizon is the capability to quickly collect the data and then move on to analysis and

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extrapolate the findings, while in longitudinal studies, there is always the chance that the studied phenomenon loses its traction or relevance (Kalaian and Kasim, 2008; Rose et al., 2015). Nonetheless, even if the two-time horizons have their unique benefits and detriments, they can be employed within any study, regardless of philosophy, approach, strategy, or data collection and analysis methods (Kalaian and Kasim, 2008; Hall, 2008; Saunders et al., 2009).

The time horizon is cross-sectional, as it aims to examine the status of the UAE energy sector's security under contemporary circumstances. Time constraints were, however, not the only reasons for choosing a cross-sectional design – at the same time, the research intended to offer recommendations for the sector. These were based on existing challenges and prospects, and thus needed to be somewhat quickly delivered to be relevant to the contemporary context.

4.6 Research Data Collection Methods

The data collection process can consist of either a mono-method or multi-method and either be quantitative, qualitative or a mix of these methods (Saunders et al., 2009). However, the research philosophy, approach and strategy must inform the type and amount of research data gathered (Crotty, 1998; Creswell, 2013). Taking into account the fact that this research follows the interpretivist philosophy, that it employs an inductive approach and that the chosen strategy was that of the case study, the researcher strived to collect a large amount of detailed data from different sources, as such, the choice was made to utilise qualitative multi-method research.

Even so, the selection between quantitative and qualitative data, or whether the study would employ mixed methods, was considered, as each data type presents benefits and drawbacks. For instance, collecting quantitative data can be done quickly via remote formats (e.g. questionnaires transmitted via electronic means); however, the reliability of the answers can be at risk, as participants might respond quickly and randomly to conclude their active contribution as soon as possible (Walliman, 2016). This being said quantitative data is not solely collected from human participants; instead, statistical data from various organisations can also be collected, thus increasing the reliability and validity of the findings (Saunders et al., 2009).

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In contrast, for qualitative data collection (e.g. via interviews, observation), a more direct and flexible approach is more commonly employed, and as such, both participants and the researcher are encouraged to ask and answer additional questions, the participants being free to address issues that might not have been previously anticipated – yet which may enhance the scope of the research, while this approach is generally not encouraged in quantitative studies, which aim to test the initial hypotheses (Rahman, 2016). However, the time period for collecting qualitative information can be greater than that needed for quantitative studies, despite the sample size being greater in quantitative analysis (Saunders et al., 2009). In addition to the large data size, quantitative studies also tend to make use of probability sampling styles, and as such, the produced findings turns out to be more representative of the entire population, while qualitative studies typically use non-probability sampling as they focus more on collecting detailed accounts from a smaller sample size that is unique to a specific context and not as such the generated data is not usually generalisable or replicable (Rahman, 2016; Walliman, 2016). As a result, quantitative data tends to be employed more in positivist and realist studies that follow a deductive approach to test one or several hypotheses, while qualitative data collection is largely adopted in pragmatist and interpretivist studies that follow an inductive approach (Saunders et al., 2009; Sekaran and Bougie, 2016).

Resilience interventions and, as a consequence, emergency management and mitigation plans can simultaneously depend on quantitative measurements (e.g., how likely a strong earthquake is) and qualitative evaluations (e.g., how big a priority the earthquake threat is for civil authorities). This being said, in this project, the goal was not to quantify the threats to the UAE energy sector or measure their potential impact, but rather to examine them from a sociological perspective through the meanings that human actors ascribe them, thus favouring a qualitative approach for data collection and analysis (Day, 1993). For instance, one of the study objectives was to evaluate the UAE energy industry's vulnerability to hazards, but the project's interest in that pertains more to the vulnerability's social causes, such as the level of staff competence, the disaster and risk management measures implemented or the

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systems introduced to ensure the resilience of the system in the wake of a disaster, rather than the structural characteristics of the technological components of energy providers – which would still be viewed from a social lens (Dey, 1993; Flick, 2009). A benefit of using qualitative data was that it allowed a holistic approach to the issue of energy sector hazard security – whereas, using quantitative data might have been better suited to study one or two specific natural hazards threatening the industry, but this type of data could not examine man made threats and accidents, nor the challenges in implementing measures (Flick, 2009).

Having to account for various possible hazards meant that the research data had to be rich in information, which also characterises qualitative data because it is usually expressed through verbose descriptions and opinions rather than concise measurements (Keele, 2012). Therefore, deep analysis of the same piece of data could reveal more detailed and even unforeseen information on the examined issue and local context, which can help recognise the significance of linked variables (Keele, 2012; Khan, 2014). A further consequence of qualitative data's information wealth and flexibility is that it can be collected from relatively few expert sources, which helps overcome the difficulties of research in novel fields with its corresponding lack of existing knowledge (Rao and Perry, 2003), such as the research study presented in this thesis. To that end, it often employs purposive sampling, which helps easily collect participant observation data to fully use their insights (Saunders et al., 2009; Keele, 2012). Reliance on a small and subjective number of expert sources creates threats to the research's reliability (e.g. introduction of observer bias), but these can be countered through a critical evaluation of the obtained information and an attempt to verify it (Saunders et al., 2009), which this study also performs via a focus group interview to test the proposed recommendations.

4.7 Research Instruments

The researcher used two types of data for the purpose of conducting the research presented in this thesis. First and foremost, primary qualitative data was collected through interviews to utilise the expertise of local practitioners,

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and furthermore, secondary qualitative data was also employed to inform and verify the former data set.

4.7.1 Primary data – Semi-structured Interviews

Interviews are a good method to view the examined topic from the participants' perspective (Alshenqeeti, 2014). The fact that interviews are interactive, unlike surveys, for instance, means the gathered data has more depth, as the subjects have more room to express their opinion, and the researcher has the chance to press for clear answers or focus on emerging topics (Kvale, 2003; Alshenqeeti, 2014).

Interviews fall into three categories, each with its own merits and weaknesses. Structured interviews are rigid in form and dependent on a specific list of questions that is settled in advance, and that should not be altered (neither the ordering nor the content), thus having little capacity for moving away from the central themes examined in the pre-set questions (Edwards and Holland, 2013; Saunders et al., 2009). Often, questions in structured interviews are closed, with a list of possible answers for the participant to choose from, while the interviewee's personal input may be sought through a separate question at the end, having a supplementary role (Mathers et al., 1998; Saunders et al., 2009). This is because structured interviews seek to collect and examine structured data rather than trying to extract large amounts of detailed information from the participants, and as a result, the main benefit of such interviews is their ability to increase the findings' generalisability (King and Horrocks, 2010). These traits make structured interviews more suitable for quantitative research, as they resemble questionnaires and are inappropriate for this project (Saunders et al., 2009).

The opposite of structured interviews is unstructured or in-depth ones, which are informal in tone and without a pre-set list of questions – instead, the interviewer discusses one or two general topics with the participant, whose responses shape the following questions (Mathers et al., 1998). Although unstructured interviews may reveal deep insights into a phenomenon, they tend not to focus on particular themes (Saunders et al., 2009). In fact, unstructured interviews are more akin to normal conversations, with both the researcher and

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the participant being encouraged to address relevant issues as they emerge (Guest et al., 2013). At the same time, it is almost impossible for the data gathered from unstructured interviews to be representative of the population (King and Horrocks, 2010).

Between these two types is the semi-structured interview type, which is the one that is employed in this project. Semi-structured interviews use a list of predefined questions, which can be both open-ended and closed-ended or topics that need to be addressed, depending on the issues under investigation and the researchers' interviewing skills (Saunders et al., 2009). However, contrary to the structured interview, the semi-structured one does not adhere to the pre-set questions strictly, instead allowing the researcher to change the order of the questions so that the discussion follows a more natural flow, to remove some questions entirely if they have been inadvertently addressed by a participant, to ask for and respond to requests for clarifications in order to ensure that the information is transmitted and received correctly, to make follow-up inquiries, to ask the participant to elaborate or to shift attention and focus onto an interesting point mentioned (Bjørnholt and Farstad, 2014; Bryman, 2012). As such, they provide both flexibility and a higher degree of reliability than the unstructured interviews, and additionally, the data collected via semi-structured interviews is more comprehensive than the amount of detail gathered via structured interviews (Saunders et al., 2009). The semi-structured approach to qualitative interviews thus allows the exploration of the topics of interest to this research, while at the same time making the most of the participants' expert knowledge without the danger of the discussion stirring off-subject (Bryman, 2012). Interview schedule is presented in appendix 1.

4.7.1.1 <u>Focus Group Interview</u>

To assess whether the recommendations derived from the work are pertinent to the Dubai context, a focus group interview was conducted. The method was chosen, as focus groups which consists of gathering perspectives from a small group of relevant individuals via open, yet moderated discussion (Kamberelis and Dimitriadis, 2013). In essence, this discussion was conducted with 5 other experts than the study's participants, similarly following the structure of the semi-structured interview.

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This approach was selected first and foremost due to its application to exploratory and explanatory studies that expand upon insufficiently explored phenomena (Carson et al., 2001), such as the one in question. Focus group interviews can produce more truthful feedback on any topic, as participants themselves stimulate each other to contemplate issues from various perspectives (Kamberelis and Dimitriadis, 2013). Thus, participants are more likely to offer unfiltered insights based on what others share, especially when there are no obvious status differences within the group – as such the participants were chosen based on a unitary selection criteria. To ensure that the candidates were well versed in the topics pertaining to disaster and crisis management, as well as resilience and sustainability within the Emirati energy sector, the sampling criteria used was largely the same as the one employed for the primary data collection (as presented in the upcoming Section 4.8.) – the only differences being that lecturers were also considered, as their theoretical and practical expertise was sought out, whereas the current place of employment was considered irrelevant to the discussion.

The goal of this focus group was to ascertain whether the recommendations offered to improve the resilience of the Emirati energy sector, as they have been illustrated in the developed conceptual framework (see Section 6.3.2.2.), were perceived as being adequately relevant and beneficial to the sector by experts with experience in this context. More specifically, the focus group interview was employed, on the one hand, to improve the validity of the study results and, on the other hand, to verify whether the recommendations provided were likely to aid the Emirati energy sector. The interview schedule that guided this group discussion is presented in Appendix 3.

4.7.2 Secondary Data

In addition to the primary data collected from the interviews, secondary data was gathered from various documentation. While documentary data may come from written (e.g. books, journals, newspapers, reports, websites, databases) or non-written sources – such as audio or video recordings (Saunders et al., 2009: 259), this thesis focused on the former. The main reasons for collecting data from documentations are the abundance and versatility of information that such sources can offer and the ability to provide an additional long-term

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perspective due to its archival nature (Tight, 2019; Zikmund and Babin, 2007). Even more so, procuring knowledge from documentation reduces the bias in the practice of data gathering, as the documentation is accessed relatively easily and with little additional costs for the researcher while at the same time acting as a means of validating the information obtained from the primary data (Saunders et al., 2009). The main detriments of examining documentary sources can range from its inaccessibility to disorganised or improper means of storage or to the content itself – which may be damaged, incomplete, inaccurate or difficult to understand due to the use of localised terminology that is not explained (Zikmund and Babin, 2007). However, using documentary data in parallel with other data sources and subsequently analysing the multiple data sets through triangulation increases the validity of gathered data overall (Tight, 2019).

Even though there is limited literature on the UAE energy industry and its resilience to disasters, some existing studies along with data from UAE industry providers could help contextualise the primary data findings (Dubey and Krarti, 2017; McClean, 2018). Additional sources of information for this project were domestic and international reports about the incidents that the UAE energy infrastructure had faced in the past, as well as emergency and contingency plans prepared by international authorities, energy providers and emergency respondents, guidelines for emergency preparedness, recovery and response that had outlined the best practices that the UAE had followed in the pursuit of building the vulnerability of its energy industry. The main reason why secondary data has been collected for this work is that it has been validated through peer review, which means it was a valuable tool to contrast and verify the study's results against current knowledge, bolstering its reliability (Johsnon, 2014).Focus group questions that are used for the study are presented in appendix 2

4.8 Sampling Type and Sampling Criteria

Sampling refers to the techniques and the means employed in order to gain access to the population or the candidates who are most fit for addressing the research questions, and as such, sampling can make use of a multitude of

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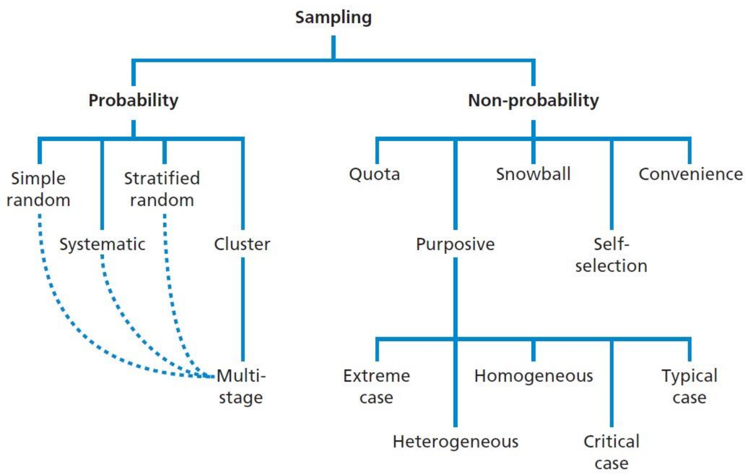
either probability or non-probability techniques based on the representativeness of the entire population, as presented in Figure 31 below (Saunders et al., 2009: 212-213). Because of this, probability sampling tends to be utilised in studies that collect and analyse data via quantitative methods that reveal trends, while non-probability sampling is more suited for qualitative studies that focus on examining the specific characteristics of a non-representative group (Ritchie et al., 2003).

Figure 31: Sampling Techniques



Source: Saunders et al. (2009: 213)

The selection of the sampling types has been based on Saunders et al. (2009: 234) decision tree (Figure 32) and was influenced by the following attributes. First and foremost, the data could not be collected from the entire population given the particularities of the studied phenomenon (i.e. resilience in the UAE energy sector). The individuals who could contribute to the study were those possessing relevant knowledge of UAE energy security and are difficult to identify; thus, the sampling style could not be random – instead, there was a need to target specialists who could pertinently address the questions posed directly. Secondly, statistical inferences did not need to be made, as the data that is collected is qualitative. Thirdly, the sample did not need to be representative, given the fact that this is an interpretivist case study research. However, as there is a limited number of specialists in the energy field in the UAE, a degree of representativeness could be achieved even with a lower participant number. Even more so, the research is exploratory and explanatory;

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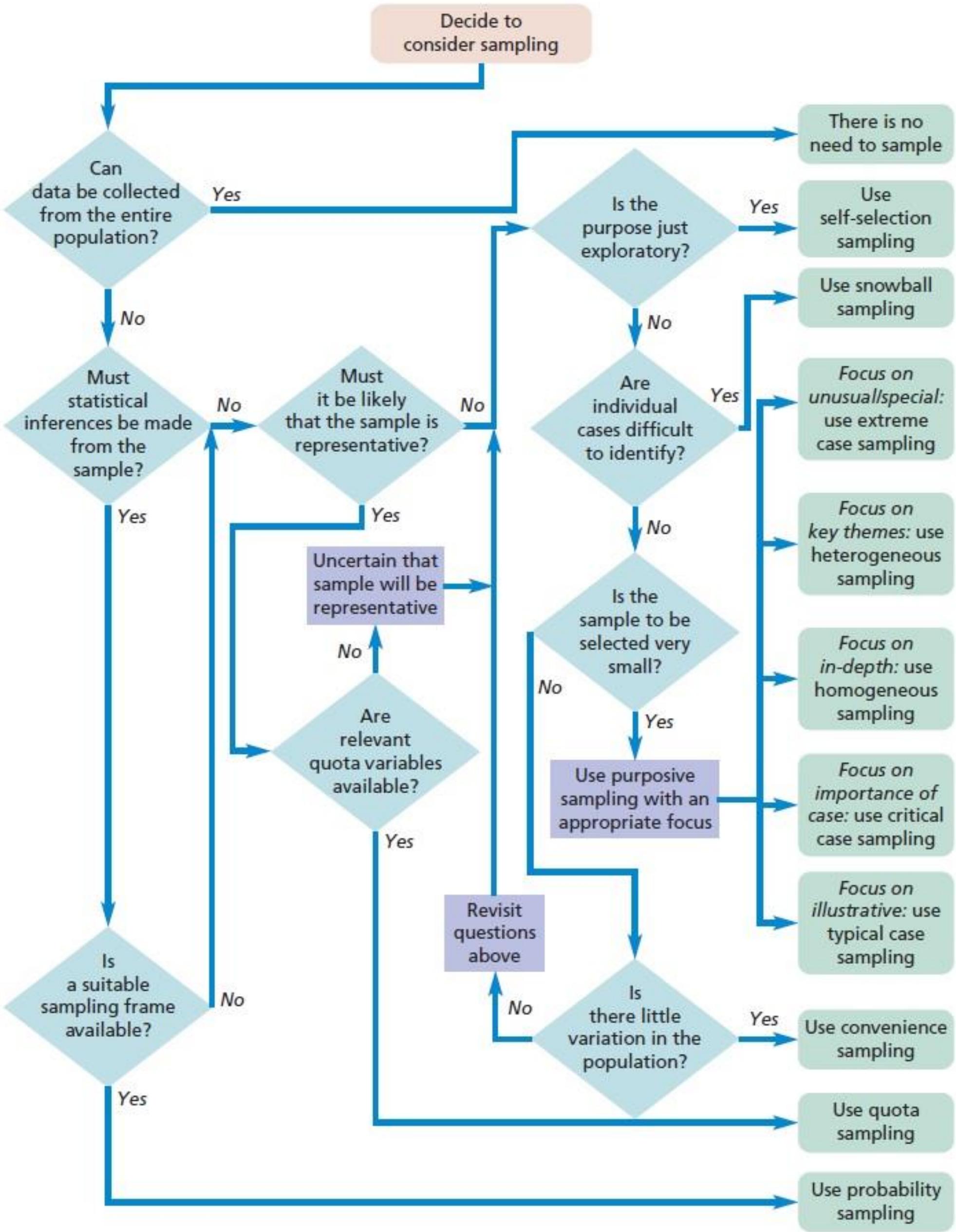
therefore, the sample size needed for such an investigation would be relatively small to ensure that the data gathered is sufficiently comprehensive to avoid the unnecessary repetition of information. As a result, to ensure that the data could be collected from a varied sample and notably since the research is focused on exploring the UAE energy sector in general – and not an Emirati energy company in particular, the researcher decided to employ two types of sampling, respectively snowball sampling and purposive sampling.

Figure 32: Sampling selection decision tree



Source: Saunders et al. (2009: 234)

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On the one hand, purposive sampling was selected as it is consistent with the effort to acquire primary qualitative data from key sources who could provide invaluable, detailed and relevant insight in relation to the research questions, due to their knowledge and experience (Keele, 2012), in this case, experts in UAE energy security. Furthermore, as the data is collected directly from authorities in the field, the margin for errors is considerably lower when compared to other non-probability sampling types (Bryman, 2012). More specifically, a homogeneous purposive sampling strategy was chosen, as the study focuses on providing a comprehensive perspective on the resilience interventions in the energy sector, but the decision was also influenced by the lack of extreme variations expected among the field practitioners (Saunders et al., 2009). Homogeneity was ensured by employing inclusion and exclusion criteria (found in the subsection below), which were necessary to ensure the informants' usefulness to the study since purposive sampling depends on the participants' competence and reliability (Tongco, 2007).

However, the main detriment of purposive sampling is the researcher's bias, as the sample population is selected based on the researcher's own judgement (Saunders et al., 2009). Therefore, in order to counteract and minimise this potential bias, the researcher also employed the snowball sampling technique, which consists of a chain referral method that encourages participants to identify and refer suitable people to participate in the study. Such a sampling technique allows the researcher to contact suitable candidates when participants are difficult to locate (Atkinson and Flint, 2004, Saunders et al., 2009). Thus, the introduction of snowball sampling and purposive sampling allowed the researcher to reach a wider variety of candidates through participant referrals, which are inexpensive and easy to implement (Babbie, 2008). However, the main detriment of this technique is the selection bias that accompanies it, as participants would more than often refer to potential candidates the people they know well (Atkinson and Flint, 2004: 1044). Considering that this research employs two distinct sampling types, this issue did not constitute a major disadvantage. Even more so, the goal of gathering and analysing primary data from experts in the Emirati energy sector was to collect data that is topical and high in quality, as the specialists are trained and

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have experience with resilience within their field. The participants were asked to refer other candidates who were well-versed in the subject matter, and more importantly, the participants refered other specialists for whom they could vouch, as they have at one point worked together. Increasing the sample size through snowball sampling only helped increase the reliability of the gathered data and thus of the study results, as the people interviewed have been suggested by independent experts who considered the proposed candidates highly competent and knowledgeable, thus specifically suited for approaching this task professionally and reliably.

The sample size was decided to be twenty (N=20) participants. While the size largely depends on the research objectives, a sample of this size is generally considered sufficient for non-heterogeneous groups (Guest et al., 2006). Having between ten and thirty participants would enable the researcher to ensure a degree of representativeness of the study without falling into the pitfall of interviewing too many individuals who might have limited knowledge in the sphere, and who might provide the researcher with the depth of details and expertise to answer the research questions (Guest et al., 2013).

Therefore, given that the interviews were held with UAE nationals and that all the personnel referred through snowball sampling spoke Arabic as their native language, the interviews were conducted in this language. As this likelihood was very high considering the contacted organisations – all from the UAE – the researcher translated the interview scheme, attached in Appendix 2, from English to Arabic. The interviews were conducted in Arabic to allow the collection of unfiltered data, unhindered by any potential language barriers that could result in misunderstandings. Once completed, the researcher selected the relevant answers from the interviews and translated them into English so that a larger audience could read and understand the public version of this project. The interviews all largely followed the interview schedule (Appendix 2) that the researcher developed before contacting the researchers' participants; however, the interview schedule was modified as the research progressed to accommodate emergent findings following the semi-structured interview method.

4.8.1 Participant Presentation

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As a first step towards identifying the potential interviewees through purposive sampling, contact with the upper management of energy production facilities and with energy regulators in the UAE was made to request permission to conduct the interviews with their employees and seek assistance with participant recruitment. The contacted representatives consented to allow the interviews with their employees and offered a list of candidates that fit the inclusion and exclusion criteria (explained below). As an additional step that was introduced to ensure that the sample size would reach the desired number and diversity of participants, snowball sampling was also employed, with the researcher also kindly asking the research participants for their help with further referring their business partners, co-workers or other acquaintances who met the inclusion and exclusion to participate in the project.

The energy production facilities deemed relevant for this section include the facilities for extracting and refining petroleum products and power stations, and as such, the following companies were contacted: Shuweihat Emirates Water and Electricity Company (EWEC), Al Taweelah Jebel Ali, Abu Dhabi National Oil Company (ADNOC), Madinat Zayed Power Plant, Abu Dhabi Oil Refining Company (TAKREER), Adyard ABU Dhabi LLC, Bilfinger Deutsche Babcock Middle East. To further enhance and diversify the findings, the researcher also sought to include perspectives from governmental authorities that act as energy regulators in the UAE, which from members of authorities comprising the Emirates National Grid project, which interconnects the following four state-led institutions: Etihad Water and Electricity (EWA), Department of Energy – Abu Dhabi, Dubai Electricity and Water Authority (DEWA), and Sharjah Electricity, Water and Gas Authority (SEWGA).

The list of companies and institutions that have been approached for participant selection was significant simply because it was expected that only a small number of approached enterprises would be willing to participate in this work. Firstly, from the contacted companies, ADNOC was the first that agreed to the invitation to participate, followed by Madinat Zayed, Shuweihat EWEC, and Adyard ABU Dhabi LLC, and additionally, ADNOC participants also suggesting former colleagues from ADNOC’s subsidiary, the Abu Dhabi Oil Refining Company (TAKREER). Secondly, from the contacted governmental

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organisations, only EWA and DEWA have agreed to participate, from which three candidates in total who accepted to be interviewed. The other contacted institutions have not responded to the requests for participation in the study.

4.8.1.1 4.8.1.1. Inclusion and Exclusion Criteria

Regarding the inclusion criteria for the potential participants, the main focus was on the specialists’ experience and familiarity with security in the energy sector. Therefore, it was decided that all the potential participants would need at least 8 years of experience working in UAE energy production facilities. Furthermore, to ensure that the participants were not only broadly knowledgeable in the operation of the energy sector but that they also had a firm grasp on relevant matters surrounding the resilience, risk management and vulnerability of the energy infrastructure, all candidates were required to have held a position with relevant responsibilities (e.g. managers). Contact with individuals who did not currently or previously occupy a managerial position in the organisation was also considered as a possibility if the researcher experienced difficulties (e.g. could not reach or obtain permission, lack of available personnel during the available schedule, etc.) in finding relevant participants for the study, however, such an option was not utilised, and all of the recruited study participants fulfilled the initially-set criterion.

The exclusion criteria study included, first and foremost, all friends, relatives or acquaintances of the researcher who were not eligible to participate to safeguard the data quality and integrity and minimise both researcher and participant bias. Secondly, all individuals who belong to vulnerable groups were excluded from participating in the study. Thirdly, individuals who represented extreme cases, such as employees of facilities under construction, facilities no longer functioning or who have not worked in the sector for the past 5 years, were excluded from the candidate pool. Last but not least, the candidate selection process for this research entirely excluded individuals who did not have the required experience in security and disaster management issues, even if they met all the inclusion criteria indicated above.

4.8.1.2 4.8.1.2. Participant Details

The study has gathered primary data from, 20 research participants, with seventeen (i.e. 17) candidates belonging to private organisations and three (i.e.

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3) candidates coming from public organisations, as detailed further below in the participant list. All of the candidates have held managerial positions or were, at the time when the interviews were conducted, employed in supervisory positions across institutions of the Emirati energy sector, having experience with both resilience and disaster management practices. The participants' ages ranged from 32 to 67 years old – the exact age of each candidate is not disclosed at any point in the study, to ensure the anonymity of each participant.

For ease of understanding and to preserve the anonymity and confidentiality of the participants, their names are coded using the following marker: P1, P2, P3, …, P19, P20, where "P" stands for the participant, the decision to refer to the specialists as such being made to both anonymise the data and facilitate its systematisation by easing the discussion and analysis. All of the interviewees have held managerial positions, but once again, for the sake of confidentiality, the exact rank of their managerial positions and departments are not revealed in this research. Sparing details are provided when the understanding of the interviewee's input hinges upon some knowledge of their technical expertise, experience or occupation.

This being said, the participants and their associated institutions are presented below in the order that their institution has agreed to take part in the research for this study:

<u>Private Institutions</u>

- **Abu Dhabi National Oil Company (ADNOC)** – P1, P2, P3, P4, P5
- **Madinat Zayed Power Plant** – P6 & P7 (from the Thermal Power Plant), P8 & P9 (from the Oil Power Plant), P10 (from the Solar Power Station)
- **Shuweihat Emirates Water and Electricity Company (EWEC)** – P11, P12
- **Adyard ABU Dhabi LLC** – P13, P14, P15
- **Abu Dhabi Oil Refining Company (TAKREER)** – P16, P17

<u>Public Institutions</u>

- **Etihad Water and Electricity (EWA)** – P18, P19
- **Dubai Electricity and Water Authority (DEWA)** – P20

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The goal of gathering primary data from a wide variety of private and public institutions was to present the findings from knowledgeable employees of different and diverse organisations to gain a novel and comprehensive insight into the needs of the UAE energy sector. Out of the above-mentioned participants, the following have agreed to participate in the study as a direct result of the snowballing sampling method: P16, P17, and P19. The others were directly suggested by the institutions' representatives as a result of purposive sampling. It should be mentioned that an additional 11 candidates from various organisations have been contacted; however, they have not responded or refused participation. It is important to mention that participation in the study was purely voluntary; therefore, the candidates who refused to participate have not been penalised in any way, while those who agreed to participate have also not gained any compensation or benefits for their involvement.

Table 5 presents the profile of the participants, along with the duration of each interview and the date when the interview occurred. The interviews with the first five participants were conducted in, 2020, while the remaining 17 were conducted in, 2021. Each interview lasted between 25 and 57 minutes, with an average duration of around 42 minutes. This time does not include the introductory session when the researcher discussed the thesis' goals and the roles and responsibilities of both sides.

4.9 Primary Data Analysis

The primary data analysis was performed through coding, which according to Creswell (2014: 555), is an essential procedure for interpreting primary qualitative data that consists of identifying and extracting reoccurring codes, categories or themes from the information gathered through interviews. As previously mentioned, the interviews were conducted in Arabic only after the data analysis process was concluded; the quotes used for this project were translated into English to ensure that the researcher does not misinterpret any of the data due to the pre-analysis translation. As a result, the coding was carried out manually once the primary data is collected. The coding process was carried out in several phases, starting from a more generic categorisation of commonly encountered codes and developing into a more targeted

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Table 5: Interviewing Process Details

	INSTITUTION	INTERVIEW DATE	INTERVIEW DURATION
Participant 1	ABU DHABI NATIONAL OIL COMPANY (ADNOC)	15 July, 2020	53 min
Participant 2	ABU DHABI NATIONAL OIL COMPANY (ADNOC)	17 July, 2020	49 min
Participant 3	ABU DHABI NATIONAL OIL COMPANY (ADNOC)	20 July, 2020	57 min
Participant 4	ABU DHABI NATIONAL OIL COMPANY (ADNOC)	22 July, 2020	37 min
Participant 5	ABU DHABI NATIONAL OIL COMPANY (ADNOC)	24 July, 2020	51 min
Participant 6	MADINAT ZAYED: THERMAL POWER PLANT	25 March, 2021	28 min
Participant 7	MADINAT ZAYED: THERMAL POWER PLANT	26 March, 2021	29 min
Participant 8	MADINAT ZAYED: OIL POWER PLANT	30 March, 2021	25 min
Participant 9	MADINAT ZAYED: OIL POWER PLANT	1 April, 2021	37 min
Participant 10	MADINAT ZAYED: SOLAR POWER PLANT	6 April, 2021	40 min
Participant 11	SHUWEIHAT EMIRATES WATER AND ELECTRICITY COMPANY (EWEC)	16 April, 2021	44 min
Participant 12	SHUWEIHAT EMIRATES WATER AND ELECTRICITY COMPANY (EWEC)	22 April, 2021	42 min
Participant 13	ADYARD ABU DHABI LLC	18 August, 2021	35 min
Participant 14	ADYARD ABU DHABI LLC	20 August, 2021	38 min
Participant 15	ADYARD ABU DHABI LLC	10 June, 2021	46 min
Participant 16	ABU DHABI OIL REFINING COMPANY (TAKREER)	25 November, 2021	48 min
Participant 17	ABU DHABI OIL REFINING COMPANY (TAKREER)	28 November, 2021	45 min
Participant 18	ETIHAD WATER AND ELECTRICITY (EWA)	5 January, 2021	43 min
Participant 19	ETIHAD WATER AND ELECTRICITY (EWA)	7 January, 2021	41 min
Participant, 20	DUBAI ELECTRICITY AND WATER AUTHORITY (DEWA)	17 January, 2022	55 min

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identification that ultimately selects a variety of distinct, diversified and descriptive themes (Corbin and Strauss, 2014; Saldana, 2013). The more steps a researcher employs, the more specific the resulting themes and subthemes will be (Ritchie et al., 2003). However, the coding process is dependent on the researcher’s pattern recognition ability, and as such, to ensure that the identified codes and themes are characteristic of the gathered data, a good approach is to use the participants’ own words and phrases when determining the codes and when developing the coding scheme (Ritchie et al., 2003: 222). Of course, summarising or synthesising the data can be done, and this approach allows a higher level of precision; however, this process should not be employed in the first stages of coding; instead, it should be introduced once the data has already been scanned for common themes, and usually to portray a collective message (Saldana, 2013).

4.9.1 Data Collection and Analysis: Interview

The interviews were conducted online due to the Covid-19 pandemic, which ensured the participants’ and researcher’s health and safety throughout the entire process.

Coding Scheme

The primary data was analysed via coding, the goal being to identify and extract recurring themes or codes from the transcribed interviews. The transcriptions were perused multiple times, with the researcher identifying the key issues and the common themes upon each reading to identify the material that helps to address the research question for this work. Those themes were subsequently revised and altered following the perusal of the other interview material. More specifically, the process of coding occurred in three separate stages, as such: the first stage implied the highlighting of larger fragments of the work and extracting the main idea from the text in a very detailed manner – and this step resulted in the creation of a wide array of themes, which were determined for each interview separately. Afterwards, the second stage consisted of grouping the themes identified in the first phase based on common patterns, and this process occurred incrementally once several interviews were conducted and transcribed. As a result, the preliminary coding of the first interviews revealed three patterns, respectively related to the technical vulnerabilities of the UAE

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energy sector – specifically related to the infrastructure, to the capacity to improve disaster response and mitigation at the organisational level, and to the social factors that influence resilience building. The third step, which was conducted and completed only after all of the interviews had been completed and transcribed and after the first and second phases were completed for all the primary data, consisted in further analysis of the interview themes, the purpose being to identify precise codes that summarise large quantities of data.

The interviews were conducted through online communication apps in Arabic so that the answers could be examined and presented with as few modifications as possible – all of which would solely come as a result of the translation into English. In essence, the interviews have been transcribed to ease the analysis as soon as they have been conducted; however, they have not been translated at this stage, as modifying the raw data before the analysis is not advised to reduce any possible misinterpretations. Furthermore, the coding process required multiple readings and annotating at several stages (as the process was manually carried out), with both procedures taking a large amount of time. Afterwards, the researcher selected the material that could be relevant to the research questions and objectives by highlighting it directly on the transcripts, afterwards once the coding scheme was determined, the information that could be included in the text as a means of providing evidence for the generated codes and of the emergent ideas has been translated and is featured in the form of direct quotes by the participants.

The coding scheme that resulted from the primary data analysis was easily catalogued to reflect some of the dimensions of resilience identified in the theoretical framework, more specifically, the resources affected when resilience is not sought out (i.e. impacts), and this structure was also determined by the fact that while participants did refer to the actions required to improve resilience (i.e. conditions), these comments were, for the most part, made about a specific factor. Afterwards, each code was divided into the same two major sub-codes, vulnerabilities and opportunities, as the perceptions and opinions of the participants regarding all issues discussed were split, and the interviews revealed either largely positive or negative implications. Finally, each sub-code

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is further broken down into larger themes that, for the most part, echo the indicators of resilience established in Chapter III (Theoretical Framework) to more specifically assess resilience within the Emirati energy sector as a whole. The resulting coding scheme is the following:

A) Technical and Technological Resilience

- Vulnerabilities

  Theme A: Infrastructure and System Reliability

  Theme B: Technological Progress and Hardware Hardening

- Opportunities

  Theme A: Power Generation Diversity

  Theme B: Backup Power Deployment and Redundancies

B) Organisational Resilience

- Vulnerabilities

  Theme A: Adoption of Risk Management Practices

  Theme B: Decision-making and Coordination

- Opportunities

  Theme A: Adaptive Capacity

  Theme B: Policy Reform and Capacity Building

C) Economic Resilience

- Vulnerabilities

  Theme A: Financial Stability

  Theme B: Investment Opportunity

- Opportunities

  Theme A: Buying Power

  Theme B: Availability of Emergency Funds

D) Social Resilience

- Vulnerabilities

  Theme A: Management Training

  Theme B: Multi-agency Collaboration

- Opportunities

  Theme A: Personnel Training

  Theme B: Social Support

  Theme C: Sustainable Development

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Lastly, it is important to note that the resulting codes, sub-codes and themes that ultimately emerged vary in size and complexity, reflecting the participants' unbiased contribution.

4.10 Research Reliability, Validity and Generalisability

Almost all of the research choices, be them regarding philosophy, approach, strategy, data collection and analysis methods, as well as the sampling type and sample size selected, affect the study's reliability, validity and generalisability (Saunders et al., 2009). During the development of this thesis, the researcher could have faced issues in relation to research validity, reliability and generalisability throughout, as explained below.

4.10.1 Reliability

Research reliability refers to the study's ability to produce replicable findings under similar conditions (Saunders et al., 2009). Throughout the study, reliability has been decreased by some methodological choices, for instance, by selecting the inductive approach, employing purposive sampling, and choosing to conduct a qualitative study that collects primary data through semi-structured interviews instead of structured interviews or surveys (Saunders et al., 2009). However, it is important to note that the study's reliability has been increased through several other choices as well. For instance, not opting for a realist philosophical perspective that might produce unreliable findings as details are rarely considered (Walliman, 2016), and instead using interpretivism to pinpoint the core issues. Furthermore, the possibility of conducting a study that could result in reproducible findings has been increased through additional means. According to Golafshani (2003: 601), reliability in qualitative studies can be ensured by a thorough "examination of trustworthiness", guaranteeing a high degree of validity by ensuring that the issues selected under investigation are relevant to the topic.

Additionally, the findings needed to be representative of reality in the sense that they need accurately depict real-life situations, and this could be achieved by

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selecting participants who have a high degree of credibility (Pellissier, 2007). To explain, the reliability of the research process in this study was further enhanced by the fact that the primary data was gathered from reliable participants, who have had to reach a high standard of expertise in terms of employment, subject-related knowledge, experience and as well by being referred to as a specialist in the field of resilience in the energy sector. This high standard was being imposed by the inclusion and exclusion criteria detailed in Chapter V – Data Analysis.

Similarly, the researcher chose the case study strategy to enhance the study's reliability; however, it is important to note that case studies are still considered difficult to replicate if the context and circumstances are too extreme (Yin, 2009). As such, the context is limited to the UAE energy sector and the findings would be able to be replicated in studies conducted in a similar sector in other GCC countries that share some socio-cultural similarities with the UAE (e.g. the KSA). Furthermore, the study’s reliability has been enhanced by the decision to not solely rely on collecting primary data, as the secondary data allowed the researcher to inspect the consistency of the findings at various points in time (Johnston, 2014).

4.10.2 Validity

The study's internal validity can be defined as the study’s capacity to identify and extract information relevant to the examined phenomenon (Leung, 2015). The validity of a study is dependent on making informed choices, notably during the data collection and analysis processes, although choosing an inductive approach instead of a deductive one for a field that is insufficiently explored, as is the case of this research, can also ensure that a lack of existing data does not threaten the validity (Reichertz, 2004). At the same time, while quantitative studies that rely solely on primary data collection are characterised by a higher degree of generalisability, the validity might suffer as the participants are much more likely to be disengaged from the research process or to misunderstand questions, thus unknowingly resulting in wrong assertions (Walliman, 2016).

On the contrary, qualitative studies tend to result in a higher degree of internal validity, as the study participants were not only be encouraged to ask for

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clarifications from the researcher but are also more inclined to offer candid answers in such intimate circumstances (Leung, 2015). The choice of the primary data collection method and the semi-structured interview encouraged these tendencies, as the discussion depended on building rapport with the participants, in order to enhance their involvement in the study (Saunders et al., 2009). Similarly to reliability, the internal validity of the research study presented in this thesis was enhanced by employing a multi-method approach that considers peer-reviewed documents during the analysis (Tight, 2019).

4.10.3 Generalisability

The generalisability of the data, commonly perceived as the external validity of the research, refers to the ability of the findings to be representative of the entire population within different contexts or even during different periods (Duff, 2006; Leung, 2015). Although generalisability is much more difficult to attain in qualitative studies than in quantitative ones and largely in interpretivist research than in its positivist counterpart (Saunders et al., 2009), certain steps and methods may enhance the degree of external validity. Although the sample type employed is non-representative of the population as a whole, the study sought to explore the behaviours and opinions of a particular set of individuals – namely Emirati energy security specialists, and as such, representativeness was not an issue. Nonetheless, by collecting data from a variety of homogenous and non-homogenous participants, the representativeness of the findings could be significantly increased (Flick, 2009). Therefore, to increase generalisability, the primary data was gathered from, 20 participants, the number of chosen experts being double the recommended 10 individuals for a qualitative study investigating a phenomenon that depends heavily on its context (Guest et al., 2013). Moreover, the representativeness of the findings was also enhanced by ensuring that the participant pool consists of a diverse cast of industry specialists who were selected to have varying degrees of experience in the sector, as well as different backgrounds to ensure that the knowledge they possessed – and could thus share throughout the discussions – was exhaustive.

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Even more so, determining and following a specific set of inclusion and exclusion criteria for the sample population, which this thesis has done, is another way of ensuring that the findings can be replicable, if similar criteria are employed in a similar setting (Hulley et al., 2001). Although the findings of this research are very likely to not be generalisable outside the Arab and Emirati energy sector contexts, generalisability is increased within this setting as no extreme cases have been examined. This step was taken to ensure that the gathered data applies to the investigated sector – and not solely to a particular organisation. All the study participants were employed or have been employed at sizable companies that have a history of reliability and stability within the UAE energy sector, and thus the individuals contacted could provide an accurate and generalised representation of how the sector functions and of how it has evolved in recent times.

4.11 Research Ethics and Safety

In addition to obtaining ethical approval (see appendix 3) from the university and seeking research access from the UAE energy industry, a range of ethical issues had to be addressed throughout the research collection and analysis stages.

As the study is qualitative in nature, and more importantly, taking into account the fact that primary data from participants had to be acquired as part of the study, the researcher took the necessary steps to ensure that the rights of the participants were upheld, as well as to address the requests and concerns of all participants. It should be noted that the researcher did not seek out members of any vulnerable groups and that all the participants are adults. Furthermore, the researcher ensured that the safety of all parties involved was of the utmost importance, considering the Covid-19 pandemic, by taking the recommended safety precautions. As such, the interviews did not occur in-person but online through practising social distancing, safety and sanitation rules. The researcher avoided common areas to minimise the risk of contracting or spreading the virus.

Once a suitable group of candidate participants had been selected and before continuing to interview them, they were required to provide written consent. To

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ensure the individuals were adequately informed, the researcher provided each participant with an information sheet and a consent form containing an outline of the study's background, intended aims and methods, and a list of their rights as participants and what was expected from their participation. The documents also include the researcher's contact information, which could be used to request further information on the project or to request a withdrawal from the process (referencing the aforementioned unique participant identifier). The consent form specifies that participation is anonymous, non-binding (withdrawal being possible) and voluntary. This consent form included both offering consent to participate in the study and also to record the conversations, with the mention that the audio recordings would only be accessible to the interviewer for a limited time and would not be released to the public or third parties at any point, thus ensuring both anonymity and confidentiality.

Moreover, each consent form is exclusive to each participant, who is identified by a unique identifying number. The possibility of withdrawal at any stage – prior, during or after the interviews – was stressed so that the people interviewed understood that their participation would be entirely optional and that they would not be compensated via any means for their collaboration. The documents were initially supposed to be given to the participants in double specimens to be signed, with one copy kept by the participant and one remaining in the researcher's possession until the project is completed and graded, afterwards being permanently destroyed. However, considering the emergence of the Covid-19 pandemic and the fact that the interviews were no longer carried out face-to-face but online (as explained in the next paragraph), the researcher obtained informed consent differently. As such, the researcher emailed each participant their assigned documentation a few days before the interviews so that the candidates would have the time to read them thoroughly – and to eventually ask questions regarding their participation or the study in general if they so wished. Once reviewed and upon deciding to participate in the study, the participants were requested to print out copies of the documents, sign and scan them, and afterwards send them back to the researcher via an email response. The participants were then informed to delete the email exchange and only to keep the physical copy of the forms. Similarly, the

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researcher printed each participant's scanned documentation, deleted the email exchanges and the electronic copy of the documents, and and then stored the physical copies under lock and key. This step was taken to minimise the potential of leaking sensitive information in the extreme case of an email security breach on either part (researcher or participant).

Throughout the preliminary phase, participants were encouraged to ask questions about the study, the goal being to develop a trusting environment based on information sharing and transparency so that the researcher can capture the real-life experiences and perceptions of industry specialists. This would guarantee that participants were well-informed of the study’s purpose and objectives beforehand and encourage them to offer information similarly transparently and openly – to the best of their capabilities, but nevertheless bound by their self-imposed limits. As such, the researcher also emphasised that all the information they shared should only be shared if the participants are comfortable doing so. Thus, participants’ psychological and physical well-being has been a top priority throughout this research; as such, the researcher sought to create a friendly and open environment that is free of judgement, especially transparent. To further this goal, the research did not employ any covert or deceptive research methods of data collection, and additionally, following each interview, the researcher scheduled time for a brief discussion and debriefing with each participant to provide and receive feedback.

The social distancing rules were observed to ensure the safety of the interview during the Covid-19 pandemic. Therefore, the interviews were conducted online via a video conference tool (i.e. Zoom) in private chat rooms that were secured via unique virtual numeric passcodes designated for each participant. In effect, the researcher created a new lobby for each participant so that nobody but the researcher and the participant would know their designated code. This was done in order to ensure that the information was provided without any intervention, interruption and especially without an intentional or unintentional audience, while also ensuring the privacy and integrity of the participants’ opinions. The Zoom meetings were accompanied by some technical difficulties initially, for both participants and the researcher, due to the lack of familiarity with this medium (notably with connecting the cameras, the microphones and

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headsets); however, the setbacks were minimal (i.e. than 10 minutes in each case), and none of the parties experienced issues throughout the interview process. No network interruptions were experienced during the interview process.

Withdrawing from the study was possible until the completion of the analysis and carried no repercussions for the participant. In the event of a withdrawal, a new interview with a substitute candidate could be arranged, or if it is too late in the analytical process, the findings would rely on the reduced sample size. The data corresponding to a withdrawing individual would be deleted as soon as their request was processed, meaning that all the available electronic information and hard copy documentation would be permanently deleted or destroyed beyond any possibility of recovery. None of the participants withdrew from the research developed in this study.

During the interviews, participants were allowed to express their opinions freely, without suggestions or assessments of their answers, as the main goal of the interactions was the collection of unfiltered, unbiased information relevant to the chosen topic. Before engaging in the interviews, the researcher also offered the contact details of mental health professionals that the participants could contact in case of experiencing distress during or after the private discussions, albeit this scenario was unlikely as the study does not seek out any sensitive or troublesome information from participants. Furthermore, participants were advised that they were free to pause the discussion should they feel any physical discomfort during the process.

The researcher also committed to ensuring the anonymity of the participants and anonymising all sensitive or identifying information that might be shared willingly or unwillingly during the discussions. The anonymity of participants' data was ensured by identifying them, throughout the published version of the project, only through their individual identifying numbers, complying with the, 2018 Data Protection Act and the, 2018 EU GDPR. Therefore, the sensitive data that was collected from participants (notably their own accounts of their experiences and the post held at specific companies) would either be pseudonymised (i.e. de-identifying specific information that could identify an individual via the use of pseudonyms – or in this case numerical codes) or

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completely anonymised. The researcher also shared with all participants the purpose of collecting such data (i.e. specifically for data processing), the estimated time for retaining the data and how the processed information would be shared with third parties (i.e. in an anonymised and compiled manner, in the form of a PhD thesis), as well as the fact that all raw data collected would be destroyed once the thesis was submitted and graded. The participants were also informed of their right to request the information they shared at any time before the project is handed out to the University and were also made aware that they could request their data be permanently deleted at any time before it has been analysed – and when it would thus be impossible to be identified and separated from the data shared by other participants.

More importantly, the researcher explained that the research data, as well as any personal information that the participants knowingly shared with the researcher during the interviews, would only be available to the researcher and used exclusively for the purposes of this research, while any sensitive or identifying information that participants unintentionally share underwent a process of redaction, pseudonymisation or anonymisation in its entirety, as it does not constitute the subject of the study. Physical copies of consent forms and audio tapes containing interview recordings were solely being kept in a locked cabinet, while electronic copies are being stored on a password-protected computer, with both of these locations being secure as only the researcher had a copy of the key and knew the password. Once the data analysis has been completed, notably after the final project has been graded, both data sets will be permanently deleted.

4.12 Summary

The methodology chapter explained the selection of research philosophy, approach and strategy based on the examined issues' background and the research objectives. The sampling, data collection and data analysis tools with which the research was conducted were chosen according to the study's approach and strategy, with qualitative data emerging as most suitable to the research design, while the instrument of semi-structured interviews was also comprehensively justified by the study's parameters. Recognising the

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limitations of using a small sample to generate primary data, the chapter also argued for its enhancement through the limited use of secondary data sources, thus increasing the results' validity. The target number of interviewed participants is twenty (N=20) experts from the UAE energy production sector, ranging from people employed at energy production companies, regulators, distributors, etc. Moreover, precautionary measures have been taken to ensure that not only willing individuals participate in the study but also that the participants' information is anonymised for their security.

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CHAPTER V: PRIMARY DATA ANALYSIS

5.1 Introduction

This chapter discusses and analyses the collected primary data, which was gathered in a raw format from the semi-structured interviews, and presents it in a structured and coherent manner to allow for an understanding of the interview material. The main sections of this chapter will be structured following the key themes identified following the completion, coding and analysis of the semi-structured interviews. The research used the interview schedule provided in appendix 3 and, wherever relevant, other additional questions and comments raised with the interviewees. Afterwards, the discussion moves to comprehensively explore and detail each of the identified codes, which are organised by: technical and technological factors, economic factors, organisational factors, and social factors; each discussion including both relevant vulnerabilities and opportunities, as the participants have identified them. The discussion ends with a summary of the main findings.

5.2 Code A: Technical and Technological Resilience

This section is dedicated to presenting resilience related to the Emirati energy sector's technical and technological features and components. The discussion starts by presenting the existing system's vulnerabilities and then it moves on to the opportunities for building a more resilient structure. Overall, the technical and technological resilience of the Emirati energy sector seems to be split between the idealised perspective of what progress in the industry should reflect and the more grounded reality, which shows that various physical elements of the infrastructure need to be upgraded. However, the UAE does seem to be heading towards a general overhaul of the emergency management and risk management system to diminish the existing risk, threats and vulnerabilities, striving towards an increase of reliability and efficiency of human systems and implicitly enhancing the resilience of the infrastructure as a whole. For the most part, the participants agreed that the infrastructure needs to be hardened via the adoption of new preventive technologies that could minimise the existing vulnerabilities (e.g. early warning systems), yet at the same time,

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the consensus was that the UAE energy sector is, by default, exposed to a wide variety of internal and external risks. However, one recurring issue was the dependence of Emirati energy actors on existing technologies, which is particularly true for the oil sector, which is nevertheless planned with appropriate redundancies in mind, and which seems reliable and resilient, despite some outdated technology. At the same time, the UAE has invested in alternate and renewable power generation facilities that are in line with the current international standards and practices. Indeed, the UAE's goal to move towards green energy by investing in nuclear, solar, wind and water as increasingly reliable power sources is well underway and cannot be denied.

5.2.1 Vulnerabilities

The project identified two vulnerabilities related to the technical resilience of the Emirati energy sector, namely the reliability of the existing infrastructure and systems, which is difficult to ensure due to the location of some of the facilities and stations, as well as the perceived stagnation in terms of technical progress and hardware hardening.

Theme A. Infrastructure and System Reliability

Infrastructure and system reliability is an indicator of technical resilience that refers to the capacity to ensure a reliable infrastructure at all times to facilitate rapid recovery during and after emergencies. The reliability of the infrastructure and systems refers to the capacity of the UAE energy sector to ensure a continuous output of energy, in essence, securing the stability of both the generation and distribution processes by performing frequent assessments of the potential threats, risks and hazards that may disrupt or otherwise negatively influence the power grid throughout the country (Chowdhury et al., 2021). Considering that this stability is key to rapid recovery, its main objective is ensuring that the infrastructure and its associated systems are reliable to increase resilience by strengthening security through policies that seek to identify and mitigate the most dangerous vulnerabilities. This theme was identified in all of the interviews, with all participants addressing the issue of systems and infrastructure vulnerability to various degrees; however, 11 out of, 20 participants (P1, P2, P4, P5, P8, P9, P13, P14, P15, P16, P17) criticised the UAE's energy facilities' capacity to increase the reliability of the infrastructure,

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5 out of, 20 (P3, P10, P18, P19, P20) adopted a neutral stance in relation to the infrastructure, while only 4 participants (P6, P7, P11, P12) positively discussed this issue.

When prompted about the changes they had witnessed while working in the energy sector regarding disaster planning and management, most of the interviewed participants acquiesced that their organisations, and the overall infrastructure, are still vulnerable to internal and external shocks. As P15 explains, "there is no denying that the energy sector will always be exposed to a lot of risks. Mechanical and electrical risks are normal and expected in all power plants […] Especially if we're thinking about the complexity of the systems and the possibility of human error, which cannot be completely removed", and his perspective has been mirrored by the majority of participants. In fact, internal risks have been mentioned by the participants the most in this context, and the general consensus is that the sector is a highly vulnerable one, being exposed to a multitude of internal threats regardless of location and even without taking into account more specific external risks such as the economic, socio-political and geographic factors unique to each country. As P18 puts it: "there is always a chance that someone messes up, that there is a systems failure, or that a piece of equipment deteriorates. This means that we need to dedicate more resources to identify rising threats, and especially those regarding the equipment, which has a rather short life span". Furthermore, P11 noted that for the energy sector, "every mistake, error or defect may lead to a disaster if it's poorly managed", adding that "this is exactly why we have specialised teams to monitor every component, process and decision". However, P4 emphasised the fact that while there is an increased dedication towards the "assessment, identification and analysis of external risks, sadly we do not apply the same principles for internal ones. I am sure that we could strengthen our internal resilience if we monitored and evaluated the performance of the personnel", and this may be because "it is expected that the workers know what they are doing, and that the supervisors are also doing their job, but we don't have a dedicated team of experts evaluating risks associated with human error – at least not at the micro level". In a similar manner, P16 acknowledged that "no one is perfect and no facility is secure enough to

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withstand all hazards", and related to this he continued to say that "we need to increase our efforts to identify and assess the potential human threats. I feel this is lacking at the moment, and we could easily work towards improving this because we already do this for the most common natural risks. We continually assess the likelihood of earthquakes, fires, sand storms, floods, so I think if we apply this to the potential of mistakes, we can strengthen our resilience". P10, on the other hand, said that he observed various colleagues throughout the years – and even found himself – forgetting or even skipping certain steps (e.g. announcing fixes on formal channels until they are done) simply because "sometimes, it is easier just to do your job and only afterwards tell the higher-ups of what went on". While understandable because many of the participants also complained about the number of reports and other policies required of them, which to many seem either pointless or simply too many (this issue is expanded upon in the upcoming Organisational and Social Impact sections), all of these issues hint towards a bigger issue. Namely, the Emirati energy sector seems vulnerable to internal threats, particularly those stemming from human error, as mentioned by several participants above, and this may be due to the workload associated with daily operations. While the participants seem to be largely aware of the ISO standards that the sector has adopted, and while the existing protocols for the physical infrastructure are applied, this application also seems to be focused significantly more on threats that are not passively generated by the personnel each day, leaving the sector open to such vulnerabilities.

Regarding the most commonly mentioned internal risks, it is also important to note that the participants who work in oil and gas power plants have, more so than others, emphasised chemical hazards as a major factor that could derail the stability and reliability of their company's energy system (e.g. P1, P4, P5, P8, P9, P12, P13, P15, P16), especially when considering the higher potential of "leakages, chemical fires or even explosions, which are difficult to control and recover from", as noted by P9. This being said, while some of the participants criticised the stability and reliability of the existing systems, many others also mentioned that these elements had been strengthened considerably in the past decade. For instance, P12 argued that the UAE energy sector has struggled to

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achieve this feat, given the circumstances and the environmental hazards that the infrastructure is exposed to, and because the UAE "lacks experience in disaster and crisis management". However, P12 also explained that despite this, the Emirati energy sector managed to implement a wide variety of solutions to fix the aforementioned issues, most notably implementing the ISO 50000 standard, the certification is "focused on increasing efficiency and sustainability". As P12 further stated, the campaign to introduce ISO standards within the UAE energy industry has been successful in the sense that it was proactively adopted by the industry companies, which tried as much as possible to implement its practices of reduced energy consumption and reduced carbon footprint within all facilities, as well as tried to instil the culture of efficiency at all levels. Regarding this standard, P12 concluded that its adoption has greatly improved the resilience and sustainability of the energy sector, however adding that the Emirati energy companies still need to work on other elements, yet these are mostly related to the organisational and social resilience and are therefore addressed in their upcoming, respective sections.

However, according to the participants, there is a need for the energy sector to remain up-to-date on the changes in the surroundings and environment – and notably to upgrade its disaster management and resilience strategy so that it reaches international standards. This perspective was notably expressed when the participants discussed the external threats and vulnerabilities of the Emirati energy sector's infrastructure, particularly in the context of the recent terrorist attacks on the Saudi oil production facilities, which have demonstrated the urgent need for the energy sector to develop capabilities for countering such as cyber-attacks and drone warfare. In particular, P2 argued that the perpetrator of the terror attacks is not as important – whether it is a state or independent terrorist group – as their goal is ultimately the same – "to disrupt the energy supply and security of the country". P1, P8, P13, P15, P16 and P19 dwelt upon the subject of cyber-attacks and intentional sabotage, especially if it is a state-sponsored attack. However, in the case of the energy sectors of the Gulf countries, there is a greater chance of the cyber-attack being orchestrated by a foreign state, which can cause such a large disruption.

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Consequently, P1, P8, P15 and P19 thought the UAE energy sector needed to cooperate with experts from other areas. For instance, P1 insisted, "cyber experts are sorely needed in our facilities as we need to bring them in for conferences and training – if we do not want to hire them, we can at least contract them for the training of out [in-house]". According to the research participants, currently, whenever the issue of a cyber-attack comes up in a meeting, it is not well understood by the parties involved as there is a lack of cyber experts to properly estimate the risk and comment on the feasibility of current operational capacity to prevent and withstand such attacks, as well as what actions should be taken if such an occurrence takes place.

On the other hand, participants who had little technical knowledge of this area commented that, based on their own experience, cyber-attacks would not deal as much damage as drone attacks, and they believe that their companies should place a greater priority upon preparing for physical attacks rather than cyber ones (P3, P4, P5, P9, P10, P13, P14, P16, P20). In effect, the threat of cyber-terrorism seems to be minimised by the participants, despite the growing number of such attacks worldwide, which show that these incidents can shut down entire facilities, and these findings show that this vulnerability is currently not properly addressed. Instead, a bigger emphasis is placed on other man-made threats, as put by P3, who argued that:

> "a lot of the new terrorist groups out there have managed to get drones; they are so easy to buy today. They even buy it from other terrorist groups or even countries! But it is so difficult to stop a drone – it is fast, flies below the radar, and can deal a lot and instant damage to us".

But, P3 added further on in the interview, "we are well aware of our weak points and vulnerabilities, and it is precisely because of this that we understand the need to improve". However, P3 has had more insight into this issue, actually addressing both how his company used to treat such attacks in the past and how their strategy is starting to shift, noting that "there have been so many drone attacks in the region in the last years… our staff members, execs, our collaborators, many ADNOC stakeholders fear similar attacks on our own assets […] so recently there were talks to buy anti-drone defence systems", adding that "we never expected this [drone] issue to become such a big threat,

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but I guess since they are so easy to get, it was inevitable", and concluding that "even if it took several attacks on our neighbours to make us realise the potential damage a drone can do to us, I'm glad we are taking the issue seriously now – before an attack happens". Indeed, P3's perspective hints at the shift towards preventive measures, the importance of which is tremendous in disaster and crisis management, notably when seeking to improve the safety of an infrastructure that provides power to an entire region. This shift in perspective and the importance that is starting to be placed on emergent threats, while presented by the participants as slow and ineffective at the moment, nevertheless indicates that the UAE energy sector is taking steps towards the right direction, however once again, the actual implementation of such practices seems to be lagging behind the international standards. In addition to this, P4 emphasised the exact location of the main Emirati oil production facilities –close to the coastline or in remote areas – predisposing these facilities to be targeted by air, which is more difficult to control than access by land or water. P5 mentioned the UAE had taken important measures to secure its infrastructure, but "we have not managed to – or even tried sufficiently to – prepare for such attacks, and there is an extremely high chance of such an attack doing more damage than any army or natural disaster could do to us". This perspective was mirrored by several experts, who overall believe that the UAE is, for the most part, unlikely to be affected by any natural disasters any time soon; instead, there was an overwhelming majority of interviewees who were concerned with the potential impact of man-made calamities disrupting the energy infrastructure, yet steps seem to be taken towards fixing this issue in the future.

Furthermore, the topic of the Covid-19 pandemic and its impact on the technical resilience of the energy sector has also been raised by 3 participants (P13, P15, P18), who noted that the UAE was unprepared for such a hazard, and despite the fast vaccination rate, the pandemic still managed to influence the oil industry negatively – with particular regards to international distribution. As P15 explained, "the pandemic showed us that we need to improve our logistics that we need to think of additional fail-safes in case the international demand for oil products goes down", adding that "this was a risk almost nobody took into

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account". Likewise, P18 stated that the pandemic "brought to light a lot of vulnerabilities that we simply hadn't considered"; for instance, "the drop in demand for oil products because the lock-downs meant fewer people were using transportation methods, so less fuel was used worldwide", while P13 stated that the pandemic triggered a "more aggressive approach to contingency planning in the [UAE] oil sector", similarly emphasising the need to devise solutions for various high-risk situations.

Theme B. Technical Progress and Hardware Hardening

Closely tied to the previous theme, the issue of technological progress and hardware hardening refers to the capacity of the Emirati energy sector to invest sufficient resources into continuously upgrading the various elements of the energy infrastructure. These indicators of technical resilience examine the ability to harden the existing hardware and promote technological progress as a means of adaptability. Through such methods, the energy sector can reduce vulnerability, at the same time ensuring the stability of the system in the long-term. Considering that the energy infrastructure is a complex system that is comprised of a wide variety of physical components, for instance, from generation (e.g. power stations, transformers, storage facilities), to transmission (e.g. transmission lines, power lines, pipelines) and distribution (e.g. substations), each stage in the infrastructure is dependent on numerous sub-systems, facilities, machinery, equipment etc., which are liable to physical failures. Moreover, since this tendency is particularly relevant to older components, addressing the systemic risks requires replacing or improving the individual parts that have become obsolete – or for which more efficient and reliable alternatives have been devised – which is crucial to containing the risk of system-wide disruption to a minimum, hence increasing both sustainability and resilience. While not addressed by all participants, most of those who approached the topic of progress (i.e. 15 out of, 20) were vocal about the UAE's reluctance to adopt new technologies as a means of prevention. More specifically, 7 participants (i.e. P1, P3, P5, P9, P14, P15, P16) argued that the Emirati energy sector needed upkeep, 5 participants (i.e. P6, P10, P11, P18, P20) supported the idea that the UAE is seeking to enhance the energy infrastructure, while 3 participants (i.e. P7, P8, P12) adopted a neutral stance.

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For instance, the ADNOC employees (i.e. P1, P3, P5) noted that their organisation was lagging in introducing technological changes or upgrading the facilities and equipment. In fact, a similar situation has been noted by employees of other oil power plants (e.g. Madinat Zayed, Adyard, TAKREER), who were generally more likely to support the idea that the energy sector needs to adopt significant changes, particularly regarding transmission and distribution. The discrepancy between the perceptions of oil power plant employees and those working at other facilities was the most noticeable in relation to technological progress and hardware hardening, as the other participants were much more understanding of the shortcomings of the Emirati energy sector, which according to the participants stem from several factors, including managerial oversight and the financial strain associated with an overhaul of the infrastructure. For instance, according to several such participants (P1, P3, P5, P9, P15), this slow pace of modernisation might be explained by the relative internal stability of the UAE compared to most of its neighbours, coupled with the lack of any real threats and attacks against Emirati facilities over the past few decades, as well as with the fact that Emirati companies and the UAE, in general, devotes sufficient finances to acquire the best and most recent technology as a means of strengthening its infrastructure. Related to this, P1, in particular, warned against what he termed “complacency and perhaps over-confidence about how safe we are from risks and hazards”, which might also contribute to the growing managerial reluctance for organisational changes in general. As it can be observed, while there is a drive to allocate sufficient resources towards hardening the hardware, the approach might be skewed by the perspective that the existing components of the energy system were reliable when acquired, and even if time has passed, there is a reluctance from the managers to admit that an increased level of upkeep may be necessary.

In contrast, P3 claimed that the problem does not stem from the intentions or actions of management but instead has to do with the “new emerging threats, which we cannot always anticipate and even imagine”. In his words, “the world is constantly changing, and we need to update our documentation and our training to keep up with it” (P3). Similarly, P15 argued that the challenges with

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technological upkeep stem from a “false sense of security that could have devastating consequences”, while P9 emphasised that “believing that nothing will ever go wrong is a slippery slope that results in nothing being done”. Indeed, according to the participants working in the petroleum industry, both the adoption of new strategies and the hardening of old hardware should be top priorities, especially considering the financial risks that come attached with it. As P9 explained, energy companies should strive to “never cut corners, particularly not [the energy companies] in countries that rely on the export of petroleum products”, hinting at the UAE’s dependence on the oil trade.

Another perspective was offered by P14, who explained that the “stability and security of the software that controls the physical assets”, which ensures that they operate to the optimal parameters, is “just as important and should not be overlooked”, and it seems that many managers at Adyard, where P14 is employed, seem to overlook this aspect. Thus, according to P14, the hardening of the hardware also requires the hardening of the software, especially given the “rising cyberthreat that many companies and managers keep ignoring”, a tendency that “increases security risks by promoting negligence”. Indeed, much of the infrastructure is dependent on the software running it, and a system-wide attack that does not directly target the physical assets could pose significantly more issues to untrained personnel, and this is a considerable risk, according to P14, who admits seeing personnel “using company computers as their personal ones”, or simply “not securing sensitive information with strong passwords or, even better, with universal two-factor keys”, which are uniquely generated keys meant to replace two-factor authentication – another method that according to P14 could be introduced as an industry standard to replace the less secure, currently in use password protection policies. While not commonly discussed by the participants, all these oversights are considerable threats that could develop into bigger issues if they are not addressed soon.

Still, the issue of direct attacks also remains a moderate threat to the region, and the participants’ views reflect this worry, as due to the scattered geographical layout of the Emirati energy infrastructure leaves much of the transmission grid vulnerable to isolated incidents that are difficult to fix quickly, as hinted by several participants. For instance, according to P16, it is not

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enough to rely on the full picture, instead, “more sensors need to be installed along the power line network, so we can quickly dispatch teams to the affected assets”. Another issue was raised by P5, who explained, “there are vandals, criminals, and there is sabotage”, mentioning that there is a need for Emirati energy sector actors to “collaborate more with local and national authorities to increase the infrastructure’s security and resilience”. However, P5 continued to say there may be a need for the energy companies to either “reconsider some of the substation locations, increase the patrols along the grid and implement more alarms”, mirroring the concerns of P16.

In contrast, employees in other facilities were much more pleased with the degree of hardware hardening pursued in their sector, and while the concerns regarding the safety, security and upkeep of transmission lines were also shared by several such participants (i.e. P6, P7, P11, P18), they also shared the idea that the Emirati energy sector is doing everything in its power to mitigate the risks. As P6 mentioned, in addition to investing in new avenues for power generation, the Emirati energy sector actors are also starting to collaborate more with one another, with companies working together towards strengthening the transmission and distribution infrastructure, which has not been updated for a long time, and which should be maintained at a high standard of quality so that the various elements (e.g. conductors, transmission lines, wires, straps, etc.) do not randomly fail or deteriorate. According to him, such a failure – particularly in the less populated areas where identifying the affected component would be very difficult – is not just a risk due to the natural tear of the individual elements towards the end of their recommended lifespan but is “an inevitable risk”. Another issue that constitutes a significant change in the energy sector was expressed by P18, who praised the growing number of specialists employed in the industry who are introducing innovative solutions such as “self-healing radiators, ballistic protection and drone defence systems”. However, as P18 added, such measures are expensive and require a long-term investment to be reliably and efficiently implemented. Even so, as P11 pointed out, “you need the willingness to change and invest, and this is something that many companies avoid”, especially if the financial investment is significant and despite the potential risks, which could be explained by the tendency to become

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complacent due to the limited experience with such disruptions, as explored in the text above.

5.2.2 Opportunities

The findings show that power generation diversity, system redundancies, and backup power deployment are the two main indicators that can be considered advantageous for the Emirati energy sector, mainly due to the UAE's drive to encourage the production and adoption of green energy.

Theme A. Power Generation Diversity

This theme refers to the active attempts of the UAE energy sector to not only rely on already existing means of energy generation but rather to seek out additional ways of supplementing the energy supply to ease the burden of the current infrastructure and ensure that the main networks operate at peak performance levels at all times, which can be done by investing in additional, alternate, renewable or green energy (Chowdhury, Chakrabarti and Chanda, 2021). This indicator of technical resilience refers to generating diverse power to increase the reliability and stable output of the energy grid in case of emergencies as an aspect of building robustness. While all participants have not tackled this topic, most of the opinions shared were positive. To explain, 7 out of, 20 participants (P2, P4, P6, P10, P13, P18, P20) praised the efforts of the UAE to diversify the produced energy, 2 participants (P9, P16) were reticent of the idea of sustainable energy production, another 5 participants (P5, P7, P11, P12, P15) adopted a neutral stance, while the other 6 participants (P1, P3, P8, P14, P17, P19) did not address the issue of renewable energy to a significant degree.

Among the most common arguments supporting the changes made to the Emirati energy sector was to diversify energy production by supplementing the power pool with other non-renewable power plants and including various renewable or sustainable power sources. For instance, P20, who works at the Dubai Electricity & Water Authority (DEWA), praised the recently-approved innovative project to construct a hydroelectric pumped storage plant using the already existing Al Hattawi Dam. According to P20, "the Hatta Dam has been functioning for 30 years or so, but before the onset of Clean Energy [Dubai

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Clean Energy Strategy, 2050], there were no plans to convert it into a power source", adding that although the investment is significant, this project is "not only the first of its kind in the Gulf Region, but it's also incredibly useful because it will help ease the burden of power consumption in Dubai at times of high demand". P20 added that to keep the project green almost in its entirety, Hatta will be powered by solar power from the nearby Mohammed Bin Rashid Al Maktoum Photovoltaic power station. According to him, energy diversification is particularly opportune for the industry and energy actors because this "helps a company to avoid operational disruptions as well, which increases the resilience of the sector as a whole by strengthening each element".

Indeed, other participants have also mentioned the increased use of solar energy in the UAE, with some being more optimistic than others. To exemplify, P6, who had been working at the Madinat Zayed Thermal Power Plant for more than a decade, said he was "excited to see the UAE taking steps to minimise pollution and steer away from the use of fossil fuel by investing in alternate energy source generation such as solar, nuclear, and even water", the latter which he considered a "significant feat that was thought to be almost impossible for a long time". This perception was mirrored by other participants, such as P2, P4, P10, P13 and P18, all of whom praised the changes made by the UAE to minimise the risks associated with the dependence on finite resources such as oil, gas and coal. As P2 mentioned, "while the UAE is known for its oil industry, I'm glad of the recent shift in mentality because we can't count on this resource forever – we would be lying to ourselves if we wouldn't be investing in renewable energy". Similarly, P10 who works at the Madinat Zayed Solar Power Station argued that "solar farms are a logical alternative for our region. The UAE was deemed one of the most suitable locations for building photovoltaic power stations", however adding that "the current energy levels generated through solar panels are insufficient to meet the demands, and the people in charge know this – which is why they launched projects to not only increase the number of solar farms, but also to try out new energy solutions such as water, wind and nuclear". Furthermore, P16 explained that "even if the UAE's geography seems ideal for solar farms, the issue of sand storms cannot be ignored", adding that solar panels are prone to long-term damage during sand storms: "the sand

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scratches the protective layer of the panels if they aren't spun in time... sometimes there isn't enough time to turn all of them because the crew wasn't notified sufficiently in advance before a sand storm, while other days the frequency of sand storms significantly reduces the ability of solar plants to function at full capacity", making sand storms a high risk for solar farms. With this in mind, P10 argued that investing in a wide array of alternative sources, and notably in renewable energy generation, can increase the resilience of the system if one resource is depleted or even if a power station is functioning at suboptimal levels due to environmental reasons, "there will always be at least one reliable alternative". Even so, not all participants agreed with this perspective, with P9 and P16 mentioning their scepticism in relation to alternative and renewable energy. More specifically, P9 said that "the attempt to move away from oil as the primary source of energy generation is well intended", but he added that "it won't happen anytime soon because the solar power grid is simply not developed or efficient enough to take the full load". A related issue expressed by P7, P11 and P15 was that the power grid, in its current form, cannot support the current rate of expansion for various reasons. To explain, P7 argued that the current transmission infrastructure is not capable of carrying all the energy that is being currently generated, especially considering the continuous expansion of the Emirati energy sector into renewable or green energy, saying that "the diversification of energy generation is not enough. We need to replace the ageing infrastructure, because it wasn't designed to carry this load so we record energy waste along the grid". Similarly, P11 expressed his dissatisfaction with the current transmission lines, which are "old, vulnerable to extreme weather and terrorism, and in need of regular monitoring and maintenance", and the frequency of the needed check-ups can strain a company's finances in the long-term. Both these participants hinted at the construction of additional, higher capacity transmission lines, while P15 has also expressed a similar perspective, yet further adding that "the grid could also use more substations", which would also protect and reinforce the transmission system because of their capacity to mitigate voltage fluctuations, in effect increasing the resilience of the grid by mitigating potential vulnerabilities stemming from power outages.

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Furthermore, the construction and recent inauguration of the Barakah Nuclear Power Plant have also sparked a debate among those who discussed it. On the one hand, experts such as P4, P6, P10, P11, P13, P15, P18, and P20 praised the move towards nuclear energy, while on the other hand, P5, P7, P9, and P12 focused more on the risks associated with such power plants. The most commonly mentioned advantages were the fact that nuclear power plants are "essentially carbon-free, with a high energy output, and incredibly reliable when compared to solar, wind, water or fossil fuel plants", as mentioned by P15, and this perspective was mirrored by the other proponents of nuclear energy listed above. In contrast to this, the issues of nuclear waste and the devastating impact of a potential malfunction were the main two disadvantages, with P5, for instance, saying that "an oil power plant fire or explosion results in a much more localised impact, whereas a similar incident in a nuclear power plant could destroy not only our country". Adding to this were the concerns of P12, who argued that "the move to nuclear could be dangerous because Emirati experts have very little experience with how to operate and respond to emergencies that are unique to nuclear power plants, so the risk of something going wrong is increased". However, P12 also added that "outsourcing the construction of the plant to companies with experience is a big advantage that most likely lowered this risk considerably". Another issue was raised by P6 and P10, who mentioned that the company where they work, Madinat Zayed, had been working closely with the Barakah power plant towards reinforcing the transmission infrastructure by developing a joint project to construct newer transmission lines capable of supporting a higher energy capacity. As P6 stated, "the existing transmission lines would never be able to carry the energy output from Barakah. The proposed high voltage overhead transmission lines are a great addition to the infrastructure because it means that the generated energy from the nuclear plant is not wasted". In fact, as P6 continued to explain, if the proposed project is approved, this will mean that the energy generated by the Barakah power plant will be very easily integrated into the grid, and this issue has also been mentioned by P10.

Additionally, P10 argued that while the new structure is "much more expensive, it is also much more efficient", and even more importantly – "it's new, so we

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won't need to worry about it for a long time", in effect maintenance and upkeep costs being minimal for such newly-built transmission lines compared to the older ones, which are becoming "increasingly more outdated in terms of energy capacity". Still, the perceptions regarding the adoption of nuclear energy are split among the Emirati experts, yet all in all, the overall perspective of the participants was an optimistic one, with many of the experts lauding the UAE's aim to rely less on fossil fuel and to move towards green energy as soon as possible, at least domestically. Even more so, nuclear power plants are generally perceived within the industry, despite their pitfalls, as the more resilient facilities – especially when compared to solar farms, which degrade a lot faster and which need a lot more maintenance, so the move towards nuclear energy, if done correctly, can significantly increase the resilience of the Emirati energy sector in general.

Theme B. <u>Backup Power Deployment and Redundancies</u>

This indicator of technical resilience refers to the ability to deploy backup power at the onset of a disaster as a means of resourcefulness. When referring to backup power deployment, the consensus is that each power plant, the transmission network and the distribution grid should have an adequate amount of redundancies, such as additional power supplies, to ensure that each critical element of the infrastructure is not easily disrupted as a result of intentional or accidental interference, in fact, the goal is to ensure the continuity of power generation regardless of circumstances (Lin and Bie, 2016). All participants have addressed these issues, the input being overwhelmingly positive, with 13 out of, 20 participants (P1, P2, P6, P7, P8, P10, P11, P12, P13, P14, P17, P19, P20) speaking favourably on the matter, 3 (P3, P15, P18) approaching it from a neutral perspective, and 4 participants (P4, P5, P9, P16) criticising the current system in place in the UAE.

All of the participants acknowledged that their companies ensure that the power plants themselves are not solely reliant on the electricity generated in-house to ensure the facilities work at all times, but rather that they also make sure sufficient power is stored on the premises to allow the facilities to recover from or completely bypass any potential shutdowns easily. According to P1, this process – known as a black start – is "not only recommended for power

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generation facilities worldwide, but mandatory", and most of the participants supported this assertion. Other participants admitted that their facilities are also reliant on the national grid as an additional layer of redundancy in case of the backup generators and auxiliary transformers fail; as P7 mentioned, "it is important to have several options that we can rely on", adding that while "this was never needed, but the decision was made as a precautionary measure in case of natural or man-made disasters, such as sabotage or terrorism, where the entire system – including the back-ups – could be affected". Indeed, the issue of redundancies has been favourably mentioned by most participants, who overwhelmingly commended the current infrastructure and the capacity of Emirati facilities for ensuring that power is constantly supplied to the network, with many participants praising the ability of the UAE and of Emirati energy actors to align their principles, policies and procedures with international standards of good practice. As a result, many professionals in managerial positions have pushed towards the afore-mentioned solutions to reflect the quality and security that comes from upholding such standards.

At the same time, some of the participants who criticised the grid's security also admitted that it is "nearly impossible" (P4), "incredibly expensive" (P3), or simply "unintuitive" (P9) to have redundancies in place for the entire network sometimes even despite the risks, because of the "financial burden" (P15), "lack of manpower" (P16), or even because "more parts doesn't necessarily mean increased security – it simply means that more elements are prone to deterioration, failure and sabotage" (P5). As P18 stated, "there are sufficient redundancies in place; what the UAE needs more of at this time is qualified manpower capable of taking the correct, risk-based decisions, regardless of circumstance". Even so, there were participants who emphasised the need of the Emirati stakeholders to "share information to a greater extent" (P16) or to "increase the security along the grid, but not through redundancies, but rather by increasing patrols along the distribution network" (P5).

A more specific and unique perspective was shared by P15, who urged all power generation facilities to move towards predictive artificial intelligence (A.I.) that continually assesses sensor information to anticipate potential failures and therefore compensates for these issues before the onset of a possible

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emergency or disaster. As P15 explained, "[Emirati energy facilities] need to adopt newer technologies as soon as possible to increase the reliability and stability of the system", which would – according to him – "undoubtedly enhance the resilience of the infrastructure as a whole". Indeed, considering the applications of artificial intelligence in various fields, there is an argument that such methods could help solidify the security and safety of the Emirati energy sector as a whole and, implicitly, of individual actors. However, the risk of introducing such technologies before fixing the existing issues related to hardware – which have been presented throughout this entire chapter so far – could lead to more problems, especially if the systemic issues are not addressed first. As P15 noted, "A.I. can solve many problems but also create new ones. People might become increasingly dependent on it, and we'd be back to the same issue we're having today. We must stop treating technological innovation as a solution and instead treat this newer tech as a tool".

5.2.3 Main Findings

To better illustrate the findings concerning this first code (Technical & Technological Factors), Table 6 presents the quotes, main ideas and details shared by the participants concerning the resilience of the Emirati energy sector. The code is divided into the four identified themes, which are grouped under vulnerabilities and opportunities, with the contribution of each participant being presented individually. For the themes to where participants have not contributed, the abbreviation for no data (i.e. "ND") is used.

Table 6: Code 1 - Technical & Technological Resilience Factors

	CODE 1: TECHNICAL & TECHNOLOGICAL FACTORS			
	VULNERABILITIES		OPPORTUNITIES	
	Theme A: Infrastructure and System Reliability	Theme B: Technical Progress and Hardware Hardening	Theme A: Power Generation Diversity	Theme B: Backup Power Deployment and Redundancies
P1	Spoke of the need to increase security and reliability by contracting cyber experts.	Stated their organisation focused less on technical upgrades because of the perceived safety: "complacency and perhaps over-confidence about how safe we are from risks and hazards".	ND	Confirmed black-start options, connectivity of facilities to national grid. Praised use of redundancies to ensure the stability of the power supply. Commended managers seeking to uphold international standards of good practice.
P2	Spoke of terror attacks meant "to disrupt the energy supply and security of the country".	ND	Praised the move away from energy generated from finite resources: "while the UAE is known for its oil industry, I'm glad of the recent shift in mentality because we can't count on this resource forever – we would be lying to ourselves if we wouldn't be investing in renewable energy".	Confirmed black-start options, connectivity of facilities to national grid. Praised use of redundancies to ensure the stability of the power supply. Commended managers seeking to uphold international standards of good practice.
P3	Spoke of the increased number of terror attacks in the GCC area, especially drone attacks which are "difficult to stop […] and can deal a lot and instant damage to us [ADNOC facilities]", so the company wants "to buy anti-drone defence systems".	Stated their organisation focused less on technical upgrades, saying that there is a need to improve to withstand "new emerging threats, which we cannot always anticipate and even imagine".	ND	Confirmed black-start options, connectivity of facilities to national grid.
P4	Described the energy sector's risk assessments, which focus on external risks and neglect internal ones: "I am sure that we could strengthen our internal resilience if we monitored and evaluated the performance of the personnel". Added that the location of oil production facilities (coastline & remote areas) makes them vulnerable to air strikes.	ND	Nuclear energy supporter (nuclear power plants are carbon-free, high energy output, less dependence on finite resources).	Confirmed black-start options, connectivity of facilities to national grid. Criticised the grid's security also admitted that it is "nearly impossible" to have redundancies in place for the entire network.
P5	Stated that the UAE energy sector is insufficiently prepared for terror attacks (e.g. drone, cyber-attacks), which may do "more damage than any army or natural disaster could".	Emirati energy sector actors need to "collaborate more with local and national authorities to increase the infrastructure's security and resilience", to "reconsider some of the substation locations, increase the patrols along the grid and implement more alarms" (risk of vandals, criminals, sabotage).	Nuclear concerns: "an oil power plant fire or explosion results in a much more localised impact, whereas a similar incident in a nuclear power plant could result in the destruction of not only our country".	Confirmed black-start options, connectivity of facilities to national grid. Regarding redundancies, "more parts doesn't necessarily mean increased security – it simply means that more elements are prone to deterioration, failure and sabotage". Argued there is a need to "increase the security along the grid, but not through redundancies, but rather by increasing patrols along the distribution network".
P6	Noted that they were confident in the Emirati energy sector.	Concerns regarding the safety, security and the upkeep transmission lines, although the Emirati energy sector is doing everything in its power to mitigate the risks (e.g. new power generation), but companies need to work together to strengthen the transmission and distribution infrastructure, which has not been updated for a long time. The lack of progress for infrastructure elements makes them an "inevitable risk".	Was "excited to see the UAE taking steps to minimise pollution and steer away from the use of fossil fuel by investing in alternate energy source generation such as solar, nuclear, and even water", the latter which he considered a "significant feat". Nuclear energy supporter, praised the combined efforts of Madinat Zayed's and Barakah power plant to reinforce the transmission infrastructure (i.e. construction of new transmission lines "to carry the energy output from Barakah"). "The proposed high voltage overhead transmission lines are a great addition to the infrastructure because it means that the generated energy from the nuclear plant is not wasted", in fact the energy generated by the Barakah power plant will be very easily integrated into the grid as a result.	Confirmed black-start options, connectivity of facilities to national grid. Praised use of redundancies to ensure the stability of the power supply. Commended managers seeking to uphold international standards of good practice.
P7	Thinks that the energy infrastructure is capable of "withstanding heavy hits", but that this doesn't mean they should ignore warning signs.	Concerned for the safety, security and the upkeep transmission lines, but hopeful that the UAE will do anything in its power to increase these aspects.	The existing power grid cannot support the energy that is being currently generated, "the diversification of energy generation is not enough. We need to	Confirmed black-start options, connectivity of facilities to national grid. Praised use of redundancies to ensure the stability of the power

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			replace the ageing infrastructure, because it wasn't designed to carry this load so we record energy waste along the grid".	supply: "it is important to have several options that we can rely on", adding that while "this was never needed, but the decision was made as a precautionary measure in case of natural or man-made disasters, such as sabotage or terrorism, where the entire system – including the back-ups – could be affected".
P8	Was "disappointed" with the current approach to ensuring the long-term stability and security of the infrastructure.	Thinks that "progress is inevitable", albeit "slow at times".	**ND**	Confirmed black-start options, connectivity of facilities to national grid. Praised use of redundancies to ensure the stability of the power supply. Commended managers seeking to uphold international standards of good practice.
P9	Described the most common and destructive risks "leakages, chemical fires or even explosions, which are difficult to control and recover from".	Criticised decreased focus on technical progress (due to UAE internal stability, lack of threats and attacks): "believing that nothing will ever go wrong is a slippery slope that results in nothing being done", argues that the energy companies should strive to "never cut corners".	Praised "the attempt to move away from oil as the primary source of energy generation", but "it won't happen anytime soon because the solar power grid is simply not developed or efficient enough to take the full load".	Confirmed black-start options, connectivity of facilities to national grid. Argued that increasing the grid's security via redundancies alone is "unintuitive", as there are also other risks that need to be first addressed.
P10	Admitted there is a tendency to skip some formality steps (e.g. some fixes are not announced on formal channels in advance): "easier to just do your job and only afterwards tell the higher-ups".	Praised Madinat Zayed's move to solar power and stated the facility is "up to standards".	Praised the focus on building photovoltaic power stations, but "the current energy levels generated through solar panels are insufficient to meet the demands". Argued that investing in a wide array of alternative sources, can increase the resilience of the system as if one resource is depleted or even if a power station is functioning at suboptimal levels due to environmental reasons, "there will always be at least one reliable alternative". Nuclear energy supporter, praised Madinat Zayed's joint transmission infrastructure project with Barakah, which in spite of the costs can ensure that maintenance and upkeep costs are minimised when compared to the older transmission lines, which are becoming "increasingly more outdated in terms of energy capacity".	Confirmed black-start options, connectivity of facilities to national grid. Is glad to see managers implement international standards of good practice.
P11	Argued the use of specialised teams to monitor "every component, process and decision" is necessary since a "mistake, error or defect may lead to a disaster if it's poorly managed".	Raised concerns regarding the safety, security and the upkeep transmission lines: "you need the willingness to change and invest, and this is something that many companies avoid", especially when the financial investment is significant.	Expressed his dissatisfaction with the current transmission lines, which are "old, vulnerable to extreme weather and terrorism, and in need of regular monitoring and maintenance". Nuclear energy supporter.	Confirmed black-start options, connectivity of facilities to national grid. Praised use of redundancies to ensure the stability of the power supply.
P12	Argued that the UAE energy sector "lacks experience in disaster and crisis management", nevertheless they managed to implement solutions to fix issues (e.g. introduction and adoption of ISO 50000 standard), which improved the resilience and sustainability of the sector, yet energy companies still need to improve other issues.	Expressed that the Emirati energy sector is devoting sufficient finances to newer technologies.	Argued "the move to nuclear could be dangerous because Emirati experts have very little experience with how to operate and respond to emergencies that are unique to nuclear power plants, so the risk of something going wrong is increased". However, "outsourcing the construction of the plant to companies with experience is a big advantage that most likely lowered this risk considerably".	Confirmed black-start options. Praised use of redundancies.
P13	Explained that the pandemic triggered a "more aggressive approach to contingency planning in the [UAE] oil sector", arguing there is a need to devise solutions for various high-risk situations that may affect the system's stability.	**ND**	Nuclear energy supporter (nuclear power plants are carbon-free, high energy output).	Confirmed black-start options, connectivity of facilities to national grid. Is content with the current use of redundancies throughout the energy infrastructure.

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P14	Stated the Emirati infrastructure is not secure enough to withstand physical attacks.	Mentioned that there is a need to increase the "stability and security of the software that controls the physical assets", which ensures that they operate to the optimal parameters. Emphasised that hardware hardening also requires the software hardening, given the "rising cyberthreat that many companies and managers keep ignoring", a tendency that "increases security risks by promoting negligence". Admitted seeing personnel "using company computers as their personal ones", or simply "not securing sensitive information with strong passwords or, even better, with universal 2nd factor keys", suggesting such rules should be mandatory.	**ND**	Confirmed black-start options, connectivity of facilities to national grid. Argued the use of redundancies could be more extensive. Commended the goal to uphold international standards of good practice.
P15	Admitted that the energy sector is risk-prone: "Mechanical and electrical risks are normal and expected", but "the pandemic showed us that we need to improve our logistics", adding that "this was a risk almost nobody took into account".	Argued that the challenges with technological upkeep and the introduction of new technologies stem from a "false sense of security that could have devastating consequences".	Sceptical that the power grid can support the current rate of expansion. In favour of higher capacity transmission lines and more substations, because they mitigate voltage fluctuations. Nuclear energy supporter.	Confirmed black-start options, connectivity of facilities to national grid. Argued that introducing redundancies at all levels is difficult because of the "financial burden" (P15). Urged energy actors to invest in predictive artificial intelligence (A.I.) solutions to anticipate emergencies, thus increasing "the reliability and stability of the system", thus increasing "the resilience of the infrastructure as a whole" – "we need to stop treating technological innovation as a solution, and instead treat this newer tech as a tool".
P16	Stated that "no facility is secure enough to withstand all hazards", arguing for a need to "identify and assess the potential human threats", which should be easy because they already "do this for the most common natural risks" (e.g. earthquakes, fires, sand storms, floods).	Offered a suggestion to improve the long-term security of the infrastructure: "more sensors need to be installed along the power line network, so we can quickly dispatch teams to the affected assets".	Unsure of solar farms given the frequency of sand storms: "the sand scratches the protective layer of the panels if they aren't spun in time... sometimes there isn't enough time to turn all of them because the crew wasn't notified sufficiently in advance before a sand storm, while other days the frequency of sand storms significantly reduces the ability of solar plants to function at full capacity".	Confirmed black-start options, connectivity of facilities to national grid. Criticised the stability of the grid, which suffers because of the "lack of manpower". Stated that Emirati stakeholders need to "share information to a greater extent".
P17	Stated the energy infrastructure may not be able to recover quickly after a disaster.	**ND**	**ND**	Confirmed black-start options, connectivity of facilities to national grid. Praised use of redundancies to ensure the stability of the power supply. Commended managers seeking to uphold international standards of good practice.
P18	Said "there is always a chance that someone messes up, that there is a systems failure, or that a piece of equipment deteriorates", and stated there is a need to "dedicate more resources to identify rising threats, and especially those regarding the equipment, which has a rather short life span".	Had concerns regarding the safety, security and the upkeep transmission lines, but was confident that the UAE is trying to mitigate the risks, but that such measures are expensive and require a long-term investment (monitoring, assessments).	Nuclear energy supporter (nuclear power plants are carbon-free, high energy output).	Confirmed connectivity of facilities to national grid. Commended energy actors seeking to uphold international standards of good practice.
P19	Argued that cyber-attacks and sabotage can cause "significant disruptions" to the entire system, so cyber experts need to be employed.	**ND**	**ND**	Confirmed connectivity of facilities to national grid. Commended energy actors seeking to uphold international standards of good practice.
P20	Placed emphasis on the need to secure the infrastructure against physical attacks.	Stated that improving the energy sector is a continuous goal of the UAE.	Praised the Al Hattawi Dam and its conversion to a power source, as well as it being green-powered from a solar power plant. Argued that energy diversification helps companies "avoid operational disruptions", nuclear energy supporter.	Confirmed connectivity of facilities to national grid. Commended energy actors seeking to uphold international standards of good practice.

5.3 Code B: Organisational Resilience

This section depicts resilience from the organisation's perspective as an independent unit, specifically related to the policies and procedures each institution has set to ensure that it is resilient. The segment starts with an illustration of the existing vulnerabilities and then continues with the opportunities for the Emirati energy sector, and the data shows that organisational resilience neither excels nor flops. In theory, the UAE should be prepared for crises, as they have started to adopt ISO standards for business continuity. Hence, the frameworks for increasing this type of resilience are available to the companies. Still, the findings also show that, in reality, many of the industry actors have issues with the actual application of these plans, policies and procedures. Overall, the industry is reluctant to change at the organisational level, yet it compensates by its capacity to adapt to new situations – even if the solutions are tardy in their implementation.

5.3.1 Vulnerabilities

The main vulnerabilities associated with the Emirati energy sector in terms of organisational resilience stem from the incomplete and inadequate adoption and implementation of risk management policies, procedures and practices – which are not adopted systematically and comprehensively, as well as the decision-making and coordination skills of the managers after the onset of a disaster.

Theme A. <u>Adoption of Risk Management Practices</u>

This first indicator of organisational resilience refers to not only the adoption of risk management practices but also the implementation of these strategies by all personnel members as a means of building robustness. To explain, it is not enough that a company aims to develop internationally-acclaimed standards and frameworks; for real change to occur, there is a need to ensure that a culture of risk detection, assessment and treatment permeates all levels, as resilience cannot be achieved without the direct implication and truthful dedication of all the stakeholders (Field et al., 2012). As per the participants' shared experiences, the overall perspective is a discouraging one, with 9 out of, 20 experts (P1, P2, P5, P8, P9, P12, P14, P15, P16) negatively evaluating

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the capacity of the Emirati energy sector to apply the lessons taught by risk management practices, with another 6 participants (P3, P4, P6, P7, P10, P18) abstaining or sharing neutral thoughts, and only 5 participants (P11, P13, P17, P19, P20) evaluating highly the strives the UAE energy sector has followed implementing the risk management standards.

While many participants acknowledged and praised the introduction of ISO standards, the main issue uncovered during the interviews was the lack of support that such frameworks have gathered after being formally adopted by the companies. Most interviewed experts stated that their organisation conducts risk assessments and evaluations frequently, but at the same time, they also noted that – unless there is a palpable threat involved, these assessments are carried out in a rather superficial manner. While the assessments themselves are conducted with due diligence and while both managers and employees are strict when completing the required forms, the evaluations rarely have a significant impact or hardly spur any changes for the organisational protocols, policies and procedures unless there is an urgent threat in sight. In essence, the majority of the participants explained that, on the ground level, and even by some managers, these appraisals are treated as “just another form that needs to be filled”, as stated by P9, and this perspective was also shared by P1, P7, P8, P12 and P15, all of whom admitted that the only change to the daily operations was the need to perform more examinations and fill more forms, which according to P1 and P8 slowed down the efficiency of their teams. As P7 argued, the tendency to become complacent with time might come from the fact that the risk assessments are mandatory, yet they are “not really checked by anyone”, so the experts filling them feel they are useless and that “their input doesn’t really matter that much”. P7 continued to state that, because of this, the importance of these protocols is naturally left for each company to decide whether or not they want to employ risk management strategies, and “many do not feel the need to devote additional effort towards preventive measures, because currently threats are considered negligible”. When the situation is optimal, within parameters, there is a tendency to ignore or neglect various issues – such as a poorly though-out policy, a worn piece of equipment that should be replaced, an inefficient procedure that takes up more

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time than needed and so on (according to several participants) – simply because change at that level is difficult or costly to implement safely, and therefore the assessments hold little weight in actively taking steps towards addressing some of the more minor vulnerabilities. This, in turn, may lead to a crisis or even amplify the long-term negative outcomes and the duration of a crisis.

On the other hand, four of the first five interviewees (P1, P2, P3, P5) acknowledged that all companies and facilities which belong to the ADNOC group are required under the “Code of Practice on Control of Major Accident Hazards” to establish and implement emergency plans in their facilities, which have been deemed vulnerable to high-risk hazards. The participants mainly focused on discussing this part of their organisation's emergency preparedness and disaster management framework as it is markedly the most comprehensive, adequate and widely discussed measure that ADNOC has implemented in recent years. The interview data revealed that the organisation had required a thorough risk assessment to be conducted in the high-risk facilities, which implies that, as P3 mentioned, a risk assessment strategy has been in place for at least 15 years (as long as he has been employed at the company) and it is constantly evolving. However, the participants were not shy about expressing their constructive criticism and offering suggestions on improving the sector's disaster management and resilience. For instance, P1, P2 and P5 thought that upper-level management should pay closer heed to their subordinates' statements and attitudes regarding addressing safety issues and mitigating the risks. In other words, they should not simply be content with making the assessment, but they should be equally interested in acting upon these assessments and should therefore ensure that these are regularly updated – as they currently are not – and that employees are made well aware of these. As P1 mentioned: “what use is an emergency plan if no one knows about it or understands it and knows what to do with it in the case of an emergency?” Indeed, this sentiment has been mirrored by some of the other participants as well (P7, P10, P12, P14, P16), who were disappointed in the lack of effort dedicated by their companies towards nurturing an organisational culture that seeks to improve resilience in a meaningful way. One participant

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even jokingly stated that “Of course, we are ready for any scenario until one of these scenarios happens” – because of the harsh and controversial criticism, the participant asked that he would not be quoted on the statement in order to ensure his anonymity. Another expert (P12) raised a more serious issue: the employees who smoked did not follow the set regulations, and since the managers conducting the assessments also smoked, there was little incentive to enforce the rules. According to P12, “we do not work with oil products, so everyone thinks the risk of something catching fire from a cigarette is virtually non-existent. Because of this, most people ignore the non-smoking areas. I think this is extremely risky, and things can catch fire anywhere, not only in oil production facilities”, later explaining that while indeed the risk was minimised by the fact that there were no power cords or flammable objects in the vicinity of the non-official smoking zones, “the company should create more covered smoking areas to make sure the risk is brought down to zero”. Furthermore, a different expert (P16) explained that there are loading and unloading areas where oil spills on the ground and which, according to him, are “not cleaned according to regulations – which should be daily”, and the fact that these zones are not cleaned as often as they should, could pose another significant fire hazard. According to P16, this may be because those are dedicated loading and unloading areas and that such spillage is “expected”, but at the same time, he thinks that the personnel should not simply ignore the issue because it is taken into account on paper, instead arguing that more effort needs to be devoted towards upholding the company standards.

However, the negative perspectives and the criticism towards what currently seems to be a stagnation in promoting the organisational safety culture within the industry were not widely shared. According to P20, companies should adapt even to the internal changes in behaviours, and thus if negative, risky or undesired behaviour starts to set, the company should not simply try to change it by introducing more policies or more training but instead should “try to respond to the needs of the personnel in a way that both eliminates the threat and makes the people happy”, adding that “the last thing we need is making our workers feel unheard or uncared for. This leads to a drop in employee engagement and will only lead to more issues”. Additionally, P11 and P19

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argued that it was normal for each company to seek out change for the better, even if currently they were focusing on writing the necessary documentation; as P19 said, “At the moment, we’re still learning the ropes and familiarising ourselves with the procedures; having a solid theoretical basis is the first step towards change, and I think rushing without understanding what the risk assessments and contingency plans are for could be detrimental in the long term”. However, from what P13 discussed, it seemed that in his organisation, the creation of such documentation was part of a training programme instituted to increase the participation of employees. Similarly, P11 and P17’s experience reflected their participation in seminars conducted specifically to train managers on the importance of risk and crisis management, which included more training, workshops and seminars for all the personnel members. According to P19 and P20, from their experience in assessing the application of risk management practices in various Emirati energy organisations, this approach is usually employed as a means of increasing engagement and solidifying the idea of a risk-conscious organisational culture would be a viable solution to addressing the lack of involvement that the other experts shared.

Theme B. Decision-making and Coordination

The second vulnerability to the Emirati energy sector, which is discussed in this theme, refers to the ability of decision-makers to coordinate the response and relief efforts to showcase the organisation’s resourcefulness. More specifically, this section seeks to uncover whether the UAE energy companies are prepared to make suitable decisions under duress; this attribute is extremely important to ensure that the available resources are efficiently employed and distributed based on emergent needs – the goal being to ensure the stability of the company after the onset of a disaster. The topic has been debated by only 13 out of, 20 participants, which is understandable given the limited number of emergencies or disasters experienced by the UAE, and which, at the same time, explains the focus of the participants on evaluating the Covid-19 pandemic. Out of these individuals, 7 participants (P1, P2, P5, P6, P9, P11, P15) were a bit more critical of the ability of current supervisors, while 4 participants (P13, P16, P18, P20) talked about the issue favourably.

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As mentioned, the main issue that has recently caused great concern for the Emirati energy industry is the indirect effects of the global COVID-19 pandemic. P5 was the most vocal on this subject, as part of his work was tied directly to monitoring the storage of oil supplies: “As the oil demand experienced a significant drop during the spring months of, 2020, this caused oil-producing facilities to store much more oil barrels than usual”. This raised concerns about the safety of storing so much oil in one place for prolonged periods. P5 also mentioned that this was explicitly stated in an ad-hoc risk assessment, which management had conducted at the time, but other interviewees, most notably P1 and P2, acknowledged the fact that oil production could not be easily slowed down across the UAE despite the plummeting demand, especially on such short notice. These findings were mirrored by the experiences shared by other participants as well; for instance, P9, who was part of the supervisory team for handling the export of oil products for the Madinat Zayed energy company, also admitted that “the drop in sales hit us hard… we weren’t expecting that the entire world would come to a halt so quickly. The demand dropped, we lost many customers, so we had to lay off some of the staff…, 2020 was a difficult year”. The issue of lay-offs was also briefly mentioned by another Madinat Zayed worker, P6, who works at the thermal power plant, and who admitted they heard from co-workers that the oil production facilities had had financial problems as a direct result of the pandemic – which according to him is something he “never considered a likely scenario”. P15 also expressed shock at how the pandemic impacted the industry and his company, stating that he “really thought I had to find another job”, arguing that instead of taking actual steps towards mitigating the issue, instead the company was “suspended in disbelief, just waiting for it [the pandemic] to end, for the most of, 2020”. These findings raised numerous questions surrounding the energy sector's resilience, which cannot catch up with unexpected changes fast enough to deal with emergent hazards and risks, as representatives from the actors in the Emirati energy sector seemed to depict that their companies were ill-prepared for such a scenario. As P18 explained, “things went wrong on all levels, but distribution suffered the most”, later expanding on the causes, which were “the international travel restrictions” and even the worldwide lock-downs, which caused an unprecedented “drop in demand for oil products” for both personal use, as well

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as for public and private transportation. However, as P18 also mentioned, this unprecedented scenario “helped raise the right questions regarding the supply chain of Emirati energy facilities”, which in turn spurred a call to action to “plan for similar issues in the future”, a move that, according to P18 is both “beneficial and necessary”.

Similarly, P13 argued that “the financial losses caused by the [Covid-19] pandemic opened our eyes to what can happen when we believe that everything will go according to plan”, explaining that without this emerging circumstance, the UAE energy actors may have taken a longer time to dedicate more efforts towards investing in contingency planning, and as such despite the losses, the pandemic can still be viewed as “an important step in the right direction”, for the UAE’s approach to disaster and crisis management at all levels, and for the energy sector in particular. Still, these perspectives were among the more optimistic ones, with experts such as P15 being more critical of how the pandemic had been addressed, the response and recovery efforts, according to him, showing that the UAE energy companies still need to dedicate not only applied resources such as time and money to the improvement of the industry. According to P15, it is imperative that such companies “not only acknowledge the possible impact of a crisis – any crisis for that matter, not just the pandemic, because any one threat can turn into a disaster at any point – but we need to really understand and act upon our gaps in logistics and distribution”. As P15 put it, “there is a real need to devise protocols that consider not only how distribution can be effected within the UAE, but how the international state of events influences us. We need to start focusing on threats and risks that others experienced because they are as real to us as they are to them”. Indeed, while the Emirati energy companies have not considered this risk, the lack of preparedness and the events experienced during the pandemic may hint at a bigger issue, respectively, that other similarly looming and highly consequential threats may also not be taken into account.

Therefore, such unexpected but likely scenarios need to be met with an appropriate and highly specific contingency plan rather than having the organisation rely upon general guidelines. In fact, P2 believes that general documentation and regulations that are not tailored to a specific situation and

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because they instead discuss abstract issues that are not well understood may be insufficient in enhancing resilience. This necessitates the creation of well-detailed and well-researched contingency plans for every major scenario that might damage the resilience level of the facility, and these plans should include specific and actionable exercises that the employees participate in. This being said, while the vast majority of the interviewees (i.e. 18 out of, 20) acknowledged that their companies have more specific emergency and crisis plans in effect, it is clear that a scenario such as the Covid-19 pandemic and its potential repercussions had not been taken into account, and had not been seriously considered from the onset, thus leading to the shortcomings expressed above.

Even so, several participants (P2, P5, P11) admitted that while they were not content with how this particular disaster had been managed, they were certain – at the time of the interviews – that the situation would improve, given that it is not uncommon for UAE experts have a keen ability to alter their priorities and tactics to suit unexpected situations. According to P11, even if the proper changes, namely the implementation of a faster response when a crisis arises, and more specifically "to ensure that the manufacturing of oil products is slowed down when and if the demand is plummeting" and not solely "relying on yearly sales predictions and hoping for the best" will take time to be enacted, P11 believes that the Emirati energy sector "will become stronger" as a result, because "the lessons learned from the pandemic will stick with us for a while". Similarly, P2 mentioned that while the response, or rather lack thereof, "was not ideal by any means, and we lost a lot of money as a result. But, for the first large-scale crisis, we could've handled it a lot worse and I am happy to say that the impact was not catastrophic by any means – we definitely managed to recover within a year". In relation to the response and recovery efforts, P5 concluded that "we needed to experience a situation like this ourselves before we could understand how to react and adapt to it", adding that "I am confident that the next crisis will spur a quicker response and can state as a fact that the ADNOC management started to revise the crisis response and – especially – the crisis recovery plans". Similarly, P16 argued that the UAE energy actors have a "good track record for making the right decisions, but because we lack

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the experience of other countries and because there is so much on the line, it just takes us a little bit of time to reach these good conclusions", which further reinforces the idea that the Covid-19 pandemic has made a lasting impact on many managers in the Emirati energy sector. On the other hand, not all participants shared this perspective, with P20 going in a different direction altogether and arguing that because the UAE is such a rich country, "we can afford to have a year a bad year or two. We'll recover quickly if this doesn't go on for too long, so we can start focusing on recovery and leave this unfortunate circumstance behind us".

5.3.2 5.5.2. Opportunities

The organisational resilience opportunities for the Emirati energy sector are captured in the propensity for policy reform and capacity building indicator. The other indicator explored in this section refers to the adaptive capacity of the energy organisations, which, while being characterised by a lack of proper goal-setting for employees, can still be perceived as a favourable circumstance due to the introduction of Business Continuity Management (BCM) practices for all organisations in the UAE.

Theme A. Adaptive Capacity

The first positively-reviewed indicator of organisational resilience concerns the ability to adapt in light of emerging circumstances; more specifically, this theme refers to the capacity of the Emirati energy sector to identify and act upon both the setbacks and opportunities following a crisis or disaster, the goal being to rapidly recover after an incident, in the most efficient and prosperous manner. Regarding the adaptive capacity of their companies, 10 out of, 20 participants (P3, P4, P5, P6, P9, P11, P16, P17, P19, P20) expressed their content with how flexible their organisation is, which is unsurprising considering the recent adoption of Business Continuity Management (BCM) in the UAE.

As per the information offered by the participants who addressed this issue, the introduction of BCM has created many disaster, crisis, incident and emergency management plans, along with contingency and disaster recovery plans. The energy companies have tried to increase resilience in the energy sector by minimising the potential risks and threats, prioritising the safety of employees,

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seeking to shorten the possible disruption periods and by improving the odds of maintaining the stability of daily operations throughout all stages of the disaster cycle, with most participants noting the adoption of such strategies by their companies. P17 admitted that “everyone is much more confident and relaxed coming in to work since BCM practices have become the golden standard of Emirati power companies”, offering as an argument (for the need to implement such policies and procedures) the recent security and safety threats to other GCC energy facilities. In fact, P17 also added that this is but one area recently addressed by Emirati energy organisations, mentioning that there has been a recent shift towards minimising potential risks and threats via the adoption of preventive measures such as early warning systems for earthquakes, which are prevalent in the UAE. As P17 explained, “What BCM taught us is that resilience is not only about what happens after the incident but that we need to also keep in mind the factors that happen before”, adding that “more and more focus is placed on trying to avoid incidents rather than fixating on how we can recover from them, which I think is a step in the right direction”. Related to this, P3 and P4 also noted that while they were concerned with the potential security vulnerabilities regarding external terrorist threats, such as drone attacks, both of them were confident that the current framework offered considerably more support than the past policies, which had not considered such risks at all. In addition to the changes made to the black-start capacity of ADNOC facilities which minimises the potential downtimes of the system, P3 also expressed that managers in their company discussed the issue of implementing counter-drone systems as soon as the UAE reaches an agreement with a third-party in the following years, saying that “we [at ADNOC] are willing and eager to adopt anti-drone measures to increase the security of the grid. The issue of how much this system would cost also seems to be irrelevant to the higher-ups, which raised morale for sure”. In trying to explain how such a system would increase resilience, P3 also emphasised that prevention is key, mentioning that “it is better to be safe than sorry – is what I always tell my colleagues, and they are slowly starting to agree with me that we need to devote more effort to prevention”. Related to this, P4 explained that “the issue of sabotage used to be viewed as a very low-level risk for a long period of time, so, of course, I’m glad that we’re at the very least acknowledging

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the potential harm that drone attacks or cyber-attacks can do to us. We still have a long way to go in terms of preparedness for such scenarios, but we're glad that things are moving in the right direction". In fact, this final idea was shared by other participants despite their overall positive attitude towards the UAE's adaptive capacity, such as P5, P11 and P19, who, although were critical of the slow pace of implementing changes, nevertheless admitted they had confidence in the current system, and especially in the upcoming security changes that the UAE has pursued in recent years. To explain, P19 argued that "introducing industry-wide revisions takes a lot of time and hard work, considering how many actors and stakeholders need to change the way they work", while P11 noted that "relying on our own training and experience without taking a look at what's going on around us is short-sighted, that's how major incidents happen".

This confidence was also shared by other interviewed experts, such as P6, P9, P16, P19 and P20, expressing only positive perspectives on how these regulations can help improve the Emirati energy sector and many other industries. As P20 assessed, "the [ISO for business continuity] efficiency was tested and acknowledged time and time again before the UAE decided to adopt them". Likewise, P9 emphasised that "we need to trust the experience of those who came before us, we need to learn from their mistakes, or we are bound to repeat them", this opinion being, in fact, one of the key perspectives of disaster management regardless of sector or industry. Regarding this issue, P16 stated that "the need to ensure business continuity should outweigh the reticence of relying on others for help, which is pretty common in the UAE", and according to him while the UAE still needs to devote more effort towards implementing real changes, the country is heading in the right direction. This being said, there were still some participants (P1, P8, P15) who criticised the current regulations and policies, with P8 notably mentioning that the adoption of so many new plans has been difficult and even slowed down daily operations, which "wouldn't have been affected if we didn't have to take into account so many new procedures", explaining that currently the power companies "need to devote more effort to reach the same result". Another perspective was shared by P15, who indicated that despite the numerous plans in place to ensure business continuity after a

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disruption, “many higher-ups are still lost when a big threat is looming over our heads – take, for instance, the [Covid-19] pandemic, the frameworks were available from the beginning, but many ignored the steps that they needed to take because they didn’t take the crisis seriously”. Similarly, P1 mentioned that “on paper, we’re ready for anything, but in reality, not much has changed except for the requirements to fill out more forms, or to participate in more meetings and training… this is unsustainable, something needs to change for the better, and fast”.

Theme B. Policy Reform and Capacity Building

This indicator of organisational resilience refers to the ability to use existing and available information to determine the successes and failures of the disaster, risk and crisis management policies employed to increase the energy sector’s capacity to adapt to emergent threats. The main takeaways from improving the adaptability of the Emirati energy sector are the ability to increase the efficiency of the resources employed but also to improve upon the strategies utilised based on previous experiences, the ultimate goal being to increase the sustainability and resilience of the industry by diminishing any potential impediments or deficiencies. This theme has overall garnered a positive response from the participants, with 12 out of, 20 participants (P2, P4, P5, P6, P7, P10, P11, P13, P17, P18, P19, P20) praising the capacity of Emirati organisations in the energy sector to optimise resource allocation and continuously update their policies based on either internal or external assessments, with 4 participants (P8, P9, P14, P15) expressing some negative perspectives, and another 4 participants (P1, P3, P12, P16) adopting a more neutral stance or not offering too many details.

Overall, most participants (i.e. 18 out of, 20) noted that their organisations had introduced supplementary plans and regulations dealing with highly likely scenarios such as oil spills, sand storms, fires or terrorist attacks. Many experts also mentioned that their companies have also developed more general safety plans for the industry, which cover standard safety measures, procedures and guidelines for the facility and its equipment, its personnel and their normal working conditions. According to P11, risk assessment is conducted regularly to account for new developments – which leads to “frequent improvements”,

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while P16 stated that “the managers keep an eye out for escalating situations and try to change the company strategies and policies to account for them… they keep us on our toes”. Similarly, P20 argued that “the safety of the personnel and the security of the facilities are top priorities in the [Emirati energy] industry, so there is a lot of importance placed on improving the internal procedures and practices”, adding that because of these reasons, “energy companies always strive for excellence, which most of the time is sought out through assessments and evaluations of past experiences”. Even more so, P2 also explained the dedication shown towards continuous improvement, arguing that:

> “There are a lot of good examples of how if it were not for our senior management, we would be in a much worse state. They [the management] put in strict security and safety policies and mandatory training. Then [they] also ordered drills for the whole facility. They had done their homework and had evaluated the damage that past disasters could have done [to our facility]. They had us ready and prepared for every emergency.”

Related to this, as P4 noted, “the government is doing their best, and they are performing much better than most of our neighbours”. According to him, this leads to a shared understanding among all stakeholders about the need to ensure compliance not only for the safety of the facility but also for that of the personnel itself. The interest shown by the UAE government in strengthening the resilience of the energy industry has also been noted by other participants, such as P10, who explained that, for the UAE:

> “The past decade has been a sort of an awakening. We collectively opened our eyes to the importance of … let’s say, resilience or maybe sustainability, but the idea is that we learned a lot from what others have gone through, and we’re much more careful now. We’ve definitely tried our best to increase our capacity to endure in the face of hardship, even if this hardship has been, for the most part, theoretical… but we have been thoroughly preparing for the worst, and I think this is the right approach.”

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Examining the issue from a different angle, P1 argued that the UAE has been extremely careful and strict in implementing the “standards that the international community has set for the energy sector in particular due to the importance and safety concerns”. Likewise, P13 argued that while the UAE officials have taken their time to implement changes to how crisis and emergency management is perceived and approached, “so far the changes are well informed and they make sense, it’s not like someone just took random decisions to be able to say that they did their job. We are taking this issue seriously, and it shows.” Additionally, P5 emphasised upon the understanding that the compliance with the international norms seems to be deeply integrated into the organisational culture because it was not that “someone on the top imposed them”, but it has more to do with the mindset that ADNOC leadership, managers and their subordinates share. In other words, as it can be seen from the opinions of many of the interviewed experts, the stakeholders in the energy sector have realised the importance of their work and how detrimental a potential man-made or natural hazard could be to oil production and oil supply chains, which in turn would disrupt the stability of their own country and the stability of global oil markets. “Nobody wants to see that happen”, P5 commented, adding, “we do not work in a vacuum. We are part of one big global community, which depends upon us, and we need to fulfil our responsibilities to all stakeholders in this long chain”. All of this suggests that the Emirati energy sector has been taking steps to ensure organisational resilience and that the personnel is prepared to deal with emergent risks and disasters.

However, not all participants fully agreed with the above perspectives; for instance, some experts argued that despite the UAE’s motivation and desire to improve the safety and security of the energy sector by introducing various policies and pushing for the need to rely on disaster management plans as a means of reducing vulnerability, this attempt is perhaps insufficiently taken into account at the ground level. For instance, P14 stated that “there are still many people working in the industry who treat the safety and security policies as just another regulation”. According to some participants, while the implementation of such safety and security plans has been sought out by all of the power companies investigated during the development of this thesis, and while the

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constant maintenance of the facilities is held to a high standard at these companies, for some this seems more like a consequence of the strict regulations which they had to follow and comply with, rather than a goal of the companies themselves. For instance, P9 argued that, from what he has observed throughout the years, “changes were made on paper, but the behaviours and habits of many employees remained the same”, also hinting at the discrepancy between the national goals and standards and those who need to uphold them. In line with this perspective, P3 also discussed the concept of a “safety culture”, and argued that this perhaps represents one of the most difficult changes for an organisation to make. “You can change the infrastructure, change the technology, the people, the documents and regulations”, P3 went on, “but if you cannot change the way people think, it would all go to waste if you and your people are not mentally prepared for risks and disasters”. Nonetheless, these issues seem to be less characteristic of the industry as a whole and more like outliers that differ from company to company and from station to station, especially when taking into account that the perspectives differ between members of the same organisation, for instance, P3 and P5 from ADNOC who described directly opposite thoughts on the matter.

5.3.3 5.5.3. Main Findings

To better illustrate the findings regarding the second code (Organisational Factors), Table 7 presents the quotes, main ideas and details shared by the participants regarding the resilience of the Emirati energy sector. Similarly to the previous table (Table 6), the table features the four identified themes divided under vulnerabilities and opportunities, with participants’ contributions being noted separately – with the “ND” abbreviation being used in the cases where no relevant data has been provided.

Table 7: Code 2 - Organisational Resilience Factors

	CODE 2: ORGANISATIONAL RESILIENCE FACTORS			
	VULNERABILITIES		OPPORTUNITIES	
	Theme A: Adoption of Risk Management Practices	Theme B: Decision-making and Coordination	Theme A: Adaptive Capacity	Theme B: Policy Reform and Capacity Building
P1	Confirmed ADNOC facilities are required under the "Code of Practice on Control of Major Accident Hazards" to establish and implement emergency plans, which were deemed vulnerable to high-risk hazards. Argued that upper-level management should pay more attention to subordinates when addressing safety issues and mitigating the risks: "what use is an emergency plan if no one knows about it or understands it and knows what to do with it in the case of an emergency?" Stated that risk evaluations and assessments take a lot of time and interfere with the efficiency of the team.	Admitted that oil production could not be easily slowed down.	Criticised the focus placed on the theoretical: "on paper, we're ready for anything, but in reality not much has changed except for the requirements to fill out more forms, or to participate in more meetings and trainings… this is unsustainable, something needs to change for the better, and fast".	Stated that the UAE has been extremely careful and strict in implementing the "standards that the international community has set for the energy sector in particular due to the importance and safety concerns".
P2	Confirmed that ADNOC facilities are required under the "Code of Practice on Control of Major Accident Hazards". Argued that upper-level management should take into account the statements and attitudes of their subordinates in terms of addressing safety issues and mitigating the risks.	Believes general documentation and regulations cannot enhance resilience, plans for major scenarios should exist. Admitted that oil production could not be easily slowed down, the response not being "ideal by any means and we lost a lot of money as a result. But, for the first large-scale crisis, we could've handled it a lot worse and […] the impact was not catastrophic", "managed to recover within a year".	**ND**	Is content with the decisions made in their company: "there are a lot of good examples how if it was not for our senior management we would be in a much worse state. They [the management] put in strict security and safety policies and mandatory training. Then [they] also ordered drills for the whole facility. They had done their homework, and had evaluated the damage that past disasters could have done [to our facility]. They had us ready and prepared for every emergency."
P3	Confirmed that ADNOC facilities are required under the "Code of Practice on Control of Major Accident Hazards", with a risk management strategy being in place for at least 15 years – and constantly improving.	**ND**	Concerned with security vulnerabilities regarding terrorist threats (drone attacks), but confident that the current framework offered more support than the past policies, which did not address such risks. Admitted their company wants to invest in counter-drone defence systems: "we [at ADNOC] are willing and eager to adopt anti-drone measures to increase the security of the grid. The issue of how much this system would cost also seems to be irrelevant to the higher-ups, which raised morale for sure". Emphasised the importance of prevention: "it is better to be safe than sorry".	Discussed the concept of a "safety culture", and argued that this is one of the most difficult changes: "You can change the infrastructure, change the technology, the people, the documents and regulations", "but if you cannot change the way people think, it would all go to waste if you and your people are not mentally prepared for risks and disasters".
P4	**ND**	**ND**	Concerned with security vulnerabilities regarding terrorist threats (sabotage), but confident that the current framework offered more support than the past policies: "the issue of sabotage used to be viewed as a very low-level risk for a long period of time, so of course I'm glad that we're at the very least acknowledging the potential harm that drone attacks or cyber-attacks can do to us. We still have a long way to go in terms of preparedness for such scenarios […]".	Believes "the government is doing their best and they are performing much better than most of our neighbours". According to him, this leads to a shared understanding among all stakeholders about the need to ensure compliance not only for the safety of the facility, but also for that of the personnel itself.
P5	Confirmed that ADNOC facilities are required under the "Code of Practice on Control of Major Accident Hazards", which were deemed vulnerable to high-risk hazards.	Tasked with monitoring the storage of oil supplies: "as the demand for oil experienced a significant drop during the spring months of 2020, this caused oil-producing facilities to store much more oil barrels than	Critical of the slow pace of implementing changes, but is confident in the current system, considering the latest security changes.	Argued that compliance with international norms is deeply integrated in their organisation's culture because it was not that "someone on the top imposed them", but it has more to do with the

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		usual". Admitted the pandemic raised concerns about long-term oil products' storing: "we needed to experience a situation like this ourselves before we could understand how to react and adapt to it", adding "[…] the next crisis will spur a quicker response and can state as a fact that the ADNOC management started to revise the crisis response and – especially – the crisis recovery plans".		mindset that ADNOC leadership, managers and their subordinates share. Argued that nobody wanted to see the destabilisation of the oil market happen: "We do not work in a vacuum. We are part of one big global community, which depends upon us, and we need to fulfil our responsibilities to all stakeholders in this long chain".
P6	**ND**	Mentioned lay-offs at Madinat Zayed, admitted they heard from co-workers that the oil production facilities have had financial problems as a direct result of the pandemic – which according to him is something he "never considered a likely scenario".	Mentioned their company is capable of adapting to both negative and positive situations.	Praised the existence of both generic and specific plans for various scenarios.
P7	Praised the ISO standards, but mentioned some evaluations and assessments are carried out superficially, and even if they are mandatory - they are "not really checked by anyone", so the experts filling them feel "their input doesn't really matter that much". As a result, "many [companies] do not feel the need to devote additional effort towards preventive measures, because currently threats are considered negligible". Stated that companies should act upon these assessments with actual changes that improve the workplace. Disappointed in the lack of effort to nurture an organisational culture focused on resilience.	**ND**	**ND**	Praised the existence of both generic and specific plans for various scenarios – although not all are covered.
P8	Admitted that risk evaluations and assessments are carried out superficially, and in fact "slow down the daily routine".	**ND**	Argued the adoption of new plans has been difficult and even slowed down daily operations, which "wouldn't have been affected if we didn't have to take into account so many new procedures", explaining that currently the power companies "need to devote more effort to reach the same result".	Praised the UAE's implementation of crisis management, but stated that these procedures are insufficiently considered at the ground level even if the companies try to uphold them.
P9	Admitted that risk evaluations and assessments have no real impact, are "just another form that needs to be filled".	Admitted the export of oil products for the Madinat Zayed suffered during the pandemic: "the drop in sales hit us hard… we weren't expecting that the entire world would come to a halt so quickly. The demand dropped, we lost a lot of our customers and so we had to lay-off some of the staff… 2020 was a difficult year".	Emphasised the need to learn from past experiences: "we need to trust the experience of those who came before us, we need to learn from their mistakes or we are bound to repeat them".	From their experiences, "policy changes were made on paper, but the behaviours and habits of many employees remained the same", also hinting at the discrepancy between the national goals and standards, and those who need to uphold them.
P10	Praised the introduction of ISO standards, but argued that companies should not simply be content with making the assessment, but they should be equally interested in enacting change more.	**ND**	**ND**	Was content with the improvements made to the UAE energy sector: "The past decade has been a sort of an awakening. We collectively opened our eyes to the importance of … let's say resilience, or maybe sustainability, but the idea is that we learned a lot from what others have gone through, and we're much more careful now. We've definitely tried our best to increase our capacity of enduring in the face of hardship, even if this hardship has been, for the most part, theoretical… but we have been thoroughly preparing for the worst, and I think this is the right approach."

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P11	Praised the introduction of ISO standards, as a result of these risk evaluations and assessments are carried out frequently, which is "normal" for companies – even if currently they are focusing more on the theoretical (documentation). Admitted they participated in seminars on the importance of risk and crisis management to become more familiar with such policies and procedures.	Unsatisfied with the pandemic response, as companies did not manage "to ensure that the manufacturing of oil products is slowed down when and if the demand is plummeting" because they were "relying on yearly sales predictions and hoping for the best". Still, believes the Emirati energy sector "will become stronger" as a result, because "the lessons learned from the pandemic will stick with us for a while".	Critical of the slow pace of implementing changes, but they have confidence in the current system, which is constantly improving to take into account new developments: "relying on our own training and experience without taking a look at what's going on around us is short-sighted, that's how major incidents happen".	Admitted risk assessment is conducted regularly to account for new developments – which leads to "frequent improvements".
P12	Risk evaluations and assessments are carried out superficially, have no real impact. Disappointed in the lack of effort to nurture an organisational culture that seeks to improve resilience in a meaningful way. Admitted they saw managers and employees who smoked who did not follow the safety regulations: "we do not work with oil products so everyone thinks the risk of something catching fire from a cigarette is virtually non-existent. Because of this, most people ignore the non-smoking areas. I think this is extremely risky, things can catch fire anywhere, not only in oil production facilities", arguing, "the company should create more covered smoking areas to make sure the risk is brought down to zero".	**ND**	**ND**	**ND**
P13	Praised the introduction of ISO standards, as a result risk evaluations and assessments are carried out often. Praised their organisation's solution to creating the appropriate documentation was part of a training programme instituted to increase the participation of employees.	Believes the pandemic had a positive impact as well: "the financial losses cause by the [Covid-19] pandemic opened our eyes to what can happen when we believe that everything will go according to plan", as without a major incident the UAE energy actors may have taken a longer time to invest in contingency planning, and as such despite the losses, the pandemic can still be viewed as "an important step in the right direction", for the UAE's adoption of disaster and crisis management.	Thinks their company is very adaptable.	Praised the UAE officials implementing crisis and emergency management: "so far the changes are well informed and they make sense, it's not like someone just took random decisions just to be able to say that they did their job. We are taking this issue seriously, and it shows."
P14	Believes that more effort needs to be devoted to ensuring resilience, as currently safety issues are being raised but not addressed.	**ND**	**ND**	Stated that "there are still lots of people working in the industry who treat the safety and security policies as just another regulation".
P15	Praised the introduction of ISO standards, but worries that some procedures have no real impact and that they are just there to fulfil a quota.	Expressed shock at how the pandemic impacted the industry and his company, stating they "really thought I had to find another job", arguing that the company was "suspended in disbelief, just waiting for it [the pandemic] to end, for the most part of 2020", with the response and recovery efforts needing to be improved, with companies needing "not only acknowledge the possible impact of a crisis – any crisis for that matter, not just the pandemic, because any one threat can turn into a disaster at any point – but we need to really understand and act upon our gaps in logistics and distribution". Emphasised that "there is a real need to devise protocols that consider not only how distribution can be affected within the UAE, but how the international state of events influences us. We need to start focusing on threats	Believes that despite the business continuity plans, "many higher-ups are still lost when a big threat is looming over our heads – take for instance the [Covid-19] pandemic, the frameworks were available from the beginning, but many ignored the steps that they needed to take because they didn't take the crisis seriously".	Praised the UAE's implementation of crisis management, but stated that these procedures are insufficiently considered at the ground level even if the companies try to uphold them.

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		and risks that others experienced, because they are as real to us as they are to them".		
P16	Critical of the tendency to just do risk assessments without follow-through. Is concerned with loading and unloading areas where oil spills on the ground and which are "not cleaned according to regulations – which should be daily", posing a significant fire hazard. While such spillage is "expected", he thinks that the personnel should not simply ignore the issue because it is theoretically accounted for, arguing that the company standards should be better upheld.	Believes the UAE energy actors have a "good track record for making the right decisions, but because we lack the experience of other countries and because there is so much on the line, it just takes us a little bit of time to reach these good conclusions".	Thinks the UAE needs to devote more effort towards implementing real changes, but the country is heading in the right direction: "the need to ensure business continuity should outweigh the reticence of relying on others for help, which is pretty common in the UAE".	Mentioned that "the managers keep an eye out for escalating situations and try to change the company strategies and policies to account for them… they keep us on our toes".
P17	Praised the introduction of ISO standards, as a result they participated in risk and crisis management seminars, trainings and workshops along with other managers and employees.	**ND**	Admitted that "everyone is much more confident and relaxed coming in to work since BCM practices have become the golden standard of Emirati power companies". Mentioned that there has been a recent shift towards minimising potential risks and threats via the adoption of preventive measures such as early warning systems for earthquakes: "what BCM taught us is that resilience is not only about what happens after the incident, but that we need to also keep in mind the factors that happen before", adding that "more and more focus is placed on trying to avoid incidents rather than fixating on how we can recover from them, which I think is a step in the right direction".	Praised the existence of both generic and specific plans for various scenarios.
P18	Praised the introduction of ISO standards, yet said there are still more that needs to be done.	Admitted that "things went wrong on all levels, but distribution suffered the most" as a result of "the international travel restrictions", of the worldwide lock-downs, which caused an unprecedented "drop in demand for oil products" for personal, public and private transportation. This unprecedented scenario "helped raise the right questions regarding the supply chain of Emirati energy facilities", which in turn spurred a call to action to "plan for similar issues in the future", which is both "beneficial and necessary".	Is confident that the Emirati energy sector is flexible enough to withstand the impact of large-scale incidents, especially after they experienced the impact of the pandemic.	Praised the existence of both generic and specific plans for various scenarios – although not all are covered.
P19	Praised the attempt to improve safety culture throughout the entire Emirati energy sector: "at the moment we're still learning the ropes and familiarising ourselves with the procedures; having a solid theoretical basis is the first step towards change and I think rushing without understanding what the risk assessments and contingency plans are for could be detrimental in the long term".	**ND**	Critical of the slow implementation of changes, but understanding that such changes are long-term: "introducing industry-wide revisions takes a lot of time and hard work, considering how many actors and stakeholders need to change the way they work".	Praised the existence of both generic and specific plans for various scenarios – although more changes need to be implemented, they believe the energy sector is heading in the right direction.
P20	Praised the introduction of ISO standards. Argued that companies should address risks more directly: "try to respond to the needs of the personnel in a way that both eliminates the threat and makes the people happy", adding that "the last thing we need is making our workers feel unheard or uncared for. This leads to a drop in employee engagement and will only lead to more issues". Urges the importance of employee engagement in creating a resilient and risk-conscious company culture.	Argued that the UAE is a rich country, so "we can afford having a year a bad year or two. We'll recover quickly if this doesn't go on for too long, so we can start focusing on recovery and leave this unfortunate circumstance behind us".	Praised the UAE's diligence to quality: "the [ISO for business continuity] efficiency was tested and acknowledged time and time again before the UAE decided to adopt them".	Believes "the safety of the personnel and the security of the facilities are top priorities in the [Emirati energy] industry, so there is a lot of importance placed on improving the internal procedures and practices", adding that because of these reasons, "energy companies always strive for excellence, which most of the time is sought out through assessments and evaluations of past experiences".

5.4 Code C: Economic Resilience

This section presents the findings related to the Emirati energy sector's economic resilience by examining the decision-making processes behind the distribution of funds. As a company's financial strength influences all other facets (technological, organisational and social), the importance of a secure and sustainable business cash flow is undeniable. The sub-chapter starts with the identified vulnerabilities, which surprisingly relate to the financial stability and investment opportunities of energy companies, as the participants have presented the UAE energy sector as being strong in buying power, as well as regarding the availability of emergency funds. However, while there are very obviously sufficient funds for Emirati energy companies to strengthen their financial resilience, the issues seem to stem from improper management – an issue that will be discussed in more detail in the upcoming sub-chapter, namely social resilience.

5.4.1 Vulnerabilities

The findings show that the Emirati energy sector suffers from two major vulnerabilities, namely regarding the financial stability of energy companies and their ability to secure economic growth in the long term or, more specifically, to be profitable despite hardships, while the companies' tendency to invest in progressive policies and technologies seems also to be lacking, mainly because this factor relies on other elements that have yet to be strengthened.

Theme A. Financial Stability

Financial stability is the first theme, and it refers to the capacity of a company to maintain financial flows throughout all stages of a disaster or crisis, but it is particularly relevant during the post-event stages as it indicates the company's ability to rapidly recover from the direct and indirect negative consequences of the disruption. More specifically, while financial stability is a larger goal for any company, plenty of organisations fail to ensure it in the aftermath of a disaster; thus, budgetary planning needs to take into account any potential risks that could affect both the day-to-day and long-term security of the company from a monetary perspective (Ramlall, 2019). While the vast majority of the participants spoke highly of the company they are employed at, as well as of

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the UAE in general in terms of economic strength, this section had to take into account the aftermath of the Covid-19 pandemic, which is among the few large-scale disasters experienced by the UAE, and which according to some of the participants revealed several concerns. To explain, the participants' opinions were split into two major trains of thought; on the one hand, 8 participants (P1, P2, P3, P5, P9, P12, P15, P17) argued that the Emirati energy sector needs to improve upon its financial planning, and on the other hand 5 participants (P4, P10, P18, P19, P20) championed the idea that the pandemic has had such a significant worldwide impact that the financial blow to the UAE was reasonable and taken into account once the pandemic was underway, with the remaining 7 experts not directly tackling the issues explored in this theme.

The pandemic showed that the sector is vulnerable to large-scale disaster scenarios. For instance, both P3 and P17 welcomed more investment in preventive and mitigation measures: "We do not devote as much effort as we should in preparing for financial disruptions that can result in bankruptcy" (P3), with P17 explaining that prevention is not unique to strengthening the physical elements of the sector: "the aim of planning for a crisis needs to include methods of increasing our financial security". Indeed, the energy companies in the UAE are less susceptible to external shocks because, according to multiple participants, they can easily rely upon the government for funding. However, there is an underlying issue, as raised by P2, P5 and P12, respectively "If the oil sector keeps being affected before the UAE can strengthen its other sources of income, the reserves will dry up, and there will suddenly be no more governmental funding" (P12). According to the participants, after this prolonged period of financial loss, "a terrorist attack would deal a massive blow to our operational efficiency" (P5), and after taking into account the threat of cyberattacks or drone attacks in the region, this perspective becomes increasingly more relevant, with "the impact of another crisis so shortly after the pandemic could be devastating to the stability of the energy sector", P2 stated, adding that the potential of additional costs could "put a serious dent in the bottom line, because of the mounting restoration costs and the reduced profit". Related to this, P1 argued that considering that this crisis has completely blindsided the energy sector, "it is likely we're not aware of other threats, either,

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" adding to the argument that Emirati energy companies need to focus on strengthening their economic resilience. In fact, P1 added that “the Covid-19 pandemic pretty much halted investments, losing energy supplies and economic opportunities, setting back production, " which he said will have severe financial repercussions for the oil industry once the pandemic circumstances dissipate. According to him, the global crisis showed the instability of the fossil fuel industry, namely the fact that it is “very susceptible to fluctuations in demand since we obviously only use oil and gas because people need it, and well – if people suddenly don’t use them we can all pack our bags and go home”, adding that the global switch to renewable energy might be much closer than oil companies anticipated at the start of the century.

In addition to the minimised capacity to withstand financial shocks and considering a wide array of financial risks, the issue of resilience during the disaster has also been tackled by some participants, who shared their concerns regarding the capacity of the companies to maintain employment rates within normal parameters. More specifically, P9 shared that their company had to lay off a number of employees due to the diminished demand and increasing costs. Similarly, P15 shared his concerns about possibly having to look for a different place of employment if the current situation is prolonged. Additionally, P3 disclosed that the approach when the drop in demand occurred as a result of the Covid pandemic crisis was to reduce salaries and eliminate bonuses, which according to him, is “a reasonable response” that still raised alarms because, in contrast, “when the company is doing exceptionally well not everyone is rewarded”. These approaches indeed raise issues regarding resilience, meaning the capacity to return to normal with minimum disturbances, and indeed motivating employees financially needs to be a priority to avoid the rise of employee turnover rates. In fact, according to P9 and P3, the rising turnover rates as a result of the pandemic decisions can transform into another internal crisis for the companies, as they may lose their reputation among experts, who usually take such problems into account and who will most likely seek employment elsewhere, thus affecting the quality of services and products in the long-term. Consequently, the oil sector needs to have the necessary capabilities and resources to ensure that all phases of a disaster scenario take

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into account potential financial losses to quickly return its operations to normal without the event resulting in any further delays or disruptions along the supply chain.

A unanimous opinion was shared by the members of the energy regulators (P18, P19, P20), who linked many of the shortcomings listed above to the fluctuating demand for exports more than the participants employed in the private sector. To explain, according to P18, P19 and P20, while the worldwide demand for oil products is a legitimate crisis that may affect the financial stability of Emirati energy companies, considering the sheer scale of the factors that need to be taken into account, it is almost impossible – at least at this time – to only adopt preventive strategies that ensure the companies are prepared to mitigate financial losses in case of a substantial and sudden drop in demand. To emphasise the three participants emphasised that relying on an emergency budget is much more financially secure in the long-term, as opposed to trying to solve every issue in advance, as the sector has many innate vulnerabilities which, according to P19, "would take a lot of time and resources to fix". Instead, the three participants argued that the UAE energy companies could prepare for such disruptions in a more reactive manner to ensure that they have an emergency budget set aside to offset the potential losses and thus ensure financial stability through contingency planning. Indeed, guaranteeing continuity with the aid of a financial buffer is a valid point that should not be undermined, especially when "companies are already trying to adopt risk management practices in all departments" (P20). However, this unity of perception from the energy regulators raises some questions related to the willingness or capacity of governmental representatives to either understand or accept the fact that private companies should strive towards self-sufficiency and sustainability, respectively, the organisations being capable of withstanding shocks in times of acute crises.

On the other hand, participants employed in the private sector were much more likely to argue in favour of their organisation investing in preventive measures more than in reactive ones, in effect moving away from the companies' dependence on short-term fixes such as emergency budgets and more towards long-term solutions that seek to address all issues. This being said the

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importance of having emergency funds set aside for large-scale disasters did not evade the participants from the private sector, either, all of whom also admitted that having such funds set aside is a necessity – but that it should not be the main strategy. It is important to note the difference in perception, as the former group of experts proposed more reactive solutions, while the latter largely argued in favour of a combination of proactive and reactive measures. To explain, some participants argued that there is a need for oil companies, in particular, to consider the diversification of the business, with several participants (e.g. P2, P3, P4, P10, P12, P17, and more notably P1) arguing in favour of investing in renewable energy in the coming years, as a means of securing profitability via product diversification.

Theme B. Investment Opportunities

Investment opportunities refer to the capacity of organisations to devote an adequate amount of financial resources towards the improvement of the company by advancing the technological, organisational, economic and social policies, procedures and processes as a means of strengthening the resilience of the company at all levels, thus also increasing its sustainability (Bohland et al., 2019). As this issue is influenced by and influences all other aspects discussed throughout this thesis, strengthening a company's investments and ensuring that wise decisions are made can only be a long-term goal; thus, this theme measures an organisation's adaptability. The issue of investing in new technologies and approaches as a means of increasing resilience has been approached, either directly or indirectly, by all of the participants, in different contexts. Out of the, 20 experts, 8 participants (P1, P2, P5, P8, P9, P14, P15, P16) criticised the Emirati energy sector's overall investment choices – the focus being placed more on the lack of technical improvements, 7 participants (P3, P4, P6, P7, P12, P17, P18) discussed the topic in a more neutral manner, and another 5 participants (P10, P11, P13, P19, P20) expressed their satisfaction with the current allocation of funds, yet even members of the latter group had suggestions for improving this capacity.

Most participants agreed that the Emirati energy companies where they worked were investing large sums towards improving the safety conditions and the overall power supply chain by adopting ISO standards for risk management and

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business continuity or by seeking out and acquiring new technologies. However, as demonstrated in the previous sections, these investments also seem to come short of the participants' expectations, who mostly believe that the UAE energy sector does not prioritise growth and change. Many participants believe their companies seek out modernisation at a slow pace when compared to their international counterparts, with experts such as P1, P3, P5, P6, P7, P9, P10, P11, P14, P15, P16 and P18 criticising the existing physical assets and the software used to handle the ageing infrastructure. To emphasise, according to them, the current transmission infrastructure and notably the transmission lines, towers and substations are either too old or insufficient in quantity. Thus, the infrastructure cannot withstand the current energy load (notably considering the addition of nuclear energy into the grid) in a manner that minimises energy waste, and to this point, new transmission lines were created specifically for integrating the Barakah Nuclear Power Plant's energy output. However, as some participants noted (P6, P7, P11, P18), most of the transmission and distribution infrastructure should be refurbished or replaced, as the upkeep of the current assets is much more costly in the long term than simply replacing them. Indeed, replacing these elements would incur high costs in the short term; however, it would considerably lower the risk of random elements such as conductors, wires, straps, and foundations failing or deteriorating – a situation that occurs at an increasingly alarming pace that should alert companies of the need to invest in an infrastructural overhaul (P6, P10, P11). As P11 explained, "How can we achieve resilience if we don't strengthen our existing infrastructure?" while P10 stated that "having to do constant maintenance just so some costs are cut is unsustainable". Given the current circumstances, the participants believe that the risk of the transmission and distribution grid being disrupted due to various external hazards and internal vulnerabilities is much higher than the sector, in general, considers it. While the participants believe the organisations they are employed at are trying their best to address various risks by seeking to invest in new technologies and policies (which are still adopted at a slow pace), they are also concerned that the declining condition of the physical infrastructure might be neglected. Furthermore, the "old facilities are kept afloat until they are no longer useful or needed" (P9), while "the majority of the finances are focused on new tech" (P3),

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and even if the investment in state-of-the-art technology is an important part of this theme, progress without securing the existing assets may be a hasty move, or as P2 puts it, “looking to the future while ignoring the past is imprudent”. This “imprudent” prioritisation of funds shows that currently, the Emirati energy sector’s financial resilience and sustainability are not guaranteed, as there are many structural risks regarding the integrity of the infrastructure – as mentioned above, which can result in large-scale disruptions due to neglect.

Even more so, some participants (e.g. P14, P15) are not satisfied with the technological progress regarding the software that maintains and secures the infrastructure. More specifically, they argued that while companies seek out new technological or operational means to improve their operations, the organisations fall short of the desire to adopt revolutionary instruments, such as machine learning (A.I.), which could improve both the security and the stability of the entire network. In fact, many participants discussed the sector’s lack of investment in protection against terrorist threats, be them cyber in nature (e.g. P1, P8, P13, P15, P16, P19) or physical (e.g. P3, P4, P5, P9, P10, P13, P14, P16, P20), with many arguing that the resilience of the overall sector could be increased notably via investing locally into more diverse collaborative efforts with other stakeholders. Namely, some participants argued that a more direct, hands-on partnership among the key stakeholders of the energy sector (e.g. energy companies & institutions, administrative departments, emergency services, and military) needs to be established. According to them, there is a need for all these actors to understand the existing external threats and to work together towards creating an all-encompassing framework for ensuring resilience within the energy sector – at all levels, including on the ground and administrative solutions. This is another issue that seems to be overlooked by Emirati energy companies, despite the rising terrorist threat and notably despite the growing risk of terrorist groups using technologies (i.e. drone and cyber warfare) to target the energy infrastructure that is above the UAE’s energy sector preparedness and defence capacity – however, this issue is discussed in more depth in its appropriate section.

All of these issues seem to be related to the tendency to ignore the organisational and social parts of resilience (see Sections 5.5. and 5.7.). While the funds are available to invest in domestic and international tools and mechanisms under normal circumstances, the tendency is to focus solely on tangible resources and physical opportunities, while the more abstract elements are devoted to insufficient attention, financially and conceptually. As the themes explored in the upcoming section regarding social resilience (i.e. 5.7.) show, there are not enough institutional programmes to increase the resilience of the sector by strengthening the management's or leaders' capacity for decision-making, as well as insufficient social programmes to increase the resilience of the population through means other than investing in physical, easily observed or quantified solutions. This approach not only does not address community demands but may hinder both the sustainable development and the resilience of the population.

As the findings show, in theory, the UAE-based organisations typically have a high capacity for financial investment, as well as in the technological and organisational resilience sections; the majority of the participants believe that, in practice, the Emirati energy sector currently does little to invest in resilient or sustainable practices. The dissonance between what the interviewees believe could be achieved and what their experience shows to be prioritised in reality takes away from the potential of the Emirati energy sector to further expand in a manner that will safeguard the stability and continuity of the companies. Indeed, as the participants pointed out, there is a need to strengthen the financial resilience of the sector further, as P2 explained – currently, companies are inclined to "fix issues as they emerge", with issues that could result in a more widespread financial disruption such as terrorist attacks on facilities being "swept under the rug", as administrators "hope for the best".

However, this is not an easy task to achieve; considering that the economic capacity of a company influences and is influenced by all other aspects, the investigation into the financial risks should not occur in a vacuum, independent of all other aspects. For instance, P16 explained that while he thinks his company is resilient from a financial standpoint, increasing resilience as an overall capacity of the Emirati energy sector in particular, is equally reliant on ensuring organisational resilience, the two being strongly tied together.

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According to P16, the strategy following a disruptive event of any kind should also include a continuous assessment as:

> "It's not enough to repair the damages, we need to have the proper regulations in place to ensure that similar events do not occur in the future, and we also need to make sure that companies follow these rules at all times".

Not surprisingly, the perspective of mitigating disruptive events before they emerge has been shared by most participants. However, there is a divergence between the participants' opinions regarding which preventive operations should be enacted and which aspects these preventive operations should apply to. To summarise, some participants focused on preventing technical and technological risks, others placed more importance on minimising organisational risks, and others argued that social risks need to be minimised. However, the vast majority of them believed that other aspects heavily influence economic resilience. The key element that seems to be currently lacking is an all-encompassing risk analysis that identifies the main risks that each company faces. Conducting a company-wide risk investigation that seeks to improve resilience and sustainability at all levels and for all stakeholders could highlight many of the issues raised in this thesis to the appropriate decision-makers, who need to acknowledge, plan for and start to address their company-specific vulnerabilities, in addition to the sector-wide ones that overall seem to be devoted more consideration by the higher-ups.

5.4.2 5.6.2. Opportunities

The data shows that when considering the aspect of financial resilience, the Emirati energy sector also relies on two essential strategies that can be considered opportunities for future development, respectively, the considerable buying power and the availability of emergency funds, both of which greatly help during all stages of a disaster.

Theme A. <u>Buying Power</u>

The theme of buying power refers to the total sum that can be spent within a company to increase the quality and quantity of the goods sold or services

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provided, therefore ensuring the organisation not only profits but that it continues to progress in a financially secure manner (Labaka et al., 2015b). As this purchasing power or excess equity influences the availability and quality of all other resources, as well as the capacity to ensure the stability and security of the company, the organisation needs to make sure they employ the proper monitoring and evaluation tools (e.g. audits, financial analyses, valuations) to ensure financial stability (Lee et al., 2016). Considering the importance of budgetary means throughout all stages of a disaster or crisis, this indicator of economic resilience proves an organisation's robustness. This theme has been overwhelmingly discussed favourably by the participants, unsurprisingly due to the UAE's overall financial security. Many of the interviewed experts, namely 9 out of, 20 (P4, P5, P7, P10, P11, P13, P16, P18, P19), spoke highly of this issue, while another 6 out of, 20 participants (P2, P3, P8, P12, P14, P17) approaching it from a neutral perspective.

Overall, the buying power of Emirati energy companies currently seems to be strong; however, it can and should be further strengthened. The findings revealed that the most important factor currently influencing the buying power of the companies is the economic success that these firms have amassed throughout the years, which allows them to continue supporting themselves financially, although the various disruptions and especially because of the Covid-19 pandemic that had repercussions even on the UAE energy sector is an exception. For the most part, the participants believe that their companies have strived to increase their profit continuously and minimise their costs, with P13, for instance, stating that "profitability is and always has been a priority", and all of the other experts who approached this topic shared very similar thoughts. In fact, several participants emphasised the focus that the companies they are employed at have placed throughout the years on excess equity. For instance, both P7 and P10, who work at different power plants within the Madinat Zayed company, argued that the diversification of energy generation and distribution, stemming from the increase in the number of facilities and the revisions made, is proof of the increased buying power. As P10 explained,

> "Non-profitable oil companies don't invest in other types of power plants because they already have so many issues… and diversification is a big

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> financial investment, but we [Madinat Zayed Power Plant] already have oil, thermal, water and even solar power plants! A decade ago, I used to know most people employed at the company, and now, sometimes, I feel overwhelmed by the hundreds of new faces. This clearly means we're on the right track".

Similarly, P7 stated that "we [Madinat Zayed Power Plant] must be good at what we do because we keep improving our facilities, which are newer and better equipped than many others", adding that "a company that isn't doing well financially could not make the necessary upgrades to keep up with the times". Related to this, P10 and P6 (also employed at Madinat Zayed) had also praised their company's move to collaborate with the Barakah Nuclear Power Plant and invest in the creation of higher voltage transmission lines that have an increased capacity to integrate the high energy output from the nuclear plant,[1] which similarly according to the participants is proof of their company's profitability. While other participants have not gone into such details, those who praised their company's purchasing power did use words such as "strong" (P4, P11), "stable" (P2, P13, P17), "profitable" (P5, P16), "productive" (P3, P8, P14) or "cost-effective" (P12, P18, P19) as descriptors. This being said, some participants thought that better decisions could be made at all levels to secure financial stability, with P2 notably stating that the company he is employed at (i.e. ADNOC) is "as profitable as any other company that wants to support the local economy", while P14 thought that his institution was "productive, but it could be better" – indicating that more calculated business decisions should be taken. However, as P14 further explained, "the UAE has the necessary procedures set up to help the energy sector financially as much as it can; there are funds that can be accessed by energy companies that suffer from financial burdens", which according to him could explain to an extent the continuous success of some of the less profitable energy companies.

Another issue the vast majority of the participants mentioned was the abundance of regulations, policies and procedures, both imposed by the

[1] This issue has been more in-depth addressed in section 5.4.2. (Technical and Technological Opportunities), under Theme A (Power Generation Diversity).

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government and developed by the companies individually, to ensure that profits are maximised and that losses are minimised. Most of the participants acknowledged the frequent use of monitoring and evaluation protocols, such as audits (mentioned by 14 participants), analyses (mentioned by 11 participants), and business valuations (mentioned by 8 participants). Several experts also mentioned more specific tools, such as cash-flow statements (mentioned by 15 participants), cost-benefit analyses (mentioned by 12 participants), balance sheets (mentioned by 9 participants), and income statements (mentioned by 5 participants). Additionally, all 16 participants who addressed this topic also emphasised that their place of employment had a dedicated accounting and finance department, usually supervised by a Chief Financial Officer (for private companies), which is unsurprising for an energy institution. Indeed, using all of these methods to calculate financial stability and success shows that Emirati energy companies are dedicated to strengthening their buying power to guarantee their economic resilience.

Theme B. Availability of Emergency Funds

The topic of emergency fund availability takes into account the property damages or other financial losses commonly caused by crises and disasters and thus refers to the capacity of the Emirati energy companies to quickly tap into an emergency budget that has been set aside in advance to address such issues as a means of ensuring business continuity and resilience throughout all facilities (Labaka, 2013). As the arrangements made to distribute the emergency funds need to be activated at the onset of a disaster, the availability of the cash reserve is a method of showcasing the company's resourcefulness during an unexpected situation. Most participants did not directly tackle the theme of emergency fund availability; however, those who approached it talked favourably about it, warranting its classification as an opportunity. More specifically, 12 out of, 20 participants (P1, P2, P3, P4, P7, P8, P10, P12, P13, P14, P17, P18) either lightly touched on the subject in a neutral manner or did not approach the subject at all, while 6 out of, 20 (P6, P9, P11, P15, P19, P20) depicted the factor in a positive light, and only 2 (P5, P16) addressing it in more a negative manner.

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The majority of the participants who commented on the topic of emergency fund availability from a neutral standpoint (P1, P2, P3, P4, P8, P10, P14, P18) mainly talked about it in the context of technological resilience, for instance, while arguing that the budget needs to be further adjusted to consider large-scale disasters that are for the most part neglected in the UAE due to the country's limited exposure to such events (P1, P2, P3, P4, P8, P18), or while discussing the country's tardiness in implementing novel, internationally-acclaimed disaster-management concepts in the legislation and official regulations (P10, P14). In essence, they argued that because the UAE has not experienced any localised large-scale disasters so far, many policy-makers believe there is no need to prepare for them to a great extent, which could be detrimental when and if a crisis occurs. According to these participants, the UAE should strive to improve its financial planning. Still, they argued that the country would not suffer any significant damages during the after-crisis stages if the problems could be fixed solely financially. Related to this is the more critical opinions of P5 and P16 in discussing the topic of bouncing back to the ideal state before a disaster, both of whom argued that the current approach is "naive" (P5) or "needs improvement" (P16). To explain, P5, on the one hand, approached the issue of emergency fund availability by examining emerging threats such as the recent drone oil attacks in Saudi Arabia and the rise of cyber-terrorism in general, for which "the UAE is not prepared", especially after taking into account the financial blows that can result in the wake of such aggressions, especially if they are repeated. On the other hand, P16 raised the issue of the UAE's general unpreparedness against "large-scale disasters or other system-wide disruptions that can bring the entire country to a stop" due to the importance of the energy sector to supply power to all other sectors, companies and individuals, which "could hinder the well-being of the community as a whole". Equally important is another perspective shared by P16, namely the fact that "even if we have enough emergency funds to ensure business continuity after a disaster, simply throwing money at a problem does not make it go away", adding that "fortunately our leaders are very capable of managing the day-to-day funds and the yearly budget", emphasising the idea that "business continuity management really helped strengthen our economic resilience, but there is still space for improvement".

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However, for two participants (P19, P20), this issue does not seem to pose a significant threat, as the UAE's direct involvement in the disaster relief stage in other countries is a good indicator of the state's ability to manage and deploy emergency funds in a quick, reliable and effective manner, as similarities between the two approaches to budget management can be drawn. According to P19, the UAE has so far had no issues during previous humanitarian responses worldwide, which shows the ability of Emirati organisations to "come together in the face of a disaster, no matter who it affects", the experiences having helped instil valuable disaster and crisis management lessons such as quickness to respond to an unexpected event, fund prioritisation and decision-making during times of distress. At the same time, P19 also noted that due to the reliance of the UAE on the economic security provided by oil exports, "it is unlikely that any Emirati energy company will be left to fend for itself in case of an emergency that threatens its prosperity". P20 explained that "the UAE tried to strengthen its external ties and expects that other countries will also provide us with financial relief as we have to others if it ever comes to this". However, he continued by emphasising the improbability of this occurrence, arguing instead that the UAE Government had developed and has been implementing contingency financial planning for at least two decades, arguing that economic resilience has been a crucial part of the UAE's development even before resilience became a standard around disaster management practitioners worldwide. As P20 further added, the recent terrorist threat in the area also encouraged both the UAE as a whole and the individual companies of the energy sector to dedicate additional funds and training to increase their efficiency in case of a disaster, as well as to rethink their emergency budget to ensure that all physical assets can be "quickly repaired or replaced when they are damaged or destroyed". P20 concluded that "companies already employ such tactics when something breaks". However, this emphasis on response and recovery seems to be the main issue at the core of the UAE's disaster and crisis management strategy – as preparedness is less emphasised despite being the more financially-sustainable and less resource-draining approach, as depicted not only by P20 but also by other participants throughout this entire chapter.

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At the same time, some participants mentioned that the Covid-19 pandemic tested the Emirati organisations' disaster preparedness, response and overall adaptability in the face of a large-scale emergency and, implicitly their existing emergency financial strategies. According to P9, the pandemic "showed people that it's important to plan for the worst possible outcome, even if the risks are low", which resulted in "changes to the way the budget is allocated", for instance, by instituting a priority-based, flexible budgeting plan instead of a more traditional fixed one, a measure taken to improve the economic resilience of the Madinat Zayed Power Plant. Similarly, P6, who also works at Madinat Zayed, noted that "the magnitude of the Covid-19 pandemic revealed errors in our approach to disaster relief and prompted a lot more changes in the past year compared to the past 10 years combined", explaining that the financial blow suffered from the huge drop in the oil demand throughout the world made oil production facilities to reconsider unexpected storing and selling issues that can severely impact the budget at all levels of operation. Related to this, P11 stated that "if anything good comes out of this pandemic, it's the lessons we learned to mitigate disasters", at the same time emphasising the need for Emirati energy companies to "actually implement these lessons as part of the long-term strategy, not just write them down and forget about them as soon as it [the Covid-19 pandemic] is over". However, P11 added that "this does not seem to be the case", considering the UAE's emphasis on the generation of green energy, which is sustainable and does not incur the pitfalls of the need to store and quickly distribute oil products, therefore being more a cost-effective alternative that can increase the flexibility of the sector in crisis situations. Even more so, both P15 and P20 consider the help provided by the UAE Federal Government for companies affected by the pandemic as a positive step towards increasing economic resilience, with P15 explaining that "the Government quickly recognised that there was a rising supply and demand problem that could lead to severe financial losses, and lowered a lot of property fees and taxes until the supply chain returns to normal". On this topic, P20 also contributed with more details, explaining that the governmental help consisted of a reduction in property costs, in fees and permits for commercial licenses, as well as a "substantial decrease of customs fees and clearances", with all of these measures actively seeking to diminish the financial blow dealt to Emirati

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companies, and which directly resulted in “many energy companies overcoming their financial shortcomings this past year [2020]”.

5.4.3 5.6.3. Main Findings

To better illustrate the findings regarding the third code (Economic Factors) and its four themes, the following Table 8 presents the quotes, main ideas and details shared by the participants related to the resilience of the Emirati energy sector. Each participant's contribution is illustrated individually, and for the themes where participants have not contributed, the abbreviation for no data (i.e. “ND“) is used.

Table 8: Code 3 - Economic Resilience Factors

	Code 3: Economic Resilience Factors			
	Vulnerabilities		Opportunities	
	Theme A: Financial Stability	**Theme B: Investment Opportunity**	**Theme A: Buying Power**	**Theme B: Availability of Emergency Funds**
P1	Thinks the Emirati energy sector has been blindsided by this crisis, "it is likely we're not aware of other threats, either", adding that "the Covid-19 pandemic pretty much halted investments, losing energy supplies and economic opportunities, setting back production", which shows the instability of the fossil fuel industry, as it is "very susceptible to fluctuations in demand, since we obviously only use oil and gas because people need it, and well – if people suddenly don't use them we can all pack our bags and go home". Is in favour of investing in renewable energy as a means of securing profitability via product diversification, and believes the shift is closer than anticipated by oil companies.	Admitted their company has a slow modernisation pace regarding the physical assets (transmission infrastructure – insufficient or old lines, towers and substations) and the software used. Thinks the energy sector is not safe from major economic crises, and criticised the sector's lack of investment against cyber threats.	**ND**	Argued the budget planning needs to take into account large-scale disasters that are for the most part neglected in the UAE due to the country's limited exposure to such events, which increases complacency and ignorance. Believes the UAE energy sector does not fall short financially, and that any potential disruptions could be easily addressed with budget increases.
P2	Is concerned that a terror attack could be devastating: "the impact of another crisis so shortly after the pandemic could be devastating to the stability of the energy sector", as the additional costs could "put a serious dent in the bottom line, because of the mounting restoration costs and the reduced profit". Is in favour of investing in renewable energy as a means of securing profitability via product diversification.	Thinks "looking to the future while ignoring the past is imprudent" – criticised the tendency for energy companies to "fix issues as they emerge", with issues that could result in a more widespread financial disruption such as terrorist attacks on facilities being "swept under the rug", as administrators "hope for the best". Asserted there is no company-wide risk analysis that seeks to improve resilience and sustainability at all levels and for all stakeholders.	Considers their company to be a "stable" one, financially: "ADNOC is as profitable as any other company that wants to support the local economy". Mentioned the existence of a dedicated accounting and finance department, supervised by a Chief Financial Officer, which makes use of tools such as audits, cash-flow statements, cost-benefit analyses to maintain the high buying power and ensure the longevity of the company.	Argued the budget planning needs to take into account large-scale disasters that are for the most part neglected in the UAE due to the country's limited exposure to such events, which increases complacency and ignorance. Believes the UAE energy sector does not fall short financially, and that any potential disruptions could be easily addressed with budget increases.
P3	Welcomed more investment in preventive and mitigation measures: "we do not devote as much effort as we should in preparing for financial disruptions that can result in bankruptcy". Thought their company's response to reduce salaries and cut bonuses was a "reasonable response", yet unsatisfactory when considering that these are not raised "when the company is doing exceptionally well not everyone is rewarded". Believes the rising turnover rates may transform into another internal crisis for the companies. Is in favour of investing in renewable energy as a means of securing profitability via product diversification.	Admitted their company has a slow modernisation pace regarding the physical assets (transmission infrastructure – insufficient or old lines, towers and substations) and the software used: "the majority of the finances is focused on new tech, and the old equipment is forgotten". Thinks the energy sector is overall safe from major economic crises, but criticised the sector's lack of investment against physical terrorist attacks.	Considers their company to be a "productive" one. Mentioned the existence of a dedicated accounting and finance department, supervised by a Chief Financial Officer, which makes use of tools such as audits, cash-flow statements, cost-benefit analyses to maintain the high buying power and ensure the longevity of the company.	Argued the budget planning needs to take into account large-scale disasters that are for the most part neglected in the UAE due to the country's limited exposure to such events, which increases complacency and ignorance. Believes the UAE energy sector does not fall short financially, and that any potential disruptions could be easily addressed with budget increases.
P4	Believes the energy sector is financially secure, and that the Covid-19 pandemic had a significant worldwide impact – not solely on the UAE. Is in favour of investing in renewable energy as a means of securing profitability via product diversification.	Thinks the energy sector is overall safe from major economic crises, but criticised the sector's lack of investment against physical terrorist attacks.	Considers their company to be financially "strong". Mentioned the existence of a dedicated accounting and finance department, supervised by a Chief Financial Officer, which makes use of tools such as audits, financial analyses, business valuations, cash-flow statements, cost-benefit analyses, balance sheets to maintain the high buying power and ensure the longevity of the company.	Argued the budget planning needs to take into account large-scale disasters that are for the most part neglected in the UAE due to the country's limited exposure to such events, which increases complacency and ignorance. Believes the UAE energy sector does not fall short financially, and that any potential disruptions could be easily addressed with budget increases.
P5	Is concerned that "a terrorist attack would deal a massive blow to our operational efficiency", does not believe the sector or their company is as financially stable as it should be despite the good financial planning and practices.	Admitted their company has a slow modernisation pace regarding the physical assets (transmission infrastructure – insufficient or old lines, towers and substations) and the software used.	Considers their company to be "profitable". Mentioned the existence of a dedicated accounting and finance department, supervised by a Chief Financial Officer, which makes use of tools such as audits, financial analyses, cash-flow statements,	Discussed the topic of bouncing back to the ideal state prior to a disaster, stating that the current approach is "naive", examining emerging threats such as the recent drone oil attacks in Saudi Arabia and the rise of cyber-terrorism, for which "the UAE is not prepared".

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		Thinks the energy sector is overall unsafe from major economic crises, and criticised the sector's lack of investment against physical terrorist threats.	cost-benefit analyses to maintain the high buying power and ensure the longevity of the company.	
P6	**ND**	Believes their company has a slow modernisation pace regarding the physical assets (transmission infrastructure – insufficient or old lines, towers and substations). Argued that most of the transmission and distribution infrastructure (such as conductors, wires, straps, foundations) should be refurbished or replaced, as the upkeep of the current assets is much more costly long-term, even if the initial cost is high. Asserted there is no company-wide risk analysis that seeks to improve resilience and sustainability at all levels and for all stakeholders.	Considers their company to be "profitable". Mentioned the existence of a dedicated accounting and finance department, which makes use of tools such as audits, financial analyses, business valuations, cash-flow statements, cost-benefit analyses, balance sheets, income statements to maintain the high buying power and ensure the longevity of the company. Emphasised the focus that the companies they are employed at have placed throughout the years on acquiring excess equity. Praised their company's investment into the creation of higher voltage transmission lines that have an increased capacity so as to integrate the high energy output from the Barakah nuclear power plant.	Noted that "the magnitude of the Covid-19 pandemic revealed errors in our approach to disaster relief and prompted a lot more changes in the past year compared to the past 10 years combined", explaining that the financial blow suffered from the huge drop in the oil demand throughout the world made oil production facilities to reconsider unexpected storing and selling issues that can severely impact the budget at all levels of operation.
P7	**ND**	Believes their company has a slow modernisation pace regarding the physical assets (transmission infrastructure). Asserted that the upkeep of the transmission and distribution infrastructure is more costly than replacing the ageing elements.	Praised their company's economic vision. Praised the diversification of energy generation and distribution, the increased number of facilities and the revisions made, which are all proof of the increased buying power: "we [Madinat Zayed Power Plant] must be good at what we do because we keep improving our facilities, which are newer and better equipped than many others", adding that "a company that isn't doing well financially could not make the necessary upgrades to keep up with the times". Mentioned the existence of a dedicated accounting and finance department, which makes use of tools such as audits, financial analyses, cash-flow statements, balance sheets to maintain the high buying power and ensure the longevity of the company.	**ND**
P8	**ND**	Thinks the sector is unsafe financially because of the rising risk of cyber-crimes, which can cause major financial losses. Asserted there is no company-wide risk analysis that seeks to improve resilience and sustainability at all levels and for all stakeholders.	Considers their company to be "productive". Mentioned the existence of a dedicated accounting and finance department, supervised by a Chief Financial Officer, which makes use of tools such as financial analyses, business valuations, cash-flow statements, balance sheets to maintain the high buying power and ensure the financial stability of the company.	Argued the budget planning needs to take into account large-scale disasters that are for the most part neglected in the UAE due to the country's limited exposure to such events, which increases complacency and ignorance. Believes the UAE energy sector does not fall short financially, and that any potential disruptions could be easily addressed with budget increases.
P9	Admitted their company had to lay off a number of employees due to the diminished demand and increasing costs. Believes the rising turnover rates can cause additional financial strain on the companies (losing reputation, quality of services and products offered being affected in the long-term).	Believes their company has a slow modernisation pace regarding the physical assets (facilities): "old facilities are kept afloat until they are no longer useful or needed". Deems the sector overall safe, but there is a need to strengthen it against physical terrorist threats.	**ND**	Noted that the pandemic "showed people that it's important to plan for the worst possible outcome, even if the risks are low", which resulted in "changes to the way the budget is allocated", for instance by instituting a priority-based, flexible budgeting plan instead of a more traditional "fixed" one.

P10	Believes the energy sector is financially secure, and that the Covid-19 pandemic had a significant worldwide impact – not solely on the UAE. Is in favour of investing in renewable energy as a means of securing profitability via product diversification.	Believes their company has a slow modernisation pace regarding the infrastructure, which incurs high maintenance costs: "having to do constant maintenance just so some costs are cut is unsustainable". Deems the sector overall safe, but there is a need to strengthen it against physical terrorist threats.	Argued that the diversification of energy generation and distribution is proof of the increased buying power: "Non-profitable oil companies don't invest in other types of power plants because they already have so many issues… and diversification is a big financial investment, but we [Madinat Zayed Power Plant] already have oil, thermal, water and even solar power plants! A decade ago I used to know most people employed at the company, and now, sometimes I feel overwhelmed with the hundreds of new faces. This clearly means we're on the right track". Praised their company's investment into the creation of higher voltage transmission lines that have an increased capacity so as to integrate the high energy output from the Barakah nuclear power plant. Mentioned the existence of a dedicated accounting and finance department, which makes use of tools such as audits, financial analyses, business valuations, cash-flow statements, cost-benefit analyses, balance sheets, income statements to maintain the high buying power and ensure the financial stability of the company. Emphasised the focus that the companies they are employed at have placed throughout the years on gaining excess equity.	Argued the budget planning needs to take into account large-scale disasters that are for the most part neglected in the UAE due to the country's limited exposure to such events, which increases complacency and ignorance. Believes the UAE energy sector does not fall short financially, and that any potential disruptions could be easily addressed with budget increases.
P11	**ND**	Believes their company has a slow modernisation pace regarding the infrastructure and assets, many of which are deteriorating at a rapid pace because of the natural wear and tear: "how can we achieve resilience if we don't strengthen our existing infrastructure?" Asserted there is no company-wide risk analysis that seeks to improve resilience and sustainability at all levels and for all stakeholders.	Considers their company to be financially "strong". Mentioned the existence of a dedicated accounting and finance department, which makes use of tools such as audits, business valuations, cash-flow statements, cost-benefit analyses, balance sheets, income statements to maintain the high buying power and ensure the financial stability of the company.	Praised the UAE's pandemic response: "if anything good comes out of this pandemic, it's the lessons we learned to mitigate disasters", at the same time emphasising the need of Emirati energy companies to "actually implement these lessons as part of the long-term strategy, not just write them down and forget about them as soon as it [the Covid-19 pandemic] is over", yet mentioned that "this not seem to be the case", considering the UAE's emphasis on the generation of green energy, which is sustainable and more cost-effective.
P12	Believes the energy sector is not financially secure: "if the oil sector keeps being affected before the UAE can strengthen its other sources of income, the reserves will dry up and there will suddenly be no more governmental funding". Is in favour of investing in renewable energy as a means of securing profitability via product diversification.	Asserted there is no company-wide risk analysis that seeks to improve resilience and sustainability at all levels and for all stakeholders.	Considers their company to be "cost-effective". Mentioned the existence of a dedicated accounting and finance department, which makes use of tools such as audits, cash-flow statements, cost-benefit analyses to maintain the high buying power and ensure the financial stability of the company.	**ND**
P13	**ND**	Deems the sector overall safe, but there is a need to strengthen it against physical and cyber terrorist attacks.	Considers their company to be "financially stable", as well as "profitable": "profitability is and always has been a priority". Mentioned the existence of a dedicated accounting and finance department, which makes use of tools such as audits, financial analyses, business valuations, cash-flow statements, cost-benefit analyses, balance sheets, income statements to maintain the high buying power and ensure the financial stability of the company.	**ND**

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			Emphasised the focus that the companies they are employed at have placed throughout the years on gaining excess equity.	
P14	**ND**	Admitted their company has a slow modernisation pace regarding the physical assets (transmission infrastructure – insufficient or old lines, towers and substations) and notably the software used, which can be secured and strengthened with the use of machine learning (A.I.). Deems the sector overall safe, but there is a need to strengthen it against physical terrorist threats.	Believes his institution was "productive, but it could be better", and regarding the sector thinks "the UAE has the necessary procedures set up to help the energy sector financially as much as it can, there are funds that can be accessed by energy companies that suffer from financial burdens", which according to him could explain to an extent the continuous success of some of the less prosperous energy companies. Mentioned the existence of an accounting and finance department, which makes use of tools such as audits, financial analyses, cash-flow statements to maintain the high buying power and ensure the financial stability of the company.	Argued the budget planning needs to take into account large-scale disasters that are for the most part neglected in the UAE due to the country's limited exposure to such events, which increases complacency and ignorance. Believes the UAE energy sector does not fall short financially, and that any potential disruptions could be easily addressed with budget increases.
P15	Shared his concerns with having to look for a different place of employment given the pandemic's financial strain.	Admitted their company has a slow modernisation pace regarding the physical assets (transmission infrastructure – insufficient or old lines, towers and substations) and notably the software used, which can be secured and strengthened with the use of machine learning (A.I.). Deems the sector overall safe, but there is a need to strengthen it against cyber-attacks.	**ND**	Regarding the Covid-19 pandemic, noted that "the Government quickly recognised that there was a rising supply and demand problem that could lead to severe financial losses, and lowered a lot of property fees and taxes until the supply chain returns to normal".
P16	**ND**	Believes their company has a slow modernisation pace regarding the physical assets (transmission infrastructure – insufficient or old lines, towers and substations). Argued that most of the transmission and distribution infrastructure (such as conductors, wires, straps, foundations) should be refurbished or replaced, as the upkeep of the current assets is much more costly long-term, even if the initial cost is high. Thinks their company is financially resilient, and deems the sector overall safe, but there is a need to strengthen it against physical terror threats and cyber-attacks. Criticised the fact that Emirati energy sector does not employ a continuous assessment and improvement strategy: "It's not enough to repair the damages, we need to have the proper regulations in place to ensure that similar events do not occur in the future and we also need to make sure that companies follow these rules at all times".	Considers their company to be "profitable". Mentioned the existence of a dedicated accounting and finance department, which makes use of tools such as audits, financial analyses, business valuations, cash-flow statements, balance sheets to maintain the high buying power and ensure the financial stability of the company. Emphasised the focus that the companies they are employed at have placed throughout the years on gaining excess equity.	Discussed the topic of bouncing back to the ideal state prior to a disaster, stating that the current approach "needing improvement", as the UAE is "generally unprepared to handle large scale disasters or other system-wide disruptions that can bring the entire country to a stop", due to the importance of the energy sector to supply power to all other sectors, companies and individuals, which "could possibly hinder the well-being of the community as a whole". Added that "even if we have enough emergency funds to ensure business continuity after a disaster, simply throwing money at a problem does not make it go away", "fortunately our leaders are very capable of managing the day-to-day funds and the yearly budget", emphasising the idea that "business continuity management [BCM] really helped strengthen our economic resilience, but there is still space for improvement".
P17	Welcomed more investment in preventive and mitigation measures: "the aim of planning for a crisis needs to include methods of increasing our financial security". Believes the energy sector is financially secure. Is in favour of investing in renewable energy as a means of securing profitability via product diversification.	Asserted there is no company-wide risk analysis that seeks to improve resilience and sustainability at all levels and for all stakeholders.	Considers their company to be financially "stable". Mentioned the existence of a dedicated accounting and finance department, which makes use of tools such as audits, cost-benefit analyses, balance sheets to maintain the high buying power and ensure the financial stability of the company.	**ND**

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P18	Linked shortcomings to the fluctuating demand of exports, thus it is almost impossible to adopt preventive strategies that ensure the companies are prepared to mitigate financial losses in case of a substantial and sudden drop in demand. Believes that the Covid-19 pandemic had a significant worldwide impact – not solely on the UAE, for this reason argued that the Emirati energy sector should rely more on emergency budgets.	Believes their company has a slow modernisation pace regarding the physical assets (transmission infrastructure – insufficient or old lines, towers and substations). Argued that most of the transmission and distribution infrastructure (such as conductors, wires, straps, foundations) should be refurbished or replaced, as the upkeep of the current assets is much more costly long-term, even if the initial cost is high.	Considers their company to be financially "cost-effective". Mentioned the existence of a dedicated accounting and finance department, supervised by a CFO, which makes use of tools such as financial analyses, cash-flow statements, cost-benefit analyses to maintain the high buying power and ensure the financial stability of the company.	Argued the budget planning needs to take into account large-scale disasters that are for the most part neglected in the UAE due to the country's limited exposure to such events, which increases complacency and ignorance. Believes the UAE energy sector does not fall short financially, and that any potential disruptions could be easily addressed with budget increases.
P19	Linked shortcomings to the fluctuating demand of exports, thus it is almost impossible to adopt preventive strategies that ensure the companies are prepared to mitigate financial losses in case of a substantial and sudden drop in demand. Believes that the Covid-19 pandemic had a significant worldwide impact – not solely on the UAE, for this reason argued that the Emirati energy sector should rely more on emergency budgets, instead on trying to prevent and address all issues, which "would take a lot of time and resources to fix".	Deems the sector overall safe, but there is a need to strengthen it against cyber terrorist threats.	Considers their company to be financially "cost-effective". Mentioned the existence of a dedicated accounting and finance department, supervised by a CFO, which makes use of tools such as audits, financial analyses, business valuations, cash-flow statements, cost-benefit analyses, balance sheets, income statements to maintain the high buying power and ensure the financial stability of the company.	Believes the UAE's direct involvement in the disaster relief in other countries is a good indicator of the state's ability to manage and deploy emergency funds. Believes this shows the ability of Emirati organisations to "come together in the face of a disaster, no matter who it affects", the experiences improving disaster and crisis management practices. Noted that: "it is unlikely that any Emirati energy company will be left to fend for itself in case of an emergency that threatens its prosperity".
P20	Linked shortcomings to the fluctuating demand of exports, thus it is almost impossible to adopt preventive strategies that ensure the companies are prepared to mitigate financial losses in case of a substantial and sudden drop in demand. Believes that the Covid-19 pandemic had a significant worldwide impact – not solely on the UAE, for this reason argued that the Emirati energy sector should rely more on emergency budgets, as the sector has many innate vulnerabilities. Believes that guaranteeing continuity with the aid of a financial buffer is a valid point that should not be undermined, especially when "companies are already trying to adopt risk management practices in all departments". Believes that the Covid-19 pandemic had a significant worldwide impact – not solely on the UAE.	Deems the sector overall safe, but there is a need to strengthen it against physical terrorist threats.	**ND**	Believes the UAE's direct involvement in the disaster relief in other countries is a good indicator of the state's ability to manage and deploy emergency funds. Argued that "the UAE tried to strengthen its external ties and expects that other countries will also provide us with financial relief as we have to others, if it ever comes to this", yet stated this was "unlikely" because the UAE Government has developed and has been implementing contingency financial planning for at least two decades. The recent terrorist threat in the area also encouraged the UAE energy sector to dedicate additional funds and training to increase their efficiency in case of a disaster, as well as to rethink their emergency budget in order to ensure that all physical assets can be "quickly repaired or replaced when they are damaged or destroyed", arguing that "companies already employ such tactics when something breaks". Noted that the pandemic governmental help consisted of a reduction in property costs, in fees and permits for commercial licenses, as well as a "substantial decrease of customs fees and clearances", with all of these measures actively seeking to diminish the financial blow dealt to Emirati companies, and which directly resulted in "many energy companies overcoming their financial shortcomings this past year [2020]".

5.5 Code D: Social Resilience

This final section depicts the theme of resilience from a social perspective by assessing the established policies and practices that seek to increase resilience for the people directly or indirectly influenced by possible disasters affecting the Emirati energy sector. Similarly starting with the vulnerabilities, the chapter first presents issues that are largely related to the lack of collaboration – between management and employees, among organisations, and also with the population – and then continue with the opportunities, the UAE excelling in personnel training and also taking steps in the right direction towards creating a sustainable environment. This being said it could not be stated that the Emirati energy sector is socially resilient; however, all of the current issues stem from the existing organisational culture, which discourages community involvement, which was also signalled in the previous sections. However, the flaws in the system could still be addressed easily if the engagement of all the stakeholders is ensured.

5.5.1 Vulnerabilities

The main vulnerabilities identified relate to the improper training and expertise of some members of the management, the lack of explicit multi-agency collaboration policies, procedures and practices, as well as the limited social support and disaster relief.

Theme A. Management Training

This first code refers exclusively to the training and expertise of the management teams in the Emirati energy sector, as without proper management taking efficient, apt and reliable decisions, the stability and resilience of the energy infrastructure may become compromised. While initially, this subject would have been covered in the upcoming section on personnel training, after analysing the primary data, the decision was taken to split the two issues into two separate themes. To explain, the participants' answers revealed several issues regarding the training of the managers, which was largely more negatively perceived when compared to that of the other employees. Overall, out of the, 20 participants, 9 (P1, P2, P6, P9, P10, P12, P14, P15, P18) used negative or critical language to refer to the current

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capabilities of the managers, 6 (P3, P7, P8, P11, P16, P20) used positive language and the remaining 5 made neutral comments (P4, P17) or abstained (P5, P13, P19) from addressing the issue of management training.

The majority of the participants emphasised the role of the upper management of their organization in this capacity-building process, as well as during the risk and vulnerability assessment stages. In fact, the role and level of interaction and participation of management were considered to be one of the key factors for the level of resilience within all of the institutions participating in the study. As P20 argued, “A team is only as good as its leader, so everyone needs to do their part and improve together, and this mentality can start from the top”, adding that it is “no surprise that Emirati energy companies are so adaptable when everyone is committed to stability, efficiency and long-term excellence”. P3, P11 and P16 also praised the past and current efforts of the organisation's senior management to proactively create and shape the disaster management framework of the organisation. This, in turn, the three participants believed, would improve the standing and preparedness of the organisation against natural disasters and man-made hazards, regardless of size and impact. More specifically, P3 argued that training employees and managers alike were sufficiently integrated into the organisation, stating that “everything is already in place, we know what to do, we know what resources we need to have”.

Participants mentioned that the energy sector must further focus on safety and security issues, as all employees should be regularly acquainted and re-acquainted with the contingency plans, be trained on how to respond and act during emergencies and participate in regular drills or scenario testing. Therefore, the managers across the sector as well, as P4 explained, should be trained to better understand the risk degree and exposure of the infrastructure they operate. He acknowledged this need: “Sometimes managers think that they can create the guidelines and order the exercise, but not take direct part, and in the end they learn less than everyone below them”. P4 had mentioned before this discussion that he believed that the management teams from his facility would benefit from more training. But he did not elaborate upon this and instead argued that management was doing their best and collaborating well with the state and that these two factors were the most critical for the current

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resilience level of the facility where he is employed. P4 advised that “even if your employees are experts on this topic, if the management is not doing their job properly, or the state does not want to get involved, then your organisation would still face the same risks [as if no one was an expert]”. P12, P17 and P18 shared a similar concern, yet approached the topic in a more critical manner. P18 noted the tendency for upper management from the private sector, in particular, to “encourage and expect regular training and participation in field exercises for the workers, while they [the managers] very rarely participate themselves”, and most commonly “supervise without directly being involved and without offering the much-needed guidance to their teams” or just “waiting for the simulation to finish so they can sign the papers and say that they did their job”.

Similarly, P12 stated that it “seems that the lower-ranking personnel needs to participate in much more extensive training, which made sense at the time for me as a new employee, since we were the ones who operated the machines, but sometimes the policies seemed a bit out of touch”, he recollected and adding that after he became a manager he understood why this happened: “when you become a manager you start to forget how the *machine* works, you start to become more involved with how the people should work instead, so I think management training to remind the higher-ups what the job is like in reality is needed now, much more than ever”, arguing that technology has changed considerably in the past decade – and as a result so have the risks associated with these new developments. As P17 puts it, “improving the practices within a company is difficult without the direct involvement of the supervisors”, as they are the ones that must guide the other employees and harbour the sense of participating towards a common objective, such as improving collaboration and disaster preparedness. As the participants indicate, there seems to be a disconnect between the overall involvement of the managers and of the personnel, who are starting to notice that many managers tend to neglect their self-improvement while still demanding others follow the internal practices. However, this culture is detrimental to the organisation's general resilience and adaptability, as without directly engaging with the issues, the management is less likely to understand the company's needs at the ground level, which hurts

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the process of prioritising resource distribution. Such neglect could have devastating consequences for a company, and in fact, the lack of involvement could allow certain small issues to snowball into large-scale disasters, so this issue needs to be addressed as soon as possible.

Even more so, three members from Madinat Zayed (all from different power plants), namely P6, P9 and P10, lightly touched on the subject of lack of representation from the management teams during the regular, mandatory exercises, explaining that most managers do not participate, each noting that only a select pool of lower-level managers actively take part in the exercises, usually in turns, while most never get directly involved, not even during the debriefing. Instead, they are debriefed by the same representatives every time, with most middle and upper-level managers never directly addressing the rest of the personnel. As P9 explains: “We receive feedback that in theory comes from the entire management team; however, I find this hard to believe because the debriefs happen very soon after the exercises end” he continued to explain his opinion by arguing that “only someone who participated in an exercise would be able to give their input so quickly without being debriefed themselves”. At the same time, both P7 and P8, who are also employed at Madinat Zayed, praised the overall desire for the management teams to improve; however, both participants talked about the issue by referring only to lower and middle management, who seem a lot keener on self-improvement through applied participation in company-wide exercises. To exemplify, P7 argued that the managers are doing a great job when it comes to instilling a sense of urgency and also providing adequate supervision “without micro-managing each task and actually trusting the team members to do their job to the highest standard” while P8 explained that he himself, as a manager, would “never imagine not participating in such exercises”. However, P8 did note that the involvement of managers in such exercises is among the few training opportunities for leaders, who are expected to know already how to run the daily operations even during times of distress, which “is a shame because not all [managers] come from within the company so not everyone is familiar with the more technical parts”, explaining that the expectation is that managers who are unfamiliar with more specific equipment, grids or systems should make time to engage with the

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teams and seek out their input on more precise issues, which is “not always the case”.

Related to the support provided by the management, P2 expressed his disagreement with the initial approach adopted by some managers, which he defined as “not entirely clear in its direction from the start”. In other words, he claimed that contingency planning was not actively practised and that it was difficult for the management at the time to acquaint themselves with the best practice and introduce it in the organisation. “This was also confusing for us, those who worked at the lower levels”, P2 continued, “although we did have a lot of training at one point. But these training gave us different ideas about what we need to do and what management thinks that we should be doing.” The overall statements of P1 were also in line with the commentary offered by P2, P8, P12, P17 and P18, as he also underlined the need for management – whether upper, middle or lower – to set an example for its employees down the line. This, P1 believed, would make a difference in how well contingency and capacity-building plans and guidelines are implemented throughout the whole facility and in the energy sector in general. “If there is one weak spot along this chain”, he mused, “then it can all come crashing down [upon our heads]…. Especially if you see the person above you, who should know more than you and is in a way responsible for you… I say if you see that person not knowing what to do, not understanding the instructions that he should actually give to you… then that is the real disaster”. Similar perspectives were also shared by P14 and P15, who, although not expressly mention management training, did remark that there is a noticeable difference in perception between what the management and the other employees think should take precedence. As P15 puts it, even if priorities differ, “managers should at least try to clearly explain the objectives so everyone can work on the same goals”, an approach that may increase the institutional resilience culture.

Overall, given the participants’ answers, there seems to be a tendency for managers in the Emirati energy sector – particularly those in higher positions – to neglect self-improvement, which is a dangerous approach in an industry where quality and progress are key to security. While indeed there may be no need for each manager to memorise all technical information, their familiarity

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with what occurs on the ground, respectively whether the personnel knows their roles and responsibilities, as well as with the equipment and the more common issues associated with these resources, can only increase resilience. To explain, it is common knowledge that managers should lead by example and ignore the employees' development and engagement levels, which is only encouraged by the managers' neglect to acquire new technical knowledge, coupled with the lack of engagement, which is likely to influence the corporate culture negatively. By showcasing increasingly more indifference and oversight, managers tend to relay to employees the idea that the rules set by the company can be ignored without consequences, which significantly hurts the resilience of the energy sector as the quality standards may drop. This increases the chance for corner-cutting while decreasing the chance that managers acknowledge existing problems and even increasing the likelihood that employees report issues, as they may start to feel that their input does not matter. Indeed, to strengthen the sector's resilience, the work ethic of many managers needs to change for the better.

Theme B. Multi-agency Collaboration

A multi-agency collaboration is commonly described as the sum of the joint policies, procedures and practices between the various public institutions and private companies, including non-governmental organisations, which form the task force that help prevent, mitigate, respond to and recover from potential disasters. Considering the role of the various actors throughout the disaster cycle, it is important to take into account a wide array of stakeholders, weighing the pros and cons of possible pathways and interventions as a means of not only reducing threats and vulnerabilities but which also actively seek to increase resilience and sustainability for the energy sector. Notably, it is important to ascertain the multi-agency plans and preparations and the level of communication and openness among the various institutions and stakeholders.

Compared to the previous theme, the issue of multi-agency collaboration was addressed by significantly fewer participants, with a total of 9 out of, 20 not addressing it in much detail other than a few neutral remarks (P3, P4, P6, P8, P9, P11, P15, P16, P18), with another 7 (P1, P2, P7, P10, P12, P13, P17) using more critical or negative language, and only 4 (P5, P14, P19, P20) positively

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referring to the issue. Interestingly, half of the latter group is part of the public institutions, and only 3 participants from the total number of respondents are employed in the public sector.

While most of the participants noted in straightforward language that their institution indeed collaborates with other institutions, many noted that the management does consider the need to collaborate with first responders or the authorities in case of a disaster, so several issues started to emerge. It became clear that this topic was perceived and approached from a perspective that implied the collaboration solely with the two mentioned groups, with other stakeholders not being specifically mentioned by the 9 participants who approached the subject from a neutral perspective. For instance, P8 stated that "of course, there is a continuous collaboration between us [Madinat Zayed Power Plant] and the police, firefighters, ambulance, we train together", alluding to the disaster preparedness exercises previously discussed. Similarly, P6, P9, P16 and P18 stated that the training is done with the help of first responders and following the guidance provided by the government. However, other participants considered the issue of cross-agency collaboration from a more comprehensive perspective, with P19 and P20 (both from public institutions) arguing that even though the system is not yet perfect, it is continuously improving to accommodate new developments and seeking to include more stakeholders directly. As P20 explained, the UAE "has always sought to improve through partnerships and collaborations, both internal and external ones, and so far we successfully managed to help a lot of countries with disaster relief", stating that the UAE has a rich history of external partnerships. However, when asked about the internal ones, P20 argued that the UAE and the energy sector, in particular, has "faced fewer disasters, which were much less disruptive than those in other countries, so if we managed to help people in worse states than us by collaborating with the UN and local organisations, we should have no issues here". Indeed, P19 raised a similar issue, saying that "the Emirati people can easily raise funds and send resources and people to help disaster victims worldwide, it's pretty obvious that we'll be able to do the same when our own people are affected".

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Despite this, other participants (P1, P2, P7, P10, P12, P13, P17) argued that the current strategy of their company is not sufficiently explored for ensuring resilience in case of a major disaster such as a city-wide power outage as a result of natural disasters, and especially not in the case of malicious intervention such as from terrorist groups. For instance, all the participants previously mentioned believe that there is a preoccupation in the energy sector with the financial and regulatory aspects, while a better approach to ensuring resilience and preparedness in the sector is to encompass technical, organisational and institutional stakeholders as well; however, they have communicated this in different manners. For instance, P1 talked about "including the local communities in the emergency response plans in case the plant is located close to cities or short-term army bases", arguing that the current procedures do not actively seek to engage the potential disaster victims in preparatory measures. P2 also argued in favour of involving the investors and shareholders in "high-level meetings to let them know that risks and safety issues need to be taken seriously and that they should allocate both attention and resources for that purpose", and P10, P13 and P17 also shared a similar perspective. To illustrate, P10 explained that cross-agency communication and collaboration are "almost non-existent", adding "from my experience, energy companies focus on how they work, on their flaws and on their strengths, but it seems that managers don't understand that the community should also be prepared in case of a major event". In a complementary manner, P13 stated that "from my understanding it is a good practice to encourage all stakeholders to offer input if a company wants to succeed, but in my company there is no official framework for such collaborations". When asked to further explain what collaborations he was referring to, P13 noted that "there are no specific guidelines for informing the public or the media in case of an emergency, everyone just, sort of… follows their common sense – call the police, call the ambulance, call the higher-ups, call co-workers and technicians for repairs, and that's it, there is no follow-up". Another relevant yet novel perspective was offered by P17, who purposely noted that "volunteering isn't a big thing here [in the UAE], and neither is mental health support, these are the two major problems that we need to address to improve resilience".

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Moreover, P5, P7, P12 and P14 also reckon that management should be closely aligned with their employees to ensure resilience. Yet, while P7 and P12 criticised the limited implication of the management by arguing that they solely seek to ensure that the job is done correctly by everyone in the company without actually trying to enhance collaboration between various institutions, P5 argued that management is slowly reshaping its mindset to be better able to handle new threats and crises, but that it "takes time and effort and it needs to reach to the lower levels, or it will simply not work". Nevertheless, P5 explained that he was satisfied with the way that management was changing its perceptions and actions, despite the slow pace, stating the following:

> "I have communicated with experts from other countries, and I have gone to international conferences and international trainings. And I have heard "horror stories", or at least they are such to me. I heard some people saying that their management is deaf it does not want or try to hear employees' needs. In [my] facility, some of us decided to talk to management and insisted upon a more practical approach and maybe upon including more experts and more people involved. Management received us right away and listened to us for a full two hours. And they agreed and started collaborating with us to allow our voices to be heard."

The experiences of both P7 and P12 are opposite to those of P5, as both participants recalled proposing a joint framework for disaster and crisis management in their respective companies, only to be shut down for various reasons. To exemplify, P7 explained that the answer from his higher-ups was that "a collaboration between all stakeholders would be difficult because of the decentralized nature of the energy sector", while P12 noted that he was shut down because "even if the idea is good, it will take too much time and effort to bring everyone together when the company's resources are already stretched thin". Surprisingly, P14 stated that he too was initially met with scepticism by the rest of the management team, only to be offered the chance to create a joint framework himself because of his higher position, and as he put it, "This is by no means an easy task, I needed to talk to many people and think of every little aspect, from the macro to the micro, and nobody else wanted to help, they thought it's not worth the struggle… it was a very stressful period of my life, but

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I managed to put together a pretty solid action plan", at the same time adding "little did I know, creating the framework was the easy part, getting stakeholders involved took a lot more of my time, and even to this day the effort and communication are still not at the level that I hoped it would be".

Theme C. <u>Social Support</u>

The theme of social support refers to the structures set in place within the industry at large, as well as within the companies more specifically, to offer solutions that address both the short and long-term impact of a possible large-scale disruption, which are much more likely to affect the livelihood and mental health of individuals negatively. The goal of ensuring a good social support system is to build up the social resilience and stability of the affected community, ensuring that all the stakeholders are considered in the wake of a disaster. The issue of social support was only scarcely addressed while discussing other issues, with very few participants offering more detailed accounts of the solutions in place to alleviate the impact of disasters on the community, namely 3 out of, 20 participants (P1, P13, P17) criticised the current practices, and 3 others (P14, P19, P20) praising the existing policies, with the remaining 14 participants not addressing resilience from this perspective.

All 6 participants who touched upon this topic mentioned the UAE's social support and social welfare programmes. However, P1 criticised the general lack of awareness among the population, saying that the individuals that could be affected in case of a disaster are "unaware of what they should do in case of a disaster, and from my discussions with others, I'm fairly convinced that not enough people know of the social support programme. Plus, the conditions for eligibility are pretty harsh, so I'm not sure how many people could benefit from them". Similarly, P13 noted his concern with engaging stakeholders in disaster relief, particularly noting the lack of engagement and awareness of the general population, who might be at risk because of this, stating: "I don't think the [Emirati] population is prepared enough in case of a disaster, the procedures to inform the public are vague and very little is done to improve them". A more comprehensive examination was provided by P17, emphasising the limited capacity to engage volunteers: "[NCEMA] offers guidance for volunteering programs, but this is not common knowledge. There are no awareness

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campaigns to inform the public of how they can participate in the national volunteering program; the benefits of volunteering are unclear, so very few people volunteer". Additionally, P17 was the only person who touched upon the subject of mental health, saying that the stigma for seeking psychological counsel is still prevalent within the Emirati society, and thus even though such relief programmes exist, "it is unlikely that the average person will say they were traumatised by a disaster; instead, they will say that they lost their house, that their car was damaged, and will apply for financial support. We need to change the ingrained opinion that suffering is only materialistic in nature, or we won't be able to help each other as we should".

At the same time, P14, P19 and P20 also argued that the UAE has the financial capacity for the development of all-encompassing social support policies, and according to the latter two participants, this is evidenced by the country's previous successful involvement in the disaster relief efforts in many other countries. However, the opinions were split, with P19 arguing in favour of short-term solutions by saying that "returning to normal after a disaster means that the problems that need to be fixed must be very quickly addressed. From my experience, addressing these issues quickly can be achieved when there is enough money to go around". Similarly, P20 noted that "the UAE doesn't have a lot of first-hand experience in dealing with disasters and their aftermath. We have been very lucky; most emergencies had a small impact and didn't destabilise the country. But we got involved in humanitarian projects in other countries to compensate for our limited experience and learned a great deal from these situations". On the other hand, P14 argued for both short and long-term solutions, explaining that "having money is a great first step, but it is only the first step, and others need to follow… you can't just throw money at a problem and hope it disappears… you need to have goals and a clear framework that takes into account a lot more perspectives". P14 continued by stating that

> "is directly involved in the creation of a disaster management framework at my company that focuses on cross-agency collaboration means I got to talk to many stakeholders, and let me tell you, everyone has different problems that need to be addressed. There is a clear need to not only

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> invest money in solutions but there is also a need to change the current reality to match everyone's needs. At the moment, I don't think the UAE is capable of meeting everyone's needs, but I believe we are on the right track. There have been a lot of promising developments in the past two decades, so in another two decades, I think we will be ready to face anything."

Indeed, as can be seen, the opinions are still split, and there is no consensus on the UAE's capacity to provide social support in case of a disaster.

5.5.2 Opportunities

Regarding the opportunities for increasing social resilience, the themes identified relate to the abundance of training for personnel, excluding management positions, and the recent focus on sustainable development.

Theme A. Personnel Training

In the context of the thesis, personnel training refers, on the one hand, to the knowledge, skills, competencies and experience of the people employed in the Emirati energy sector and, on the other, to the steps taken by Emirati power companies to enhance the overall competence level of their employees. Compared to other themes that briefly allude to the need for increased expertise within the energy sector, the current theme is more focused on the active and conscious decisions made within a company to diminish the vulnerabilities and risks strictly associated with human error – a threat that may negatively affect or even provoke disasters, thus warranting its own section. Compared to the vulnerabilities concerning social resilience, the training of non-management personnel was touched upon by all of the study participants to various degrees. The overwhelming majority (16 out of, 20) spoke highly of the policies and practices associated with training, and only 4 individuals (P2, P3, P12, P17) raised some issues regarding this topic.

As far as the personnel training is concerned, participants have expressed positive opinions, with the most common being the ample amount of training throughout the employees' tenure (mentioned by 17 participants), the diversity in training and disaster preparedness evaluations (according to 11 participants), as well as the quick introduction of new instructions following

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technological modernisations or organisational changes (as stated by 14 participants). The sheer amount of positive input surrounding this topic is evidence that employee training within the Emirati energy sector is given considerable attention, especially when compared to most other issues.

To exemplify, P4 mentioned he has witnessed major risk assessment tests at the facility where he is employed at regular intervals, approximately every two years: "Every single employee, no matter if they are full-time or have just started on a part-time basis, need to enrol in at least one such training, drill or exercise." P4 added: "We keep lists of who has participated and who has not, and if you want to re-take a training, take part in a second drill or just observe on the side, you are free to do so". This seems to be the standard at all ADNOC facilities, including the TAKREER sub-division, but also within the wider industry, as many participants mentioned the possibility of participating in supplementary training at any time after completing the initial mandatory ones. According to P16, "it is not uncommon that employees participate in the same training over the years, and I think this is a good approach to maintain a standard for delivering high-quality products and services", while P20 notes ", it's easy to remember daily procedures but with time, you start to forget details, especially the circumstances and actions that you need to take in the rarest occasions such as those related to disaster and emergency management, which are extremely rare for most of the energy companies here [in the UAE]". Moreover, throughout the interviews, the participants mentioned a wide array of training, tests and exercises (both internal only and multi-agency ones) designed to increase disaster and emergency preparedness, mentioned as such: one-on-one training (7 participants), seminars/workshops / other theoretical training (20 participants), simulations (10 participants), drills (13 participants), multi-agency / full-scale exercises (16 participants).

Furthermore, participants admitted, when talking about the technological updates, that training meant to familiarise the personnel with the new instruments and equipment but also to explain the most common risks and hazards associated with these, is also common. According to 9 participants who discussed this issue, this usually occurs in two stages, a theoretical one before introducing the new technology that aims to teach employees the purpose of

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the change, and a practical one once the new equipment is brought in and installed so that the personnel sees it in practice. Of course, this is common for big changes that may introduce new vulnerabilities to the system, while with less substantial changes, 12 participants debating this topic admitted to receiving and then handing out written instructions, with access to a more experienced staff member or supervisor to answer any questions and offer clarifications in case of a misunderstanding also being available for both employees and managers. Regarding this issue, P10 emphasises that “even minor changes may disrupt the supply chain, so we need to make sure that the risk of failure is minimal”, while P15 explains that “the policies in place aim to integrate change at all levels successfully”. This is also in line with the previously-identified trend within the Emirati energy sector to introduce specialised training for any new policy, procedure and practice, as well as for emergent risks and hazards.

However, not all participants equated the additional training and instructions with positive outcomes, and in fact, some participants argued that the energy sector needs to plan and prepare better for such instances by focusing more on practical drills and scenarios because, as P2 mentioned, “all this [theory] is very good to know and have, and it might even have worked in another country for another company, but that does not guarantee that it would work for us so we need to test, test, test”. And yet, some participants believe their subordinates are either not well-acquainted with the codes of control or the overarching concepts of resilience, capacity-building, disaster management and sustainability, and that improved theoretical and practical training should be scheduled with all levels of personnel in order to equip them for various scenarios better. In particular, P3 believes there is a need to train individuals on their roles and responsibilities in the disaster management framework and during the various stages of a disaster since there is currently a great deal of confusion surrounding these issues. As P3 argued, personnel training needs to be significantly more encompassing and focused, namely, “the more information is introduced, the more likely it is for newer employees to get terms, policies and procedures based on disaster stages confused”. P3 added that even “more experienced staff is not entirely familiarised with their roles and

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responsibilities". A similar perspective was shared by P12, as previously noted within the Management Training theme, who also agreed that both new and experienced personnel seemed to require more training, particularly applied exercises and simulations, which could help all staff retain lasting knowledge faster. According to P12, from his experience, the current training approach seems to be "focused on quantity rather than quality". Additionally, both P12 and P17 noted that some training does not seem to be aligned for both managers and employees, and this results in communication failures that leave workers directionless at times, with P17 explaining that the lack of implication from the supervisors can be an obstacle towards harbouring a cohesive organisational culture that is centred on disaster preparedness. Even so, these critiques are in the minority and given the lack of more specific details from the participants; these issues may be localised to a particular facility or within a specific branch of an institution, thus not indicative of the entire energy sector.

Theme B. Sustainable Development

The theme of sustainable development refers to the advancement of a community in a manner that does not compromise the prosperity and well-being of future generations, as such organisations – as part of a community – need to commit themselves to continuous progress via the adherence to charitable principles, as well as through the application of profitable, yet considerate practices (Bridges and Eubank, 2021). As sustainability can be attained only with sufficient time and resources, this code refers to the later stages of a disaster or crisis and is, therefore, a metric for a company's adaptability. This topic has been approached to various degrees and from different perspectives by all of the participants, amassing a majority of positive opinions, with 8 out of, 20 participants (P4, P5, P8, P10, P14, P15, P19, P20) speaking favourably on the adoption of sustainability practices within the UAE, with another 7 participants (P3, P6, P9, P11, P12, P16, P18) bringing both arguments for and against the current policies, and solely 5 participants (P1, P2, P7, P13, P17) being critical of the Emirati energy sector's pursuit of sustainable development.

On the one hand, concerning the quantifiable aspects of sustainability – such as the technological and financial strategies, many of the participants (P1, P2, P3, P4, P5, P8, P10, P12, P13, P15, P17, P18, P20) praised the tendency of

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the Emirati energy sector to focus more on the production of alternate and renewable energy,[2] which according to most of them is a reliable approach to building sustainable communities. As P3 stated, “moving away from fossil fuels is a step in the right direction”, albeit he admitted that “at the moment, the change is small, but it laid the right foundation towards sustainable development”. Adding to this, P10 argued that “the more green energy is used, the less impact we as a community have on the environment and future generations”, while P20 argued that “the [UAE] government promotes the sustainable development agenda because it wants the community to thrive in the long-term […] so we’re actively trying to financially encourage energy companies to diversify their energy generation with renewables”. However, other participants who supported the diversification of energy argued its importance from a more pragmatic financial perspective, with P17, for instance, saying that “expecting the oil never to run out is unsustainable… it would put companies out of business… so, of course, we needed to move towards clean energy at one point – not tomorrow or next year of course, but maybe in a few decades”. The perspective shared by P17 hints that the oil reserves being depleted may negatively affect the UAE’s long-term economy and stability, and indeed these are significant factors in securing the sustainable development of a community. A relatively unique perspective was shared by P12, who argued that “the adoption of the ISO 50000 standard to manage energy helped reduce energy consumption and also diminished the carbon footprint of some facilities”. More specifically, P12 stated that this standard had been adopted within his company rapidly and comprehensively at all levels and by the vast majority of the personnel, who were “eager to change their behaviours actually to make a difference, everyone attended training, and the management took it seriously, we have a plan that everyone follows, the results are measured, and its efficiency is reviewed yearly”. As far as P12 believes, “if everyone employed in the energy industry were to adhere to this standard as we do, the [UAE] energy sector would decrease energy waste significantly, and they would save up on a lot of money, too”.

[2] As presented throughout section 5.4. (Technical and Technological Resilience) of this chapter.

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However, some of the participants were not as hopeful as P12; some argued that the investments made towards the diversification of energy generation and production, while beneficial, had been “hasty” (P6) or used as a means of distracting stakeholders from the existing issues (P2, P7, P11, P18). According to some participants, the sustainability of the energy sector cannot be guaranteed in its current form because the financial investment into new strategies and technologies had been made without first strengthening the existing infrastructure, which is neither financially nor technically resilient, and thus not sustainable. As P2 emphasised, “I understand that we need to build sustainability, but without strengthening resilience, this approach will be a house of cards”. Furthermore, P1 noted that the current disaster management practices were “unsustainable”, and similarly, P18 stated that “you can’t achieve sustainable development without resilience, but few people know the infrastructural problems, so some people praise the move to green energy as if this will fix all our problems – it won’t”.

These more critical opinions also hint to some of the non-quantifiable aspects of sustainability, namely those regarding adopting sustainable development practices at an organisational level. Even so, the majority of the participants (16 out of, 20) mentioned that their institution adhered to the UAE’s Occupational Health and Safety Management System (OHSMS) National Standard as introduced by the National Emergency, Crisis and Disaster Management Authority (NCEMA), which provides guidelines that seek to minimise the short and long-term repercussions of disasters and crises. Additionally, these participants also mentioned that the UAE has adopted the United Nations Sustainable Development Goals (UNSDGs), and as a result, their institution is also seeking to adopt and follow these approaches to increase the sustainability of their community.

Further regarding the non-quantifiable approaches to ensuring sustainable development, participants such as P6, P9, P10, P11, P14, P18, P19 and P20 firmly believe that both resilience and sustainability are on the rise in the UAE in general, and particularly in the energy sector, even if some were more critical of the slow adoption of such policies in practice. P19 and P20, in turn, praised the UAE’s focus on disaster relief, raising the argument that both international

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humanitarian projects and the national response to the Covid-19 pandemic have been, from a social perspective, successful in lessening the impact on the affected populations. At the same time, P1 and P17 argued that not enough is being done to increase resilience and sustainability at a larger scale because there is a lack of governmental programmes to raise awareness on these issues. As P1 puts it, “sustainable development is everyone’s business, not just the government’s and not just the companies’ – all stakeholders should be involved more in creating a flourishing and sustainable environment” While related to the stakeholders’ well-being P17 explained that there was a need to “increase awareness of mental health issues that follow a disaster, and at this moment this impact on the population is not addressed”.

All in all, the issue of sustainable development seems to be indeed heading in the right direction, and notably, the quantifiable (technical and financial) aspects are prioritised and being strengthened through several approaches that seek to improve the use of resources so that future generations are not affected by the current practices. However, there is a need to explore further the non-quantifiable elements, particularly those regarding developing resilient communities.

5.5.3 Main Findings

To better illustrate these findings, the following table (Table 9) presents the quotes, main ideas and details shared by the participants regarding the first code (Social Factors) related to the resilience of the Emirati energy sector. Following the structure of the 3 previous tables, the code is divided into vulnerabilities and opportunities, with the five themes being grouped under these characteristics. Each participant’s contribution is showcased separately; for the themes where participants have not contributed, the abbreviation for no data (i.e. “ND“) is used.

Table 9:Code 4 - Social Resilience Factors

	Code 4: Social Resilience Factors				
	Vulnerabilities			Opportunities	
	Theme A: Management Training	**Theme B: Multi-agency Collaboration**	**Theme C: Social Support**	**Theme A: Personnel Training**	**Theme B: Sustainable Development**
P1	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Criticised the capacity of some managers to fulfil their roles: "If there is one weak spot along this chain", he mused, "then it can all come crashing down [upon our heads]…. Especially if you see the person above you, who should know more than you and is in a way responsible for you… I say, if you see that person not knowing what to do, not understanding the instructions that he should actually give to you… then that is the real disaster".	Confirmed multi-agency collaborative efforts with authorities, first responders, but is sceptical of the ability of the stakeholders to coordinate in case of a city-wide major scenario (e.g. terror attacks, natural disasters). Believes that stakeholders should be engaged more, for instance: "including the local communities in the emergency response plans in case the plant is located close to cities or to short-term army bases", as the current procedures do not engage the potential victims of a disaster in preparatory measures.	Stated that citizens are "unaware of what they should do in case of a disaster, and from my discussions with others I'm fairly convinced that not enough people know of the social support programme. Plus, the conditions to be eligible for them are pretty harsh so I'm not sure how many people could benefit from them".	Believes personnel training to be ample and varied, including both theoretical and practical exercises (seminars, workshops & written instructions, simulations, drills, multi-agency, full-scale exercise). Praised the quick introduction of new documentation and instructions following technological modernisations or organisational changes.	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities, yet called the current disaster management practices "unsustainable". Thinks more should be done to increase resilience and sustainability, pointing out the lack of governmental programmes to raise awareness on these issues: "sustainable development is everyone's business, not just the government's and not just the companies' – all stakeholders should be involved more in creating a flourishing and sustainable environment".
P2	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Criticised the capacity of some managers to fulfil their roles, notably offering guidance which was "not entirely clear in its direction from the start […] This was also confusing for us, those who worked at the lower levels, although we did have a lot of trainings at one point. But these trainings gave us different ideas about what we need to do and what management thinks that we should be doing".	Believes the current multi-agency collaboration strategy is lacking, and that all stakeholders need to be contacted, for instance involving investors and shareholders in "high-level meetings in order to let them know that risks and safety issues need to be taken seriously and that they should allocate both attention and resources for that purpose".	**ND**	Believes personnel training to be ample (seminars & written instructions, drills, multi-agency exercises), but thinks there is a need to emphasise practical training: "all this [theory] is very good to know and have, and it might even have worked in another country for another company, but that does not guarantee that it would work for us so we need to test, test, test".	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities, but worried that it is used to distract stakeholders from existing issues. Criticised the lack of emphasis on resilience: "I understand that we need to build sustainability, but without strengthening resilience, this approach will be a house of cards".
P3	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Praised the capacity of managers and the overall preparedness levels: "everything is already in place, we know what to do, we know what resources we need to have".	Confirmed multi-agency collaborative plans and efforts with other institutions, yet noting that some managers "forget about" first responders or even some authorities in case of a disaster.	**ND**	Believes personnel training to be complex (seminars, simulations, drills, multi-agency), yet insufficient when it comes to training individuals on their roles and responsibilities in the disaster management framework as well as during the various stages of a disaster: "the more information is introduced the more likely it is for newer employees to get terms, policies and procedures based on disaster stages confused", even adding that "more experienced staff is not entirely familiarised with their roles and responsibilities".	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities. "Moving away from fossil fuels is a step in the right direction", albeit he admitted that "at the moment the change is small, but it laid the right foundation towards sustainable development".
P4	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Criticised the capacity of some managers to understand their subordinates' roles and	Confirmed multi-agency collaborative plans and efforts with other institutions, yet noting that some managers "do not consider that they need to talk to first responders before a disaster occurs".	**ND**	Believes personnel training to be ample, offering both theoretical and practical knowledge (1-on-1s, seminars, simulations, drills, multi-agency & full-scale exercises). Praised the quick introduction of new	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities.

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	responsibilities, mentioned that upper management should participate more in exercises: "Sometimes managers think that they can create the guidelines and order the exercise, but not take direct part, and in the end they learn less than everyone below them". "Even if your employees are experts on this topic, if the management is not doing their job properly, or the state does not want to get involved, then your organisation would still face the same risks [as if no one was an expert]."			instructions following technological modernisations or organisational changes, as well as regular training when necessary (usually every 2 years): "every single employee, no matter if they are full-time or have just started on a part-time basis need to enrol in at least one such training, drill or exercise", "we keep lists of who has participated and who has not, and if you want to re-take a training, take part in a second drill or just observe on the side, you are free to do so".	
P5	**ND**	Confirmed multi-agency collaborative plans and efforts with other institutions, yet noting that the efforts to contact other parties are limited, a communication gap forming even within the company at different levels: "it takes time and effort and it needs to reach to the lower levels, or it will simply not work". Hopeful of the changes, even if they are slow: "I have communicated with experts from other countries, I have gone to international conferences and international trainings. And I have heard "horror stories", or at least they are such to me. I heard some people saying that their management is deaf it does not want or try to hear employees' needs. In [my] facility, some of us decide to talk to management and insisted upon a more practical approach, and maybe upon including more experts and more people involved. Management received us right away and listened to us for a full two hours. And they agreed and started to collaborate with us, to allow our voices to be heard."	**ND**	Believes personnel training to be ample, offering both theoretical and practical knowledge (1-on-1s, workshops & written instructions, drills, multi-agency exercises). Praised the quick introduction of new documentation and instructions following technological modernisations or organisational changes.	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities.
P6	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication, with the role and level of interaction and participation of management being a key factor for increasing resilience. Discussed lack of representation from the management teams during the regular exercises, noting that only a select pool of managers take part in the exercises in turns, while most never get directly involved, not even during	Confirmed multi-agency collaborative plans and efforts with other institutions, mentioned that training is done together with first responders and following governmental guidance.	**ND**	Believes personnel training to be diverse in both general training and crisis preparedness, offering both theoretical and practical knowledge (seminars, workshops & written instructions, simulations, drills, multi-agency exercises). Praised the quick introduction of new documentation and instructions following technological modernisations or organisational changes.	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities, but called the investments "hasty". Believes that the UAE energy sector is increasingly more resilient and sustainable.

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	the debriefing. Instead, they are debriefed by the same representatives every time, with most middle and upper-level managers never directly addressing the rest of the personnel.				
P7	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Criticised the capacity of upper managers to engage with employees and to participate in trainings and exercises, while praising lower and middle management, who seem a lot more keen on self-improvement through applied participation in company-wide exercises. Admitted that most managers are doing a great job when it comes to instilling a sense of urgency and also providing adequate supervision "without micro-managing each task and actually trusting the team members to do their job to the highest standard".	Believes the current multi-agency collaboration strategy is lacking, and that all stakeholders need to be contacted and engaged, both internal and external, as managers tend to ignore other parties and only implement the changes superficially. Admitted to proposing a joint framework for disaster and crisis management, which was shut down: "a collaboration between all stakeholders would be difficult because of the decentralized nature of the energy sector".	**ND**	Believes personnel training to be ample, offering both theoretical and practical knowledge (seminars, workshops & written instructions, simulations, drills). Praised the quick introduction of new documentation and instructions following technological modernisations or organisational changes.	Thinks the Emirati energy sector's focus on alternate and renewable energy is a method of distracting stakeholders from current issues.
P8	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Criticised the capacity of upper managers to engage with employees and to participate in trainings and exercises, while praising lower and middle management, who seem a lot more keen on self-improvement through applied participation in company-wide exercises. Explained that as a manager, they would "never imagine not participating in such exercises", as they are among the few training opportunities for leaders, who are expected to already know how to run the daily operations even during times of distress, which "is a shame because not all [managers] come from within the company so not everyone is familiar with the more technical parts", explaining that "the expectation is that managers who are unfamiliar with more specific equipment, grids or systems should make time to engage with the teams and seek out their input on more precise issues, which is "not always the case".	Confirmed multi-agency collaborative plans and efforts with other institutions, mentioned that training is done together with first responders and following governmental guidance: "of course there is a continuous collaboration between us [Madinat Zayed Power Plant] and the police, firefighters, ambulance, we train together".	**ND**	Believes personnel training to be diverse in both general training and crisis preparedness (seminars, workshops, multi-agency, full-scale exercises). Praised the quick introduction of new documentation and instructions following technological modernisations or organisational changes.	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities.
P9	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Criticised the capacity of some managers to engage with employees and to participate in trainings and exercises: "we receive feedback that in theory comes from the entire management team, however I find this hard to believe because	Confirmed multi-agency collaborative plans and efforts with other institutions, mentioned that training is done together with first responders and following governmental guidance.	**ND**	Believes personnel training to be diverse in both general training and crisis preparedness (seminars, multi-agency, full-scale exercises). Praised the quick introduction of new documentation and instructions following technological modernisations or organisational changes.	Believes that both resilience and sustainability are on the rise in the UAE in general, and particularly in the energy sector.

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	the debriefs happen very soon after the exercises end", he continued to say that "only someone who participated in an exercise would be able to give their input so quickly without being debriefed themselves".				
P10	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Criticised the capacity of some managers to engage with employees and to participate in trainings and exercises.	Confirmed some multi-agency collaborative efforts with other institutions, but believes these need to be improved, as cross-agency communication and collaboration plans are minimal or "almost non-existent", adding "from my experience, energy companies focus on how they work, on their flaws and on their strengths, but it seems that managers don't understand that the community should also be prepared in case of a major event".	**ND**	Believes personnel training to be diverse in both general training and crisis preparedness, offering both theoretical and practical knowledge (1-on-1s, seminars, workshops & written instructions, simulations, drills, multi-agency, full-scale exercises). Praised the quick introduction of new documentation and instructions following technological modernisations or organisational changes: "even minor changes may disrupt the supply chain so we need to make sure that the risk of failure is minimal".	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities: "The more green energy is used, the less impact we as a community have on the environment and on future generations". Believes that both resilience and sustainability are on the rise in the UAE in general, and particularly in the energy sector.
P11	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Believes the role and level of interaction and participation of management was considered to be one of the key factors for increasing resilience. Praised the senior management's strategies and practices.	Confirmed multi-agency collaborative plans and efforts with other institutions.	**ND**	.Believes personnel training to be diverse in both general training and crisis preparedness, offering both theoretical and practical knowledge (1-on-1s, workshops & written instructions, simulations, drills, multi-agency exercises). Praised the quick introduction of new documentation and instructions following technological modernisations or organisational changes.	Glad of the surge in resilience and sustainability goals, praised the investment in alternate energy, yet thinks that other issues regarding existing energy industries still need to be addressed.
P12	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Stated that it "seems that the lower-ranking personnel needs to participate in much more extensive training, which made sense at the time for me as a new employee, since we were the ones who operated the machines, but sometimes the policies seemed a bit out of touch", he recollected and adding that after he became a manager he understood why this happened: "when you become a manager you start to forget how the machine works, you start to become more involved with how the people should work instead, so I think management training to remind the higher-ups what the job is like in reality is needed now, much more than ever", saying technology has advanced and so have the risks.	Confirmed some multi-agency collaborative efforts with other institutions, but believes these need to be improved to facilitate communication with both internal and external stakeholders. Recalled proposing a joint framework for disaster and crisis management in their respective companies, only to be shut down because "even if the idea is good, it would take too much time and effort to bring everyone together when the company's resources are already stretched thin".	**ND**	Thinks all personnel could use more training, particularly theoretical exercises and simulations (to supplement the currently used drills and multi-agency exercises), which could help all staff retain lasting knowledge faster. Currently the trainings are "focused on quantity rather than quality", while managers and employees receive different levels of training which leads to miscommunication.	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities. Praised the current practices: "the adoption of the ISO 50000 standard to manage energy actually helped reduce energy consumption, and also diminished the carbon footprint of some facilities". Noted the personnel were "eager to change their behaviours to actually make a difference, everyone attended training and the management actually took it seriously, we have a plan that everyone follows, the results are measured and its efficiency is reviewed yearly", thus, "if everyone employed in the energy industry were to adhere to this standard as we do, the [UAE] energy sector would decrease energy

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					waste significantly, and they would save up on a lot of money, too".
P13	**ND**	Is not confident in the current strategy of their company for ensuring resilience in case of a major disaster, as stakeholders are not engaged: "from my understanding it is a good practice to encourage all stakeholders to offer input if a company wants to succeed, but in my company there is no official framework for such collaborations", adding "there are no specific guidelines for informing the public or the media in case of an emergency, everyone just, sort of… follows their common sense – call the police, call the ambulance, call the higher-ups, call co-workers and technicians for repairs, and that's it, there is no follow-up".	Noted the lack of engagement and awareness of the general population, who might be at risk because of this, stating: "I don't think the [Emirati] population is prepared enough in case of a disaster, the procedures to inform the public are vague and very little is done to improve them".	Believes personnel training to be diverse (seminars, workshops & written instructions, simulations, drills). Praised the quick introduction of new documentation and instructions.	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities.
P14	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Remarked that there is a noticeable difference in perception between what the management and the other employees think should take precedent.	Confirmed multi-agency collaborative plans and efforts with other institutions, mentioned that management should be closely aligned with their employees and vice versa to effectively ensure resilience. Was tasked to create a joint framework himself because of his higher position, and as he put it "this is by no means an easy task, I needed to talk to many people and think of every little aspect, from the macro to the micro, and nobody else wanted to help, they thought it's not worth the struggle… it was a very stressful period of my life, but I managed to put together a pretty solid action plan", at the same time adding "little did I know, creating the framework was the easy part, getting stakeholders involved took a lot more of my time, and even to this day the effort and communication is still not at the level that I hoped it would be".	Believes the UAE has the financial capacity for the development of all-encompassing social support policies. Argued for both short and long-term solutions: "having money is a great first step, but it is only the first step and others need to follow… you can't just throw money at a problem and hope it disappears… you need to have goals and a clear framework that takes into account a lot more perspectives". "Being directly involved in the creation of a disaster management framework at my company that focuses on cross-agency collaboration means I got to talk to many stakeholders, and let me tell you everyone has different problems that need to be addressed. There is a clear need to not only invest money in solutions, but there is also a need to change the current reality to match everyone's needs. At the moment, I don't think the UAE is capable of meeting everyone's needs, but I believe we are on the right track. There have been a lot of promising developments in the past two decades, so in another two decades I think we will be ready to face anything."	Believes personnel training to be diverse and ample, addressing both theoretical and practical knowledge (1-on-1s, workshops & written instructions, simulations, drills, multi-agency exercises). Praised the quick introduction of new documentation and instructions.	Believes that both resilience and sustainability are on the rise in the UAE in general, and particularly in the energy sector.
P15	Believes upper management to have a significant role in capacity building and during the	Confirmed multi-agency collaborative plans and efforts with other institutions,	**ND**	Believes personnel training to be diverse and ample, addressing both	Praised the Emirati energy sector's focus on alternate and renewable energy as a

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	preparatory stages, especially concerning collaborative efforts and team communication. Criticised the capacity of some managers to understand and guide employees: "managers should at least try to clearly explain the objectives so everyone can work on the same goals", an approach that may increase the institutional resilience culture.	mentioned that training is done together with first responders and following governmental guidance.		theoretical and practical knowledge (workshops & written instructions, drills, multi-agency, full-scale exercises). Praised the quick introduction of new documentation and instructions: "the policies in place aim to successfully integrate change at all levels".	step to building sustainable communities.
P16	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Praised the efforts of the senior management to shape the disaster management framework of the organisation.	Confirmed multi-agency collaborative plans and efforts with other institutions, mentioned that training is done together with first responders and following governmental guidance.	**ND**	Believes personnel training to be sufficient (seminars, simulations, multi-agency). Praised the quick introduction of new documentation and instructions, and the multitude of opportunities to improve: "it is not uncommon that employees participate in the same training over the years, and I think this is a good approach to maintain a standard for delivering high quality products and services".	Believes that both resilience and sustainability are on the rise in the UAE in general, and particularly in the energy sector.
P17	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Criticised the involvement of some managers: "improving the practices within a company is difficult without the direct involvement of the supervisors", as they are the ones that must guide the other employees.	Believes their company is unprepared to achieve resilience in the wake of large scale disasters, because many stakeholders are not involved: "volunteering isn't a big thing here [in the UAE], and neither is mental health support, these are the two major problems that we need to address to improve resilience".	Stated that "[NCEMA] offers guidance for volunteering programs, but this is not common knowledge. There are no awareness campaigns to inform the public of how they can participate in the national volunteering program, the benefits of volunteering are not made clear so very few people volunteer". Regarding mental health, addressed the stigma for seeking psychological counsel within Emirati society, and even though such programmes exist, "it is unlikely that the average person will say they were traumatised by a disaster, instead they will say that they lost their house, that their car was damaged, and will apply for financial support. We need to change the ingrained opinion that suffering is only materialistic in nature, or we won't be able to help each other as we should".	Thinks all personnel could use more training, particularly applied exercises and simulations (to supplement the currently used 1-on-1 discussions, seminars and workshops), which could help all staff retain lasting knowledge faster. Currently the trainings are "focused on quantity rather than quality", while managers and employees receive different levels of training which leads to miscommunication and confusion, the lack of supervisors' engagement being an obstacle to creating an organisational culture built on preparedness.	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities: "expecting the oil to never run out is unsustainable… it would put companies out of business… so of course we needed to move towards clean energy at one point – not tomorrow or next year of course, but maybe in a few decades". Criticised the lack of governmental programmes to raise awareness on general resilience and sustainability. Related to the stakeholders' wellbeing, stated there is a need to "increase awareness of mental health issues that follow a disaster, and at this moment this impact on the population is not addressed".
P18	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Criticised the capacity of some managers to engage with employees, as they "encourage and expect regular training and participation in field exercises for the workers, while they [the	Confirmed multi-agency collaborative plans and efforts with other institutions, mentioned that training is done together with first responders and following governmental guidance.	**ND**	Believes personnel training to be sufficient (seminars, multi-agency, full-scale exercises). Praised the quick introduction of new documentation and instructions.	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities, but said "you can't achieve sustainable development without resilience, but few people know the infrastructural problems, so some people

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	managers] very rarely participate themselves", and "supervise without directly being involved and without offering the much-needed guidance to their teams" or just "waiting for the simulation to finish so they can sign the papers and say that they did their job".				praise the move to green energy as if this will fix all our problems – it won't". Believes that both resilience and sustainability are on the rise, albeit slowly and inefficiently.
P19	**ND**	Confirmed multi-agency collaborative plans and efforts with other institutions, and the system is continuously improving. Believes the UAE's involvement in external humanitarian relief reflects the ability to withstand internal struggles: "the Emirati people can easily raise funds and send resources and people to help disaster victims worldwide, it's pretty obvious that we'll be able to do the same when our own people are affected".	Believes the UAE has the financial capacity for the development of all-encompassing social support policies: "returning to normal after a disaster means that the problems that need to be fixed need to be very quickly addressed. From my experience, addressing these issues quickly can be achieved when there is enough money to go around".	Believes personnel training to be adequate (seminars, multi-agency, full-scale exercises).	Believes that both resilience and sustainability are on the rise in the UAE in general, and particularly in the energy sector. Praised the UAE's focus on disaster relief, raising the argument that both international humanitarian projects and the national response to the Covid-19 pandemic have been, from a social perspective, successful in lessening the impact on the affected populations.
P20	Believes upper management to have a significant role in capacity building and during the preparatory stages, especially concerning collaborative efforts and team communication. Praised managers' dedication: "a team is only as good as its leader, so everyone needs to do their part and improve together, and this mentality can starts from the top", adding that it is "no surprise that Emirati energy companies are so adaptable when everyone is committed to stability, efficiency and long-term excellence".	Confirmed multi-agency collaborative plans and efforts with other institutions, and the system is continuously improving. Believes the UAE's involvement in external humanitarian relief could help the UAE in the long-term, as the country "has always sought to improve through partnerships and collaborations, both internal and external ones, and so far we successfully managed to help a lot of countries with disaster relief". Added that the energy sector has "faced fewer disasters, which were much less disruptive than those in other countries, so if we managed to help people in worse states than us by collaborating with the UN and local organisations, we should have no issues here".	Believes the UAE has the financial capacity for the development of all-encompassing social support policies, despite the lack of internal experience: "the UAE doesn't have a lot of first-hand experience in dealing with disasters and their aftermath. We have been very lucky, most emergencies had a small impact and didn't destabilise the country to a great extent, but we got involved in humanitarian projects in other countries to compensate for our limited experience and learned a great deal from these situations".	Believes personnel training to be ample and diverse (1-on-1 talks, seminars, workshops multi-agency, full-scale exercises). Praised the quick introduction of new documentation and instructions, and the continuous dedication to excellence: "it's easy to remember daily procedures but with time, you start to forget details, especially the circumstances and actions that you need to take in the rarest occasions such as those related to disaster and emergency management, which are extremely rare for most of the energy companies here [in the UAE]".	Praised the Emirati energy sector's focus on alternate and renewable energy as a step to building sustainable communities: "the [UAE] government promotes the sustainable development agenda because it wants the community to thrive in the long-term […] so we're actively trying to financially encourage energy companies to diversify their energy generation with renewables". Believes that both resilience and sustainability are increasing. Praised the UAE's focus on disaster relief, raising the argument that both international humanitarian projects and the national response to the Covid-19 pandemic have been, from a social perspective, successful in lessening the impact on the affected populations.

5.6 Summary and Analysis

This chapter was dedicated to presenting and examining the primary data gathered for this thesis. The data was collected via semi-structured interviews conducted via online means with, 20 experts employed at several energy companies in the UAE, including private institutions such as Abu Dhabi National Oil Company (ADNOC), Madinat Zayed Power Plant, Shuweihat Emirates Water and Electricity Company (EWEC), Adyard ABU Dhabi LLC, Abu Dhabi Oil Refining Company (TAKREER), as well as from public institutions, namely Etihad Water and Electricity (EWA) and Dubai Electricity and Water Authority (DEWA).

The data analysis process produced 17 unique themes or codes, which were then grouped into 4 areas concerning the various types of resilience, namely Technical and Technological, Organisational, Economic and Social, all of which included either four or five themes that are separated – based on the participants' perspectives – into vulnerabilities and opportunities. A table was generated further to illustrate the coding scheme (Table 10 below). The table includes all of the four codes, along with each generated theme, as they have been structured and presented throughout this chapter – thus, the themes are similarly separated between vulnerabilities and opportunities. More importantly, the following table indicates the overall response of each participant to any and each of the themes in a concise manner. As such, the table indicates whether a participant had an overall positive response (indicated by a " + " sign), a negative response (indicated by a " - " sign), a neutral and typically short / less descriptive account of their perspective (indicated by a " 0 "), or did not address the issue at all (indicated by the abbreviation " ND "for no data). Among the themes identified, theme C of the Social Factors' vulnerabilities (i.e. Social Support) had been discussed with only 6 participants, while themes A and B of the Social Factors' opportunities (i.e. Personnel Training & Sustainable Development), along with theme A from the Technical Factors' vulnerabilities (i.e. Infrastructure and System Reliability) had been addressed by all participants.

Table 10:Participant Answers by Codes & Themes

	Code 1: Technical Factors				**Code 2: Organisational Factors**				**Code 3: Economic Factors**				**Code 4: Social Factors**				
	Vulnerabilities		**Opportunities**		**Vulnerabilities**		**Opportunities**		**Vulnerabilities**		**Opportunities**		**Vulnerabilities**			**Opportunities**	
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**C**	**A**	**B**
P1	-	-	ND	+	-	-	-	0	-	-	ND	0	-	-	-	+	-
P2	-	ND	+	+	-	-	ND	+	-	-	0	0	-	-	ND	-	-
P3	0	-	ND	0	0	ND	+	0	-	0	0	0	+	0	ND	-	0
P4	-	ND	+	-	ND	ND	+	+	+	0	+	0	0	0	ND	+	+
P5	-	-	0	-	-	-	+	+	-	-	+	-	ND	+	ND	+	+
P6	+	+	+	+	ND	-	+	+	ND	0	+	+	-	0	ND	+	0
P7	+	0	0	+	0	ND	ND	+	ND	0	+	ND	+	-	ND	+	-
P8	-	0	ND	+	-	ND	-	-	ND	-	0	0	+	0	ND	+	+
P9	-	-	-	-	-	-	+	-	-	-	ND	+	-	0	ND	+	0
P10	0	+	+	+	0	ND	ND	+	+	+	+	0	-	-	ND	+	+
P11	+	+	0	+	+	-	+	+	ND	+	+	+	+	0	ND	+	0
P12	+	0	0	+	-	ND	ND	ND	-	0	0	ND	-	-	ND	-	0
P13	-	ND	+	+	+	+	+	+	ND	+	+	ND	ND	-	-	+	-
P14	-	-	ND	+	-	ND	ND	-	ND	-	0	0	-	+	+	+	+
P15	-	-	0	0	-	-	-	-	-	-	ND	+	-	0	ND	+	+
P16	-	-	-	-	-	+	+	0	ND	-	+	-	+	0	ND	+	0
P17	-	ND	ND	+	+	ND	+	+	-	0	0	ND	0	-	-	-	-
P18	0	+	+	0	0	+	+	+	+	0	+	0	-	0	ND	+	0
P19	0	ND	ND	+	+	ND	+	+	+	+	+	+	ND	+	+	+	+
P20	0	+	+	+	+	+	+	+	+	+	ND	+	+	+	+	+	+

LEGEND | Positive: **+** ; Negative: **-** ; Neutral: **0** ; No answer / no data: **ND**

Firstly, the vulnerabilities related to technical resilience included the perceived stagnation related to technical progress and hardware hardening, where notably, the transmission and distribution infrastructure was pinpointed by the participants as the main component that needs to be improved, as well as the reliability or lack thereof of the infrastructure and systems, which is difficult to secure due to the location of the physical assets and notably due to the various natural and man-made hazards that directly or indirectly affect the UAE's energy sector, notably sand-storms, earthquakes, fires, floods, terrorism and human error. On the other hand, the opportunities for ensuring technical resilience for the Emirati energy sector included the recent trend to diversify the power generation by investing in alternate and renewable energy (i.e. hydro, solar and nuclear) and additionally, the redundancies implemented to ensure that the backup power deployment is guaranteed regardless of interference.

Secondly, the vulnerabilities regarding the organisational resilience of the Emirati energy sector refer, on the one hand, to the adoption of risk management practices, which have yet to be fully embraced by all members of the personnel despite the robust documentation that was designed by each company, and on the other hand to the capacity of the higher executives for making decisions that increase the personnel coordination to distribute the available resources for disaster relief and response efficiently. Concerning the opportunities to increase organisational resilience, an important one is the adaptive capacity of the companies is a favourable characteristic that is continuously enhanced following the adoption of Business Continuity Management practices, and another is the tendency to modify and improve the disaster and crisis management policies to minimise a company's exposure to internal and external hazards.

Thirdly, the vulnerabilities concerning the economic resilience of the UAE energy institutions include their financial stability and ability to be reliably profitable despite disruptions, in effect avoiding bankruptcy without relying on financial help from the UAE, along with the propensity to only invest in new policies, processes and assets without strengthening the existing ones, which occur despite the financial strength of the Emirati companies. In contrast, the

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economic opportunities reflect this financial capacity. The buying power of the UAE energy sector is considerable, guaranteeing at least in the short-term and medium-term the security of its actors, and similarly, the availability of emergency funds is another aspect that ensures resilience.

Fourthly, the vulnerabilities influencing the social resilience of the Emirati energy companies include the inadequate disaster and crisis management training of some members of the management, the lack of comprehensive multi-agency collaboration strategies that could ease disaster response and relief efforts, as well as the fact that there are very few policies to provide social support for the stakeholders in case of a disaster or crisis. In opposition, an incredible opportunity for the sector is the preparedness and training of the personnel, who frequently participate in both theoretical and practical exercises, along with the general tendency to focus on sustainable development, which is a new development and thus can still be improved.

The following table (Table 11) further systematises the data illustrated throughout this chapter, quantifying the number of responses to assess the intensity and frequency of a vulnerability or opportunity. As a result, the scale will indicate which issues are more prevalent within the Emirati energy sector according to the participants to inform which key issues need to be either encouraged or corrected. A scale has been developed to help differentiate between the various phenomena explored, with the scales for both positive and negative totals being highlighted below. After estimating this total number for each theme, the set scale is used to determine the severity of each phenomenon. More specifically, issues that result in a balance between positive and negative reactions are considered minor or negligible as they are more likely to result from internal issues pertinent to a company – rather than being representative of the entire energy sector.

Positive Scale | 0-1: MINOR | 2-4: MODERATE | 5-7: MAJOR | 8+: MAIN

Negative Scale | -1-0: MINOR | -2-4: MODERATE | -5-7: MAJOR | -8: MAIN

Table 11: Classification of Codes & Themes by Frequency of Answers

Classification of Codes & Themes				
By Overall Responses			By Number of Responses	
Code 1: Technical Factors	Vulnerabilities	Theme A: Infrastructure and System Reliability	- 7	Major V.
		Theme B: Technical Progress and Hardware Hardening	- 2	Moderate V.
	Opportunities	Theme A: Power Generation Diversity	+ 5	Major O.
		Theme B: Backup Power Deployment and Redundancies	+ 9	Main O.
Code 2: Organisational Resilience	Vulnerabilities	Theme A: Adoption of Risk Management Practices	- 4	Moderate V.
		Theme B: Decision-making and Coordination	- 3	Moderate V.
	Opportunities	Theme A: Adaptive Capacity	+ 9	Main O.
		Theme B: Policy Reform and Capacity Building	+ 8	Main O.
Code 3: Economic Resilience	Vulnerabilities	Theme A: Financial Stability	- 3	Moderate V.
		Theme B: Investment Opportunity	- 3	Moderate V.
	Opportunities	Theme A: Buying Power	+ 10	Main O.
		Theme B: Availability of Emergency Funds	+ 4	Moderate O.
Code 4: Social Resilience	Vulnerabilities	Theme A: Management Training	- 3	Moderate V.
		Theme B: Multi-agency Collaboration	- 1	Minor V.
		Theme C: Social Support	0	Minor V.
	Opportunities	Theme A: Personnel Training	+ 12	Main O.
		Theme B: Sustainable Development	+ 3	Moderate O.

The table 11 indicates that, in general, the participants are more pleased than displeased with the Emirati energy sector, as many of the positive aspects have been praised, and the negative ones were not criticised in a similarly vehement manner. While the findings seem to reflect the UAE's ability to steer away from any major emergencies in the energy sector so far, as most vulnerabilities are minor, this does not mean that the risk of major accidents is diminished. The findings show that some vulnerabilities have been understood, perhaps more clearly than others, and as a result, various attempts have been made to address them and improve overall resilience. Even so, while several major and moderate vulnerabilities were detected, this does not mean the risk for a major incident to occur is increased; instead, the findings show that several issues

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need to be addressed and contained – preferably as soon as possible, to continue avoiding any large-scale incidents. To better illustrate these findings, the following table (Table 12) organises the themes by the intensity deemed from the scales set above.

Table 12: Classification of Codes & Themes by Intensity

	VULNERABILITIES	OPPORTUNITIES
MINOR	**Social Resilience:** Multi-agency Collaboration **Social Resilience:** Social Support	-
MODERATE	**Technical Resilience:** Technical Progress and Hardware Hardening **Organisational Resilience:** Adoption of Risk Management Practices **Organisational Resilience:** Decision-making and Coordination **Economic Resilience:** Financial Stability **Economic Resilience:** Investment Opportunity **Social Resilience:** Management Training	**Economic Resilience:** Availability of Emergency Funds **Social Resilience:** Sustainable Development
MAJOR	**Technical Resilience:** Infrastructure and System Reliability	**Technical Resilience:** Power Generation Diversity
MAIN	-	**Technical Resilience:** Backup Power Deployment and Redundancies **Organisational Resilience:** Adaptive Capacity **Organisational Resilience:** Policy Reform and Capacity Building **Economic Resilience:** Buying Power **Social Resilience:** Personnel Training

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As a disclaimer, it is understandable that the participants may try to downplay the vulnerabilities of their companies and of the sector they are employed in; however, such a claim cannot be proven or disproven as part of this thesis, the researcher starting from the assumption that the participants were not purposely dishonest. This is further corroborated by the fact that even the themes that were overwhelmingly perceived as positive among most participants (such as the major and main opportunities) were still criticised by some participants, and vice-versa. Even more so, participants working at the same facilities were more likely to point out similar vulnerabilities and opportunities, which further enhances the reliability and validity of the findings, as patterns have very obviously emerged and connections can be drawn. This being said opinions started to diverge between the participants from the same company, yet who are working in different industries and facilities (e.g. petroleum vs. solar energy plants), which tends to suggest that while there are common policies throughout a company, the practices tend to differ especially at the middle and lower levels. Additionally, the experts from the energy regulators – meaning they are employed in the public sector – were much more likely than those from the private sector to present any of the issues discussed from a more constructive – and implicitly less critical perspective, as proven by the fact that, for the most part, participants 18, 19 and, 20 discussed the topics raised in an overwhelmingly positive manner. This being said, it is important to mention that the distinction between possible diverging perspectives between experts in the same field, from the same country, employed in different sectors, had not been made in advance – so this avenue could not be explored significantly.

Additionally, it is important to keep in mind that solely three experts from the public sector took part in the study, and while they are employed at two different institutions, given the low number, the difference in perspectives could simply be a coincidence rather than a pattern as it seems at first glance. Even so, the possibility that the private sector – even in spite of the UAE's efforts to sustain and preserve the financial strength of the energy sector as a whole – is much more economically reliable and secure, as well as more stringently regulated to ensure the institutions' reliability than its counterpart, could also be valid reasons

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that need to be examined more comprehensively to reach accurate conclusions. Therefore, it is important to consider that this thesis considers and explores the energy sector in the UAE as a whole.

All things considered, the findings show that the Emirati energy sector is affected by various deficiencies that need to be addressed to strengthen its institutions' resilience and sustainability. At the same time, numerous favourable circumstances, resources and policies are employed throughout the sector that can be further strengthened and utilised to ensure the stability of the energy industry, along with the safety of its stakeholders.

To further illustrate how each issue affects the industry and as a means of assessing whether the measures that can be taken for them to be addressed – namely, if they should be tackled by each company individually or if a multi-agency collaborative effort is needed, a SWOT analysis has been conducted (Table 13). In essence, the developed SWOT analysis, showcased below, is afterwards used as a starting point in the creation of a conceptual resilience framework that is uniquely designed to suit the UAE energy sector's capacities, needs, deficiencies and benefits.

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Table 13: Classification of Codes & Themes – Strengths, Weaknesses, Opportunities, Threats

STRENGTHS	**WEAKNESSES**
1. Focus on new technologies 2. Focus on energy diversification 3. Investing in new transmission lines to and from the Barakah nuclear power plant 4. Multiple redundancies in place to ensure the stability of the energy infrastructure 5. Adoption of early warning systems for some threats (earthquakes) 6. Companies are willing to make changes following the pandemic developments 7. Good financial planning & strong buying power 8. Fast adoption of organisational measures -> increasingly more internal protocols, policies, plans & regulations for disaster, crisis and emergency management 9. Existence of plans to facilitate multi-agency collaboration 10. Adoption of ISO standards & BCM practices 11. A dedication to providing quality products and services 12. Expertise & experience of personnel employed in the energy sector, particularly oil industry -> people are familiar with their roles and responsibilities to conduct their daily operations 13. Continuous & varied training opportunities, both internal and external 14. Employees are keen on raising issues with the management	1. Ageing components / equipment that may result in fires, explosions, collapses, technical failures etc. 2. Inadequate resources being spent on fixing current infrastructure 3. National grid is insufficiently developed to carry the entire energy load from all the current facilities – especially with the inauguration of the Barakah nuclear power plant – so some energy is wasted 4. Awkward geographic positioning of some facilities (desert, coast) that takes a lot of time to get to when fixes are necessary, the sectors cannot be all monitored & patrolled 5. Poor contingency planning for storing & distributing oil products 6. Poor cyber security measures, lack of cyber experts & lack of counter-terrorist / defensive tools / equipment 7. Limited adoption of crisis & risk management practices in spite of numerous regulations 8. Insufficient or inexistent risk assessments & specific scenario plans 9. Reluctance towards big organisational changes 10. Possibility of human errors that may result in leakages, chemical fires, explosions etc. 11. Lack of disaster & crisis management experience of both managers and personnel 12. Limited focus on preventive methods 13. Poor safety & resilience organisational culture (decisions are not explained to the employees and certain standards are not upheld even by managers) 14. Too much bureaucracy (reports, papers to be filled etc.) that slows down daily productivity 15. Managers & personnel forgetting or purposely skipping security steps 16. Multi-agency collaboration is generally neglected, stakeholders not engaged in resilience & sustainability planning 17. Few social policies to reduce the impact of a potential crisis situation 18. Employee input is neglected, diminishing the employee engagement 19. Managers rarely participate in trainings and exercises 20. Upper management unfamiliar with on-the-ground circumstances & issues

OPPORTUNITIES	**THREATS**
1. Introduction of ISO standards & BCM throughout Emirati sectors and industries	1. Existence of natural risks & threats (earthquakes, sand storms, floods, etc.)
2. Adoption of UN Sustainability Goals -> less energy consumption, reduced carbon footprint, interest in renewable and alternate energy	2. Unstable / fluctuating demand for fossil fuel products that can drop quickly and without warning (as proven by the Covid-19 pandemic)
3. Emergent disaster management & resilience strategies that have been tested with positive results by others	3. Finite resource reserves (fossil fuels) are depleting
4. Financial support from the government in case of an emergency	4. The cohesion of the Emirati energy industry and government, coupled with the lack of foreign competitors, may result in a diminished interest in improving domestic infrastructure
5. Governmental policies to reduce financial burden on energy companies during the pandemic	5. Increased risk of man-made threats to the energy infrastructure (drone and cyber terror attacks, sabotage)
6. Covid-19 pandemic put things into perspective (first industry-wide crisis), that preventive measures are considered more	6. Few or no community support, outreach and awareness programs for disaster relief and prevention
7. Few worldwide competitors in the oil industry so financial incentive to improve foreign export is heightened	7. Seeking mental health support is largely stigmatised in the UAE
8. Technological advancements in the energy sector (higher capacity transmission lines) and in general (predictive technology – A.I.)	
9. Good geographical environment for energy diversification (solar, hydro)	
10. Outsourcing of projects to companies and experts in areas where Emirati experts have limited experience	
11. Changing international and local perspectives regarding nuclear energy, which is increasingly seen as a green alternative to fossil fuel	

The Table 13 shows the strengths, weaknesses, opportunities and threats relevant to the Emirati energy sector, as the participants have identified them during the interviews and as they have been showcased throughout this chapter. The SWOT table thus created includes all of the technological, organisational, economic and social elements that affect the industry's resilience and its stakeholders. As can be seen, this analysis identified fourteen (14) strengths, eleven (11) opportunities, twenty (20) weaknesses and seven (7) threats for the energy actors in the UAE, and adding the positive and negative issues shows that the balance is currently slightly shifted towards a negative scale, which

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indicates the need to address the mounting issues – especially because many of these problems are already known by the energy actors. This being said, identifying both the positive and negative aspects of the Emirati energy industry is solely a first step towards improvement. Considering the purpose and objectives of this thesis, this classification will therefore be used as a starting point to suggest a risk and crisis management framework that seeks to improve the resilience of the Emirati energy sector. This framework will be developed and presented in the upcoming and final chapter.

With this in mind, the upcoming chapter investigates and ascertains the significance, pertinence and implications of the findings by further examining the results presented throughout this chapter through the lens of the academic perspectives detailed in the Literature Review (Chapter II).

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CHAPTER VI: DISCUSSION

6.1. Introduction

This chapter compares and contrasts the key findings extracted from the primary data with the lessons learned from the secondary data explored throughout Chapter II (Literature Review). This analysis helps identify which of the technical, organisational, economic and social factors related to resilience could and should be addressed in order to increase the resilience of the Emirati energy sector.

6.2. Factors Affecting Resilience in the UAE Energy Sector

6.2.1. Technical and Technological Resilience Factors

The research study presented in this thesis demonstrated that the technical and technological resilience of the energy sector depends on adopting four strategies mirroring the four pillars of resilience identified. As such, guaranteeing robustness before a disaster can be done by having a diverse means of generating power; resourcefulness during a disaster is showcased by the ability to deploy backup power quickly and to initiate redundancies so that the energy output is as stable as possible; rapid recovery after a disaster is achieved by relying on the infrastructure and existing systems – which ideally need to function within parameters at all times; and lastly, adaptability in the long-term is ensured by investing in technological progress and the hardening of the hardware.

The literature uncovered that the energy sector is inherently vulnerable to technical and technological risks that are both internal and external (e.g. mechanical and electrical failures, human error (Lin and Bie, 2016; McLellan et al., 2012), and the primary data findings demonstrate that similarly, the Emirati energy sector suffers from such shortcomings. To address such issues, the sector strictly follows industry standards to minimise the chance of a complete shutdown of a facility, with Emirati energy actors focusing on optimising redundancies (e.g. black-start capacities, backup generators, auxiliary transformers) to ensure the stability of their energy output.

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However, the study uncovered a variety of additional risks, threats and vulnerabilities specific to the Emirati energy sector. For instance, there are a multitude of natural hazards originating from the UAE’s geography, topography and climate (e.g. earthquakes, sand storms, hurricanes, and tsunamis affecting locations that are difficult to access), as well as many man-made risks considering the international geo-political scene (e.g. sabotage, drone and cyber-terrorist attacks) and gaps in risk management procedures (e.g. human error resulting in mistakes or oversight of real needs). Currently, the national guidelines emphasize mitigating natural hazards (NCEMA, 2013); however, academic scholarship has lamented that the local legislation is not offering robust standards – with only buildings in certain areas, with more than 5 floors needing to withstand 5.5 magnitude earthquakes and above, meaning that any other buildings (e.g. low-rise constructions in production, distribution or storing) might be ill-prepared to withstand such incidents (Bardsley, 2018; Harnan, 2013). Indeed, the findings from the participants support the conclusion that even the risks that are given more attention are still not sufficiently explored in terms of potential impact.

Considering that these risks have already been identified in the Emirati official guidance and yet are not devoted the proper attention and guidance for prevention, it is clear that recently-emerging issues (e.g. cyber and drone threats) are devoted even less consideration than needed. The neglect to consider the critical infrastructure's actual needs and available resources is a major vulnerability of the Emirati energy sector. More specifically, the national transmission and distribution grid was revealed to be vulnerable, with issues such as the natural wear and tear of various critical infrastructure elements and higher energy waste due to the transmission lines being unable to carry the entire load. Past studies on the topic have noted that private actors have taken steps to address the issue of energy waste, with new transmission lines being constructed to carry the entire load generated by the nuclear facility (Power Technology, 2020; Turak, 2020). This research uncovered similar findings – as several company employees overseeing the implementation of high voltage overhead transmission lines (i.e. Madinat Zayed) confirmed the project’s progress. However, the introduction of new technologies, albeit slow, still

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seems to be preferred by the UAE over refurbishing and securing the existing infrastructure – with many experts showing concerns over this tendency, which according to them, should come only after the existing hardware has been hardened. These findings support Lin and Bie’s (2016) conclusion that the energy sector's resilience is threatened, especially when dormant hazards become augmented when currently-used facilities, mechanisms and tools that are supposed to ensure the security of the critical infrastructure are not adequately maintained at a high functional level.

Other issues uncovered in the research process illustrated in this thesis included the multiple flaws in the risk management procedures employed in the UAE, which became more apparent during the Covid-19 pandemic. The sudden drop in oil demands at the onset of the Covid-19 pandemic has revealed an insufficient number of oil storing facilities – and this resulted in a significant financial loss. The UAE’s recent move towards diversifying the energy generated proves to be a significant opportunity for the sector, as energy actors increased the number of renewable and alternate energy facilities (e.g. hydro, solar, wind, nuclear power plants), the goal being to ensure a wide array of sustainable energy that can complement the existing fossil fuel output. Indeed, while not all participants favour energy diversification, the study found that these perceptions are slowly but surely changing, this discovery mirroring the international trends in energy production (O’Malley et al., 2016). In addition to increasing the stability of the infrastructure by providing a sufficiently diverse energy source to support the national grid in case of an incident, the introduction of alternative energy sources also resulted in much-needed improvements to the existing grid, and this trend needs to be further encouraged to enhance the technological and technical resilience of the Emirati energy sector. In addition, the introduction of predictive A.I. to help increase the security of the industry as a whole, especially if it is implemented as a means of identifying potential failures before they occur, can further strengthen the sector's resilience (Hamdan et al., 2021), and the findings mirror this conclusion. While such technologies are already used in earthquake detection in the UAE (Webster, 2015), some participants agree that the sector would benefit from implementing more predictive technology.

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6.2.2. *Organisational Resilience Factors*

The research uncovered that ensuring the energy sector's resilience from an organisational perspective depends on four pillars: robustness before a disaster can be ensured via the adoption of risk management practices, resourcefulness during a disaster can be attained by improving the decision-making patterns and the overall coordination between the industry actors and key stakeholders, rapid recovery after a disaster can be achieved if the sector has the adaptive capacity to delegate resources as needed, while the overall level of adaptability in the post-incident phase depends on the desire to reform inadequate policies and to focus on capacity building for all stakeholders.

The findings from the primary data prove that the UAE is currently insufficiently prepared to address the emerging risks associated with a rapidly growing energy sector, especially considering the international environment. The findings indicated that the official UAE disaster management planning arrangements frameworks and standards adopted are lagging in implementing international safety and security standards – as the study has reinforced the conclusions from other academic publications. More specifically, the UAE National Response Framework (NRF) does not include clear definitions of what constitutes a disaster, crisis or emergency and does not provide a clear framework for the incident lifetime. It also does not offer an exhaustive list of potential disasters and crises, with little guidance on these can be tackled (NCEMA, 2013). Instead, the documentation indicates the need for developing specific plans for specific risks – with incidents simply being colour coded based on their magnitude and the response needed to address it (i.e. from green, yellow, orange, to red depending on how many organisations should become involved in the response), with limited additional guidance on the stakeholders and how they should collaborate in case of some incidents (NCEMA, 2013: 23-31). Related to this, a significant vulnerability that needs to be addressed is the limited opportunities for interagency collaboration, despite the existing plans and multi-agency training that occur in most facilities. In essence, the stakeholders are familiar with each other, but industry-wide decisions are taken separately, and not all companies are involved in resilience interventions that were evidenced in the gaps in the transmission infrastructure, the lack of

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hardening interventions despite its natural wear and tear that could affect all of the stakeholders.

The study's findings revealed that the lack of experience in disaster management, in general, has resulted in improper or lacking documentation, especially industry-specific guidance, that is crucial for the stability of critical infrastructure. In addition to the lack of clarifications about what qualifies as a disaster, crisis or emergency, the NRF does not include risk analyses to portray which threats are potentially the most harmful to the sector and the country, while the list of potential incidents (i.e. hurricanes, winds/storms / floods, earthquakes, transportation accidents, disease/epidemics, blight – NCEMA, 2013) does not include some of the man-made disasters identified by the experts – namely those related to human failure and intentional interference (e.g. any other accidents that are unrelated to transportation, sabotage, cyber-attacks, drone attacks). Academic insights also show that the Emirati energy sector is currently the least prepared to handle the identified human threats (Abel et al., 2004; Dancy and Dancy, 2017; Dorfman, 2019; Kamel and Gnana, 2018; Rogoway, 2019; Turak, 2019). At the same time, it is important to consider that the data also uncovered growing attention on training and risk management in the aftermath of adopting BCM and ISO standards that have improved resilience at all levels and industries in the UAE. However, both the primary data and the literary investigation show that many considerable risks are not properly considered. While there is a rise in man-made disasters in the Gulf region, and while the UAE energy sector actors place emphasis on improving upon training and preparedness, it is clear that some risks are not correctly identified and addressed, so the personnel cannot properly prepare to mitigate or respond to such disasters.

Another issue related to the introduction and adoption of various risk management and resilience frameworks is the abundance of new protocols that personnel need to adapt to in a short time frame, which according to the findings, results in an influx of new bureaucratic procedures that need to be completed, which tends to slow down the daily activities and which as a result are often neglected. This, coupled with the reticence to enact significant changes within an organisation at all levels – which the findings indicate that it

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stems from the lack of experience in disaster and crisis management – and especially at an upper management level (as evidenced by the limited involvement of the higher-ups in the development of new, specific plans to address rising threats, risks and vulnerabilities, or by the inability to take significant decisions or enact measures soon enough once a crisis is identified) leads to a culture of complacency and ignorance of the safety protocols, which lowers the overall employee engagement levels since many managers are already not engaged. Despite this, some middle managers and employees remain motivated to propose actual changes to increase the resilience of their institution, which is an opportunity that needs to be further pursued and encouraged to increase the organisational resilience of the Emirati energy sector.

6.2.3. Economic Resilience Factors

The analysis shows that economic resilience within the energy sector can be achieved by addressing four dimensions of resilience based on the actions or conditions required, respectively increasing the buying power of institutions to ensure robustness, ensuring the availability of emergency funds to deploy at the disaster onset as proof of resourcefulness, guaranteeing the financial stability of the energy actors at all times showcases the ability to recover quickly from an incident while seizing the opportunities to invest in various technologies and procedures is proof of the sector's long-term adaptability.

The primary data indicates that the economic resilience of the Emirati energy sector suffers from poor contingency planning, which is a consequence of the decision-making flaws explored in the organisational resilience sections. The budget planning is rather strict, and significant modifications, even during a high-impact scenario (e.g. the Covid-19 pandemic), are difficult to implement in a timely manner. The Emirati energy sector prioritises funds for new investments over ensuring the existing facilities, machinery, and other infrastructure elements are stable, secure and safe. The stringency of the budgetary decisions is partially influenced by the over-reliance of the energy sector on the UAE subsidies from the public sector, creating unstable financial stability for the individual actors. Indeed, the findings show that measures taken by the UAE to lessen the financial burden of the energy entities (e.g. cutting

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taxes, property and maintenance costs) during the pandemic were helpful, and even more so, the UAE's budget has funds set aside for international and national humanitarian relief, which ensures that the impact of incidents puts less strain on the sector. However, such approaches only manage to destabilise the sector financially in the long-term, as companies tend to become over-reliant on external support, leaving them vulnerable to socio-political and economic fluctuations (Labaka et al., 2015b), as well as to logistical errors – especially in centralised systems such as the UAE's energy sector (McLellan et al., 2012), and similar repercussions were also signalled by the participants.

Another vulnerability uncovered as part of the research process developed in this study is the lack of funds set aside to ensure the Emirati companies function under normal parameters at all times. This lack of funds becomes more obvious during an incident (e.g. Covid-19 pandemic), especially given the lowered demand and high maintenance costs that can surface during a disaster or crisis scenario. Indeed, considering that the vast majority of disasters result in physical damages, allocating funds that can support relief in both the short and long term is required to ensure the resilience of the critical infrastructure (Labaka, 2013; Ramlall, 2019). With this in mind, the Emirati energy sector's capacity to adapt to the changing economic climate following a large-scale disaster – especially international ones that may have a high impact on the oil industry – seems limited. In the case of the pandemic, this lack of adaptability resulted in the adoption of sudden measures that solely targeted the employees – which is understandable given the diminished production and the corresponding need for less manpower. However, the latter were displeased to suffer the financial consequences of having to look for new jobs or having their pay cut when they did not do anything wrong, especially considering the lack of warnings in advance or the fact that they are not rewarded in a similarly proportional manner when the company's profits are skyrocketing – the outcome having a significant impact on the social resilience of the industry and its stakeholders, as well.

This being said the Emirati energy sector is nevertheless, under normal parameters, a very lucrative industry, and this is evidenced by their focus on continuous economic growth, making use of many financial monitoring &

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evaluation tools that are overseen by a dedicated department to ensure the financial plans are met even during times of distress. While the willingness to cut costs is overall perceived as a strength and as an indication of adaptability to emergent situations by Emirati experts, the cost-cutting measures seem not to be properly selected, once again pointing towards the managerial flaws that sometimes affect the individual Emirati energy institutions and their ability to become resilient. The findings show a poignant need to introduce prevention and mitigation measures at all levels and for all resource types as a direct means of enhancing the energy sector's resilience – while currently, the approach adopted at an institutional level focuses almost entirely on response and recovery. The study's findings indeed mirror those from the literature, as the capacity to withstand and recover from major incidents is rooted in the capacity to manage an incident during all stages (Coppola, 2011; Fagel, 2012; Subramanian, 2018), and this perspective also needs to be applied to the financial component of disaster management – as having a strong economic foundation is key to improving all other facets of resilience (Labaka, 2013; Labaka et al., 2015b).

6.2.4. Social Resilience Factors

This research identified that the social resilience of the energy sector could be attained based on four conditional dimensions of resilience, namely the training of the entire staff as a means of attaining robustness, the collaborative efforts between the various agencies as proof of resourcefulness, the implementation of social support policies to ensure rapid recovery, as well as the overall sustainable development of the community as a demonstration of the sector's adaptability to any escalating situation.

The primary data findings show that the Emirati energy sector emphasises the training of the employees, in particular, who participate in numerous and varied training and practical exercises (i.e. one-on-one training, seminars, workshops, theoretical training, tests, simulations, drills), including collaborative ones with various agencies (multi-agency, full-scale exercises). However, a significant vulnerability that was uncovered is the fact that while middle and lower management is encouraged to also participate in such training, the majority of upper-level managers rarely participate in such activities. Indeed, the primary

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data findings are similar to the academic conclusions in the sense that a wide variety of training and exercises could and should be employed, as each can be used to address various objectives (e.g. informing the stakeholders of their roles and responsibilities, identifying risks and vulnerabilities, considering emerging risks and devising solutions based on these, familiarising stakeholders with plans and strategies, and so on) – and additionally the literature stresses upon the importance of the management's involvement as a means of engaging the personnel (Fagel, 2012; Green, 2000; McCreight, 2011). However, the study findings have shown that the lack of participation from the higher-ups in the UAE energy sector leads to diminished levels of trust and engagement of the remaining personnel. Existing evidence shows that the participants have expressed their discontent with their managers' lack of familiarity with on-the-ground practices, which results in implementing bureaucratic and redundant processes, effectively slowing down daily activities. It is unclear from the findings whether bureaucratic procedures are indeed justified or not; however, the literature seems to suggest that the lack of involvement from upper-level management prevents the creation of a resilience-oriented organisational culture as employees begin perceiving resilience as unimportant, negligible, unnecessary or excessive (Johnsen, 2010; Johnsen et al., 2012; Wasilkiewicz et al., 2018) and indeed the primary data supports this perspective. More specifically, the lack of managerial involvement creates a noticeable difference in perceptions regarding the needs, vulnerabilities and resources on the ground level, with many participants feeling as if their input does not matter as much as it should. However, the study findings have revealed that commitment to improving resilience in the Emirati energy sector remained strong. This was evidenced by both the commentary in relation to how strategies for improving resilience were adopted and applied, but more specifically by the fact that several participants expressed their involvement in the proposal and creation of company-wide frameworks to make their organisations more resilient.

It is important to mention that while multi-agency exercises and training occur in many institutions, the collaboration between Emirati energy actors, first responders and other energy sector stakeholders is lacking. The study revealed

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that there are plans in place that promote multi-agency collaboration; however, the findings show that few changes are made based on the input of other agencies, and notably based on emerging circumstances (e.g. Covid-19 pandemic) or newly identified risks and vulnerabilities (e.g. the rise of cyber-terrorism, drone warfare), yet, in reality, the interactions between stakeholders are very limited. The approach exhibited in the UAE supports concerns of the literature, which has shown that while a good collaboration between stakeholders encourages engagement in developing practical and sustainable solutions for addressing vulnerabilities and mitigating risks, in reality, various stakeholders not feeling sufficiently prepared for a large-scale incident (Hollnagel, 2015; Ronan and Johnston, 2005). Specifically for the UAE, this limited collaboration and communication results in the local communities is the most neglected, with neither the Emirati state and local government nor the energy companies providing any specific guidance on what steps must be followed in case of a disaster or crisis. However, disseminating such information to the public during the pre-disaster stages not only improves morale – but also produces additional benefits; for instance, the public is aware of the evacuation strategies and thus, the risk of piling damage in the wake of an incident is considerably lowered (Coppola, 2011). Even more so, the Emirati energy sector's social resilience further suffers due to the lack of community support, outreach and awareness programs for both disaster prevention and relief, including the lack of mental health support, which is not at all considered. Indeed, while it is difficult to change such perspectives, the benefits of including programs that aim to include and prepare the community for a potential crisis cannot be denied, as seeking to engage the public is more likely to help identify both vulnerabilities and opportunities that may not have been taken into account – and this is an important step in developing sustainable and resilient communities (Paton and Johnston, 2001).

Another issue that the study uncovered is that volunteering as a practice is neither encouraged nor particularly sought out by the energy actors in the UAE, even if there is a national volunteering program in which members of the public can enrol. However, the research into the literature shows that encouraging the population to volunteer and participate in training, especially in disaster relief,

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increases the awareness and overall engagement of the population by presenting the potential problems and offering the means of addressing these, which increases the community's resilience by both increasing the public's preparedness and by empowering the individuals to take proactive steps towards mitigating the impact of an incident (Labaka et al., 2015b). The study also uncovered a significant opportunity for building social resilience within the Emirati energy sector by adopting the UNSDGs within all sectors and industries in the UAE. More specifically, the UNSDGs place a great emphasis on the sustainability of communities as a whole by promoting social change to diminish inequality and thus ensure the well-being of all individuals, and even more so, the goals highlight the importance of multi-agency partnerships as a pillar of achieving sustainability (Bridges and Eubank, 2021). All things considered, changes to the way social resilience is perceived and approached are slow to implement in the UAE, however for the most part, the energy actors seem to be dedicated to upholding the UNSDGs, so social changes are likely to occur, and thus the needs of all of the stakeholders have to be considered when developing new resilience frameworks.

6.3. Summary

This chapter explored the implications of the primary data findings by further examining the results through the lens of secondary data, in effect identifying which factors related to either the technical, organisational, economic and social resilience of the UAE should be addressed in order to increase the resilience of the Emirati energy sector.

The upcoming final chapter demonstrates the link between this thesis' research objectives and questions, as they have been presented in the Introduction (Chapter I), and the findings extrapolated from the primary data in the Data Analysis (Chapter V) and in this Discussion chapter. Two additional objectives that will be addressed in the following chapter are related to the suggestion of possible improvements for the resilience of the Emirati energy sector. This was done via the development of a conceptual framework based on both the

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findings and on industry standards, which has also been tested for relevancy with industry experts.

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CHAPTER VII: CONCLUSION

7.1. Introduction

This chapter starts with a short presentation of the research process conducted in this thesis, which showcases how the research objectives have been addressed. Afterwards, the key research findings and recommendations are presented, in light of the project's set research questions.

To further ensure that the findings are relevant and useful to the Emirati energy sector, this closing section includes a conceptual framework which was informed by the findings of the study, based on the vulnerabilities and opportunities identified, and which also takes into account the SWOT analysis (Table 12). This framework (Table 13) provides a list of technological, organisational, economic and social policy recommendations that could be employed to increase the resilience of the energy sector in the UAE. The key takeaway is the need to focus much more on prevention and mitigation strategies, as the existing disaster management strategy currently relies mainly on response and recovery. The two main issues influencing the majority of the Emirati energy sector's vulnerabilities are the limited application of risk management practices, together with the limited engagement of the stakeholders throughout the entire disaster cycle. A focus group interview has been conducted with experts in the field to validate the data and the recommendations derived from the work, and this information was used in drawing the final conclusions.

The chapter ends with a small section that considers the areas that can be enhanced via further research, the main suggestion being a mixed-methods meta-analysis of each energy industry individually.

7.2. Research Summary

The overarching goal of the reseach developed for this study was to identify and assess the disaster management initiatives, policies, procedures and practices currently employed in the Emirati energy sector to determine to what extent the sector is resilient. The research first contextualised the phenomenon

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under investigation by providing a comprehensive literary foundation on the various concepts, theories, standards and frameworks relevant to the larger field of disaster management and afterwards pinpointed the factors, vulnerabilities, risks, hazards and opportunities that characterised the unique Emirati context from an individual (primary data) perspective.

The following seven research objectives have been set to guide the research:

1. To identify and explain essential disaster management concepts, theories and frameworks.
2. To analyse disaster management policies and practices and their suitability for the energy industry and the UAE.
3. To explore the importance of resilience within the energy sector in general, particularly for the UAE.
4. To design a framework for assessing the resilient capacity of the energy sector in general and as a means of exploring the disaster management and resilience practices of the UAE energy sector in particular.
5. To identify the opportunities and barriers that influence resilience-building within energy facilities in the UAE.
6. To formulate recommendations for the UAE energy sector to increase resilience and mitigate potential future disasters.
7. To evaluate the validity and relevance of the recommendations.

To achieve these objectives, the research process explored in this thesis employed an interpretivist philosophy that follows an inductive approach. These choices were made, on the one hand, due to the lack of available information regarding the Emirati energy sector, and on the other hand, as they allowed the researcher to approach the topic without any preconceptions, thus permitting the collection of vast amounts of relevant, context-specific data without previously-set constraints. Having decided upon the Emirati energy sector as the case study under investigation, the researcher conducted a cross-sectional analysis that investigated the case in a contemporary context. The investigation considered social, political, economic and scientific factors, the goal being to investigate the phenomenon from a comprehensive perspective. Adding to this goal was the decision to collect primary qualitative data via semi-structured

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interviews, which was analysed via coding, while also taking into account secondary qualitative data in the form of relevant literature that was explored using thematic analysis.

A theoretical framework for resilience building was developed (Chapter III), which identified four pillars of resilience based on the resources that are affected, namely including technical and technological, organisational, economic and social factors, as well as four pillars of resilience based on the actions required to improve the preparedness of an organisation, namely robustness (before a disaster), resourcefulness (during a disaster), rapid recovery (after a disaster) and adaptability (post-incident). It is important to mention that the latter group of resilience pillars have been chosen by the researcher for this study based on existing resilience frameworks to determine several indicators of resilience that the participants were most likely to touch upon. Indeed, the primary data analysis indicates that these pillars and indicators of resilience seem to be characteristic of the energy sector in general and in the UAE. The analysis resulted in the creation of the following framework for assessing resilience (Table 4), which addresses the first and fourth research objectives.

Furthermore, the data explored and illustrated in the second chapter (Literature Review) and fifth chapter (Data Analysis) contributed to completing the second, third and fifth research objectives, these findings being examined and consolidated in Chapter VI (Discussion).

Based on the key findings of the research presented in this thesis, which are grouped and summarised in the upcoming Section 7.3, a conceptual framework has been developed to address the sixth and seventh objectives, effectively offering informed, specific and contextualised recommendations for increasing the resilience of the Emirati energy sector (Section 7.4). Together, these upcoming sections address the research questions set at the start of the research process presented in this thesis, namely:

- What strategies are there for improving resilience within the energy sector and which of these strategies can be applied to the UAE?

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- What is the current capacity for resilience building for UAE energy facilities, and what factors influence it?

- What are the measures that the Emirati energy sector can adopt to increase its overall resilience?

7.3. Key Research Findings

This section presents the key findings oobtained from this research.

7.3.1. Theoretical reccomendations for improving resilience of the energy sector

This section seeks to address the theoretical part of the first research question, which sought to assess what strategies there are for improving resilience within the energy sector in general, the goal being to use this knowledge as a starting point to pinpoint which of these strategies can be applied to the UAE – an issue that is addressed in Section 6.3.2.3. Thus, the investigation of the literature revealed that a large-scale incident that affects the energy sector could have significant repercussions on all other sectors and industries, thus significantly threatening the livelihood of all stakeholders; it is important to acknowledge that the organisational factors influencing resilience development are key to mitigating disruptions (McLellan et al., 2012). As such, the research has uncovered that one of the most important steps to enhancing resilience is to first and foremost adopt or create adequate disaster, crisis and risk management frameworks, policies and procedures that take into account the needs, deficiencies and strengths characterising the energy sector (Rehak et al., 2019). This process needs to start with providing clear yet encompassing definitions of key terms, for instance, differentiating between threats and risks or between an emergency, crisis and disaster, to ensure that all stakeholders quickly understand which procedures they should employ to tackle a situation (Alexander, 2003). However, the project has shown that this is insufficient planning; thus, an additional preliminary strategy is the adoption of the disaster cycle with clear delimitations of the four stages (i.e. mitigation, preparation, response, recovery) as a framework to identify the steps needed to be taken at any given time will also help identify these emergent problems, as well as allow

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industry experts to prioritise the distribution of resources when confronted with an emergency (Subramanian, 2018).

The study found many frameworks and tools that can be adopted by an institution, organisation or company; however, the internationally-recognised ISO standards for risk management stand out as a comprehensive method of identifying, assessing and treating hazards, threats and risks (Coppola, 2011). However, it is not enough that such tools are only adopted on paper; instead, there is a real need to conduct an organisation-wide investigation into the available capacities and resources, especially comparing these to the vulnerabilities that the sector, organisation or facility is facing, and especially taking into account both the likelihood of a disaster to occur and its potential impact (Labaka et al., 2015a). As the Sendai Framework proposes, it is not enough to reduce economic loss and damage to the critical infrastructure; there is a need to ensure that as few people as possible are negatively affected by a potential incident (UNISDR, 2015a). Therefore, the research emphasised the need to not only continuously invest in new technologies (e.g. early warning systems, defence systems) but to ensure that adequate collaborative plans have been developed as a means of facilitating the response and recovery efforts – which need to be efficient, yet encompassing, and most importantly grounded in reality (Khan, Vasilescu and Khan, 2008). Furthermore, to increase social resilience, it is important to engage all stakeholders in the conversation, increasing awareness for the public and training all personnel on what they should do in case of both generic (lower likelihood) and specific (higher likelihood) scenarios (Fagel, 2012).

Lastly, considering that resilience in the energy sector is understood as the ability to recover from an incident to a previous, stable stage where energy continues to be supplied to other sectors and consumers (McLellan et al., 2012), the literary investigation pinpointed another important factor to consider when seeking to enhance resilience – namely the need to strengthen the physical components of the critical infrastructure. Among the industry standards to increase the technical and technological resilience of the energy sector that have been determined during the investigation are: the incorporation of various redundancies (e.g. black-start options for all facilities, backup generators and

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auxiliary energy storage units), while a need to continuously monitor, fix, reinforce, replace failing parts or worn-down constructions, or even relocate elements the grid if these are situated in an area that is deemed vulnerable (Lin and Bie, 2016). In essence, the research illustrated in this study shows that an all-encompassing approach that includes good financial planning for both short and long-term damage or disruptions, together with monitoring and evaluation procedures for all physical elements, resources and stakeholders, increases the awareness of existing faults, failures and emerging threats, and which is used to diminish these potential issues via capacity building, is required to increase the overall resilience of the energy sector.

7.3.2. Practical reccomendations for improving the resilience of the energy sector

This section seeks to address the second research question, which sought to uncover the current capacity for resilience building in Emirati energy facilities, as well as what are the factors that positively or negatively influence it. The information explored throughout this section, together with that illustrated in the previous one, is used as a basis to pinpoint what measure the Emirati energy sector can successfully adopt to increase its resilience.

The findings of this research reveal that the Emirati energy sector has taken measures to improve resilience from a technological, organisational, economic and social perspective, but some weaknesses need to be addressed and strengths that can be further emphasised. The project has demonstrated that a positive step in improving sector resilience is the willingness of organisations to diversify their power generation by investing in renewable or alternate energy facilities (e.g. solar, hydro, nuclear power plants), which is a significant shift from the reliance on fossil fuels, which will allow energy actors to both increase their financial strength and ensure that sufficient power is generated even if a certain facility is affected. However, the findings uncovered that such facilities were built before improving the existing transmission infrastructure, consisting of many outdated, worn-out or failing transmission lines and towers that cannot carry and distribute the energy currently generated. Even more so, while there is a tendency to adopt and incorporate new technologies, this adoption is slowed down by a reticent organisational culture that is over-reliant on

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superfluous documentation that affects the daily operations and puts a significant strain on employees – especially considering that many of the forms that need to be completed are solely formalities that managers tend to overlook. Additionally, the investigation found that funds allocated to strengthening the critical infrastructure are not adequately prioritised, with more money being devoted to adopting new technologies – as slow as it is – despite the need to refurbish the existing grid elements that are deteriorating due to insufficient maintenance.

Even so, this is not the only risk uncovered by this research. Another issue that seems to affect the capacity building of the Emirati energy sector is the multitude of risks that, on the one hand, innately characterise energy facilities (e.g. fires, floods, earthquakes, sand-storms, human error) and which, on the other hand, are emergent to the UAE and the entire Gulf area (i.e. increased terrorism – sabotage, cyber-attacks, drone strikes). Indeed, the UAE energy actors are currently better prepared to manage natural disasters, as specialists are more familiar with such scenarios; however, the findings revealed that the sector is vulnerable to man-made disasters, especially considering that the country had not experienced any large-scale disasters until the Covid-19 pandemic.

Related to this, the research demonstrated that the training and exercises that the personnel frequently go through provide capacity-building opportunities for familiarising the key stakeholders with their roles and responsibilities in disaster scenarios. However, a significant vulnerability uncovered during this research is the fact that the public is not included in the wider outreach efforts for resilience building, with very few awareness campaigns being designed to disseminate critical information in case of incidents. Furthermore, a major vulnerability that the study has uncovered is the lack of participation from the management, who are perceived as disconnected decision-makers by many employees, which significantly lowers the engagement of the personnel and puts strain on the internal communication channels. As a result, there is no cohesive organisational culture to promote all level resilience, with many managers and employees becoming ignoring occupation hazards (e.g. smoking in non-smoking areas, using work computers with minimal interest in

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security, skipping security steps to finish jobs quicker, filling reports superficially because nobody checks them, offering impractical suggestions and feedback, and so on). Even so, the study uncovered that there are still some specialists who are more than willing to devote additional effort to increasing the security and stability of the energy sector, yet these efforts need to be adequately praised and compensated to ensure that such work continues to be done. This is particularly relevant in light of the Covid-19 pandemic and its economic impact, as organisations were forced to make budget cuts in the form of lowering salaries or laying off employees who are not satisfied that they suffer the consequences of an ill-prepared sector – notably when they are not offered significant bonuses when the sector performs strongly. Even without considering this pandemic, the findings show that the industry has struggled to introduce exhaustive disaster management protocols, with policies and frameworks being adopted segmented and incompletely. Indeed, the implementation of ISO standards was incomplete, and ISO risk management strategies are not employed comprehensively to assess all possible risks in light of the individual companies' assets and vulnerabilities, which results in the poor prioritisation of some risks and vulnerabilities. In conclusion, while the Emirati energy sector has made significant strides in enhancing resilience in the past two decades, the study found that much work still needs to be done until it can be considered resilient and sustainable.

1.4 Conceptual Framework

Context and Purpose

This research developed a theoretical framework to examine the potential issues hindering resilience in the energy sector (Table 4). The theoretical framework identified two major axes, respectively the resources characterising the energy sector that can be affected (i.e. Impacts), as well as the timing when certain actions that can be taken during the 4 stages of the critical infrastructure resilience cycle (i.e. Conditions / Capacities) to enhance resilience for each resource type. The intersections between each impact and condition are the major strategies that can be examined and strengthened by the energy industry to mitigate or avoid repeating negative incidents.

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Of course, it would be unlikely that the UAE energy sector's resilience would require the implementation of all these strategies. Making use of the 16 general indicators of resilience identified, the researcher examined the primary data to identify key positive and negative elements, which were presented in the SWOT analysis for the UAE energy sector (Table 12 in Section 5.6.). Considering that this research sought to improve the Emirati energy sector, and particularly considering that so far, no study has specifically pinpointed both existing issues and feasible recommendations that are based on the experiences of local experts and the opinions of international practitioners, the researcher sought to provide a conceptual framework that organises these findings in a simple, yet clear manner that could be easily applied. Thus, the theoretical framework developed was meant to inform the conceptual framework on what elements should come into focus when proposing solutions. More specifically, the axis representing the four 'Impacts' (i.e. technical, organisational, economic, social) proved to be the most pertinent approach to offering recommendations in a structured manner, as the research found that all of these demonstrated substantial vulnerabilities.

7.1.1 Measures to Improve Resilience in the Emirati Energy Sector: A Conceptual Framework based on Key Findings

Taking into account the findings showcased in the previous Section (i.e. Section 7.3.), this segment offers relevant and applicable recommendations for increasing the Emirati energy sector's resilience. This is also achieved by considering the primary and secondary data findings, as they have been illustrated throughout chapters II: Literature Review, V: Primary Data Analysis and VI: Discussion. Accordingly, the following conceptual framework (Table 13) has been generated based on: the identified resilience dimensions (i.e. technological, organisational, economic and social resilience), the identified vulnerabilities and opportunities characterising the Emirati energy sector (i.e. factors affecting resilience), and the elements separated into strengths, weaknesses, opportunities and threats in the SWOT analysis (Table 12) that was produced as part of the last section of the primary data analysis chapter.

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Table 14: Conceptual Framework for the Emirati energy sector

	EXISTING ISSUES	RECOMMENDATIONS
TECHNICAL & TECHNOLOGICAL RESILIENCE	- Inherent vulnerability to various risks - Existent natural risks and emergent man-made risks - Over-reliance on fossil fuel - Ageing national grid - Focus on maintenance rather than improvement - Energy loss during transmission - Slow & limited adoption of early warning systems	- To continue adopting internationally-tested, innovative technologies for disaster management, as well as to test, monitor and evaluate these solutions for efficiency - To introduce trainings against cyber-attacks for all stakeholders - To replace the ageing elements of the national grid with more advanced ones – notably to change the existing transmission lines and towers with newer, higher capacity alternatives - To further pursue energy diversification by constructing additional renewable and alternate power plants - To invest in predictive A.I. monitoring as a means of increasing security by identifying threats in advance

ORGANISATIONAL RESILIENCE	- Lack of experience, leading to a limited adoption of disaster, crisis and risk management practices (e.g. risk identification, risk assessments, risk treatment, specific scenario planning, contingency planning) - Few preventive measures to address vulnerabilities, threats and needs - Adoption of too many new protocols that are inconsequential - Reluctance for significant organisational changes - Limited multi-agency collaboration - Lack of a resilient organisational culture	- To adopt international best practices (e.g. frameworks, standards, guidelines, policies, procedures), to monitor and evaluate their implementation in the UAE - To encourage the shift towards an organisational culture focused on resilience by formulating regulations that provide more specific information on the classification and impact of incidents, on the lifecycle of an incident and the strategies that can increase resilience at each stage - To encourage all stakeholders to share information by developing a real-time communication strategy - To adopt the ISO 31000 standard for risk management - To conduct more and specific risk analyses for the entire process - To simplify the bureaucratic process and emphasise the need for safety by reducing the number of unnecessary forms and replacing these steps with quick and crucial safeguards - To inform all employees and stakeholders of the new organisational changes

ECONOMIC RESILIENCE	- Major investments without addressing existing vulnerabilities - Limited disaster preparedness efforts - Dependency on public sector for disaster relief	- To prioritise budget allocation based on the most urgent needs - To develop long-term strategic plans for both disaster preparedness and relief, as a means of becoming financially independent from the national reserves

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SOCIAL RESILIENCE	- Inconsistent training between personnel and management - Upper management has limited applied knowledge - Reduced employee engagement - Public is not engaged, nor aware of potential impacts of incidents - Limited volunteering	- To introduce mandatory, routine and comprehensive training for managers, similar to the ones already available to other personnel - To introduce new mandatory trainings for managers, to increase their operational, decision-making and dispatch capabilities - To encourage employees' dedication towards ensuring resilience by rewarding and implementing helpful suggestions - To introduce awareness campaigns informing the public of the various high-likelihood scenarios, which need to include clear and concise plans on what citizens should do in case of a disaster - To engage the public by promoting volunteering - To actively include various stakeholders (e.g. private & public institutions, media, NGOs, citizens) in the process of achieving resilience & sustainability by first providing information and then asking for feedback, as a means of identifying the community needs, vulnerabilities and expectations - To pursue the adoption of all UNSDGs, at all levels and for all stakeholders

Overall, the key takeaway from the study is the need to introduce and implement more prevention and mitigation strategies at all levels, as currently, there is a focus on response – an approach that not only results in more damage, but which puts a significant strain on managers who do not have the necessary disaster management training to oversee a smooth recovery in case of a large-scale incident, as proven by the Covid-19 pandemic. While the table (Table 14) above showcases many factors preventing the sector from becoming resilient, these can be grouped under two significant and encompassing points across all industries, at all levels and affecting all resilience pillars, namely the inadequate adoption of risk management practices and the limited engagement of the stakeholders. The identified issues

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and recommendations of the conceptual framework have been validated via a focus group interview.

7.1.2 Verifying the Conceptual Framework

To ensure that the recommendations offered in the previous sub-section could be applied to the entire UAE energy sector, the conceptual framework was tested for relevancy via a focus group interview with other Emirati crisis management and resilience experts. More details on this process can be found in Chapter IV (Methodology), ection 4.7.1.1. This section explores the key issues identified by the conceptual framework, as well as the proposed recommendations to address these, in light of the opinions offered by the focus group members.

The group discussion began with an inquiry into the recent trends to diversify the generated energy by investing in additional renewable and alternate energy solutions, namely by constructing more wind, solar, hydro and nuclear power plants to supplement the energy generated by fossil fuels. The perspectives were split into two camps; on the one hand, some experts thought that including more such options was beneficial and could help spur the much-needed upgrade of the national grid, while on the other hand, other experts argued that there are many other issues needed to be addressed before focusing on alternate energy. Indeed, both of these perspectives were shared in the primary data, which showed that renewable energy is still not considered the best financial solution, even if perspectives are slowly shifting – and the focus group proved this to hold true. Following the interview schedule, the following question yielded positive results on the study’s suggestion to adopt, implement and focus on prevention and mitigation policies, with the experts noting that this particular approach – while internationally praised – does not currently describe the Emirati energy sector’s approach to disaster or crisis management. Indeed, the participants raised the issue that the current strategy is much more focused on response and recovery – which can be detrimental in the long term, mirroring the primary data findings of the study. When probed about the current capacity of the sector to identify, assess and treat risks, the experts debated the importance of risk management at all levels, from the extraction of primary material and energy generation to transmission and distribution to consumers

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and the group consensus was that there is a need to include more risk analyses for both natural and man-made threats.

Similarly, when the discussion moved to the suggestion to introduce mandatory disaster, crisis and risk management training for all the managers, the participants' answers were overwhelmingly positive, with many noting that this is indeed a significant issue that needs to be tackled as soon as possible. According to them, the inclusion of such training – especially if they are not done simply on paper and if managers actually devote themselves to increasing their expertise – can help with the prioritisation of policies, funds and manpower based on the current needs of not only individual institutions but of the sector as a whole. It is important to mention that this suggestion was by far the most well-received and praised during the group discussion, with some participants later during the talk returning to point out that many of the identified vulnerabilities are influenced by poor management and that ensuring the managers are motivated to enhance resilience can indeed positively influence the way other internal and external stakeholders perceive resilience – this conclusion further reinforcing the primary data findings.

Furthermore, when asked to weigh in on the need to include more specific guidance on how the Emirati energy sector stakeholders (i.e. public institutions, private companies, NGOs, media, and citizens) should collaborate and communicate, the experts expressed their concern that currently, the cooperation among stakeholders is limited to only some training, while generally, they do not share information – a vulnerability also uncovered by the research done for this study. As the participants debated this issue, they agreed that there needs to be more official national guidance and monitoring of the dissemination of information, which needs to occur as a means of enhancing resilience from both an organisational and a social perspective, as all stakeholders will become more familiarised with their roles and responsibilities in disaster preparedness, mitigation, response and recovery. Lastly, when probed on introducing awareness campaigns to inform the public on the potential issues and current solutions by asking for feedback to engage the citizens, the experts agreed that strengthening the sector's resilience cannot be unilateral. Instead, the discussion concluded with the participants agreeing that

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a resilient energy sector considers the needs of all individuals and entities, so engaging the public can not only help identify the community's needs and vulnerabilities that may have been otherwise neglected, a perspective that is also aligned with the study's findings.

Overall, the discussion proved that the recommendations are not only suitable for the Emirati energy sector, but that they were much needed, and that experts are keen on implementing them if it helps increase the sector's resilience.

7.2 Future Research

This thesis explored the disaster and crisis management policies and practices currently applicable to the Emirati energy sector, assessing which of these procedures impact various types of resilience in light of the sector's vulnerabilities and strengths. However, the study has gone a step beyond the theoretical and offered practical recommendations for improving the procedures that influence the energy sector's resilience in the UAE, which are based on international standards of best practice and contextual insights from Emirati experts. This being said, while this thesis has offered both a comprehensive account of and an overarching insight into the Emirati energy sector as a whole, the findings can be supplemented in the future by additional research that further expands the pool of knowledge.

For a better understanding of the development of resilience in the Emirati energy sector could be the investigation of resilience initiatives conducted in each emirate, as even though energy policies are regulated at the federal level, various discrepancies in both protocol and implementation exist at the local level. Related to this, another interesting perspective that can be explored in future studies can be the investigation of the resilience measures taken by the public and private sectors separately, as this thesis has not uncovered any notable differences between the two sectors. As such, the research could be further conducted to more accurately pinpoint the abilities, assets, vulnerabilities and needs of the entire Emirati energy sector, creating a discrepancy between the public and the private energy companies.

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Furthermore, to ensure this is possible, future research will need to examine the perspectives gathered from a larger sample size, and more notably by including more participants employed at public institutions in the UAE.

On a related note, the scope of the research itself has perhaps been too widely decided upon, as the energy sector – consists of multiple fossil fuel (e.g. oil, natural gas) and renewable/alternate (e.g. solar, hydro, nuclear, wind) industries. This thesis tried to grasp and illustrate an overarching perspective of the entire energy sector, and as a result, the participants were gathered – from various companies and facilities. Considering the four pillars of resilience identified during the investigation of the relevant theory, the amount of data that can be extracted and analysed under these circumstances is vast and thus, a further investigation into this topic could benefit from a more focused examination of each of these factors: public vs private sectors, fossil fuel vs renewables industries, each from a technological, economic, organisational and social resilience perspective.

The topic can be further explored from a mixed-methods approach. More specifically, online questionnaires that can be easily distributed and answered could be designed to allow participants to grade most of the elements identified in the SWOT analysis developed in Chapter V: Data Analysis (Table 12) as they perceive them in relation to their organisation. This approach can therefore be used as a method of validating the results of this research, in effect standardising the findings for the entire Emirati energy sector, regardless of the differences in the governmental, organisational or industrial processes. Additionally, with approval from the companies, a longitudinal analysis that incorporates an examination of the official documentation (i.e. disaster and crisis management plans) and procedures implemented within each organisation could also provide a unique perspective into how the Emirati energy sector functions and how individual actors seek to achieve resilience at all levels. Continuing the assessment of the Emirati energy sector from multiple complex perspectives and circumstances would further help depict the current context to the international public and provide more specific assistance to various actors in the Emirati energy sector.

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All things considered, the current research significantly contributed to the theoretical and applied knowledge regarding the resilience of the Emirati energy sector in several major ways. Firstly, it provided a much-needed investigation that was focused solely on the energy sector in the UAE by first presenting the needs, risks and resources available to various actors. Secondly, the research identified the vulnerabilities and opportunities that characterise the sector directly from experts, afterwards contextualising this data with national and international publications. Thirdly, this data was used to design a conceptual framework that offers recommendations to address the most significant threats currently affecting the Emirati energy sector, and moreover, these proposed solutions were then further tested for validity to ensure the suggestions could actually help enhance the resilience of the energy actors in the UAE. Overall, the major discovery of the research presented in this thesis was the fact that many issues stem, on the one hand, from the limited focus on preventive strategies, such as the implementation of risk management at all levels, and on the other hand, from the lack of managerial experience and training in disaster, crisis and risk management. These are significant findings that can be used as a starting point to address the many vulnerabilities of the Emirati energy sector, hoping to enhance its resilience across all dimensions and pillars.

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Appendix 1: Interview Schedule

1. Can you please explain what is your experience in the management of the facilities in the UAE energy sector? Please share with me your tenure in the sector, the position that you hold and the years for which you have been working.
2. During your tenure, what are the main changes you have witnesses in relation to the way the sector plans for disaster and emergencies?
3. What are the main disaster vulnerabilities of the UAE energy sector and the organization you work for?
   a. What is being done in your organization to address those vulnerabilities?
   b. How would you evaluate those efforts and responses?
   c. What must your organization do to ensure that it is better capable to address disasters?
4. Do you think that your organization is resilient to natural and man-made disaster - please explain and justify your answers?
5. What are the factors that make your organization resilient and able to withstand to natural and man-made disasters?
6. What do you think must be done to improve the resilience and reduce the vulnerabilities of your organizations?
7. To what extent the management of your organization is paying sufficient attention to reducing risks and improving the resilience of your organizations?
8. What do you think about the UAE government regulatory requirements for addressing risks and vulnerabilities of the UAE energy sector?
   a. How the state oversight of the UAE energy sector (in relation to managing risks and vulnerabilities) can be improved?
   b. To what extent the UAE energy sector is prepared to address the challenges of business continuity? What recommendations can you offer for enhancing the BCM framework of your organization.
9. Is there anything else we haven't covered that you would like to share in the discussion?

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Appendix 2: Focus Group Interview Schedule

1. How do you feel about energy diversification? Do you think investing in renewable and alternate solutions (such as wind / solar / hydro / nuclear power plants) could help strengthen the economic and technological resilience of the Emirati energy sector?
2. Do you think focusing on prevention and mitigation can be beneficial to the Emirati energy sector?
3. How do you feel about the current capacity of the Emirati energy sector to identify, assess and treat risks?
4. What you think about the introduction of mandatory disaster, crisis and risk management trainings for managers?
5. How do you feel about including more specific guidance on the collaboration and communication efforts between the Emirati energy sector stakeholders (public, private, media, NGOs, citizens)?
6. Do you think introducing awareness campaigns could improve the engagement of the public?

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Appendix 3: Ethics approval form

The University requires all research involving human participants, animals, human or animal tissue, or sensitive data conducted by its academic staff, research degree candidates and taught UG and PG students be subjected to ethics panel's scrutiny. This means that most researchers within the University are required to apply for ethics approval from the relevant Ethics Panel before commencing data collection.

Ethics applications take a minimum of 4-6 weeks to turn around and this should be considered in relation to deadlines and data collection.

The student must discuss the content of the form with their dissertation supervisor who will advise them about revisions. A final copy of the summary will then be agreed, and the student and supervisor will 'sign it off.'

The signed Ethics Application Form and application checklist must be e-mailed to your Research Centre Support team in the Research & Knowledge Exchange Division:

School of Arts & Media	A&M-ResearchEthics@salford.ac.uk
Salford Business School	SBS-ResearchEthics@salford.ac.uk
School of Built Environment	S&T-ResearchEthics@salford.ac.uk
School of Computing Science & Engineering	
School of Environment & Life Sciences	

Document	Enclosed? (Indicate appropriate response)		Date	Version No.
Application form	**Mandatory**	**If not required, please give a reason**		
Data Protection Checklist	**Mandatory**			
Risk Assessment Form	YES			

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Participant Invitation Letter	YES			
Participant Information Sheet	YES			
Participant Consent Form	YES			
Participant Recruitment Material – e.g. copies of posters, newspaper adverts, website	NO	The participants will be recruited from their workplace and no recruitment will be carried out through adverts.		
Organisation Management Consent / Agreement Letter	NO			
Research Instrument – e.g. questionnaire	NO			
Draft Interview Guide	YES			
National Research Ethics Committee consent	NO			

The form must be completed electronically; the sections can be expanded to the size required.

School	
Course of Study	
Expected end date of project:	
Is this application a resubmission from a rejected application? Please state the reference number	NO Reference number:
Is this an amended version of a previous approved application? Please state the reference number	NO Reference number:

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Is this a revision of an ongoing application? Please state the reference number	NO Reference number:
Has this project received external funding?	NO If **YES**, please provide name of Research Council or other funding organisation:
Do you use non-human genetic materials from outside UK for your research?	NO If **YES**, has this been collected since the 12th October, 2014? Choose an item.
Does your study involve a clinical trial?	NO If **YES**, do you intend to register your trial on a clinical database? Choose an item. Please note that most academic journals will **not** publish trials which have not been registered on a clinical trial registry before the onset of patient enrolment. For the purposes of registration, a clinical trial is any research study that prospectively assigns human participants to one or more health-related interventions to evaluate the effects on health outcomes. "Interventions" covers any treatment which can affect an individual's health, e.g. medical devices, behavioural treatments, dietary interventions, etc. For more details, see: http://www.icmje.org/recommendations/browse/publishing-and-editorial-issues/clinical-trial-registration.html

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1a. Title of proposed research project	
Building disaster-resilient energy sector within the United Arab Emirates – a critical analysis of the approaches for mitigation, vulnerability reduction and preparedness	
1b. Is this project purely literature based?	NO

2. Project Focus

In order to develop a strategic disaster management and mitigation plan and build resilience in the UAE energy industry, it is important to identify the potential hazards it faces. Aside from natural disasters that pose a risk to UAE critical infrastructure because of local geological activity, like earthquakes and tsunamis (Pathirage and Al-Khaili, 2016), the impact of climate change also causes new vulnerabilities to energy systems. These include the introduction of novel hazards (e.g. more frequent and severe storms), negative effects on energy production, for instance due to disruptions of the water cycle, or the need to consider additional criteria when deciding where to build or expand facilities (Schaeffer et al., 2012). Meanwhile, aside from enhancing the sector's resilience in the event of an accident, planning has to include provisions against deliberate attacks, most prominently by terrorists, aimed either at physical structures and facilities (Abel et al., 2004) or at the technological support system that facilitates the industry's operation (Dancy and Dancy, 2017). Intensive training and improvement of cybersecurity capabilities are major aspects of terrorism preparedness (Dancy and Dancy, 2017). Conversely, there is no history of pipeline oil theft in the country. Further research is needed to explore those issues in further details

Additionally, a, 2013 survey noted the stark number of fatal injuries, which have occurred within the Emirati industry (where the energy sector comprises a critical part) – and the percentage out of all such injuries in the country is no less than 40% (Statistics Centre Abu Dhabi, 2013). Although the Emirati authorities have not neglected the various risks that the energy sector needs to address, its legislative framework and resilience-building practices in this area have been found to be lacking in sufficient scope and practical results and advancements (Al-Kaili et al., 2014). It can also be argued that Developing responses to the challenges to emergency management and business continuity in the UAE must be built on scholarly evaluation and analysis. Without independent assessments on the risk factors and the barriers that the industry faces in managing and mitigating risks, disaster and resilience (like the present project), advancements in the area can hardly be made.

The purpose of the project is to analyse the disaster vulnerabilities in the Emirati energy sector and shape the development of a strategic disaster mitigation plan to build resilience against hazards and disaster events in the future, as well as to identify the barriers this resilience building process could come up against.

3. Project Objectives

The research will aim to address the following objectives:

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- To analyse the literature on existing practices pertaining to disaster management including their suitability within the energy industry
- To review the extent to which the energy infrastructure and industry in UAE is vulnerable to hazards
- To evaluate the barriers that influence the application of disaster management practices within energy facilities in UAE
- To identify the best approaches for building a strategic disaster management and mitigation plan that would help to manage and mitigate potential future disasters in the UAE

4. Research Methodology

(e.g. Outline of research methodology, what information/data collection strategies will you use, where will you recruit participants and what approach you intend to take to the analysis of information / data generated).

Hazard assessment, and by consequence, emergency management and mitigation plans can at the same time depend on both quantitative measurements (e.g. how likely a strong earthquake is) and qualitative evaluations (e.g. how big a priority the earthquake threat is for civil authorities). In this project, the goal is not to quantify the threats to the UAE energy sector or measure their potential impact, but rather to examine them from a social perspective, through the meanings that human actors give to them, thus favouring a qualitative approach for data collection and analysis (Dey, 1993). For instance, one of the study objectives is to evaluate the UAE energy industry's vulnerability to hazards, but the project's interest in that pertains more to vulnerability's social causes, like the level of staff competence, than structural characteristics – which would still be viewed from a social (Dey, 1993, Flick, 2009). A benefit of using qualitative data is that it allows a holistic approach to the issue of energy sector hazard security – instead, using quantitative data might have been better suited to study one or two specific natural hazards threatening the industry, but this type of data could not examine man made threats and accidents, nor the challenges in implementing measures (Flick, 2009).

Having to account for a variety of possible hazards means that the research data has to be rich in information, which also characterises qualitative data due to the fact that it is usually expressed through descriptions and opinions, rather than measurements (Keele, 2012). Therefore, deep analysis of the same piece of data can reveal information on the examined issue, as well as on local context, which can help recognise the significance of linked variables (Keele, 2012, Khan, 2014). A further consequence of qualitative data's information wealth and flexibility is that it can be collected from relatively few expert sources, which helps overcome the difficulties of research in novel fields, with its corresponding lack of existing knowledge (Rao and Perry, 2003). To that end, it often employs purposive sampling, which helps easily collect participant observation data to fully use their insights (Saunders et al., 2009, Keele, 2012). Reliance on a small and subjective number of expert sources creates some threats for the research's reliability (e.g. introduction of observer bias), but these can be countered through a critical evaluation of the obtained information and an attempt to verify it (Saunders et al., 2009).

The researcher will use two types of data for the purpose of this assignment. First, primary qualitative data will be collected through interviews, so as to utilise the expertise of local practitioners, and second, secondary qualitative data will also be used. The methods and the procedures for the collections of the primary data are presented in the section below, so it merits justifying in this section how secondary data will be collected for this work.

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Even though there is limited literature on the subject of the UAE energy industry and its resilience to disasters, some existing studies along with data from UAE industry providers will help to contextualize the primary data findings. Potential sources of information for this project will domestic and international reports about the incidents that the UAE energy infrastructure had faced in the past, the emergency and contingency plans prepared by the local authorities, energy providers and emergency respondents, guidelines for emergency preparedness, recovery and response that had outlined the best practices that the UAE had followed in the pursuit of building the vulnerability of its energy industry. Data will also be collected from the UAE energy regulator if access to the institution is being obtained. Secondary data will also be sought from the companies that the researcher approach for the interview. The main reason why secondary data is being collected for this work is that it is often been validated through peer review, which means it can also be a valuable tool to contrast and verify the study's results against current knowledge, bolstering its reliability

The primary data will be collected via the conduction of interviews with 15 managers from various companies operating in the energy sector. Between these two types is the semi-structured interview type, which is the one that will be employed in this project. Semi-structured interviews use a list of questions, but do not stick to them strictly, instead allowing the researcher to make follow up inquiries, ask the participant to elaborate, or shift attention and focus on an interesting point mentioned (Bjørnholt and Farstad, 2014, Bryman, 2012). This allows the exploration of the topics of interest to this study, while at the same time making the most of the participants' expert knowledge without the danger of the discussion stirring off subject (Bryman, 2012).

The study will employ **purposive sampling**. Purposive sampling seeks individuals who are relevant to the research questions, in this case experts in UAE energy security. A **homogeneous sampling strategy** will be chosen, as there are no extreme variations expected among the field practitioners. Homogeneity was ensured through the employment of some inclusion criteria (to be outlined below), which were necessary to ensure the informants' usefulness to the study, since purposive sampling depends on their competence and reliability. To ensure the speed of the data collection, the researcher will allow the participants to refer their colleagues to participate in the study (provided that the person meets the inclusion criteria indicated above) so the study might have **an element of snowballing sampling**.

The size of the sample was decided to be fifteen (N=15) participants.

Inclusion criteria for participants concerned:

- Experience and familiarity with energy sector security.
- All potential participants needed to have a minimum of 8 years' experience working in UAE energy production facilities.
- Potential participants will be recruited from: Shuweihat, Al Taweelah Jebel Ali, Madinat Zayed plant, Abu Dhabi Oil Refining Company, Adyard ABU Dhabi LLC. Bilfinger Deutsche Babcock Middle East
- Energy production facilities includes the facilities for extracting and refining petroleum products and power stations
- The list of companies that will be approached for participant selection is large because it is expected that only a small number of approached enterprises will be willing to participate in this work.
- All participants will be knowledgeable on security matters; they were required to have a position with relevant responsibilities (e.g. managers).

- Contact with individuals who do not have a managerial position in the organization might also be made in case the researcher experience difficulties in finding relevant participants for the study.
- Contact with management of energy production units will be made via e-mail to request permission and help with identifying possible candidates.
- Participants belonging to vulnerable groups or otherwise representing extreme cases will be excluded

Exclusion criteria:

- Individuals who do not have experience in security and disaster management issues will not be interviewed for the study even if they meet all the inclusion criteria indicated above
- Government officials and representatives will not be interviewed for the study due to the risk of contamination of study results
- Friends, relatives and acquaintances of the researcher will also not participate in the study to safeguard the data quality

Research schedule for 12 months of data collection

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Arriving in the UAE												
Approaching the relevant organizations												
Negotiating research access												
Obtaining secondary data from the institutions												
Analyzing the secondary data												
Revising the interview schedule												
Approaching potential participants												
Arranging dates and times for the interview												
Conducting interviews												
Conducting backup interviews												
Transcribing the interviews												
Analyzing the interviews												
Preparing a draft of the findings chapter												

5. What is the rationale which led to this project?

(e.g. Previous work – give references where appropriate. Any seminal works must be cited).

The booming economy of the UAE has been historically founded upon its energy sector, and to this day the country relies on this industry which contributed 26% to the state annual GDP in, 2016 with oil activities increasing from, 2017 to, 2018 by 35.1% (Hamdan, 2019). However, many of the Emirati energy production facilities are located either in terrain where natural

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disasters are prone to occur or close to border areas where terrorists or adversarial foreign actors could attempt to deliberately sabotage them and thus threaten both the security and economy of the country (Paul, Al Tenaiji and Braimah, 2016). The extent and complexity of this wide production and distribution energy network demonstrate the complexity surrounding the Emirati government task in relation to building resilience and reducing disaster risks. In addition, a series of hostile events (with potentially Iranian origin) took place in the Strait of Hormuz, off the port of Fujairah that resulted in the decommissioning of four oil tankers earlier this year which suggest that energy production and transportation infrastructure might be at risk in case the tensions in the Gulf escalate (Wintor, 2019). In the light of the growing volatility in the Strait of Hormuz, undertaking an extensive assessment of the degrees of risks and the level of resilience of the Emirati energy infrastructure is a priority for researchers and for the Emirati government. Energy sector resilience is not an issue that has been widely explored in the Emirati context, let alone in the light of the recent troubling developments which suggest that energy sector will be a primary target of hostile foreign attacks even if there is no direct confrontation between the Gulf States, the USA and Iran (Wintor, 2019)

Paul, P., Al Tenaiji, A.K., and Braimah, N. A. (2016) 'Review of the Water and Energy Sectors and the Use of a Nexus Approach in Abu Dhabi'. *International Journal of Environmental Research and Public Health* 13, 364.

Statistics Centre Abu Dhabi (2014). Occupational Health and Safety. Yearly Environment Survey, 2013.

Al-Kaili, K., Pathirage, C., and Amaratunga, D. (2014) 'Vulnerability of the Emirati Energy Sector for Disaster: A Critical Review'. *Procedia Economics and Finance* 18 (1), 701-709.

6. If you are going to work within a particular organisation, do they have their own procedures for gaining ethical approval?

(e.g. within a hospital or health centre?).

NO

If **YES** – what are these, and how will you ensure you meet their requirements?

7. Are you going to approach individuals to be involved in your research?

(e.g. within a hospital or health centre?).

YES

If **YES** – think about key issues – for example, how you will recruit people? How you will deal with issues of confidentiality/anonymity? Then make notes that cover the key issues linked to your study.

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The anonymity of participants' personal data will ensured by identifying them, throughout the published version of the project, only through their individual identifying numbers, complying with the, 2018 Data Protection Act.
The interviews will be arranged to be conducted at private rooms at the participants' place of work, and therefore carried no safety risks for either the interviewees or the researcher. Still, participants will be advised that should they feel any discomfort during the process, they are free to interrupt and seek help from the facility's medical staff.

8. More specifically, how will you ensure you gain informed consent from anyone involved in the study?

Firstly, once a suitable group of candidate participants has been chosen and before continuing with the process of interviewing them, they will be required to provide written consent. To ensure they were adequately informed, they will be provided with an information and consent form containing an outline of the study's background, intended aims and methods, as well as a list of their rights as participants and what was expected from them. The consent from will specify that participation is anonymous, non-binding (withdrawal was possible) and voluntary and it was unique for each participant, identified by a separate identifying number. It will also include the researcher's contact information, which could be used to request further information on the project or to request withdrawal from the process (by referencing the aforementioned identifier). This will be possible up to the completion of the analysis, and carries no penalty for the participant. In the event of a withdrawal, a new interview with a substitute candidate will be arranged. The data corresponding to a withdrawing individual would be deleted as soon as their departure was verified.

Throughout this preliminary phase participants will be encouraged to inquire about the study, to develop a trusting environment and help them contribute in the best way possible. To further this goal, the research will not employ any covert or deceptive research methods and after each interview finished, there will be a brief discussion with each participant to provide feedback. During the interviews, participants will be allowed to freely express their opinion, without suggestions or assessments of their answers.

9. How are you going to address any Data Protection issues?

See notes for guidance which outline minimum standards for meeting Data Protection issues.

Research data, as well as personal information, will be available only to the researcher and used exclusively for the purposes of this study. Physical copies of consent forms and audio tapes containing interview recordings were kept locked in a cabinet, and electronic copies will be stored in a password protected computer. Once the analysis of the data was over and the final project written, both sets of data were deleted. The only person who will have access to this data will be the researcher, and upon request his supervisor.

10. Are there any other ethical issues that need to be considered? e.g. Research on animals or research involving people under the age of 18.

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No
11 (a) Does the project involve the use of ionising or other type of "radiation"
NO Choose an item.
11 (b) Is the use of radiation in this project over and above what would normally be expected? E.g. in diagnostic imaging?
NO
11 (c) Does the project require the use of hazardous substances?
NO
11 (d) Does the project carry any risk of injury to the participants?
NO
11 (e) Does the project require participants to answer questions that may cause disquiet/or upset to them?
NO

If you have answered YES to any of the questions in 11(a)-(e), then you MUST complete and submit a Risk Assessment Form with your application.

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12. How many subjects will be recruited / involved in the study / research? What is the rationale behind this number?
The primary data will be collected via the conduction of interviews with 15 energy sector practitioners. This will enable the researcher to ensure a degree of representativeness of the study without falling into the pitfall of interviewing too many individuals that might have limited knowledge in the sphere and provide the researcher with the depth of details and expertise to answer the research questions.
13. Please state which code of ethics has guided your approach (e.g. From Research Council, Professional Body etc).
The applicable code of ethics will be ESRC Framework for research ethics

Remember that informed consent from research participants is essential.

Please refer to the guidance on how to prepare your Participant Information Sheet and Consent Form.

Projects that involve NHS patients, patients' records or NHS staff, will require ethics approval by the appropriate NHS Research Ethics Committee. The University Ethics Panel will require written confirmation that such approval has been granted. Further information and details on how to apply to NRES can be found at http://www.hra.nhs.uk.

Where a project forms part of a larger, already approved, project, the approving REC should be informed about, and approve, the use of an additional co-researcher.

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17:55

Ethical approval STR1920-08 - Chair - TEMPLATE APPROVAL LETTER
DOCX - 65 KB

University of Salford MANCHESTER

:esearch, Innovation and Academic
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28 January 2020

Saqer Alqassimi

Dear Saqer

RE: ETHICS APPLICATION STR1920-08 – Building disaster-resilient energy sector within the United Arab Emirates – a critical analysis of the approaches for mitigation, vulnerability reduction and preparedness

Based on the information you provided, I am pleased to inform you that your application STR1920-08 has been approved.

If there are any changes to the project and/ or its methodology, please inform the Panel as soon as possible by contacting S&T-ResearchEthics@salford.ac.uk

Yours sincerely,

Dr Devi Prasad Tumula
Deputy Chair of the Science & Technology Research Ethics Panel

Page 2 of 1

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