QATAR UNIVERSITY

COLLEGE OF ENGINEERING

HOW TO ENHANCE THE RESILIANCE OF SURFACTANT SUPPLY CHAIN TO ENSURE THE CONTINUES PRODUCTION OF AL-SHAHEEN, DURING POLITICAL DISPUTES IN THE REGION

BY

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ABSTRACT

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Title: HOW TO ENSURE THE OIL PRODUCTION CONTINUITY OF AL-SHAHEEN FIELD DURING POLITICAL DISPUTES IN THE REGION

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This master's dissertation investigates the established supply chain of surfactant used in Enhanced Oil Recovery (EOR) activities in Al-Shaheen oil filed based of a pilot project conducted. It focuses on risks can rises from political disputes in the region specifically, potential blockade and trade exchange cutoff and repetitive Houthi attacks on petroleum targets in Saudi Arabia and United Arab of Emirates. Risk assessment conducted to visualize the likelihood and severity of each of the risk. Finally, it suggests QatarEnergy to expand Tawteen initiative to include enabling local surfactant producers to produce Enhanced Oil Recovery (EOR) surfactant and to build strategic reserve.

DEDICATION

Efforts of this work is dedicated to the nomadic Bedouin who have travelled the sunny and hot deserts of Arabia, on the back of his camel, heading to the fields, to the rigs, to the platforms …

In Aramco, Dhahran …

To Qatar Petroleum, Dukhan …

To the Shura council seat …

Making the better future for his grands …

We have been told a lot about you … that we wished we saw you …

Mohammed Bin Omair Al-Naimi

Thank you for making us all earned privileges …

May your soul rest in peace

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CHAPTER 1: INTRODUCTION

Research Background

There are many significant challenges that face oil producers globally and put them at risk resulting in shortage in both production and supply. Therefore, oil producers are unable to fulfil their commitments to their customers, shareholders, and landlords. Such challenges might be the outcome of a pandemic, disasters, or political disputes etc. Here comes the importance of building resilient production operations. Looking from upstream perspective, oil and gas industry have two upstream stages namely exploration and production.

The exploration stage is considered high risk because of the high cost associated with it as producers will fund uncertain operations using corporate funds. Exploration activities can be geological surveys such as testing subsoil for onshore fields, seismic scanning for offshore reservoirs and drilling of appraisal wells. According to the Library of Congress, drilling well can cost $5 to $20 million and in some cases it can be more. Therefore, drilling a dry well is a loss to the producers as they will bear the cost. In best cases, exploration activity will be successful when it results in economically recoverable amount of oil, and this means the quantity of oil that would be extracted will cover the cost of exploration activities and make financial profit.

The second stage of oil and gas upstream is the production activities. Where the well performance plays a critical role. Nowadays, advancements in technology can visualize the subsurface of field formation which enables engineers to assess more accurately the field potential well-by-well continuously during the field life cycle. Therefore, more accurate production forecast and optimization strategy can be initiated. It is important to mention that conventional extracting methods can extract up to 30% of Original Oil in Place (OOIP). Production of oil is categorized into three phases; Primary phase,

where the production of oil will depend on the reservoir pressure -which is initially high and will decrease over time; to push Oil to the wellbore. Secondary phase: where producer will inject water or gas to maintain the reservoir pressure by creating what is called artificial pressure through injecting well parallel to the production well and the aim is to make water or gas pushes the oil to the production wellbore. Primary and secondary phases will produce up to 40% as per Office of Fossil Energy. Due to the scarcity of oil reserves around the world compared to the growing demand, so much investment in Research and Development has been done during previous decades resulting in what is called nowadays Enhanced Oil Recovery (EOR) that enables oil producers extracting up to 60% and more of Original Oil in Place (OOIP).

Enhanced Oil Recovery (EOR) is several advanced methods being used to increase the production capacity after the reservoir natural and artificial pressure is reduced, thus, resulting in the decline of production capacity. Enhanced Oil Recovery (EOR) is divided into three categories; firstly, thermal recovery where the steam that is injected into the reservoir aims at reducing the viscosity of oil and increasing the flow rate. Secondly, gas recovery uses natural gases like Nitrogen, Hydrocarbon, Carbon dioxide and others. Lastly, chemical recovery. Chemical recovery can increase the oil flow by injecting chemicals like polymers to lower the surface tension and encourage the flow of oil droplets. In fact, there is no specific Enhanced Oil Recovery (EOR) method that can be used for all reservoirs and many criteria must be taken into consideration when selecting a proper Enhanced Oil Recovery (EOR) method. Criteria such as petrophysics of the reservoir, geology, chemistry, fluid property and other should be taken into account.

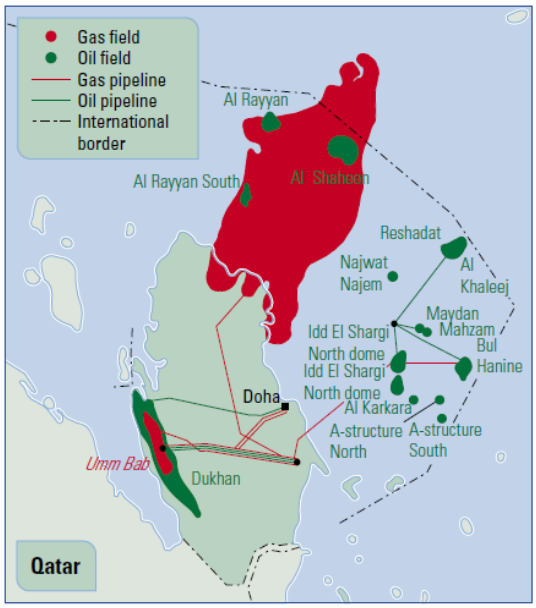

Figure 1 Map of Al-Shaheen Field location

The State of Qatar has many oil fields Al-Shaheen is the largest. It produces approximately 40% of the state total production. It is an offshore field facing the North-East cost. It was discovered in the 1970s through appraisal drilling. Initially, due to its complicated nature the field seemed to be not a commercial field. However, in 1992 QatarEnergy (Qatar Petroleum in 1992) signed an Appraisal and Production Sharing Agreement (APSA) with the Danish Maersk Oil Company (previous operator). Maersk succeeded in unlocking the potential of Al-Shaheen through horizontal drilling and by avoiding the hard formations (Al-Sadah, Abdulla Badr, 2019). Over the time and with continues production from the field, support technologies were needed to be implemented to maintain the field's pressure to ensure the flow rate of oil. Since 2001, the water injection approach (secondary production phase) was introduced to the field, and it has succeeded in keeping the oil flow. Since then, Al-Shaheen production has been managed through water injection approach M. Pal et al., (2019). However, after

25 years of introducing the water injection, the field has become mature and the remaining Original Oil In place (OOIP) in Al-Shaheen field was estimated to be between 30% and 50% of its total capacity. Therefore, to maintain oil production in Al-Shaheen field Enhanced Oil Recovery (EOR) technology should be introduced. During the 20th European Symposium on Improved Oil Recovery that held in France in 2019, a feasibility study paper was introduced by both the current operator, North Oil Company, and The DOW Chemical Company. The objective of the feasibility study presented in the paper was meant to assess the efficiency of using surfactant in Enhanced Oil Recovery EOR implementation in Al-Shaheen field.

Al-Shaheen field is Oil-wet Carbonate field, hence, the technique investigated was to alter the wettability of the field by using surfactant. There was laboratory screening done to select the best Surfactant, by injecting small volumes through the water. The selected Surfactant has shown improved water injection and oil recovery. The success of screening was a reason to plan for a pilot in the field to measure efficiency of oil recovery in a large scale. Two major stages have been planned for this pilot: a) conducting laboratory experiments to select the injecting strategy and to enable quantifying the oil recovery b) conducting injection strategy and monitoring its performance in cost effective manner.

In lab evaluation, ELEVATE™ WA1528 was selected as potential Surfactant as it showed wettability altering ability in screening tests (Patil et al. 2018a and Patil et al. 2018b) and several tests were conducted to ensure the efficiency of using it for Enhanced Oil Recovery (EOR) activities. For example, the emulsion test was conducted on oil samples collected from different locations in the field and mixed with Synthetic Sea water brine, in Interfacial Tension test (IFT). The test included usage of water baths, Eberbach shaker, reservoir temperature of 60 C degree centigrade, and Spinning Drop

Tensiometer (SDT) to measure the Interfacial Tension (IF) between the oil and brine. Results shown that the Surfactant injecting will not lower the Interfacial Tension (IF), so, it will not make emulsion in the field. In addition, a static adsorption test is conducted to examine the adsorption of the solution using crushed rocks collected from Kharaib formation (specific producing level of the field) and placed in bottles with specific amount of Surfactant solution with predefined concentration. The test involved shaking the mixture and storing it in 60 degrees centigrade for a duration of ten days.

During field pilot the goal was to check the field response to the Surfactant injection and measure the increase in oil recovery. The selected injecting strategy consisted of one injecting well and two producer wells. The pilot has been conducted in 6 months. There were multiple options of concepts to measure the success, and Surfactant Induced Improvement in Injectivity and Productivity (S3IP) was selected based on modeling simulation that considers field facility limitations. Moreover, the criteria of success were focused on injectivity sustainability, and avoiding choking or major injecting reduction, increase in oil recovery in time duration of 2 years and to have no leak of surfactant in the producing wells. The study results have shown that the use of Surfactant ELEVATE™ WA1528 increased the oil recovery of the Carbonate reservoir of Al-Shaheen field, by at least 15% from OOIP.

Al-Shaheen has become a mature field and surfactant will be the future of the oil production. Production forecasts and budgets will consider surfactant as the primary chemical substance required to keep the field production capacity. Hence, not only the cost of obtaining surfactant will be considered, but also the extra recovered amount of oil will be part of selling deals. Here comes the importance of making resilience supply chain to avoid any sudden interruption of surfactant flow into the field, which will result in reputation damage and extra cost for the operator and the State of Qatar as well.

Research Question

"How to enhance the resilience of surfactant supply chain to ensure continues production of Al-Shaheen, during political disputes?".

Research Motivation

The motivation for this master's dissertation is knowing that suppliers of surfactant including The Dow Chemical Company has regional presence in Jabal Ali, Dubai and Dhahran, Eastern province of Saudi Arabia where there are in ongoing political disputes in the region which has put the surfactant supply chain at risks.

Research Objectives

The objective of this master dissertation is to come up with solutions to prevent the supply chain of surfactant away from the influence of political disputes in the region and to ensure the production continuity of Al-Shaheen field.

Research Methodology

1- Analyzing "Dreaming Big "Surfactant Injection in a Giant Offshore Carbonate Field", From Successful Injection Trials to Pilot Design and Implementation" that was published during the 20th European Symposium on Improved Oil Recovery which was held in France in 2019

2- Investigating the established supply chain of surfactant that is used for enhancing oil recovery activities for Al-Shaheen filed. The supply chain has started from the manufactory of the supplier The Dow Chemical Company in Freeport, TX, USA and was shipped from there to the local distributing point of

the supplier in Jabal Ali, Dubai and was delivered to Al-Shaheen field from there.

3- Analyzing the risks associated with the supply chain which has resulted from the ongoing and potential political disputes in particular the potential cutoff trade exchange between the State of Qatar, and Saudi Arabia and UAE. like what happened in June 2017. In addition to the risk of the repetitive Houthi attacks on petroleum activities targets in Saudi Arabia and United Arab Emirates.

4- Finding solutions that can make the supply chain of Surfactant more resilience and not influenced by these risks.

5- Finally, selecting the best solution to be implemented by the State of Qatar Energy.

CHAPTER 2: LITERATURE REVIEW

The Concept of Resilience

Resilience is a concept that emerged from socio-ecological systems' studies, and it means the ability of corporates to quickly adapt the dramatic changes that results from internal or external events by changing used procedures without changing performance and quality Bento F. et al., (2021). As mentioned previously, in oil and gas upstream it is important to produce volumes that are embedded in the budget because it satisfies signed contracts. This dissertation is investigating strategies that should be considered and implemented to ensure the continues flow of Surfactant to Al-Shaheen field in the State of Qatar, bearing in mind what happened between 2017-2020 during the blockade which was imposed on the State of Qatar as well as the repetitive Houthi attacks on petroleum activities in the region.

Resilience Concept in Oil and Gas

The scoping review which was finalized by Bento F. et al., (2021) provides a wider picture on resilience in oil and gas industry as a study area and taking into consideration various contexts, research methods and types. The objective of this paper, rather than answering a narrow question, was meant to build knowledge about resilience in oil and gas industry and highlight potential future research areas. The scoping review sheds light on five major categories: resilience conceptualization, paper types and research methods, area of resilience been researched and unit of analysis, resilience and Safety, and trendy topics in the reviewed papers. The scoping review was based on a collection of previous research papers gathered in September 2019. The databases used were Academic Ultimate Search and Scopus. Moreover, the search terms were "resilience" and "oil" or "petroleum", and research areas were Engineering, Economy, Decision Science etc. The timeline of the gathered research papers between 2006 and 2019 and

there were all written in English. Initially a total of 617 research papers were selected by Rayyan platform. For sorting papers according to their relativeness, Rayyan platform excluded 113 duplicated abstracts. Three authors had to assess the relativeness of remaining 505 abstracts and excluded 467 papers. Only 38 research papers were fully assessed and 20 were eligible to be reviewed. Throughout the analysis of the research papers, it was found that 45% of the reviewed research papers considers resilience as an outcome, 40% as capabilities, and remaining 15% believes it is both outcome and capabilities. Most of research papers in the area were empirical, following both quantitative approach that depends on surveys for data collection, and qualitative approach that depends on action research, basic interpretive studies, and participant observations. Previous research papers investigated resilience in oil and gas industry have covered different contexts, production, production and integrated operations, petrochemical plant, drilling, transportation system, environmental and resource sustainability, and oil spill recovery. Furthermore, majority of previous works considers resilience as a system property rather than individual and discussed resilience as a contribution of safety or related concept. It was found that none of the previous research papers discussed resilience as practices to be implemented.

Modeling and Frameworks to Improve Supply Chain Resilience

Some of the research papers carried out on resilience in different industries used applied modeling, and operations methods to improve supply chains which can be applicable in oil and gas too. For example, a research aimed at improving resilience of humanitarian supply chain, E.Gutierrez T., & S.Mutucb J.(2018) used the Center Gravity method which is an operation research approach to identify optimum location of temporary or fixed facility in a certain geographic area in Philippines, where

unexpected overflowed of the Marikina River. The application of the operation research aimed at reducing cost and increasing response time. Using Center of Gravity method, the study found that optimum location of a single facility can reduce up to 40% of the total transportation cost and that the better the position of the facilities, the quicker the movement of relief goods which will meet the pre-defined standard of 72 hours.

Another research by Chen et al., (2020) used System Dynamic (SD) simulation to investigate the resilience of oil import system of China under external shocks. It pictured the curve of resilience for the oil import system, measured the value of resilience during different scenarios, highlighted the main influencing factors and suggested actions to be implement during those scenarios. The study established resilience measurement model and according to the SD modeling steps, the system causality diagram and the system flow diagram were constructed, and the relationship between variables was also determined. Moreover, the system performances of different scenarios were simulated according to different parameters, and the system resilience value under different conditions was calculated through the evolution curve. The main findings of the study, policy makers can contribute to system recovery through introduction of diversified measures. Also, it highlights the role of strategic reserve of crude oil in making most of the system recovery during external shocks, followed by the extraordinary production of coal-to-oil.

In another case, E.Roege P. et al., (2014) conducted action research, a type of research was meant to find solutions to solve problems or improve process. The research used a model to improve resilience of processes of HSE (Health, Safety and Environment) in oil and gas facilities installation and move from reactive approach to proactive. The research was part of StatoilHydro Organizational Development Process and considered a real-life example of an instillation in North Sea of Heidrun TLP, which marked high

number of LTI (Lost Time Injury) that counted as one of HSE Key Performance Indicators, a team formed to enhance the process included researchers, installation crew and onshore leaders. A was model built based on Hollnagel resilience concept that requires organizations to be able to anticipate, observe and respond to dynamic developments. Moreover, focusing on LTI (Lost Time Injury) the team had defined the sufficient time, knowledge, ability, resources and working surroundings as model factors required to meet resilient procedure of installation. The discussions with safety staff resulted on adding external factors to the model that are the safe behavior program, open safety talks, cost and contracts, and organizational changes. The developed model was used to conduct interview with around 40 workers, from different work levels and most of them were offshore personnel. Furthermore, the interviews findings were categorized under HSE activities, therefore, nine HSE activities were highlighted as area of improvement and specific actions under each were defined. The nine activities and their relevance to the main resilient qualities are shown in the table.

Table 1 Activities Suggested to Improve

	Anticipa-tion	Atten-tion	Response
Safety conversation	x	x	(x)
Buddy system	x	(x)	(x)
Collaboration in practice	x		
The supervisor role	x	(x)	(x)
Consistent management	x	(x)	
Clarification of "visible management"		(x)	
Session for chiefs of op-eration	x		
Risk perception course	(x)	(x)	
Visualization	(x)	(x)	

CHAPTER 3: METHODOLOGY

Surfactant and Enhanced Oil Recovery (EOR) Surfactant

The surfactant is a chemical substance that has the ability of wetting, dispersing, cleaning etc. It is produced in several standards to meet different requirements. Therefore, the major producers of surfactant used in enhanced oil recovery (EOR) activities have other surfactant lines used for different purposes like home cleaning. In oil and gas, the use of surfactant is not only limited to the enhanced oil recovery (EOR) activities, but also used as lubricants, dispersants, corrosion inhibitors, and others. However, the increasing demand of surfactant resulted from the advancement of enhanced oil recovery (EOR) technologies and the increasing oil price pre-2015, the market size is expected to increase in the near future due to the increasing of production activities in U.S., increasing number of new projects of oil and gas in Europe and increasing number of governmental initiatives in exploration.

Considering the previously mentioned research on enhanced oil recovery (EOR) Surfactant in Al-Shaheen Field with The Dow Chemical Company, this dissertation considers The Dow Chemical Company as a potential supplier of The Dow Chemical Company enhanced oil recovery (EOR) surfactant for the Al-Shaheen Field in the future and shipping from Freeport, TX, USA.

Description of Surfactant Supply Chain

Figure 2 The Supply Chain of Surfactant

Production of Surfactant

Surfactant is produced using petrochemical feedstocks that is initially produced by processed gas, oil, and chemicals. The petrochemicals can be processed further with other components to produce surfactant with specific properties for specific uses. On the other hand, surfactant can also be produced by bio-based feedstock extracted from plant oils namely coconut and palm trees. These are used in large plantation in tropical areas where they are chemically processed with esterification, hydrogenation, and distillation to produce fatty alcohol. Moreover, the bio-based feedstock can be further processed in similar methods to the petrochemical feedstock to produce the same types of surfactant. The difference between the petrochemical feedstocks and bio-based is is that the former feedstock is more flexible to meet certain technical demand than the later. The surfactant product types are defined by their properties in the water. These types are anionic, nonionic, cationic, and amphoteric.

Transportation of Enhanced Oil Recovery (EOR) Surfactant

There are multiple variables to be investigated to define the best transportations options contributing to a resilient supply chain. Next sections will discuss these variables namely, product Surfactant origin, Surfactant statues, mode and method of transport, and surfactant storage.

Surfactant Origin

Supply chain analysis always starts from where the input is produced and shipped. It is

where the logistical arrangements like ports' registration, berthing fees, and transportation cost starts to count. In many cases, rethinking of the input's origin can improve the supply chain. In enhanced oil recovery (EOR) surfactant market, most of leading producers are in the USA like Stepan and The Dow Chemical Company, and in Europe like BASF. However, it is a common practice of suppliers to use existing plants that have initially been built for production of surfactant used for other applications, to reduce cost (J. R. Barnes et al., 2018).

Surfactant Statue

In the surfactant industry, the supplier can ship feedstock which is considered as a semi-final of ready mixed surfactant. The Dow Chemicals Company produce what is estimated to be 100 billion pounds of both semi-final and final products of surfactant annually. Moreover, in the pilot project which was conducted in Al-Shaheen field, the cross-functional team decided to install a well-designed storage unit in the field to store surfactant and to inject it directly into the reservoir any movements. Thus, the supplied surfactant for the pilot project were readly mixed.

Mode and Method of Transport of Enhanced Oil Recovery (EOR) Surfactant

Depending on the volume of the order, enhanced oil recovery (EOR) surfactant can be shipped in three types of containers:

a) For small projects, orders that is around 180kg can be filled in drums and moved by hands to be loaded and installed to/from the transportation mode. For larger volumes that is around 900 kg, Intermediate Bulk Container (IBC) is used and is moved on pallet truck.

b) For mid or big projects, order can exceed 900 Kg and for these projects 20-ton ISO tankers are used. The ISO tanker usually will be filled in the supplier's facility and shipped on a ship, road, or rail. This is resulted in reduced contamination risk as it involves minimized handling.

c) For giant projects, the concentration degree of Active Matter, and viscosity modifier will be considered. As per (J. R. Barnes et al., 2018) it is recommended to manufacture the final product in the country of the field or the field itself. However, the ideal transport mode would be rails using 75-kton ISO tanker. As the sea transportation modes require up to 1.5-kton ISO tanker, there is a need to lease port entry and arrange further land transportation. Therefore, this will include more movements and cost.

Figure 3 Distance between Jabal Ali and Freeport

According to the published feasibility study for Al-Shaheen filed, the enhanced oil recovery (EOR) surfactant used in the pilot project was manufactured in Freeport, TX,

USA, shipped in 20ft container, travelled in not less than 9,655 nm in appositely 40 days and finally reached The Dow Chemical Company regional branch in Jabal Ali in Dubai. The quantity was not clearly stated; however, it mentioned it is minimum inventory of two months.

It is worth to point out that "regular shipping lines" were used in logistics of the pilot project, in other words, surfactant passed by ports or stored in supplier's warehouses in the region. Although The Dow Chemical Company has been in the Middle East for more than 50 years, they have only one regional location located in Jebal Ali, Dubai, UAE. Other forms of presence of The Dow Chemical Company in the region is through commercial offices that is one of the conditions to practice commercial activities, like the case in the State of Qatar. Furthermore, the commercial office will handle managerial activities, and does not include storage or production facilities. In this case, if The Dow Chemical Company will deliver to Al-Shaheen field the semi-final enhanced oil recovery (EOR) surfactant in large volumes, it will need to process it further to make the final product in Dubai. Then, like many other equipment and chemicals used in the State of Qatar's fields, the final product will be shipped though land lines from Dubai to Ras Laffan (685.8 Km), where it will be transported in the sea to the Al-Shaheen field. It is not common that materials and chemicals to be directly shipped through the sea from Jebal Ali to the fields.

Storage of Enhanced Oil Recovery EOR Surfactant

For conducting the pilot project in Al-Shaheen filed, the project cross-functional team decided to install injecting skid where surfactant will be stored and injected directly from the platform to the reservoir. The skid will have capacity of 20 m3 ISO tank that

will receive supplies in predefined time intervals.

Uncertainties of current Enhanced Oil Recovery (EOR) Surfactant Supply Chain

The supply chain of enhanced oil recovery (EOR) surfactant used in the pilot project with The Dow Chemical Company and major service suppliers are having regional locations in Jebal Ali. They store and further process chemicals which might cause risks to the supply chain in the near future.

Risk Assessment Methodology

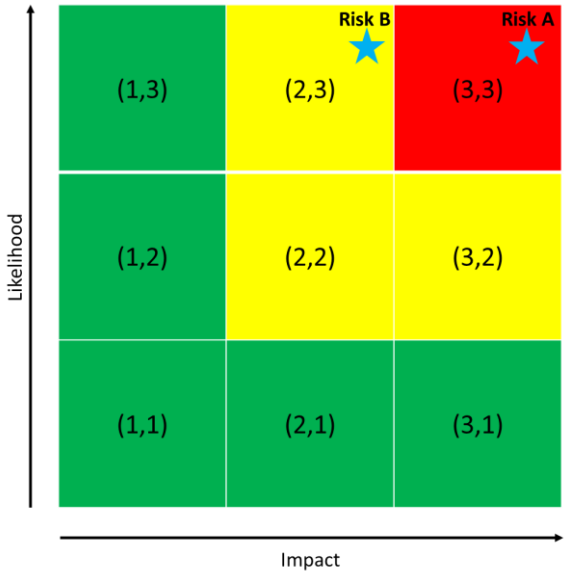

Figure 4 Risk assessment matrix

An Enhanced oil recovery (EOR) surfactant risk assessment matrix was developed to visualize the likelihood and severity of identified risks where the y-axis indicates how probable the event will occur and x-axis how sever the impact. Moreover, the likelihood of occurrence measured is based on the number of event occurrence during usual time

intervals used in business operations and that is short term (3 months), medium term (3 to 6 months) and long term (over 3 years). On the other side, x-axis gives a hint on how bad the situation will be if the risky event happened in term of cost and time. Cost assessment is calculated based on the assumption of 10% of Al-Shaheen fields daily production is being extracted by enhanced oil recovery (EOR) surfactant injection and the monetary valued is $135 per barrel based on Goldman Sachs forecast for brent price in 2022.

((Al-Shaheen daily production) * (10%)) * 135= assumed monetary lose/day

300,000 barrel * 10% * $135 = $ 4,050,000/day

In case of risky event happened, the extra cost resulting from surfactant re-procurement, re-route, ports' registration fees and berthing fees, are excluded because there is no available information on how much it will cost.

Table 2 Likelihood criteria

	Frequency	Likelihood	Likelihood degree
Short term Last three months	2 1 0	Very probable probable Not probable	3 2 1
Medium term Last three to six months	2 1 0	Very probable probable Not probable	3 2 1
Long term Over last three years	2 1 0	Very probable probable Not probable	3 2 1

Table 3 Severity criteria

Cost	Impact	Severity degree
More than $1 million per day	Very Sever	3
Less than $1 million per day	Sever	2
No cost	Not Sever	1

Risk A: Risk of Blockade and Suspend of Trade Exchange

There is a risk of interruption in enhanced oil recovery EOR Surfactant supply chain due to political disputes like what happened during the blockade of 2017-2020 imposed by Saudi Arabia, United Arab of Emirates, Bahrain, and Egypt on the State of Qatar. The impact of blockade was not limited to the oil and gas fields operators in the State of Qatar, but also to the government as other sectors suffered logistical issues. Qatar imports from these four countries made 60% from total imports. Moreover, the State of Qatar spent $38.5 billion to support its economy during the first two months of the blockade. Oil and gas operators and their suppliers had suffered logistical issues as a considerable amount of chemicals and equipment were in Jebal Ali, Dubai or in Dhahran, Saudi Arabia. The State of Qatar had to redirect goods to Sohar port in Oman and from there to the State of Qatar or re-shipped from other locations of their suppliers outside the Middle East. This resulted in delays and extra cost for the extra distance travelled, berthing fees for Sohar port, resources used etc.

On the risk matrix, this blockade event happened once in the recent 6 years and least for three years and six months, hence, the likelihood is of its re-occurrence “probable” and degree on the matrix is “2”. Assuming another blockade will disrupt the surfactant supply chain that ships from Freeport, TX, USA, and pass by Jabal Ali, Dubai a loss of barrels worth $ 4,050,000/day will take place. Consequently, the risk of another blockade is marked on the risk matrix.

Risk B: Houthi Attacks on Petroleum Targets

Due to the volume of petroleum activities in Saudi Arabia in 1970s and easier commercial restrictions on establishing business in Dubai, top service providers in oil and gas industry chose to setup their regional plants, warehouses and carry out some manufactory activities there. During the recent years, both Saudi Arabia and UAE led a military war against Houthi militia in Yemen. In response, Houthi militia have had several drone attacks targeting petroleum facilities in Eastern province of Saudi Arabia, and others on oil ships against UAE coasts. Some examples of such attacks that took place are:

- On 14th September 2019 the Houthi militia attacked the world's largest crude oil plant that has the capacity to process 7 Mbbl per day. The attack resulted in huge fire and forced the operator to shut down the plant for two days. The efforts to restore the full capacity took several weeks. Overall, the attack has destabilized the global energy market by cutting off 5% of global production.
- On 7th July 2020, there was an explosion took place on a docked container ship in Jeba Ali, Dubai that thought to be a Houthi attack. The back and forth fight caused tension between the two countries and the militia, thus, a red flag was risen for any potential cutoff for the regular shipping lines including enhanced oil recovery (EOR) surfactant.
- In January 2022 Houthi militia attacked oil facility in Abu Dhabi and the international airport of Abu Dhabi.

Houthi attacks become very repetitive and reaching farther distances, targeting energy security and international trade hubs. On one hand, therefore, it is "very probable" on

the risk matrix and degree “3”. On the other hand, it marks “sever” because Houthi attacks does not directly reduce the production resulted from surfactant injection in Al-Shaheen feild. However, the regular shipping routes that cross the Jabal Ali port can result on delays of surfactant delivery and this in turn will result in extra cost because of the extra distance travelled and time consumed.

CHAPTER 4: DISCUSSION AND SUGGESTIONS

Building a resilient supply chain for enhanced oil recovery (EOR) surfactant is very important for of the mature Al-Shaheen field which plays a significant role in keeping the oil flow until the original oil in place (OOIP) is no longer economically feasible. This master dissertation suggests four actions to be further investigated and implemented by the Supreme Council for Economic Affairs and Investments, and QatarEnergy:

Action A: Establishment of Enhanced Oil Recovery (EOR) Surfactant Company Through Joint Venture

Joint Venture (JV) is an agreement where two or more companies participate in a business activity that can be a project or running an affiliate company for a pre-defined time frame and will form a separate entity from their initial business. All parties will be contributing to the expenses and resources and share the profit. On the other side, QatarEnergy have a vision to be one of the best energy companies in the world, originated from the State of Qatar and having a strong international presence. One of its strategies undertaken to achieve its vision is to maximize the upstream value for the state of Qatar. Currently, QatarEnergy have several joint ventures (JV) that emphasize the extraction and export of oil and gas.

Action A: is to establish an enhanced oil recovery (EOR) surfactant company in the State of Qatar through joint ventures (JV) where QatarEnergy will do a tender call for 49% of the company's ownership for companies which are already exists in enhanced oil recovery (EOR) surfactant market, hence, they will pool necessary resources like know-how and procedures. QatarEnergy produces LNG, GTL, Helium, Fertilizers, Steel, aluminum and other. Enhanced oil recovery (EOR) surfactant market is a growing and will be a new market for QatarEnergy. Consequently, this will be a good

opportunity for QatarEnergy to grab market share and enhance its international presence.

The advantages for signing a joint venture (JV) to form a company which produces enhanced oil recovery (EOR) surfactant for Al-Shaheen field are:

- Insuring continues supply of enhanced oil recovery (EOR) surfactant to Al-Shaheen on time of trade cutoff and other disruptions in the region, as the supplier is an affiliate of QatarEnergy and operates locally.
- Sharing cost and resources with an experienced partner to ease the process of establishment of the company, like procurement of manpower, building production facility as per specific standards etc.
- Saving the cost of shipping and ports registration fees from the country of origin as it was the case of the pilot project in the USA, on the long-term. Specially, there will be gradual increase in the need for enhanced oil recovery (EOR) surfactant because the pressure of the filed falls by time.
- Creating new investment for QatarEnergy in a growing market where it has the potential of having significant market share.

The company that will take 49% of the ownership will have the chance to expand its production capacity and enter new geographical areas with less cost by sahring production cost and manpower, securing long term contracts and getting support from the state-owned partner, which opens a door for other new opportunities.

Action B: Expand Tawteen Initiative

Tawteen is QatarEnergy's initiative introduced after imposing the blockade imposed in 2017 it aims at localizing the supply chain of energy sector in the State of Qatar. Under supplier development program, Tawteen conduct forums to facilitate building

relationships among the investors, local suppliers and the companies operating in oil and gas industry in the State of Qatar. Moreover, it Twateen initiative provides the local suppliers with forecasted demand of or different materials, equipment and other needs for the coming 3 to 5 years. The forecasted demand will help local suppliers to adjust their production capacity to meet the demand and invite investors to grab their opportunity of making business. More importantly, Tawteen helps small to mid-businesses in technical, operational, and business matters to raise the competitiveness standards in the local market. The initiative can also help investors and local supplier to find land where they can establish manufactory, and coordinate with banks to provide financing packages.

In their research J. R. Barnes et al., (2018) stated that it is common in enhanced oil recovery (EOR) surfactant market to use existing surfactant plants to produce the enhanced oil recovery (EOR) surfactant and cut cost and scale up production effectively. Furthermore, this can be applicable in the State of Qatar where there are existing surfactant and detergents plants.

Action B: Tawteen should take an expanded approach where it calls on local surfactant and detergents producers after providing them with the necessary technical and financial support to encourage them to meet Al-Shaheen field needs for enhanced oil recovery (EOR) surfactant. Likewise, to secure their new production line, Tawteen can mandate field's operator to sign long term contracts with them. This action will enable Al-Shaheen operator to reduce the cost of shipping and lead time, increase responsiveness time, allow a better application of Just in Time inventory management strategy.

Action C: Acquisition

Acquisition strategy is when a company buys another company and takes full control of it. There are several types of acquisitions that this depends on companies' relation to each other, like supplier or distributor or on the industry they are operating in. Acquisition allows access to new resources, lower entry barrier, new product types, achieved higher asset value … etc.

Action C: QatarEnergy should acquire an enhanced oil recovery (EOR) surfactant supplier outside the State of Qatar, avoiding countries that have conflicts and targeting countries with low-cost labor and land. This step should prevent the high cost of making business in the State of Qatar and put production and supplies of enhanced oil recovery (EOR) surfactant in immediate effect. In fact, acquisition will be a step to diverse the products basket of QatarEnegry as well. However, there are some disadvantages associated with acquisition which can be handled through carful transition process such as culture conflict, objectives conflict etc.

Action D: Building a Strategic Reserve

Building a strategic reserve is usually meant to stock commodities or materials for emergency times where the supply chain it disrupted, or the price no longer affordable. Governments usually builds strategic reserves for the critical items and commodities used in people daily life or for significant economical operations, for example, the Petroleum Strategic Reserves (SPR) in USA.

Action D: building a strategic reserve for enhanced oil recovery (EOR) surfactant is becoming vital for the 45% of oil production of the State of Qatar. A move toward stocking enhanced oil recovery (EOR) surfactant should consider uncertainties in the region due to political disputes and dynamic petroleum products prices in the world.

The size of the reserve should take into account the volumes of surfactant injected into the field on daily basis and anticipate its growth. Additionally, it should be kept in mind the minimum inventory that determined by how long Al-Shaheen field can produce in steady capacity until another line of supply is secured. Moreover, the operation research approach of center gravity should be applied to find the optimal location of the reserve considering the mode and methods of transport from the reserve to the offshore field of Al-Shaheen. There is no available information of the volumes needed to be injected to keep the current production capacity. Hence, there is no calculated estimatationon potential reserve capacity and size.

Overall, a blend action of extending Tawteen initiative and strategic reserves is what believed to be a very securing of supply chain. Ensuring local suppliers through Tawteen will eliminate the possible risk disruption of supply chain that comes from disputes between the state of Qatar and other countries and will keep the surfactant flow away from the Houthi attacks in the region. Moreover, it will eliminate the cost of transportation through the sea, berthing and registration fees in ports, and shorten the lead time. It will enable a better Just in Time inventory management strategy, which will reduce the cost of warehouse. On the other hand, building a strategic reserve for surfactant in the State of Qatar, will help in time of raw materials used for making surfactant cannot be shipped to the local supplier due to any reason, like weather conditions.

CHAPTER 5: CONCLUSION

It is very important to build resilient production operations for Al-Shaheen oil field to ensure the continues fulfillment of sales contracts and cash inflow for operator and the State of Qatar as well. Considering the field's life cycle, original oil in place (OOIP), well performance etc, are key elements for planning fields production. Furthermore, the study is conducted to measure the efficiency of moving from the secondary phase of oil recovery to chemical enhanced oil recovery (EOR) technologies. This will enable 15% extraction of original oil in place (OOIP) that is around 43 billion of barrels (Wood Mackenzie, 2021). In other words, injecting surfactant will enable at least the extraction of additional 645 million of barrels and that it would not be possible to extracted without injecting it. The supply of surfactant to Al-Shaheen field travelled long distance through sea to pass by the regular shipping lines in Jabal Ali, as many other materials and equipment and this might impose a risk of supply chain disruption.

Moreover, the blockade has a acquainted us and made us realize the serious concern in the supply chain in the State of Qatar, that is there is no plan B for the regular shipping line. Here comes the major role which QatarEnergy plays in the petroleum sector where it should investigate the supply chain of critical materials to enhance the upstream in the State of Qatar.

This master dissertation suggests to QatarEnergy extends its Tawteen initiative to include support local chemical companies to produce enhanced oil recovery (EOR) surfactant with standards and to build a strategic reserve to stock enhanced oil recovery (EOR) for emergency uses.

APPENDIX:

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