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This thesis is the representation of knowledge gain in Master of Offshore Technology program Universitetet i Stavanger. I dedicated this thesis to Pertamina as my employer and is truly intended to deliver an excellent contribution to the growth of the company.

Stavanger, 7th of June 2016

Pipit Hendra Nurwinahyu

Abstract

Integrated operations is proven operating model to manage offshore assets smartly. BP with its *Field of the Future* program, Shell with its *Smart Fields* program, and Statoil with its *Integrated Operations* program have deployed on their global assets since early 2000's and successfully deliver value through *better and faster decision making*. IO has been global practice, consequently more and more companies initiate efforts to deploy on their assets.

Pertamina is the sole NOC and bears public obligations to fulfill oil and gas security of supply in Indonesia. This national obligation has exposed Pertamina to significant challenges since most of its onshore fields are in mature phase. Moreover, national oil production also shows sign of adversity due to inability to fulfill domestic demand. On the one hand, gas is still promising despite its substantial challenge to build infrastructure network. Additionally, recent data implies strong tendency to go offshore since most of the large discoveries are located in offshore blocks.

Obviously, Pertamina has proven its excellent capability to manage onshore assets. However, current offshore assets have quite a small contribution than onshore assets. It leads to an impression that there is a room for improvement to leverage offshore assets performance.

This thesis is an academic contribution to capture IO best practice from global players (BP, Shell, and Statoil), apply its key knowledge through literature review, and package them as **IO strategy**. The main objective of IO strategy development is to configure systematically strategic plan to develop and deploy IO as offshore operations capability in Pertamina. IO strategy is expected to be a high-level guideline that gradually transforms Pertamina as top performing IO operators in Indonesia through the *integration of people, process, and technology*. IO strategy also encapsulates, IO operating model that enhances the interface between offshore and onshore team through the establishment of "*Smart Collaborative Network*", and *IO capability model* that offers a systematic end-to-end guideline in building IO as capability. Besides IO strategy, this thesis also presents *IO implementation plan* as an initial reference for long-term development and deployment.

In general, this thesis offers a thorough IO strategy that is dedicated to accelerating offshore operations capability as Pertamina's competitive advantage in the future.

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List of Abbreviations

B2B : Business-to-Business Network
CAGR : Compound Annual Growth Rate
CWE : Collaborative Work Environment
E&P : Exploration and Production
ICT : Information and Communication Technology
IO : Integrated Operations
IOC : International Oil Company
NCS : Norwegian Continental Shelf
NOC : National Oil Company
PSC : Production Sharing Contract
SCN : Smart Collaborative Network
SPV : Special Purpose Vehicle
UKH : Upstream Knowledge Hub
UTC : Upstream Technology Center

1 Introduction

1.1 Background of study

Indonesia used to be one of the prolific hydrocarbon producers in South East Asia region. Nevertheless, nowadays Indonesia's oil and gas industry is in alert signal indicated by downtrend of oil production exacerbated with the insufficient discovery of new giant fields to offset the declining production. The backbones of oil production in western Indonesia have surpassed the peak production period and a couple of them are entering the tail end period. These fields are mainly onshore fields. Despite this predicament, Indonesia still has promising future exploration ventures located in eastern Indonesia. In eastern Indonesia, exploration is highly challenging due to the location of petroleum play is mostly situated in the offshore area. Additionally, gas is still promising venture due to the abundant of potential resources. Even though, there is a need of new gas infrastructure to connect supply and demand point. Moreover, it is predicted that future of Indonesia's petroleum play will be more and more situated in offshore areas. Given these obvious challenges, a novel way of offshore operating model that is underpinned by new offshore operations capability is urgently required to sustain the future competitiveness of petroleum firms in the offshore petroleum business.

Pertamina, an Indonesian's NOC, has to be aware of these challenges. In fact, portfolio of Pertamina's assets is mostly built of onshore mature fields. Interestingly, Pertamina has started to acquire offshore operatorships in Indonesia such as Offshore Northwest Java and West Madura Offshore. However, Pertamina has to start thinking on elaborating strategic response plan to strengthen its position in Indonesia offshore business by building internal offshore operations capability as a new source of organic growth on top of inorganic growth from acquisition initiatives. It will form integrated source of growth that will deliver sustain value creation to Pertamina in the future.

In fact, current trends show that major international oil companies (IOC) have started to deploy *integrated operations/digital oilfield/smart fields/field of the future* model that integrate people, process, and technology as a strategic operating model for offshore asset management. Integrated operations (IO) operating model will enhance operations capability of production optimization, well operations and optimization, and remote operations. Intelligent IO infrastructure enables seamless collaboration between an onshore-offshore team that integrates them as one team approach despite geographical and organizational barriers. This setting promotes capability of joint decision making between offshore as an actor of execution and onshore multidisciplinary experts center as an actor of planning and operations support. Decisions are made collectively with assistance from decision support system that has the capability of providing diagnostic and prognostic analytics. As a result, IO operating model enhances the quality of decision making which is better and faster decision making. The benefit of IO is obvious through additional production, better well placement, and improve regularities.

Given these apparent challenges and current trends in IO operating model deployment, Pertamina shall elaborate IO strategy to accelerate offshore operations capability. IO strategy will provide a high-level guideline to drive Pertamina as one of the leading IO model operators in Indonesia.

1.2 Objectives and scope of study

The main objective of the thesis is to elaborate IO strategy in order to achieve sustainable operations in offshore fields. IO model will integrate people, process, and technology into one working system as a result providing better and faster decision making.

The scope of the thesis is mainly on developing basic concept and strategy that encompasses standard IO operating model and IO implementation plan. The results of this thesis are a strategic recommendation to deploy IO concept on Pertamina offshore operations in the future.

1.3 Limitations

The thesis is limited to high-level IO strategy within the boundary limits of upstream to midstream. Upstream is defined as a system incorporating from well into the well head. Midstream is the system incorporating from well head into offshore topside facilities. The ideas of the thesis are purely based on writer’s effort to apply applicative academic knowledge obtained from courses in Offshore Technology Master Program in Universitetet i Stavanger. By the time of this thesis is written, IO model is not yet established as a corporate initiative in Pertamina.

The limitations of this thesis provide fruitful future specific research on individual components of IO capability such as research on decision support system, IO infrastructure, and IO centers to be deployed in Pertamina.

1.4 Methodology

The thesis is based on current trends of oil and gas industry and development of IO implementation across all subsystem of the petroleum industry to enhance the quality of decision making in oil companies.

A literature review is conducted from academic literature, journals, papers, reports and business intelligence data from consultants. Implementation of BP's *Field of the Future*, Shell's *Smart Fields* and Statoil's *Integrated Operations* is reviewed as the most extensive IO operators in the world. It is intended to gain insights and information on building generic capability model, key success factors and challenges in the implementation of IO. Applicable features and attributes will be selected and customized based on business environment in Indonesia. This is the foundation to formulate standard IO capability model for Pertamina.

Most importantly, IO strategy is crafted based on well-known theory in strategy. Porter's Five Forces theory, Resource-based theory are referred to conduct external and internal analysis. Whereas, scenario planning is referred to map plausible future scenarios in Indonesia petroleum industry. Additionally, Stakeholder Theory, Network and Cluster Theories, are referred to design IO smart collaborative network organization and IO innovation clusters. Finally integrated performance theory is referred to encapsulate results on previous work as IO Strategy for Pertamina. Public data is used as the basis of strategic analysis due to confidentiality and limited access to internal company data.

1.5 Structure of thesis

The thesis is divided into six main sections :

1. The first section incorporates background of study including objectives, methodology, and limitations of the study.
2. The second section incorporates relevant theoretical foundation as the basis of academic literature. Competitive strategy theories are described to explain the strategy formulation process of the company to win the competition in the market.
3. The third section incorporates the literature review and analysis corresponding the practical implementation of IO model. Capability model, key success factors, and challenges are defined to gather best practices and lesson learned from current key players.
4. The fourth section incorporates Pertamina as a case study. Based on the relevant theories and current best practices on integrated operations, new integrated operation strategy is crafted. In addition, the implementation plan is also configured.
5. The fifth section is aimed to elaborate discussion about the result of IO strategy including key findings, impression on the thesis, lesson learned during the work, challenges, and further work opportunities.
6. The sixth section is conclusion incorporating summary about the thesis and strategic rationale on the importance of IO strategy for Pertamina.

2 Theoretical foundation

2.1 Strategy

Strategy is a high-level planning or roadmap of actions that firm will take to achieve its mission and objectives [1]. Strategy will integrate firm's goals and actions cohesively that steer resources and capabilities effectively. It will be a guideline for selecting strategic priorities and corporate decisions from top management into the lowest level of organization.

Strategy shall be elaborated in action-oriented words which can be communicated in crystal clear way throughout all levels of the firm organization. This setting will create an environment which drives all levels of the firm to cooperate hand-in-hand into the common direction in order to achieve the firm goals. Strategy will drive the firm to focus on the smart way in maximizing opportunities in industry, increasing assets productivity and minimizing business operation risks. Strategy is classified into corporate strategy and business strategy.

Corporate strategy deals with firm initiatives to maximize value of assets [2]. The focus of corporate strategy is deciding on where to allocate firm resources. Portfolio management is an example of corporate strategy. In oil firm, portfolio management will influence corporate decisions on expanding into new business ventures. The new business will create a diversification of existing business portfolio, imposing the firm to capitalize on new opportunities at the same time risk exposure derived from new business.

Business strategy is polarizing the effort of the firm on the smart way to outperform the competitors in such a specific business industry [2]. Business strategy casts the firm on how to make differentiation provided that firm has the capability to offer niche quality to the market. This differentiation will formalize the firm position in the market and sustain performance in the short and long term. As an example, the decision of petroleum firm to deploy IO operating model is considered business strategy. IO is a novel way of working to maximize value of petroleum asset by integration of people, process, and technology.

Strategy, itself, is planned from corporate level, business level, and integrated into operating level by utilizing performance management system. According to Simons [2], strategic planning process can be depicted in Figure 2.1.

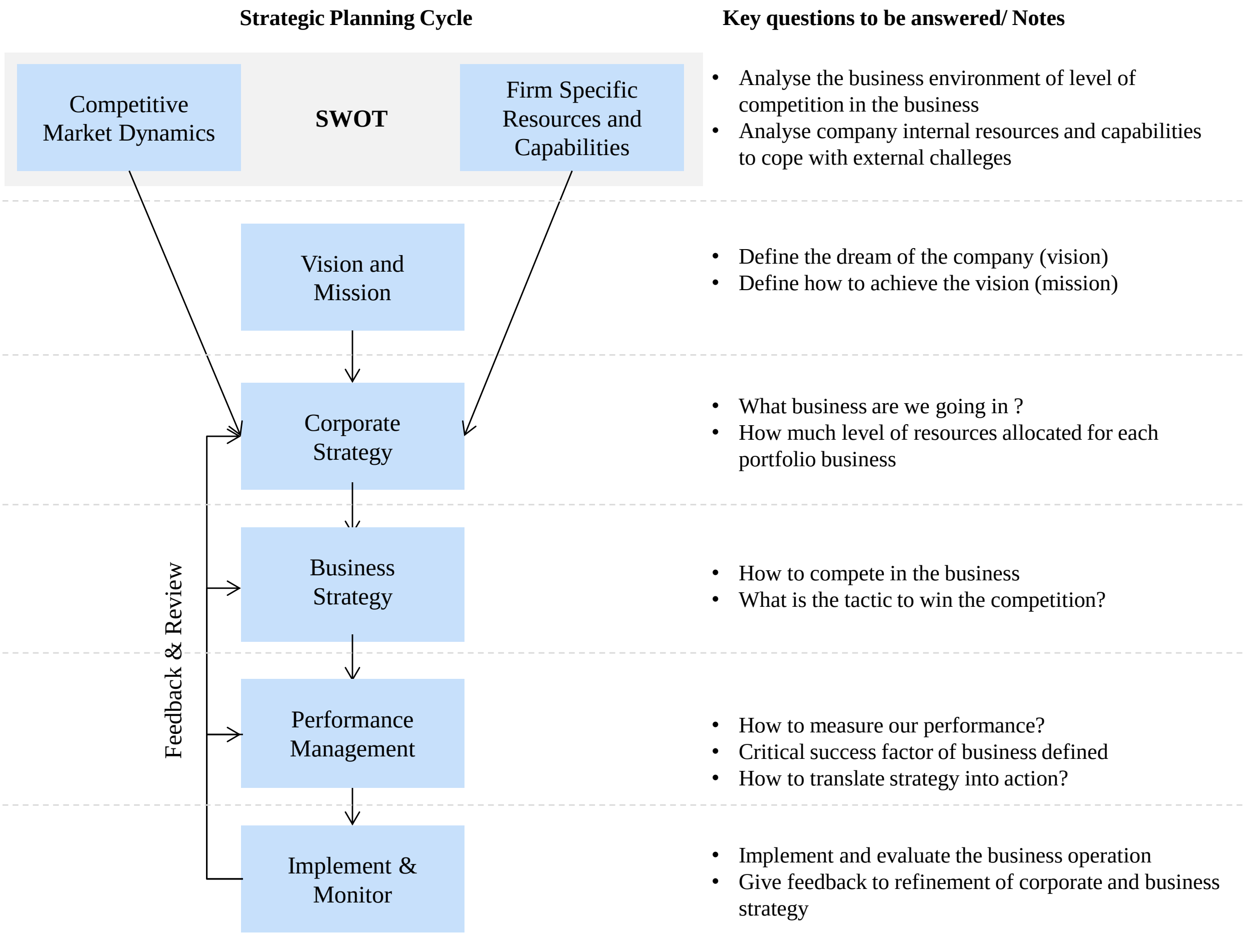


Figure 2.1 Strategic planning cycle

SWOT is a critical phase of strategic planning cycle. It is conducted to identify the opportunities and threats derived from business environment. Porter's five forces model can be used to analyze external environment while resource-based theory can assist in analyzing firm-specific resources and capabilities.

2.2 Competitive strategy

Firm is established to maximize shareholders value. Value means maximizing shareholders return on investment in terms of financial profit. Firm can only earn profit in some extent that it can compete and win market competition. Competitive advantage is inevitably necessary as core weapon to float the firm ahead of competitors in industry. Moreover, future business is so dynamic and uncertain that pushes current firm to elaborate novel ways to sustain its competitive advantage in the future. Competitive strategy will direct firm to manage its resources and capabilities in order to maximize success potentials of the firm. Success potentials of the firm are defined as a strong position in the dynamic market, long-term competitive advantages in market offers, and long-term competitive advantage in resources [3]. Strong position relates to company position in the current market or industry. Position means whether the firm can lead the market and influence the market as a whole.

2.2.1 Porter's Five Forces

Competitive strategy concept was firstly introduced by Michael Porter in 1980. The model was designed as structural and systematic way of thinking to understand unique attributes that determine the profitability of different industries. Porter described that there are five competitive forces that shape the degree of competition in the industry. The five forces model incorporates potential entrants, suppliers, buyers, substitutes and competitors [4]. Porter argues that five competitive forces will drive the underlying profit potential of the firm. Customers can determine the behavior of price in the market. Suppliers have power to regulate raw material cost that can limit profit margin. New entrants, with new competences and capabilities, may have new way to win market share that can influence other players profit performance. Substitutes will erode the current product market by altering customer preference on new type of products [5]. This theory is a powerful way to analyze competitive market dynamics, driving forces, opportunities, threats and to map future trends of the industry. The result of the analysis will be an important input into strategy formulation, thus, it provides winning formula to compete in the industry. Diagrammatic illustration of Porter's Five Forces can be seen in Figure 2.2.

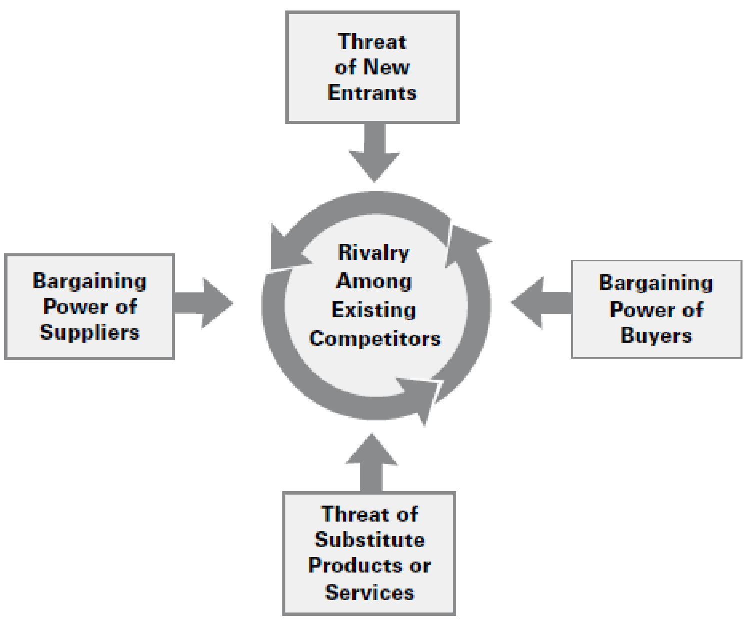


Figure 2.2 Porter's Five Forces

This model will enable firm to depict the degree of value creation that is delivered to the customer and to compete with rivals. The understanding of industry structure will direct management to identify key success factors to maintain sustainable business in the future.

2.2.2 Stakeholder theory of the firm

Stakeholders are individuals, groups, and organizations who can affect or is affected positively or negatively by the achievement of organization's objectives [6, 7]. Stakeholders are classified into primary and secondary stakeholders [8]. Primary stakeholders are organizations or individuals who are essentials for business to operate and to create output. Customers, employees, suppliers, communities and financiers/shareholders are classified as primary stakeholders. Whereas, secondary stakeholders are organizations or individuals that play fundamental roles in obtaining business credibility and acceptance of its activities such as governments, competitors, and media. The firm's stakeholders are depicted in Figure 2.3 [6].

Business is about maximizing interaction between stakeholders to produce high-quality product or services which deliver maximum value creation to the firm. Financiers and shareholders have the interest to gain maximum return. Employees have expectations on job security, good salary, benefits and exciting working environment. Customers and suppliers collaborate in exchanging resources and give value added to the products. Local community will gain benefit from economic and social contributions from the firm to develop their region. It implies that stakeholder management is critical to ensure sustain value creation of firm in the future.

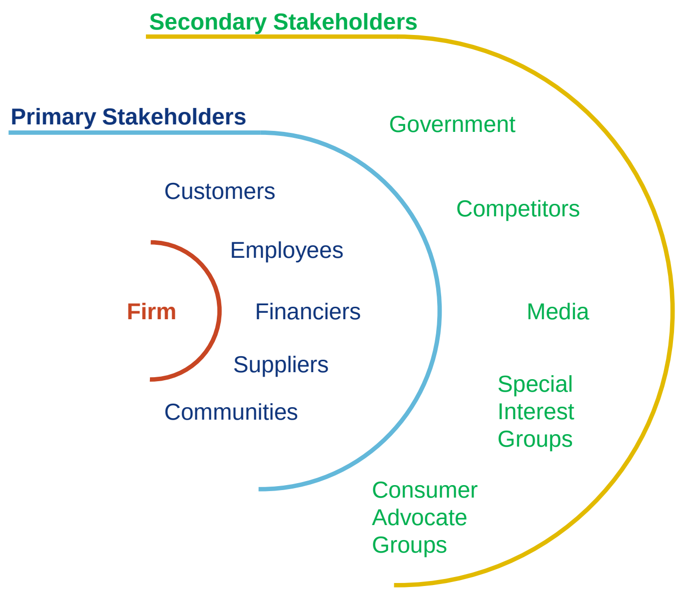


Figure 2.3 Corporate stakeholders

Firm executives shall have strategy in place to understand needs, expectations, perceptions and values of internal and external stakeholders Balance of interests among stakeholders is an essential consideration in making strategic decisions. Managing conflict of interest between stakeholders is key by balancing trade-off on interest between stakeholders. Management of firm resources and stakeholder relationships is essential to establish competitiveness [6]. Ability to establish and maintain relationships within entire stakeholders network shall be built by the firm in order to obtain sustainable top performance in the long run and improve organizational flexibility. Technology at some point is easier to imitate than strong relationship and networking with stakeholders. Top performer firms have greater reputation to acquire valuable resources and stronger networking with stakeholders that promote competitive advantage against competitors [6]. Building stakeholders network is one of the key success factors in building complex system as exemplified in IO operating model [9].

2.2.3 Resource-based theory

Resource-based theory has different approach with five forces competitive strategy. Resource-based theory states that firm competitive advantage can be attained by utilizing firm's resources as a strategic vehicle to outperform rivals. Firm resources are all assets, capabilities, organizational processes, firm attributes, information and knowledge controlled by a firm that enables them to conceive and to implement strategy [10]. Controllable resources of the firms will likely deliver economic benefit for the firms [11]. This theory focuses on internal capability building to be exploited in order to win the competition in the market.

Internal capability can be shaped by reinforcing attributes of the firm's controllable resources. Resources or assets in this context cover the visible and invisible assets. Visible assets can be financial, physical, and human. Meanwhile, invisible assets are information and knowledge-based resources such as technology, organization, work process and reputation [12]. Invisible assets of the firm have become the major source of business competitive advantage in the modern environment [13]. Visible assets shall be integrated with invisible assets to create competitive success. Invisible assets play important roles in driving the competitive power and adaptability, and can be used in multiple ways simultaneously as input and output of business activity [11]. People in this context act as accumulators and producers of invisible assets. As a result, firm is urged to select business or development project that conforms with firm area of capabilities. New business development initiatives may require novel capabilities and competencies that can be built internally or by acquiring other firm.

Resource-based theory is applicable to shape corporate level and business level strategy [14]. Business strategy can be shaped from unique resources and capabilities that are hard to imitate. On the other hand, corporate strategy can be shaped by matching resources to market opportunities through the creation of business units. Internal attributes and capabilities of firms will provide a stellar foundation to shape winning strategy. *Capability, in this context, is the combination of process, infrastructure, knowledge and skills which are bundled inside decisive organization as special purpose vehicle*. Firm has to able to identify the key capabilities and alter them to become distinctive capabilities for the sake of building core competencies of the firm. Distinctive capabilities are powerful attributes to gain against competitors. Portfolio of core competencies shall be managed around the circle of firm's business and be integrated with appropriate assets to build strategic assets. Strategic assets are the foundation of sustainable competitive advantage. Additionally, innovation initiatives shall be focused on strategic assets to enhance the attributes of organization to confront with uncertainty, complexity and dynamic of recent market setting. In general, the interconnection between resources, capability and sustainable competitive advantage can be well represented by a pyramid of value creation in Figure 2.4 [1].

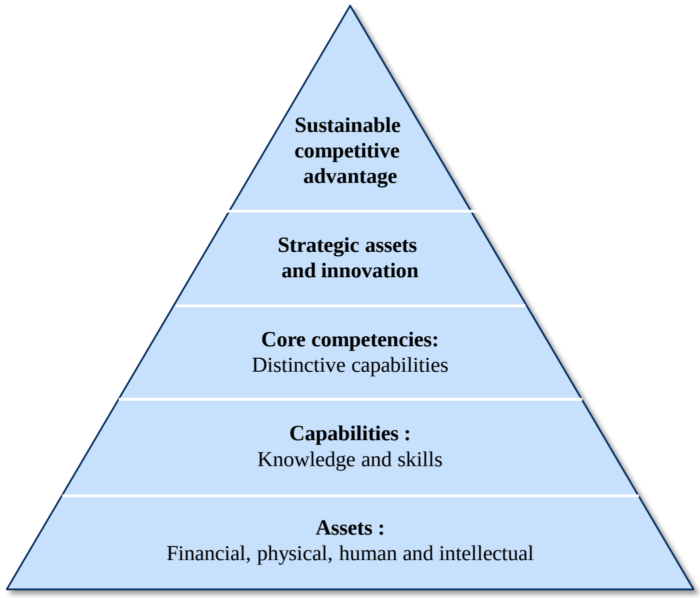


Figure 2.4 Pyramid of value creation

In addition, VRIO (Value, Rarity, Imitability, Organization) is a useful tool to assess the internal resources or capabilities based on resource-based theory [11]. This framework shows the interplay between resource-based analysis and competitive advantage of the firm. It is a powerful method to understand why such top performer firm can outperform competitors by deploying the maximum potential of their assets. VRIO framework is depicted in Figure 2.5.

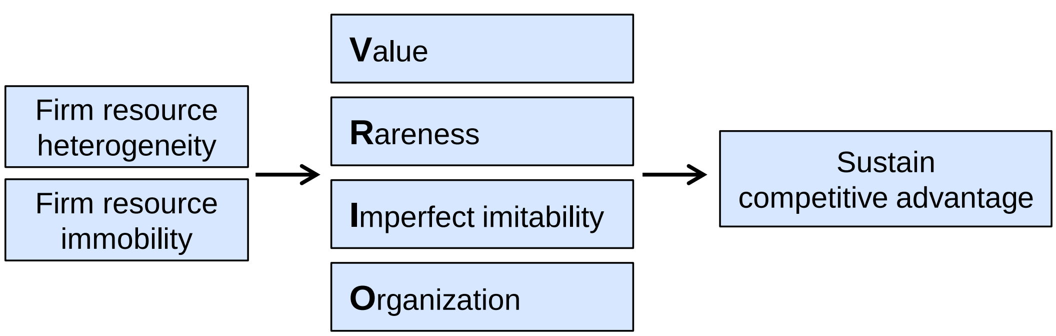


Figure 2.5 VRIO framework

The critical assumption of this framework is that firm resources have unique heterogeneity and immobility. Resources heterogeneity assumes that different firm has different resources. Resource immobility assumes that it is costly for firm without certain resources or capabilities to acquire resources or capabilities from another firm [15]. Each of the resources or capabilities will be faced with certain question according to category describe in Barney [11]:

a. Value. Do a firm's resources and capabilities enable the firm to respond to environmental threats or opportunities?
b. Rarity. Is a resource currently controlled by only a small number of competing firms?
c. Imitability. Do firms without a resource face a cost disadvantage in obtaining or developing it?
d. Organization. Are firms' other policies and procedures organized to support the exploitation of its valuable, rare, and costly to imitate resources?.

The results of answers are then summarized in VRIO table in order to define whether it contributes to firm competitive advantage. The generic VRIO table is as follow [11, 16]:

Is resources or capabilities …..					
Valuable?	**Rare ?**	**Costly to imitate ?**	**Exploited by organization ?**	**Competitive implications ?**	**Economic performance?**
No	-	-	No	Competitive disadvantage	Below average
Yes	No	-	↑	Competitive parity	Average
Yes	Yes	No	↓	Temporary competitive advantage	Above average
Yes	Yes	Yes	Yes	Sustain competitive advantage	Consistently above average

Table 2.1 VRIO analysis

2.2.4 Cluster and network

2.2.4.1 Cluster

Cluster is defined as a geographic agglomeration of interconnected firms, specialized suppliers, service providers, firms in related industries and associated institutions (e.g universities, standards, agencies, trade associations, financial providers) in a particular field of activity that not only compete but also cooperate [17, 18, 19]. Firms which form cluster will obtain positive benefits in terms of technology innovation, commercialization of new business, higher productivity, and more competitive. These parties are interlinked by externalities and complementarities structured in geographic proximity. This setting creates a synergy which promotes economic growth by providing better accessibility of skilled human resources, niche suppliers, knowledge spillovers, and intense pressure for higher performance of head-to-head competition [19]. Trust between parties in the clusters is glue that connects each other as a bond to achieve common ultimate objectives which are sustain value creation.

Well-defined clusters initiatives will promote national competitiveness in certain industry segment. Cluster is complementary and interrelated work between institution bodies, agents and stakeholders whose have large impact on cluster operations performance. The network created is pipelines for synergy and knowledge spillovers which will accelerate coordination, diffusion of best practices and efficient access of public goods [19]. Cluster's performance plays key roles to be the catalyst to boost the economic growth rate of the region by providing vehicle for smooth deployment of knowledge, capabilities, skilled human capital, institutional and organizational structures [20]. Clusters are classified into three different types according to Markusen [21] :

a. *Hub and spoke district*, which is industrial hub consists of multiple industries interconnected around one or several major corporations.
b. *Satellite industrial platform*, which is a region where multinational firms are gathered in one location. It can be a group of high-tech industry or low labor cost region.
c. *State-centered district*, where clusters are formed around the capital, research centers facility or public firms.

Cluster is the unique mechanism which differs from cooperation and network. They are interconnected by interdependency in value chain thus created horizontal span of chain of network to serve common customers. This system is the powerful strategy to enhance network organizations competitiveness by increasing the productivity of firms in the clusters, guiding innovation to improve future productivity, and creating new work areas as empowerment to the strength of clusters network [21].

2.2.4.2 Collaborative Network

Collaborative network is "an alliance that comprises of variety of entities (organizations and people) that are largely autonomous, geographically distributed and heterogeneous in terms of their operating environment, culture, social capital and goals" [22]. The actors in collaborative network collaborate together to achieve common objectives in which interactivity are supported by the existence of Business-to-Business (B2B) network. B2B network is inter-organizational information and management system [23]. It removes inter-organizational boundaries by deploying ICT technology that enables sharing of data, information and business application.

Virtual team, virtual enterprise and industry clusters are among form of collaborative networks [22]. Virtual team is "a group of people who work interdependently with a shared purpose across space, time and organization boundaries using technology" [24]. Meanwhile, virtual enterprise is "an organizational form established through B2B networking that involves geographically distributed discipline groups, technical departments, and business partners to serve a common purpose of industrial importance" [25].

In summary, collaborative network can be only built with prerequisite of powerful ICT technology to support interactive communication despite geographical and organizational barriers. This system will support fluid sharing of knowledge, skills, and core competencies to achieve mutual benefits among collaboration actors. In addition, it may reduce business process cycle time through capability of ICT networks. Consequently, it can be a powerful strategy to cope with dynamic and uncertain business environment that require high business agility and speed.

2.2.5 Scenario planning

Phelps, Chan and Kapsalis [27] define scenario planning as neither forecasting nor prediction. It is an exploration that develops few possible description of the futures This concept can help to establish future planning. It can identify potential negative scenarios so that firm can prepare for preventive strategy, and maximize future opportunities by preparing the firm assets and resources to maximize them. The leadership of the firm can view the future in a broader context and think about different possibilities of each of the scenarios to happen.

Scenarios are “vivid descriptions of plausible futures” [26]. Most scenarios consider global factors, such as economic growth, inflation, interest rates, supply and demand, geopolitics, and social factors [26, 27]. This is an effective strategic planning tool for medium to long term planning under uncertain conditions. It also helps the organization to sharpen the strategies and keeps track in the right direction and in the right issues. The possible scenarios in the future are illustrated in Figure 2.6 [26].

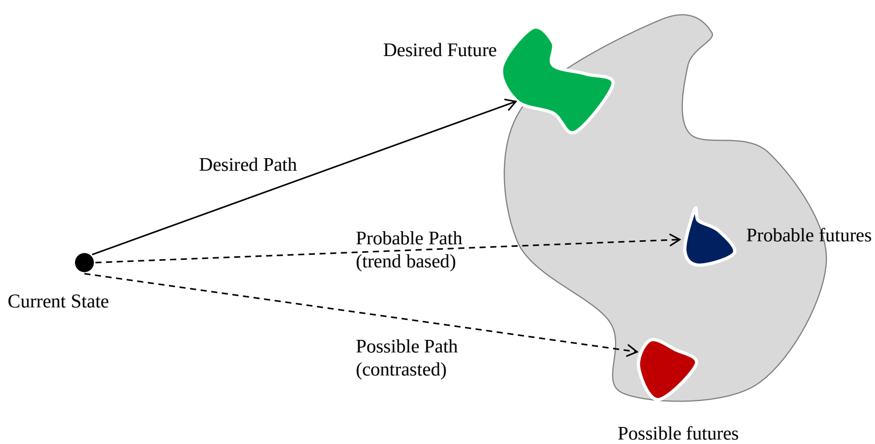


Figure 2.6 Possible future scenarios concept

Based on above illustration, there are many possible scenarios in the futures which imply the uncertainty of the future. There are diverse possible scenarios in the future, as a result screening into the most logical and plausible scenarios is inevitably necessary. TAIDA (Tracking-Analysing-Imaging-Deciding-Acting) method is used to craft scenario planning [26]. The description of the method is as follow :

a. *Tracking*. The purpose of this step is to detect and to trace changes in surrounding environment of the firm which may impact the future vision of the firm. In order to detect trends, outside-in perspective can be used as tool to help in analysis. Outside-in perspective is a framework to analyze outside world changes by scoping analysis into arena trends and driving forces on outside world. Arena trends may comprise of supply-demand, buyers, competitors, and substitutes. Driving forces can be technology, market, economy, legislation, and politics.

b. *Analysing*. This step is aimed to analyze each of the trends and to define interconnection between trends. Trends may be interdependence each other like influence network. Influence network can be drawn for each of the trends to learn the interconnection between them. This network will identify the main actors of the trends that drive the uncertainty in the future. Plausible future scenarios are identified based on this result.

c. *Imaging*. Subsequent to analyzing the process, plausible future scenarios are identified. Consequently, strategic vision can be designed based on this scenarios. Vision is what firm desires on the future shape of the firm. It is a vivid description what it will be like when the goal of the firm is achieved.

d. *Deciding.* As an end-to-end point of the firm has been identified, firm can map the current and future state point. The next strategic step is to craft out stellar step to achieve the vision. It will guide the firm to identify what kind of resources or capabilities needed to achieve the vision.

e. *Acting.* This step is putting strategy into action. Implementation plan is carefully built to execute the strategy on the market. It also involves on monitoring performance of the firm subsequent to execution.

Generating future scenarios is challenging due to multiple factors involved, interdependency between trends, degree of uncertainty and dynamic behavior of the business environment. As a guideline, Lindgrend and Banhold [28] develop seven criterias of good scenarios as below:

a. *Decision making power*. The scenarios must provide useful insights in response to the question being considered. The problem perception raised shall improve the effectiveness of decision making [28]. Decision makers, as one of the stakeholders on scenarios, shall be well informed about the content of the scenarios.

b. *Plausibility*. The scenarios shall be realistically possible to draw the condition of the future. Plausible scenarios will generate plausible outcomes. The plausible scenarios have the comfortable continuum between history in the past, current situation, and future scenarios [29]. The assumptions, quantification and the impact of different patterns of individual and collective choices as a basis for constructing scenarios are plausible [27].

c. *Alternatives*. The scenarios should be at least probable and stretch within the range of more or less equal probability. The range of probability to some extent is within the possible range of uncertainty.

d. *Consistency*. The scenarios shall be internally consistent, to form the credibility and logic of scenarios. It is based on the causal logic of how particular scenario unfolds from the past to the present and to the future [30].

e. *Differentiation*. It focuses on different future concerns rather than variations one theme. It is structurally and qualitatively different each other.

f. *Memorability*. It should be easy to remember and to differentiate. The potential scenarios are recommended to the limited number and named on easy to remember words to make it easily immerse on the mindset of people.

g. *Challenge*. It challenges the organization to receive wisdom about the future and stretch people beliefs [28].

According to Phelps, Chan and Kapsalis [27], scenario planning has a couple of advantages in strategic analysis under dynamic business environment based on the following arguments:

a. Scenario planning answers some of the concerns associated with formal planning methods by providing an approach to flexible planning, taking into account several possible alternative views of the future.

b. Firms reported improved decision making after deploying scenario planning. Scenario planning generates more realistic possible futures and improves the quality of decision making.

c. Scenario planning allows firms to adapt their strategies to maximize their financial returns.

2.3 Integrated performance

A systematic strategic planning approach, which is firmly grounded in reality, is an essential requirement for long-term corporate success [3]. One of the important concepts which unify between strategic planning concept and performance management concept is integrated performance planning. Integrated performance planning is a holistic process based approach by which an organization defines its future state or a vision of the future [31]. This concept emerges as the recent organizations realize that the condition of business becomes more dynamic, higher price volatility, higher uncertainty of supply and demand, shorter market lifecycle, harsher market competition, and fast-growing technology. In addition, it also plays key roles such as providing guidelines for each of the decisions to ensure the actions taken are aligned with corporate strategy, creating commitment to organization members to work through the same direction/ objectives and becoming a yardstick to manage the future performance of organization. The basic concept of integrated performance planning can be illustrated as follow :

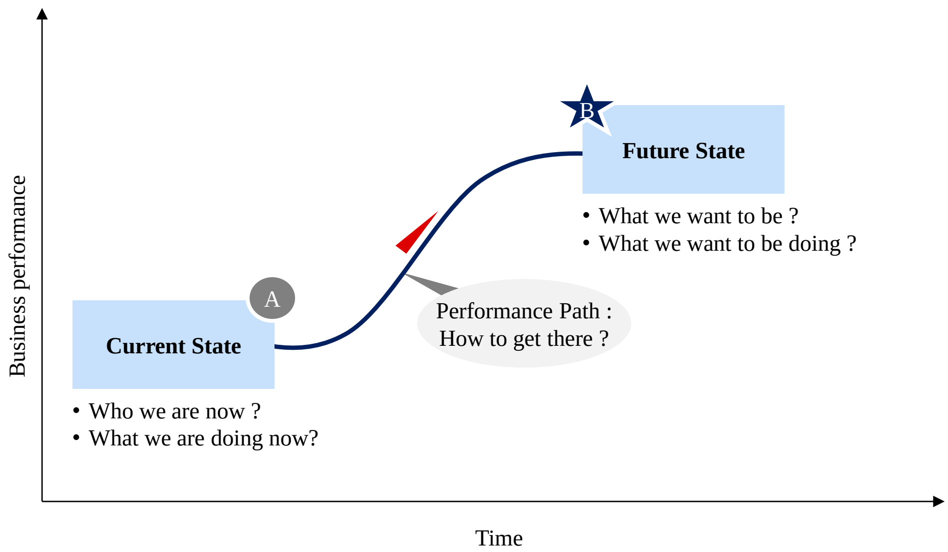


Figure 2.7 Integrated performance management framework

Corporate strategy and tactical components shall be aligned with well-integrated methodology [31]. This concept shall be implemented systematically by considering all related aspects such as firm resources, leadership, products/services outcome, and operating principles. Christopher and Thor [33] identify eight main steps of integrated performance model as follow:

a. *Preparing to Plan*. The main concept of this step is laying the foundation for the performance planning process. The main activities involved in this phase are identifying key players and clarifying roles and responsibilities. Critical databases are prepared to support the further phases. Additionally, communication plan is established to allow effective information sharing systems.

b. *Defining the future state*. This step involves the visualization of the organization in the future. This should be an innovative and creative environment. The strategic component shall cover the dedication to customer, commitment to excellence and contribution to organizational success.

c. *Assessing the environment*. This step is aimed to assess and to analyze the internal and external conditions impacting the organizations. The typical external aspects to be considered are political climates, global economic trends, social or community relations, technological development, environment regulation, legal or regulatory compliance and customer relations. Key aspects of this step are gathering data to be analyzed and concluding the implication to organization.

d. *Identifying the issues and opportunities*. This phase is aimed to analyze the organization current state (strengths and weaknesses). The internal aspect may cover the analysis of assets, capabilities, and resources. The senior managers and members need to prioritize the internal and external business opportunities and to assess the potential impact to organizations.

e. *Formulating strategic priorities and objectives*. This phase provides the strategic business direction and focuses the business into specific timeframe in the future. The result is the strategic roadmap for the organization's transition to future states. The powerful tool to formulate strategic priorities is direction statement bridge in Figure 2.2. This concept draws the path of the organization in developing its business and gradually improving performance to achieve its future objectives.

f. *Identifying operational performance gaps and tactical alternatives*. The main activity in this phase is identifying factors that can prevent transition to the future. It will be the basis of selecting performance improvement process that best fit the organization.

g. *Selecting and integrating tactical strategies*. This phase constitutes the selection of the most appropriate tactical responses and the development of the implementation strategies. The organization should select the best fit and cost effective resources as a basis to configure effective implementation plan to achieve its objectives. The strategic and tactical plan shall be synchronized.

h. *Implementing and measuring*. The main activity of this is the implementation of the plan and monitor the performance results with the targeted plan. The monitoring system is a macro level which focuses on gathering and dissemination of performance data.

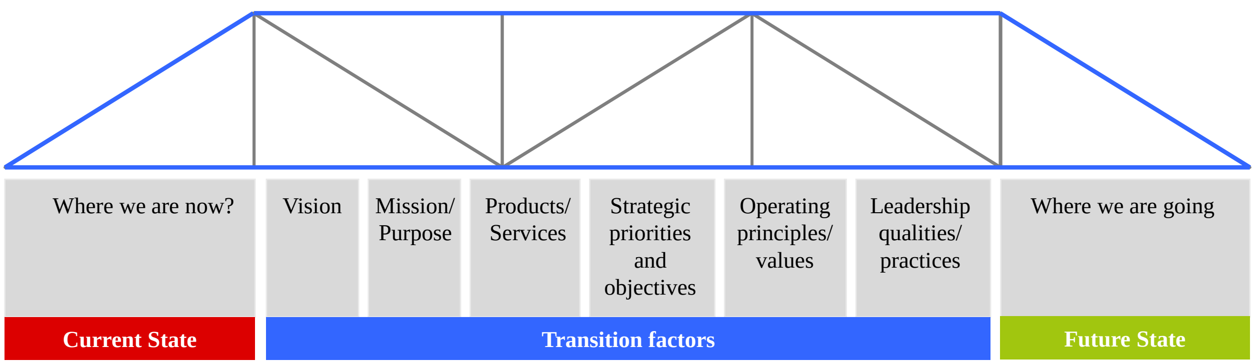


Figure 2.8 Direction statement bridge

Among those steps above, direction statement bridge is the most important tool to craft business strategy. It is the comprehensive framework to assist in defining essential factors that will influence the effectiveness of strategy and drive success level of strategy implementation.

3 Integrated Operations

3.1 Overview

The era of easy oil is gloomy indicated by depleting production that pushes current petroleum players to shift exploration and production (E&P) activities into more frontier areas. It is clear signal that the future of petroleum industry will be situated in highly challenging areas such as offshore deepwater, remote areas, and more complex reservoirs. Untapping new hydrocarbon potentials will be more and more costly, risky, highly complex and highly uncertain. In addition, emerging concerns to preserve environmental ecosystem will be more influential in determining the future state of petroleum business. Furthermore, regulatory compliance is predicted to push petroleum company to operate on less carbon emission in order to reduce the rate of climate change. Petroleum facility design shall accommodate this issue that contributes to the system design complexity. Additionally, seventy percent of petroleum experts workers in the USA are between the age of 41 and 65, while twenty percent of them are younger than 36 years old [32].

Given these obvious challenges, big questions arise in the industry on how petroleum industry response to the challenges in a smart way. Petroleum industry, itself, has taken a significant effort by maximizing the utilization of ICT to facilitate smart asset management. However, it is realized that technology deployment alone is insufficient to cope with highly dynamic business environment that requires speed and agility. As a result, petroleum industry came out with a new solution that is IO model.

IO is "the integration of people, work processes, and technology to make smarter decisions and better execution. It is enabled by using shared real-time information, collaborative techniques and multiple expertise across disciplines, organizations and geographical locations" [33]. The interconnection between people, process and technology can be viewed clearly by using capability model [34].

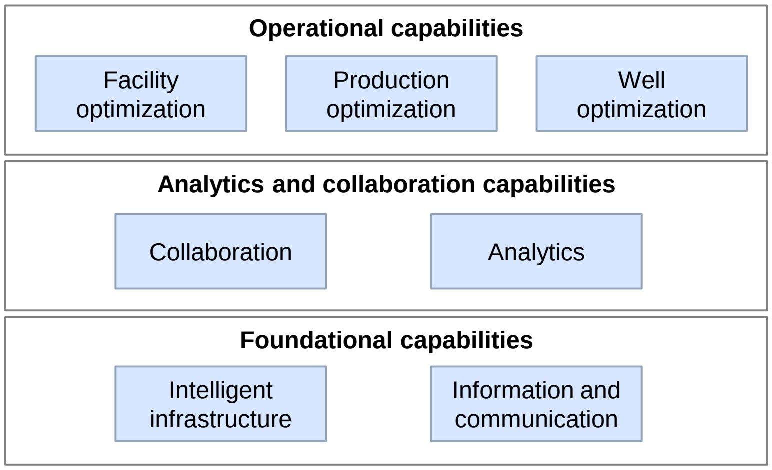


Figure 3.1 Generic IO capability model

ICT builds the *foundational capabilities* of IO that support extensive capability for oil companies to transfer data in high speed with massive bandwidth capacity from remote offshore assets to onshore support centers. Installations of subsea fiber optic and current 4G/LTE wireless network are the milestones of IO capability. IO center is a representation of *collaboration* node to generate Collaborative Work Environment (CWE). CWE is a forum where integration of people, processes, and technology is well-facilitated to improve cross-functional and virtual collaboration, learning and high quality decision making [35]. CWE support in decision making by providing "system view" environment that requires multidisciplinary input base on relevant real-time data as the basis of decision analysis [36]. CWE is collaboration arena that is equipped with *analytic* tools that allow team members to share ideas seamlessly, to analyze data and to interpret graphical representations collectively in real-time. Joint decision making is made through multidisciplinary teamwork within asset or global expertise that facilitate faster and better decision making. CWE implementation has transformed the way of working from the traditional organization into the boundaryless virtual organization. As a result, integration of foundational, analytical and collaboration capabilities enhance operational capabilities in reservoir, well and facility as exemplified in production optimization, well optimization and facility optimization.

Superior Oil was the first company that conducted the first effort to implement IO by establishing drilling data centers, providing real-time log, and MWD (measurement while drilling) data to onshore support center [37]. The main idea behind this way of working was a collaboration between multidisciplinary experts that created decision based on common information in real-time by utilizing high-tech appliances in order to ensure better decision making while drilling. In medio of 1990's, several oil companies set up distributed collaboration and decision making by deploying real-time and communication links between operators in offshore platforms and onshore engineers. Joint decisions are made in a team-based setting by deploying real-time data analysis. The results were promising by increasing scheduled maintenance, enhancing drilling efficiency and improve oil production [38]. The root causes of this improvement were better information coordination (closer to real-time) and better interactions across disciplines in different locations.

In fact, IO has been deployed for around 10 years with significant tangible results. CERA estimates that value creation of digital oilfield implementation come from enhancing recovery factor, increasing production rate, improving regularities, improving operations efficiency and reducing drilling cost. The benefit of IO is depicted in Figure 3.2 [39].

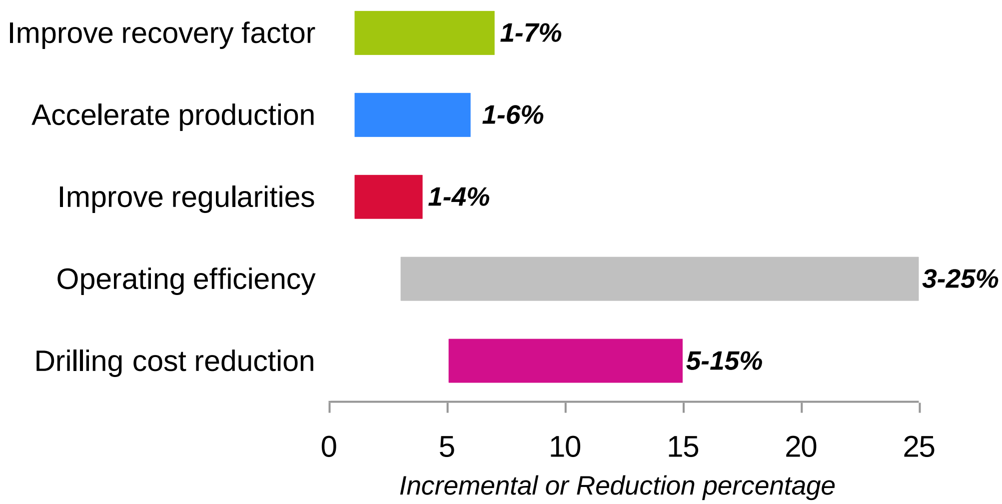


Figure 3.2 Digital oilfield benefits

Most of the major oil companies have been formally applied IO since the early of 2000's. BP, Shell, and Statoil are among global leaders in IO deployment throughout their international assets operations. They use different terminology to identify IO. The identification of IO program is *"Field of the Future"* (BP), *"Smart Field"* (Shell) and *"Integrated operations"* (Statoil). In Norwegian Continental Shelf (NCS), IO is mutual cooperation between offshore operators that operates petroleum fields in NCS. NCS is considered as one of the most mature areas in the world that apply IO model.

Emerging trends of IO deployment accelerate the growth of digital oilfield technology market. Digital oilfield market is predicted to grow at around 4.8% (CAGR) [40]. Current mature markets are in Europe (North Sea) and Americas (Gulf of Mexico). The picture of digital oilfield market is depicted in Figure 3.3 [40].

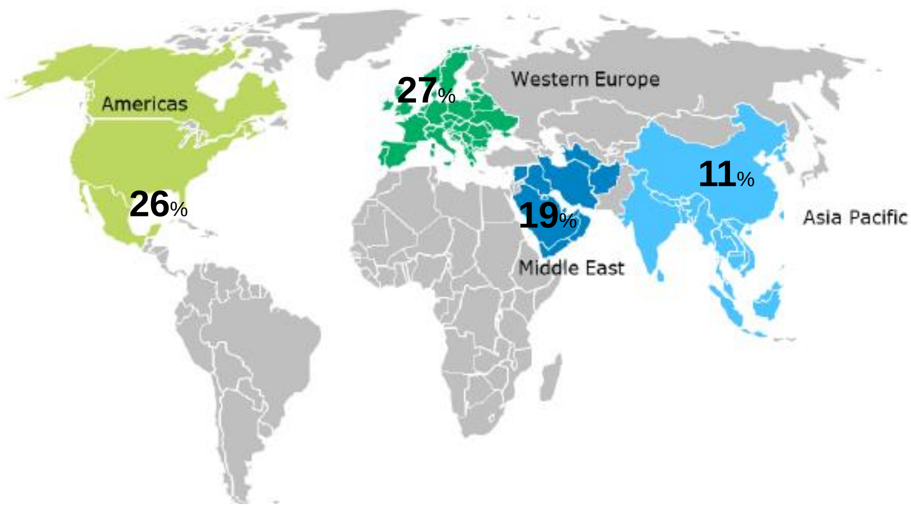


Figure 3.3 Digital oilfield markets

In this thesis, a literature review on BP's Field of the Future, Shell's Smart Fields, and Statoil's Integrated Operations is conducted to gain insights on specific capability model, key success factors, and challenges.

3.2 BP *"Field of the Future"*

Field of the Future (FotF) is strategic program launched by BP to deploy the maximum merit of IO model. It is part of technology flagship own by BP as illustrated in Figure 3.4 [41].

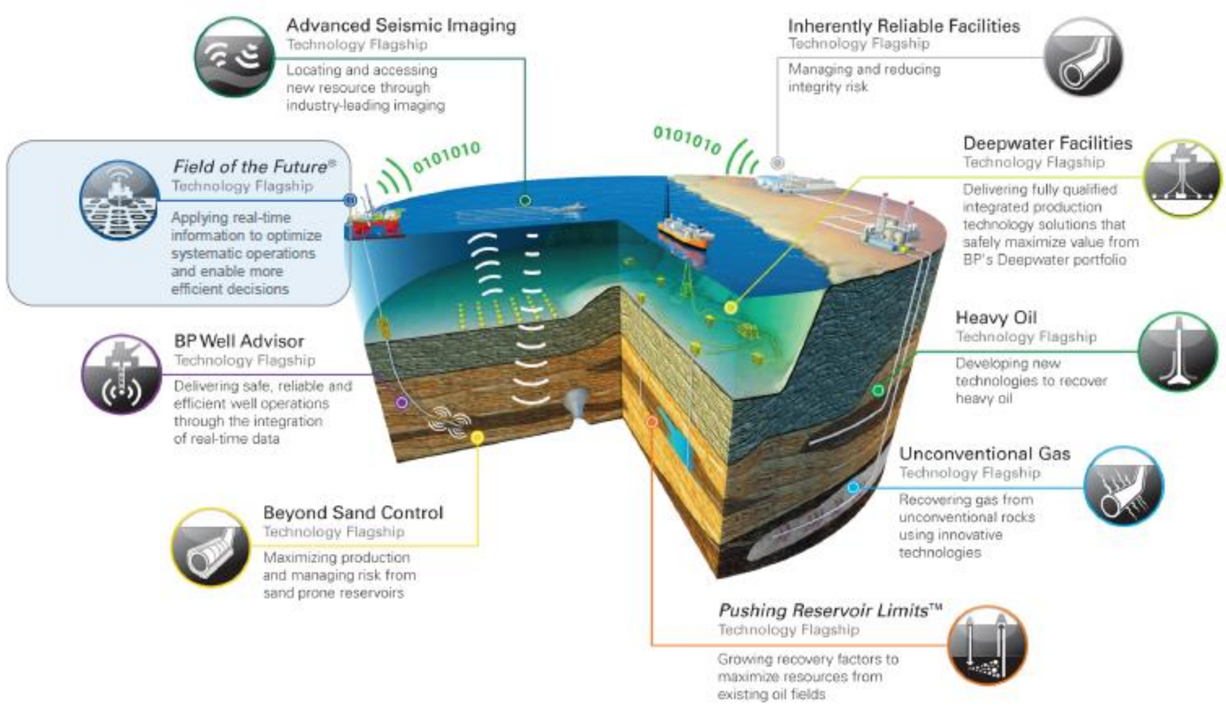


Figure 3.4 BP Technology Flagship

FotF incorporates development and deployment of technology and business process solutions throughout key value chain (reservoir, well, and facility management) [42]. It is deployed across various assets such as green fields, mature fields, offshore and onshore. The key themes of FotF program are deploying real-time reservoir management, production optimization, remote performance management, advanced collaborative environments (ACE) and 24/7 global connectivity in order to enhance quality and efficiency of decision making [42].

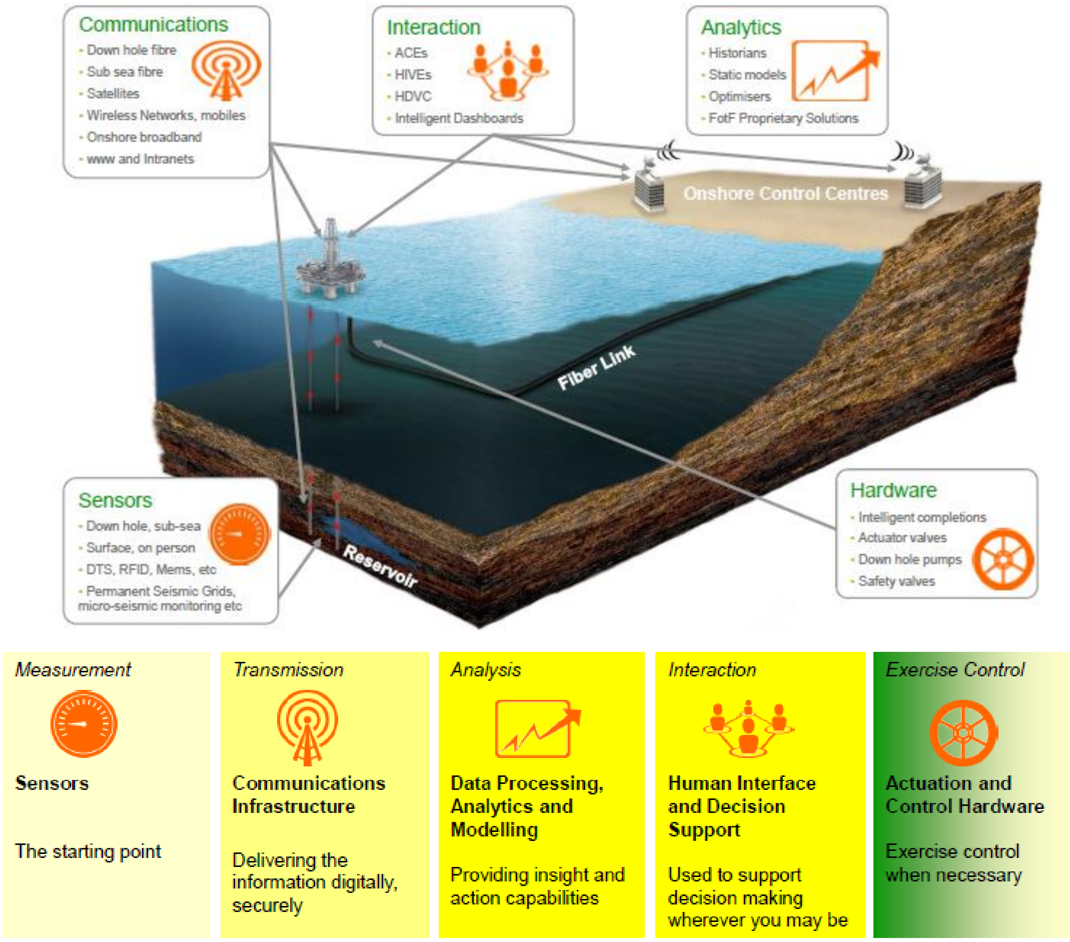
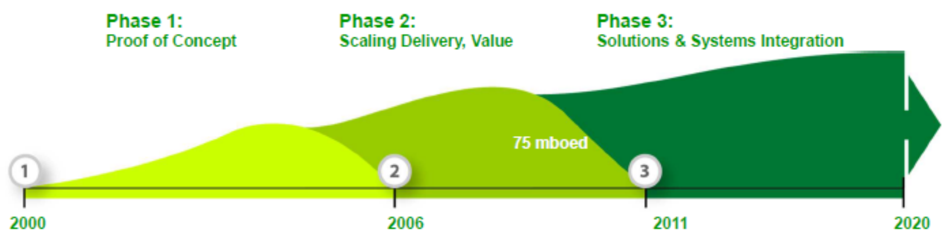


Figure 3.5 Field of the Future

Indeed, FotF is part of technology flagship in BP. Conversely, technology is merely enabler factor. Correspondingly, new technology deployment will affect the way people work that also evoke the effectiveness of the organization. Consequently, work process and people work culture shall be transformed to fit with new technology. In other words, people, process, and technology shall be integrated into one system. For this reason, BP established ACE program to facilitate interaction between people to create joint decision making. ACE is collaboration arena that integrate people, process, and technology, physical environment and organization as one system [43]. FotF system, itself, comprises of five key subsystems which are *measurement*, *transmission, analysis, interaction,* and *control.* The elements of FotF system is depicted in Figure 3.5 [44, 41].

The embryo of FotF program was the installation of fiber optic network on Valhall and Ula assets in the North Sea in 1999. This digital infrastructure has overwhelming capacity in transferring large amount data captured from sensors installed on the offshore facility to onshore operations center throughout 24/7 connectivity. It is the hallmark steps arising opportunities on how to utilize the communication infrastructure effectively in order to gain full-scale benefit of digital technology.

Meanwhile, FotF program was formally established as a corporate initiative in 2003. It energized FotF as a strategic corporate action to accelerate accomplishment of FotF vision. FotF program has the vision to deliver high quality decisions made by right person, based on the right knowledge independent of time and place [45]. Real-time decisions will contribute to differentiation factor that establishes BP as sustainable world class operator [43]. In the future, BP expects that 95% of production is impacted by FotF program [42].



PHASE	Proof of Concept 2000 – 2005	Initial Flagship Program 2006 - 2011	Integration Program 2011 – 2020
Goal	Demonstrating the value of the Digital Oil Field concept	Scaling the digital oil and gas fields	Drive value through integration across geographies, functions, assets, systems and solutions

Figure 3.6 Journey of Field of the Future program

In order to achieve the vision of FotF, BP established three gradual stages of FotF development and deployment. The stages are *proof of concept (Phase 1), proof of delivery at scale (Phase 2)* and *solutions plus system integration (Phase 3)* [41, 46]. *Proof of concept* was focused on engagement and deployment of advanced digital technology on BP's limited number of assets. It was aimed to validate the benefits and to build up technology foundation as a basis for subsequent development process [47, 42]. Initial prototyping and piloting were initiated to conduct assessment about FotF system behavior and measuring the "prize" delivered. The key action, in this phase, was "team engagement" to understand the value of real-time based operation and integrate diverse set of technology solutions to prove up concept [48]. The early value creation was promising such as additional production, improve well and reservoir management, improve onshore-offshore collaboration and remote performance monitoring [42]. Following success on proof of concept phase, BP launched *proof of delivery at scale* phase. It was aimed to accelerate deployment of FotF at pace and scale. The key actions are delivery on real-time remote monitoring solutions, well monitoring, surveillance by exception, equipment reliability, and production optimization [48]. Nowadays, BP is being in *solutions plus system integration* phase. BP is deploying FotF throughout global assets and integrate across geographies, assets, functions, systems and solutions. This phase provides an integrated system that enables assets to be operated and monitored anytime, anywhere by the right person, at the right time and in the right place removing geographical and organizational barriers. The FotF journey is illustrated in Figure 3.6 [46].

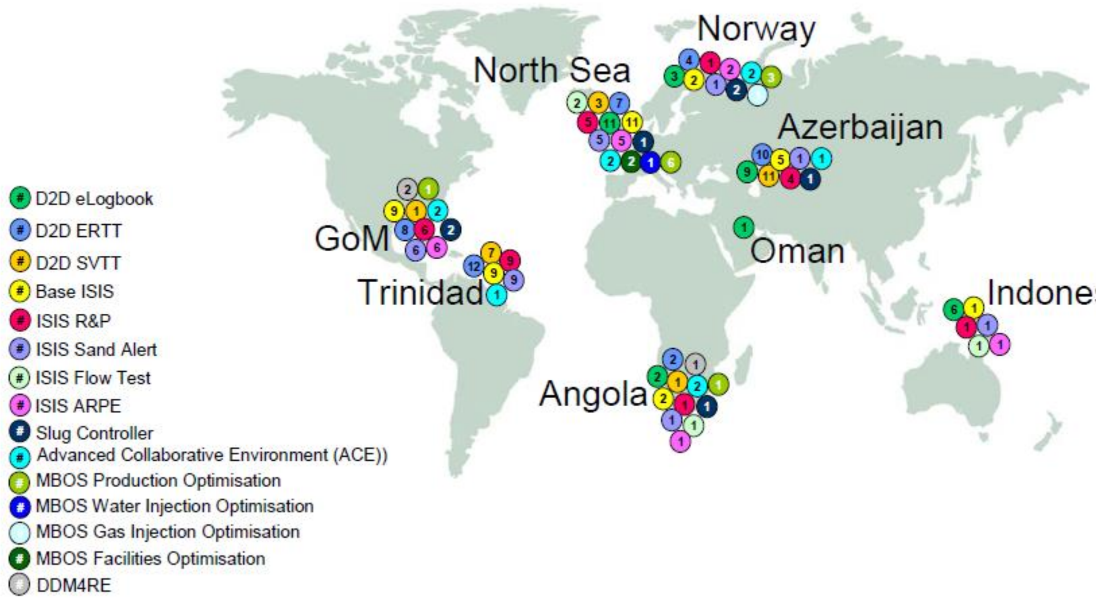


Figure 3.7 Field of the Future global deployment

BP has implemented FotF across its global assets as depicted in Figure 3.7 [48]. The portfolio of solutions has a wide range of diversity such as D2D (Data to Desktop), ISIS (Integrated Subsurface Information System), MBOS (Model Based Operations Support) and ACE (Advance Collaborative Environments).

Currently, FotF has been considered as proven concept and has delivered fruitful value creation of providing 70 mboepd additional production, improving collaboration between the offshore and onshore team, improving cost efficiency, increasing staff efficiency, improving decision cycle time and enhancing HSSE level [48, 49, 50, 51, 43, 52]. The value creation of FotF is depicted in Figure 3.8 [46].

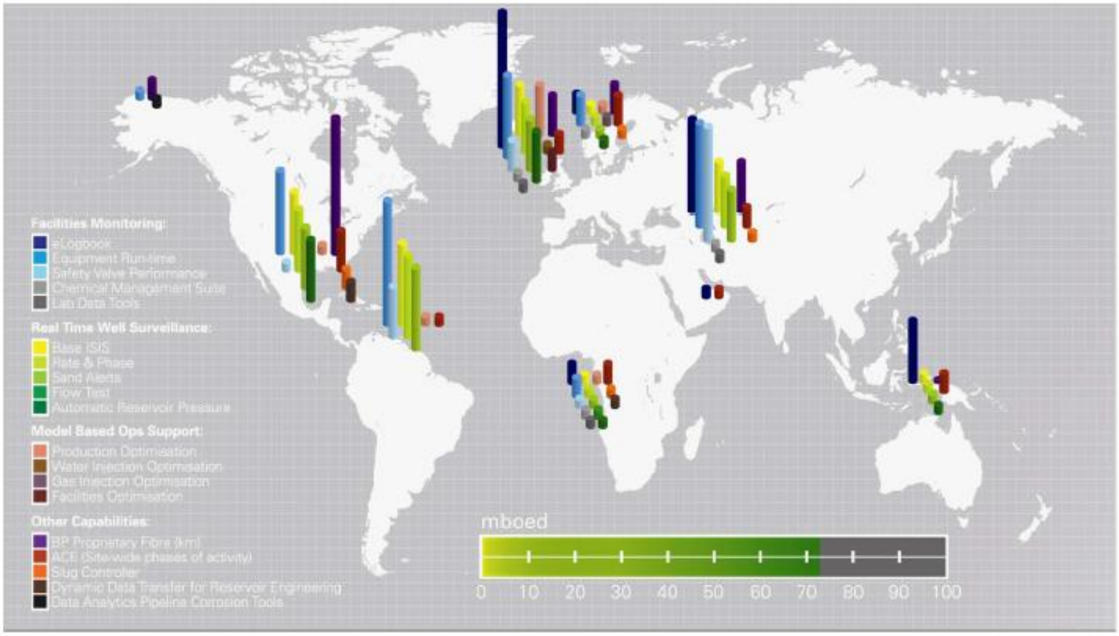


Figure 3.8 Field of the Future value creation

3.2.1 Field of the Future capability model

FotF is built upon FotF pyramid as depicted in Figure 3.9 [44]. The main function of each of the layers in pyramid is described below :

a. *Measurement*. It comprises of smart sensors and instrumentation that measure key operational metrics such as pressure, temperature, and flow. The samples of smart sensors are LoFS (Life of Field Seismic) to monitor reservoir and DTS (downhole temperature sensing) to monitor wells. Real-time data is acquired for the sake of inspection, monitoring, and optimization.
b. *Transmission*. It comprises of advanced IT communication infrastructure that gather, transmit, consolidate and distribute digital data to the right place (e.g transmit to onshore control center).
c. *Analysis*. It comprises of systems that process and analyze data in order to produce decision information. These systems have the capability to detect unwanted events, to create system modeling, and to optimize assets based on data input.
d. *Interaction*. It comprises of advanced visualization and collaboration technology to facilitate experts interaction in ACE. Visualization technology provides better understanding and interpretation while collaboration technology facilitates interactive communication between multidisciplinary experts across geography and organization. Consequently, real-time or near real-time decision making can be made that improves asset performance.

e. *Exercise and control hardware*. It comprises of systems that provide the ability to conduct actions subsequent to decisions in interaction layer. Valves, pumps, and intelligent completions are belong to this system.

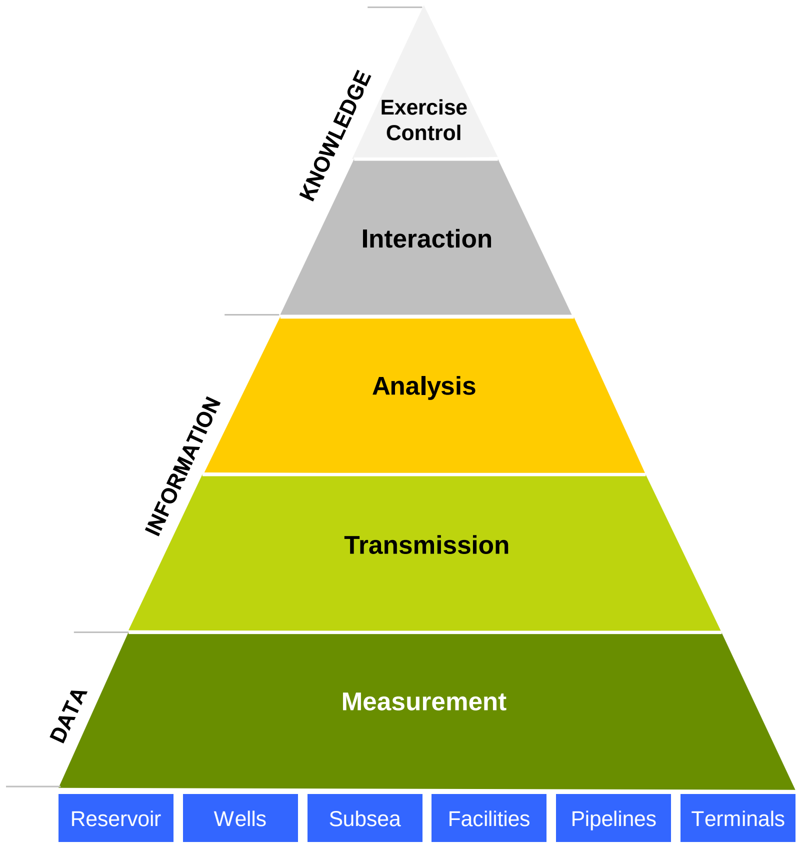


Figure 3.9 Field of the Future pyramid

Refer to IO capability model, The FotF capability model can be configured based on three basic layers. The foundation is sensing and communication infrastructure, the mid-layer is decision analytics and human interaction, while the top layer is operations capabilities. FotF capability model is illustrated in Figure 3.10.

Sensing and communication infrastructure encompass intelligent sensors, data transmission, data historian and data security system. Intelligent sensors are required to capture high quality process data from reservoir, wells and facilities [53]. High quality input data will produce high quality analysis in decision support system, in contrast, low quality data will produce inaccurate analysis that can lead to decision failure. Meanwhile, communication link requires high quality, high capacity, and low latency communication from asset to BP world in order to transmit data, voice and video [53]. Fiber optic is still the most preferred communication link due to its large data transmission capacity and durability, nevertheless, this option requires more investment. Finally, data historian is needed to store and connect real-time data to BP networks.

Decision analytics and human interaction encapsulate ISIS (Integrated Surveillance Information System), D2D (Data to Desktop), MBOS (Model Based Operational Support), ACE, and Business Transformation.

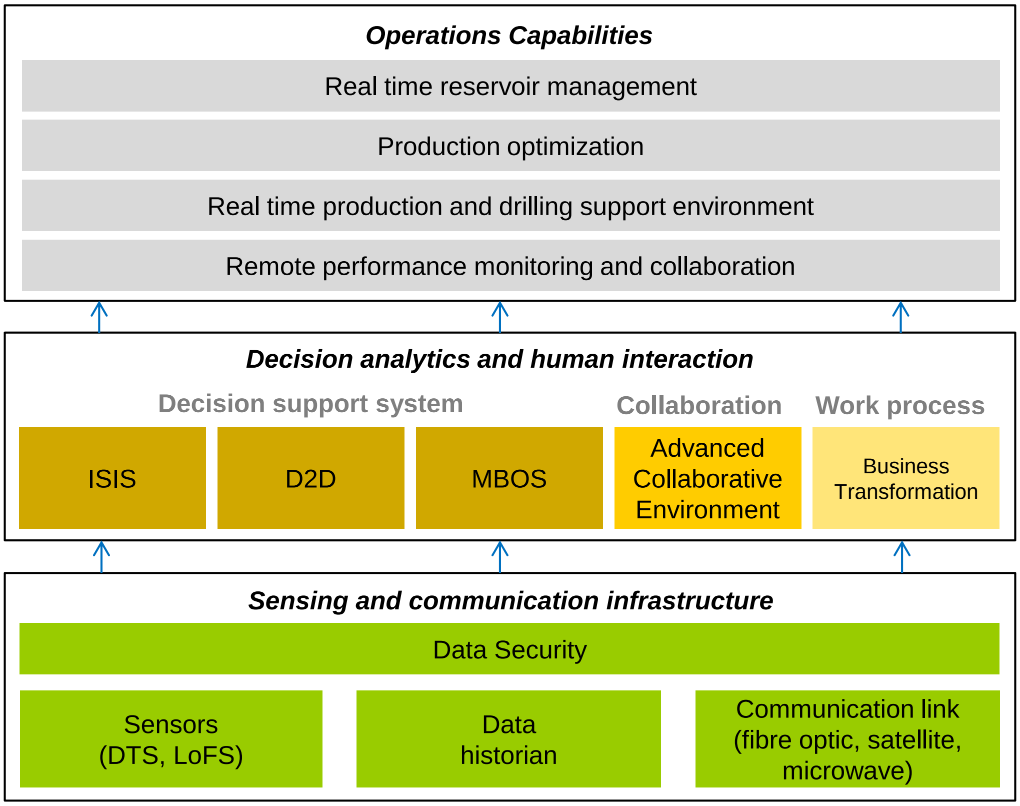


Figure 3.10 Field of the Future capability model

ISIS is a real-time surveillance tool that provides analysis and visualization of real-time surveillance data, information and knowledge processes [54]. It remotely monitors sensors placed in wells and production facilities, delivering real-time information (e.g pressure, temperature, sand detectors, erosion probes, valves and chokes condition) to experts as decision information [49]. Surveillance data is displayed through interactive web-based displays comprised of time series graph, cross plots, tables and topological diagrams that can deliver experts with the information they require [54]. ISIS automatically cleans and conditions data, provides alert on events, provides visualizations on topography (such as well, flowline, separator), and trending [55].

D2D is a real-time-based operations oriented solution to enhance remote performance management [49, 48]. It plays a key role as visualization tool to improve data understanding by providing decision information [49]. It also enables the onshore office to see exactly the same data and graphics as offshore control room (bring offshore control room to onshore) [45]. Therefore, D2D enhances collaboration and integration between offshore and onshore team by bringing real-time data to desktop. The access is not only from internal discipline but also external specialist contractors such as condition monitoring experts to provide proactive diagnostic and prognostic capability [49]. D2D includes solutions such as eLogBook (operations handover system), ERTT (equipment run time tracker), SVTT (safety valve travel timer) and alarm management system [48, 45]. This is the basic foundation of remote operations as exemplified in Valhall [49].

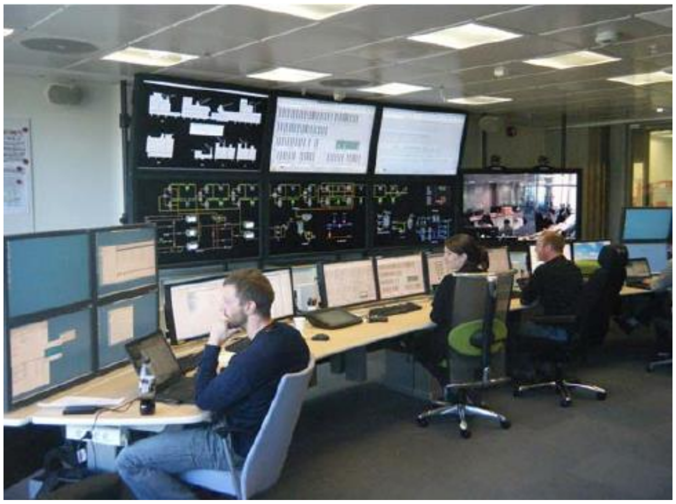


Figure 3.11 Valhall Onshore Control Room

MBOS is modeling and optimization solutions which provide capabilities of integrated optimization modeling from wells (subsurface) up to topside facilities (surface) [48, 49]. Scenario modeling will provide predictive analytics, “what if” analysis, optimization, visualization, and interpretation. Thus, MBOS enhances quality of decision to increase production in short-term and long-term. Additionally, It also plays an important role in measurement reconciliation across asset and helps to improve understanding of individual well production allocations and operating equipment performance [56].

ACE is collaboration arena to provide concept of “one team independent of location” by deploying modern video conferencing and visualization facilities based on input from real-time and near real-time data in historian [49]. This new way of work will drive top asset performance by strengthening teamwork, facilitating coaching and mentoring, and enabling fast response to dynamic situations thus creating dynamic capabilities against the uncertain situation. ACE provides three major capabilities [57]:

a. *Shared knowledge and situational awareness*. It is about the ability to provide a common understanding on asset operation state, regardless geographical and organizational barrier. Accessibility to high quality information, mutual understanding, and trust across the team are prerequisites to enable them to act on information in safe and reliable manner.
b. *Leveraged knowledge*. It is about the ability to leverage information into knowledge by engaging relevant multidiscipline expert judgment and utilizing collaborative technology and analytical application in order to perform high quality decisions.

c. *Global access to knowledge*. It is about the ability to engage in global knowledge and experts network. The network may expand across different assets, external organization, or global expert center.

Figure 3.12 Ula Integrated Operations Environment

As an example, Valhall asset has deployed ACE to facilitate collaboration. OOC (Onshore Operations Center) was built to support interactive collaboration in drilling campaign while IOE (Integrated Operations Environment) was built to support collaboration between operations team onshore and offshore. OOC is run on 24/7 pattern to support Valhall injection platform drilling operations. Valhall OOC is depicted in Figure 3.13 [58]. Meanwhile, IOE focus on two key process areas; firstly, integrated planning and maintenance support and secondly, production and wells optimization [49]. Ula IOE is depicted in Figure 3.12 [58].

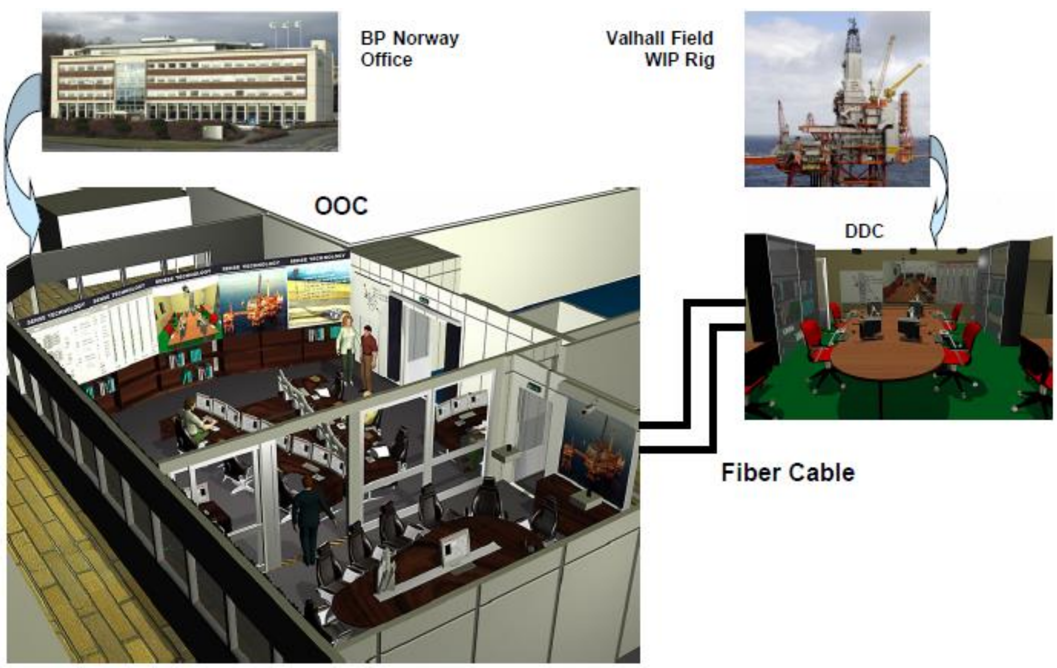


Figure 3.13 Valhall Onshore Operations Center

Implementation of FotF program requires an integrated design and effective change management approach to the business process, information flows, and people's roles and responsibilities [59]. Balancing and harmonizing of people, process, and change management is strategic differentiator imperatives to outperform FotF against other company's IO/ digital oilfield initiatives.

Business transformation is an initiative to enhance alignment between business strategy and technology as an enabler. It is basically an alignment of people, process, and technology [59]. One of the key issues is the transformation of work process to underpin team based and seamless type way of working which integrate multidisciplinary people around the globe. On the onset of FotF, the main focus of work process change is on the production optimization process. New work process is organized based on roles, information, and systems by the activity that uses them. Digital database is adopted to assist on responsibility distribution across team members, defining unique rules on certain activities, standardized workflows, linking to relevant procedures and promoting changes and modifications [59]. New workflows are developed based on human factor technique to ensure concepts and systems are properly embedded in internal organizations also with external contractors and suppliers [49]. Initial team engagement in the change process is crucial due to integrated work process involve people in cross-discipline, extending organizational span and work boundaries. Consequently, stewardship during the implementation of new work process is inevitably necessary to provide guidance on performance issues throughout the process. Active process stewardship, on-going communication, senior management attention, and performance management may provide a robust mechanism to institutionalize change and alter people mindset from acceptance to commitment [59].

3.2.2 Field of the Future key success factors

Based on extensive experience in deployment of FotF program, BP identified several key success factors as follows :

a. High commitment and engagement of organization [47].
b. Engagement and communications to assure relevant stakeholders are well informed and involved effectively to support during project implementation. Dedicated functional department is built to lead the implementation and to assure the sustainability of FotF program across specific assets [47].
c. Alignment with business needs and functional priorities as basic foundation material of deployment assessment [50].
d. Effective and balanced approach to R&D, deployment and value realization [50].
e. Project integration by the formation of the dedicated delivery team which consists of technology development and deployment function [47].

f. Establish integrated team comprises of operations, engineering, subject matter experts and information technology to represent the interest of multistakeholders and enhance engagement [60].

g. Technical system integrations and global standards application throughout all operating assets. FotF central team has developed global blueprint as guidance on design and implementation [47].

h. Availability of high bandwidth and low latency communications infrastructure to optimize digital oilfield solutions [45].

i. The design of collaborative environment needs to promote open information flow and behaviors that would lead to improvement in operational and production efficiency [52].

j. Establish applications and technical user support to assist asset in system implementation and operations especially during uptake phase [47].

k. Business transformation program to alter the current way of working into the new way of working as an adaptation to the implementation of new technology in order to gain maximum benefit to the organization. Change management is designed in place to be a fit for purpose [47].

3.2.3 Field of the Future challenges

Meanwhile, the challenges of the FotF deployment are defined on the following items :

a. Changes in culture of work and organizational capability is much slower that fast and rapid technology development.

b. Benefit measurement is challenging as it becomes “business as usual” [45].

c. There is an issue that large screen display is used for video surveillance of employees arising discomfort way of working offshore [49].

d. Standardize solutions for each field since equipment is manufactured by different suppliers [49].

e. Data security to protect vital data from stranded inside highly secure process control networks [49].

f. Competition with other business priorities and initiatives especially when the opportunity window is tight such as required cost to implement [50].

g. Sustaining uptake and utilization due to active barriers from technical, business, organizational diversity in portfolio assets [50].

h. Resistance to change from the traditional way of working due to existing performance contracts, technology plans, existing procedures, limited number of skilled people, and operational funding [60].

i. Engagement with operations staffs in the early design and operation of ACE project [47].

j. Integration of new systems with existing systems in brownfield asset implementation [55].
k. Substantial impact on human factor such as the perception that changing of work location from offshore to onshore will reduce "field experience", reduce field remuneration, less of direct people interaction, lack of physical activity, miscommunication and change in work life balance [51].
l. "*Big data*" management as the impact of real-time operations.

3.3 Shell's *"Smart Fields"*

Smart Fields is a strategic initiative of Shell to operate their global assets smartly. It transforms Shell's global assets into smart assets by integrating capability of people, process, and technology. Smart technology and CWE will integrate offshore team, onshore team, and global experts as one virtual team enabling them to work together smartly in order to make better and faster decision making. Smart Fields has successfully increased production and hydrocarbon recovery factor.

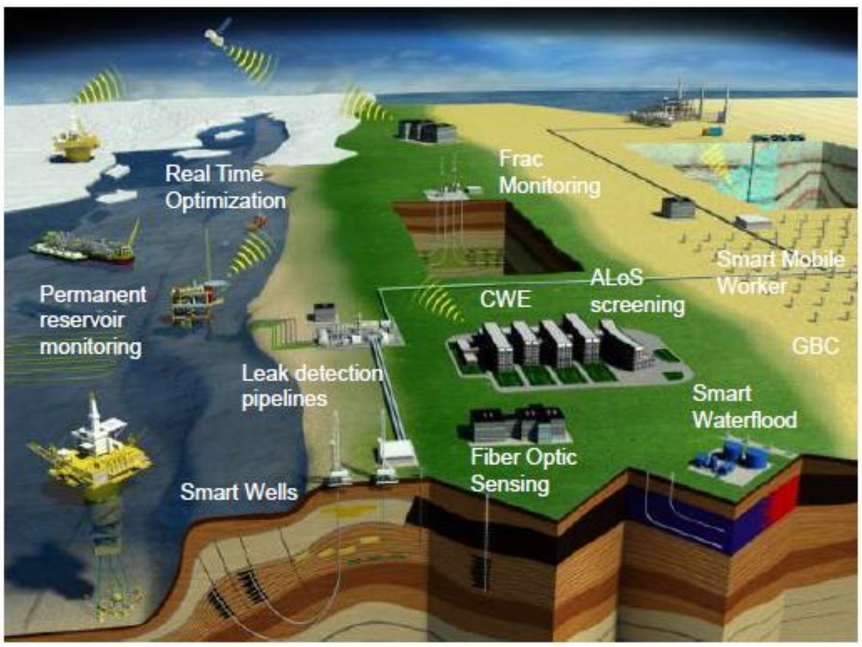


Figure 3.14 Smart Fields

Shell's *Smart Fields* is digital oilfield concept that is aimed for continuous optimization of an asset or group of assets through the integration of people, tools, and processes [61]. It provides intelligent capabilities for asset team to optimize production in short-term and long-term in an effort to maximize lifecycle value of assets. Smart field approach is more on proactive rather than reactive approach to the reservoir and asset management [62]. Proactive means that the system is designed for solutions capability rather than fix the problem subsequent to system malfunction. The investments are focused on key infrastructure to build operational responsiveness and greater flexibility in work process. Smart fields concept is illustrated in Figure 3.14 [63, 61].

Shell initially started Smart Wells initiative as the embryo of Smart Fields program in 1999. Experience and insights from implementation of Smart Wells in a number of assets are the foundations of the establishment of Smart Fields initiatives in 2002. Smart Fields program was initiated by formation of global Smart Fields team that was aimed to implement smart fields on global asset operations. Initially, Smart Wells initiative was designed to have a narrow focus on the development of downhole control and monitoring. Instead, Smart Fields coverage are extended widely into integration on end to end process from reservoir to point of sales [64]. The journey of Smart Fields is illustrated in Figure 3.15 [65].

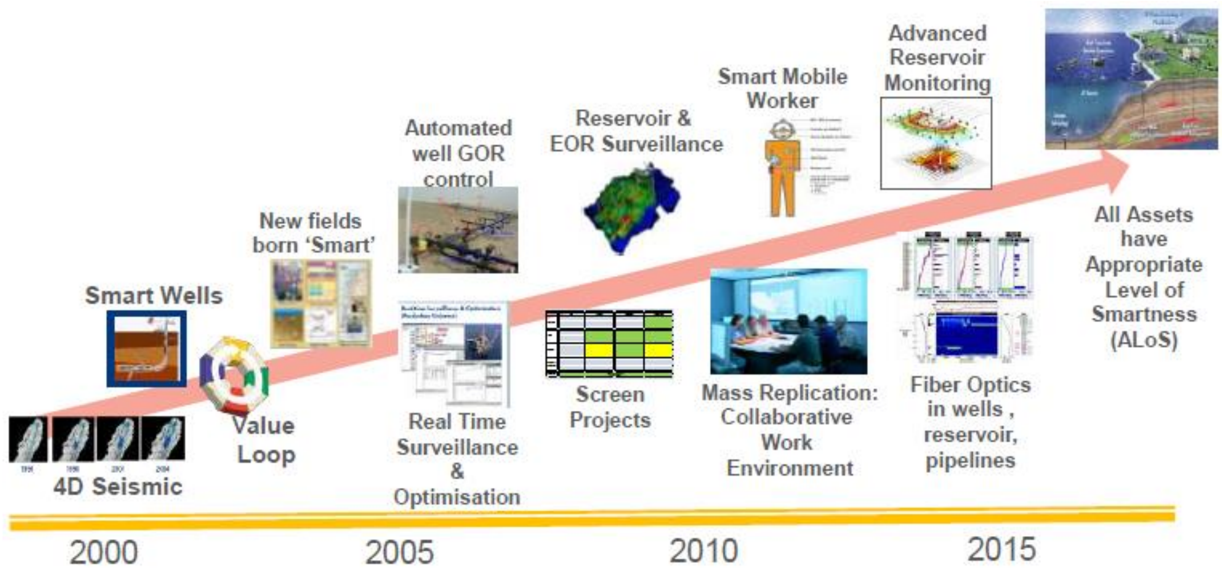


Figure 3.15 Smart Fields journey

During the first decade, Smart Fields were focused on making business cases and implementing new technology to obtain the feasibility of value creation to business [66, 65, 63]. The global implementation of Smart Fields is led by Shell Research and Development organization which continuously coordinate with regional team in charge in new asset development and reservoir management. The portfolio of solutions in the first decade is 4D seismic, Smart Wells, and real-time surveillance.

By the second decade, the focus of program has shifted on accelerating implementation across assets to achieve ALoS (Appropriate Level of Smartness) which deploy the mix of right ingredients of solutions to achieve sustainability deployment and continuous value creation [66]. Real-time monitoring center was expanded to become CWE to achieve better collaboration, faster and better decision making in drilling and production activities [67]. In addition, a couple of new solutions, such as Advance Reservoir Surveillance and Fiber Optic Monitoring, are added into Smart Fields deployment pipeline [65].

Shell has implemented Smart Fields solution into global asset operations with various diversity environments such as deep water, arctic, land, heavy oil, EOR, water flood and integrated assets [65]. The Smart Fields deployment is focusing on core business process which are *field development, well and reservoir management, facilities management, and operations* [68]. According to value assessment of Smart Fields in 2008, fifty global assets had been deployed with Smart Fields spectrum of solutions ranging from brownfields into green fields assets [68, 65, 63, 69]. The global footprint of Smart Fields is represented in Figure 3.16.

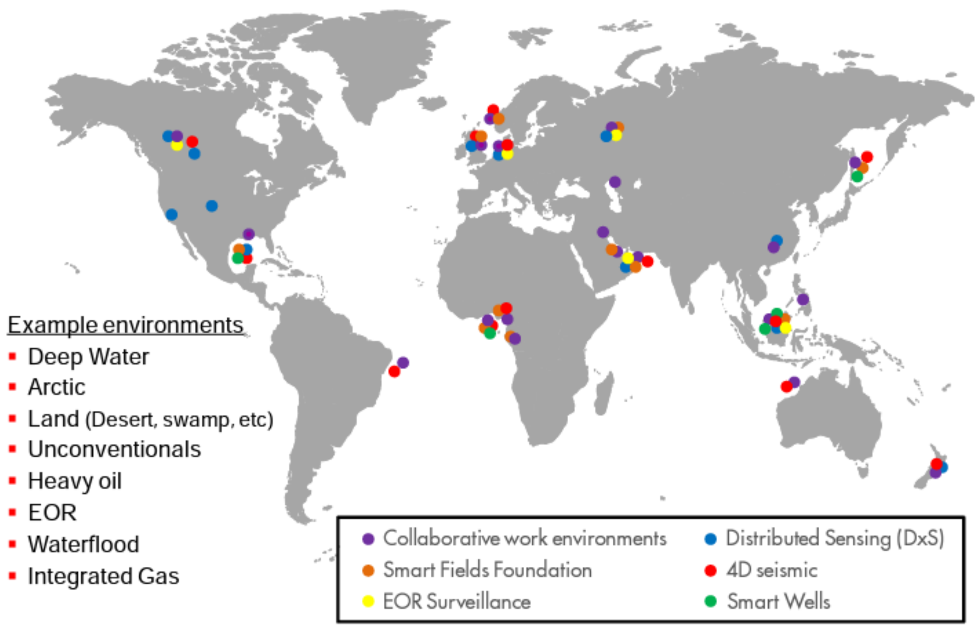


Figure 3.16 Smart Fields global footprint

The value creation of Smart Fields is exceptionally significant reaching US$5 billion according to assessment on Shell's global assets throughout 2002-2009 [68]. Core work processes are the key sources of value creation in Smart Fields that bring capex reduction, increasing recovery factor, increasing production, and improving HSSE. The valuation rationale coupled with value creation is depicted in Figure 3.17 [68]. The valuation is assessed on a wide range of Smart Fields deployment from retrofitting brown fields with ALoS (Appropriate Level of Smartness) into configuring new green fields to fulfill "*born to be smart fields*" principle. *Born smart* is enabled by bringing together (in one room or virtually) multidisciplinary experts to jointly understand decision problems, based on relevant information at hand, and coupled with inherent uncertainties, in order to make better and faster decisions that improve asset performance in present and future [36].

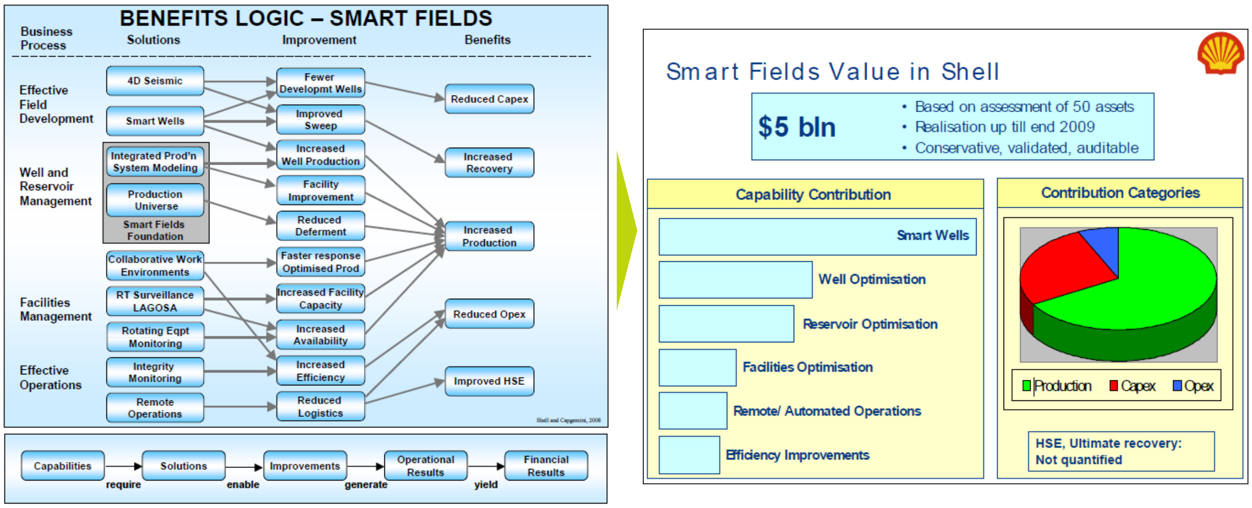


Figure 3.17 Value of Smart Fields

3.3.1 Smart Fields capability model

Smart Fields are designed and deployed based on guiding principle stated in "Value Loop". *Measure – Model – Decide – Execute* is the basic principle of Value Loop [62].

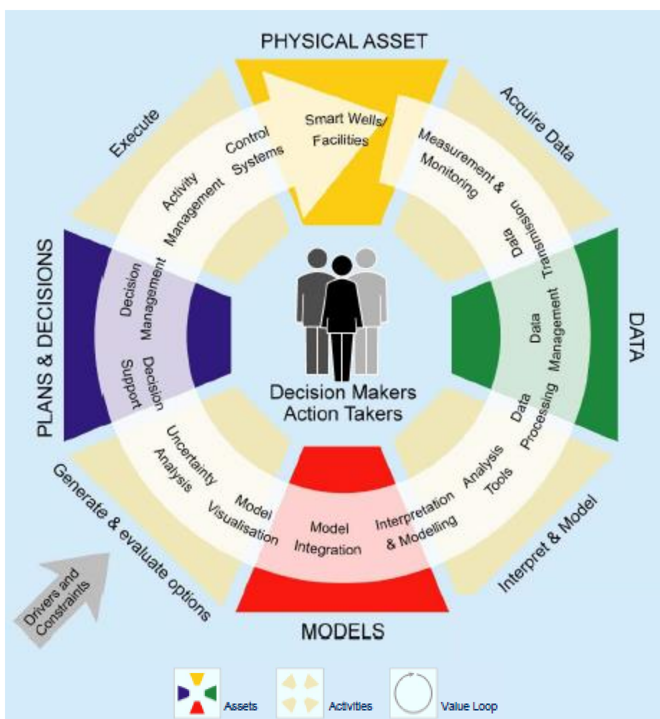


Figure 3.18 Value Loop

It is an integrated system design philosophy encapsulating people, process, and technology as one system approach. Interconnection of multiple subsystems in Value Loop implies that technology can be smartly capitalized through smart integration of all subsystems by closing the loop in order to realize valuable business objectives [70, 61, 62]. This concept has been robust as a guideline in the deployment of Shell's global asset in a nearly decade [66]. Value Loop governs that Smart Fields is a field in which all key subsystems of value loops are completely integrated in terms of data, models and decisions [71]. Smart Fields is not merely about technology deployment in oilfields. Each element in the value loop shall be interactively interconnected and integrated (closed-loop). The performance of each subsystem in the Value Loop will determine the asset performance in global context. Collaboration, between people with the right skillsets and experiences, is key components to complete the jigsaw of the system in order to create continuous and sustainable value in the future. Work processes are defined appropriately in place to lubricate the circulation of work in the value loop enabling high quality decisions and planning. All of the elements in the Value Loop cycle shall be fulfilled to enable continuous optimization throughout all lifecycle of the field.

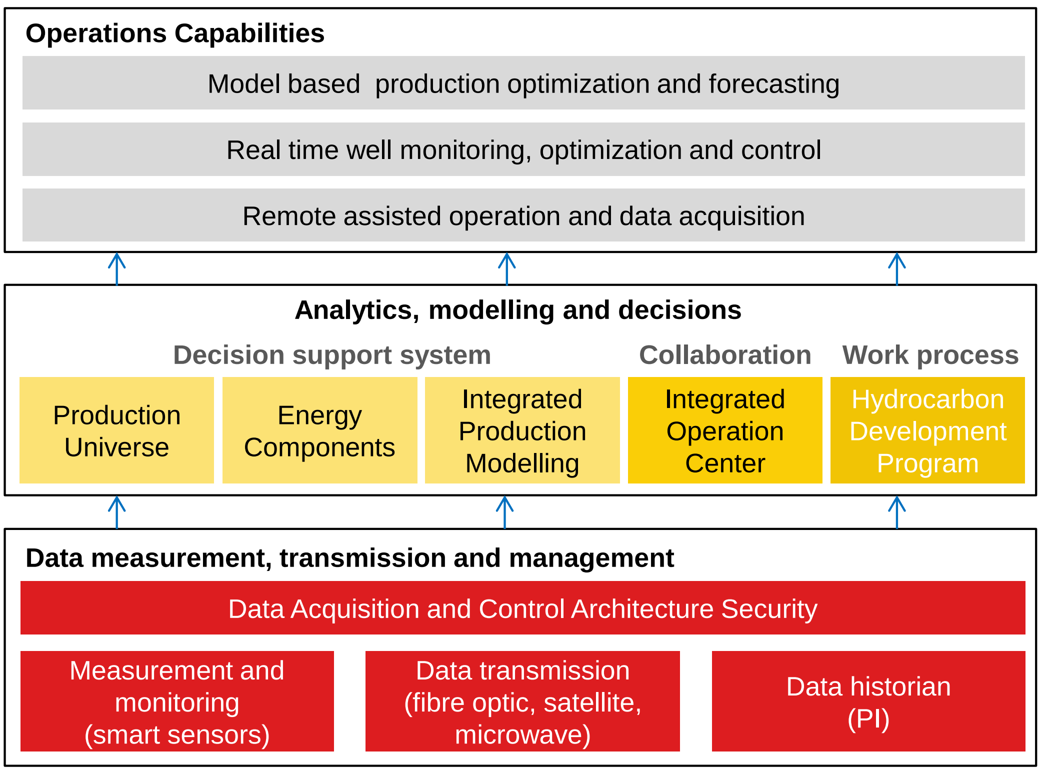


Figure 3.19 Smart Fields architecture

Smart Fields is a capability-based model to create a competitive advantage for Shell. Capability in this context is the integration of skills, tools and work process in CWE facilitated by advanced technology and management system [62]. Smart Fields' capability architecture comprises of data and telecommunication infrastructure, decision support system, collaboration and work process system as illustrated in Figure 3.19 [61, 70].

Data and telecommunication infrastructure build the foundation of Smart Fields system. It comprises of measurement and monitoring system and data management and processing system.

Smart sensors and instruments are agents of measurement and monitoring system. They are located on remote assets to acquire real-time data from well, subsea, pipeline and topside facilities. Pressures, temperatures, flow rates, and other key operational data are monitored in real-time continuously. Multiple sensors and instrumentations are connected to PI system that unifies streams of information into a single and comprehensive system that enable personnel to capture and store data efficiently [70]. In addition, DACA is interconnected as firewall system to assure system security. It is a defense mechanism that enables asset operator to set up and control from a field whenever what happen in the office (separate system). DACA and PI are agents of data management and processing system. Then real-time data is transmitted from offshore facilities to onshore control centers via fiber optic line, satellite or microwave communication pipeline as agents of data transmission system. The data can also be transferred from anywhere in the world through internet or intranet removing geographical barriers and create remote operations capability.

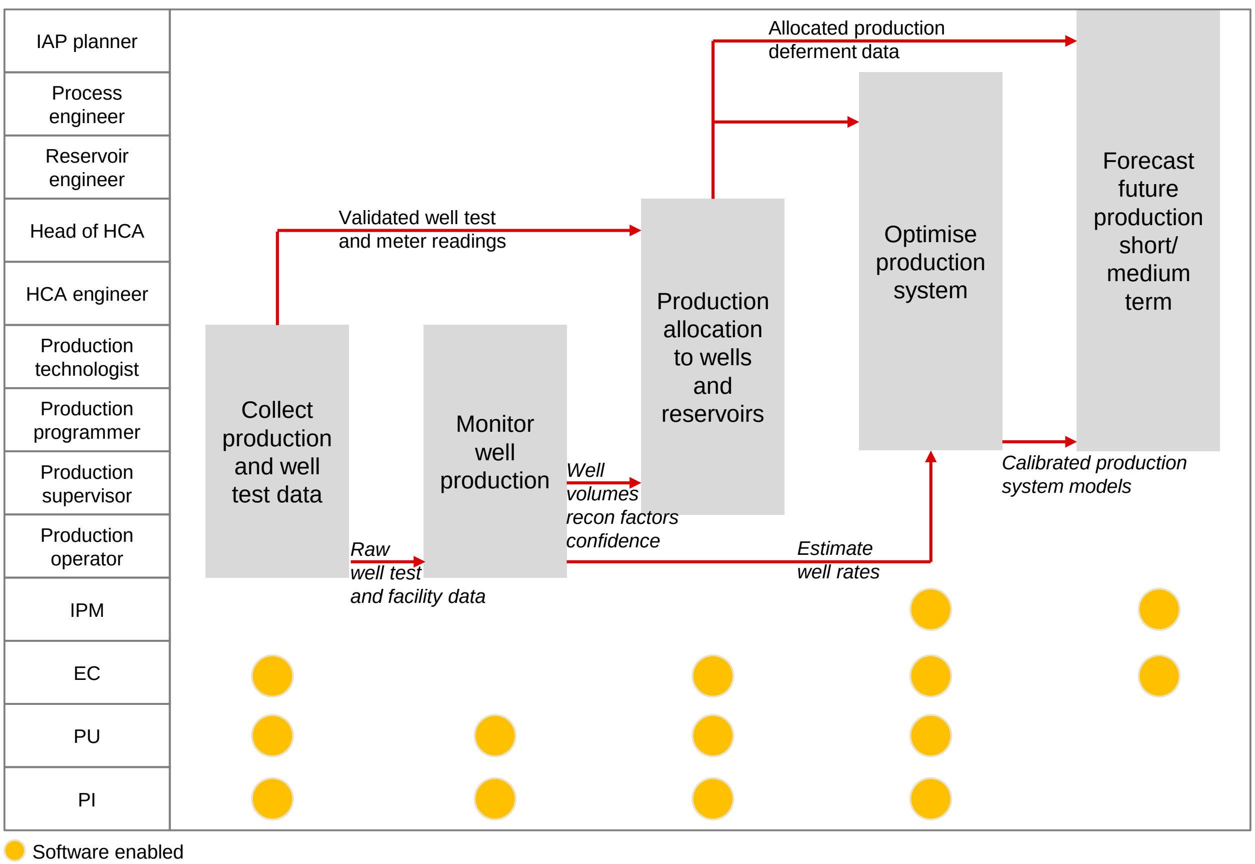


Figure 3.20 Example of Smart Fields work process

Decision support system is deployed mainly to support decision making in better and faster way. A set of software collections is designed and deployed to enhance the quality of decision making in core work process. These softwares are enablers to provide powerful information as a basis for strategic, tactical and operational decision loops. There are three main softwares that build decision support system.

Firstly, PU is used to calculate the correlation between flow rates and any other associated well measurements such as tubing head pressures and temperatures; flowline pressures and temperatures; downhole pressures and temperatures; choke positions; gas lift rates; and ESP frequencies, currents or power fluid rates [70]. It is a bank of well-by-well production data that can be deployed to make a field smart especially in production allocation process. It provides continuous real-time estimates of well-by-well oil, water and gas production based on data driven models from production well tests and real-time production data [72].

Secondly, EC is a software that stores production data and well parameters and then automatically process this information into daily or monthly allocation [70]. It can generate production, status and deferment reports that become an input of production historical data for the objectives of field management and hydrocarbon allocation.

Thirdly, IPM is an advanced tool which has the capability to model complex integrated system from the reservoir to topsides. The deployment of IPM will benefit from multidisciplinary integration in updating and calibrating model thus producing more robust production forecast [73]. This tool can also create "*what-if*" scenarios that can simulate the potential value addition during the lifecycle of an asset. The example of work process that is integrated with decision support system and people allocation is depicted in Figure 3.20 [61, 74].

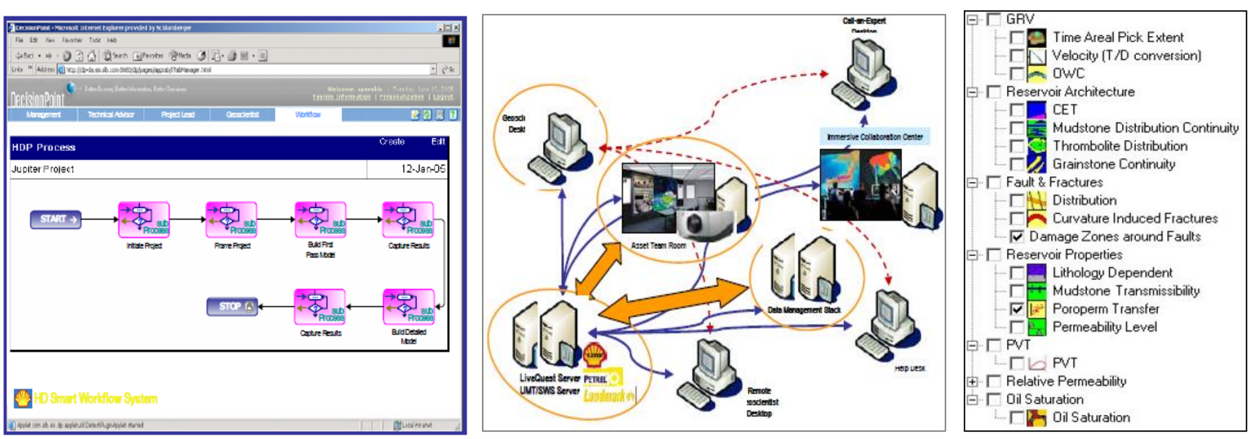


Figure 3.21 SWS, SCE and UMT

Work process is integrated by deploying Hydrocarbon Development Program (HDP). The goal of HDP deployment is delivering integrated solutions to combine skills, work processes, data, application tools, and knowledge within CWE in order to reduce cycle time, foster better collaboration, and improve the quality of decisions under uncertainty [36]. There are three important solutions of HDP which are SWS (Smart Workflow System), SCE (Smart Collaborative Environment) and UMT (Uncertainty Management Tool).

Firstly, SWS provides an integrated framework that combines skills, application, data, knowledge and work processes [75]. It is also interconnected with modeling software such as Petrel, MoRes and fully integrated with SCE. Each plan and activities are executed and managed based on integrated workflow in SWS. SWS has capabilities of providing workflow guideline from a decision support based perspective; facilitating relevant data acquisition, storage, decisions, rationale and work results; acting as events management during operation process; supporting project planning; managing necessary resource; managing progress tracking and reporting functions; and integrating Shell's intellectual capital such as guidelines, standards and knowledge [75].

Secondly, SCE is a network of individual offices (secure desktop), development team rooms (an information hub and collaborative workspace linked to real-time drilling and production surveillance centers), satellite team rooms (remote parties to connect for collaborative review sessions) and high-end 3D visualization facilities (such as cave automatic virtual environment) [75]. It supports collaborative network spaces encapsulating IT, data, and knowledge management as key enablers to collaborate effectively. As a result, effective collaboration will facilitate distinctive operations capabilities.

Thirdly, UMT is a tool to capture and manage contextual information on uncertainties. It enables the collaborative team to define key uncertainties, documents decisions, risks, and comments associated with plans and tasks. Consequently, it provides integrated decision making that enables a better understanding of interconnections between decisions and uncertainty involved [75].

Figure 3.22 CWE Smart Fields

There are two types of worldwide CWEs implementation in Shell [67]. Firstly, Asset Production Surveillance and Field Management CWEs that focus on the single asset to provide effective collaboration between onshore support office and remote assets. All asset management team members are co-located in the CWE where it has access to audiovisual rooms enabling collaboration with remote assets personnel, internal and external experts, external organizations (contractors, vendors, suppliers) and other stakeholders. Continuous collaboration between onshore programmers and asset operations supervisors facilitated via uninterrupted video communication link. Field surveillance and decision making are conducted based on standard business processes as a common guideline. Secondly, the category is Drilling Real-time Operations Center (RTOC). This type of CWE is specially dedicated to supporting drilling activities in a 24/7 connectivity. Well experts in the office are supporting on-site drilling engineer by providing real-time analysis and alert to onsite drilling engineers, while accountability and control remain on onsite drilling engineers [67]. Given the valuable benefit of CWE, Shell leadership team decided to apply CWE projects in 100 assets around the globe [67]. According to Perrons [72], the typical CWE setting is depicted in Figure 3.22.

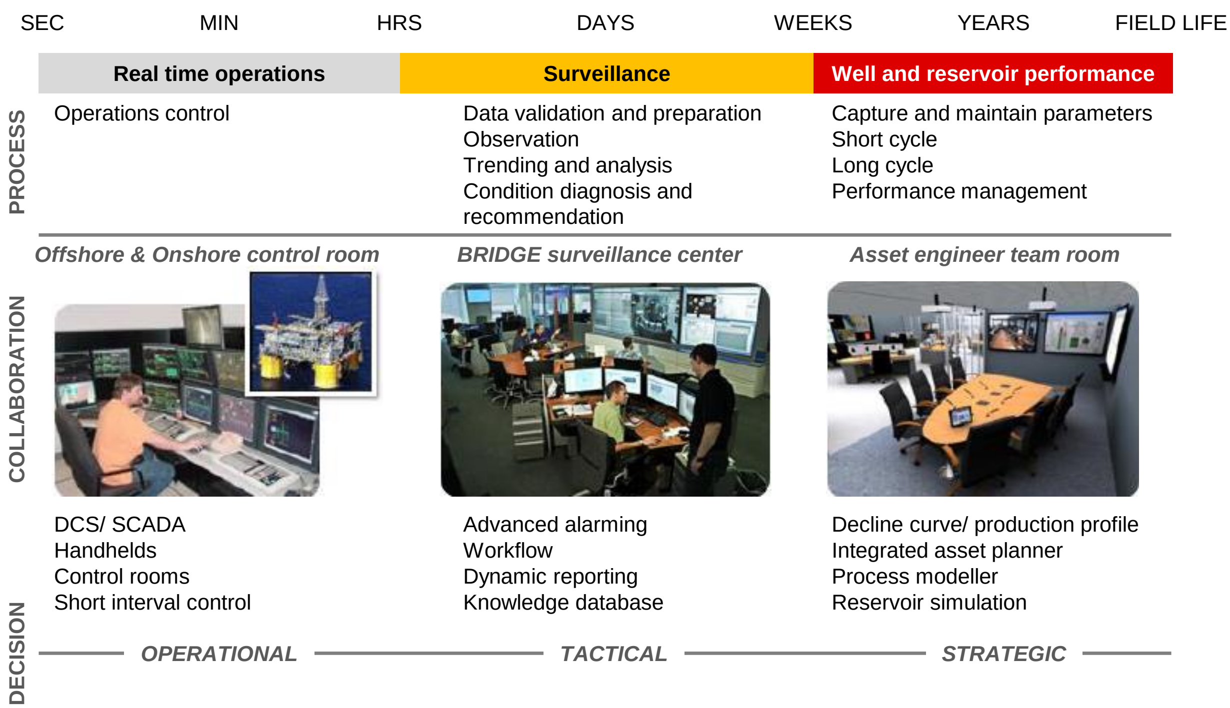


Figure 3.23 Shell work process continuum

Alternatively, other types of CWEs are deployed based on decision loop continuum as depicted in Figure 3.23 [32]. It is designed to support lean operations and maximum utilization of onshore engineering experts in Shell America. Effective utilization of experts and engineers are gained through the elimination of waste in surveillance engineers day, allowing them to focus on tasks with the highest value and also removing unnecessary analysis [32].

Real-time operations are operated under RAO (Remote Assisted Operations) that provides an onsite link between offshore central control room and RCR (Remote Control Room) in onshore.

This operation setting will enable additional control, monitoring capabilities, and remote operations [76, 77]. This center also provides remote real-time monitoring of wells and facilities across a number of assets [67]. *The Bridge* is functioning as central surveillance center by continuously scanning data from offshore to identify anomalies to be observed and monitored by experts. The experts will provide alerts, diagnosis and decision recommendation to offshore engineers by utilizing relevant tools and models, and collaboration with external experts (such as vendors or contractors) when necessary. VAT (Virtual Asset Team) is the actor in *well and reservoir performance* planning and analysis. Experts will utilize well and reservoir data for the sake of field development planning, optimization and providing decision alternatives to maximize long-term performance of assets throughout its lifecycle. The objectives of this virtual team are to optimize ultimate recovery, identify complex intervention opportunities and recovery process evaluation. CWE network is established to create active connectivity between offshore assets (CCR), RCR (onshore remote operations), The Bridge (asset surveillance center), VAT (well and reservoir performance improvement center) and external organizations (external experts and vendors) [76].

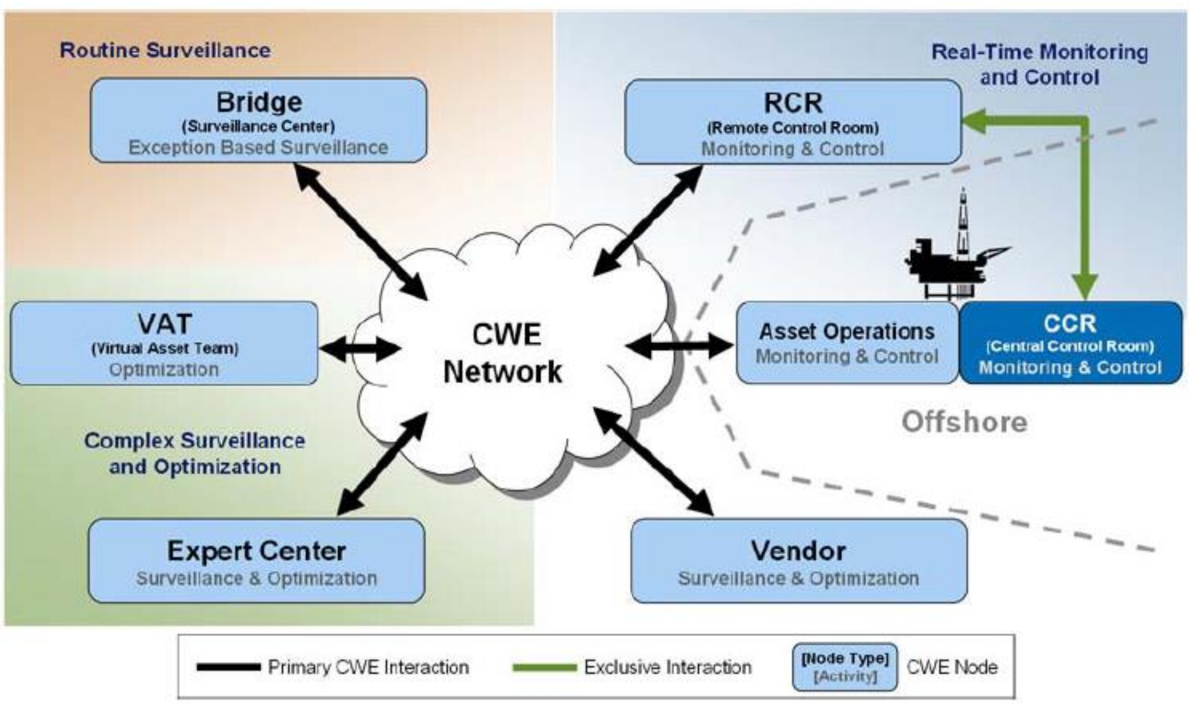


Figure 3.24 CWE network

3.3.2 Smart Fields key success factors

Based on deployment of Smart Fields, Shell has identified several key success factors as follow :

a. Link the performance of Smart Field implementation into key performance indicators (KPI) to engage commitment and business ownership of the team and senior management in order to realize the sustainable value of Smart Field program. KPI is allocated in clear role, responsibility and accountability within team members [67, 66, 78].

b. Integrate technology with people and organizational elements to build sustain integrated capability development in the future [66, 63]. Human is the central focus of Smart Fields program while technology plays a key role as enabler [79].
c. The goodness of fit between solutions and asset architectures. Technology is deployed in closed loop principles creating lean work process and effective organization. Solutions are aligned with business needs and Appropriate Level of Smartness (ALoS) [66, 63].
d. The quality of leadership and level of expertise within the project and asset team [66, 63].
e. Global and local learning network to facilitate knowledge sharing between experts and team members. [66]
f. Establish central Smart Fields organization as a strategic node to coordinate and support all implementation initiatives across global assets [63]. Virtual team existence is critical to the success of Smart Fields implementation that it can promote collaboration between asset team and central Smart Fields organization [80].
g. Effective change management program to shift from a traditional way of working into new work culture, new work process, and new people’s skillsets. The regular intervention of leaders is essential to embed expected behavior from team members [61, 65, 81].
h. Continuous learning of staff in Smart Fields tools and processes to ensure minimal knowledge gaps between implementation and required level of capability [61].

3.3.3 Smart Fields challenges

Meanwhile, the challenges of Smart Fields implementation are as follow :

a. New type of organization requires change that may create conflict in new matrix type organization. There is potential conflict arise between functional authority and process authority that has different point of focus in objectives [82].
b. Each of the assets has its own unique features and challenges with different level of complexity. Smart Fields is not a “*one-for-all*” concept [70]. Brownfields and Greenfields have different approaches and methodology to obtain success. Greenfields project can be born smart with certain level of smartness while brownfields are selectively deployed depending on size of opportunity window. Project initiatives shall be consistently screened and deployed with appropriate standards [63].
c. Organizational capability to accept change and transform into new operating model .
d. Management of “*big data*” to proactively filter and process data into meaningful information to support decision making [65].
e. Integrating people with a wide diversity of technology solutions, complex process, tools in order to perform real-time analysis and decision making [36].

3.4 Statoil *"Integrated operations"*

IO was established as a national program in Norwegian petroleum industry since 2003. It was initiated by petroleum industry players in NCS to establish operational networks and collaborative partnerships between field operators and oil services-support-supply companies through active integration framework enabled by advanced digital technology [83]. This is regional initiatives to response on the major challenge on operations in Norwegian Continental Shelf (NCS) such as declining oil production, rising operation costs, oil price volatility, declining investment in petroleum activities which may hamper future sustainability [83].

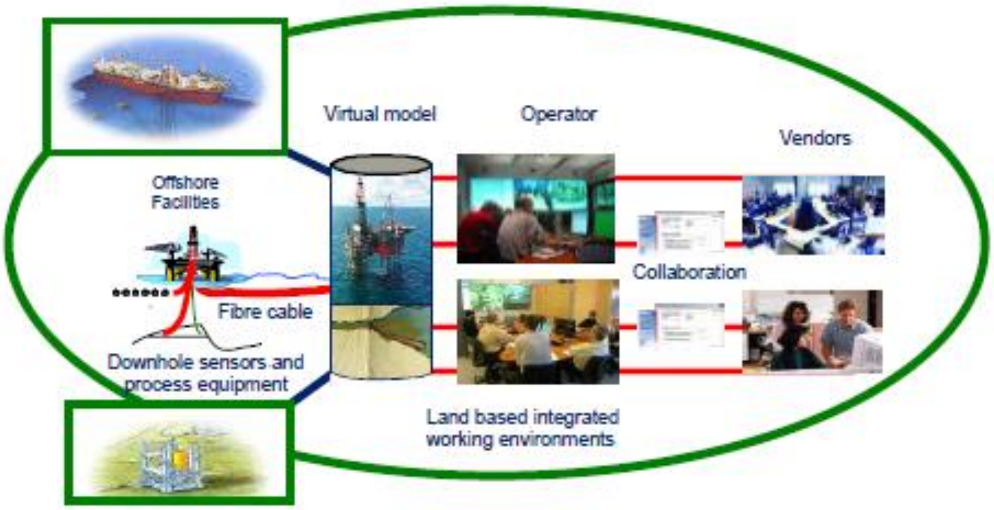


Figure 3.25 Integrated operations

IO is defined as "*new work process which uses real-time data to improve the collaboration between disciplines, organizations, companies and locations to achieve safer, better and faster decisions*" [84]. Real-time data and information are available and enabled from downhole monitoring into topside facilities transferred to the onshore operations center via high bandwidth and low latency communication infrastructure such as fiber optic. Collaboration is facilitated in the onshore operations center, supported by utilization of visualization and video conferencing technology to support CWE. Co-located multidisciplinary experts in CWE promote multifaceted perspectives on decision problems, as a result enhancing the level of knowledge on problems that lead to high quality decision making. Effective implementation of IO relies on harmonization and synergy between technology nodes, multidisciplinary collaboration of people and integrated work process. The basic concept of IO is illustrated in Figure 3.25 [85].

The milestone of IO program is the installation of subsea fiber optic networks called SOIL (Secure Oil Information Link). It is a highly reliable, secure and high-bandwidth digital infrastructure which supports key intelligent activities such as joint online monitoring between offshore and onshore support center, real-time data acquisition, joint data analysis and interpretation, and 24/7 connectivity for collaborative decision making and work planning [86]. The capability of SOIL enables offshore and onshore team to be integrated into "*one team*" concept removing geographical and organizational barriers. Nowadays, SOIL coverage is also extended to UK interconnecting offshore oilfields in UKCS. SOIL infrastructure and capabilities are depicted in Figure 3.26 [86].

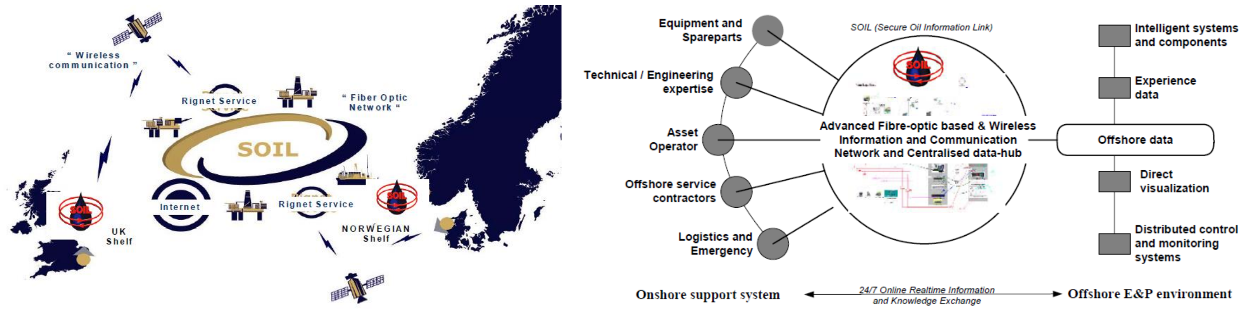


Figure 3.26 Secure Oil Information Link

4G/LTE wireless technology is the latest adoption of digital communication technology to support offshore high bandwidth communication network in the North Sea. It enables not only faster and better data transfer between assets but also connectivity with wireless handheld communication for better collaboration. The wireless network infrastructure is depicted in Figure 3.27 [87].

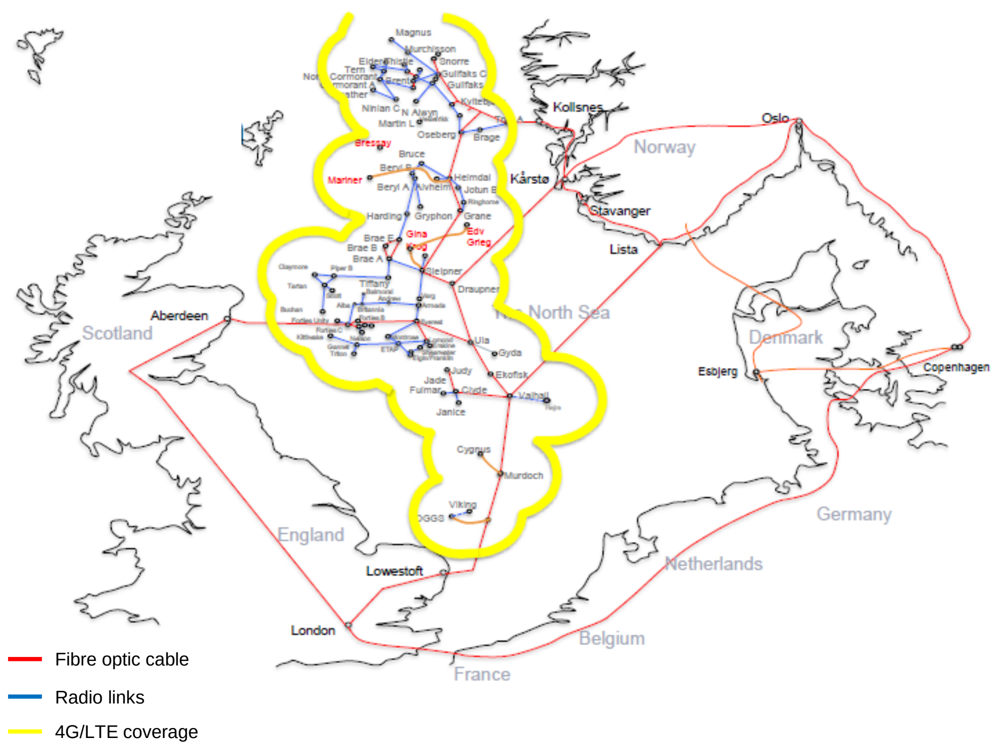


Figure 3.27 North Sea offshore communication infrastructure

IO is developed into several key stages. The stages are designed based on results on pilot project and result evaluations. OLF (Norwegian Oil Industry Association) distinguishes IO development in NCS into two essentials stages which are G1 (integration across offshore and offshore) and G2 (integration across oilfield operators and vendors). G1 focused on integrating process and people (offshore and onshore) supported by ICT technology as an enabler to improve offshore operations and onshore operations support. G2 is the extended scope of G1 by broadening the boundary limits of integration throughout external organizations such as oil services, suppliers, and vendors. This is operating model with seamless boundary within internal and external organizations enabling maximum value creation through learning and knowledge transfer between nodes in IO. Oil operators will have access to utilize distinctive capabilities of services company to enhance operational performance such as reservoir modeling update, real-time drilling well control, remote well completion, and integrated optimization from the reservoir to export lines. In the future, IO seems to extend integration across portfolios and global regions The development of communication infrastructure will support capability of integration across global operations portfolios that shape macro-scale integration [83]. The uptake process for each of the phases is illustrated in Figure 3.28 [88].

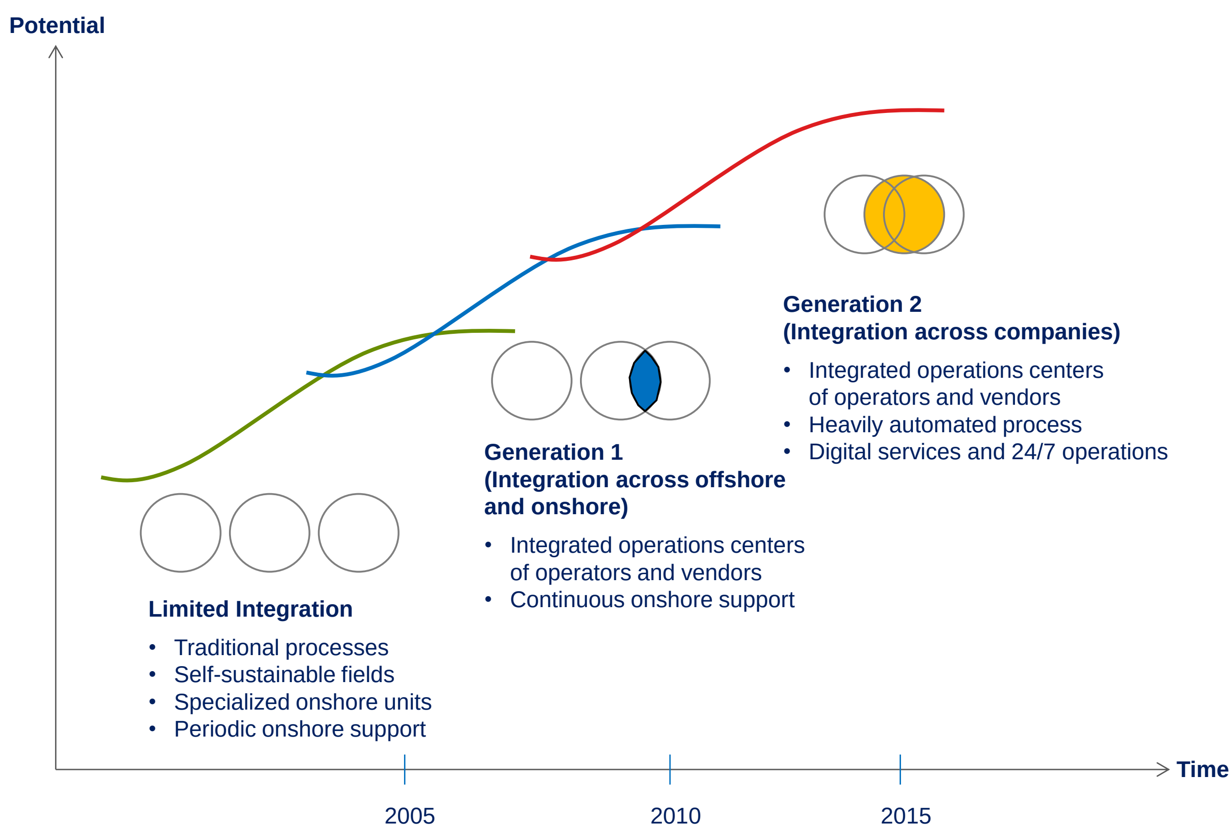


Figure 3.28 Integrated operations journey

The focus of IO implementation is on key work processes such as well planning and execution, well completion, production optimization, and maintenance management. The deployment is expected to generate value through better well placement, reduce non-productive time (drilling efficiency), improve well operations (well productivity), improve production rate and export capacity and improve regularity [88]. In addition, OLF estimated that IO implementation will bring additional value creation with expected value potential at around NOK250billion over the period 2005 to 2015 as illustrated in Figure 3.29 [89].

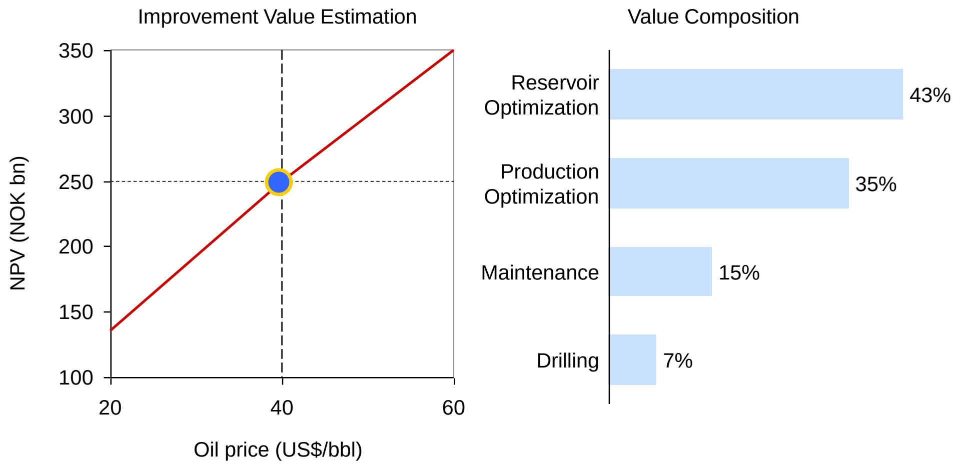


Figure 3.29 Potential IO value creation

3.4.1 Statoil's Integrated Operations capability model

Statoil, that is the largest hydrocarbon producer in NCS, plays a major role in the implementation of IO in NCS. It is also one of the early movers of digital oilfield initiatives. With approximately 80% of its hydrocarbon reserves located in NCS, it is estimated that IO initiative will deliver value creation at around US$33bn to Statoil [90]. Statoil believes that the sources of value creation come from increasing recovery factor, improving well placement, improving drilling and well operations, increasing regularity, reducing operations and maintenance (O&M) cost, enabling proactive and situational awareness, and improving HSE. Accordingly, this huge value creation may become the strategic rationale for Statoil to declare IO as one of their top corporate strategic initiatives. Statoil top management gives strong support to IO initiative. Helge Lund (former Statoil CEO) stated that "*Real-time competence sharing is necessary for complex and demanding industry. It is all about integrated operations and people in seamless collaboration, independent of organization, time and place. Our future success is dependent on our ability to draw on our experience from the Norwegian Continental Shelf (NCS) when we go global. New work processes and interaction by means of IO will facilitate the sharing of knowledge between Norwegian experts, suppliers, and local operators in other countries*" [91]. Transition from traditional way of working into IO way of working is illustrated in Figure 3.30 [92]. Roland [92] explained that the main differences are as follow :

a. *Serial to Parallel*. The main enabler, in IO way of work, is collaboration work arena where multidisciplinary experts are either co-located or distributed forming virtual team. This team will jointly work in parallel to analyze and interpret common real-time information hence, they are capable of synchronizing multiview ideas to produce better and faster decision making.

b. *Single discipline into Multi-discipline*. The new way of work will involve multidisciplinary experts by removing "functional silos" and "serial way of working". In traditional way of working, each of the functions works individually and information is flown like a relay. Due to the existence of collaboration arena, multidisciplinary experts are jointly working together in one location hence reducing decision loop and cycle time.

c. *Dependent of physical location to independent of location*. Deployment of ICT technologies enables faster transfer of real-time data from offshore facilities to onshore support center and communication through video-conferencing and visualization. This technology enables integration of offshore and onshore team as "one team" despite geographical and organizational barriers. As a result, this capability reduces offshore trip and headcount of offshore personnel that reduces personnel exposure to offshore hazards.

d. *Decisions based experience data to decisions based on real-time data*. In IO framework, decisions are made based on real-time data thus producing near real-time decisions as exemplified in condition-based monitoring maintenance. Experts are co-located in onshore support center and give direct advice about relevant actions to be performed by offshore personnel. This work setting is proven in enhancing facility regularity.

e. *Reactive to Proactive*. IO work processes offer on more proactive approach by increasing predictive capability. Therefore, relevant decisions can be made prior to incidents (proactive approach) instead of after incidents (reactive approach).

Before Integrated Operations	With Integrated Operations
Serial	Parallel
Single discipline	Multidiscipline teams
Dependent of physical location	Independent of location
Decisions based on experience data	Decisions based on Real-time Data
Reactive	Proactive

Figure 3.30 IO shift way of work

Based on the explanation above, collaboration between people and organization is the key nucleus of IO. Collaboration is facilitated by collaborative and visualization technology. Effective change management to shift smoothly from traditional way of working into IO way of working is inevitably necessary. Organization needs to be modified to support effective organization. As an example, onshore support center can be transformed into matrix type organization with greater emphasis on process. Novel management can be transformed from more hierarchical type into controlling role which stimulates openness, trust, knowledge, learning and innovation. Training and pervasive support from leadership are essential to obtain effective change.

As IO has been perceived as key success factor of operations, IO has been formalized as Statoil's standard operating model. IO is deployed on basic principles that administrative tasks such as planning and decision making will be done onshore while offshore will be more focus on facility operations and safety issues. The key nucleus of IO is collaboration in core process that are drilling and well, subsurface, and O&M. The IO operating model is depicted in Figure 3.31 [93].

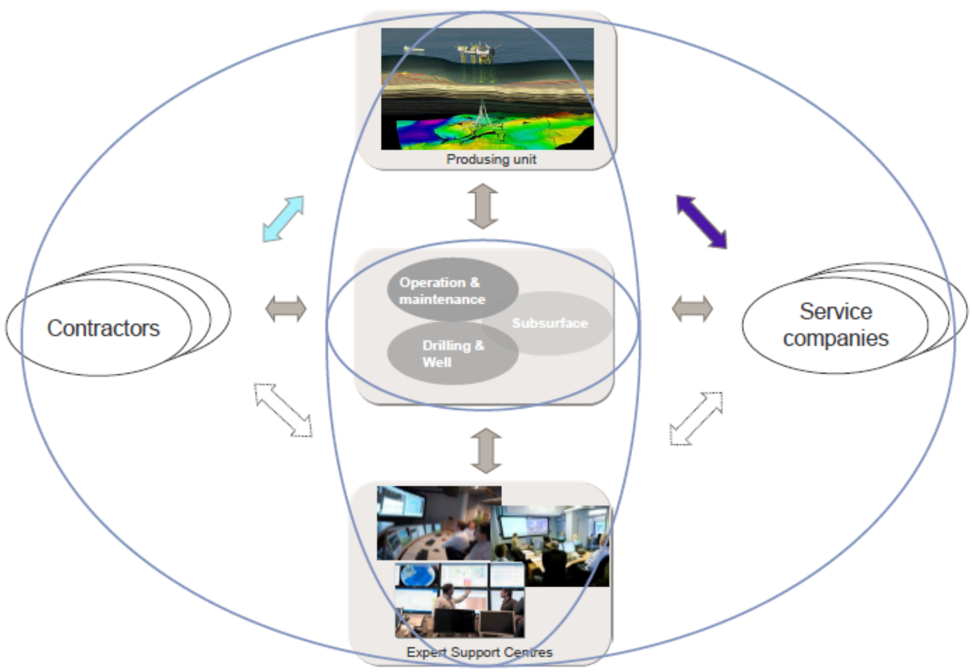


Figure 3.31 Statoil common operating model

Statoil develops and deploys IO based on *Statoil's IO stack model*. It consists of seven interdependent success criteria elements that have to be accomplished to obtain maximum value of IO. Capability stack is representation of people, process and technology integration as one system. Statoil's stack model is depicted in Figure 3.32 [93, 94].

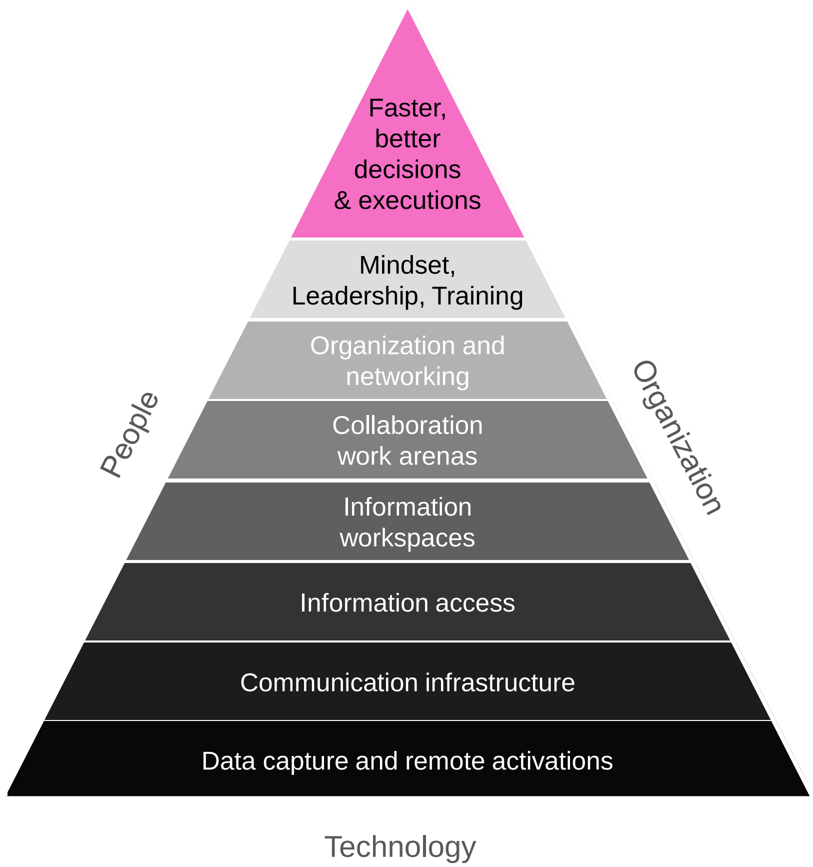


Figure 3.32 Statoil stack model

Lileng and Sagatun [95] explains each layer of Statoil's capability stack as follow :

a. *Data capture and remote activation*. This layer comprises of basic technology infrastructure for data acquisition from fields. It ranges from downhole smart sensors into facility monitoring systems. In drilling and wells, the sensors can be logging while drilling tools, downhole distributed sensors, smart completions, and seismic while drilling. In subsea, the application can be 4D seismic, subsea multiphase meters, and downhole electrical pumps. Those sensors and instrumentations provide the capability of data acquisitions and remote activation capability that enhance operational advantage. Despite these advantages, challenges remain on improving data measurement reliability, maintaining data quality assurance, and managing to avoid information overload that may influence the effectiveness of IO deployment.

b. *Communication infrastructure.* Increasing demand of data acquisition requires high capacity communication system to transfer data into the control facilities. Recent technology on fiber optic, radio links, 4G/LTE wireless technology are applied to accommodate fast and reliable data transmission. Ontology and semantic web are developed to ensure data integration and applications interoperability. WITSML, PRODML, OPC are worldwide data exchange standards in well, production and operations activities.

c. *Information access.* This layer concerns on how to process the data smartly in order to convert data into high quality information that is accessible to multidisciplinary experts. In addition, a large diversity of database systems and applications increases the complexity of system integration. Automated file transfer and interoperability between trending, modeling and interpretation applications shall be properly designed to enhance proper visualization of information. Data and communication standardization, object-based semantic models between assets, service-oriented architecture (SOA) and web services are deployed to create profound integration. Therefore, many-to-many setting can be achieved to enhance distribution and accessibility of data across multidiscipline experts and multicompanies collaboration.

d. *Information workspaces.* This layer concern on how to orchestrate information displays and produce visualization solutions in order to produce relevant information for everyone who needs in the right work process contexts. The ultimate goal is creating a common understanding and effective interactions between team members.

e. *Collaboration work arenas.* The focus of this layer is on how to supply all team members with required technology and interfaces at hand, therefore supporting information accessibility and communications between team members. Collaboration tools and desktop solutions are essential to enable virtual organization between distributed teams across geography. Consequently, common situational awareness is built up among team members.

f. *Organization and networking.* This layer focuses on how to build social networking capabilities between people, to define roles and responsibilities, to configure decision authorities, and to manage resources within work process. Statoil established harmonized work process through business process model (BPM). The BPM includes clear and standardized notations defining roles and responsibilities, resource requirements, best practices and information needs. It incorporates modeling inputs that are assigned to the tasks defined for each work process.

g. *Mindset, leadership and training.* This layer concerns on how to set up IO as the mindset of operations, to define leadership requirements and to design training required. The right information shall be brought to the right people on right time. IO mindset incorporates values of transparent leadership, new ways of working, and integration competence. Continuous change management is obligatory items to ensure IO as sustain value in the future. Based on Statoil observation, collaboration is key to IO deployment. Collaboration, in an atmosphere of trust, will improve team spirit and decision efficiency, promote team ability. In addition, it creates common situational awareness that may lead to better control of uncertainty. Consequently, it enhances management of risk and unexpected event.

In capability perspective, Statoil's IO can be illustrated Figure 3.33.

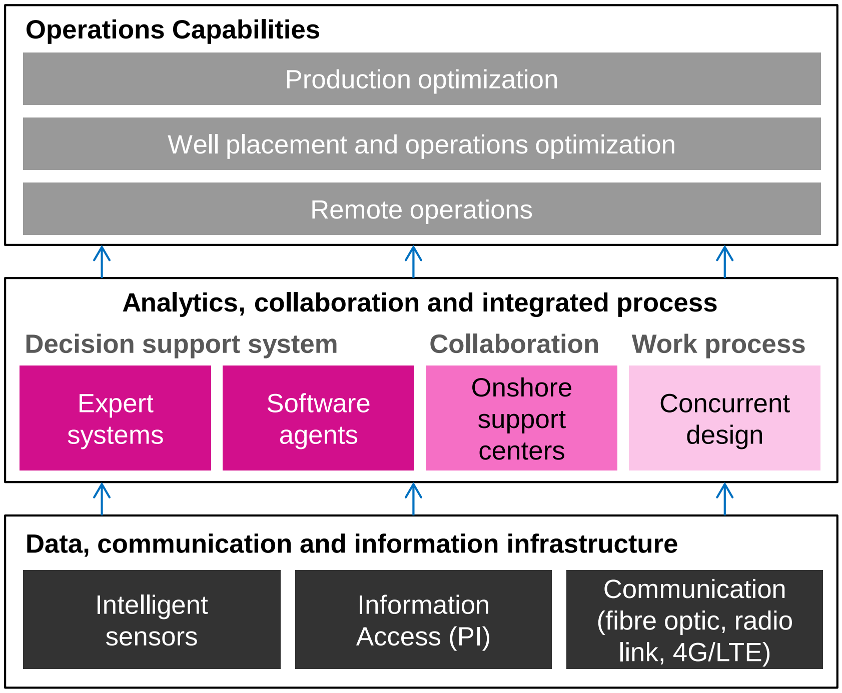


Figure 3.33 Statoil IO capability model

Intelligent sensors are installed throughout the end-to-end of hydrocarbon production system from downhole to topside locations. They have automatic monitoring features that are designed to reliably capture high quality data to support "situational awareness" of the system, thus providing clear information about what is going on in the system.

PI (Plant Information system) is data historian system to collect, store and manage real-time data acquired from sensors. It has the ability to create displays with data from multiple vendors [95]. The data is then transmitted via high bandwidth and low latency communication infrastructure. SOIL is the main IO communication infrastructure in NCS.

Decision support system consists of an expert system and intelligent software agents. Software agents are computer systems that have capability of autonomous action in a certain environment to meet a certain set of objectives, consequently these agents promote proactive and social interactive system capabilities instead of reactive [96]. Drilling simulator is one kind of software agent which can transform the real-time data into decision information by building hydraulic model, mechanical model, and temperature model. The output of modeling system will be fed into an expert system that is drilling advisor. Drilling advisor will process modeling result from drilling simulator to create uncertainty model, causality model, reasoning and prioritized the preferred plan. Expert systems basically provide advice to drilling operators in the control system to make better decisions by providing meaningful interface communication and applicable relevant actions. Drilling advisor and drilling simulator are an example of decision support system [94].

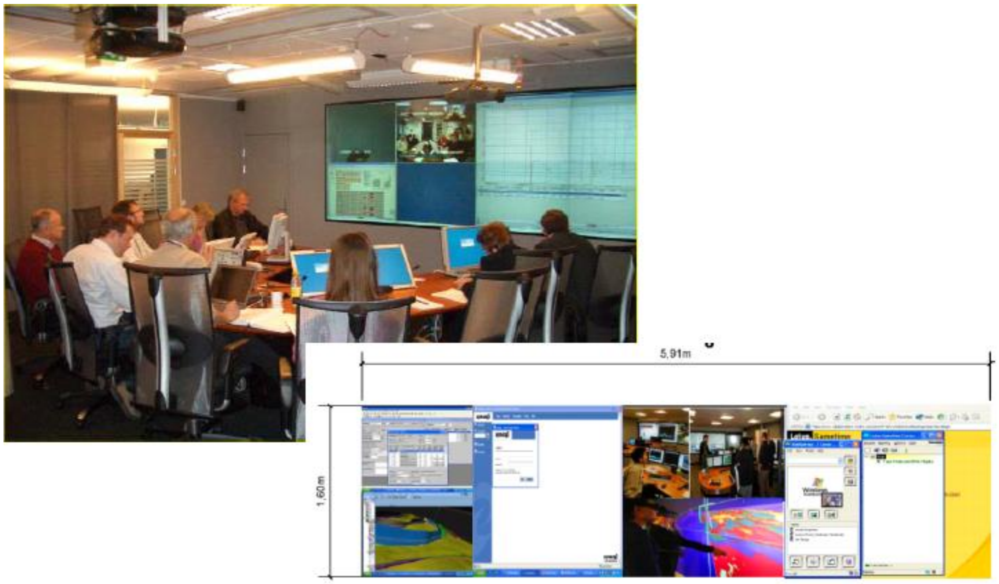


Figure 3.34 Onshore support center at Bergen

Statoil has established multiple *onshore support centers* to assist offshore operations to achieve maximum value of IO. Marine Operations Support Center (MOC), Sub-Surface Support Center (SSC), Real-time Data Center (RTC), Production Support Center (PSC) and Condition Monitoring Center (CMC) are dedicated to supporting marine operations (MOC), well construction and drilling operations (SSC), real-time well data transfer worldwide (RTC), production (PSC), and rotating machinery activities (CMC) [93]. These are collaboration arenas where multidisciplinary experts are co-located in onshore support centers.

Statoil has started to conduct pilot project on concurrent design as a new method to perform effective parallel fashion of work process in Gudrun/Sigrun fields. *Concurrent design* is "a multidisciplinary work method where all the elements of IO are present, but in a planned and structured fashion" (Figure 3.35) [97]. This way of work is considered as effective work strategy to cope with more and more complex problems in offshore operations problem. The rationale is that complex problem requires integration of knowledge from different expertise [97].

In order to gain successful implementation of concurrent design, there are six elements of successes that have to be fulfilled. The elements are clear targets, adequate resources, reliable information, training, regular feedback, and technical support [97]. Firstly, clear targets mean that concurrent design team has clear roles and responsibilities in achieving common team target. The targets are well-communicated that generates common understanding among team members. Secondly, adequate resources mean that the work sessions are attended by relevant discipline experts, provided by sufficient work arena, and well-equipped with relevant tools on site. Thirdly, reliable information means that team is equipped with relevant access to application and sources of high quality information as sources of decision information. Fourthly, training means that each of the members is well-trained with multidisciplinary way of working prior to joining the concurrent team. Fifthly, regular feedback means that people have to be encouraged to share their ideas, appreciate others and directly give effective feedback for improvement and enhancing team motivation. Lastly, technical support means that there is available technical support assistance to give direct assistance to team members if there are problems arise during the concurrent work session. It will help each team members to focus on their core tasks.

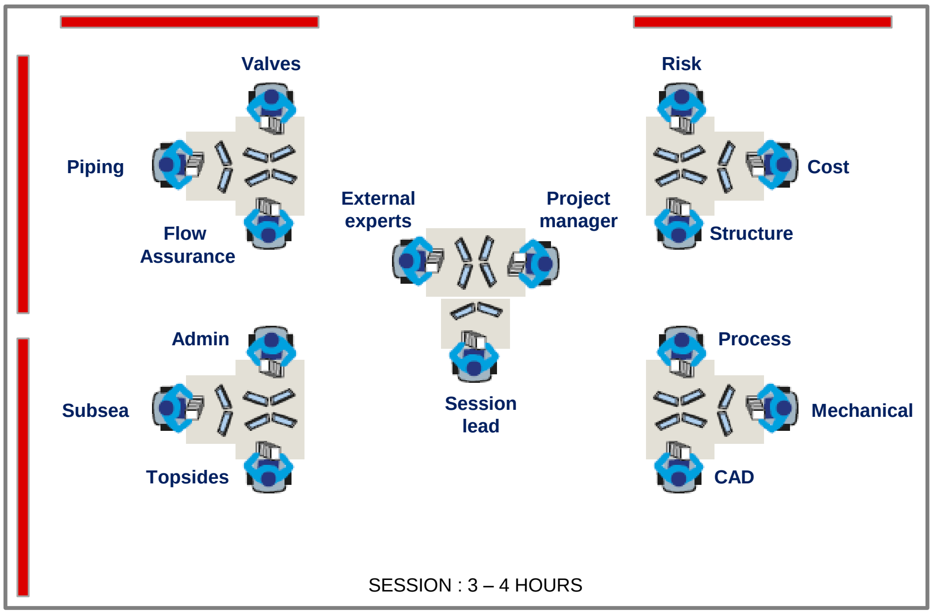


Figure 3.35 Concurrent design work arena

3.4.2 Integrated Operations key success factors

Based on IO implementation in NCS and Statoil, the key success factors identified are as follow :

a. Focusing the improvement initiatives on key value adding decisions and end-to-end value chains [88].

b. An integrated approach is implemented along key work process for planning, prioritization and execution activities [88].

c. Decision authority is delegated to the operational team whenever required consequently, the members shall have the appropriate level of competencies [88].

d. Deployment of advanced ICT solutions to enhance real-time collaboration and decision making [88].

e. Effective utilization of information filtering to support situational awareness, automate routine workflow and control process within safe operating limits [88].

f. Full accessibility to real-time information about production, equipment, and performance of processing and operational facilities [98].

g. The design of collaboration arenas (onshore support center) that considers MTO (Man-Technology-Organization) design requirements. Transparency, simplicity, similarity, fun and flexibility are the design criteria of good onshore support center [99].
h. Balance development and harmonization of people, technology, and organization. People shall have required IO competence, workplace shall be designed to support task execution and, the organization shall be transformed to accommodate concurrent design and proactive support [100].
i. IO is initiated as a corporate initiative, gain support and engagement from top management such as CEO and SVP Exploration and Production [101].
j. A robust change management system which involves strong core team involving discipline and asset expertise formalized in the corporate organization [101].
k. Define clear roles, responsibilities, and liabilities in contract with contractors under integration work model [102].
l. Design performance management system to accelerate and drive change [102].

3.4.3 Integrated Operations challenges

Meanwhile, IO development and deployment also arise challenges as follow :

a. Semantics and ontology for data integration [103].
b. Security and reliability of digital infrastructure [103].
c. Information quality, data filtering, and common data exchange platforms [103].
d. Competence development programs for change absorption [103].
e. Trust and openness between disciplines and business partners [103].
f. Performance incentives for knowledge-based industry integration [103].
g. Information quality, data filtering and common data exchange platforms [103].
h. The acceleration of technology development is more rapid than the acceleration of change and adaptation from people and organization that may undermine IO value creation [83].
i. Ill-defined interfaces and high system complexity and data solutions may lead to unforeseen consequences, greater vulnerability, and greater risks [83].
j. Resistance to change into new work process from workforce [100].
k. Team based and distributed decision making which blur lines of command [100].
l. Big data acquisition and transmission requirement may create information overload [100].
m. Reduction of field sense since decision makers are working from onshore center [100].
n. Increasing complexity and interactivity that cause difficulties for decision makers to maintain situational overview during an incident [100].
o. Integration of planning across disciplines, geography and organizations [104].

3.5 Summary of literature review

Based on literature review above, it can be summarized that IO model of BP, Shell and Statoil comprise of the following capability elements :

Capabilities	BP	Shell	Statoil
Data and communication infrastructure	▪ Sensors (DTS, LoFS) ▪ Data historian ▪ Data security ▪ Communication link (fiber optic, satellite, microwave)	▪ Measurement and monitoring sensors ▪ Data transmission (fiber optic, satellite, microwave) ▪ Data historian (PI) ▪ Data acquisition and control architecture security	▪ Intelligent sensors ▪ Information access (PI) ▪ Communication (fiber optic, radio link, 4G/LTE)
Decision support system	▪ ISIS (subsurface) ▪ D2D (facilities) ▪ MBOS (production)	▪ Production universe (production allocation) ▪ Energy components (production allocation) ▪ Integrated production modeling (production optimization)	▪ Expert systems ▪ Software agents
Work process	Business transformation	Hydrocarbon development program	Concurrent design
Collaborative work environments	Advanced Collaborative Environments	Integrated operations centers	Onshore support centers
Operations capabilities	▪ Production optimization ▪ Real-time reservoir management ▪ Real-time production and drilling support environment ▪ Remote performance monitoring and collaboration	▪ Model-based production optimization and forecasting ▪ Real-time well monitoring, optimization, and control ▪ Remote assisted operation and data acquisition	▪ Production optimization ▪ Well placement and operations optimization ▪ Remote operations

Table 3.1 Summary of IO capability review

Correspondingly, IO capability is built of three main layers that are *digital and communication infrastructure layer; decision analytic, collaboration, and work process layer; and operations capability layer* (Figure 3.36).

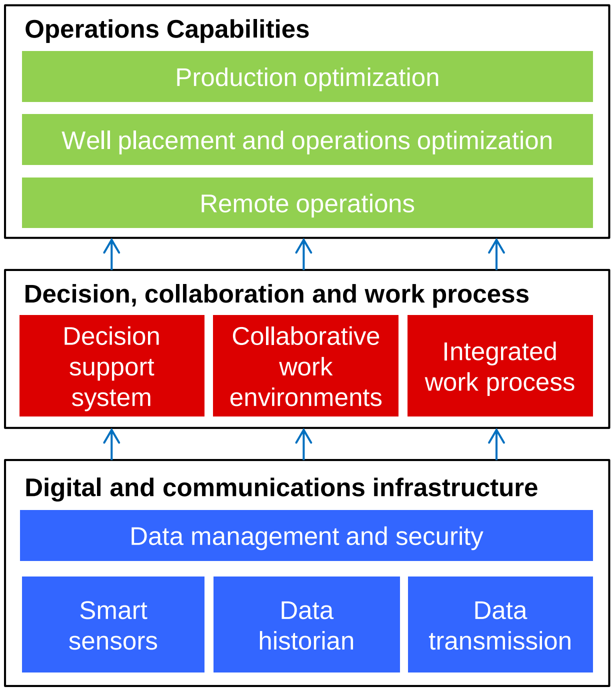


Figure 3.36 Integrated operations capability

Firstly, *Digital and communication infrastructure layer* encapsulates measurement system (sensors and instrumentations), data transmission system (fiber optic, satellite, wireless network) and data management system (historian, security system). It becomes the foundation of IO capability. The key performance factors of this layer are data measurement reliability and data quality (sensors and instrumentations); and capacity of data transmission (high bandwidth, low latency and uninterruptable). Sensors shall be reliable in real-time data measurement as it plays as starting point of the whole system input. Most importantly, they shall produce high quality data to inform actual condition of assets. Unreliable and low quality data affect the quality of decision information. Moreover, data shall be transmitted in large capacity, fast and without interruption. These requirements are prerequisites to enable common data view between onshore and offshore. Additionally, it also supports capability of remote operations. Subsequent to transmission, data is collected, stored, managed and shared to right places by data historian. Additionally, firewall system is installed as data security system. Based on this description, it can be concluded that this layer is a technology-rich layer.

Secondly, *decision support, collaboration, and work process layer* comprise of decision support system, collaborative work environment and work process.

Decision support system comprises of a collection of analytic softwares that have main function to transform real-time data into decision information and alternatives. It has the capability of online diagnostic and prognostic in order to optimize well, reservoir, and facility as an integrated system.

In collaboration perspective, CWE is established with the common goal to energize the power of collaboration in drilling and operations activities. Empowering collaboration is considered as the key rationale behind IO operating model. All of technology and work processes are designed to support effective collaboration in CWE. In addition, CWE is not only a collaboration arena but also a network of organization and people that promote knowledge sharing and innovation. Effective collaboration will lead to better and faster decision making.

Interestingly, complementary learning points are found between BP, Shell, and Statoil in work process perspective. BP emphasizes on Business Transformation to integrate people, work process, and change management in order to align business strategy and technology. In comparison, Shell has Hydrocarbon Development Program that integrates solutions to combine skills, work processes, data, application tools, and knowledge within CWE. Correspondingly, Statoil initiated Concurrent Design method to streamline work process and promote more effective collaboration session. Clear targets, adequate resources, reliable information, training, regular feedback, and technical support shall exist to form powerful concurrent design. Generally, it can be concluded that integrated work process shall be well-equipped with appropriate tools, standard process, relevant skillsets, high quality and reliable information, common performance targets, effective work environment, and effective change management.

Integrating the first and second layer will promote substantial operations capabilities in production optimization, well placement and optimization, remote operations, and real-time reservoir management. These capabilities are proven to deliver *value creation on reducing capex, increasing recovery factor, increasing production, and improving HSSE*. In holistic view, it can be concluded that IO is not merely deployment of technology but more on asset operations capability. It is an envelope of capabilities that integrate people, process, and technology to produce better and faster decision making through a new way of working that swept over on key work process. The building elements of IO are interdependent each other such a way that underperformance in one component will undermine value creation of IO at the whole.

In order to gain full-scale benefit of IO, *key success factors* are elaborated according to implementation in BP, Shell and Statoil.

Aspects	**BP**	**Shell**	**Statoil**
People	▪ Effective collaboration	▪ Leadership quality ▪ Continuous learning	▪ Senior management engagement
Technology	▪ Technical system integration and global	▪ Goodness of fit between solutions and	▪ Accessibility to real-time information

Aspects	BP	Shell	Statoil
	standards ▪ Technical user support ▪ Fast and reliable communication infrastructure	asset architecture	▪ Advanced ICT solutions to support collaboration ▪ CWE design to empower collaboration
Process	▪ Business transformation	▪ Effective change management	▪ Clear roles and responsibilities at integration with external organization ▪ Effective change management system ▪ Concurrent design ▪ Automate routine workflow
Organization	▪ Senior management engagement ▪ Dedicated IO team	▪ Link performance to IO ▪ Establish central IO organization	▪ Performance system to drive change ▪ Delegation of decision authority to operational team

Table 3.2 Key success factors IO

On the other hand, the *challenges* of IO implementation that are elaborated as below:

Perspectives	BP	Shell	Statoil
People	▪ Changes in culture are slow ▪ Changes in life balance ▪ People engagement in early phase ▪ Resistance to change	▪ Resistance to change	▪ Competence development program for change ▪ Resistance to change
Technology	▪ Standardized solutions ▪ Data security ▪ Big data management	▪ Each asset has unique characteristics ▪ Big data management	▪ Data integration ▪ Security and reliability of digital infrastructure ▪ Data security ▪ Data and information quality ▪ Big data management
Process	▪ Integration between new and existing systems	▪ Integrating people with tools, process, and technology	▪ Integration of planning across functions, geography

Perspectives	**BP**	**Shell**	**Statoil**
			and organizations
Organization	▪ Competition with other initiatives	▪ Conflict of authority in CWE matrix organization	▪ Performance incentives ▪ Trust and openness between functions and partners ▪ Team-based decision making blurs line of command

Table 3.3 IO deployment challenges

In summary, it can be concluded that IO has transformed oil and gas industry into smarter operating model in order to strategically managing high complexity, high risk environment, dynamic and uncertain offshore petroleum operations. It becomes the key operating model of BP, Shell, and Statoil to establish themselves as world-class international players through *improving quality of decision making that is better and faster* within their global asset operations. IO is exploited as the strategic capability to gain competitive advantage. In general, the main capabilities that build IO are *data and communication infrastructure; decision support system; collaborative work environments; integrated work process; and operations capabilities*. In addition, key success factors and challenges shall be main considerations in development and deployment of IO model. Opportunity enhancement and debottlenecking actions are imperative to gain sustain value creation of IO in the future.

4 Case study : Development of Integrated Operations Strategy

4.1 Pertamina corporate overview

Pertamina is the sole NOC in Indonesia that is owned 100% by the government of Indonesia. Ministry of State Own Enterprises is the representative of government shares in Pertamina. Pertamina was established in 1957 and since then has built a legacy as Indonesian's largest petroleum flagship. It has also started to expand its international business through block acquisitions initiatives (inorganic growth). Existing business platform topped up with extensive inorganic growth has successfully grown corporate performance and established Pertamina as the first Indonesian company to enter Global Fortune 500 companies [105]. Additionally, Mrs. Karen Agustiawan, former CEO Pertamina, was also recognized as the 6th most powerful women in global business [106]. As of 2014, Pertamina employs around 27 thousand of workers and manages the wide diversity of assets that are valued at around US$50 billion.

The company's vision and mission are described as follow [107]:

VISION : "*To be a World Class National Energy Company*".

MISSION : "*To Carry Out Integrated Core Business in Oil, Gas, Renewable, and New Energy Based on Strong Commercial Principles*".

Pertamina has extended its business span from hydrocarbon producer company into an energy company. It is reflected in new corporate objectives that are described below [107]:

a. "*To conduct an energy business that includes oil and natural gas, new and renewable energy, both domestically and internationally as well as other related activities or supporting business activities in energy, namely oil and natural gas, and new and renewable energy*".
b. "*To develop and optimize the resources of the company to produce high quality and strong competitive goods and/or services*".
c. "*To generate profits to increase the value of the company by implementing Limited Liability Company principles*".

In order to harmonized way of work, Pertamina institutes sixth core corporate values as guideline, mindset and lifeblood of company operations on all asset based business [107]. The sixth values are :

a. **Clean**. "*Professionally managed, avoid conflict of interest, never tolerate bribery, respect trust and integrity based on good corporate governance principles*".
b. **Confident**. "*Involvement in national economic development, as a pioneer in State-owned Enterprise reform and to build national pride*".
c. **Commercial.** "*Create added value based on commercial orientation and make decisions based on fair business principles*".
d. **Competitive**. "*Able to compete both regionally and internationally, support growth through investment*".
e. **Customer-focused**. "*Focus on customers and commit to give best services to customers*".
f. **Capable.** "*Managed by professional, skilled and highly qualified leaders and workers, committed to building research and development capabilities*".

Pertamina business portfolio is one of the widest span in Indonesia ranging from upstream, midstream, downstream, business supporting enablers (drilling and trading) and non-core business (hotels, investment management, consulting, health and medicine, airline and insurance). The Pertamina's business portfolio that is swept over across value chain is illustrated in Figure 4.1 [108].

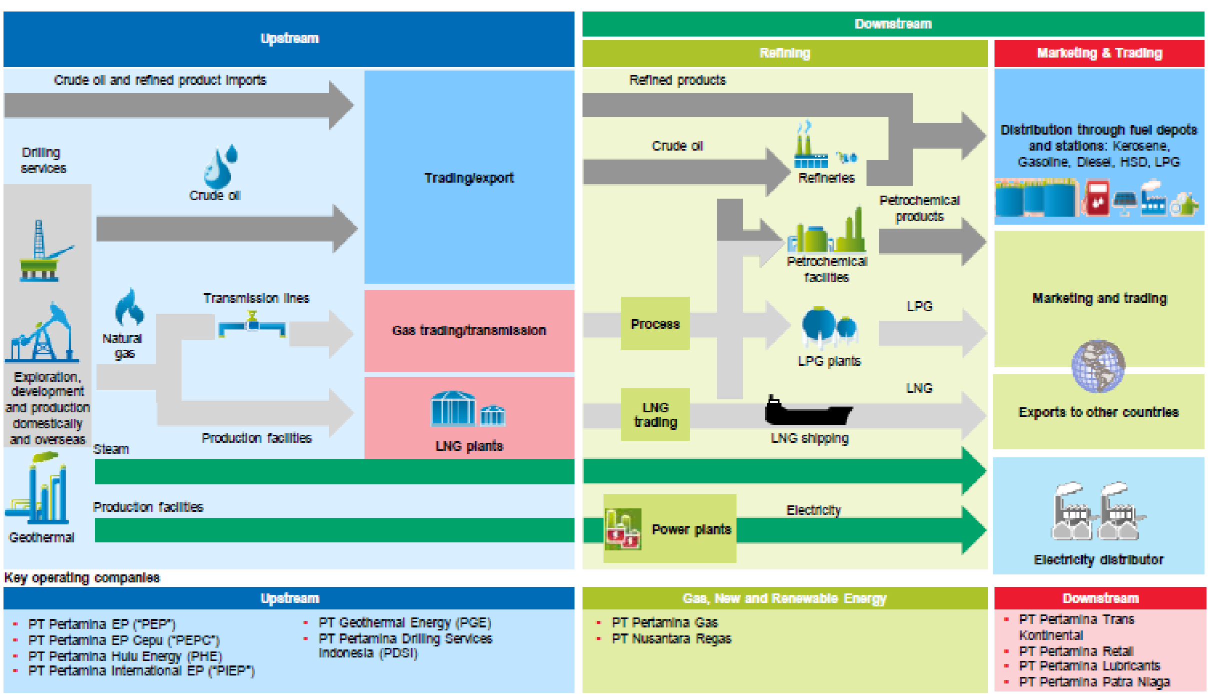


Figure 4.1 Pertamina value chain

In the upstream business, Pertamina involves in exploration and production (E&P) of hydrocarbon and geothermal. The upstream business activities incorporate conventional oil and gas, coal bed methane, shale gas, drilling services and geothermal. In petroleum E&P, Pertamina has active petroleum licenses in domestic and international (Iraq, Algeria, Malaysia, Vietnam). The arm-lengths of Pertamina's upstream operations in Indonesia are PT Pertamina EP (PEP), PT Pertamina EP Cepu (PEP Cepu), and PT Pertamina Hulu Energi (PHE). In addition, Pertamina established PT Pertamina International EP (PIEP) as Special Purpose Vehicle (SPV) to manage international E&P business (Figure 4.2 [109]). Besides E&P business, Pertamina also established PT Pertamina Drilling Services Indonesia (PDSI) to support E&P drilling operations.

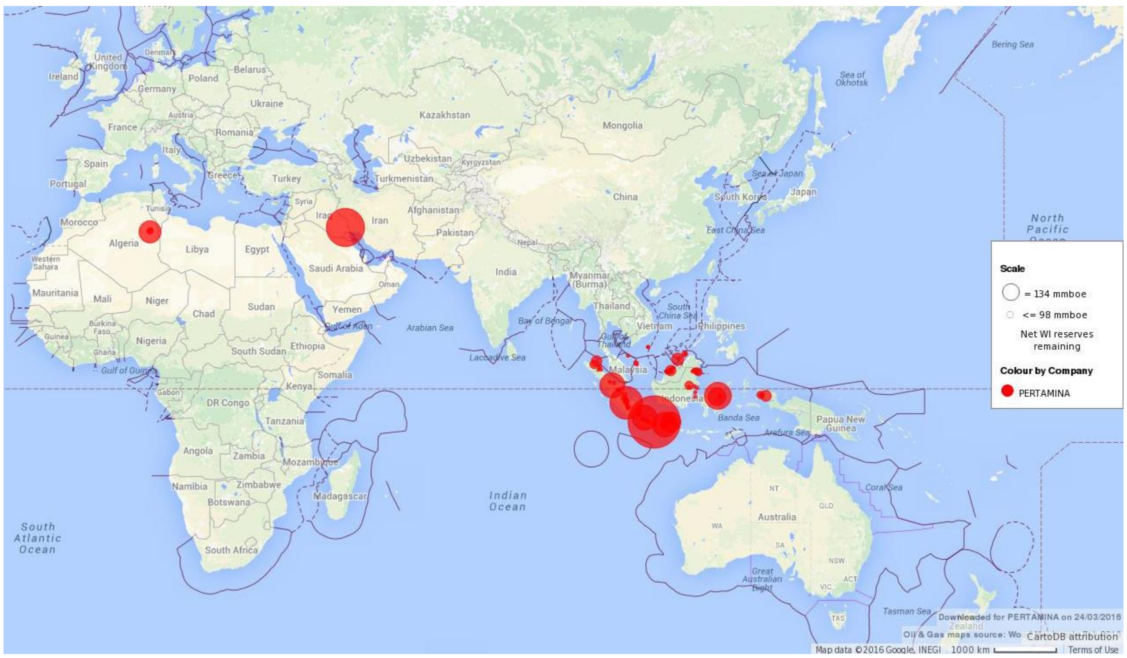


Figure 4.2 Pertamina international upstream portfolio

Oil that is produced, from domestic and international oilfields, is transported into refineries owned by Pertamina to be processed as fuel products. Meanwhile, gas is transported via pipeline that is owned by PT Pertamina Gas or processed into LNG that is operated by Pertamina to domestic customers. In addition, PT Nusantara Regas is joint venture with Perusahaan Gas Negara (PGN) to operate the first Floating Storage Regasification Unit (FSRU) unit in Indonesia. LNG, from gas producers, is transported via vessel then it is gasified in FSRU and finally, it is sold to supply power plant owned by PLN (Indonesian State Owned Electricity Enterprise).

Meanwhile, geothermal E&P focuses on domestic operations, since Indonesia has the third largest geothermal resources in the world. Geothermal assets are managed by PT Pertamina Geothermal Energy (PGE) to explore, develop and produce geothermal steam and electricity power that is, then, supplied to PLN's power plant or distributed to PLN's power network.

In downstream business, Pertamina has the largest fuel supply and distribution network in Indonesia. The infrastructure is spread over across Indonesia's archipelago that is dedicated to supplying and distribute fuel products across Indonesia's region. The downstream assets incorporate six refineries with 1 mbopd total processing capacity [108], fuel pipelines, vessels, terminals, aviation filling units and others. Downstream infrastructure networks in Indonesia are considered as one of the most complex supply chain networks in the world.

4.1.1 External analysis

4.1.1.1 Porter's Five Forces Analysis

Porter's five forces analysis is performed to analyze petroleum industry in Indonesia. The boundary of analysis is current condition and possible future trends that may influence industry trends. It is important to address that petroleum industry is highly dynamic and uncertain therefore continuous evaluation is necessary to validate the analysis. The main objective of the analysis is to identify key indicators or trends that may influence Pertamina as one of the players in Indonesia. Most importantly, it systematically helps in defining potential threats and opportunities that become essential information to design powerful competitive strategy.

4.1.1.1.1 Existing competitive rivalry between firms

In Indonesia, the petroleum industry is flooded by national companies and multinational companies. IOCs, NOCs, and other independent players have active licenses in exploration and production. The main players are depicted in Figure 4.3.

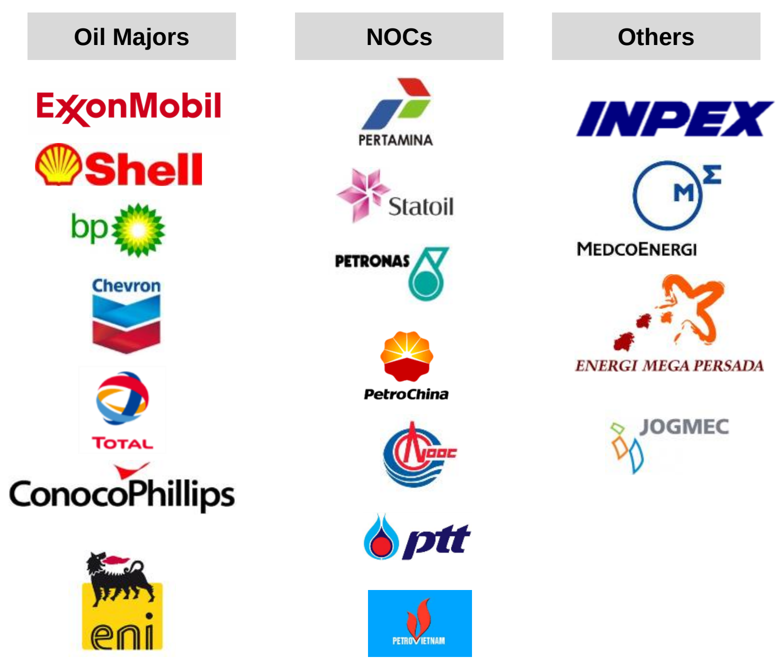


Figure 4.3 Key petroleum players in Indonesia

Currently, there are around 200 active PSC licenses. Chevron is the major oil producer while Pertamina is the major gas producer (Figure 4.4 [109]). Instead, Pertamina still holds the largest commercial hydrocarbon reserves [109]. Apart from the domestic landscape, the emergence of North America unconventional plays affects the decision of multinational companies to invest in Indonesia. A couple of US-based independent oil companies has decided to restructure their portfolio, focusing their resources on developing US unconventional plays. As an example, Marathon, Anadarko, and Hess have divested their assets in Indonesia. Therefore, this trend changes the competition landscape of industry by promoting new opportunities for local companies to acquire assets. Local companies, such as Pertamina, have greater window to expand their E&P footprint in Indonesia. In addition, IOCs also reduced their exposure in Indonesia. BP has divested their stakes in ONWJ asset and transfer their operatorship right to Pertamina [110]. In another way, Chevron also announced to return their operatorship right, in East Kalimantan block, to the government after expiring in 2018 [111].

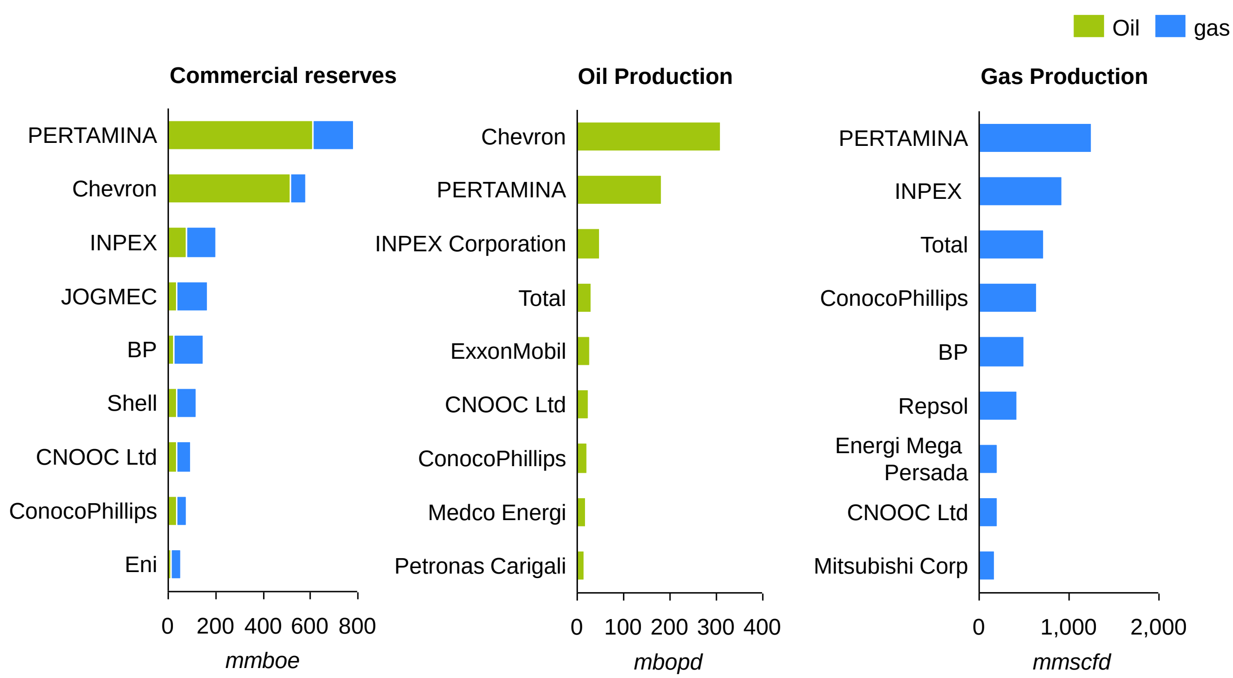


Figure 4.4 Company production and reserves

Portfolio refocuses of US-based oil companies and reducing exposure of IOCs in Indonesia are expected to reduce the degree of competitive rivalry in Indonesia. For this reason, it can be assessed that existing competition and rivalry between oil companies is "*Moderate*".

4.1.1.1.2 Threat of new entrants

Threat of new entrants perspective is intended to identify potential new players that can change competition landscape of petroleum industry. Current trend indicates that oil production is continuously declining exacerbated by the lack of new big oil discoveries. This situation has shift

Indonesia into oil deficit country. On the other hand, recent discoveries are more gas prone that position gas replacement rate in better figure than oil (Figure 4.5 [112]).

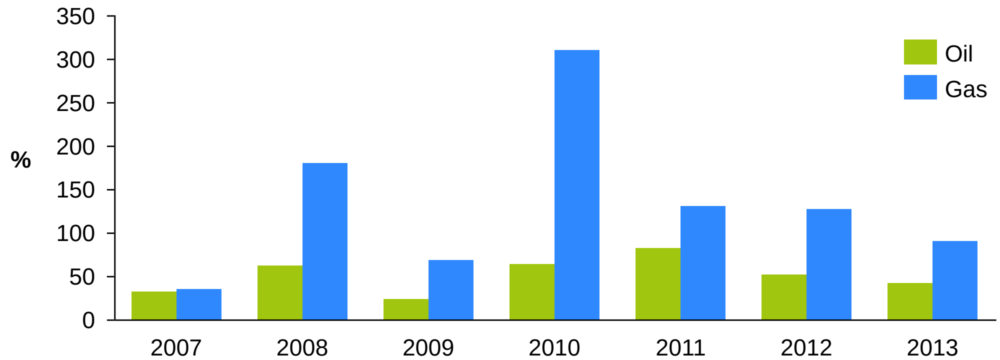


Figure 4.5 Reserves replacement rate

Furthermore, petroleum operations seem to be exposed to the more challenging environment. Easy oil in onshore fields has entered mature period, while offshore fields have more gas prospects than oil. Indeed, data on last 10 years discoveries shows that offshore ventures have more discoveries with potential reserves of more than 50 mmboe (Figure 4.6 [109]).

Figure 4.6 Discovery by water depth

On the one hand, Eastern Indonesia is a glimpse of light for new players to roll the dice in Indonesia's petroleum exploration. USGS estimates that Indonesia still has potential undiscovered reserves up to 4.6 bboe [113]. East Kalimantan and West Papua are highly potential areas where most of recent "*big fish*" gas discoveries are located (Figure 4.7 [114]).

Figure 4.7 Last 10 years discovery

Despite its large potential, most of the offshore new ventures in Eastern Indonesia is situated in deep water areas coupled with geologically complex petroleum plays. Moreover, Eastern Indonesia has less mature infrastructure that reduces market and investment attractiveness. This situation may also contribute to the longer time needed to commercialize oil and gas fields in Indonesia. The time to commercial is prolonged from around 10 years (in the 1990s) to around 14 years (in 2000s) [114].

Another indication is declining number of petroleum licensing awards. A number of new contract awards are showing a trend of the downturn. Unconventional licenses are entering the playground despite there is no proven unconventional production. Nevertheless, addition in unconventional awards is insufficient to rebound the decline of conventional licenses awards (Figure 4.8 [115]).

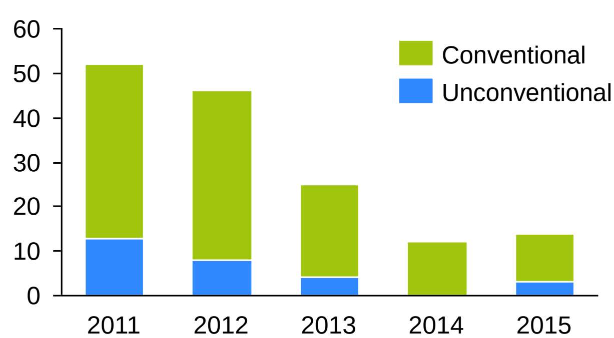


Figure 4.8 Contract awards

Apart from technical issues, non-technical issues also contribute to affect the attractiveness of industry to new players. Regulatory and fiscal uncertainties that are indicated by BP Migas, as the supervisory body of petroleum operations, dissolution in 2012. Land acquisition and government permits that create problems to complete exploration commitments [112]. Social problems, such as oil illegal tapping, well operation blockades, and closing the road to operation fields, also hamper current E&P operations [116].

Technical challenges combine with non-technical challenges are expected to be the negative factors that hinder new players to enter Indonesia. Nevertheless, these challenges may still attract global players with technical know-how to manage high complex assets. New players, that have proven capability and experience in IO, are expected to enter Indonesia. It is indicated by Shell's acquisition on Masela block in 2011 and 2013. Shell is well-known as one of the global players in IO. Masela block is a giant gas field that is located in the remote area (Timor region). Due to its remoteness, development and operations will be highly complex and challenging. It is previously planned to be developed by offshore FLNG (Floating LNG), however, Government of Indonesia has decided to decline and prefer on onshore development scheme. In general, it can be assessed that threat of new entrants is considered as "*Moderate*".

4.1.1.1.3 Bargaining power of buyers

Bargaining of power analysis is intended to assess potential market of the petroleum industry in Indonesia.

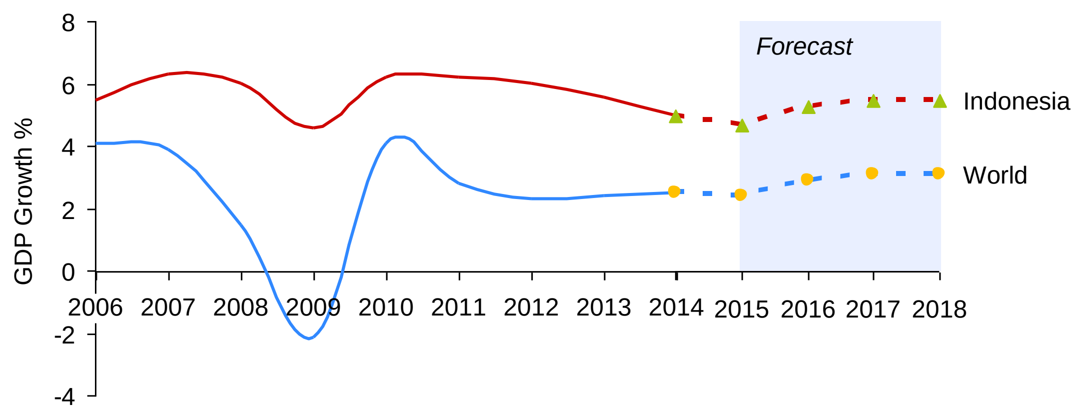


Figure 4.9 GDP growth

Indonesia economy is one of the strongest and of the most consistent in Asia Pacific. Data on GDP growth shows that Indonesia's economy grows faster than world economy growth [117]. Relatively stable economic growth is underpinned by industry and domestic consumption. Indonesia is one of the largest populous countries in the world. For this reason, it will drive positive growth in domestic oil consumption to fulfill demand on transportation, industry and power generation sector. Oil demand is rising rapidly and is predicted to grow at 3% (CAGR) from 2016 to 2034 [118]. Unfortunately, it is not balanced with domestic production. Apparently, Indonesia has been net crude oil importer since 2003. Indonesia is not only importing crude oil but also fuel since the capacity of refineries is less than demand. The necessity to fulfill oil demand is expected to reduce bargaining position of Indonesia to oil producers.

Apart from oil, gas demand is also predicted to grow at 2% (CAGR) [118]. Instead, natural gas supply-demand balance is still on surplus position. Currently, most of the gas volume is supplied from conventional gas fields. On top of conventional gas, unconventional gas is expected to chip in as a new source of growth. In the future, Indonesia is estimated to have 450TCF of CBM (Coal Bed Methane) prospective resources [119].

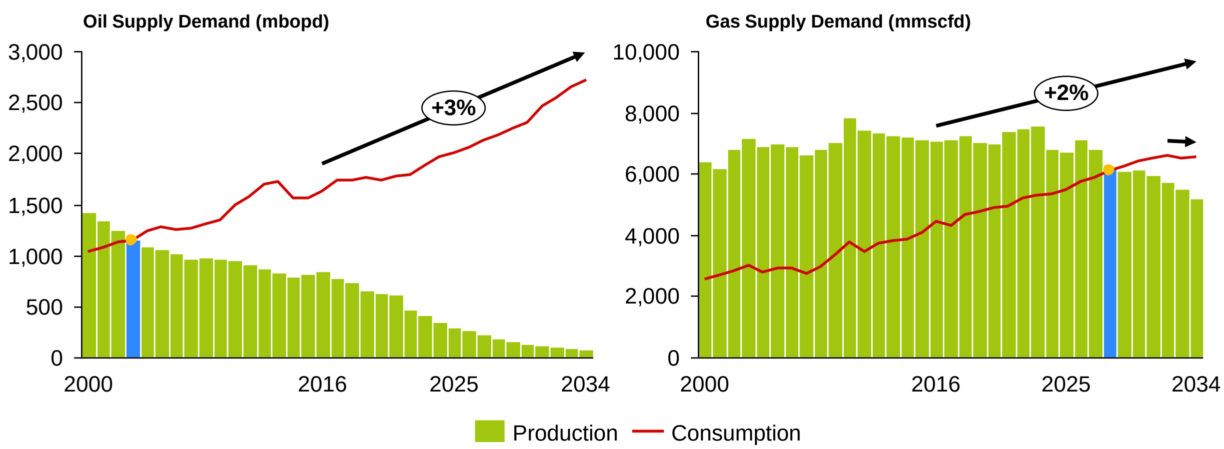


Figure 4.10 Oil and gas supply demand

Despite abundant supply of gas, the location of gas producers are scattered and distance away from the market. Sumatera and Kalimantan regions are the main gas producers while Java region is the largest market. Gas is largely needed to supply power generation, fertilizer, and other industries. To integrate supply and market, the government of Indonesia has encouraged to build new gas infrastructure. Deficit supply of oil and lack of gas infrastructure are expected to leverage oil and gas producers bargaining position. As a result, it can be assessed that bargaining position of buyers is "*Low*".

4.1.1.1.4 Bargaining power of suppliers

Bargaining power of suppliers is intended to assess the potential opportunities that are able to leverage future production. Indonesia is still one of key oil producers in South East Asia region. The total proven oil reserve, at of the end of 2014, is expected at around 3.6 bbo while proven gas reserve is expected around 100 Tcf [112]. BP Statistical Review [120] estimates that the reserves to production for oil is around 12 years meanwhile gas is around 39 years. Sumatera and Java region are the backbones for oil reserves with approximate 6.4 bbo of reserves. The gas reserves are spread from Sumatera, Natuna, Kalimantan and Papua. The portfolio of reserves by region is depicted in Figure 4.11 [112, 109].

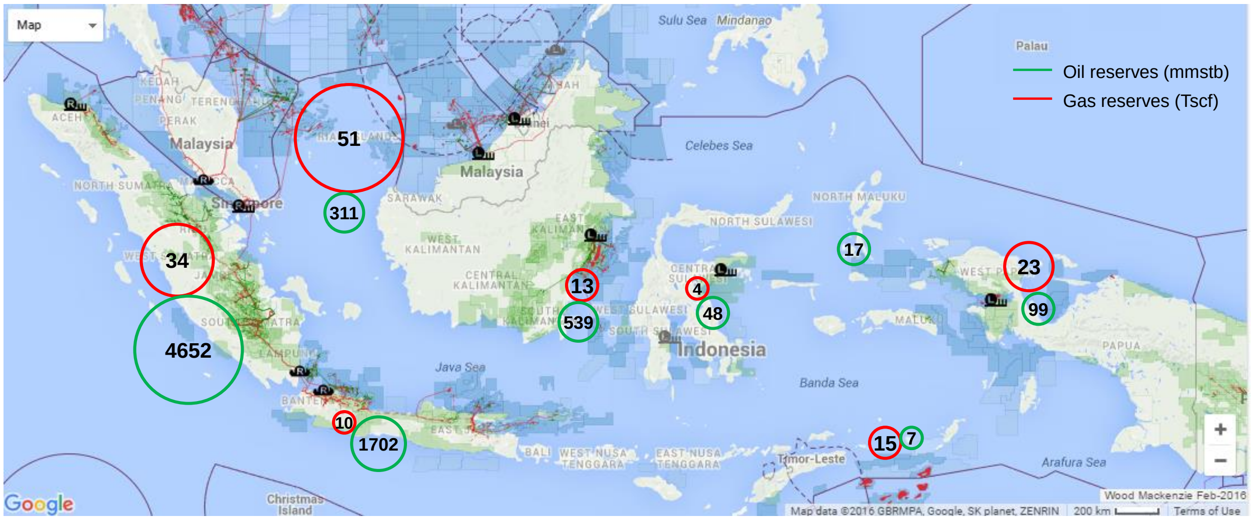


Figure 4.11 Indonesia oil and gas reserves by region

Sumatera, Kalimantan, and Java are the most prolific oil and gas producing regions. Sumatera region is the most prolific areas with oil and gas fields span from north west to south east. Kalimantan is well-known as main LNG producer with giant fields in offshore Mahakam. Java region is an oil-prone area with oilfields located from onshore to offshore shallow water in western and eastern part of the region. The future production potentials will come from West Papua and Timor areas. Currently, West Papua has Tangguh offshore block as the main producer of LNG. Timor area has Masela offshore block that is subject to POD (Plan of Development) approval. Meanwhile, Natuna area has East Natuna offshore block as future giant gas producer. Oil production decline is very steep (14% CAGR) while gas production decline is considered moderate decline (5% CAGR) (Figure 4.12 [121]).

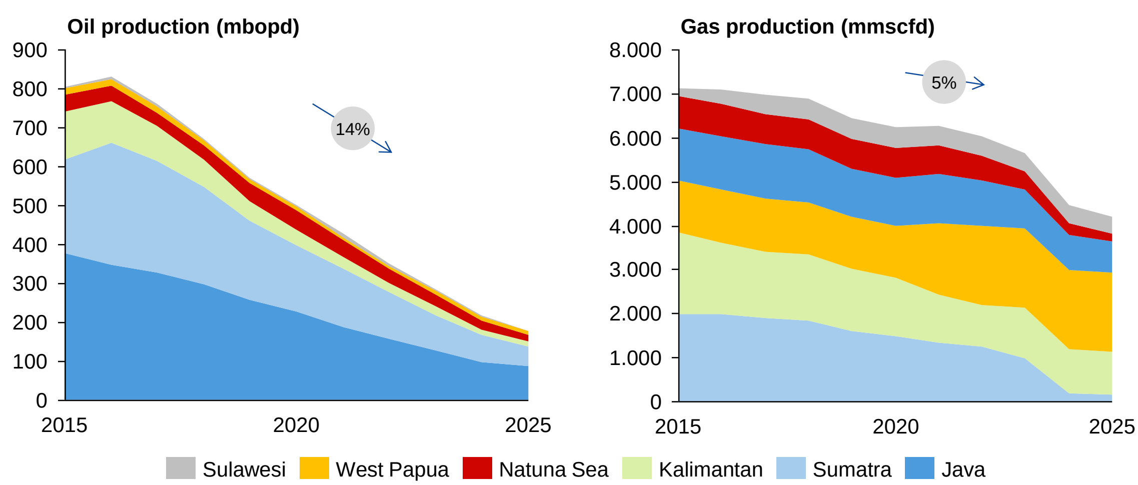


Figure 4.12 Oil and gas production forecast by region

Meanwhile, Figure 4.13 shows that future of oil and gas production will be more dependent on offshore fields [109]. The forecast is based on current producing fields and near production fields (subject to POD approval). It seems that national effort to re-energize field development acceleration and exploration incentives is essential to rebound the production decline.

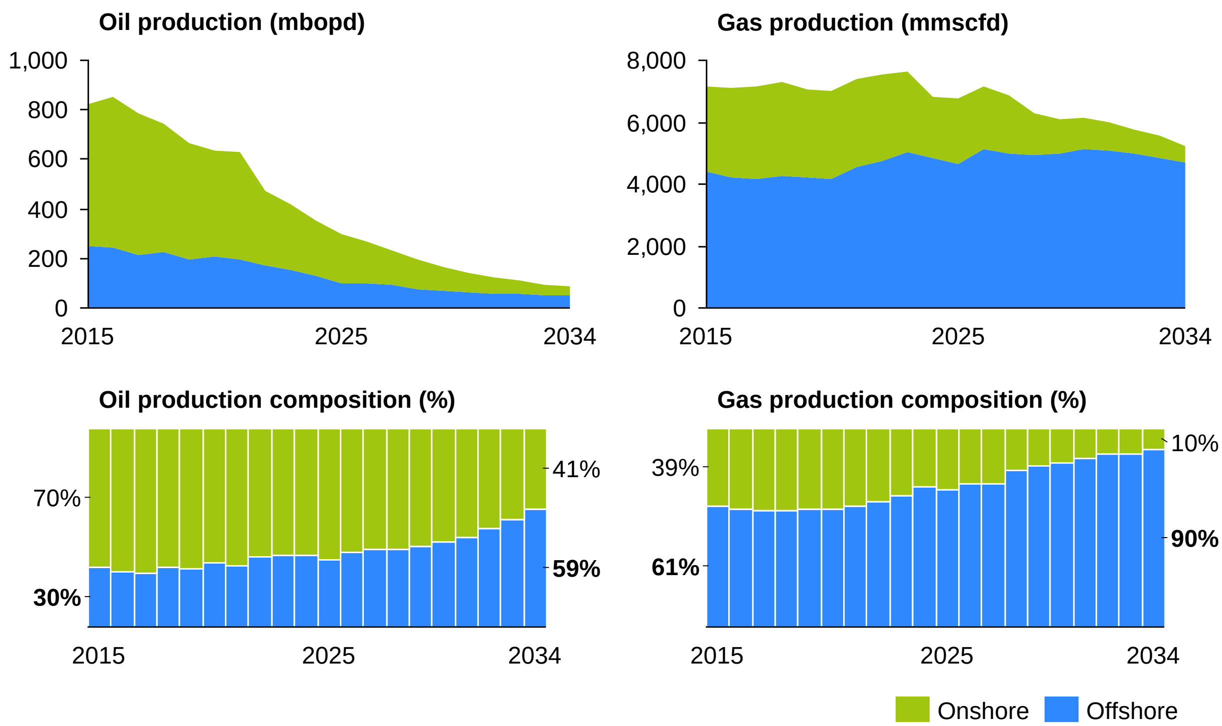


Figure 4.13 Future forecast offshore and onshore production

In general, it can be concluded that offshore fields are expected to be the backbone of future oil production. System complexity, capital requirements, technical know-how, and management system to operate in complex offshore assets are the leverage attributes of offshore field operators. In addition, there are only a few global oil companies that have these attributes. Therefore, it can be assessed that bargaining position of suppliers is "*High*".

4.1.1.1.5 Threat of substitute products

Threat of substitutes analysis is intended to identify potential replacement of oil and gas as source of energy. Currently, oil is still the primary source of energy for industry, power generation, household, and transportation sectors. The industry needs liquid fuel to burn up their boiler and processing their products while power plant needs fuel to generate electricity. Household uses kerosene to cook despite decreasing demand due to LPG conversion program in 2007 [122]. In fact, the major fuel demand comes from the transportation sector. Positive GDP growth heat up the national economy increasing demand for fuel for transportation. On the other hand, domestic crude oil production is declining below 1 mmbopd forcing Pertamina to open the valve of crude import as refinery intake.

Realizing national energy security situation, Government of Indonesia declared a strategic action to reduce the dependency of liquid fuel by planning to increase renewable energy as future source of energy. Presidential Decree No.5 year 2006 is the commitment of the government to enhance utilization of renewable energy from 6% in 2005 up to 17% in 2025 (Figure 4.14 [123]). Indonesia has huge potential energy to diversify source of energy combining hydrocarbon with renewable (geothermal, hydro, biomass and biofuel).

In fact, Indonesia is well known as one of the largest geothermal energy resources in the world with potential resources about 28.6 GW [124]. On the contrary, the utilization of geothermal is still low with only 1.2 GW installed capacity [124]. Low geothermal utilization is the effect of low investment attractiveness. Geothermal drilling cost is approximately at the same level with petroleum onshore drilling, nevertheless, the price is negotiated with only one single offtaker. New government policy is still needed to stimulate new investments into more economic-friendly to investors.

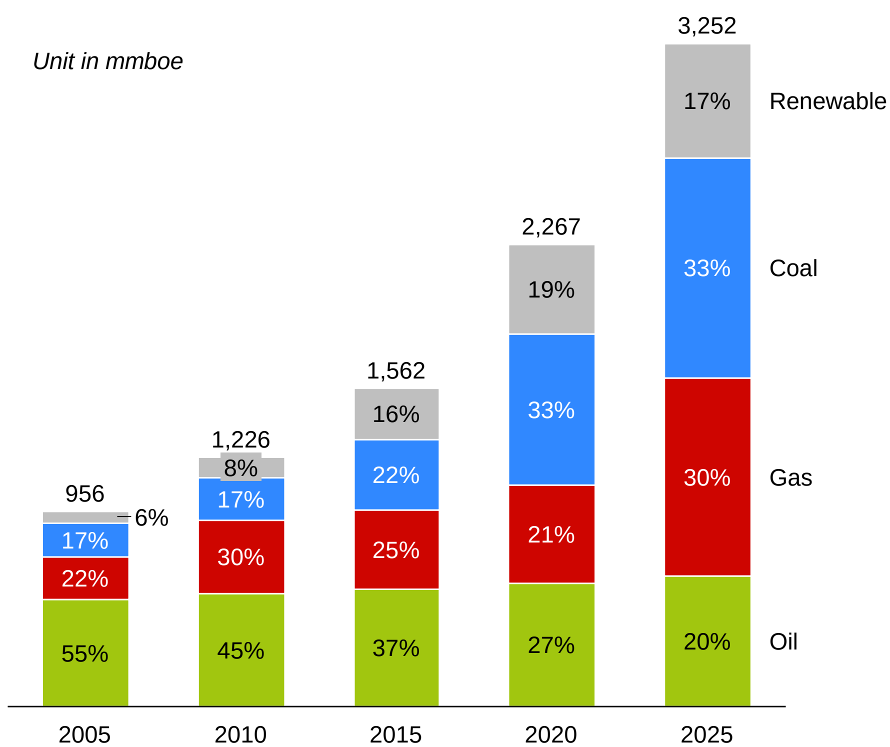


Figure 4.14 Indonesia's energy mix

Apart from renewable, Government of Indonesia launched the first Fast Track Program (FTP 1) to accelerate construction of coal-fired power plants with total capacity 10 GW [124]. The leverage factor of coal-fired power plants initiative is pricing. Coal price is much lower than oil and gas price. More importantly, Indonesia has abundant coal resources in Kalimantan and Sumatera region. Nevertheless, the progress of FTP 1 is slower than initial plan due to the slow land acquisition, permits, and financing issues [124]. In addition, carbon emission is still global environmental issue in accelerating coal-fired power plants. Despite these shortcomings, coal proportion in the energy mix is expected to increase from 17% (2005) to 33% (2025).

Another factor that is expected to reduce oil is growing consumption of biofuel. Biofuel is mixed with gasoline to reduce gasoline consumption in the transportation sector. Biosolar and Biopertamax, are mixtures of gasoline and biofuel, that gradually become more popular since green energy campaign was launched. Nevertheless, increasing biofuel consumption creates potential conflict of priorities. Biofuel is mostly processed from palm oil that is produced from plantation. Expansion of plantation may reduce natural forestry areas. Furthermore, Indonesia is considered as one of the largest natural forestry areas in the world. Preservation of natural forest is global concerns to restrain global climate change. Therefore, this environmental factor is expected to restrain acceleration of biofuel consumption. Generally, it can be concluded that alternative sources of energy still have bottlenecks on policy and environmental issues. Therefore, it is assessed that threat of substitute products is "*Low*".

4.1.1.1.6 Summary of Porter's Five Forces Analysis

The result of the analysis shows that the most influencing power is bargaining power of suppliers against petroleum industry in Indonesia. It is due to an indication that easy oil in onshore fields are declining while offshore fields are predicted to take over in the future. Offshore operations capability is expected to be the key success factor that differentiates highly capable companies with their competitors. Highly capable offshore operators are expected to win the competition in the future.

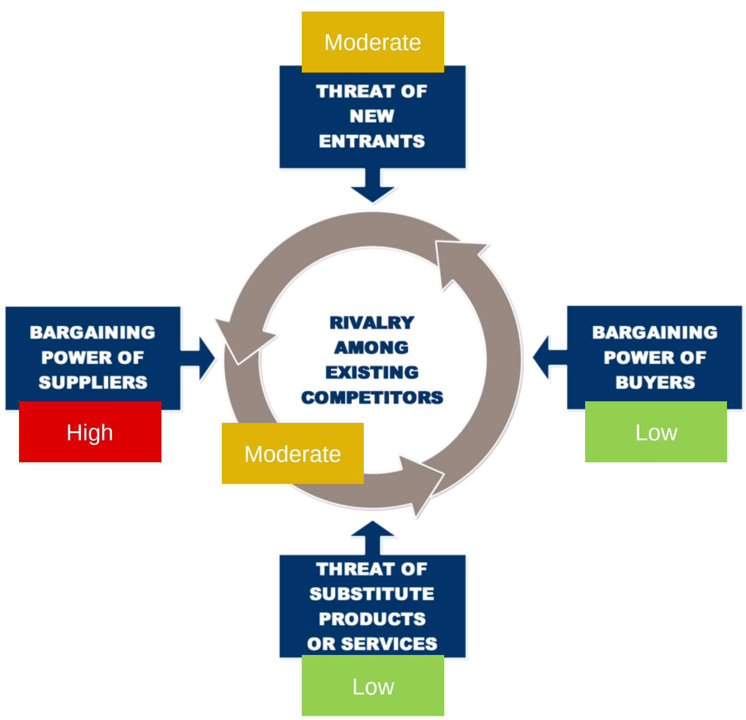


Figure 4.15 Porter's five forces analysis in Indonesia

4.1.2 Internal analysis

4.1.2.1 Resource analysis

VRIO framework is utilized to analyze resources in Pertamina. It is powerful tools to assess which resources or capabilities are the key core competencies of Pertamina. Core competencies are key factors to success in the petroleum business. A couple of key resources or capabilities are discussed below:

4.1.2.1.1 Petroleum assets and infrastructure network

Pertamina is one of the largest petroleum producers in Indonesia. Its assets are swept over from Western into Eastern part of Indonesia. However, most of its assets are located in Western Indonesia. Onshore mature fields are still the backbone of oil and gas production. Indeed, Pertamina has successfully managed the decline rate into as minimum as possible. Moreover, excellent exploration performance has successfully kept Reserves Replacement Rate (RRR) at above 100%. Pertamina's E&P performance is indicated in Figure 4.16 [107, 109].

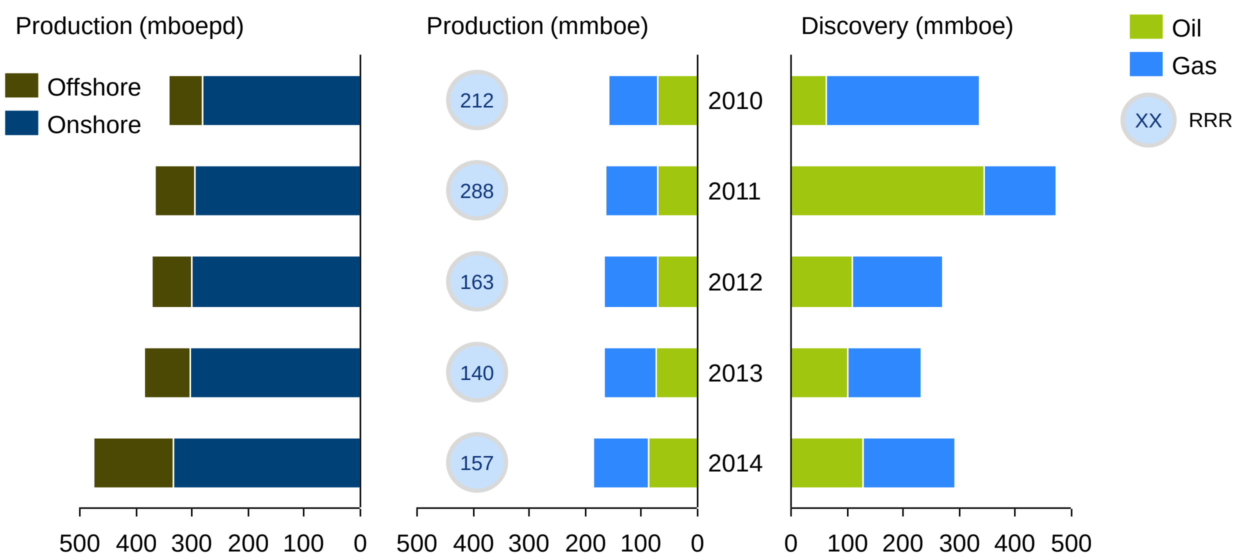


Figure 4.16 Exploration and production performance

Pertamina EP (PEP) is the largest producer with core assets located in onshore. PEP produced 296 mboepd [125] that accounts approximately 65% of Pertamina oil and gas production in 2014. However, most of the assets owned by PEP are onshore mature fields that contribute to production decline trend. PEP's production was declined from 309 mboepd (2012) to 296 mboepd (2014) [125]. Furthermore, unaccomplished drilling target, technical problems on operations, government licenses, and oil illegal tapping also influence fields operations [125].

Currently, Pertamina has only two offshore production operatorships which are Offshore North West Java (ONWJ) and West Madura Offshore (WMO). The other offshore operatorship asset, which is Nunukan PSC, is on near production phase following POD approval in April 2016. The spread of Pertamina's asset reserves and infrastructure networks are depicted in Figure 4.17 [109]. East Natuna block is promising offshore new ventures with giant gas discoveries in it. Nevertheless, this block remains undeveloped since CO_2 content is very high at 70%. Ongoing negotiation is still taking place between Government of Indonesia, Pertamina, and partners. Pertamina is considered to be the future operator of this block.

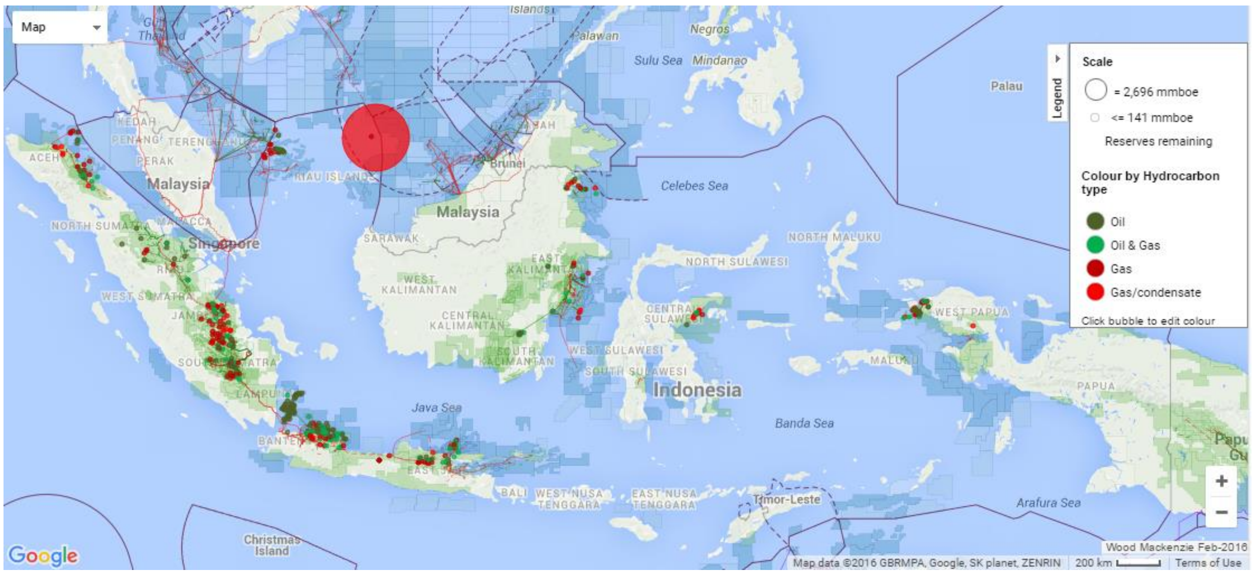


Figure 4.17 Petroleum fields and infrastructure networks

In midstream, Pertamina is one of the largest owners of gas infrastructure. In Northern Sumatera, LNG regasification plant was constructed to supply consumers in Sumatera. In Java, gas pipeline network is also operated to distribute gas for industry and power generation. In addition, new pipeline network is planned to be constructed which will integrate West Java and East Java gas network. FSRU was also installed in North Java to supply gas for power plant owned by PLN.

In general, it can be concluded that petroleum fields and integrated gas network are *valuable* resources. They are considered as *rare, costly to imitate, and exploited* by Pertamina to grow its business.

4.1.2.1.2 Business portfolio diversification

Pertamina has a wide diversity of portfolio business ranging from oil and gas, geothermal, drilling services, refineries, marketing and trading, and other non-core business (insurance, hotel, airline, training, medical). Instead, the mainstream of business is still in the energy business. The oil business is still the main cash generator, despite its price volatility may create profit uncertainty. Apart from oil and gas business, "non-oil" business portfolio has less uncertainty, providing balance effect on profit. Geothermal and gas are less volatile since they are contract-based. Additionally, this diversity not only balancing profit but also risk exposure. Most importantly, corporate cash flow remains excellent.

As a result, it can be assessed that business portfolio diversification is *valuable* capability, *rare*, *costly to imitate*, and *exploited* to manage corporate cash flow.

4.1.2.1.3 Government support

Pertamina has substantial support from Government of Indonesia to develop petroleum operations. Current trends show that Pertamina has the privilege to take over expiring petroleum licenses. It is indicated from WMO block operatorship transfer in 2011 [126] and Mahakam block operatorship transfer in 2017 [127]. WMO block is used to be operated by Kodeco Energy while Mahakam block contract is currently operated by Total.

In exploration ventures, Pertamina has also privilege on direct offer mechanism based on Ministry of Energy and Mineral Resources regulation No. 35 year 2008. It allows Pertamina to conduct the initial G&G study, correspondingly has first right to acquire new exploration blocks offered by Ministry of Energy and Mineral Resources.

In summary, strong government support and regulations have allowed Pertamina to capture additional value creation through acquisitions. As a result, it can be assessed that government support is *valuable* capability, *rare, costly to imitate* and *exploited* by Pertamina.

4.1.2.1.4 Technical competencies

Pertamina has excellent technical competencies on operating onshore mature fields. It is indicated from success story in maintaining low decline rate in domestic mature fields. Thus, production level is kept at relatively stable with low growth. Instead, Pertamina has less experience in operating offshore fields. The offshore production assets operatorship are only subjected to two offshore shallow assets (ONWJ and WMO). ONWJ is petroleum block acquired from BP in 2009. Since then, Pertamina has fairy tale story in this block by enhancing oil production in almost double since it is acquired. Despite this fact, Pertamina still needs more exposure and operating experience in offshore fields. Assets in offshore deepwater, offshore heavy oil, offshore HPHT and any other complex challenges have not been own-operated by Pertamina. Most importantly, offshore will be the future source of growth in Indonesia.

In midstream sector, Pertamina is well known as experience operator of LNG plants. Bontang LNG which is operated by Pertamina is one of the largest LNG plants in the world. It is one of key center of excellence to maintain and develop LNG operatorship capabilities in the future. Experience in LNG operations can be valuable capability, once Pertamina discovers "*giant gas fields*", that is economically developed with LNG scheme.

In general, it can be summarized that onshore fields operations capability and LNG operations capability is *valuable, rare*, and *costly to imitate*. Conversely, *it needs more exploitation* to develop offshore operations capability by gaining more experience in offshore assets.

4.1.2.1.5 Upstream Technology Center

Pertamina established UTC (Upstream Technology Center) as the center of excellence to develop best practices and E&P technology. The goal of UTC is to enhance technology leadership capability, value creation, and to provide engineering solutions to Pertamina assets. Technology innovation is the mainstream of UTC activities by conducting research and development (R&D) network with research centers, universities, or other companies. The scope of business is, not only conventional hydrocarbon but also unconventional hydrocarbon. In recent years, new energy and renewable expertise are established to support the development of geothermal assets. UTC also plays key roles in subsurface data management, subsurface data processing and interpretation, reservoir characterization, production and well analysis, and processing facility improvement. Interestingly, UTC has insufficient focus to develop and deploy IO capability. In fact, IO is emerging trend of smart asset operating model. Global players have extensively deployed and developed IO, especially to operate offshore assets, since the early 2000s. In other words, it is implied that UTC is not fully driven to address development and deployment of IO. IO capability is strategic to address the complexity of offshore operations in the future.

In summary, it can be concluded that UTC is *valuable* resource, *rare*, and *costly to imitate*. Nevertheless, it is *not exploited* by Pertamina to develop IO capability.

4.1.2.1.6 Leadership and people development

Pertamina already has a system to develop future leaders inside the organization. It is aimed to create a smooth succession of leadership to sustain operations. A couple of training initiatives such as Junior Business Management Program (JBMP), Senior Business Management Program (SBMP), and TLE (Transformation Leadership Engine) are designed to nurture and equipped new leaders with relevant competency requirements to drive future business.

However, top management (CEO) tenure in Pertamina is considerably shorter than other global players. The average tenure of CEO is about 3 years. In comparison, Helge Lund, former Statoil's CEO, has around 10 years of leadership tenure. Thus, he has sufficient timespace to implement his strategic directions and initiatives. IO is one of them. He successfully leads Statoil to increase production capacity from 1.1 mmbopd to 1.9 mbopd during his leadership tenure [128].

In general, it can be concluded that leadership development program is clearly *valuable*, however, it is *not rare*. In addition, unstable top management tenure may impact the sustainability of corporate strategic directions and priorities.

4.1.2.1.7 Financial Strength

Pertamina has relatively stable financial performance. Shifting from oil and gas company into energy company help to achieve stable performance through portfolio diversification. Profit is continuously growing as a result of existing assets performance coupled with incremental from field acquisitions. The positive growth of net income and EBITDA is the indication of positive operation performance. Nevertheless, as a vehicle of national energy security, Pertamina still has to boost oil production amid low oil price that reduces profit at around 50% in 2014. Meanwhile, return on equity is excelled at around 30%. Interestingly, cash ratio is relatively managed at around 28% average. It is an indication that Pertamina has excellent cash structure. The financial performance indicators are depicted in Figure 4.18 [107].

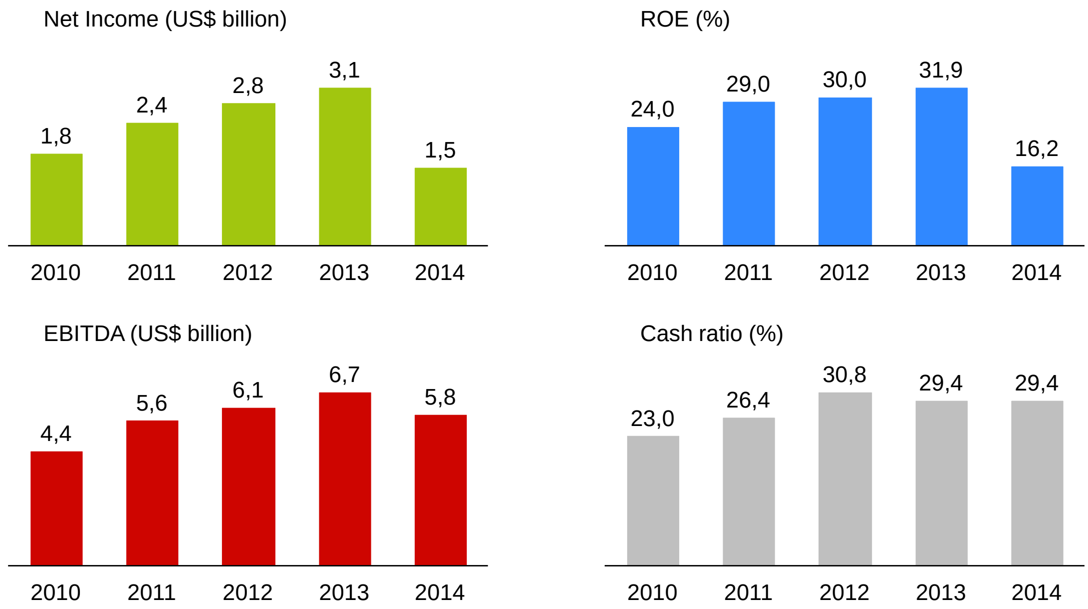


Figure 4.18 Financial performance

Excellent financial performance affects fundraising capability in the financial market. Pertamina has successfully raised fund from Global Bond package which grabbed around US$8.7 billion from global investors. External funding is important to manage corporate financial balance and also essential to support new investment as a source of growth.

Consequently, it can be assessed that Pertamina has *valuable* strength on financial performance. Nevertheless, it is *not* considered as a *rare* resource since there are IOCs that have more financial strength.

4.1.2.1.8 Brand and reputation

In Indonesia, Pertamina is the largest State Owned Company which deliver the sublime revenue to Indonesia. Pertamina was voted as Indonesia Most Admired Company and was elected as Most Admired Company to Work For in 2015 [129]. These rewards leverage Pertamina as an excellent brand and build a reputation as high profile company. They created strong magnet effects that are expected to attract high potential talents to join Pertamina. Unquestionably, high potential talents will build the foundation of strong human capital as drivers of leadership and innovation. In addition, excellent brand and associated network to Government of Indonesia are attractiveness factors that appeal global players to do business with Pertamina in Indonesia.

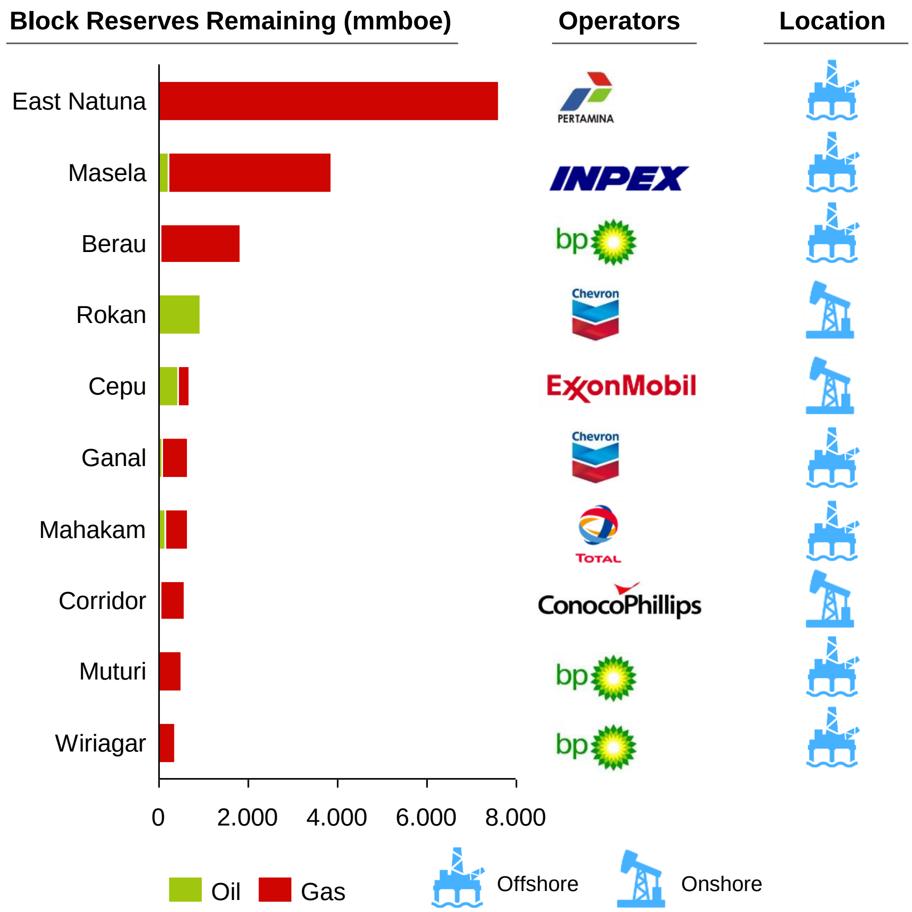


Figure 4.19 Top 10 remaining reserves

However, IOCs that operate in Indonesia have also magnet factor for new talents to join them. Moreover, they mostly hold operatorship in highly potential blocks that have giant fields (Figure 4.19 [109]).

In summary, brand and reputation are *valuable* assets, nevertheless, it is *not rare* that other IOCs have comparable values.

4.1.2.1.9 Drilling services business

PDSI is Pertamina's subsidiary to provide onshore drilling services. It is one of the largest landrigs operators in Indonesia with total of 39 landrigs. Currently, oil and gas production sources are mainly from Sumatera. For this reason, PDSI allocated 19 rigs in Sumatera, 10 rigs in Java, 9 rigs in Kalimantan, and 1 rig in Sulawesi (Figure 4.20 [130]). Meanwhile, Papua has less activity in onshore since most of the fields are in offshore. PDSI's rigs are productive assets since they successfully grabbed 20% of market share in onshore drilling market. More importantly, the existence of onshore drilling services is expected to ensure drilling rigs security of supply in onshore operations. Nevertheless, PDSI doesn't have a core competency in offshore drilling. On the other hand, Apexindo, one of the PDSI's main competitors, has complete drilling services from onshore to offshore. Therefore, it can be concluded that PDSI is *valuable* resource, however, it is *not rare*. Apexindo has similar capability in onshore, more importantly, it has offshore drilling capability.

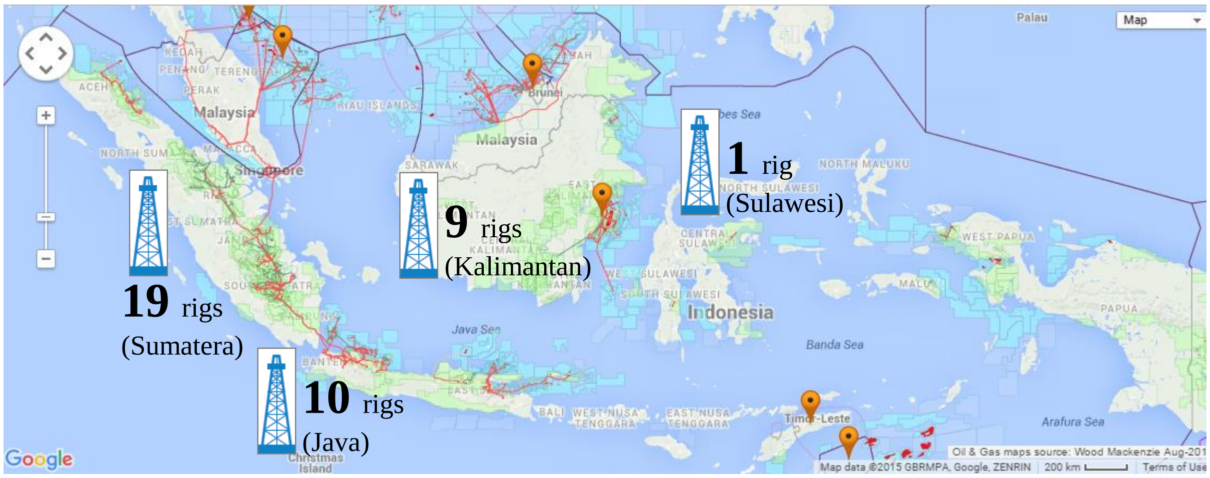


Figure 4.20 PDSI rigs

4.1.2.1.10 VRIO analysis summary

Based on above discussions, there are three core competencies and two resources or capabilities that need more exploitation. The *core competencies* are: firstly, *petroleum assets and infrastructure network*; secondly, *business portfolio diversification*; and lastly, *government support*. The *resources or capabilities that need more exploitation are*: firstly, *upstream technology center*; and secondly, *technical competencies*. These are the focal points that shall be enhanced and exploited in order to transform them into core competencies. Development and deployment of IO as offshore operations capability shall be regarded as a strategic priority to gain competition advantage.

Resources or Capabilities	**Valu able?**	**Rare?**	**Costly to imitate?**	**Exploited by orga nization?**	**Competitive impli cations?**	**Economic perfor mance?**
Petroleum assets and infrastructure network	Yes	Yes	Yes	Yes	Sustain competitive advantage	Consistently above average
Business portfolio diversification	Yes	Yes	Yes	Yes	Sustain competitive advantage	Consistently above average

Resources or Capabilities	Valu able?	Rare?	Costly to imitate?	Exploited by orga nization?	Competitive impli cations?	Economic perfor mance?
Government support	Yes	Yes	Yes	Yes	Sustain competitive advantage	Consistently above average
Technical competencies	Yes	Yes	Yes	No	Temporary competitive advantage	Above average
Upstream technology center	Yes	Yes	Yes	No	Temporary competitive advantage	Above average
Leadership and people development	Yes	No	-	-	Competitive parity	Normal
Brand reputation	Yes	No	-	-	Competitive parity	Normal
Financial strength	Yes	No	-	-	Competitive parity	Normal
Drilling service business	Yes	No	-	-	Competitive parity	Normal

Table 4.1 VRIO analysis Pertamina

4.1.3 SWOT analysis

External analysis, which has been performed with Porter's Five Forces analysis, along with internal analysis, which has been performed with VRIO framework, are integrated into SWOT analysis. The summary of SWOT analysis is summarized below:

4.1.3.1 Strength

a. Massive petroleum assets that are integrated with complex infrastructure network to facilitate commercialization.
b. Highly diversified business portfolio that spans from oil and gas, geothermal, drilling services and other non-core businesses.
c. Strong support from Government of Indonesia as sole shareholder.
d. Excellent experience in onshore mature fields, LNG operations, and FSRU.
e. Drilling service subsidiary to secure rig supply in onshore drilling operations.
f. Robust financial performance that underpinned by strong cash flow management.

g. Powerful brand and reputation as one of the best State Owned Company.

4.1.3.2 Weaknesses

a. Lack of experience in operating offshore assets, especially highly complex assets environment such as offshore deepwater.
b. Most of Pertamina assets are onshore mature fields that have entered declining period.
c. UTC is not fully exploited to develop innovation on smart operating model such as digital oilfield/integrated operations/smart field.
d. Relatively short tenure of top management may affect the sustainability of strategic direction and corporate top priorities.
e. Lack of experience in offshore drilling services.
f. Brand and reputation power is still lower than IOCs in global operations.

4.1.3.3 Opportunities

a. Potential offshore new ventures in Eastern Indonesia.
b. Highly considered as operator in East Natuna block.
c. Rapid growth of domestic oil demand will guarantee future oil market.
d. Bright prospect of gas demand especially in industry and power generation sectors.
e. Transfer of operatorship on expiring blocks.
f. Development and deployment of IO as new offshore operations capability.

4.1.3.4 Threats

a. Most of the future new ventures are highly complex offshore environments that is not align with current core competencies.
b. Late adoption of IO model in offshore operations may reduce the level of competitiveness in the future.
c. Lack of offshore operations capability may reduce the probability to win in licensing rounds or tenders to acquire offshore blocks. Operations capability is one of major decision criterion in selecting preferable contractors, especially tenders that are subject to government approval.
d. Continuous decline in current onshore assets may reduce profitability since lifting volume is the fundamental factor of revenue growth.
e. Increasing non-technical challenges of onshore operations may leverage preference of offshore operations.
f. Future competition of block acquisitions (inorganic growth), especially easy oil in onshore, is expected to be more competitive.

Generally, it can be summarized that Pertamina needs to accelerate deployment and development of IO as new capability and operating model. IO will be the new core competencies to remain competitive in the future offshore operations business.

4.2 Integrated operations strategy development

The previous section discussed that the future of petroleum business is expected to be more dependent to offshore assets operations. For this reason, current strategy will be more powerful and align with future trends by embedding IO strategy to complete pieces of the jigsaw that shape Pertamina's business strategy. In this section, scenario planning and integrated performance framework are performed to systematically craft Pertamina's IO strategy. In addition, stakeholder theory, cluster and network theories are also performed to design smart collaborative network as a new system to spread over IO knowledge throughout the organization.

4.2.1 Scenario planning

Scenario planning is aimed to define the future plausible scenarios. Based on current trends in Indonesia petroleum industry, scenarios can be built to envisage what may happen in the future. External and internal analysis in the previous section are the groundwork of identifying trends in Indonesia petroleum industry. The trends identified are documented and mapped to analyze the impact to *future Pertamina's offshore business* versus *degree of predictability*.

Mapping is intended to prioritize trends and conduct an in-depth analysis (Figure 4.21). The prioritized trends and their rationale are discussed below :

a. Positive economic growth which is indicated by relatively stable GDP growth of Indonesia at around 6% year-on-year (Figure 4.9).
b. Growing domestic gas demand with average 2% (CAGR) which will change the energy balance in the future (Figure 4.10).
c. Growing oil demand with average 3% (CAGR) which is driven especially by transportation sector (Figure 4.10). It is expected to enlarge the oil deficit provided that no significant new oil discoveries in the future.
d. Domestic oil shortage which is indicated by reducing oil production in Indonesia on the other hand supply is increasing rapidly at 3% CAGR (Figure 4.10).
e. The decline of onshore production that changes the landscape of future production source. Production is predicted to be more dependent on offshore fields (Figure 4.13).
f. Increasing pressure to sustain energy security. It is indicated by the downturn of oil production which is far less than oil demand. Gas supply is lucrative nevertheless, the gas fields locations are scattered and distance away to the market. Most of the gas producers are located in Kalimantan, Papua and Sumatera while the gas market is dominantly located in Java.

g. New gas infrastructure is built to distribute gas from producers to consumers. It is indicated by new construction of FSRU, LNG regasification plant, and plan to build a new gas pipeline in Java.

h. Offshore new ventures are available, especially in eastern Indonesia. Nevertheless, the location is considered remote, geologically complex and less mature infrastructure to be commercialized.

i. EOR in mature fields is one of the key future opportunities to increase recovery factor. Western part of Indonesia is the playground of EOR projects.

j. Longer time to field commercial. New offshore new ventures are expected to require sufficient timespace in order to conduct exploration and development. Additionally, immature gas infrastructure network in Eastern Indonesia also contributes to longer field commercialization.

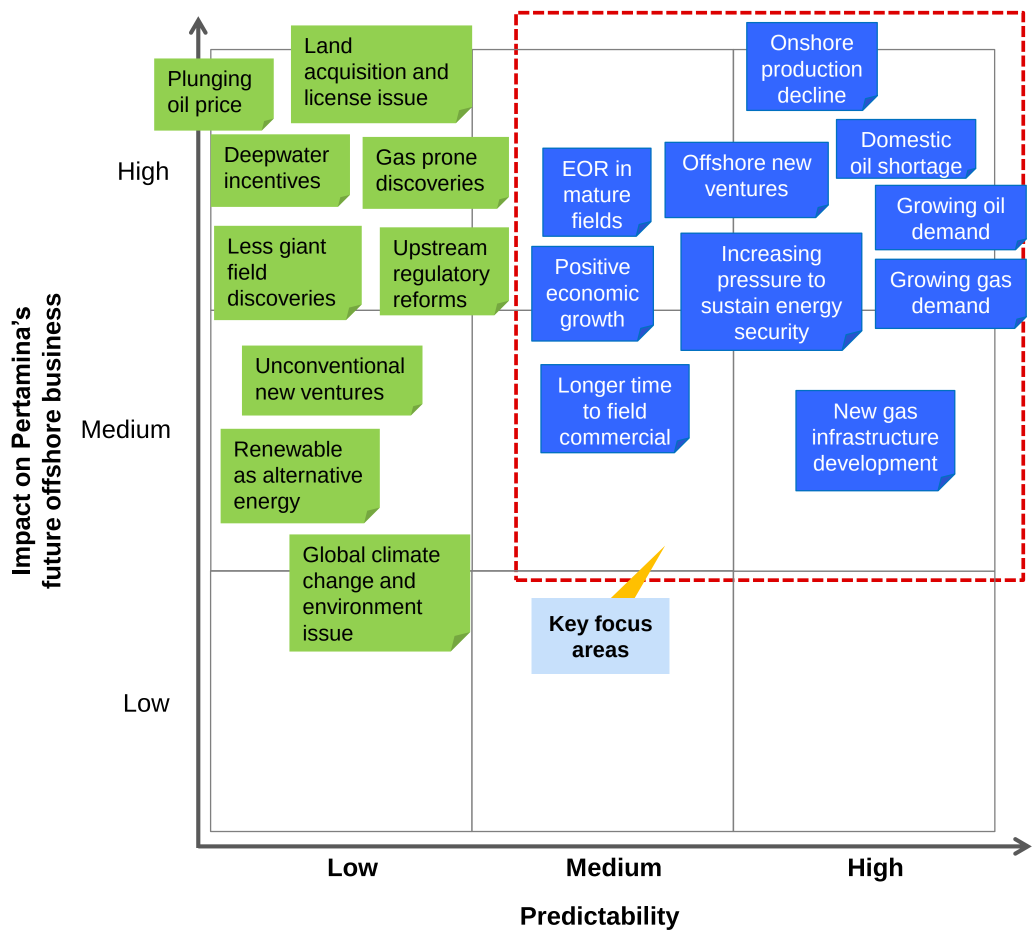


Figure 4.21 Key trends mapping

Subsequently, each of the trends is analyzed to draw the influence network and, finally defined the key drivers of future scenarios (Figure 4.22).

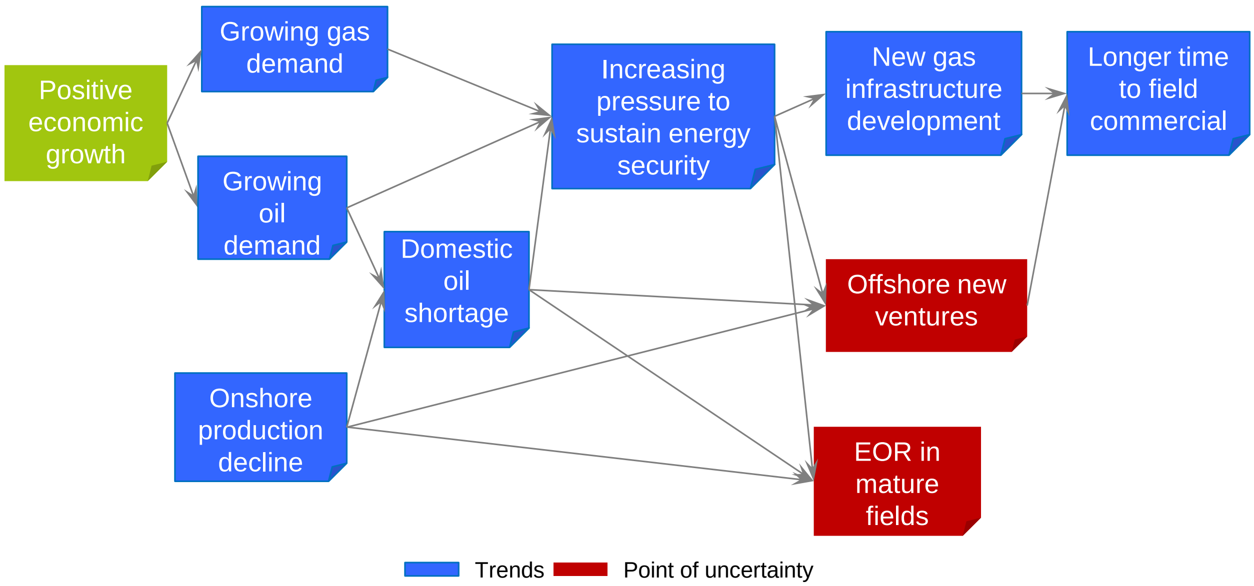


Figure 4.22 Key trends influence network

Positive economic growth is expected to drive demand for oil and gas. The transportation sector is the largest demand of oil. Meanwhile, power generation and industry is the largest consumer of gas. In other words, growing economy is the key driver of *oil and gas demand growth*. To repeat, oil is predicted to grow at around 3%, whereas gas is 2% (Figure 4.10).

Unfortunately, the growing demand for oil is not at equilibrium with domestic supply (*domestic oil shortage*). Onshore oilfields, as the backbone of crude oil supply, are mostly entering the mature periods subjecting them to larger *decline* rate. In contrast, gas supply is still outperforming demand (gas surplus). Unfortunately, most of the gas fields are scattered and distance away from marketing points. Java is the largest market while gas fields are mostly situated in Sumatera and Kalimantan.

Therefore, *domestic oil shortage* coupled with *growing gas demand* will *increase pressure to sustain domestic energy security*. For this reason, Government of Indonesia pushes construction of new gas infrastructure. Construction of FSRU, LNG regasification plant, and new pipeline networks are the indications. As a result, immature infrastructure networks contribute to *longer time required to commercialize fields*.

On the one hand, *increasing pressure to increase supply*, *domestic oil shortage*, and *onshore production decline* may become “pull factors” for operators to select decision alternatives that are expanding to *offshore new ventures* or initiating *EOR in mature fields*. Indonesia still has large prospective plays in offshore. It seems like the key decision criterion of oil players is exploration success ratio in offshore. Large success ratio coupled with new giant discoveries will drive offshore new ventures on the forefront of EOR. On the other hand, low success ratio will float EOR as better decision alternative. To conclude, the success ratio of *offshore new ventures* is the key uncertainty that is expected to change the landscape of the future.

In general, it can be summarized that the key driver of trends is positive economic growth that drives along other trends interactively. Additionally, the performance appraisal of offshore new ventures will be the key uncertainties. Most importantly, *probable scenarios can be derived from mapping key driver against key uncertainty*. As a result, Figure 4.23 shows the probable future scenarios of Indonesian's petroleum industry.

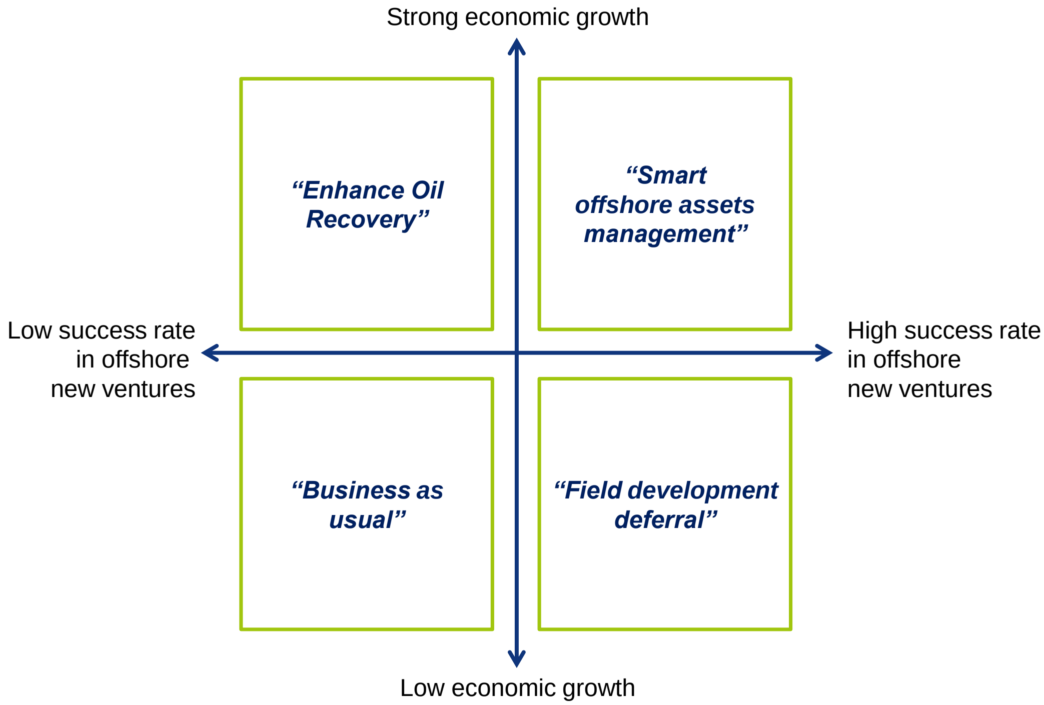


Figure 4.23 Plausible future scenarios

Each of the scenarios is further discussed in the following explanation :

a. ***Smart offshore asset management***. In this world, offshore E&P is mushrooming. More companies allocate their resources to drill, develop and accelerate production in offshore. High complexity of offshore operations emerges IO as the powerful capability to manage operations. Integration between people, process and technology is a key theme of operations removing organizational and geographical barriers. Collaboration is enhanced through the establishment of IO centers to support drilling and operations. Additionally, smart collaborative network is established to become active knowledge and innovation pipeline between asset team, research centers, oil companies, universities, contractors, suppliers and government. People are trained to build novel IO skillsets. In parallel, organization is also redesigned to promote collaboration, knowledge spillovers, innovation, and teamwork. In general, smart offshore asset management will be the emerging trend in this world.

b. ***Enhanced oil recovery***. In this world, low success rate of offshore ventures will drive oil companies to accelerate EOR projects as a new source of growth. In other words, EOR projects is expected to be more attractive than offshore new ventures. Oil companies will cooperate with research centers, universities, contractors, and suppliers to accelerate R&D on EOR. Government of Indonesia may legalize new policy, such as Fiscal Term revision, to enhance economic of EOR projects. EOR piloting and testing will be largely implemented driving demand for onshore drilling rigs and injection fluids.

c. ***Field development deferral***. In this world, fairy tale success rate of offshore new ventures may escalate offshore operations. Nevertheless, slow economic growth coupled with abundant supply from offshore is expected to create a world of hydrocarbon oversupply. As a result, it will reduce the bargaining power of oil companies in controlling project economic. In conclusion, oil companies are expected to halt their decision on field development. They will exercise the option of waiting since they seek for better project return.

d. ***Business as usual***. In this scenario, petroleum companies are expected to operate as a current way of operations. Consequently, national oil production keeps declining. They are expected to assess carefully about the prospect to go offshore since offshore prospects are technically complex coupled with less attractive fiscal term

Based on above scenarios, alternatives of strategy are evaluated against probable future scenarios in order to assess the applicability between them.

Strategy alternatives	Smart offshore asset management	Enhance oil recovery	Business as usual	Field development deferral	Notes
Integrated operations capability development	Supportive	-	Supportive	Supportive	-
EOR project acceleration	-	Supportive	Supportive	-	Pertamina EP has been implemented EOR
Block acquisitions	-	-	Supportive	Supportive	Current strategy

Table 4.2 Strategy against scenarios

Table 4.2 above shows that *IO capability development* is expected to be appropriate in three potential future scenarios. On the other hand, block acquisitions and EOR projects have been implemented in Pertamina. EOR projects have delivered 2 mbopd additional production in 2014 [125]. Block acquisitions in domestic and international also leverage production performance.

In global summary, IO capability development is the top priority to transform Pertamina as an *agile* organization that can cope with multiple future scenarios. IO is the smart solution that delivers better and faster decisions that bolster asset performance under ever-changing and uncertain offshore operations.

4.2.2 Integrated operations strategy

Knowledge gain on literature review (Chapter 3), Porter's Five Forces analysis, VRIO analysis, and SWOT analysis, are strategic input to design IO strategy. Subsequently, integrated performance theory is referred to design IO strategy building blocks. Finally, Pertamina's IO strategy is presented in Figure 4.24.

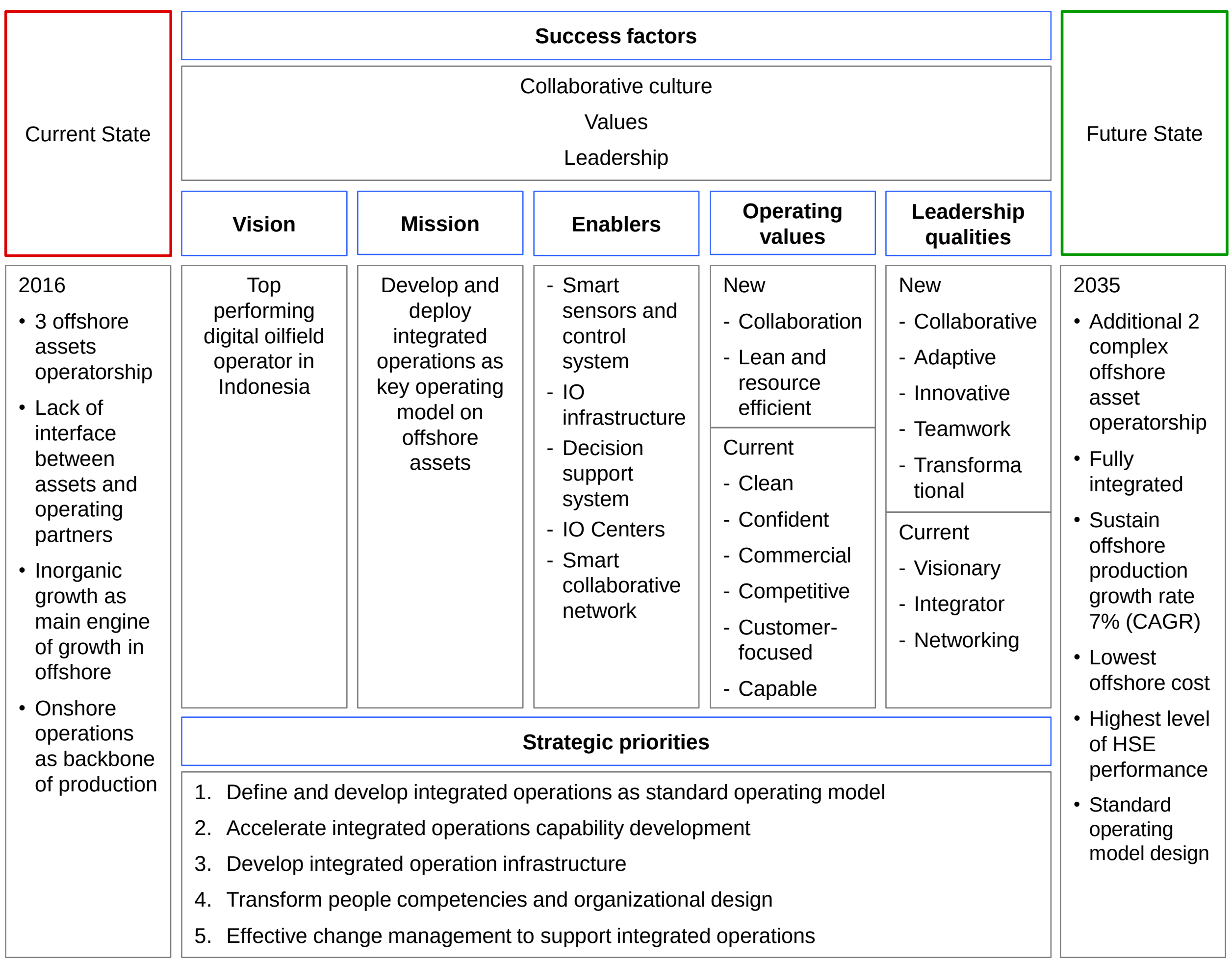


Figure 4.24 Integrated operations strategy

Strong engagement and commitment of all levels of organization are imperative to integrate vision, mission, enablers, operating values, leadership qualities, and strategic priorities since they are key transition factors in order to transform Pertamina from current state to future state. Each of the factors is discussed below:

4.2.2.1 Current state

Currently, Pertamina has only three offshore operatorship assets. Two of them are in production phase (ONWJ and WMO) while the other is in near production (Nunukan). The contribution of these assets to total Pertamina's production is still lower than a collection of onshore assets controlled by Pertamina EP. Onshore assets are still the main producers. Inorganic growth through block acquisitions is still the main source of production growth since it provides quick yield effect.

In managing offshore assets, the interface between operators and external parties (e.g. contractors, suppliers, external experts) still needs more integration. More importantly, integration is strategic to generate complementary ecosystem that empowers collaboration. The absence of IO centers and IO corporate are the key indication.

4.2.2.2 Vision

The vision of IO strategy is to float Pertamina as *top performing integrated operations/digital oilfield operator in Indonesia*. It shall be the main aspiration of the company that drives all levels of organization to work together in realizing future state. IO is expected to be Pertamina's strategic capability to win the competition in offshore business. Additionally, value creation, that is expected to be delivered from IO deployment , will be the new source of organic growth.

4.2.2.3 Mission

The mission of IO strategy is to deploy and to develop IO as key operating model on offshore assets. IO model will be the standard way of Pertamina's offshore operations. As a rule, it will be developed and deployed on current and future assets.

4.2.2.4 Strategic priorities

During 2016-2035, there are five strategic priorities to build Pertamina's IO model. Each strategic priorities is explained in the following discussion :

4.2.2.4.1 Define and develop integrated operations as standard operating model

Digital technology is the foundation of IO model, however technology alone can not deliver the maximum value of IO. Unquestionably, technology is a key enabler of IO and has a direct influence on people and work process. For this reason, IO operating model shall be developed by integrating people, process, and technology.

Correspondingly, Pertamina needs to formalize corporate direction that IO *shall be defined and developed as standard operating model on offshore assets*. IO shall be formalized as standard operating philosophy and guideline in developing future offshore assets. Figure 4.25 shows design of generic IO operating model.

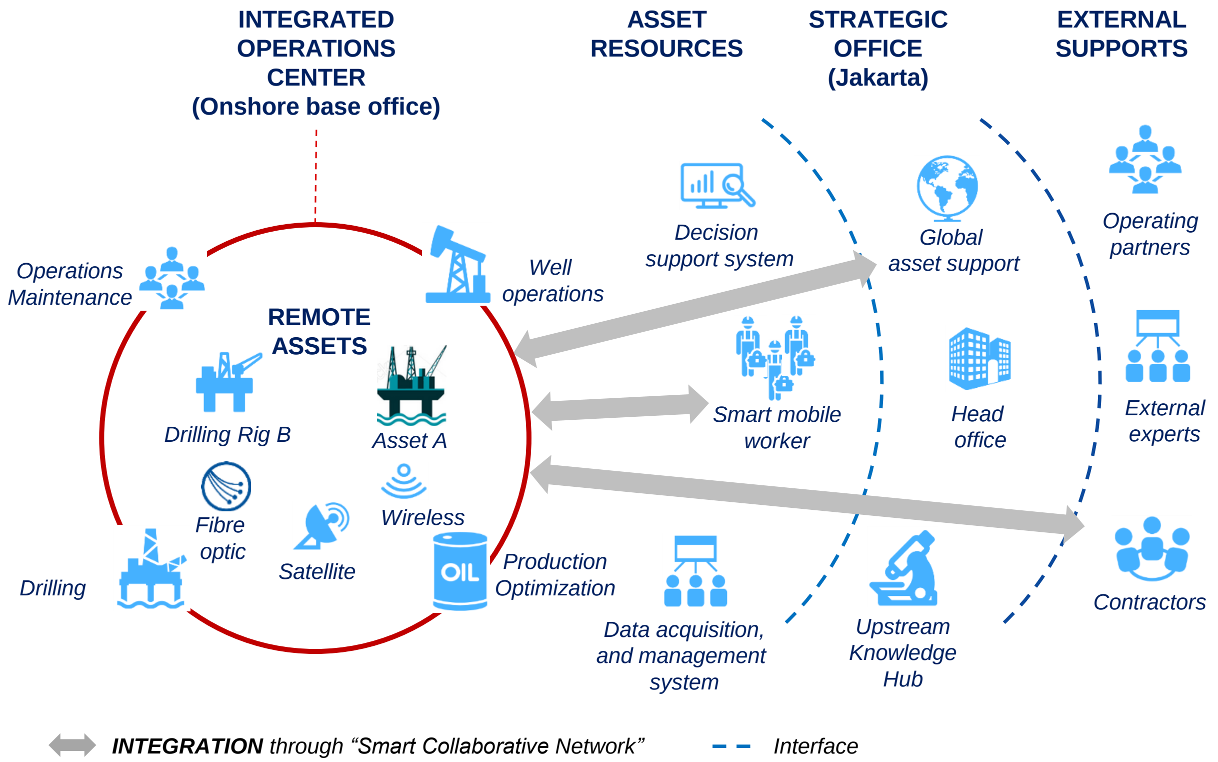


Figure 4.25 IO standard operating model

Offshore assets such as wells, subsea equipments, topside facilities, pipelines and drilling rigs are classified as remote assets. These assets shall have 24/7 active communication with IO centers in onshore base office. Thus, high bandwidth and low latency communication infrastructure (combination of fiber optic, wireless, and satellite) shall be in place to underpin uninterrupted (fail safe system) data transfer between offshore assets and IO Centers providing "*common situational awareness*". In other words, communication system will create seamless collaboration between onshore and offshore team, as a result integrating them as "*one team*" despite geographical and organizational barriers. In addition, communication system is also essential in supporting remote operations capability that enables onshore control room to have a *common view* with offshore Central Control Room (CCR).

IO Centers are dedicated as the central node of offshore asset management enabling 24/7 operational support for drilling, well operations, production optimization and O&M (Operations and Maintenance) activities. Multidisciplinary experts (subsurface and surface experts) are co-located in IO centers that promote interactive and supportive collaboration by removing functional silos. Collaboration and teamwork are the key philosophy of IO operating model. This work setting is comparable with NASA's interactions during space mission. IO centers play role similar to NASA Johnson Space Center at Houston while offshore assets play similar to Astronaut team in space. Refer to chapter 3, Liyanage [26] and IHS [117], the generic landscape of IO center can be depicted in the following figure :

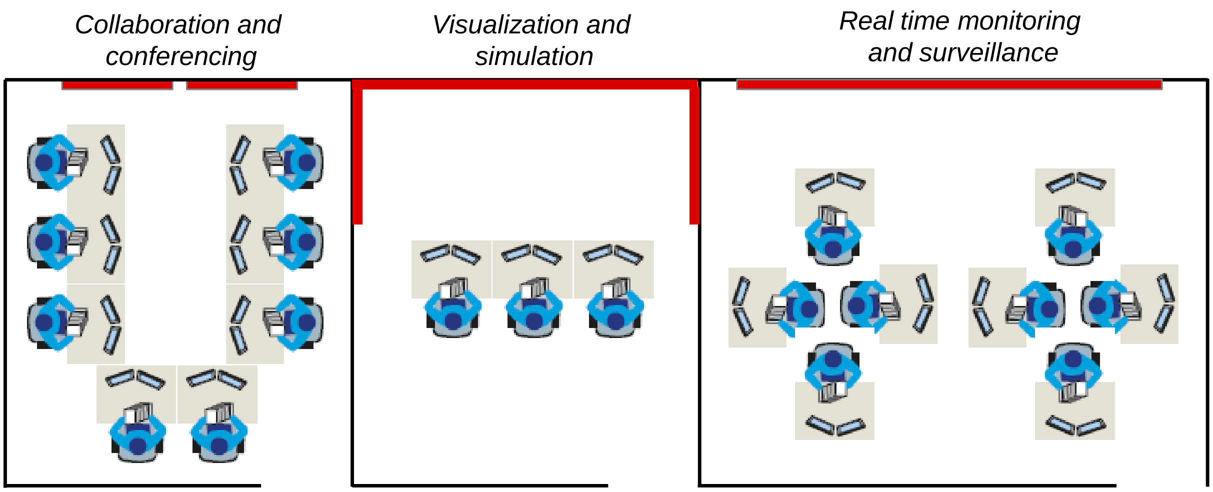


Figure 4.26 Generic CWE landscape

IO centers comprise of three main sections which are collaboration and conferencing room; visualization and simulation room; and real-time monitoring room. Firstly, collaboration and conferencing room are designed base on "*We*" type collaboration mode to promote interactions on building consensus, joint decision making, and energize idea sharing on more experts [131]. The landscape is set up to facilitate active communication between multidisciplinary experts and offshore team. The main objective is joint decision making. Secondly, visualization and simulation room is designed to promote collaboration on more strategic decision loop such as subsurface modeling. Collaborative review is essential in subsurface visualization, modeling and simulation to sharpen model interpretation. Thirdly, real-time monitoring room is designed based on "we" type collaboration to promote collaboration on cross-sharing information, comparing and contrasting, and shared-tasks [131]. The point of this design is close proximity between experts that will promote faster decision making. It is appropriate for tactical and operational decision loop such as real-time monitoring, surveillance, and drilling operations support environment.

IO centers also play key roles in assets planning and decision making (strategic and tactical decision) while offshore team focuses on more execution (operational decision). Seamless collaboration between onshore and offshore will connect planners, decision makers, and executors together in common situation awareness facilitated by online video monitoring and conferencing tools. More importantly, joint decision making, between onshore and offshore team, will create "system view" on operational problems creating better interpretation and reasoning on complex problems under uncertainty. In general, Pertamina needs to accelerate the establishment of IO centers as the center of collaboration. Correspondingly, potential locations for IO centers are Jakarta (IO center Java), in Batam (IO center Natuna), Balikpapan (IO center Kalimantan), and Sorong (IO center Papua and Timor).

Integration between IO centers and offshore assets are enabled by three key asset resources. They are data acquisition and management system; decision support system; and smart mobile worker. Firstly, data acquisition and management system is the actor of measurement and monitoring. It provides the capability of acquiring real-time data (e.g pressure, temperature, flow, rpm, etc), real-time data management (e.g cleansing, mining, quality assurance, and storage) and human interactive monitoring system (remote operations). Secondly, decision support system is the key actor of analytics, visualization, and workflow management. It provides capability of surveillance system (anomalies detection and trending); system diagnostics (data-driven root-cause analysis and predictive analytics); system modelling (interoperability with engineering modelling tools); system optimizers (what-if analysis and decision alternatives optimization) and smart workflow system (delivering data, information, and knowledge to the right person at the right time). Finally, smart mobile worker provides the capability of remote expert mode between onshore experts and offshore workers that enable anytime-anywhere accessibility (Figure 4.27 [132]). They collaborate with digital oil and gas engineers in IO centers. Digital oil and gas engineers are GGR (Geology, Geophysics, and Reservoir) and facility experts who are equipped with digital technology skillsets.

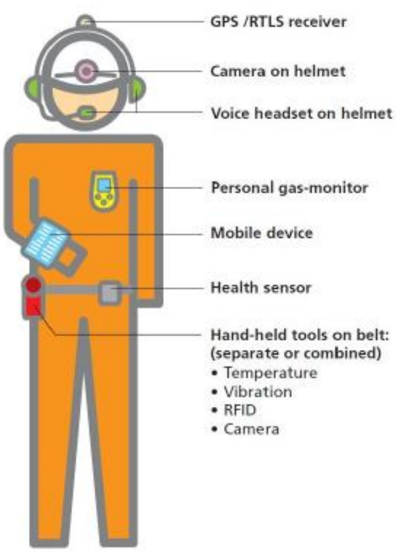


Figure 4.27 Smart mobile worker

In order to enhance the interface between assets and to embrace external assets stakeholders (strategic office and external supports nodes), Smart Collaborative Network (SCN) shall be established to connect Upstream Knowledge Hub, IO centers, offshore assets, and external assets stakeholders as one business ecosystem. The strategic rationale is to embed operational knowledge and to foster innovation across Pertamina offshore assets.

Upstream Knowledge Hub (UKH) is the nucleus of SCN. UKH has also active network with IO centers in Java, Natuna, Kalimantan, and Papua. Each IO centers has an active network with offshore assets, global asset, support, head office, operating partners, external experts, contractors and other key stakeholders. It forms virtual network enterprise as a vehicle to leverage quality of asset decision making process. For this reason, B2B network shall be established to facilitate active communication with external organizations. More importantly, contractors and external experts shall be bound by performance-based contract to encourage active support based on assets performance.

Figure 4.28 Smart collaborative network

In order to exploit UTC (Jakarta office) as one of core competencies, it shall be assigned as the main actor of UKH that transforms it into IO innovation center. For this reason, existing UTC shall be facilitated with required resources and most importantly in line with IO strategy. UTC will be the engine and producer of IO new solutions supporting goals of IO strategy. It shall also be equipped with high profile digital oil and gas engineers who have a high level of academic and professional experience in IO deployment and development. Pertamina Human Resource function shall support this initiative by cultivating Master and Doctoral degree in digital oilfield or integrated operations. Additionally, it shall be equipped with representative research center areas and other facilities that support its activities. UTC shall also B2B network to enable collaboration and teamwork with external organizations (e.g contractors, external research centers, universities, etc).

Active collaboration and teamwork, between nodes in SCN, will enable Pertamina to maximize distinctive capabilities of external organizations in leveraging offshore assets performance. Additionally, UKH has also direct network with IO corporate team (Head Office) who has roles as IO Strategic Leader as well as responsibilities to develop corporate-wide IO strategy and IO project portfolio management. IO corporate team in collaboration with Upstream Knowledge Hub monitor IO deployment projects in each of the assets, measuring IO value creation and conducting annual IO maturity assessment.

In addition, global asset support center shall also be established to capture operational problems throughout all offshore assets. This center is encapsulated inside UKH, thus has a direct link with *IO Innovation Clusters in UKH*. It has also active network with IO centers in Java, Kalimantan, Natuna, and Papua & Timor to underpin its function as global technical support center. Unsolved issues in IO centers, due to limited resources and level of expertise, can be distributed to Upstream Knowledge Hub to be resolved. The solutions are documented in IO active knowledge management system for the sake of continuous improvement.

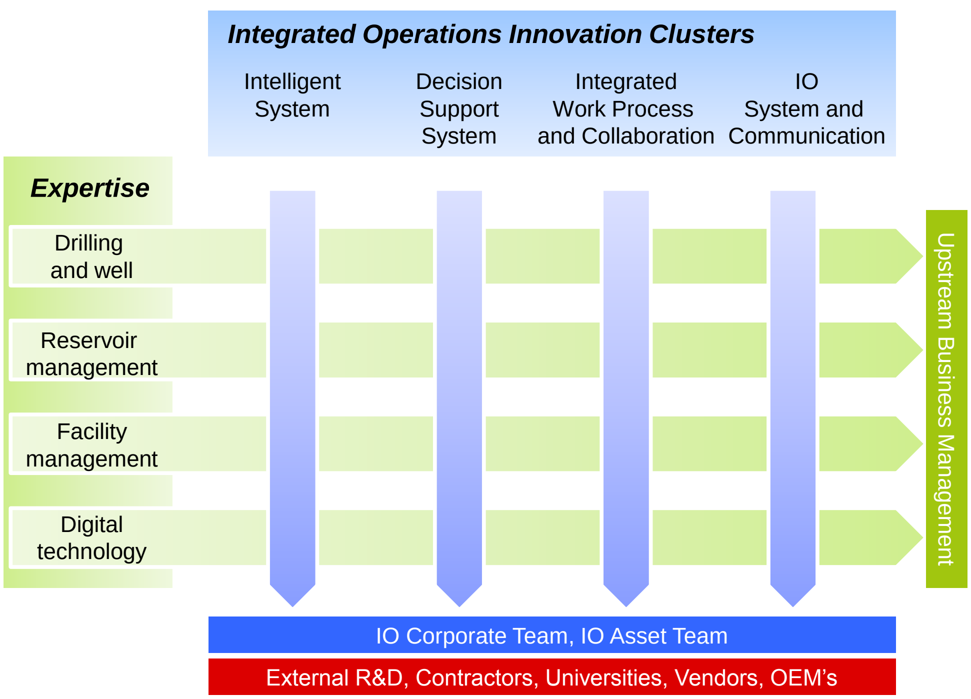


Figure 4.29 IO Innovation Cluster

IO Innovation Clusters are devoted to conducting R&D in *intelligent system; decision support system; integrated work process and collaboration;* and *IO system and communication*. Figure 4.29 depicts the IO innovation clusters in UTC. IO Innovation Clusters are an agglomeration of experts that collaborate together to accelerate innovation on IO capabilities. Multidisciplinary experts, ranging from drilling and well, reservoir, facility and digital technology, are co-located in the same office space to empower value of concurrent design. The clustering mechanism will increase the speed of innovation by removing functional silos, and work together based on common performance goals. Admittedly, experts in UTC shall be reorganized to facilitate cluster thinking and promote concurrent design mechanism. Basic concept of office space to facilitate cluster thinking is depicted in figure below:

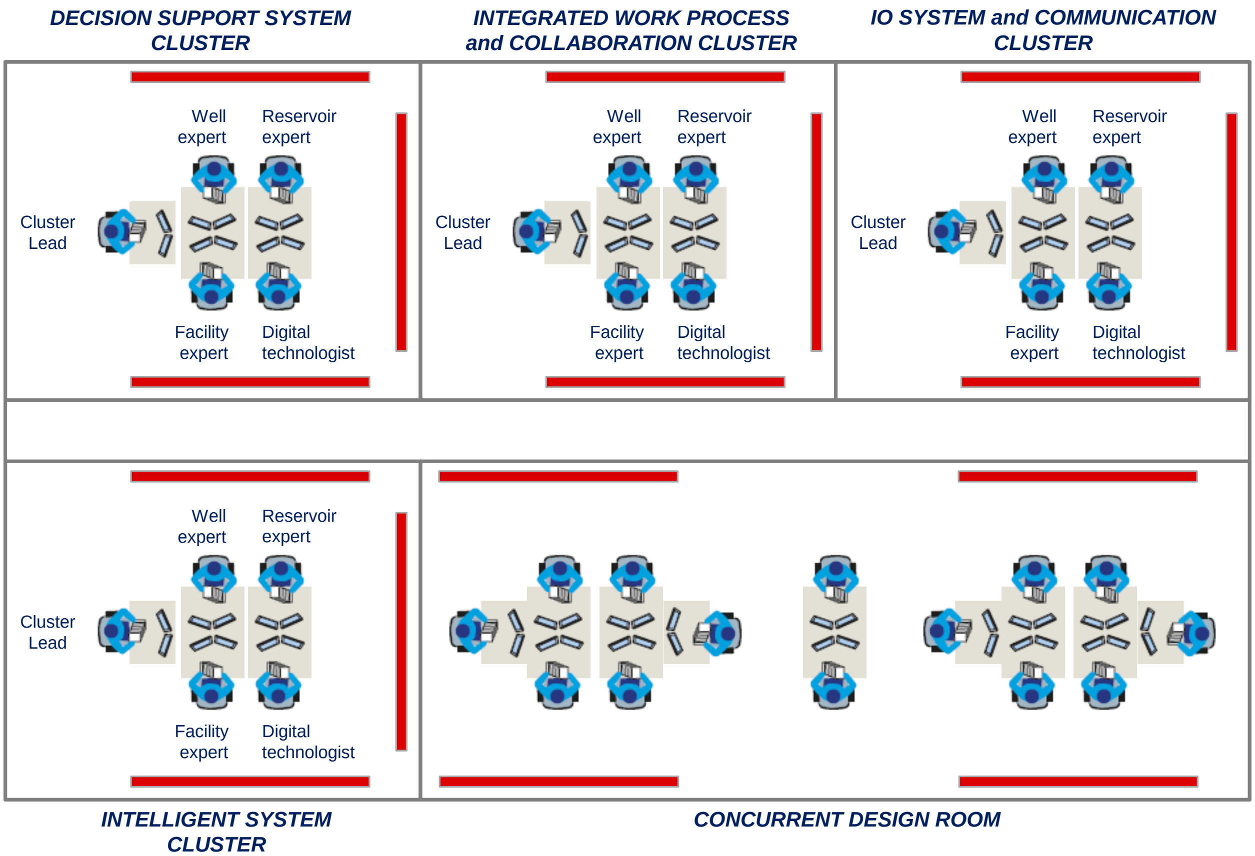


Figure 4.30 Experts in IO clusters

Each of the clusters has an active collaborative network with IO corporate team, IO asset team, and external organizations. Link with IO corporate team is dedicated to aligning innovation with strategy. Meanwhile link with IO asset team is to gain insights, challenges, and implementation issues regarding IO deployment. Additionally, link with external organizations is devoted to facilitating collaborative design that utilizes niche competencies or distinctive capabilities of external organizations.

In summary, IO shall be established as a standard operating model. Integration is provided through the establishment of SCN that provides seamless collaboration intra-organizationally and inter-organizationally. It will leverage agility of decision making through active collaboration and joint decision making that can lead to better and faster decision making.

4.2.2.4.2 Accelerate integrated operations capability development

IO operating model is built based on IO capability model. Figure 4.31 shows the building blocks of Pertamina's IO capability model. The capability model is constructed of seven interdependence layers encapsulated with two enabling philosophy. Pertamina shall accelerate fulfillment of each layers to deliver top asset performance.

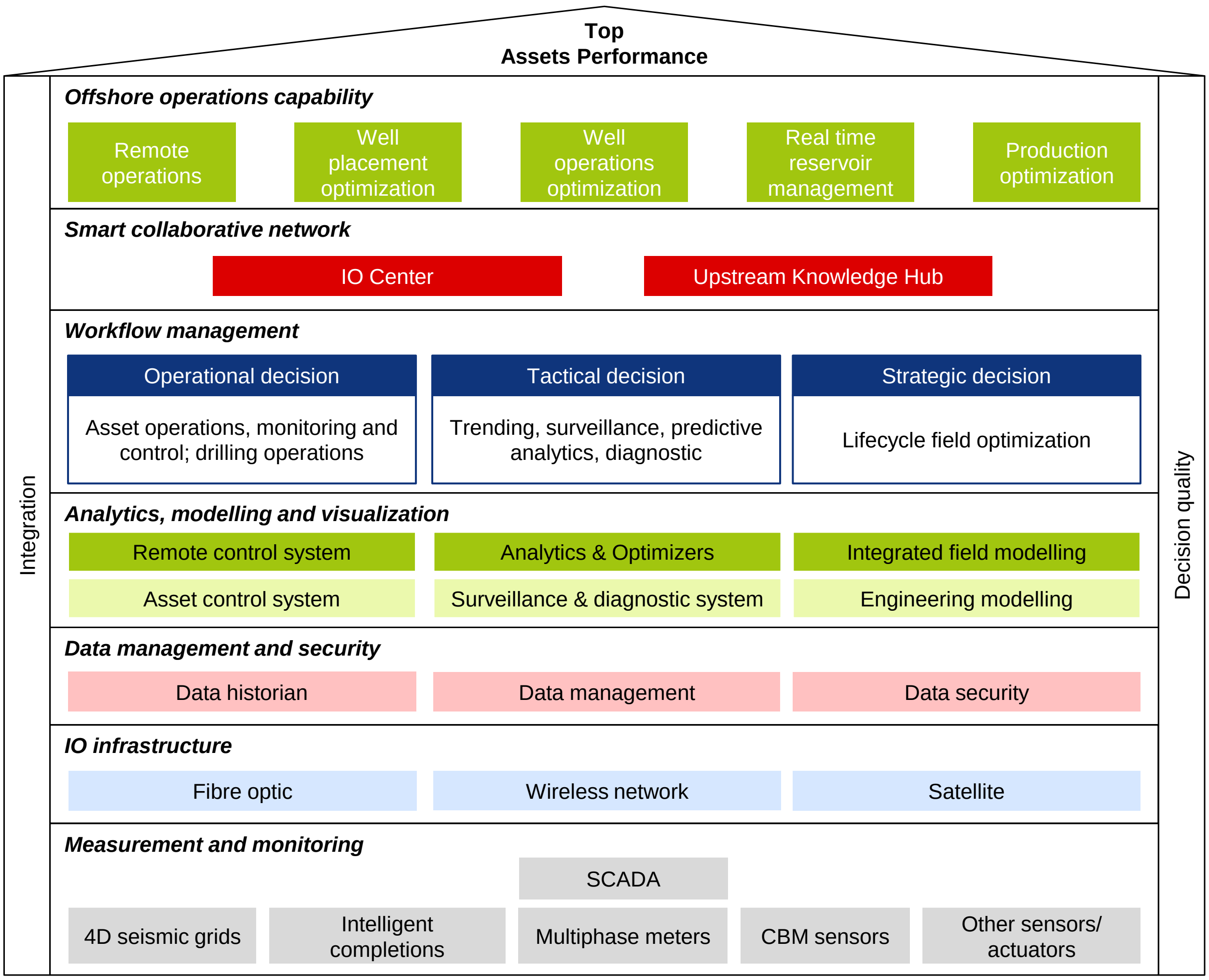


Figure 4.31 IO capability model

First layer is *measurement and monitoring*. The main function of this layer is providing high quality data acquisition as well as robust monitoring and control system. High quality data is very important since low quality data will lead to poor decision making. Smart sensors, control system and actuators are combined as intelligent system. The examples are SCADA, permanent 4D seismic grids (time lapse seismic), wells (intelligent completions), multiphase meters (pipeline), CBM sensors (rotating equipments), and other smart sensors/actuators. It is a heavy technology layer that build foundation of IO. Intelligent system cluster is assigned to lead the development and deployment of this layer.

Second layer is *IO infrastructure*. This is the main foundation of IO capability. The function is providing uninterrupted, high bandwidth and low latency communication pipeline. High bandwidth capacity is needed to transfer big data to onshore historian while low latency is essential to provide common view (between onshore and offshore) and remote operations capability. Additionally, data exchange standards such as WITSML, PRODML, and OPC shall be encapsulated in innovation pipeline led by IO system and communication cluster. Related to communication network, Pertamina doesn't need to build it (e.g fiber optic network) by itself. Business-to-Business partnership with well-known telecommunication firms are preferred to develop this layer. Alternatively, Pertamina may build joint consortium, with other adjacent field operators along with telecommunication industry, or establish SPVco to develop or to construct new telecommunication network. IO corporate team, IO asset team and IO system and communication cluster shall be assigned together to implement this initiative.

Third layer is *data management and security*. The main function is providing system that has capability of data mining, cleansing, storing (database), searching, maintaining data assurance, and securing (against cyber attack). Pertamina may collaborate with well-known companies that develop PI (Plant Information) system and data security system. IO system and communication cluster is the leader to promote innovation on this system while IO asset team is the leader of asset deployment and also ensuring smooth upgrading to new system. Real-time data transfer from offshore assets may require new PI system that has capacity to manage big data.

Fourth layer is *analytics, modelling and visualization*. The main function of this system is providing asset control system, surveillance capability, diagnostic, optimizing and integrated modelling. Generally, this layer comprises of advance application and tools. Asset control system is basically HMI (Human Machine Interface) system that enable operator in offshore and onshore to monitor health of assets and perform operational decision to manage assets. Surveillance and diagnostic system is a collection of applications that can detect anomalies, and provide trending that will help in diagnosis to identify root cause and action to mitigate problems. Engineering modelling applications (reservoir, well, and facility modelling) are interconnected with integrated field modelling to provide more holistic view during field optimization. Interoperability and orchestration between applications are essential to enable system integration. Analytics and Optimizers are the software agents to provide "what if" analysis and decision optimization. Decision criterion shall be agreed and set on optimizers. The main decision criterions are cost, production, and economic parameters. Pertamina may utilize third parties products combine with own-developed applications or tools to enhance quality of optimization. The result of analysis, optimization and modelling is presented in highly advanced visualization technology to enhance ability to interpret information. Graphs, dashboards, 3D visualization can be presented in desktop or immersive visualization tools. Requirements to develop analytics system, optimization system and visualization technology are key reasons why existence of digital oil and gas engineers become essential. In innovation aspect, IO decision support cluster shall be the leader to develop decision support system.

Fifth layer is *workflow management*. The main function of this layer is to manage decision loop by delivering data, information and knowledge to the right person, on the right time. Decision loop is classified into operational decision (minutes to hours timespace), tactical decision (days to weeks) and strategic decision (months to years). Decision control system shall be in place to provide workflow of certain process, to deliver data and information to the right person (based on role and responsibilities in workflow), to provide access to best practice (such as procedure, guideline, lesson learn from previous project), to access required modelling software, and to connect to other experts (collaboration links). As a result, this system will integrate people with relevant skillsets, technology (application and tools) and process (workflow management). Pertamina shall enhance capability on this layer based on evaluation on current workflow against integrated work process. Brainstorming and discussion with asset experts are critical to define new parallel work process. Integrated work process and collaboration cluster is the leader of innovation on this layer.

Sixth layer is *smart collaborative network*. The main function of this layer is enhancing knowledge-based decision that is underpinned by multidisciplinary decision making in CWE. CWE is facilitated in IO centers that is well-equipped with collaboration facility (video monitoring and video conferencing) and advanced visualization technology (immersive visualization such as HIVE and CAVE). The main functions of IO centers are drilling support center and operations support center. ONWJ and WMO shall be considered as priority of assets to be connected to the first IO center in Java. Jakarta is the potential location for IO Java.

Last layer is *offshore operations capability*. Integration of all capability layers will create distinctive operations capabilities that underpin high decision quality, thus it leads to better asset performance. Decision quality concept is made of six interconnected chains [133].

Figure 4.32 Decisions quality chain

Helpful Frame chain is strengthened by capability on data management and surveillance system. This system will help on extracting useful data to be analysed and evaluated. Unnecessary data is omitted providing management by exception setting. Following decision framing, relevant data is then analysed and transformed as information (analytics and modelling system) which strengthen Useful Information chain. Subsequent to existence of useful information, potential solutions are defined through diagnostic system. Understanding the problems clearly will help in identifying possible alternative solutions, as a result it strengthens Create Alternatives chain. Each alternatives is then analysed, by analytics system, to generate "what if" analysis to generate potential consequences. Consequently, it will strengthen Clear Values chain. Those alternatives coupled with consequences are then optimized, by optimizers, to identify the best solution based on agreed decision criterion. The results of optimization is evaluated through multidisciplinary experts in CWE that enable system view on problems. Finally, joint decision making mechanism will generate more engagement and commitment to decisions, thus it strengthens Commitment to Follow Through chain. In general, IO capability will strengthen all chains in Decision Quality chain. High decision quality will improve probability of gaining top assets performance in Pertamina.

4.2.2.4.3 Develop integrated operations infrastructure

IO infrastructure is high bandwidth and low latency communication system that enable integration of offshore asset team and onshore team. Unfortunately, Indonesia does not have mature fiber optic network that is dedicated to oil and gas industry. Consequently, IO infrastructure is planned to be developed gradually and in line with IO implementation phases that are *proof of concept, full asset integration* and *global integration*.

In proof of concept phase, most potential fields under ONWJ and WMO blocks are selected as pilot project. The investment required to construct new fiber optic line is expected to lay within Pertamina's financial investment window. The rationale is VRIO analysis in section 4.1 which provide insight on Pertamina's excellent financial strength.

Nevertheless, investment is expected to be high in full asset integration phase. Since oil and gas fields are scattered around archipelago (Java, Kalimantan, Papua, and Natuna), they may generate challenging situation to connect multiple oil and gas fields in Java, and Kalimantan. Obviously, combination of fiber optic and wireless is critical to build redundant communication system (fail safe system). Therefore, substantial investment is expected to occur. For this reason, it will be better alternative if Pertamina establishes strategic alliance with other stakeholders such as telecommunication companies, other oilfield operators, and oil services. This setting will reduce Pertamina's investment exposure, risk in operating assets that are outside of its core competency and requirements of experts in digital telecommunication infrastructure. Despite this reason, Pertamina shall be major shareholder to hold better control to SPVco decision making. High profile companies, with excellent financial performance and technology know-how, shall be priority as partners since it will strengthen bankability of SPVco. Excellent bankability is expected to reduce equity requirements. Correspondingly, consortium of State Owned Banking Companies are preferred to finance this project since it will leverage government support on this project.

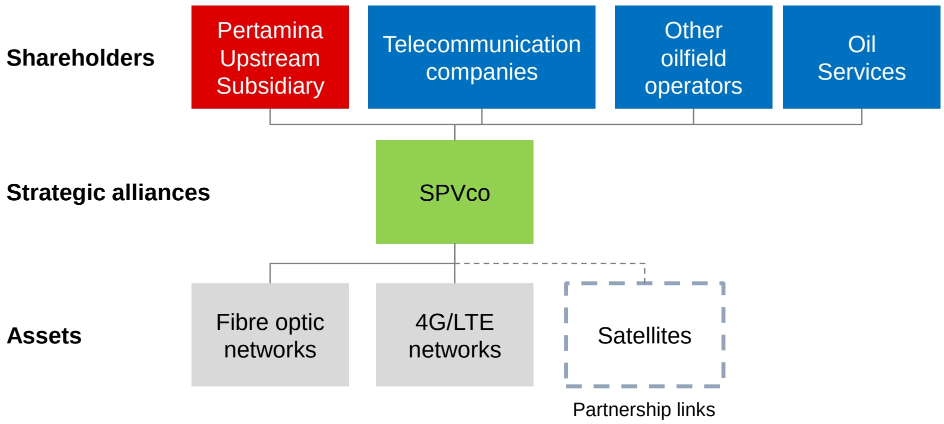


Figure 4.33 IO infrastructure strategic alliance

Meanwhile, in global integration phase, more robust IO infrastructure is needed to support global asset integration and remote operations capability. High speed satellites communication are needed to connect Global Support Center with international assets. SPVco may establish partnership with international companies that hold ownership or operatorship in high speed satellites infrastructure.

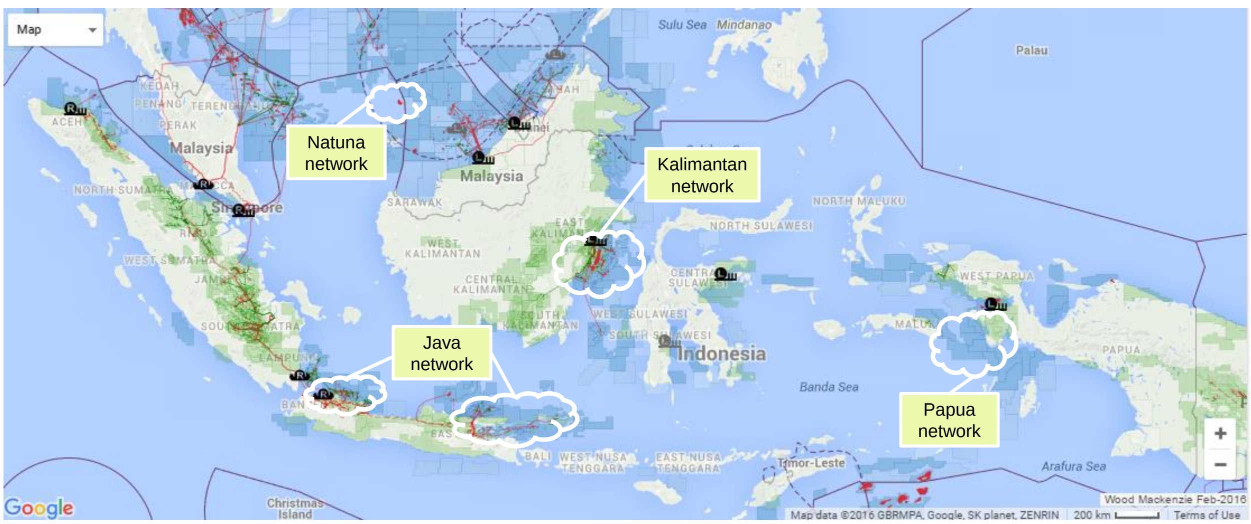


Figure 4.34 IO infrastructure

4.2.2.4.4 Transform people competencies and organizational design

Nurturing digital oil and gas engineers shall be integral part of Pertamina's IO deployment. These are people who have extensive combination of digital skill sets and oil and gas skillsets [134]. In line with IO capability model in Figure 4.31, digital skillsets and soft skillsets are defined in Figure 4.35.

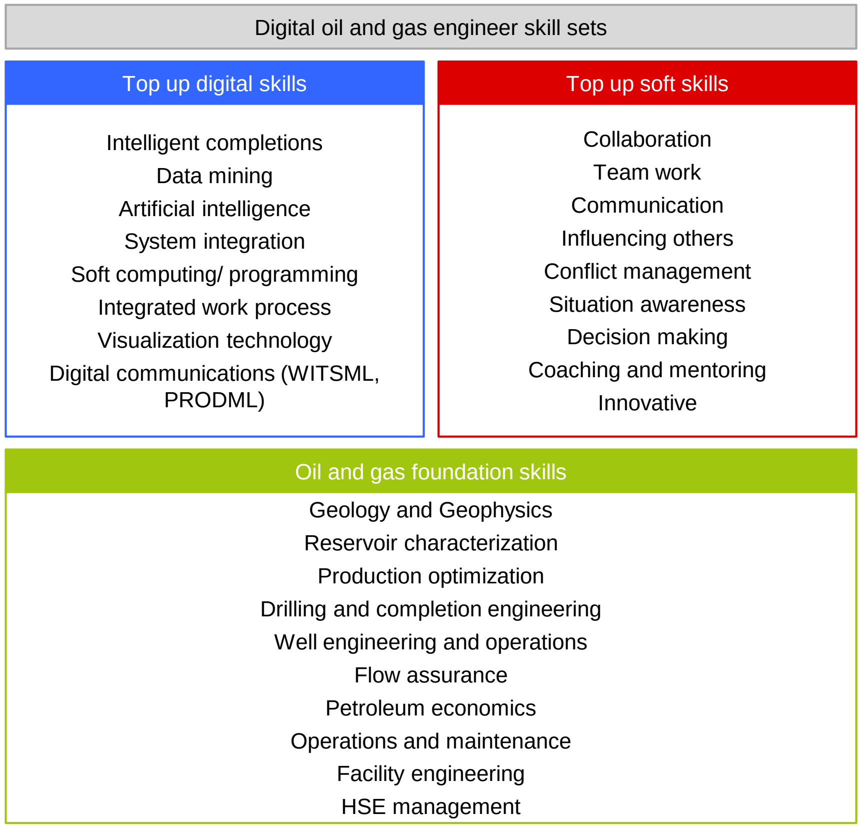


Figure 4.35 Digital oil and gas engineer skillsets

Most of engineers in Pertamina, have foundation skillsets which they got from education, professional training and work experience. Nevertheless, it will be in line with IO strategy, if they are equipped with digital skillsets and soft skillsets. The strategic rationale of new soft skillsets is integrated work process. It obviously requires people who has skillsets to empower collaboration and joint decision making. Silos thinking is no longer prevailing since multidisciplinary collaboration is the one prevails in IO. In addition, heavy utilization of digital technology shall be supported with people who have excellent knowledge and skillsets in it. Consequently, these major skillsets shall be guideline to develop education and training in Pertamina. Human Resource function shall develop talent on digital oil and gas engineers.

In addition to new skillsets, novel asset organizations shall also be transformed as vehicle to achieve fullscale benefit of IO. It is based on generic smart fields organization presented by Guldemond [137, 84]. Figure 4.36 shows the new asset organization.

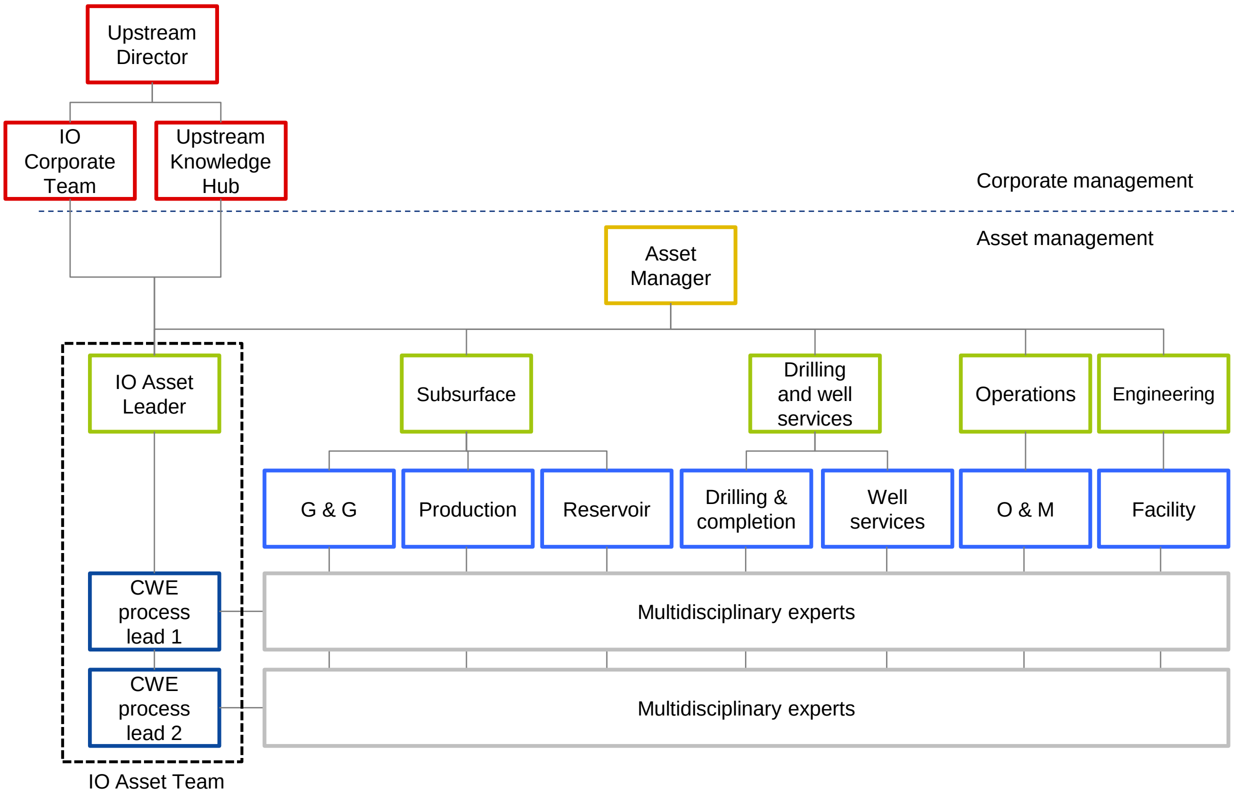


Figure 4.36 New asset organization

The organization is matrix type organizations. Functional organization line remains as professional and career responsibility while its leaders are responsible to develop functional specific skills, career path for each experts or engineers. Each functions consist of digital oil and gas engineers in subsurface, drilling, well services, operations and engineering. Process line will be led by CWE process lead as operational leader in co-located experts under IO centers. They play role as process management leaders who facilitate joint decision making during certain CWE process thus they hold formal authority on process. The CWE process leads are selected based on process characteristics. As an example, production optimization process shall have CWE leader that have excellent expertise in oil and gas production. Each CWE process lead will report to IO leader as ultimate leader of IO deployment in assets. IO leader and CWE process leads are interlinked with other IO centers, IO Corporate Team and Upstream Knowledge Hub that forms Smart Collaborative Network. In this organizational setting, asset manager will be the ultimate decision maker to determine the most priority actions in conflict of priority situation.

4.2.2.4.5 Effective change management programs

Effective change management is obviously strategic to accelerate changes from current way of work into IO model. Kotter's 8 accelerators of change [135] is better to be applied in Pertamina. Prior to discussing the Kotter's eight accelerator, big opportunity statement shall be clearly defined to conceive positive energy and vision. Big opportunity statement is a window into a winning future that is realistic, compelling and memorable [135]. The big opportunity statement shall be communicated to all levels of organization from corporate to asset. The big opportunity statement is stated: "*Pertamina is the sole NOC in Indonesia which is given mandate by government to sustain hydrocarbon security of supply in Indonesia. Given this national duty, we shall devote our fullscale commitment, effort, resources and capability to transform Pertamina as leading offshore operator in Indonesia. Development of digital capability has swept over our industry as strategic operating model in dealing with uncertain, complex and ever-changing oil and gas business environment. Our battlefield is more on more uncertain, dynamic and challenging pushing us to be more agile, faster and better on making decisions. Integrated operations capability development is our big opportunity capitalization to float Pertamina into the next level of offshore operational core competencies as leading IO operator in Indonesia. We need this system to build up basic foundation of our sustainable competitive advantage. We shall collaborate together as one team and change into more integrated way of working. We need full contribution and energy from all levels in corporate and assets. Change is urgently needed for our future, future of Indonesia.*"

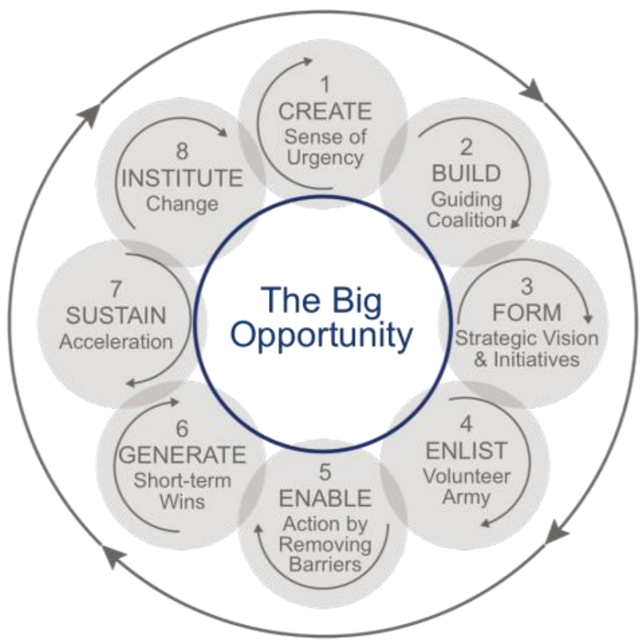


Figure 4.37 Kotter's 8 accelerators

Once big opportunity statement has been established, the next step is crafting action for each accelerators. The eight accelerators are discussed below :

a. *Create sense of urgency*. Pertamina has to initiate massive efforts to propagate widely sense of urgency that IO is the smart solutions to obtain top asset performance. The focal objective is to embed change mindset to all offshore asset teams by removing sense of complacency. IO corporate team is the locomotive change agents who lead the corporate wide IO implementation. In addition, dedicated IO asset teams shall be formalized in offshore assets organization to connect link of smart collaborative network. IO asset teams will be the operational management of IO deployment. They continuously communicate with offshore asset team about the vision of IO and share the gaps between future vision and current situation in order to stimulate sense of urgency to change. Continuous brainstorming, dialogue and change campaign shall be promoted to offshore asset team in order to embed IO change. Clear roadmaps of IO shall also be communicated to offshore asset team to create shared-vision. Strong engagement and ongoing support from senior management is critical at this stage.

b. *Build guiding coalition*. In this accelerator elements, Pertamina shall build transformational leadership team to lead and act as change agents in offshore asset team. It comprises of people from each functional departments who are inspirational and feels the sense of urgency on IO. Middle and top management in asset shall take bigger role in this transformational team. People in this level commonly have experience, high quality of leadership and power of authority to influence large part of asset organization. Dedicated IO asset team can be an excellent alternative to lead change in asset. Role of transformational leadership team is essential, especially in the initial phase of IO deployment. In initial phase, resistance to change can be the bottleneck of IO deployment.

c. *Develop vision and strategy*. IO vision and strategy has been clearly identified in Figure 2.1. Pertamina's IO vision is to be "*Top performing digital oilfield operator in Indonesia"*.

d. *Enlist volunteer army*. IO vision shall be communicated in order to generate and cultivate IO mindset. The goal of communication is to gain support and high commitment from all levels of organization. Campaign from top corporate management, such as Upstream Director, will be highly influential to embed mindset that change to IO is urgently necessary. Management walkthrough from corporate management can be one alternative to energize people in asset to be involved in IO initiatives. IO initiatives shall also be included in asset performance target to glue engagement that IO performance result will affect the asset performance. Leaders in asset shall also involve in influencing their members about the importance of IO for the sake of future asset performance. The more people commit and support to IO initiatives, the more value creation will be delivered.

e. *Remove barriers*. Speed and agility are essential success factors to cope with dynamic offshore business environment. Collaboration within functions, assets, and external organizations shall be cultivated to remove barriers and silos. It will unleash people to innovate more and deliver best result of work. Collaborative work environment is an effective arena to train people in integrated work process, collaboration and joint decision making.

f. *Generate short term wins*. Pertamina shall start to deploy pilot project in existing offshore asset such as in ONWJ and WMO assets. The pilot project is the representation of short term win strategy. It is a strategic action to learn, gain new knowledge, identify challenges and success factors of change. Training in IO shall be prepared by Human Resource function to build up understanding on IO way of working. The main topic of training may include introduction to IO, collaborative work environment and integrated work process. Leaders play key role in giving coaching and mentoring to team members in pilot phase in order to sustain enthusiasm, full commitment and engagement on IO pilot project. The pilot project result will be the basis for future improvement on IO deployment acceleration.

g. *Sustain acceleration*. Pilot project is just the initial step of IO deployment. Continuous improvement is needed to enhance effectiveness of IO implementation. Subsequent to pilot project success, changes are still needed to step on the next level of integration (full scale integration). Bigger changes are still needed to transform onshore as center of decision making and planning, while offshore as executor. Ongoing support from asset and corporate team are necessary to foster on bigger changes and refinement from pilot project results. The scope of changes are extended on one particular asset such as ONWJ and WMO. The boundary of collaboration is extended into external organizations such as contractors and vendors who support operations in ONWJ and WMO. The success of changes in ONWJ and WMO assets will be formalized as standard operating model.

h. *Institute change*. Once the winning IO model has been established in one asset, the next step of change is deploying IO standard operating model into global operations. Global assets owned by Pertamina such as asset in Algeria can be an initial deployment. All global asset shall be interconnected with Upstream Knowledge Hub in Jakarta. Upstream Knowledge Hub shall be reinforced with experts from subsurface to surface. Continuous changes and improvement shall be improved to create better IO model in order to support better and faster decision making. Global asset interactivity will create *follow the sun principles* which disperse knowledge around the globe.

4.2.2.5 Enablers

Enablers are products or services which shall be in place to develop and deploy IO strategy.

Capability layer	**Enablers**
Measurement and monitoring	Smart sensors and control system
Digital communication	IO infrastructure
Data management and security	Decision support system
Analytics modeling and visualization	
Workflow management	
Smart collaborative network	IO centers, Smart Collaborative Network

Table 4.3 IO Enablers

The table above shows the interconnection between each capability layer and enablers. Pertamina shall allocate resources to create these enablers. Existence of enablers is prerequisite in transitional phase from current state to future state. Partnership with well-known contractors or own development by IO Innovation Clusters can be alternative of solution to accelerate generation of enablers.

4.2.2.6 Operating values

In order to empower the 6 Cs (Clean, Confident, Competitive, Commercial, Customer-focused, and Capable), *collaboration* and *lean and resources efficient* are proposed as new operating values. These new values reflect IO as new operating philosophy that will provide guidance to asset operations management and stakeholders management.

First additional value is *collaboration.* Collaboration represents value of promoting collaboration, trust and open innovation to enhance quality of decision making. Pertamina shall cultivate collaboration as main operating values in offshore assets. Collaboration is the central philosophy of IO model. IO centers shall be built to facilitate collaboration between offshore and onshore team, asset team and external experts, interregional collaboration and any other form of collaboration. In the future, Pertamina will need global collaboration across time zones to support its international assets. Smart collaborative network can be enhanced to support asset operations across the globe, thus creating 24/7 active assets support around the globe which shape "*follow the sun*" operating principles. It also plays key role as active knowledge hub which become the main IO platform. Telecommunication and visualization technology shall be enhanced to enable effective collaborative working environment. Continuous campaign into asset organization shall be continuously conducted to reinforce collaboration as main operating values and achieve collaboration as *business as usual* in the future of Pertamina offshore operations. Additionally, individual performance target shall be linked with collaboration performance result to engage people in giving their total commitment in collaboration. Furthermore, functional target shall also be linked with collaboration performance to minimize conflict of interest between functional and process leaders. Moreover, senior management role is also essential to be role model in embedding collaboration. Silo thinking shall be removed to enhance fluid flow of open innovation. Trust and mutual respect between team members are compulsory to shape effective collaboration. Trust in this case means trust to other people and system. As a result, effective collaboration between onshore and offshore team will create "*one team*" work setting which integrate value chain and remove organizational and geographical barriers. This boundaryless operations are expected to reduce backlog of communication and coordination which can reduce decision cycle time thus supporting better and faster decision making.

Second additional operating value is *lean and resource efficient.* Lean and resource efficient means accelerating development of people's knowledge and technology as main foundation in creating standardized streamline process, reducing non-productive time, and maximizing offshore asset productivity. Standardized streamline process means innovation in work process by deploying maximum expertise of people to collaborate in parallel way of working instead serial way of working thus reducing decision cycle time. IO will involve digital technology as enabler to support offshore asset operations. Digital technology such as video-conferencing and visualization will enable onshore and offshore asset team to view common operational data and share situational awareness. This setting will reduce the requirements of experts to travel to offshore locations. Onshore IO centers will have capability to view real-time data as in CCR (Central Control Room) and directly able to give advice via communication technology. Consequently, non-productive time in waiting experts advice can be reduced. In case of changes required immediately, offshore team can request for advice from onshore team to simulate and provide predictive analytics regarding the effect of changes in short term or long term horizon which may affect future asset value creation. As a result, resource allocation to support changes can be planned effectively at the same time reducing risk that may have direct effect on asset performance as a whole. In addition, onshore experts can also monitor the actual consequences of changes to design continuous improvement actions. Consequently, it will expand knowledge about assets as a system. In summary, lean and resource efficient operating value is essential to be one of corporate theme values. Senior management shall be proactively involved by becoming role model. Breakthrough initiatives to define potential process to be streamlined are needed to support this new operating value. Streamline process is expected to improve resource efficiency and reducing asset expenditure which will potentially deliver maximum value creation.

4.2.2.7 Leadership qualities

Leaders are key factors to achieve successful performance of IO strategy. Leaders will shape the way organization behave and determine the end result of organizational activities. Role modelling is one of the most effective method for leaders to influence team members in organization. Leadership qualities are extremely important to drive collaboration and teamwork between stakeholders as a result underpinning on-going success of IO deployment. The transition phase is quite critical since intrinsic behaviour of people is resistance to change. In this time period, strong leaders play key role as champions of change that is extremely influential to the effectiveness of IO deployment in offshore assets.

Current leadership qualities in Pertamina is considered in line to accommodate implementation of IO strategy. The ingredients of current leadership qualities encompass three leadership attributes which are *visionary, integrator* and *networking* attributes.

First existing leadership quality is *visionary*. Visionary leaders have capability to draw representation about future, detect sense of changes and innovate to create new strategy in order to obtain future vision [136]. This leadership quality will enhance the immersion of IO model to the mindset of leaders in Pertamina. It will spur the leaders to take the lead and inspire team members to empower collaboration in order to achieve future vision of IO strategy. Vision of IO strategy will be the key basis of work. Visionary leaders have the capability to articulate clear vision and fluidly communicate the shared vision of IO to team members. As a result, all team members will have common understanding about IO vision, consequently act based on this common vision.

Second existing leadership quality is *integrator*. Integrator is capability to utilize multiple resources and innovate from current resources [136]. Most of offshore assets operated by Pertamina are mature fields which is subject to production decline. Nevertheless, the production performance of assets are increasing due to multiple initiatives in the assets. This successful story will not be exist without integrator leadership who integrate resources in asset to produce successful performance. It is a positive value for IO deployment that needs integration of people, process and technology.

Third existing leadership quality is *networking*. Networking is leadership attributes to build business cooperation and mutual partnership with other parties. Pertamina has many partners to conduct their business in terms of joint venture, joint operations and any other type strategic alliances. It is the indication that Pertamina leaders have excellent leadership qualities to build mutual cooperation with other partners that bring positive value creation to the company. IO is about integrating multidisciplinary experts inside company and external company. Silo thinking is no longer valid to this type of operations model. Process-based way of working that reduces organizational and geographical barriers are the key melody of this model. Leaders which has attributes in building positive networking is extensively essential to deliver maximum value of networking between nodes in IO.

As complementary to current leadership qualities, it will be more powerful and highly supportive to deployment of IO model if it is topped up with new leadership qualities. The new leadership qualities are *collaborative, agile, innovative,* and *transformational*.

First additional leadership quality is *collaborative*. Collaborative leaders have the capability to design constructive process to work in parallel, engage relevant stakeholders, facilitate and sustain effective interaction between them [137]. Traditional chain of authority is normally command and control pattern. Nevertheless, collaboration culture is more on collective decision making setting which is underpinned by active collaboration networks. Active collaboration networks setting are more effective and faster to tackle more complex and dynamic offshore operations environment. Collaborative leaders operate based on coalitions, alliances and partnership [137]. This leadership quality is very essential in IO model to promote collaboration and teamwork. IO centers are central nodes of IO active collaboration networks. It is a center of collaboration between co-located and distributed multidisciplinary experts. Each members shall have collaborative leadership quality to be effectively working in parallel and making team-based decision making in case of problem solving. This leadership quality will promote mutual understanding, trust and respect among team members that are obviously required to create positive collaborative working environment. For this reason, people will openly share their ideas and gain respect from others within collaboration and teamwork. This atmosphere will affect on quality of decisions in solving problems. Correspondingly, relevant training to cultivate collaborative leadership shall be designed by Human Resource function. Leaders play key role in role modelling as well as performing and nurturing collaborative leadership quality.

Second additional leadership quality is *agile*. Agile leadership quality is ability to lead effectively under conditions of rapid change and high complexity [138]. Agile leaders can reveal complex issues and see the interconnections between elements in the bigger picture [139]. Offshore operations are considered highly complex equipped with multifaceted interdependencies between elements. Operations system is very complex consisting of elements from reservoir to processing facilities with high level of uncertainties. Highly interdependence between components may cause unexpected events which may lead to unexpected consequences. The system behaviour is rapidly changing affected by multifactor which are controllable and uncontrollable. IO model is the system to deal with this high complex and rapidly changing environment. Integrated team is devoted to view complex problems from different perspective which is aimed to complete picture of complex operational problems. Complete view of problems will help team to come up with sensible decisions to mitigate problems. It requires agile leadership quality of every members of offshore assets to adapt quickly to rapidly changing situations. This leadership quality is essential to ensure that every members are ready to respond effectively in ever-changing offshore operations environment. Different situations will demand different approach to problem solving. The decision support system may offer predictive analytics about possible future consequences. Nevertheless, agile leaders will have the level of situational awareness and knowledge to sense the changing situations and perform sensible decisions.

Third additional leadership quality is *innovative*. Innovative leaders are essentials role to be champions to lead IO deployment in corporate and assets. They have five essentials skills which are questioning, observing, networking, experimenting and associating [140].

a. Questioning is skill to imagine future by asking “what if” questions. Capability of “what if” analysis is essential to identify what are probable future scenarios. Questioning skill is important to define whether the predicted future scenario is plausible and coming up with most probable scenarios through optimization.

b. Observing is skill to observe surrounding environment to gain insights and ideas about new ways to do things. Subsequent to defining plausible future scenarios, leaders shall have ability to creatively identify alternatives on what team can do to solve operational problems based on current insights from external environments.

c. Networking is actively seek ideas to gain a new perspective. It can be connecting to experts under Smart Collaborative Network who may have similar experiences in solving certain problems.

d. Experiment is testing new ideas to learn the behaviour of the systems by implementing pilot project and virtual modelling of system.

e. Associating is ability to connect seemingly unrelated ideas and combine the into novel ways. Innovative leaders will utilize questioning, observing, networking and experiment skills to help associating several pieces of unrelated elements and combine it creatively to find new ways of solving problems. It will result in different type of action and thinking.

Last additional leadership quality is *transformational*. Transformational leaders are agents of change who will inspire team members to shift rapidly but smoothly from traditional way of working into IO way of working. They elicit top performance by cultivating IO mindset, communicating IO campaign effectively, facilitate IO visioning, and furnishing IO inspiration to asset team members. There are four factors which differentiate transformational leaders. They are charismatic, inspirational, individual consideration and intellectual stimulation [141]. Firstly, charismatic is indicated by role of transformational leader in becoming role model, shared vision, and embed trust by overcoming business obstacles smartly. Secondly, inspirational is indicated by ability to empower team members to work together in achieving challenging objectives and mission. Thirdly, individual consideration is treating team members individually, acknowledging personal respect and perceiving individual aspiration. Lastly, Intellectual stimulation is ability to deploy new ideas and bolster new way of thinking instead of conventional practice. Transformational leadership quality is very essential to lead change management process which will bring IO to be business as usual practice as a result sustain full-scale benefit of IO can be retrieved.

4.2.2.8 Success factors

4.2.2.8.1 Values

To achieve full-scale benefit, IO shall be deployed not only as standard operating model but also as corporate values across offshore assets. It is a shared values among members of organization. Values are the main driver of IO sustainability. The proposed IO values are collaboration, lean and resource efficient. These values will drive individual behaviours in asset. Once every members of organization has common values, integration will be smoothly executed reducing risk of values conflict. Different values among team members may create distraction and trust reduction which can lead to slow adoption of IO model into asset operating system. It will create harmony which will deliver maximum power of collaboration and resource efficiency to Pertamina. This value embedment is essential especially when global integration is implemented in the future. Different cultural values may impact the solidity and synergy across nations. Cultivating common IO values across nations will create common understanding, trust and shared vision which will lead to effective cooperation across different nations. Continuous value embedment is key success factors to take up Pertamina IO level into the future desired state.

4.2.2.8.2 Leadership

Leadership plays substantial role throughout the take up process from current state into future state. Leaders are the one who directly drive the team to sustain effective operation by acting as role model, key actor in establishing mutual relationship with various stakeholders, coach and mentor to team members and empowering multidisciplinary collaboration. Strong leadership is inevitably required to pivot the direction of organization from traditional way of working into new collaborative way of working. It is essential element which shape the effectiveness of IO deployment. Dynamic property of petroleum industry requires agile leaders who can adapt quickly to ever-changing business environment. Leaders shall be proactive in sensing the abnormal situations, continuously monitor and communicate with multidisciplinary experts to gain the complete puzzle of problems, subsequently make better and faster decisions. Leaders need to support cultural change required to successfully transform from traditional work practices to IO. Culture is founded and sustained through an organization's beliefs, behavior and relationship. Changing behavior takes a long time but strong leadership can accelerate the momentum towards the desired change [142].

Senior management engagement and ongoing support are very essential is IO deployment especially in upfront phase. Leaders, in asset and corporate, have main contribution during take up process by leading capability development acceleration, establishing IO direction, aligning people into IO vision, motivating people, inspiring, mobilizing people to change, and propelling asset performance into desired future state. Consistent and strong leadership quality is the pillar of IO success which will continuously safeguard stable IO operations throughout asset lifecycle. They also play important role in ensuring that most appropriate solutions are implemented and deliver sustain value creation.

4.2.2.8.3 Collaborative culture

Collaborative culture is one of the most key success factors to the success of IO strategy implementation in Pertamina. It is a key to energize the power throughout Pertamina global asset operations. Collaborative culture is defined as practice in which people engage with intraorganizational and/or interorganizational partners to discuss, share, ideas or experiences [143]. It is the practice which provide ideation of knowledge transfer and sharing between organizational members. This IO culture shall be embedded extensively throughout Pertamina offshore asset organization to shape the foundation of integrated way of working. People shall be able and committed voluntarily to participate actively in collaboration especially during interactions in IO centers. Trust between people is largely required to cultivate collaborative culture and gain benefit of collaboration. Once trust is growing positively, people expertise will combine complementarily uniting pieces of jigsaw resulting on more thorough understanding of complex operational problems. Pertamina's experts in geology, geophysics, reservoir, well, and facility shall collaborate together seamlessly in spite of geographical and functional barriers. Telecomunnications infrastructure is the key enabler to support success of collaboration.

Fostering collaborative culture in Pertamina will be challenging due to inhibiting factors such as resistance to change, silos thinking, and interorganizational culture differences. Senior management in asset and corporate shall jointly work proactively to support the campaign on collaborative culture embedment. They play key roles in giving inspiration, role modeling, promoting and rewarding collaboration performance results. It will advocate collaborative culture level from awareness into higher degree which is business as usual for offshore assets. There are several key actions to promote collaborative culture which are :

a. All levels of asset organization shall be encouraged to explore and exploit knowledge [143].
b. Provide technology to support collaboration such as video conferencing, visualization, decision support system, and smart workflow system.
c. Configure clear guideline, role and responsibility system to govern people in collaboration including conflict resolution strategy in order to promote maximum innovation and knowledge sharing between collaborators.
d. Maximize utilization of IO centers as collaboration arenas, which bring together co-located multidisciplinary experts as well as forming virtual team with external organizations, to solve complex and uncertain decision problems in offshore assets.
e. Activate IO centers as 24/7 expert support centers, which create “always on” support system and enlarge widespan opportunities to collaborate between the onshore-offshore team.
f. Effective performance system which grants exceptional rewards to active, effective and value creation of collaboration initiatives.

Those actions above shall be done by Pertamina to accelerate collaborative culture embedment in offshore asset which can lead to better quality of decision making, active knowledge transfer, improve social networking, improve open innovation, and promote the lean process.

4.2.2.9 Future State

By fulfilling all transitional factors, it is expected that Pertamina will achieve desired future state. Offshore and onshore teams are fully integrated. The onshore team will comprise of internal experts, which are co-located in IO centers, and external organizations, who are interactively connected through capability of digital communications technology. It will form virtual enterprise that collaborates together to achieve agreed performance of assets. This operating model is expected to deliver positive additional yield in terms of more sustain production growth at 7% CAGR. The sustain production growth is expected to come from production optimization, better well placement, better production facility uptime and increase recovery factor. The level of HSE performance is also expected to improve due to better collaboration between offshore and onshore team. The power of collaboration will help to detect unexpected events which may lead to catastrophic safety consequences. The number of personnel offshore is expected to be lesser reducing exposure time to safety hazards. Most importantly, IO is formalized as standard operating model around Pertamina global assets.

4.3 Implementation and operation planning

Following to the establishment of IO Strategy, implementation and operation planning is designed to execute IO strategy in offshore assets. The implementation plan consists of four crucial phases that are pilot project planning, proof of concept, full asset integration, and global asset integration. It creates systematic step how to put IO strategy into actions.

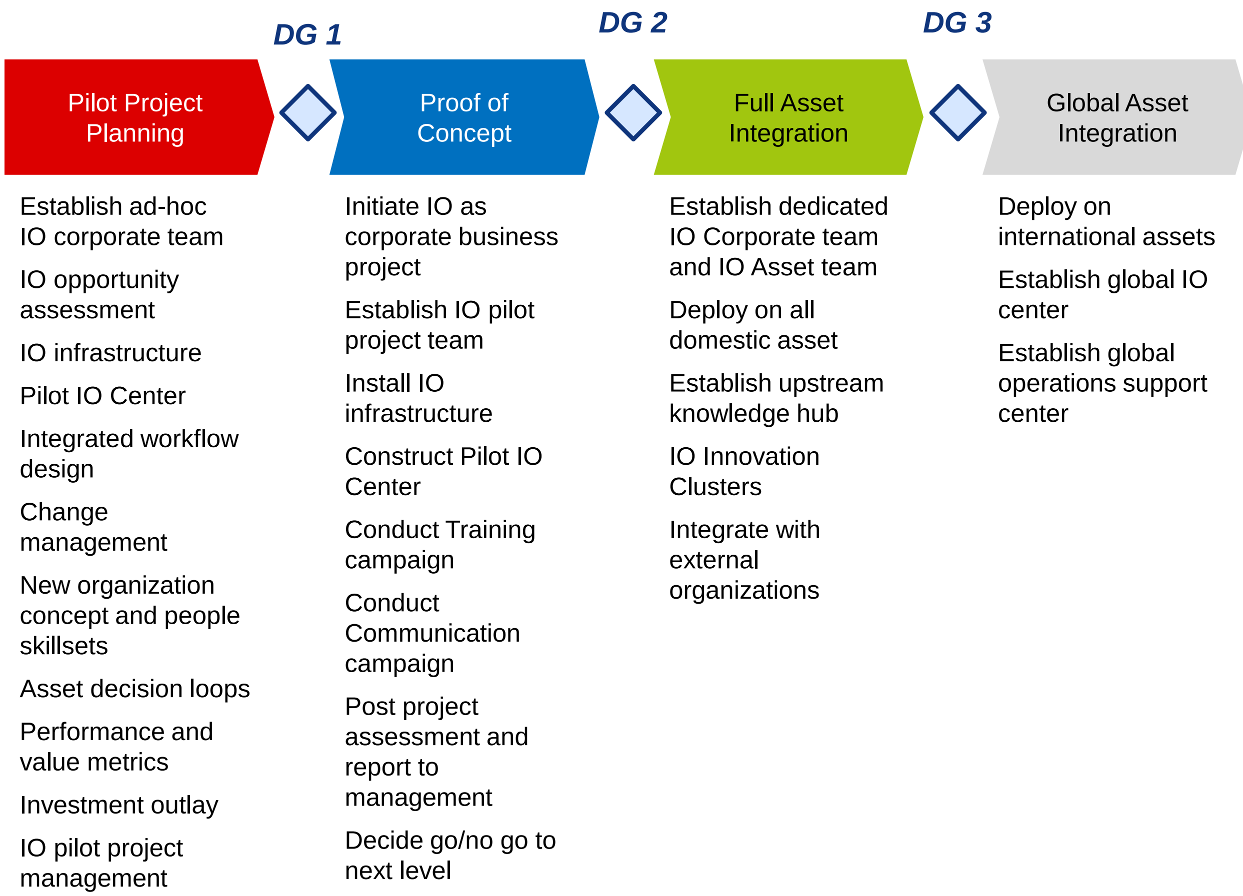


Figure 4.38 Implementation and operation plan

4.3.1 Pilot project planning

In this phase, the main objective is creating feasibility of the pilot project. Ad-hoc IO corporate team shall be established in Pertamina's head office that plays role as project initiator. The responsibility of this team is delivering IO pilot project feasibility study. The team consists of cross-functional experts from corporate and asset team. A corporate representative will be responsible for strategic and stakeholders management while asset team will be responsible for contributing innovative ideas on IO field implementation. Pilot project feasibility study comprise of following assessments :

a. *IO opportunity assessment*. It is aimed to identify which fields in ONWJ or WMO blocks that are potential for the pilot project. Correspondingly, production optimization is the main capability to be exercised in the pilot project.

b. *IO infrastructure*. It is aimed to design fiber optic network combined with wireless network (4G/LTE) to connect selected fields, and investment requirements.

c. *Pilot IO center*. It is aimed to design the first IO center in the pilot project. It shall be designed to facilitate collaborative work environment in production optimization process. It will be important to perform seamless collaboration between offshore and onshore team. Figure 4.26 can be an initial reference to design CWE additionally, it can be enhanced by evaluating Human Factor aspect on the landscape.

d. *Integrated workflow design*. It is aimed to identify potential integration of work process to simulate functional integration. Existing workflow shall be analyzed to identify potential parallel way of working and multidisciplinary collaboration process. Brainstorming with highly experienced experts is necessary to identify relevant workflow to be exercised. Production optimization workflow is the priority of analysis.

e. *Change management*. It is aimed to identify what kind of change is required and the potential consequences of change. Champions of change is also elected in corporate and asset team.

f. *New organization concept and people skillsets*. Ad-hoc IO asset team organization is designed based on Figure 4.36. IO leader and CWE team leaders are appointed to lead production optimization process. This re-organization shall minimize disturbance on existing asset operations.

g. *Asset decision loops*. It is aimed to define operational, tactical and strategic decision loops in production optimization process. It also defines role and responsibility between offshore team and onshore team within the loops. Clear responsibility matrix between onshore and offshore team during collaboration shall be in place. Typical decision loop for oilfield is depicted in Figure 4.39 [144].

h. *Performance and value measures*. It is aimed to design new performance management based on collaboration and teamwork in IO model. IO performance is linked with individual performance target to enhance engagement and commitment to pilot project. The value measures are additional production, decision cycle time, cost and HSE.

i. *Investment outlay*. It is aimed to plan investment phasing out to conduct a pilot project. It shall be communicated to finance function to be included in the annual budget.

j. *IO pilot project management*. It is aimed to define work package, project critical path, resources, project performance metrics (time,cost and quality) and any other project management related tasks. The pilot project is targeted to be completed in one year.

The results of point above are encapsulated into IO pilot project feasibility study. It is then submitted to Pertamina top management for approval (Decision Gate 1).

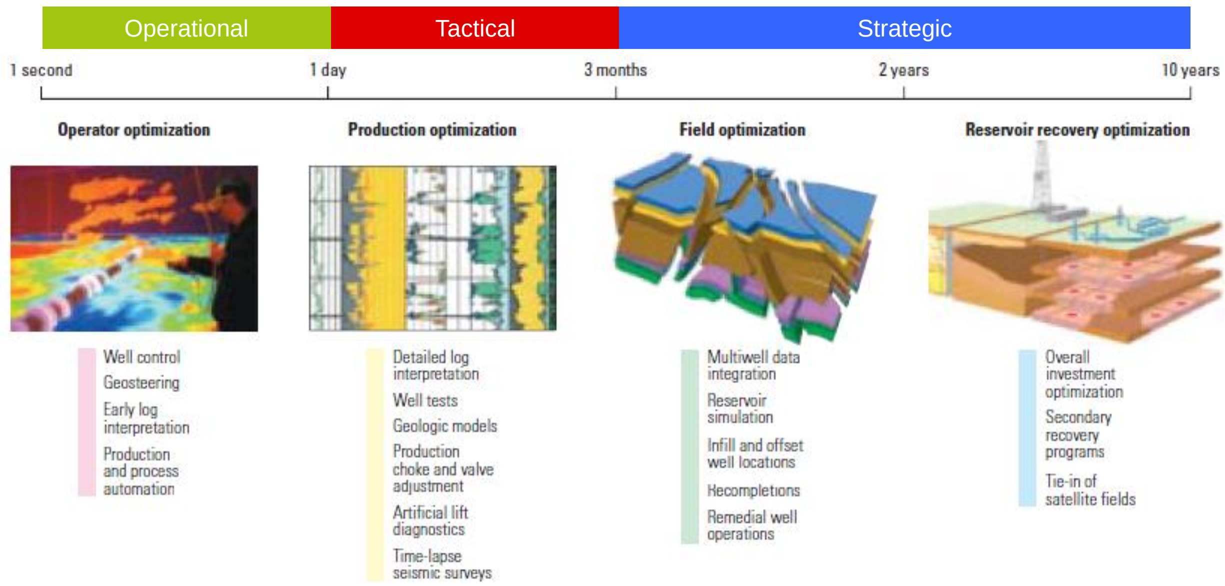


Figure 4.39 Asset decision loop

4.3.2 Proof of concept

Following approval in Decision Gate 1, IO shall be formalized as a corporate business project to increase proximity and performance monitoring from corporate decision makers. This landscape will enhance project agility since values and bottlenecks are directly informed to senior management.

Then, IO project management team shall be established in the asset to manage project. It consists of experts from asset and UTC. IO project team directly reports to Asset Manager and IO corporate team.

Next, IO infrastructure is installed to connect offshore assets and Pilot IO center. Parallel with IO infrastructure, Pilot IO center is also built to establish new collaborative work environment in Jakarta. Multidisciplinary experts are gathered and co-located in this arena and play central role as onshore support center. In addition, decision support system is also interconnected to Pilot IO center to support better and faster decision making.

Continuous training campaign is also conducted since the pilot project is initiated. This is essential to equip asset personnel with required IO skillsets. Human Resource function and IO asset team collaborate to conduct personnel training.

Parallel with training campaign, communication campaign shall be broadcasted extensively to energize sense of urgency to change into IO model. Ad-hoc IO corporate team shall collaborate with IO project team to conduct effective campaign actions.

Once all off required elements in pilot project have been completed, IO pilot is operated and continuously monitored to measure the value creation. After 16 months of operations, the result of the pilot project is documented as a post-assessment report. It is then submitted to corporate management to gain approval for full-scale integration. Ad-hoc IO corporate team is the one responsible for report submission and approval process.

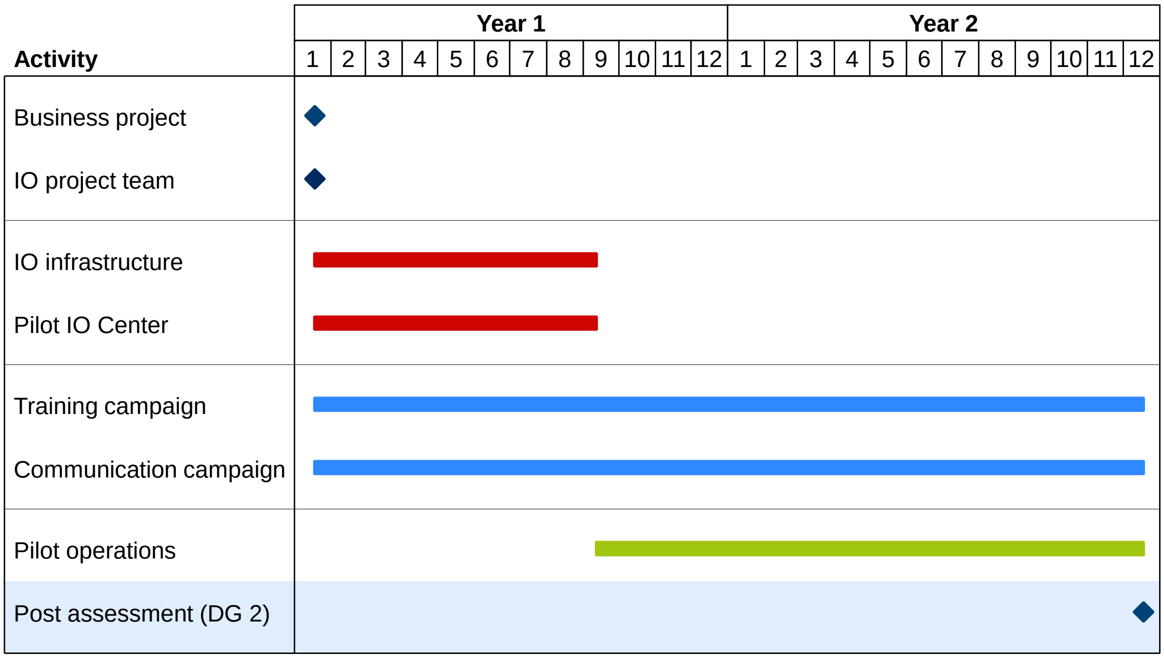


Figure 4.40 Proof of concept plan

4.3.3 Full asset integration

In case IO pilot project delivers excellent value creation and is granted decision to progress, full asset integration can be deployed throughout all offshore assets in Indonesia (Decision Gate 2). Brownfields are priority (ONWJ and WMO) while green fields will be implemented based on experience in brownfields. In this stage, IO ad-hoc team and IO pilot project team shall be formalized into dedicated IO corporate team while IO asset team shall be formalized in asset organization. B2B network is established to integrate asset teams with external organizations (contractors, external experts, and other external stakeholders). Upstream Knowledge Hub is formalized in Jakarta and connect with other nodes forming Smart Collaborative Network (Figure 4.28). Additionally, IO Innovation Clusters are also established to acceleration IO innovation. The main objective of full integration is integrating asset with external organizations, and also integrating with other assets. Drilling services subsidiary can also be expanded to provide offshore drilling services and, then integrated into smart collaborative network. This setting will enable Pertamina to control all offshore assets in "one portfolio" as a result, inter-assets optimization will be possible to manage lean process and allocate resource efficiently. Once full asset integration has been successfully obtained, formal report shall be prepared by IO corporate team. It is then submitted to top management for approval (Decision Gate 3).

4.3.4 Global asset integration

Once the full asset integration has been successfully deployed in Indonesia, the next strategic phase is integration across global asset. Global Support Center is established, in Jakarta, to support global assets around the world. Follow the sun principles will be established in this phase enhancing better and faster decision making all over Pertamina international assets. It will not only support offshore assets but also large onshore fields in international ventures. Assets in Algeria will also be integrated into global assets network in this phase. If in the future Pertamina has international offshore assets, global IO centers shall be established based on experience in Indonesia. In this phase, it is expected that IO will have been the core competency of Pertamina in operating offshore assets.

5 Discussion

Pertamina has declared its future vision "*To be a World Class National Energy Company*". Correspondingly, it shall have a competitive strategy and actions in place that aligns with future trends. Unquestionably, future is largely uncertain and there is no one can precisely predict what will happen in the future. However, we can gain insights through current trends and set up our resources to be well-prepared. In the same way, this thesis has highlighted several key findings that shall be materialized in Pertamina's future strategy. Those findings indicate that Pertamina's current state requires fine tuning to be more competitive and align with future trends. The key findings are :

a. ***BP, Shell, and Statoil have exploited Integrated Operations effectively as key offshore operations capability***. Literature review on IO deployment in BP, Shell and Statoil indicates that they already exploited IO capability on their global assets since early 2000's. BP with its *Field of the Future*, Shell with its *Smart Fields*, and Statoil with its *Integrated Operations* have proven IO value through the integration of people, process, and technology. Integration will deliver *better and faster decision making* in core work processes (reservoir, well, facility). Consequently, they can increase recovery factor, reduce cost, improve regularity (facility) and enhance HSE. In addition, IO also shapes these companies to be agile in coping with highly complex offshore assets environment. In general, there is an impression that IO capability is the strategic rationale behind their excellent assets performance. Most importantly, IO capability enables *smart asset management* that shapes their competitive advantage. It conforms with prevailing resource-based theory that resources or capabilities management are the foundations of firms competitive advantage.

b. ***The future of Indonesian petroleum industry will depend on offshore ventures***. Porter's Five Forces analysis and Scenario Planning have shown that offshore will be the future of Indonesia oil and gas. Onshore fields have been mature, in contrast, offshore fields offer more opportunities. This situation leads to the expectation that offshore will replace onshore as the backbone of production in the future. Indeed, there are opportunities to undertake EOR on onshore mature fields. Nevertheless, recent large discoveries in offshore may float offshore to be a better alternative source of growth.

c. ***Pertamina has excellent performance in onshore operations, in contrast, offshore operations still need improvement***. VRIO analysis has indicated that Pertamina has excellent performance in operating onshore fields. In contrast, Pertamina still needs more experience and exposure in operating offshore assets. Admittedly, onshore capability is competitive advantage for current situation, nonetheless, it is not fit with future trends in offshore. In other words, onshore capability is a *temporary competitive advantage*. Interestingly, Pertamina has UTC as the center of excellence. Though, it is not sufficiently exploited to develop offshore operations capability. Apart from UTC, Pertamina has also two operatorships in offshore shallow water that can be the onset of offshore capability development. In general, a combination of UTC and offshore assets can be strategic assets and sources of innovation to leverage offshore operations capability.

Key findings above give an academic impression that Pertamina needs a strategic solution to address future challenges in offshore operations. Best practices from IO players (BP, Shell, Statoil) coupled with existing resources (UTC and offshore assets) is obvious opportunity to be capitalized. Unquestionably, Pertamina needs ***IO strategy to accelerate offshore operations capability***.

This thesis offers IO strategy in a holistic view that also encapsulates IO operating model, IO capability model, and IO implementation plan in it. First, IO strategy presents a global overview to shift from current state to future state. Integrated performance theory provides end-to-end landscape incorporating current state, vision, mission, enablers, operating values, leadership qualities and strategic priorities, and future state. Secondly, IO operating model presents standard integration platform through the establishment of "Smart Collaborative Network". It is a network of people that is aimed to promote operational knowledge spillovers and foster IO innovation across Pertamina's assets. Thirdly, IO implementation plan offers operation planning to gradually deploy IO from a pilot project to global integration.

However, a literature review can only capture key learnings instead of more end-to-end view on IO deployment in BP, Shell, and Statoil. They may have their own proprietary solutions that are concealed in company confidentiality data. Additionally, data, that is used for strategic analysis (Porter Five Forces, VRIO, Scenario planning), is based on current producing fields and near-production fields. Petroleum industry is largely uncertain that may create surprise events to turn the landscape of the industry. Large discoveries, geopolitical, or other substantial events may overturn current trends into other new trends. Moreover, detail picture on asset architecture can not be gain due to confidentiality issues in Pertamina. This situation limits the scope of the thesis into more high level instead of going into details.

Consequently, there are fruitful opportunities to become future research. The first opportunity is the development of IO infrastructure in Indonesia. It will be appealing research since Indonesia is still an immature network. Joint research with telecommunication industry is considerable to design fiber optic and wireless network that are dedicated to the offshore industry. The second opportunity is the development of IO centers in Pertamina. It may also become excellent research opportunities since the design of IO centers will involve utilization of multiscience ranging from people's skillsets, technology, organization and business processes. The third excellent opportunity is the development of decision support system in Pertamina. Pertamina needs novel decision support system that is powerful to assist in better decision making. *Good decisions are key to create sustain value creation*.

6 Conclusion

Pertamina is the sole NOC that bears great responsibility to maintain energy balance in Indonesia. As Indonesian's national flagship, it shall take a strategic step forward to assist Government of Indonesia in cropping oil deficit and sustaining gas supply that is extremely important to sustain value creation to the nation. Indonesia macro economy growth is still highly dependent to hydrocarbon as fundamental materials to spark the engine of transportation, power generation, and industry. However, the future of petroleum industry is expected to be extremely challenging situation. Easy oil, especially onshore fields, is continuously declining. Thus, it provides expectations that offshore will take over the role of onshore in the future.

Obviously, Pertamina has excellent credentials and technical know-how in operating onshore fields. On top of this capability, aggressive block acquisitions have delivered significant incremental in production. Instead, relying on current onshore assets coupled with production acquisitions leads to academic impression that it is expected to be a temporary competitive advantage. If we scrutinize further, Pertamina has UTC and offshore operatorship that can be jointly integrated as strategic assets and source of innovation to retain competitive advantage in the future. On the one hand, other major oil players have proven that IO has become strategic offshore operations capability.

Most importantly, this thesis presents academic perspective of IO strategy as strategic solutions to build offshore operations capability in Pertamina. IO strategy provides an end-to-end strategic landscape to transform Pertamina as top performing IO operator in Indonesia. The package of IO strategy also encapsulates IO operating model and IO capability model that provide guideline of interface enhancement and capability building platform. IO operating model transparently defines the interface between UTC (as Upstream Knowledge Hub), IO centers (assets), and external stakeholders as novel "Smart Collaborative Network". This is the shape of virtual enterprise that becomes a network of knowledge and innovation and mutually collaborate as an ecosystem of offshore operations capability development. Meanwhile, IO capability model presents systematic capability platform to develop and deploy IO on all offshore assets. *In general, the focal objective of IO capability is to bolster the quality of decision (better and faster decision making) that will lead to top asset performance.*

In strategic overview, IO strategy is expected to be the *last piece of the jigsaw* that complete existing organic growth through EOR and inorganic growth through block acquisitions. Integration between IO, EOR and block acquisitions strategy will form a strategic triangle of growth that brings Pertamina as an agile company against future scenarios. Correspondingly, People-Technology-Process perspective shall be an integral part that plays role as strategic foundation. *Smart People-Smart Technology-Smart Process* will bring Pertamina to the next level and establish position as global players in the future.

Bibliography

[1] T. H. Byers, R. C. Dorf and A. J. Nelson, Technology ventures, New York: McGraw Hill, 2015.

[2] R. Simons, Performance measurement and control systems for implementing strategy, Prentice Hall, 2000.

[3] R. Grünig and R. Kühn, Process-based strategic planning, Springer, 2011.

[4] M. E. Porter, Competitive strategy: Techniques for analyzing industries and competitors, New York: The Free Press, 1980.

[5] M. E. Porter, "The five competitive forces that shape strategy," Harvard Business Review, 2008.

[6] R. E. Freeman, J. S. Harrison, A. C. Wicks, B. L. Parmar and S. de Colle, Stakeholder theory: The state of the art, Cambridge University Press, 2010.

[7] P. D. Gardiner, Project management: A strategic planning approach, Palgrave Macmillan, 2005.

[8] S. Ayuso, M. A. Rodriguez, R. Garcia and M. A. Arino, "Maximizing stakeholders' interests: An empirical analysis of the stakeholder approach to corporate governance," IESE Business School, 2007.

[9] T. Rosendahl, A. Egir, L. K. Due-Sørensen and H. J. Ulsund, "Integrated operations from a change management perspective," in *Integrated operations in oil and gas industry*, IGI Global, 2013, pp. 285-303.

[10] J. Barney, "Firm resources and sustained competitive advantage," *Journal of Management*, vol. 17, no. 1, pp. 99-120, 1991.

[11] J. B. Barney and D. N. Clark, Resource-based theory: Creating and sustaining competitive advantage, New York: Oxford University Press, 2007.

[12] H. Itami and T. Roehl, "Mobilizing invisible assets," Harvard University Press, 1987.

[13] K. Verweire and L. V. Berghe, Integrated performance management: A guide to strategy implementation, London: SAGE Publications, 2004.

[14] A. Campbell and K. S. Luchs, Core competency based strategy, London: International Thomson Business Press, 1997.

[15] J. Barney and W. S. Hesterly, Strategic management and competitive advantage, Pearson, 2006.

[16] J. Pearson, D. Pitfield and T. Ryley, "Intangible resources of competitive advantage : Analysis of 49 Asian airlines across three business models," *Journal of Air Transport Management,* vol. 47, no. 2015, pp. 179-189, 2015.

[17] M. E. Porter, "Clusters and competition: new agendas for companies, governments, and institutions," in *On Competitiveness*, Boston, Harvard Business School Press, 1998, pp. 197-288.

[18] M. E. Porter, "Location, competition and economic development: Local clusters in a global economy," *Economic development quarterly,* pp. 15-34, 2000.

[19] World Bank, "Cluster for competitiveness: A practical guide and policy implications for developing cluster initiatives," World Bank, 2009.

[20] S. Breschi and F. Malerba, Clusters, networks and innovation, Oxford University Press, 2005.

[21] H. Eraslan, M. Bulu and M. Turkay, "Clustering analysis of networked organizations," in *Encyclopedia of networked and virtual organizations*, Information Science Reference, 2008, pp. 199-208.

[22] L. M. Camarinha-Matos and H. Afsarmanesh, "Classes of collaborative networks," in *Encyclopedia of networked and virtual organizations*, Information Science Reference, 2008, pp. 193-198.

[23] S. Eom, "Business-to-Business Networks," in *Encyclopedia of networked and virtual organizations* , Information Science Reference, 2008, pp. 121-128.

[24] J. Lipnack and J. Stamps, Virtual teams, John Wiley & Sons, Inc, 2000.

[25] J. P. Liyanage and M. Herbert, "Collaborative networks and virtual support enterprises," in *Encyclopedia of networked and virtual organizations*, Information Science Reference, 2008, pp. 237-243.

[26] M. Lindgren and H. Banhold, Scenario planning, Palgrave McMillan, 2009.

[27] J. Bentham, "The scenario approach to possible future of oil and natural gas," *Journal of Energy Policy,* vol. 64, pp. 87-92, 2014.

[28] P. Schoemaker, "When and how to use scenario planning: A heuristic approach with illustration," *Journal Forecasting,* vol. 10, pp. 549-564, 1991.

[29] G. Wright, G. Cairns and P. Goodwin, "Teaching scenario planning: Lessons from practice in academic and business," *European Journal of Operation Research,* vol. 194, pp. 549-564, 2009.

[30] G. Wright and P. Goodwin, "Decision making and planning under low levels of predictability: Enhancing scenario method," *International Journal of Forecasting*, vol. 25, pp. 813-825, 2009.

[31] W. F. Christopher and C. G. Thor, Handbook of productivity and performance measurement, Productivity Press, 1993.

[32] J. Yero and T. A. Moroney , "Exception based surveillance," *Society of Petroleum Engineer,* vol. SPE, no. 127860, 2010.

[33] IO Center, "Annual report 2010," IO Center, 2010.

[34] J. Henderson, V. Hepsø and Ø. Mydland, "What is capability platform approach to integrated operations ? Introduction to key concepts," in *Integrated Operations in the oil and gas industry*, IGI Global, 2013, pp. 1-19.

[35] D. Taylor and K. Fosse, "Collaborative decision making in operatin center environments," *Society of Petroleum Engineer,* vol. SPE, no. 100704, 2006.

[36] S. Yawanarajah, J. Williams, K. Carrell, T. Webb and M. Cox, "Improving lifecycle project delivery through better decision making under uncertainty," *Society of Petroleum Engineer*, vol. SPE, no. 118128, 2008.

[37] T. Rosendahl and V. Hepsø, Integrated operations in the oil and gas industry, IGI Global, 2013.

[38] A. Quaadgras and A. R. Edwards, "Intelligent energy - changing how works get done," *Society of Petroleum Engineer,* vol. SPE, no. 167497, 2013.

[39] R. Murray, C. Edwards, K. Gibbons, S. Jakerman, G. de Jonge, S. Kimminau, L. Ormerod, C. Roy and G. Vachon, "Making our mature fields smarter - An industrywide position paper from the 2005 SPE forum," *Society of Petroleum Engineer,* vol. SPE, no. 100024, 2006.

[40] A. Modi, "Emergence of digital oilfield technology in exploration & production industry," Beroe Inc, 2014.

[41] J. Foot, "The Field of the Future technology flagship," BP, 2014.

[42] C. Reddick, "Field of the future: Making BP's vision a reality," *Society of Petroleum*

Engineer, vol. SPE, no. 99777, 2006.

[43] T. Edwards, M. Saunders and K. Moore-Cernoch, "Advanced collaborative environments in BP," *Society of Petroleum Engineer,* vol. SPE, no. 100113, 2006.

[44] S. Z. Kamal, J. Williams and J. Liddle, "Continuous improvement of assets through existing and new digital oilfield technology," *Society of Petroleum Engineer,* vol. SPE, no. 167908-MS, 2014.

[45] P. Hocking and M. Shahly, "BP Norway's Field of the Future implementation: A case study," *Society of Petroleum Engineer,* vol. SPE, no. 112147, 2008.

[46] S. Roberts, "Experience and future perspectives from the Field of the Future program," in *IO Conference,* Trondheim, 2012.

[47] C. Reddick, A. Castro, I. Pannett, J. Perry, J. Dickens, C. Sisk, G. Verra and S. Shirzadi, "BP's Field of the Future program: Delivering success," *Society of Petroleum Engineer,* vol. SPE, no. 112194, 2008.

[48] J. Dickens, D. Feineman and S. Roberts, "Choices, changes, and challenges: Lessons for the future development of the digital oilfield," *Society of Petroleum Engineer,* vol. SPE, no. 150173, 2012.

[49] E. Larsen and P. Hocking, "Skarv and Valhall re-development a journey to the second generation of digital oilfields," *Society of Petroluem Engineer,* vol. SPE, no. 150160, 2012.

[50] J. Dickens, D. Latin, G. Verra, W. Blosser, G. Edmonds and G. Grimshaw, "The BP Field of the Future programme: The continuing mission to deliver value," *Society of Petroleum Engineer,* vol. SPE, no. 128672, 2010.

[51] K. Lauche, S. J. Sawaryn and J. L. Thorogood, "Capability development with remote drilling operations," *Society of Petroleum Engineer,* vol. SPE, no. 99774, 2006.

[52] G. Dudley, J. Perry, S. Goodwin, C. Critchley, P. Hocking, M. Shahly, O. I. Barkved and D. Saul, "The challenges of implementing at scale: Field of the Future - Technologies in the North Sea," *Society of Petroleum Engineer,* vol. SPE, no. 99829, 2006.

[53] A. Thomson, "Deploying Field of the Future on major projects," *Society of Petroleum Engineer,* vol. SPE, no. 112117, 2008.

[54] J. Foot, M. Webster, D. Trueman, G. Yusti and T. Grose, "ISIS - A real-time information pipeline," *Society of Petroleum Engineer,* vol. SPE, no. 99850, 2006.

[55] D. A. Toth, J. S. Dickens and D. Overton, "Pace and scale deployment of a real-time information system," *Society of Petroleum Engineer,* vol. SPE, no. 112118, 2008.

[56] B. Stenhouse, M. Woodman and P. Griffiths, "Model based operational support - Adding assurance to operational decision making," *Society of Petroleum Engineer,* vol. SPE, no. 128694, 2010.

[57] K. Moore-Cernoch, "Advanced collaborative environments stay the course, transform the business," *Society of Petroleum Engineer,* vol. SPE, no. 138595, 2010.

[58] K. O. Stornes, "Risk assessment of integrated operations at the Valhall field," [Online]. Available: http://www.ptil.no/getfile.php/z%20Konvertert/Helse,%20milj%C3%B8%20og%20sikkerhet/Sikkerhet%20og%20arbeidsmilj%C3%B8/Dokumenter/microsoftpowerpoint8bpstornes.pdf. [Accessed 10 May 2016].

[59] D. R. Feineman, "The Field of the Future business process transformation : Insights and challenges," *Society of Petroleum Engineer,* vol. SPE, no. 99779, 2006.

[60] G. Hickey, A. Crossland, A. Fox and M. Skile, "Factors for successful deployments," *Society of Petroleum Engineer,* vol. SPE, no. 128703, 2010.

[61] E. Udofia, O. Oni, A. S. Chaker and O. Oghedegbe, "Smart fields management in deepwater field: Experience and perspectives," *Society of Petroleum Engineer,* vol. OTC, no. 24078, 2013.

[62] P. Kapteijn and J. Deknatel, "Smart fields," Closed-Loop Reservoir Management Workshop, 2004.

[63] C. F. Chai, "A journey to smart fields," Trondheim, 2014.

[64] P. M. Bogaert, W. Yang, H. C. Meijers, J. van Dongen and M. Konopczynski, "Improving oil production using smart fields technology in the SF30 satellite oil development offshore Malaysia," *Society of Petroleum Engineer,* vol. OTC, no. 16162, 2004.

[65] C. F. Chai, F. van den Berg, P. Engbers and G. Sondak, "Smart fields-10 years experience in intelligent energy collaboration," *Society of Petroleum Engineer,* vol. SPE, no. 167872, 2014.

[66] L. de Best and F. van den Berg, "Smart fields - Sustaining and accelerating benefits from intelligent fields," *Society of Petroleumm Engineer,* vol. SPE, no. 150407, 2012.

[67] F. van den Berg, A. R. McCallum, M. Graves, E. Heath and A. Evans, "Collaborative work environments in Shell - Global scale, learning and evolution," *Society of Petroleum*

Engineer, vol. SPE, no. 167455, 2013.

[68] F. van den Berg, R. K. Perrons, I. Moore and G. Schut, "Business value from intelligent fields," *Society of Petroleum Engineer,* vol. SPE, no. 128245, 2010.

[69] J. van Ballegooijen, "The smart fields technology journey," Shell Exploration and Production, 2007.

[70] R. K. Perrons, "Perdido: The first smart field in the western hemisphere," *Society of Petroleum Engineer,* vol. SPE, no. 127858, 2010.

[71] P. Kapteijn, "Smart fields: How to generate more value from hydrocarbon resources," in *WPC*, 2002.

[72] K. Goh, C. E. Moncur, P. V. Overschee and J. Briers, "Production surveillance and optimization with data driven models," *Society of Petroleum Engineers,* vol. SPE, no. 11647, 2007.

[73] E. Okoh, S. Sathyamoorthy, E. Olaniyan and O. Ezeokeke, "Application of integrated production system modeling in effective well and reservoir management in Bonga field," *Society of Petroleum Engineer,* vol. SPE, no. 140632, 2010.

[74] G. C. Gerrard, H. McCabe and A. D. Beck, "Installation and implementation of "Smart fields foundation" on a brown field asset, adding value without major capital investment," *Society of Petroleum Engineer,* vol. SPE, no. 127849, 2010.

[75] R. D. Peterson, S. Yawanarajah, D. Neisch and S. James, "Improving the quality and efficiency of subsurface workflows," *Society of Petroleum Engineer,* vol. SPE, no. 99482, 2006.

[76] M. Chevis and C. Weiss, "Development and adoption of remote assisted operations capabilities in Gulf of Mexico," *Society of Petroleum Engineer,* vol. SPE, no. 127861, 2010.

[77] R. Cramer, T. Moroney, F. Akpoghiran and A. Murthy, "Remote operations - A remote possibility, or the way we do things round here ?," *Society of Petroleum Engineer,* vol. SPE, no. 145293, 2011.

[78] E. van Oort, R. Rosso and J. Caballero-Montero, "Evolution of real-time operations monitoring: From concept to global implementation," *Society of Petroleum Engineer,* vol. SPE, no. 97059, 2005.

[79] R. Knoppe and S. Holloway, "The application of knowledge and continuous learning to the implementation of collaborative work environments at Shell," *Society of Petroleum*

Engineer, vol. SPE, no. 112060, 2008.

[80] S. James and D. Gullhav, "Utilizing remote collaboration and visualization technologies in a collaborative work environment to connect Indian experts with worldwide operations," *Society of Petroleum Engineer,* vol. SPE, no. 113593, 2008.

[81] R. Lameda and F. van den Berg, "Integration is about people," *Society of Petroleum Engineer,* vol. SPE, no. 123352, 2009.

[82] E. Guldemond, K. ten Have and R. Knoppe, "Organizational structures in collaborative work environments: The return of the matrix?," *Society of Petroleum Engineer,* vol. SPE, no. 128274, 2010.

[83] J. P. Liyanage, M. Herbert and J. Harestad, "Smart Integrated eOperations for high risk and technologically complex assets: Operational networks and collaborative partnerships in the digital environment," *Supply Chain Management: Issues in the New Era of Collaboration and Competition,* pp. 387-414, 2007.

[84] Statoil, "Integrated operations in Statoil," *Monthly newsletter,* May 2007.

[85] V. Hepsø, "When are we going to address organizational robustness and collaboration as something else than a residual factor ?," *Society of Petroleum Engineer,* vol. SPE, no. 100712, 2006.

[86] J. P. Liyanage, "Smart assets through digital capabilities," in *Encyclopedia of Information Science and Technology*, Idea Group, 2009, pp. 3480-3485.

[87] Tampnet, "The largest high capacity communication network," 2014. [Online]. Available: https://www.nito.no/contentassets/6adb187a07ce4853bfec142661488720/fiberoptisk-nettutbygging-i-nordsjoen-varnt-erling-skavdal.pdf. [Accessed 16 March 2016].

[88] OLF, "Integrated work process: Future work processes on the Norwegian Continental Shelf," OLF, 2005.

[89] R. Ruså, "IO valuation cases from the Petoro Assets on the NCS," in *IO Conference 2007*, Trondheim, 2007.

[90] S. Roland, O. Yttredal and I. O. Moldskred, "Successful interaction between people, technology and organization - A prerequisite for harvesting the full potentials from Integrated Operations," *Society of Petroleum Engineer,* vol. SPE, no. 112251, 2008.

[91] Statoil, "Heavy focus on integrated operations," 2008. [Online]. Available: http://www.statoil.com/en/NewsAndMedia/News/2008/Pages/AmsterdamIO.aspx. [Accessed 16 March 2016].

[92] A. U. Bindingsbø, *Integrated and remote operations, the future of oil and gas production*, Stavanger: StatoilHydro, 2009.

[93] T. Lileng and S. I. Sagatun, "Integrated operations methodology and value propositions," *Society of Petroleum Engineer,* vol. SPE, no. 128576, 2010.

[94] H. Wesenberg and E. Landre, "Systems of action - A blue print for real-time decision support systems," *Society of Petroleum Engineer,* vol. SPE, no. 174857-MS, 2015.

[95] M. E. Hohman, "PI at Statoil "Sleipner"," in *OSISoft Regional Seminar Series,* Stavanger, 2010.

[96] E. Landre, J. Ølmheim, G. O. Wærsland and H. Rønneberg, "Software agents - An emergent software technology that enables us to build more dynamic, adaptable, and robust systems," *Society of Petroleum Engineer,* vol. SPE, no. 103354, 2006.

[97] T. Rosendahl, A. Egir and E. Rolland, "How to implement multidisciplinary work processes in the oil industry: A Statoil case," in *Integrated operations in the oil and gas industry*, IGI Global, 2013, pp. 155-170.

[98] ABB, "TAIL IO project newsletter," [Online]. Available: http://www02.abb.com/global/noabb/noabb068.nsf/bf177942f19f4a98c1257148003b7a0a/5ab6c518058273c1c125743300332194/$FILE/Newsletter08NEW.pdf. [Accessed 10 May 2016].

[99] B. Moltu and J. Nærheim, "IO (Integrated Operations) design gives high efficiency," *Society of Petroleum Engineer,* vol. SPE, no. 126534, 2010.

[100] A. J. Ringstad and K. A. Andersen, "Integrated operations and the need fo a balanced development of people, technology, and organization," *Society of Petroleum Engineer,* vol. IPTC, no. 11668, 2007.

[101] A. Henriquez, I. Fjærtoft, C. Johnsen, O. Yttredal and T. Gabrielsen, "Enablers for the successful implementation of Intelligent Energy," *Society of Petroleum Engineer,* vol. SPE, no. 111470, 2008.

[102] T. Halland, L. K. Jensen, M. Eike and D. Solnørdal, "Implementing intelligent energy - Change management experiences and recommendations," *Society of Petroleum Engineer,* vol. SPE, no. 167451, 2013.

[103] J. P. Liyanage, "Integrated eOperations-eMaintenance: Applications in North Sea offshore assets," in *Complex system maintenance handbook*, Springer, 2008, pp. 585-609.

[104] Y. Bai, "Collaborative work processes in integrated oil and gas production environments,"

Universitetet i Stavanger, 2013.

[105] FORTUNE, "130. PERTAMINA," 2015. [Online]. Available: http://fortune.com/global500/pertamina-130/. [Accessed 24 March 24].

[106] FORTUNE, "50 most powerful women in business: The global 50," 2013. [Online]. Available: http://archive.fortune.com/magazines/fortune/most-powerful-women/2013/global/. [Accessed 24 March 2016].

[107] PERTAMINA, "Annual report 2014," PERTAMINA, 2014.

[108] PERTAMINA, "Performance report Q3 2015," [Online]. Available: http://www.pertamina.com/media/7afa9d59-d2ae-436e-976d-04ca347f9046/Pertamina%203Q2015%20Highlight%20-%20Web.pdf. [Accessed 22 March 2016].

[109] Wood Mackenzie, *Upstream data tool,* Wood Mackenzie, 2016.

[110] Reuters, "Indonesia's Pertamina buys BP West Java gas field," [Online]. Available: http://uk.reuters.com/article/bp-indonesia-idUKJAK37943720090625. [Accessed 12 May 2016].

[111] Indonesia-Investments, "Oil & gas mining Indonesia: Why Chevron exits the East Kalimantan block?," [Online]. Available: http://www.indonesia-investments.com/business/business-columns/oil-gas-mining-indonesia-why-chevron-exits-the-east-kalimantan-block/item6403. [Accessed 12 May 2016].

[112] SKK Migas, "Annual report 2014," SKK Migas, 2014.

[113] BMI, "Indonesia oil and gas report: Q4 2015," Business Monitor International, 2015.

[114] E. Saputra, "Indonesia's top 7 energy issues: Focusing on what really matters," *Society of Petroleum Engineer,* vol. SPE, no. 176396-MS, 2015.

[115] IHS, "South East Asia/ Indonesia E&P activity trends and opportunities," IHS Energy, 2016.

[116] L. Mahfoedz, "Improving oil and gas investment climates in Indonesia," in *Indonesia Petroleum Association Annual General Meeting*, Jakarta, 2014.

[117] World Bank, "Indonesia GPD growth," World Bank, 2016. [Online]. Available: http://www.worldbank.org/en/publication/global-economic-prospects/data?region=EAP. [Accessed 28 March 2016].

[118] Wood Mackenzie, *Energy markets,* Wood Mackenzie, 2016.

[119] Hadiyanto and S. H. Stevens, "Indonesia: Coalbed methane indicators and basic evaluation," *Society of Petroleum Engineers,* vol. SPE, no. 88630, 2004.

[120] BP, "BP statistical review," BP, 2015.

[121] Wood Mackenzie, "Indonesia upstream summary," Wood Mackenzie, 2015.

[122] H. Budya and M. A. Arofat, "Providing cleaner energy acces in Indonesia through the megaproject of kerosene conversion to LPG," *Energy Policy,* vol. 39, no. 2011, pp. 7575-7586, 2011.

[123] ESDM, "Blueprint of Indonesia National Energy," ESDM, 2006.

[124] BPPT, "Indonesia energy outlook 2014," BPPT, 2014.

[125] Pertamina EP, "Annual report 2014," Pertamina EP, 2014.

[126] Jakarta Post, "Pertamina to operate West Madura Block," 15 September 2010. [Online]. Available: http://www.thejakartapost.com/news/2010/09/15/pertamina-operate-west-madura-block.html. [Accessed 5 May 2016].

[127] Antaranews, "Pertamina given full control of Mahakam block," 12 March 2015. [Online]. Available: http://www.antaranews.com/en/news/98088/pertamina-given-full-control-of-mahakam-block. [Accessed 15 May 2016].

[128] Statoil, "Statoil's president and CEO Helge Lund resigns," 15 October 2014. [Online]. Available: http://www.statoil.com/en/NewsAndMedia/News/2014/Pages/15Oct_HelgeLund.aspx. [Accessed 14 May 2016].

[129] PERTAMINA, "Pertamina Kembali Raih IMAC 2015," 19 May 2015. [Online]. Available: http://www.pertamina.com/news-room/seputar-energi/pertamina-kembali-raih-imac-2015/. [Accessed 15 May 2016].

[130] PDSI, "Annual report 2014," Pertamina Drilling Service Indonesia, 2015.

[131] E. Scholtz, J. Meares and L. Wood, "Integrated collaboration working environment acts as catalyst in leading upstream improvement strategy," *Society of Petroleum Engineer,* vol. SPE, no. 171996 MS, 2014.

[132] J. E. van Dijk, "Smart mobile worker - Bringing our facilities closer," *Society of Petroleum Engineer,* vol. SPE, no. 167426, 2013.

[133] R. B. Bratvold and S. H. Begg, Making good decisions, Society of Petroleum Engineers, 2010.

[134] M. Mahdavi, "The digital petroleum engineer: Carpe diem!," *Journal of Petroleum Technology*, pp. 16-17, October 2008.

[135] J. P. Kotter, Accelerate, Harvard Business Review Press, 2014.

[136] R. Kasali, Mutasi DNA powerhouse: Pertamina on the move, Jakarta: Gramedia Pustaka Utama, 2008.

[137] D. A. Cameron, "Tough times call for collaborative leaders," *Industrial and Commercial Training,* vol. 41, no. 5, pp. 232-237, 2009.

[138] B. J. Josephs, "Developing agile leaders," *Industrial and commercial training,* vol. 39, no. 1, pp. 35-42, 2007.

[139] B. McPherson, "Agile, adaptive leaders," *Human Resource Management International Digest,* vol. 24, no. 2, pp. 1-3, 2016.

[140] J. Dyer, H. Gregersen and C. M. Christensen, The innovator's DNA: Mastering the five skills of disruptive innovators, Harvard Business Review Press, 2011.

[141] B. M. Bass, Leadership and performance beyond expectation, Free Press, 1985.

[142] J. Crompton, "The digital oil field hype curve: A current assessment the oil and gas industry's digital oil field program," *Society of Petroleum Engineer,* vol. SPE, no. 173441-MS, 2015.

[143] APQC, "Why and how to build a collaborative culture," APQC, 2010.

[144] Schlumberger, "Acting in time to make the most of hydrocarbon resources," Schlumberger, 2005.

[145] R. A. Burgelman, C. M. Christensen and S. C. Wheelwright, Strategic management of technological innovation, Singapore: McGraw Hill, 2009.

[146] E. G. Frankel, Quality decision management: The heart of effective future-oriented management, Springer, 2008.

[147] M. A. Schilling, Strategic management of technological innovation, New York: McGaraw Hill, 2013.

[148] G. S. Parnell, P. J. Driscoll and D. L. Henderson , Decision making in systems engineering and management, Wiley, 2011.

[149] D. O. Faulkner and A. Campbell, The oxford handbook of strategy: A strategy overview and competitive strategy, vol. 1, New York: Oxford University Press, 2003.

[150] R. Phelps, C. Chan and S. C. Kapalis, "Does scenario planning affect performance? Two exploratory studies," *Journal of Business Research,* vol. 51, pp. 223-232, 1998.

[151] M. Godet , Scenarios and strategic management, Butterworts, 1987.

[152] P. Schoemaker, "Scenario planning: A tool for strategic thinking," *Sloan Management Review,* vol. 37, no. 2, pp. 25-39, 1995.

[153] R. Dye, O. Sibony and P. Vigier, "Strategic planning: Three tips," *McKinsey Quarterly*, April 2009.

[154] CERA, "The digital oilfield of the future: Multi-client study," Cambridge Energy Research Associates, 2002.

[155] T. Edwards, Ø. Mydland and A. Henriquez, "The art of intelligent energy: Insights and lessons learned from the application of iE," *Society of Petroleum Engineer,* vol. SPE , no. 128669, 2010.

[156] J. Crompton and H. Gilman, "The future of integrated operations," *Society of Petroleum Engineer,* vol. SPE, no. 127715, 2010.

[157] L. O. Grøvik, "Operation centers, real-time data and data management: Quo vadis ?," *Society of Petroleum Engineer,* vol. SPE, no. 110399, 2007.

[158] V. Hepsø, H. H. Olsen, F. Joanette and F. Brych, "Next steps to a framework for global collaboration to drive business performance," *Society of Petroleum Engineer,* vol. SPE, no. 126207, 2010.

[159] P. Williams, "How collaborative environments influence culture and behavior," *Society of Petroleum Engineer,* vol. SPE, no. 100195, 2006.

[160] L. Fæste, T. Gumsheimer and M. Scherer, "How to jump-start a digital transformation," BCG, 2015.

[161] F. Lind, D. Field, R. Sandhu, D. Ståhlberg and J. Eriksson, "The CMO transformation agenda: Winning in digital marketing," BCG, 2016.

[162] E. Guldemond, "Collaborative work environments in smart oil fields: The organizational matters !," in *Integrated operations in the oil and gas industry*, IGI Global, 2013, pp. 59-75.

[163] A. Markusen, "Sticky places in slippery places: A typology of industrial districts," *Economic Geography,* vol. 27, no. 3, pp. 291-313, 1996.

[164] M. Bronzo , M. P. Oliveira and K. McCormack, "Planning, capabilities and performance:

An integrated value approach," *Management Decision,* vol. 50, no. 6, pp. 1001-1021, 2012.

[165] ESDM, "Indonesia energy outlook 2013," Ministry of Energy and Mineral Resources Indonesia (ESDM), 2013.

[166] Schlumberger, "Seizing the EOR opportunity," Schlumberger, [Online]. Available: https://www.sbc.slb.com/Our_Ideas/Energy_Perspectives/2nd%20Semester13_Content/2nd%20Semester%202013_Seizing.aspx. [Accessed 12 April 2016].