Scientific Framework for the Danish Hydrocarbon Research & Technology Centre

Introduction

Research activities at the Danish Hydrocarbon Research and Technology Centre (DHRTC) can take place within four core scientific themes. The themes span from subsurface to surface, from geoscience to engineering. They encompass critical parameters which all have direct influence on hydrocarbon recovery efficiency and associated cost and therefore also on the total amount of oil and gas which can be produced from the existing fields and discoveries in the Danish North Sea. The four scientific themes are:

1) Reservoir characterisation
2) Enhanced Oil & Gas Recovery Processes
3) Drilling & Production Technology Concepts
4) Production Facilities & Material Research & Design

To comply with the commission of DHRTC all financed projects must have the potential to improve current concepts and practice in field development and operations in the Danish North Sea, leading to improved oil or gas recovery from existing fields or unlock hydrocarbon bearing intervals which currently are considered unlikely to have sufficient reservoir quality (flow capability) to substantiate a development. This does not imply that all projects must provide results that are directly applicable offshore, but all projects must have a documented line of sight to concrete deliverables such as prototypes, models/simulations or larger-scale pilot tests (Figure 1).

The ability to significant increase oil and gas production and ultimate recovery from the Danish North Sea is to a large extent influenced by the ability to generate progress in six areas of application:

- Improved sweep efficiency
- Reduced residual hydrocarbon saturations
- Detect and produce by-passed hydrocarbons
- Enable development of marginal and tight oil and gas discoveries
- Extend well integrity and well life
- Extend life of surface installations

To achieve substantial progress in any one the these areas, new ideas and solutions will be needed in more than just one scientific theme due to the complexity of the challenges that exist within the six areas of application. The success of DHRTC will therefore be dependent on the ability to derive technological answers which span across all scientific themes, either through cross-thematic projects or through closely coordinated and well aligned project work streams. The project portfolio of DHRTC should thus be viewed as an ecosystem where the value of a single project to a large extent relies on its synergy with other projects and their collective potential for generating improvements.

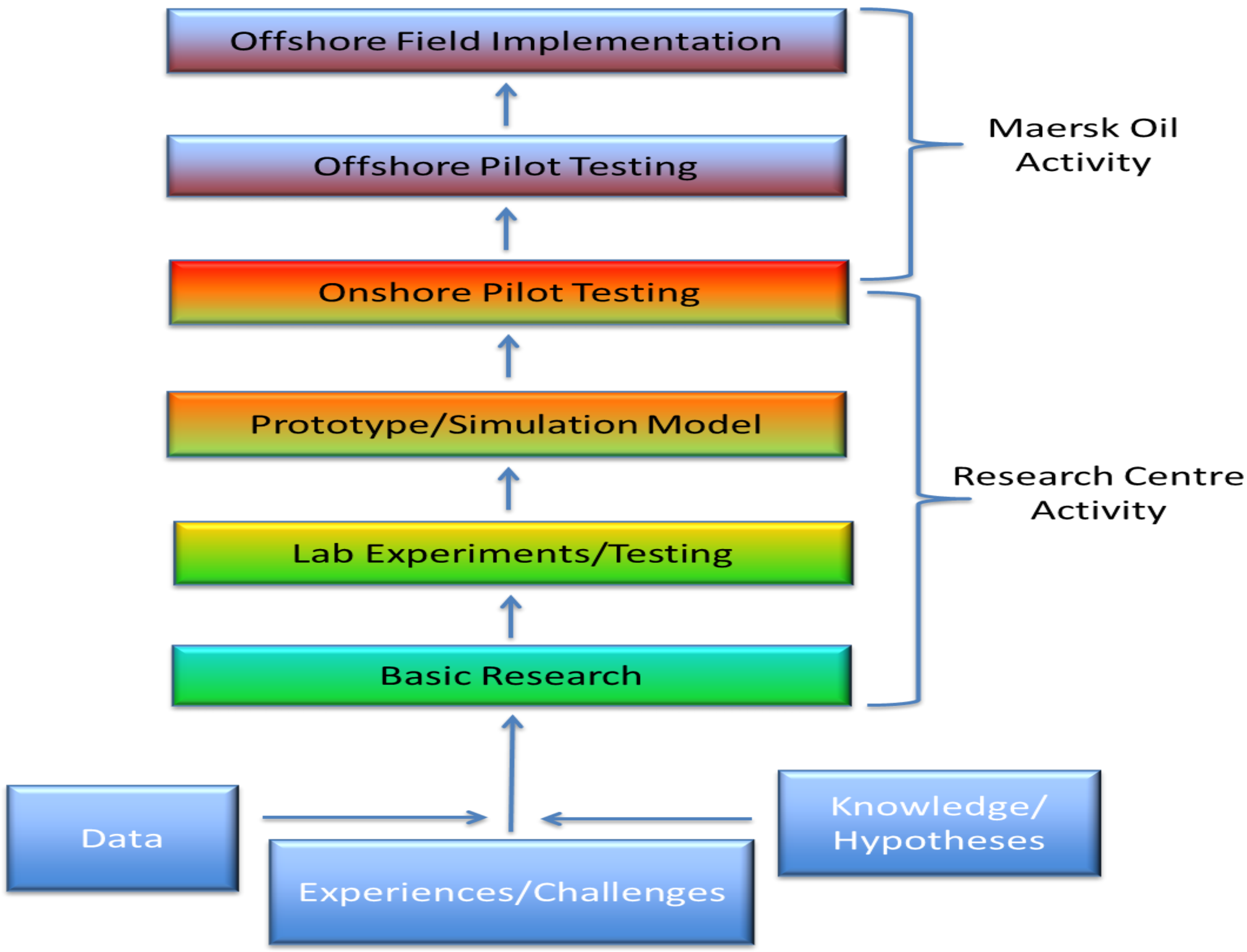

Figure 1: Simplified overview of the maturity path for the DHRTC based activities, illustrating development path to concrete concepts or ideas ready to be tested.

In all four scientific themes it is expected that a need to undertake basic research projects will emerge. This may be due to requirements to fill critical gaps before further progress of existing ideas and results can be made, or to establish basic knowledge in new, promising and hitherto underexplored topics. For such basic research projects it may not always be meaningful to specify concrete deliverables, such as prototypes or computer simulations. Instead these must demonstrate a feasible roadmap which substantiates a potential to mature the project findings into tangible deliverables that can impact the North Sea oil and gas recovery.

Scientific Theme 1: Reservoir Characterisation

Research activities within the theme of Reservoir Characterisation will aim to develop new methods and concepts to describe and model reservoir rock and the pore surface interaction with pore fluids. Overall the research activities at DHRTC should be directed towards a holistic approach through integration of geology, geophysics, petrophysics, reservoir fluid chemistry and numerical modelling to reach a new level of understanding of the reservoirs. This involves the integration of a wide range of data from nano to kilometre scale into computer models to simulate fluid movements and changes in reservoir properties in response to production and fluid and gas injection. For many projects, close interaction with Theme 2 will be required to deliver tangible results which can be implemented in the Danish North Sea fields. Research under Theme 1 should focus on:

Modelling of reservoir heterogeneity & characterisation of low permeability reservoirs
Activities should focus on the development of new or improved methods or technologies to characterise and model reservoir heterogeneities which impact reservoir fluid flow during production and/or injection. In this context studies can place emphasis on the reservoir matrix or fault and fractures and their impact both as potential seals or conduits. Projects can also aim to develop improved methods for characterising and modelling oil bearing low permeability reservoirs which have not previously been exploited in the Danish North Sea. This can include fractured shaley/silty formations (Farsund Formation), dolomite stringers within organic rich shales, or tight or shale rich sections within the Chalk Group (e.g. Ekofisk and Hod Formations).

At present, there is a relatively advanced level of understanding of the empirical relationships between petrophysical and seismic parameters based on laboratory analyses of cores and borehole logs. This understanding can be further strengthened by quantitative geoscience data analysis and multivariate statistics. The close integration of field experiments and modelling has the potential to lead to the development of new algorithms which link critical petrophysical/rock mechanical data with geophysical and geological parameters on the scale of 1-10.000 m^3 rock volumes. This will allow a better description of the fine-scale reservoir heterogeneities and improved upscaling of these to practical reservoir modelling scale.

Geohistory analysis of undeveloped discoveries
The interplay between subsidence, hydrocarbon charge and diagenesis (carbonate and siliciclastic) can impact the reservoir character to an extent where it creates a highly complex hydrocarbon distribution which significantly affects development and recovery potential. While regional basin modelling lies outside the scope of DHRTC, the centre can host studies which aim to decipher or model the geohistories (incl. fluid migration and filling history) of marginal and undeveloped discoveries in the North Sea. The focus of these should be on

improved assessment of development potential and reduction of the risk associated with further appraisal or early development drilling.

Analysis and modelling of fluid properties

While distinct analysis and modelling of fluid properties (e.g. PVT analysis) naturally falls under Theme 2, research activities under Theme 1 can focus on the development of a more integrated and unified hydrocarbon fluid characterisation and modelling approach of the accumulations in the Danish Sector. This could provide new insights into hydrocarbon migration and filling histories, potentially providing a more comprehensive understanding of the character and potential variability of residual oil and gas saturations in the Danish North Sea.

Surface properties of reservoir rocks

Research activities under this topic will by their nature have close ties to activities taking place under Theme 2. Projects under Theme 1 should focus on the microscopic scale of rock characterisation aiming to understanding the impact of such aspects as mineralogy and rock fabric on micro- and macroscopic sweep efficiency. Research projects may also aim to improve the understanding of reservoir properties at the nano scale. There is currently a lack of tools for characterisation of three dimensional pore structure with sufficient resolution to reach the important length scales (about 5nm) needed to for a more comprehensive link to reservoir fluid flow properties. Presently SEM can give excellent resolution in two dimensions, whereas FIB-SEM has the potential to give information in three dimensions. While the centre may decide to place emphasis on improved computer and modelling tools to handle the appropriate amount of data, it is also estimated that research projects in this area in many cases will, need to be done in collaboration with parallel activities taking place outside DHRTC.

Scientific Theme 2: Enhanced Oil & Gas Recovery Processes

A large fraction of the known hydrocarbons initially in place in the Danish North Sea sector is trapped either as un-swept (by-passed) or as residual saturations, which makes these hydrocarbons unavailable to conventional development schemes. Mobilizing un-swept hydrocarbons or lowering residual saturations and thereby increase recovery from known accumulations is of substantial value because such projects can make use of existing infrastructure to process and export the additional hydrocarbons.

Improved and enhanced oil and gas recovery methods and concepts related to greater sweep and displacement efficiency cover a broad range of processes. Improved oil recovery (IOR) generally refers to optimization of existing recovery methods, while enhanced oil recovery (EOR) implies the introduction of new concepts. Theme 2 research activities at DHRTC can focus on both IOR and EOR relevant topics and must take into consideration the fact that the Danish oil and gas accumulations are located offshore and mainly in low permeable reservoirs.

EOR processes involve interplay between physics and chemistry, which dominate on a small scale, and reservoir heterogeneity and fluid flow, which dominate on a larger scale. It is difficult to evaluate the outcome of complex EOR processes without utilizing reservoir simulation that properly accounts for the involved physics and chemistry. It is therefore expected that research efforts will be needed at DHRTC to strengthen existing simulation techniques, particular in relation to improved description of the underlying physics and chemistry of EOR processes and in relation to upscaling. Research activities under Theme 2 should focus on:

Water based EOR processes and methods
Many chalk reservoirs in the Danish North Sea have been subject to waterflooding for a long time. High recoveries associated with waterflooding in combination with limited requirements in terms of well and facility upgrades makes water based EOR techniques attractive.

As outlined under Theme 1 a successful implementation of IOR and EOR processes requires an in depth understanding of the displacement paths. For some of the major chalk fields water injection may take place along induced fracture paths, which in turn are determined by the geomechanical characteristics of the chalk. To reliably predict reservoir response under IOR and later EOR, behaviour and impact of the injection induced fractures should be well understood and ideally represented in models that reflect the dynamic response of the fracture network geometry. Good understanding of the fracture characteristics and link to the dynamic behaviour under waterflooding will therefore be critical elements in successful IOR/EOR implementation. Close integration with Theme 1 will be a pre-requisite for success.

Several methods of modifying the injection water composition have been suggested and tested during recent years (e.g. smart water). It is a relatively new concept which has attracted much attention since the cost of implementation is relatively low, but there is no consensus on how different types of smart water work. It is speculated that changing the brine salinity/composition may result in physical/chemical changes on the rock/fluid interface such that part of the residual oil can be released and hence recovered. This technique has already been tested in some sandstone reservoirs, however its effects on chalk are not very clear. A significant research effort is required in order to fully understand the mechanisms of smart water. Considering that the controlling mechanisms can be multiple and the outcome is highly rock/fluid-dependent, it may be valuable to establish laboratory procedures and field tracer tests that can give less ambiguous evaluations of the salinity effect. The laboratory studies should be able to cover different types of oil, brine and reservoir/outcrop rocks. Reservoir simulation of smart water is still at a primitive stage where the salinity effect is accounted for by simply changing the relative permeability. Hence, currently available modeling tools are far from capturing the underlying physical/chemical mechanisms.

Surfactant flooding reduces residual oil saturation primarily by interfacial tension reduction. Major challenges are the cost of surfactant, loss of surfactant due to adsorption on the reservoir rock, and the formation of emulsions with the produced oil. Development of low cost, low adsorption surfactants are the key for the viability of a surfactant flooding project. Investigations of low concentration surfactant flooding in chalk with a modest reduction in interfacial tension may be of relevance for the most heterogeneous chalk types, however, previous studies and lab tests have shown a need for a very substantial reduction in interfacial tension before sufficient effects materialise. Substantial research progress outside of DHRT may therefore be needed before this topic should become a main focus area of investigation at the Centre.

Addition of polymer to the injected water is used to increase water viscosity and hence decrease the mobility ratio. For tight chalk, this can be paradoxical since increasing viscosity will apparently reduce the injectivity. However, several innovative techniques like nano-sized linked polymer solution (LPS) and silicate particles can potentially be applied to chalk reservoirs. Like for the smart water methods, these methods may be rock dependent. Unlike the traditional polymer flooding which mainly relies on macroscopic mobility, these new techniques reduce residual oil saturation by microscopic diversion. Polymer flooding also has logistical challenges as in surfactant flooding.

Gas based EOR processes and methods

The theory and modelling of these processes are relatively mature and pilot and full scale projects have been in operation since the 1950's. Options for injection gas include CO_2, hydrocarbon gas and Nitrogen.

Although CO_2 EOR is considered a mature and well proven EOR technique the specific response for particular fields and reservoirs is still open to investigation. A particular scope for CO_2 injection in the Danish North Sea sector is the large residual oil zones. The effect of CO_2 injection on these is uncertain and needs further investigation. Compared to other injection fluids, CO_2 has a complex phase behavior once mixing with reservoir fluids. Issues such as multiple phase equilibrium and asphaltene precipitation (in certain cases) could be addressed both for understanding and planning the process as well as to prevent production loss at a later stage of the field development. CO_2 has much higher solubility in brine than other gases, meaning that CO_2 loss to brine should be taken into account. The high solubility in brine has large implications on how CO_2 comes into contact with residual oil blocked by water in tight chalk, which is not a well understood phenomenon. Dissolution of CO_2 in brine forms carbonic acid which may dissolve chalk and affect its mechanical properties. Possible secondary scale formation, such as gypsum/anhydrite, due to the increased concentrations of calcium ions and gas impurities are effects related to chalk dissolution that have not been clearly described yet. Research activities to clarify the specific response of chalk formations and their associated heterogeneities to injection of CO_2 provide a clear link to research activities under Theme 1. Like other gas injection processes, CO_2 injection can be implemented via water-alternating-gas (WAG) injection schemes. In this context, optimization of WAG cycling with regard to slug size and cycling timing should be investigated further.

Hydrocarbon gas injection is more readily available than CO_2, but is often less miscible with oil. Most gas injection operations in the North Sea utilize hydrocarbon gas in WAG injection mode. The composition of the hydrocarbon gas influences its miscibility with the reservoir fluid. Although most hydrocarbon gases are not miscible at the injection conditions, oil recovery can still increase via mass exchange which results in a reduction in interfacial tension and/or oil viscosity as well as swelling of the oil. Overall, this effect calls for a study with lab tests and reservoir simulations. Moreover, miscibility conditions can be changed by enriching the injection fluid via solvents. Any components heavier than methane can serve that purpose and careful design of the injection gas composition is helpful to maximize the potential of EOR. It is particularly worth considering new solvents that are not originally present in the gas mixture but can dramatically change the miscibility pressure at a low level of addition. In addition to its efficiency, an ideal solvent should be affordable, environmentally friendly, and safe to use. A secondary challenge caused by adding solvent is that the solvent can partition between gas and oil and a chromatographic separation may happen along the displacement.

Nitrogen is less miscible than hydrocarbon gas and CO_2. It can however be obtained by air separation at a presumably low cost if large quantities of N_2 are needed for offshore injection. The largest challenge for N_2 injection is its low miscibility and poor sweep efficiency due to high mobility contrast. The low viscosity of N_2 can make it attractive for tight and/or deep reservoirs, since the miscibility improves with pressure. In addition to the reservoir engineering challenges, N_2 injection needs to deal with air separation and N_2 compression. As for the other gas based methods, injectivity during WAG and optimization of WAG cycling is also an issue.

Biologically based EOR processes and methods

Microbial EOR utilizes microorganisms within the oil reservoirs to realize in situ production of surfactants to reduce capillary forces. In addition, adsorption of bacteria in water-saturated zones can lead to flow diversion which may increase oil recovery. Another possible bio-related EOR technology is through addition of selected and optimized biological enzymes. Both methods are relatively easy to implement, but the underlying mechanisms as well as the field-scale response remain uncertain. EOR through biotechnological solutions is not well understood and represents a research challenge. The effects are reservoir specific, and hence a customized design with extensive trials and screening is needed. The well injectivity may be adversely affected due to microbe or enzyme injection. Bio-competition between different types of microbes can occur and it is a challenge how to selectively promote the growth of the desired types.

EOR reservoir management and surveillance

Prior to advancing an EOR concept to the full field development stage it is most often necessary to demonstrate viability of the concept in a pilot where field data to prove the technique are collected. Effective surveillance technologies can therefore contribute significantly to realising an incremental recovery potential. Areas with scope for improved surveillance technology include seismic acquisition (time lapse), processing and analysis technology, chemical and isotopic tracer technology and horizontal well production logging technology. Further studies in downhole data collection and downhole control to optimize WAG floods by adjusting the inflow profile in horizontal wells would also be valuable.

Operationalizing offshore EOR

One of the key challenges in operationalizing EOR offshore is the high cost environment. To reduce costs, there is a very considerable research potential in creating and delivering pilot projects and test cases onshore, which also can evaluate equipment and designs before expensive and potentially risky offshore employment. Experiments and tests could be done in local quarries or through the development of strategic relationships with for instance universities and independent operators who have access to the necessary experimental facilities .

Scientific Theme 3: Drilling & Production Technology Concepts

Projects categorized under the Theme 3 will aim to develop new technology concepts for producing and injecting wells which in a safe and efficient manner will improve their productivity and life span. This also includes focus on reduced drilling and completion costs. Projects are expected to have the potential to add value in all six areas of application. With the high number of existing wells in the Danish fields a high impact research area is linked to concepts which have the potential to improve secondary and tertiary recovery from existing developments through enhanced use of the existing well stock. This is expected to require a strong focus on new technologies for evaluation and monitoring, well integrity maintenance and intervention, re-stimulation, and conformance control. Research under Theme 3 should focus on:

Concepts for completing and producing tight/ thin reservoirs

Activities can focus on the development of new and improved concepts for completing and producing tight, and often thin, reservoirs in a more efficient manner, including more cost-effective wells and completions. Significant hydrocarbon resources are residing in the Ekofisk Formation, several Lower Cretaceous Formations and the Farsund Formation. Currently many discoveries in these units are considered marginal or non-economic to develop. Research projects could cover aspects such as, improved understanding of rock mechanics, slimmer well concepts, new well concepts maximizing reservoir exposure, new fluids minimizing drilling inducing formation damage and emulsion formation tendencies with reservoir and stimulation fluids, and improved techniques for completion and stimulation.

Conformance control and well interventions

A key focus area of research activities should be the development of enhanced methods for conformance control, including improved techniques to locate, characterize and treat non-conforming intervals as well as innovation deployment methods to facilitate quicker and more cost efficient response to observations (e.g. robotic devices). Successful operation of the current secondary recovery schemes with water injection and successful implementation of any future tertiary recovery schemes will rely on the ability to effectively control lateral and vertical displacement efficiency.

The research topic also covers techniques which permit repair of wells where well integrity has been lost. This will allow extended production in wells where remaining reserves cannot economically justify a full scale work over. Such techniques may for example include designing of fit-for-purpose chemical solutions providing seals when exposed to certain downhole conditions and innovative mechanical straddling solutions. Considerable potential also exists with respect to research aiming to improve re-stimulation of already existing well concepts.

Remote sensing and operation

A significant potential is anticipated to exist in the research area of remote sensing and monitoring. Topics to focus on could be “Smart Wells” featuring monitoring and control of reservoir intervals with sensors and valves. These could either be connected to the surface through for instance hydraulic lines, electrical or fiber-optic cables, or have no surface connection using wireless communication and downhole power generation. Emphasis could be placed on research in the area of distributed fibre-optic sensing for well completions and surveillance interventions, including distributed acoustic, pressure and chemical sensing.

Improved drilling techniques in depleted reservoirs

As producing field mature, pressure differentials along wells increase leading to more complex and risky drilling operation. Development of more marginal areas will also lead to more complex and possibly extended reach drilling trajectories, which will pose challenges with maintaining wellbore stability. Considerable value is therefore present if research activities can lead to improved drilling, formation stabilisation and casing isolation techniques for depleted reservoirs and overburden to ensure safer and more cost-effective well construction.

Abandonment techniques for horizontal wells

Current techniques do not provide efficient or cost-effective hydraulic isolation along horizontal wellbores during abandonment of wells, which can lead to short-circuiting of injection fluids along these wellbores, hence reducing the ability to control lateral sweep efficiency. Research activities in this area may help improve the hydrocarbon recovery in mature fields.

Corrosion and scale management

Corrosion as an area of research also constitutes a significant part of Theme 4 and very close synergies exists between corrosion in wellbores, surface structures and pipelines. Full integration of research projects across the two themes is therefore expected to be the norm. An example would be the development of improved understanding and modelling tools for predicting and potentially mitigating reservoir souring. Significant potential lies in further studies of materials, corrosion mechanisms and scale deposition mechanisms within wellbores. This could include new methods for scale management. Research projects could focus on the development of corrosion and scale prevention methods leading to improved well operating life and ability to make well interventions. Research in alternative materials also provide potential to reduce the impact of corrosion, for instance fibre re-enforced composites which have superior strength and are more corrosive resistant than currently used materials. Areas of relevance include well tubulars, well intervention wirelines, rods and coiled tubulars.

Scientific Theme 4: Production Facilities & Material Research & Design

Safe and efficient oil and gas production depends on adequate North Sea facilities being available for the next 30 years and more. During this period new demands and requirements on facility and material design rise as a consequence of the increasing maturity of the producing fields and the drive towards advanced enhanced oil and gas recovery mechanisms. In addition to growing requirements, the need for maintenance also grows as the facilities are continuously exposed to fatigue due to cyclic loading of structures and pressure containing equipment and corrosion. One important element to support long term use of existing facilities is improved and automated inspection methods to ensure that integrity management is timely and effective. Today a wide range of inspection methods exist, but most need significant preparation of the sites to be inspected, as well as direct operator intervention during the inspection. High cost and critical safety aspects are related to these activities. Automation of these processes would be of great benefit

As a consequence of the wide range of challenges within facility improvement and material research, potential research topics within Theme 4 covers a wide variety of engineering disciplines, including chemistry, mechanics, materials, electronics, robotics, sensors, planning and construction. Research projects under Theme 4 should focus on:

Corrosion mechanisms

Understanding the mechanisms involved in CO_2-induced or CO_2-enhanced corrosion, particularly in combination with other corrosion mechanisms is of crucial importance. This includes the presence of H_2S, either as a result of its presence in crude oil or as a consequence of microbial activity. Research projects should focus on identifying and quantifying the synergistic effects of various corrosion mechanisms in complex environments, particularly at relatively high temperatures and pressures. Furthermore, the interplay of corrosion with erosion, fatigue and mechanical stress is important. Corrosion should be described both from a material and from a chemical environmental point of view. The research should combine experimental laboratory work and numerical modeling, including thermodynamic and electrochemical modeling. Research in microbial-induced corrosion should focus on understanding the mechanisms and identifying responsible key organisms.

Materials that can withstand the hostile corrosive environments associated with CO_2 EOR are currently lacking. The design and development of materials solutions to prevent excessive materials degradation could involve the design of new corrosion resistant alloys, surface engineering of existing metals or the application of other materials such as polymers and composites. Research projects aiming at developing new strategies to combat microbially induced corrosion will therefore also form part of Theme 4. Corrosion studies should aim to provide deterministic and stochastic input necessary to develop numerical models that allow a description of materials degradation by synergistic corrosion mechanisms under various conditions of corrosion protection. Such models could be paramount for decision-making in relation to life-time extension and planning of inspection intervals.

The presence of H_2S gas in oil is unwanted. Currently scavengers are used for H_2S removal, potentially leading to separator precipitation and corrosion. Research projects could focus on a combination of modelling and complex experimentation to improve the understanding and develop efficient remedies and/or alternatives.

Scale formation and gas-hydrates

Scale formation and deposits can create production blockage posing a safety hazard. Research projects should focus on means to minimizing or, preferably, avoiding its formation. However, the effect of scale formation on corrosion can also be protective for corrosion and research could focus on providing a better general understanding of its impact. If water-alternating-gas (WAG) injection is applied during CO_2 EOR blockage of equipment by high pressure ice-like gas-hydrates is a possible hazard. Prevention of gas-hydrates is necessary to enhance off-shore safety. It is currently unknown how the various inhibitors for corrosion, scale and gas-hydrate formation affect each other. This deserves further study. Furthermore, development of environmentally neutral inhibitors is considered an enabling technology to expand the lifetime of existing facilities.

Risk-based decision making and planning

Research projects could aim at the development of risk-based decision tools for subsea (incl. pipelines) and topside components exposed to fatigue, corrosion and wear. This research should be coupled to the research in deterioration mechanisms and research in systems for decision making. Risk- and reliability-based approaches considering both components and systems for decision making should be developed for application to new and existing platforms, where service-life extension and condition assessment is needed. Research in risk-based inspection planning using automated methods should focus on including information from various sources, incl. traditional and automated inspection methods. Prototype systems need to be developed and installed such that a gradual change from traditional to fully implemented automated inspection can be investigated. This includes development of planning/optimization tools for monitoring as a means of structural health management.

Sensor technology and sensor systems

These systems are crucial for monitoring structural responses, for navigation and process monitoring. Research projects could be conducted which aim to allow assessing good combinations of sensors, optimal topology of sensors and adequate processing of data so that the essential information is obtained. Special focus should be given to sensor systems that do not only measure local phenomena, but provide information about the behaviour of the entire system. High level control and monitoring of pipeline structures is important for leak protection and safety. Research projects directed towards sensor systems for monitoring of the pipeline flow, the content characteristics and the mechanical state of the pipeline should be considered with the aim to improve optimization of operating decisions. New sensors and sensor systems could be developed for monitoring particularly harsh environments of high pressure and high temperature.

Fatigue and damage estimation

Research could be carried out on the application of modal parameters obtained from the operating response of platforms and/or substructures to estimate possible damages and hereby contribute to the automated inspection of the structural reliability. Efforts could also focus on improved management of fatigue crack integrity incl. theoretical prediction of probability of detection (POD) curves for different details, verification by fatigue testing and measurements of cracks and development of a “live” probabilistic inspection planning format, allowing continuous updating. Enhanced autonomy of smart pigs such that they are able to inspect, act, and repair down-hole and in transportation lines will take the pigging technology to the next level.

Model predictive control

Efficient and robust utilization of existing assets in an oil field such as gas lifting systems, compressor stations, separators with water injection to multiple injection wells as well as oil from several production wells requires coordination, feedback control, and optimization. Flow instability in wells, pipelines and risers due to slugging causes disturbance in process equipment and may result in production losses. Research projects could focus on adaptive and/or predictive methods to support suppression of slugs and their knock-on effects by active process control. Economic Model Predictive Control for the operation and optimization of such systems could be developed and tested. Potentially, it enables increase of the oil production rate with existing facilities as well as reduction of the costs for operation of the system at a given capacity.

New platform concepts

For new and marginal oil & gas fields cost-efficient platform concepts are needed. New concepts could include application of new materials as a supplement to steel. It is proposed that both fixed and movable platform concepts are studied. The research may focus on both reduction of the initial investment and reduced maintenance costs. More automation for enhanced safety is an issue and so is better knowledge of the environmental loads acting on the platforms and substructures. Research could focus on new or improved platform materials, modeling of environmental loads from the waves and current, especially for sites with substantial subsidence, or optimization of platform designs and planning and execution of (re-)installation. The focus here should be on concepts considering both installation, removal/re-location and finally re-cycling of the platform that opens the marked for new installation vendors.

New pipeline concepts

Pipeline re-use is important for construction management and fluid transport designs taking service life strategy into account. New cost-efficient pipeline concepts would be highly attractive for application of new materials, installation and operation aspects, and extreme loading scenarios. The physical transport and installation at offshore conditions is currently limited to only a few vendors. Cheaper methods will open for development of marginal reservoirs. Long delivery time is an issue to address. Research on propagation of buckles in subsea pipelines could be carried out with the aim of proposing better ways of avoiding failure by design of buckle arrestors and preventing buckle initiators. Vibration problems that might lead to excessive fatigue should be analysed.

Handling of produced water

There is a need to develop new oil/water separation techniques to remove trace hydrocarbons from the produced water that has to be reinjected or discharged. There is also an apparent demand for regeneration of upstream added chemical agents from oil or produced water with the purpose of reducing the cost of chemicals and creating a sustainable chemical practise. The challenges are to obtain reproducible low quantities of oil/chemicals in water, and the development of effective degassing and treatment chemicals used for reinjection of produced water. There is a potential for new efficient environmentally friendly additives. Spectroscopic and chromatographic analysis techniques, combined with chemometrics are tools to be matured, so that fast screening of oil in water and detailed characterisation of the oil composition becomes feasible. Innovative principles may potentially remove the need for off-shore topside water treatment, and the associated scale and aqueous corrosion problems. A radically different separation technique is required for down-hole water separation and re-injection in the water zone.

Data Documentation

To strengthen collaboration and transparency of the ongoing research, all data generated or purchased by the research projects at DHRTC must be documented and stored in a common database. The database will be available for usage by all researchers at DHRTC. As part of the data sharing, research projects must also provide a comprehensive written documentation of data, analyses and results. This must be in a format and detail level that allows other research projects at DHRTC, as well as Maersk Oil and DUC partners to utilize the results effectively. The format and nature of the data storage, documentation and knowledge sharing will be determined by the management of DHRTC.