Scientific Framework for the Danish Hydrocarbon Research & Technology Centre

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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 practices 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 significantly 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
- Detection and production of by-passed hydrocarbons
- Development of marginal and tight oil and gas discoveries
- Integrity and extended lifespan of wells, surface facilities and structures
- Transformation of cost and reliability of production operations

To achieve substantial progress in any one of 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.

To preserve the license to operate on behalf of the Danish state and maintain a viable oil and gas production in the North Sea for the years to come, it is essential that efforts are made to continuously reduced the environmental footprint from all aspects of production and operation in the four scientific themes. Projects focussing on technical solutions for improving environmental sustainability within the four themes are therefore also part of the DHRTC scope. Overall, the project portfolio of DHRTC should be viewed as an ecosystem where the value of a single project to a large extent depends on its synergy with other projects and their collective potential for generating sustainable improvements.

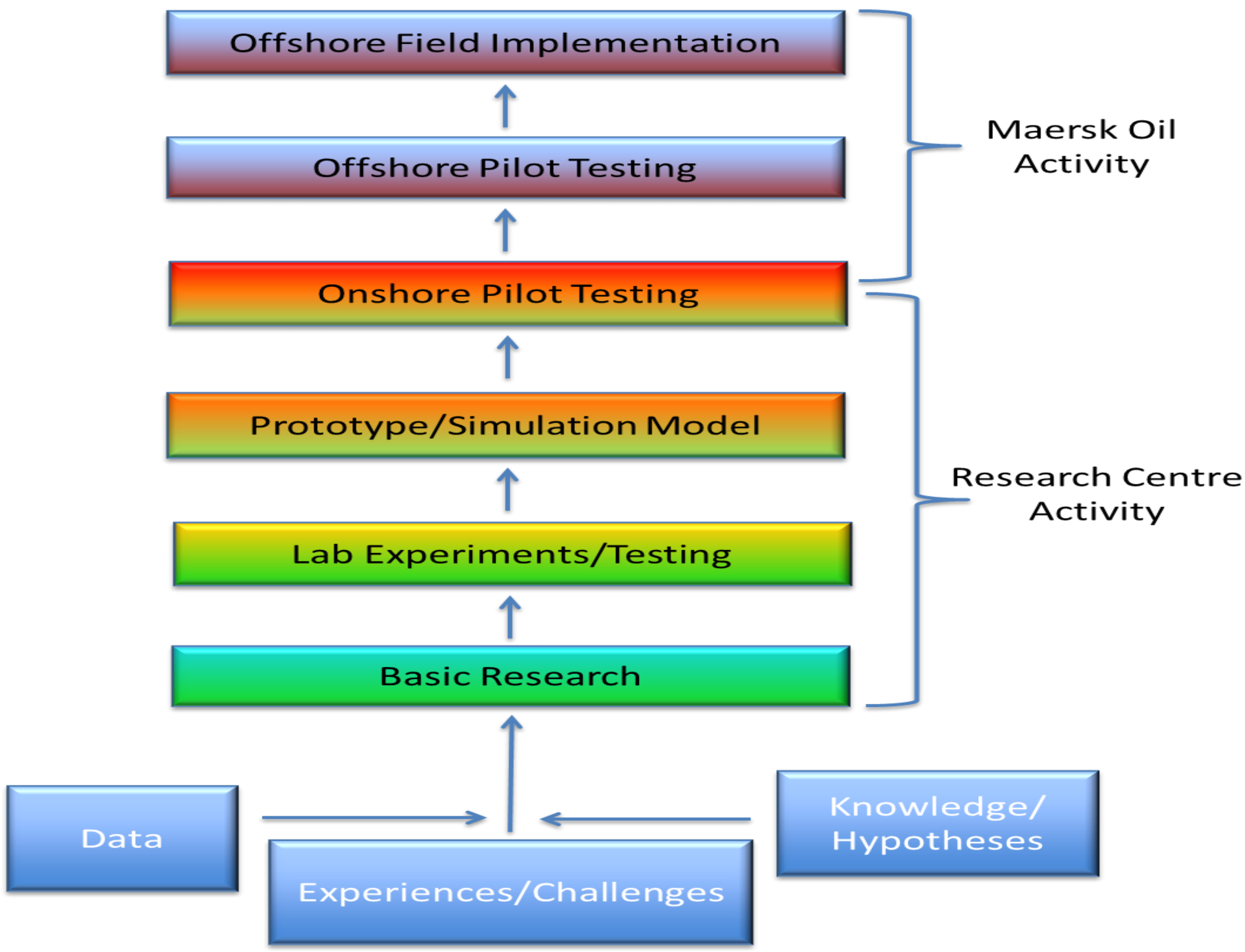

Figure 1: Simplified overview of the maturity path for the DHRTC based activities, illustrating development path to concrete concepts or ideas ready to be tested.

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, in terms of increased reserves, lower cost and enhanced environmental sustainability.

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 been discovered, but not yet been developed in the Danish North Sea.

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 using new and emerging techniques. 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 can impact the reservoir character and create 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 the characterisation of three dimensional pore structure with sufficient resolution to reach the important length scales (about 5nm) needed for a more comprehensive link to reservoir fluid flow properties.

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 could be of substantial value if 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, which potentially can deliver economically attractive incremental reserves with an overall neutral or improved environmental footprint for the asset. Research programmes under consideration much be evaluated in the context of the fact that the Danish oil and gas accumulations are located offshore, mainly in high porosity, but low permeable reservoirs and produced through mature offshore installations.

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.

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. A significant research effort is required in order to fully understand the mechanisms of smart water in chalk reservoirs. 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 modelling tools are far from capturing the underlying physical/chemical mechanisms.

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.

CO_2 EOR is considered a mature and well proven EOR technique onshore in areas with a readily available source. CO_2 EOR has been considered for the mature Danish fields on several occasions, but the availability of CO_2 and the investments needed to adapt existing infrastructure to accommodate CO_2 have in the past made it unattractive to pursue this technology further. From a pure EOR perspective research activities related to CO2 injection are considered outside the scope of DHRTC. Recently, however, global focus on carbon capture utilisation and storage (CCUS) as a means to reduce CO_2 emissions has increased significantly. This shift in focus has lead to a change in the conditions which today could make CO_2 injection options of interest in the Danish North Sea, and research activities related to combining CO2 capture, transportation, storage and enhanced hydrocarbon recovery can be re-introduced to the scope through approval from the DHRTC Steering Committee.

If CO_2 injection and storage is introduced in the scope of DHRTC, one area of investigation could be on the effect of CO_2 injection on chalk. Compared to other injection fluids, CO_2 has a complex phase behaviour once mixing with reservoir fluids. Dissolution of CO_2 in brine forms carbonic acid which may dissolve chalk and affect its mechanical properties. 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.

Hydrocarbon gas injection is more readily available than CO_2, but is often less miscible with oil. 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, enriching the injection fluid via solvents can change miscibility conditions. An ideal solvent should be affordable, environmentally friendly, and safe to use.

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. Alternatively, flue gas obtained by combustion of hydrocarbon gas could be considered. The flue gas contains nitrogen (~80%) and combustion products, mainly CO2 and water, miscibility properties would be expected to be close to clean Nitrogen, but this would need to be confirmed by laboratory studies for each specific flue gas . The energy efficiency of this process could be enhanced by using the combustion process to drive the compression. Another gas-based recovery method that might be applicable is water alternating gas (WAG) and this could be studied as part of an opportunity screening process.

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. Diversion of flow in mature waterfloods can be effective because the microbes deploy in the preferential pathways of the injection water and plug these. After initial deployment of microbes and a nutrient package the methods do not need continuous injection of chemicals. As such the process has been deployed with some success as a late life EOR method in mature water-flooded fields. EOR through biotechnological solutions is not well established 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 of inflow profiles in horizontal wells would also be valuable. Close integration with Theme 3 will be a pre-requisite for success.

Operationalizing EOR offshore

One of the key challenges in operationalizing EOR offshore is the high cost. Therefore research should focus on reducing cost elements with the aim to deliver pilot projects and test cases onshore initially, which will evaluate equipment and designs before expensive and more risky application offshore. Experiments and tests could be done in 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 and the use of environmental sustainable chemicals. 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. Currently many resources in these reservoirs 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, environmentally sustainable 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

Successful operation of the current secondary recovery schemes with water injection and effective implementation of any future tertiary recovery schemes will rely on the ability to control lateral and vertical displacement efficiency. 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 innovative deployment methods to facilitate quicker and more cost efficient response to observations.

The research topic also covers techniques, which permit repair of wells where well integrity has been lost. This will allow extended safe production in wells where remaining reserves cannot economically justify a full-scale work over. Such techniques may for example include designing 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 re-stimulation of already existing well concepts. Included in the topic is also the development of chemical solutions, which leave a smaller environmental footprint than chemicals currently used.

Improved drilling techniques in depleted reservoirs

As producing fields 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.

Well abandonment techniques

It is anticipated that focus and activity in well abandonment and platform decommissioning operations will grow in the years to come; robust well abandonment practices are essential for long-term environmental protection. Research activities could aim to develop cost efficient and permanent methods for well abandonment, improved barrier verification techniques, passive and active surveillance technologies and multidisciplinary, integrated models for risk management. An improved understanding of 'what is good enough' in terms of long-term well integrity and long-term reservoir pressure recharge is required if well abandonments are to be designed and executed cost-effectively. Furthermore, the industry today is increasingly focusing on re-establishment of the cap rock and the use of rig-less methods (frequently utilising alternatives to cement) in order to achieve this objective.

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 a prerequisite for success. An example would be the development of improved understanding and modelling tools for predicting, potentially mitigating or managing 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 mitigation or management. Research projects could focus on the development of corrosion and scale prevention methods leading to improved well operating lifetimes whilst using increasingly environmentally sustainable chemicals. 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 and operation depend on adequate North Sea facilities being available for the next 30 years or more. During this period, new demands and requirements for facility and material design and increasing cost effective production are expected to arise due to the increasing maturity of the producing fields. In addition, 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. As a consequence operating cost will increase significantly with time unless solutions are found which both allow more cost-effective operation of the installations and strengthen human and environmental safety.

Important elements to support long term, safe use of existing facilities is considered to be the enhanced application of advanced data analytics and artificial intelligence. This in particular in relation to production optimisation, predictive and automated maintenance (including integrity management). Effective exploitation of existing data, combined with gathering of new (digital) information is together with the development and application of new algorithms and machine learning techniques considered to hold a significant potential for decreasing the need for human intervention offshore. Other key areas of focus within Topic 4 include chemistry, mechanics, materials, electronics, robotics, sensor systems, planning and construction. With increasing awareness on environmental sustainability by society, stakeholders and DUC, the license to operate the aging facilities also requires focus on solutions, which can effectively reduce the environmental footprint created by the oil and gas production and operation. Research projects under Theme 4 should focus on the following themes:

Corrosion of wells, process systems and pipelines

Understanding the mechanisms involved in corrosion of wells, process systems and pipelines is of crucial importance. This includes the presence of H_2S. 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 researched both from a material and from a chemical environmental point of view. The research could combine experimental laboratory work and numerical thermodynamic and electrochemical modelling. Research in microbial-induced corrosion should focus on understanding the mechanisms and identifying responsible key organisms.

Materials that can withstand hostile corrosive environments 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 microbe-induced corrosion will therefore also form part of Theme 4. Corrosion studies could 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 risk based 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, corrosion and environmentally challenging waste products. Research projects could focus on improving the understanding and develop efficient remedies and lower cost, environmentally sustainable alternatives to scavenger chemicals.

Scale formation and gas-hydrates

Scale formation and deposits create production blockage posing safety hazards and flow assurance challenges, which may limit the economic well life. Research projects should focus on means to manage scale and deposit 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. Furthermore, development of environmentally neutral inhibitors is considered an enabling technology to expand the lifetime of existing facilities.

Handling/cleaning of produced water

There is a need to develop improved oil/water separation techniques to remove trace hydrocarbons from the produced water prior to reinjection or discharge. 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 prior to reinjection or discharge of produced water. There is a potential for developing 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. Other alternative methods capable of fast and accurate screening and measuring of oil in water and any associated impact could also be investigated. 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 to enable down-hole water separation or re-injection of produced water. Overall the aim is to reduce the quantity of chemicals required and minimise their environmental impact.

Risk-based decision making and planning

Research projects could aim at the development of risk-based decision tools for well, 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 and maintenance planning using data analytics and 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 analytical 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. The research may focus on both reduction of the initial investment and reduced maintenance costs and could include research and development of new modularisation and standardisation concepts and approaches. 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, modelling 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 the full range from installation, removal/re-location and finally to re-cycling of the platform that opens the marked for new 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.

Energy Efficiency

Offshore production facilities are designed, maintained and retrofitted/upgraded with energy efficiency in mind and the supply chain continuously develops new approaches to improving energy efficiency and reducing emissions. Research can help accelerate these improvements and remove barriers to application. However, thermodynamic processes have an efficiency characteristic that implies a penalty when operating off-design, the most extreme being flaring during ESD. Off-design operation can have many causes, ranging from maintenance interventions to adjustments in process set-points to accommodate variations in well conditions. Research into improved energy efficiency therefore should aim to address more energy effective equipment and systems, and develop effective means to support the operation of facilities as close to peak efficiency as possible.

Remote control and automation

One means to reduce operating cost and simultaneously increase safety of personnel is to enhance the use of remote (onshore) control. By increasing the functionalities that are controlled from onshore, exposure to risks of offshore operations can be reduced. With the rapid development within advanced data analytics and artificial intelligence it is expected that many new solutions and opportunities will arise. Given the age of the existing DK installations, effective automation and associated reduced offshore manning is no simple task. It is expected that such a shift will happen only through gradual improvements. Research at DHRTC could focus on identifying solutions for specific and well defined challenges, through research using the huge, existing DUC database in combination with the extensive amount of live data streaming available from offshore production and operation.

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 funded by DHRTC. As part of the data sharing, research projects must also, as a general principle 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 Total and DUC partners to utilize the results effectively. Request for exemptions from this can only be granted by the Head of DHRTC. The format and nature of the data storage, documentation and knowledge sharing will be determined by the management of DHRTC.