RCN#331644

National Centre for Sustainable Subsurface Utilization of the Norwegian Continental Shelf

WORK PLAN 2022-2023

NCS2030

Contents

About NCS2030

Vision: Facilitate the creation of an energy-efficient, multi-purpose ”Sustainable Subsurface Value Chain” to reach the Net-Zero-Emissions goals on the Norwegian Continental Shelf (NCS).

Theme 1 – Subsurface energy systems: This Theme focuses on finding sustainable solutions for the Norwegian Continental Shelf (NCS), where the subsurface is utilized not only to produce oil and gas, but to store CO_2 and H_2, and for geothermal energy production. In addition, this theme targets fluid migration, understanding the subsurface behaviour for other applications beyond petroleum, and developing technologies and workflows necessary to move the NCS into a sustainable energy value chain.

Theme 2 – Net-zero emission (NZE) production: On the NCS it is critical that CO_2 emissions are significantly reduced, and hydrocarbons (HC) are energy-efficiently produced at lower water-cut. Many EOR methods are environmentally unfriendly and energy intensive, thus methods that improve reservoir sweep, accelerate oil production and reduce water handling will be developed for achieving NZE. Possibilities of combining Smart Water/Low salinity water, utilization of CO_2 in oil recovery processes and CO_2 tracer technology will be investigated. A particular focus will be to establish a link between new observations at the pore- and core-scale to field-scale displacement mechanisms. Efforts will target implications for co-optimizing CO_2 EOR and CO_2 storage. This fundamental research will lead to improved understanding of the mechanisms involved in better HC recovery with reduced water production. The generated results will supply input data in simulation models for decreasing modelling uncertainty.

Theme 3 – Digitalization: Digitalization and machine learning (ML) are becoming the processes and tools that can lead a transformation into an efficient and sustainable industry. Multi-fidelity (MF) modeling is a rapidly growing area in many science disciplines, but it has not been extensively applied to the subsurface. Since porous-media properties vary with fluid types and scales, and it is unclear how these will influence modelling results, porous-media flow for multi-purpose reservoir usage seems a natural habitat for MF modeling. We expect developments of new theoretical and methodological advancements within MF modeling for applications to reservoir modeling. Development of techniques and workflows that permit predictive and quantitative models with integrated data sources of analogues and large subsurface datasets, assisted with ML and fast forward models, will be a continuous process targeting the sustainable transition.

Theme 4 – Society: After 50 years of successful operations, the NCS is experiencing mixed signals from policy makers and society. The markets are in the short run positive, with a rising oil and gas price at the wake of the pandemic, the war in Ukraine and an investment deficit globally to replace declining supply. In the long-term, climate mitigation actions are likely to reduce demand and the price for oil and gas. This is likely to increase the competition for investments in oil and gas. The project will investigate the role of the business climate for the continued operations on the NCS. The project will lead to tangible results on economic costs and benefits as well as on risk analysis. In turn, these will help policy makers and the industry to balance the challenge of investing in profitable projects, while avoiding stranded assets and contributing to lower Green House Gas (GHG) emissions.

Education and outreach: Education of professionals with new competencies that will drive the transition is an important priority. Further, public perception and research impact is a major goal of the NCS2030 Centre.

Innovation and collaboration: Through the innovation program and an ample network of collaborators both in academic and industry, the centre NCS2030 will enable collaboration between policy makers, field operators, technology providers and academic groups, and will complement established research initiatives to create new solutions through a parallel innovation program.

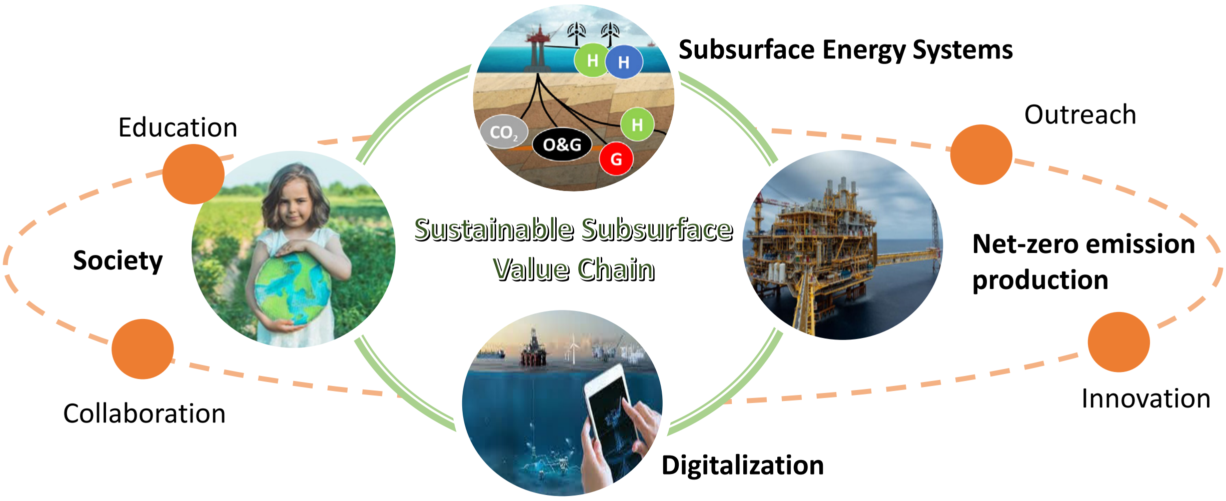


Figure 1. Four research themes of NCS2030 and related activities.

NCS2030 partners

The Centre consists of four main academic and research partners, six industrial user partners and two major technology partners.

In addition, the Centre has collaboration with at least three national and 13 international academic institutions and eight innovation companies. The innovation companies will be part of the innovation program and will ensure high relevance, impact and dissemination. Furthermore, the Research Council of Norway, Petoro and the Norwegian Petroleum Directorate participate as observers.

Academic partners

Industrial user partners

Observers

The primary objective of NCS2030 is to fill knowledge gaps and provide solutions for maximizing value creation of subsurface resources to reach the net-zero emissions goals on the NCS. The research themes (Figure 1) represent the basis for research to solve the industry challenges in the NCS. These challenges include:

- 50% emissions cut by 2030 and net-zero by 2050 (stop global warming; CO2 taxation; Taxonomy)
- Exploration and production life-time and license regulations
- Large scale storage of CO2 and CO2-EOR
- Reduction of water production and energy consumption
- Development of renewable and sustainable energy sources: H2 (blue, green), geothermal, offshore wind; and extend life and value of existing infrastructure
- Energy security (energy mix) for accelerating the transition towards a sustainable society

The ambitious goals will be reached by following seven secondary objectives (table 1) that focus on future sustainable subsurface utilization, which positions NCS2030 to meet the scientific, technological and societal needs.

	Secondary objectives	Research domains / WPs	Main deliverables / Key performance indicator
SO1	Build integrated near field subsurface holistic models for increasing reserve base and evaluating the potential of geological CO2 and H2 storage, and renewable energy production	Subsurface energy systems: WPs 1-2-5	Surface hub models, workflows, and methodologies; geological scenarios to reduce uncertainty
SO2	Develop new IOR solutions for improved and accelerated HC production at low environmental footprint to help reach 50% emission reduction by 2030	NZE production, Society: WPs 3-4-5-6	Proposed new solutions with large increased reserve and reduced emissions by 50%.
SO3	Develop data-driven and machine learning approaches to integrate subsurface characterization, uncertainty quantification and management workflows for better decisions	Digitalization: WPs 1-2-3-4-5	New digitalization workflows with improved functionalities and computational efficiencies.
SO4	Recommend field cases on the NCS with high potential for NZE production based on renewable energy and the Sustainable Subsurface Value Chain	Subsurface energy systems: WPs 1-3-5-6	At least 5 potential cases in collaboration with Centre's industry partners.
SO5	Strengthen the business climate, create awareness and establish acceptance of NCS2030 activities and NCS exploitation	Society: WPs 1-2-3-4-5-6	White papers to policy makers, society, stake holders. News articles in national media.
SO6	Establish an innovation platform as catalyst for new technology development in collaboration with industrial players on the NCS.	Innovation, collaboration: WP7	10-15 innovation projects for new technology development and field implementation.
SO7	Attract and train the next generation of scientists and skilled professionals for the energy transition, together with user partners and disseminate results of high quality and impact	Education, Outreach, All WPs	21 PhDs/Postdocs, 40 master theses, workshops, conferences, > 150+ peer-reviewed publications

Table 1. NCS2030 secondary objectives

The management structure of the centre (figure 2) facilitates the industry's active involvement and is fundamental for the Centre's success.

The Centre Management (CM) is responsible for the daily research activities and coordination across WPs. The General Assembly consists of representatives from all research and industry partners (majority) and elects the Board which consists of all industrial and research partners. The Norwegian Research Council (RCN), the Norwegian Petroleum Directorate (NPD) and Petoro have observer status. The Board provides overall directions and goals, and monitors operations according to the Consortium Agreement. For effective collaboration and dissemination, the Technical Committee (TC) consists of representatives from the industrial partners to follow research activities and give technical input to ensure its relevance. The WP leaders are responsible for scientific research and deliverables. Researchers, students and user partners work closely through frequent meetings and seminars. Task Forces (TF) are established on an as-needed basis and consist of technical experts and users from industry and researchers across WPs to build the research portfolio for the TC. TF will collaborate with the Innovation Program to create new spin-off projects. Further, the Scientific Advisory Committee (SAC) consists of international experts to provide advice and ensure scientific quality at the international level. The Board, TC, TF and SAC work closely with CM according to the centre's governance.

The research activities of NCS2030 are organized into eight work packages (WP): six WPs in research, one WP in education and outreach and one WP in management (see pages 11-43).

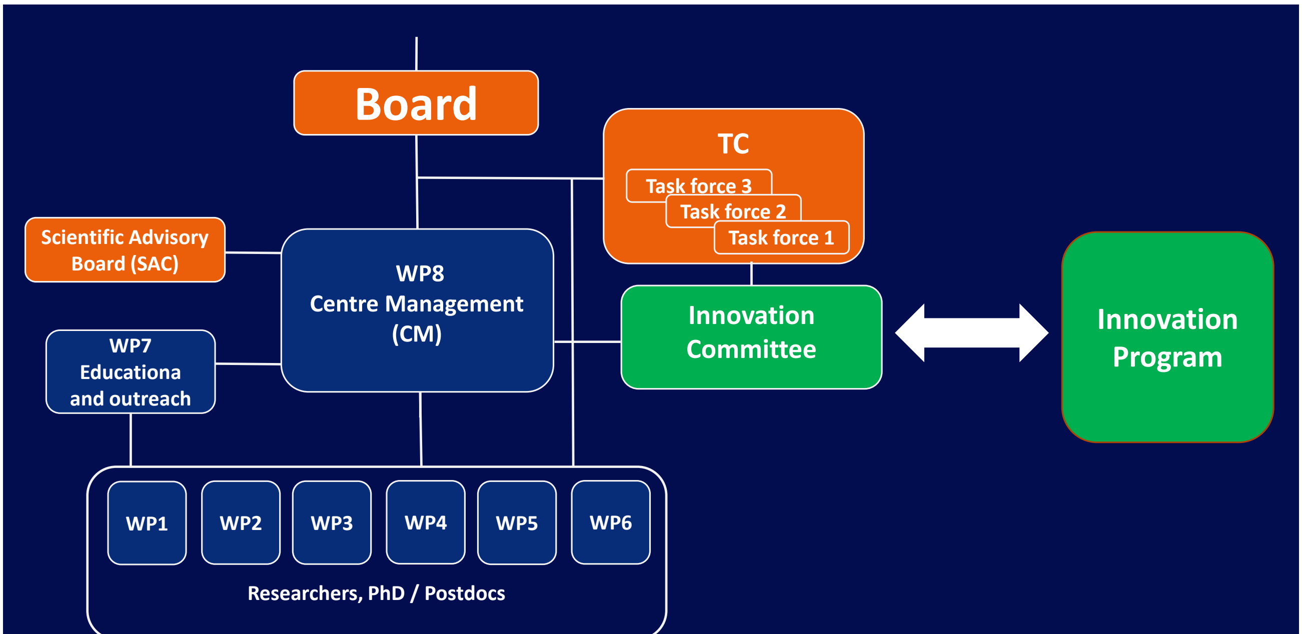


Figure 2. NCS2030 structure

Centre management – WP8

The Centre Management (CM) is responsible for the daily research activities and will coordinate across work packages in regard to education, industry contacts, innovation and outreach (see Figure 2). All research partners are represented in the management team.

- The Centre's director, Professor Alejandro Escalona at the Department of Energy Resources (UiS) has more than 25 years of both industry and academic experience. Prof. Escalona also act as Education and outreach Director.
- The Assistant Centre Director is Ying Guo, PhD, Special Advisor and Senior Business Developer at NORCE. She has over 30 years' experience within both research, and the oil industry. Dr. Ying Guo also act as the Industry Contacts Director.
- Christian Dye, Cand. Scient. is Research Director for Environmental Technology at IFE and is appointed as Innovation Director.
- Dr. Zachary Paul Alcorn is a researcher at UiB at the Department of Physics with long experience in EOR projects and is appointed as a Research Director.
- Dr. Siv Marie Åsen at UiS is appointed as project coordinator and Kjersti Riiber at UiS as communications advisor.

Alejandro Escalona
Centre director
University of Stavanger

Ying Guo
Assistant director
NORCE

Christian Dye
IFE

Zachary Alcorn
University of Bergen

Siv Marie Åsen
Project coordinator
University of Stavanger

Kjersti Riiber
Communications advisor
University of Stavanger

Board

Camilla Vavik Pedersen
Chair of the Board
Equinor Energy ASA

INDUSTRIAL USER PARTNERS:
Thierry Lauprete (to Sept. 2022)/
Samuel L. Kvernes (from Sept. 2022) (Aker BP ASA)
Kent Høgseth (DNO Norge AS)
Robert Berendsen (Landmark Graphics AS)
Tormod Slettemeas (Schlumberger Information Solutions AS)
Johanna N. Ravnås (Wintershall Dea Norge)
Audun Fykse (Vår Energi ASA)

RESEARCH PARTNERS:
Øystein Lund Bø (UiS)
Erlend Vefring (NORCE)
Martin Foss (IFE)
Arne Graue (UiB)

Scientific Advisory Committee

Chair: Erik Saenger (Bochum University, DE)
Lesley James (Memorial University of Newfoundland, CA)
Marcio Carvalho (PUC-Rio, BR)
Lorena Moscardelli (University of Texas at Austin, US)

Technical Committee

Chair: Mohsen Rafiee (Wintershall Dea Norge)
Robert Berendsen (Landmark Graphics AS)
Pierre Le Guern (Schlumberger Information Solutions)
Tao Yang (Equinor Energy ASA)
Egil Boye Petersen (Aker BP ASA)
Paul Spencer (Vår Energi ASA)
Odd Kjørholt (DNO Norge AS)
Thomas Lerdahl (OKEA ASA)

Innovation Committee

Rune Dahl Fitjar (UiS)
John Zuta (NORCE)
Christian Dye (IFE)
Geir Ersland/Arne Graue (UiB)
Robert Berendsen (Landmark Graphics AS)
Michael Nickel (Schlumberger)
Tao Yang (Equinor Energy ASA)
Egil Boye Petersen (Aker BP ASA)
Paul Spencer (Vår Energi ASA)
Kent Høgseth (DNO Norge AS)
Johanna N. Ravnås (Wintershall Dea Norge)
Thomas Lerdahl (OKEA ASA)

Task Forces were organized to maximize dialogue between research and industry partners, and drive integration between work packages.

In the task forces, fine tuning the projects, collaboration arenas and study areas were discussed. The initial task forces, shown in Figure 6, were defined based on the centre themes, and served as the arena to build the first project portfolios.

As the Centre matures, we expect that research collaboration will expand to other national centres and networks such as Digiwells, other Petrocentres, GGER, the new hydrogen centres, etc. This can be via direct project collaboration between researchers, or networking in conferences such as the Norway Energy Conference. In addition, the national and international collaborators will be included in the relevant projects.

The Centre will hire 8 Phds and 1 Postdoc within the related research themes in the first two years as highlighted in the relevant projects. Part of their training will be spent at our international partner locations and UiS will provide support via the research strategy program for guiding them in their career path. They will also participate in the activities at the Petroleum School of Norway (NFiP) hosted at UiB, interact with academic and industrial partners in meetings and research visits, and present their research at the annual Energy Norway Conference and centre workshops. UiS, as the main host, offers bachelor, master and PhD study programs in all relevant areas such as subsurface, energy, risk, decision analysis, economy, etc., where the centre's results will be part of the research-based education. As for today, relevant bachelor and master projects are being offer to the students which will contribute to the centre results.

Furthermore, the Department of Energy Resources is working towards increasing subsurface competence for the transition with several awarded projects that are associated to NCS2030. In this regard, two recently awarded projects will contribute to improved education and relevance to industry and technology transfer within Europe. The SUBSET project, aims to define future subsurface education needs in collaboration with the energy industry and was granted by the Norwegian Directorate for Higher Education and Skills (DIKU) with the support of 5 companies. The TWINN2SET is a consortium between Institute of geoenergy (FORTH/IG) in Greece, IFPN in France and (Department of Energy Resources (IER) at UiS granted by the EU. It aims to integrate and transfer the knowledge from Geological Storage of CO2 and H2 for Sustainable Energy Transition practices. In addition, other Phds and Postdocs at UiS and UiB will work associated to the centre in relevant projects (Figure 7).

The Centre will also deliver publications, the Energy Norway Conference (first one delivered in April 2022), and set the stage for effective administration and management during these two initial years.

Work Package 1

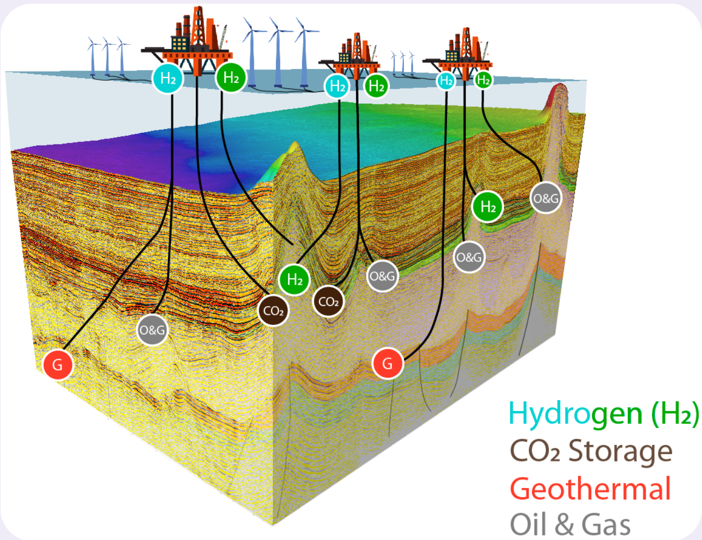
Near field resource evaluation

The growth in energy demand, combined with climate change, requires the use of new integrated strategies and multi-disciplinary methods for the long-term sustainable exploration and exploitation of subsurface energy resources and storage capacity to reach the NZE goals by 2050 (SO1, SO4, SO7). Specific targets of WP1 are:

- Produce an integrated holistic geological model and workflows for a selection of nearby existing infrastructure (hubs; ca 50km radius) to provide energy and storage opportunities.
- Unlock yet-to-find reserves in mature, near-field areas and provide new energy opportunities to extend the life of existing infrastructure.
- Map fluid migration pathways and model basin-scale fluid dynamics to identify locations of best reservoir facies, reduce failure in exploration drilling, and to reduce environmental impact caused by leakage from storage sites

Six projects have been defined:

1. WP1.1 Quantitative cross-disciplinary resource evaluation
2. WP1.2 Salt characterization and modelling for the future energy mix (PhD)
3. WP1.3 Basin-scale fluid connectivity
4. WP1.4 Next Generation of Petroleum/ CO_2-Brine Petroleum/CO_2-Brine System Models
5. WP1.5 Develop new workflows in the salt province of the Norwegian North Sea for evaluating the potential for CO_2/H_2 storage and geothermal energy
6. WP1.6 Near Field resource evaluation using solutions from the DELFI's Petrotechnical Suite



Lead: Stéphane Polteau (IFE)

WP1.1 Quantitative cross-disciplinary resource evaluation

Project Manager: Tuhin Bhakta (NORCE)
Key Personnel: I. Sandø, K. S. Eikrem, X. Luo (NORCE)
Budget: 2.0 MNOK

The project will support the mapping and updating the reservoir potential and integrity of storage in near field areas for hydrocarbons, CO2, H2 and waste waters. We will produce workflows for the quantitative use of geo-and reservoir characterization methods and resource evaluation including quantitative uncertainty estimation. The strategy is to integrate the quantitative geophysical techniques and rank the geological scenarios using all relevant background data and co-operation across other projects in WP1, WP2 and WP5.

OBJECTIVE

- Contribute to integrated near field subsurface holistic models for increasing reserve base and evaluating the potential of geological CO2 and H2 storage and renewable energy production.
- Quantitative geophysical data driven understanding of key risk factors.
- Ensemble based geological scenario analyses to reduce uncertainty

KNOWLEDGE GAPS

Mature fields have a wealth of relevant background data (well logs, 3D, 4D, RFT, cores, pressure data, production data, petrophysical data, geo-and reservoir models). Optimal extraction of useful information from these big data sets to support the project's objective is a large challenge that will require substantial cross-disciplinary efforts.

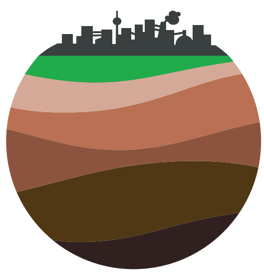
There is a need to close this gap by implementation of workflows using advances within novel methods in quantitative uncertainty evaluation and ML.

PLANS 2022-2023

- Quantitative geophysical analyses with estimation of petrophysical and uncertainties, sensitivity analyses, forward geophysical modelling and extraction of features from the geophysical data.
- Establish framework for geological scenario analyses integrating ML for screening and performance improvement.

EXPECTED OUTCOME 2023

- Establish and perform initial studies related to one or two case studies from NCS.
- Testing methodologies for quantitative evaluation of reservoirs and storage sites.



WP1.2
Salt characterization and modelling for the future energy mix

Project Manager: Dora Marín (UiS)
Key Personnel: N. Cardozo (UiS); M. Wangen (IFE); G. Caumon (U. Lorraine); H. Koyi (U. Uppsala)
Budget: 1.9 MNOK

Evaporitic sequences play an important role in the future energy mix. Their impermeable properties make them excellent locations for underground storage caverns, and their high thermal conductivity and associated thermal gradients are ideal for geothermal energy. Salt deformation can contribute to form traps in the pre- and post-salt sequences (for CO_2 or hydrogen storage and hydrocarbons); in either hydrocarbon reservoirs or aquifers. However, evaporites are not just salt (halite), but they are layered evaporitic sequences (LES) consisting of sedimentary rocks such as claystones, sandstones, carbonates. The proportion of these varied components determine the sealing and thermal properties of the LES.

OBJECTIVE
The main objective of this project is to determine the composition, sealing and thermal properties of the upper Paleozoic evaporites of the Zechstein Group in the Norwegian North Sea, via subsurface interpretation, data science (machine learning), and geomechanical modelling. This will allow us to estimate the potential of these sediments for geological storage and its role in geothermal energy. Optimal CO2 storage locations in salt-related minibasins will be evaluated.

KNOWLEDGE GAPS
A net zero emission goal for 2050 demands diversification in the use of cleaner energy sources such as hydrogen or geothermal energy. Salt caverns constitute one of the most promising geological storage sites (e.g. hydrogen storage), due to their low permeability, high solubility and low contamination by bacteria action. However, salt heterogeneities can cause deformation in salt caverns and affect seal quality.

Moreover, salt diapirs have poor seismic image and lithological heterogeneities are below seismic resolution.

PLANS 2022-2023
The plan for the first year is to have a PhD student working on the characterization of the evaporites of the Zechstein Group for geological storage. Additionally, master students and other researchers will start working in topics such as: 1) geothermal energy exploration potential; 2) reservoir, seal and trap definition for CO2 storage; and 3) near-field exploration.

EXPECTED OUTCOME 2023
- Mapping the lithological variations in the Zechstein Group using well and seismic data.
- An initial database of potential geothermal reservoirs for the southern part of the Norwegian North Sea and a preliminary energy output model for a selected field.
- Mapping optimal CO2 storage sites and underexplored reservoirs in salt-related minibasins.

WP1.3
Basin-Scale Fluid Connectivity

Project Manager: Stéphane Polteau (IFE)
Key Personnel: V. Yarushina, M. Wangen (IFE); T. Bhakta (NORCE); D. Marín (UiS)
Budget: 1.3 MNOK

The characterization of the fluid connectivity from reservoir levels to the surface can be used to evaluate the ability of the overburden to keep fluids (hydrocarbons or injected CO_2/H_2) trapped in reservoirs or identify leakage pathways through the overburden. In this project, we will use the strontium isotope system 87Sr/86Sr as a natural tracer to identify connected bodies of formation waters and help pinpoint important flow barriers in reservoirs and overburden. The strontium patterns will be integrated with other types of dynamic data (production, pressure, density …) that equilibrate at different time scales with the seismic data to identify and characterize low permeability barriers to fluid flow away from the well path.

OBJECTIVE

The aim of this project is to map the basin-scale fluid connectivity from below reservoir levels to surface in a HC-brine system using static and dynamic fluid data and seismic interpretation.

KNOWLEDGE GAPS

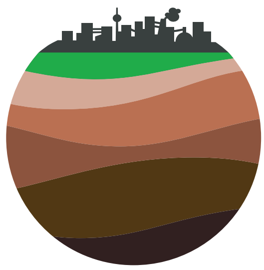
In theory, the connectivity of formation water in sedimentary basins reflects the distribution of heterogeneities that can either segregate fluids into a series of isolated compartments or form migration pathways from a reservoir to the surface. However, the basin scale fluid connectivity is limited because most of our knowledge of the subsurface is based on geophysical and geological data, while fluids geochemistry mostly focussed on hydrocarbons and not formation waters. In this context, this project is directly relevant to the characterization of the overburden when evaluating the suitability of reservoirs for storing CO_2 or H_2.

PLANS 2022-2023

- Develop the strontium residual salts method on core chips to characterize the fluid connectivity in the overburden.
- Build a database with dynamic (pressure, fluid density, production data, ...) and static data available over a selected site.
- Map the distribution in the overburden of carrier beds, faults, gas clouds, chimney structures, reservoirs and traps using 2D, 3D and 4D seismic.

EXPECTED OUTCOME 2023

- Strontium method applicable on core chips.
- Database of available fluid data.
- Seismic interpretation with geological bodies.



WP1.4
Next Generation of Petroleum/CO_2-Brine System Models

Project Manager: Stéphane Polteau (IFE)
Key Personnel: M. Wangen (IFE); T. Bhakta (NORCE); D. Marín (UiS)
Budget: 0.5 MNOK

The transition from petroleum-dominated to a low-emission energy mix requires a new petroleum system type of model that will be as applicable to nearfield hydrocarbon exploration as to the storage of CO_2. In this context, we will develop a holistic and process-oriented model that will focus on the interaction between petroleum-brine from source, reservoir to overburden, and brine-CO_2 from reservoir to overburden levels. The model will be constrained by multidisciplinary data, including analogue modelling, borehole, static and dynamic fluid data, and seismic data.

OBJECTIVE

The aim is to develop a holistic petroleum/CO_2-brine system model that will be relevant to both exploration and storage activities on the NCS. For hydrocarbon exploration, the new model will consider source, reservoir and overburden levels, while only reservoir and overburden for CO_2 storage.

KNOWLEDGE GAPS

Understanding fluid migration from source to surface is crucial for exploration as it makes the difference between a discovery or dry well. Therefore, fluid migration is very relevant since the main causes of failure in exploration are charge and phase. Fluid migration is also important for CO_2 storage to reduce risk of leakage and lower the cost of operations. However, little is known on the process of hydrocarbon generations and primary migration, as well as the effect of brine on hydrocarbon or CO_2 migration. We assume that fluid expulsion from shales is related to overpressure buildup, but the pressure transfer and fluid exchange between tight rocks like shales and permeable rocks like sandstones are still poorly understood.

PLANS 2022-2023

Microscale flow in shales will be determined by compiling the results of source rock maturation experiments that were conducted at IFE using autoclaves. Fluids were extracted and analyzed during the experiments, while petrographic observations were made on the rock before and after the experiments. This unique dataset will further be used to constrain a microscale fluid migration numerical model in shale, which will be relevant to primary migration and evaluating the mechanisms of fluid migration in shale-dominated overburden sequences. The experiments will also allow us to evaluate volumes of expulsed hydrocarbons from source rocks. Follow up projects will expand to the scale of a basin by using geophysical, well and fluid data from a selected field to constrain the numerical model that will predict the effect of brine on petroleum and CO_2 migration from reservoir to the surface.

EXPECTED OUTCOME 2023

- Initial numerical model.
- Draft publication on the source rock maturation experiments.

WP1.5
Develop new workflows in the salt province of the Norwegian North Sea for evaluating the potential for CO_2/H_2 storage and geothermal energy

Project Manager: Rob Berendsen (Landmark)
Key Personnel: P. Sabharwal, G. Christopher, C. Badis (Landmark); D. Marín (UiS); S. Polteau, H. Wang (IFE), T. Bhakta (NORCE)
Budget: 1.0 MNOK

Landmark Graphics provide software and solutions to build new subsurface workflows to ensure geological plausibility in all steps when creating complex geological models. The use of these tools is particularly important in mature areas where the vast amount of 4D data can hinder the efficiency of geoscientists due to issues in identifying and accessing the right dataset. In this context, DecisionSpace Geoscience and Permedia software can be utilized to accelerate the development of near field holistic models for evaluating the potential of geothermal energy and CO_2 and H_2 storage.

OBJECTIVE

The aim of this project is to apply and tune the Landmark Graphics tools to develop new workflows and geological models for evaluating the potential of geothermal energy and CO_2 and H_2 storage in the salt province in the Norwegian North Sea.

KNOWLEDGE GAPS

Landmark Graphics Suite supports decision making about finding, drilling, and producing oil and gas. In the energy transition, several optional toolkits have been developed, such as Permedia CO_2. The latter has been validated in most of the well-known storage sites, but Permedia CO_2 have yet to be tested in salt provinces.

This project will further look into integrating Permedia CO_2 capabilities with the Salt body mapping utilizing cloud-based ML tool. We plan to also understand better how CO_2 migrates through the subsurface by utilizing the Sleipner 4D data that shows the evolution of CO_2 clouds escaping the storage site. The overall dataset will be used for ranking CO_2 and H_2 storage sites, but also evaluate the potential for geothermal energy.

PLANS 2022-2023

- Provide DecisionSpace Geoscience suite and Permedia software for rapid access and use to different data types and sources
- Comprehensive Salt body mapping utilizing cloud-based ML tools.
- Provide training in Halliburton Landmark Graphics tools through different workshops
- Provide a public Sleipner 4D data set
- Incorporate other non-public data
- Explore possibilities of building new workflows

EXPECTED OUTCOME 2023

- Established new workflows with field data demo
- Workshops for Halliburton software training and information exchange

WP1.6
Near Field resource evaluation using solutions from the DELFI's Petrotechnical Suite

Project Manager: Pierre Le Guern (Schlumberger)
Key Personnel: P. Salomonsen, A. Sharma, L. Schulte (Schlumberger); T. Bahkta, I. Sandø (NORCE)
Budget: 1.0 MNOK

Schlumberger's Petrotechnical Suite hosted in DELFI offers many solutions for subsurface mapping, interpretation, characterisation and forward modelling. These solutions have a long history track of efficiency in the context of traditional O&G projects. The geological, petrophysical and geophysical insights gained through the usage of these solutions are essential for safe and successful reservoir and seal integrity assessments for net-zero energy production and storage. The solutions are deterministic, Machine Learning driven or a combination of both. They address the structure of the subsurface as well as properties, integrating a variety of available data (seismic, well logs, geological processes, interpreters' knowledge, etc.).

OBJECTIVE
The objective is to build accurate geological and geophysical inputs to perform scenario analysis. This has to be leveraged by automation and Machine Learning solutions in order to drastically cut the turn-around-time inherent to interpretation and characterisation tasks, hence reducing costs. The solutions address tectonic and stratigraphic interpretation, depositional processes forward modelling, property prediction, geological interpretation, etc.

KNOWLEDGE GAPS
The Schlumberger's Petrotechnical Suite regroup several state-of-the art technologies for subsurface modelling. These solutions have been developed and orchestrated into workflows aiming at answering traditional O&G challenges.

Schlumberger is willing to fast track the development of new technologies supporting the new energy transition. Our strategy is to re-purpose existing successful solutions, by understanding potential gaps and creating new functionalities and workflows in a short turn-around time. Data flow and integration is a key element.

PLANS 2022-2023
- Provide access to Machine Learning solutions within the DELFI environment (Fault ML, ML Tracker), to solutions for Geological Mapping (eXchroma SG), geological forward modelling (GPM) and property prediction (EMBER) experts and perform subsurface interpretation, mapping and property characterisation;
- Provide training for students;
- Identify potential gaps and/or limitations for accurate utilization in CO_2 projects.

EXPECTED OUTCOME 2023
- Subsurface static model(s) with properties;
- Onboarding of Master and PhD students;
- Training sessions and review of results.

Work Package 2

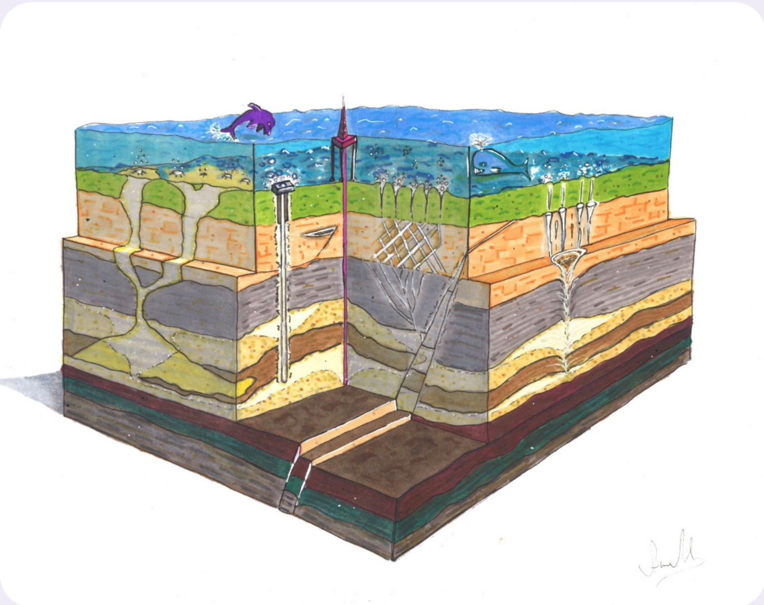
Reservoir Utilization for Energy Transition

Achieving the NZE target by 2050 requires further development of CO2 sequestration sites and exploration of alternative energy, such as H2 and heat. Therefore, developing methods and tools that can enhance the capacity of geological sites for storage (CO2 and H2), and production of geothermal energy on the NCS is of importance (SO1, SO4, SO7). Specific targets of WP2 are:

- Improve the reservoir energy production strategy with carbon capture and storage.
- Describe and understand H2 storage and retrieval mechanisms in different geological formations.
- Provide tracer monitoring, leakage remediation and mitigation strategies for waste and energy storage.
- Model reactive flow transport in deformable porous rocks for reliable assessment of storage sites.
- Investigate if HPHT reservoirs can be utilized as geothermal heat mining sites.

Four projects have been defined:

1. WP2.1 Physics of focused fluid flow in sedimentary basins
2. WP2.2 Recommended practice for numerical modeling of geomechanical behavior of various fields on the NCS
3. WP2.3 Tracers and tracing methods for utilization of the NCS in the energy transition
4. WP2.4 Hydrogen storage and back-production in porous media



Lead: Viktoriya Yarushina (IFE)

WP2.1
Physics of focused fluid flow in sedimentary basins

Project Manager: Viktoriya Yarushina (IFE)
Key Personnel: H. Wang, R. van Noort, S. Polteau (IFE)
Budget: 1.6 MNOK

The North Sea is considered to be the most important region for CO2 Storage in NW-Europe. Chimney structures and pockmarks are widespread in this area. They have been reported from existing and proposed storage sites. Speed-up of CCS in Europe requires identification and characterization of more available storage space. Very little is known about the leakage potential of chimneys and about the factors triggering their formation. Understanding these processes is crucial for assessing the geotechnical significance of such features and for the development of a CCS infrastructure in the North Sea.

OBJECTIVE

The overall project objective is to obtain a scientific understanding of the impact of existing chimney structures on caprock integrity and the possibility of triggering the formation of new chimneys during CO2 injection.

KNOWLEDGE GAPS

Deformation structures and shallow gas accumulations, such as sand injections, seismic pipes, and chimneys, associated with pockmarks, are widespread in unconsolidated sediments underneath the North Sea and have been reported from existing and proposed storage sites, or in their close vicinity (Sleipner, Snøhvit, GoldenEye, P-18). Despite the well known, widespread occurrence of such deformation structures in the overburden of storage formations underneath the North Sea, little is known about the internal structure and hydraulic properties of seismic chimneys and pipes, critical conditions in unconsolidated sediments, the factors triggering and controlling their generation, and the dynamics of the processes leading to the mobilization of sediments and fluids resulting in deformed sediments.

PLANS 2022-2023

- We will develop models for chimney formation and for fluid flow through both forming and pre-existing chimneys
- Physical laboratory experiments will provide knowledge on critical geomechanical and flow parameters and enable high-resolution insights into processes of chimney formation and evolution
- Geochemical characterization study of a long-term record of fluid migration from fields with available core samples

EXPECTED OUTCOME 2023

- Geochemical data on historical fluid migration in relevant reservoir/seal pairs.
- Coupled geomechanical/reservoir model of identified seismic chimneys and their leakage rates, risk assessment of generation of new chimneys as a result of the injection.
- Laboratory measurements on critical geomechanical and flow parameters.

WP2.2
Recommended Practice for Numerical Modeling of Geomechanical behavior of Various Types of Fields on the NCS

Project Manager: Viktoriya Yarushina (IFE)
Key Personnel: M. Wangen, H. Wang (IFE)
Budget: 0.3 MNOK

The NCS has a wide variety of fields modelled with finite element technology to estimate deformation and stress change in the subsurface resulting from the exploitation of oil and gas. Typical reservoir types modeled with finite element technology are cases that will induce large scale (meters) of seafloor subsidence or significant subsurface deformations that can impact the well structures themselves and their integrity. These are fields like Troll, Ekofisk area, and Valhall area. The development of HPHT fields on the NCS has also increased the use of these models. Thus, there is a need for cooperation between industry and academia to address geomechanical problems.

OBJECTIVE
This project aims to maintain close collaboration between geomechanical specialists from the industry and NCS2030 in the existing geomechanical industrial network framework to address geomechanical problems in challenging fields.

KNOWLEDGE GAPS
Although coupled reservoir-geomechanical models are used in industry, they cannot always reproduce observed geomechanical behavior. Many challenges related to modeling of inelastic behavior, stress path, well integrity, faults, and induced seismicity remain. It is unclear what needs to be considered during the derivation of rock mechanical properties of different reservoirs, overburden, and underburden.

PLANS 2022-2023
- Contribution to the existing industrial geomechanical network with lectures and discussions
- Further development of self-consistent models for coupled deformation, reaction, and fluid flow and their numerical implementation for different types of reservoir rocks that account for elasticity, viscosity, and plasticity
- Coupled seismo-hydromechanical modeling of failure processes and induced seismicity

EXPECTED OUTCOME 2023
- Publication on developed models of coupled reaction, deformation, and fluid flow;
- Publication on modeling of failure processes

WP2.3
Tracers and tracing methods for utilisation of the NCS in the energy transition

Project Manager: Mário Silva (IFE)
Key Personnel: S. O. Viig, Ø. Brandvoll, A. Krivokapic, L.F. Climent (IFE); I. Fjelde (NORCE); R. Gholami (UiS)
Budget: 2.3 MNOK

This project intends to develop tracing methods and tracers to produce data that will increase the understanding of the subsurface on the NCS aiming for its use for CCS and H_2 storage. CO_2-EOR will also be considered. Tracers remain as the only dynamic tool available for description of fluid saturation and distribution in the reservoir and thus can significantly contribute for value creation within the energy transition framework. We will aim for the development of new CO_2 tracers, and a tracing methodology to monitor the development of salt caverns for H_2 storage.

OBJECTIVE

Develop new tracers that accurately describe the flow and distribution of CO_2 plumes inside porous media and tracing methods that can be used for monitoring of the development of salt caverns for H_2 storage. Emphasis will be placed on online/on-site tracer detection to ensure feasibility of the method.

KNOWLEDGE GAPS

Tracers can be used for on-site monitoring of the development of salt caverns. This requires the development of i) onsite or online tracer detection and quantification methods; ii) tracer curve interpretation models; and eventually iii) new tracers developed for this purpose. Existing gas tracers do not accurately trace CO2 flow in porous media. The presence of hydrocarbons introduces additional challenges. As the use of CO2 increases on the NCS, more accurate CO2 tracers are necessary to optimise methods and projects. There is also insufficient understanding about the consequences of fluid-rock interactions alterations in CO2-rich porous media.

PLANS 2022-2023

Tracing the development of salt caverns: planned activities include the development of online/onsite tracer identification and quantification methods, building a transparent 2D salt cavern analogue experimental setup on the lab scale for dynamic experiments, and interpretation of the tracer production curves for different types of tracer injections. CO2 tracers: evaluation of relevant physico-chemical and thermodynamic properties for a systematic identification of new tracer candidates. Identification of priority candidates and evaluation of long-term stability, rock-interactions, and oil solubility.

EXPECTED OUTCOME 2023

- Tracing the development of salt caverns: identification of the most suitable detection principle for online/on-site tracer analysis, functional experimental setup, tracer production and interpretation data to develop a field model.
- CO2 tracers: shortlist of new tracer candidates for lab-scale dynamic flooding experiments with 14CO2 as reference.

WP2.4
Hydrogen storage and back-production in porous media

Project Manager: Ingebret Fjelde (NORCE)
Key Personnel: M. Silva (IFE); R. Gholami, P. Andersen (UiS)
Budget: 0.9 MNOK

Injection of H_2 for storage and back production in reservoirs will give variation of conditions (temperature and pressure). The potential for modification of porous media properties during H_2-storage should be determined. Proposed project is based on experience with periodic CO_2 injection, improvement of volumetric sweep in EOR processes, injectivity challenges, flow assurance and chemical analysis. The project will establish method for efficient and safe injection, storage and back production of H_2 in porous reservoirs of different types.

OBJECTIVE

Establish method for efficient and safe injection, storage and back production of H_2 in porous reservoirs of different types.

Secondary objectives:

- Optimize injectivity with variation in temperature and pressure.
- Optimize storage capacity and secure efficient back-production by maximizing volumetric sweep and secure flow assurance.
- Secure rock integrity for relevant reservoir rock and cap rock compositions.

KNOWLEDGE GAPS

Important to obtain high injectivity, high volumetric sweep, efficient back-production and maintain rock integrity in reservoirs selected for H_2-storage.
Interactions/reactions of H_2 with fluid-phases and rock can change the properties of fluids and porous media.
Safety experts invited to secure experiments are carried out in a safe manner.

PLANS 2022-2023

- Establish flooding-rig based on recommendation from safety experts.
- Interactions of H2-phase with rock/minerals and fluid phases with focus on low temperature and pressure, related to injectivity and rock integrity.
- Initiate simulation/modelling of experiments
- Establish procedures to optimize storage capacity and back production.

EXPECTED OUTCOME 2023

- Flooding-rig based on recommendation from safety experts is established.
- Interactions of H_2-phase with rock/minerals and fluid phases with focus on low temperature and pressure, related to injectivity and rock integrity.
- Initiate simulation/modelling of experiments
- Establish procedures to optimize storage capacity and back production.

Work Package 3

Net Zero Emission production

HC production is energy intensive and emits large amounts of CO_2. There is an urgent need to develop concepts and implement new energy-efficient solutions to produce hydrocarbons (HC) resources at the lowest possible emissions (SO2, SO4, SO6, SO7). Specific aims of WP3 are:

- Develop IOR concepts for improved, accelerated, profitable and sustainable HC production at low environmental footprint, to reach 50% emission reduction by 2030 and NZE by 2050.
- Propose new sustainable field development strategies integrated with renewable energy sources offered by the upcoming green offshore industries.

Three projects have been defined:

1. WP3.1 Tight reservoir solutions (PhD)
2. WP3.2 CO_2 utilization (PhD)
3. WP3.3 Improved tracing

Lead: Tina Puntervold (UiS)

WP3.1
Tight reservoir solutions

Project Manager: Aruoture Omekeh (NORCE)/ Tina Puntervold (UiS)
Key Personnel: R. Askarinezhad, A. Lohne (NORCE), A. Mamonov, S. Strand, A. Hiorth, P. Andersen, R. Korsnes (UiS), M. Wangen (IFE), Z. Alcorn (UiB)
Budget: 3.1 MNOK

Substantial hydrocarbon reserves are located in tight reservoirs on the Norwegian Continental Shelf (NCS). These reservoirs are challenging to produce primarily due to pore heterogeneity, low permeability, and deep locations. Stimulation of the near well region can increase the productivity in such reservoirs. Several stimulation methods can be employed but their suitability to NCS need to be evaluated. Tight reservoirs require an optimal drainage strategy. Gas/Waterflooding can be used for pressure maintenance, and spontaneous imbibition of water into the oil-containing matrix can be important for successful oil mobilization and recovery optimization. Can optimized injection water also be used for improved stimulation?

OBJECTIVE
Evaluation of well stimulation methods for tight oil and gas reservoirs to produce hydrocarbons, and addressing the methodology of monitoring the stimulated reservoir volume. Identify environmentally friendly IOR solutions and drainage strategy for tight reservoirs, with initial focus on Smart Water and potential for wettability alteration and spontaneous imbibition, and as a stimulation fluid. Contribute to better modelling of reduced permeability reservoir systems.

KNOWLEDGE GAPS
Tight reservoirs include naturally fractured reservoirs with low matrix permeability, reservoirs with zones of low permeability in otherwise good reservoirs and low permeability reservoirs. Well stimulation has the potential to make the exploitation of tight reservoirs commercially viable. Different methods will be evaluated for their suitability for NCS tight reservoirs. Improved fundamental understanding of tight reservoir properties, phases and their interactions will aid in selecting the optimum drainage strategy.

PLANS 2022-2023
- Evaluate well stimulation methods based on the state-of-the-art technologies and application for the NCS, and monitoring of stimulated reservoir volume.
- Establish modelling strategy and demonstrate its capabilities on the proposed methods. Apply modelling tool for well productivity estimates for real reservoir.
- Identify rock materials as analogue for tight reservoirs. Evaluate porosity and permeability effects on spontaneous imbibition and waterflooding tests.
- Identify specific effects of wettability and wettability alteration potential for tight systems. Survey fluid-rock interactions by streaming potential measurements.

EXPECTED OUTCOME 2023
- Establish methodology for NCS tight reservoir selection for well stimulation, and improved methods for characterization of stimulated reservoir volume.
- Develop a satisfactory core restoration protocol, and identify suitable outcrop analogues and possible case studies

WP3.2
CO_2 utilization

Project Manager: Zachary Alcorn (UiB)/Ingebret Fjelde (NORCE)
Key Personnel: A. Graue (UiB), A. Omekeh (NORCE); R. Gholami, P. Andersen, T. Puntervold (UiS); M. Silva (IFE)
Budget: 2.9 MNOK

CO_2 storage in subsurface reservoirs is a solution for reducing anthropogenic CO_2 emissions. This potential will give rise to combined CO_2 EOR and CO_2 storage efforts. However, the high mobility of CO_2, unstable displacement front and reservoir heterogeneity strongly limits the CO_2 displacement storage potential due to poor reservoir sweep efficiency. The displacement efficiency can be improved by the application of CO_2 foam or carbonated water (CW).

OBJECTIVE

Provide advice to develop and optimize an environmentally friendly and resource efficient EOR and CO_2 storage technology. Screen, characterize, and optimize CO_2 foam formulations at NCS reservoir conditions, which are suitable for different rock types, brine salinities and temperatures. Perform modeling and numerical reservoir simulation to upscale the CO_2 foam technology, determine optimal CO_2 storage and displacement strategies in selected NCS reservoirs. Determine potentials for CW injection for EOR, well stimulation and storage in reservoirs. Establish method for screening of reservoirs for technical and economical potentials for CW-injection, using CO_2 from smaller and larger sources.

KNOWLEDGE GAPS

A major problem during CO_2 injection in subsurface reservoirs is the low density and viscosity of CO_2, which result in viscous fingering, gravity override, and flow in thief zones causing poor reservoir sweep efficiency and low CO_2 storage and displacement efficiency. CW and CO_2 foam are expected to improve the volumetric sweep efficiency. CW has been reported to be able to alter wettability of chalk and sandstone to more water-wet and thereby improve oil recovery. CW can be prepared with CO_2 from smaller or larger sources. Previous CO_2 foam field tests using surfactant-stabilized foam have been reported as technical successes, whereas others were unsuccessful due to injectivity problems and limited foam propagation into the reservoir. An improved foam system are needed to improve predictive modeling of CO_2 foam to advance the technology for combined EOR and CO_2 storage.

PLANS 2022-2023

- Laboratory screening, verification, characterization, optimization, and sensitivity studies of CO_2 foam systems for EOR and associated CO_2 storage.
- Investigate reactions between CW and rocks related to injectivity and wettability alteration for different reservoir types.

EXPECTED OUTCOME 2023

- Laboratory design and foam optimization for selected NCS reservoirs. Derived foam model for upscaling.
- Description of most important mechanisms for interactions CW and rock related to injectivity and wettability.
- Estimates of technical and economical potentials for improved oil production.

WP3.3
Improved tracing

Project Manager: Sissel Viig (IFE)
Key Personnel: M. Silva, A. Krivokapic, B. Antonsen, L. Stavsetra (IFE); I. Fjelde (NORCE), A. Hiorth (UiS)
Budget: 2.4 MNOK

The purpose of this project is to develop tracers to increase the knowledge about the flooded volume of the reservoir and thereby generating data to maximise the value creation on the NCS. Tracers and tracer methods for investigation and evaluation of important parameters as remaining oil saturation, relative permeability and wettability will be the focus for the development. The goal is to have a tracer method that can determine several of the parameters in-situ from the same tracer test by co-injection of tracers with different properties in the near well region. The main focus in 2022-2023 will be on tracers for wettability.

OBJECTIVE
To perform a feasibility study to clarify and substantiate the ability to measure in-situ wettability by using ionic and neutrally charged tracers together. Develop a new set of reactive tracers for measuring Sor and relative permeability in the near well region.

KNOWLEDGE GAPS
Wettability is an important parameter in subsurface flow and determines the potential for many EOR operations. A possible in-situ method will provide a more representative wettability for several reasons. e.g., reservoir wettability cannot be measured at single points, drilling mud or other well fluids change the core properties, pressure depletion can cause micro-cracks in the cores, laboratory chemicals may lead to uncontrolled influence on the cores.
The traditional SWCTT has been in use for several years, however mainly one tracer for such operation has been applied. By developing a group of tracers with varying degree of partitioning to the oil phase it will be possible to verify an earlier theoretical study (Deans, 1978) claiming that Sor, fractional flow and relative permeability can be determined in-situ using tracers.

PLANS 2022-2023
- Wettability: Planned activities are the evaluation of tracer properties and selection of possible tracer candidates. The candidates will be included in a lab concept study to evaluate their ion exchange affinity and capacity as well as gaining knowledge of chromatographic behaviour of ionic and neutrally charged tracers.
- Sor and relperm: Planned activities include synthesis of selected tracer candidates and testing them at realistic conditions to study thermal stability and hydrolysis rates. Detection methods will be developed with focus on low detection limits and the possibility for online/onsite detection.

EXPECTED OUTCOME 2023
- Wettability: Promising results for feasibility study will end in an application to the RCN for extension of the project.
- Sor and relperm: Results from experiments at realistic reservoir conditions and appropriate detection methods developed

Work Package 4

Efficient water management

The amount of water injected, produced and discharged to sea in aging fields on the NCS is increasing. Water handling is energy-intensive and costly, and represents about 50% of the total energy for field operation. Therefore, efficient water management is crucial for field economics and emission reduction. Specific aims of WP4 are:

- To further investigate solutions for improved macroscopic sweep of reservoirs.
- To minimize injection water recirculation with reduced energy needs, thus reducing CO_2 emissions.
- To implement LCA methodology for energy system analysis for calculating NZE indicators such as Unit Energy Invested and Energy Recovery Factor.

Three projects have been defined:

1. WP4.1 Deep water diversion for minimizing CO_2 footprint
2. WP4.2 Optimization of injection water for IOR (PhD)
3. WP4.3 IORSim modelling for near well-bore geochemistry and geomechanics (PhD)

Lead: Ying Guo (NORCE)

WP4.1
Deep water diversion for minimizing CO_2 footprint

Project Manager: Reza Askarinezhad (NORCE)/Pål Andersen (UiS)
Key Personnel: A. Stavland, Y. Guo, A. Lohne (NORCE); Børre Antonsen (IFE)
Budget: 2.0 MNOK

The CO_2 footprint depends strongly on water-cut and methods to lower the water injection and -production in high water-cut fields. This will contribute to achieve the 2030 goal to lower CO_2 emission by more than 50%. Oil will be lost if only flow rate is reduced. Methods to improve the sweep efficiency will minimize the oil loss and if optimized, contribute to improved oil production at lower water-cut and CO_2 emission. It is important to evaluate IOR potential from large perspective when making decisions for field implementation. The traditional industrial practice at companies in the preliminary and conceptual phases will form basis to estimate cost and feasibilities. New elements to be included in the NZE production context are CO_2 emission, cost saving related to energy efficiency and renewable energy phase-in.

OBJECTIVE
1. Identify and recommend feasible technologies to reduce water cut and to improve sweep efficiency for matured/new fields.
2. Re-evaluate the NZE effect of the most promising deep water diversion and conformance control technologies that have been proposed earlier for field implementation.
3. Implement LCA methodology to support field implementation.

KNOWLEDGE GAPS
A number of possible technologies using polymer- or silicate gel for water diversion in high permeable zones or fractures have been proposed at laboratory and conceptual level, a few have been tested in fields, such as Snorre silicate water diversion. Many proposed methods can be further scaled up for field trial but will need to be evaluated for its technical feasibility, economic benefit and NZE effect. LCA analysis is a very much new research topic for NZE production. It is important to identify the boundaries of LCA for water management systems and to build cost and business models for the LCA analysis. The methodology in the recent publications will be used as start point.

PLANS 2022-2023
- Recommend a short list of most relevant technologies for select fields and reservoir types and their potential implementation.
- Performance necessary experiments to acquire necessary data for pilot and field implementation.
- Establish LCA methodologies and develop recommend practice of using NZE indicators, such as Unit Energy Invested and Energy Recovery Factor. for technology selection and ranking.

EXPECTED OUTCOME 2023
1. Recommendation of most promising deep water diversion technologies to further mature for potential field pilots with focus on minimizing CO2 footprint
2. Establish LCA methodology for calculating NZE indicators
3. Short list of potential field pilot
4. 2-3 MSc theses, at least 1 on LCA

WP4.2 Optimization of injection water for IOR

Project Manager: Ingebret Fjelde (NORCE)/ Tina Puntervold (UiS)
Key Personnel: A. Mamonov, S. Strand, A. Hiorth (UiS); A. Omekeh (NORCE); M. Silva (IFE)
Budget: 2.9 MNOK

Waterflooding of heterogeneous reservoirs often lead to high water production and significant energy is needed to process this water. Modifying currently injected seawater may give better sweep and the reduced back produced water will therefore contribute to net-zero emission (NZE) production. This project will explore possibilities of using environmentally friendly clay, particles, and remaining oil as emulsion from back produced water, CO2 and other chemical components to modify injection water to improve waterflooding and reduce back produced water.

OBJECTIVE

1. Identify promising additives and understand their feasibility for improved injection water flooding performance leading to better reservoir sweep.
2. Determine potential to block fractures and high permeability zones and the potential to consolidate carbonate and sandstone rocks with eco-friendly clay materials.
3. Recommend optimized usage of back produced water for re-injection with IOR effect.

KNOWLEDGE GAPS

The proposed additives such as eco-clay, particles, emulsions of oil in back produced water and various ion compositions in injection water have previously been studied previous at laboratory and conceptual level.

Further development of the process understanding and the field requirements are needed using tailor-made experiments at relevant conditions and scales. The experimental results will form input to the field scale modelling to predict the IOR and NZE potential.

PLANS 2022-2023

- Experimental design and testing plan will be developed to study the clay particles and oil emulsions flow in core samples of various rock types.
- Smart Water of various ion composition and combined with CO_2 will be studied with focus on wettability alteration.
- Establish experimental monitoring using tracer in the planned experiments.
- PhD topics will be defined in details based on the preliminary findings in 2022.
- Identify matured concepts for potential field implementation, pilots and new innovative tools in collaboration with operating companies.

EXPECTED OUTCOME 2023

1. Overview of relevant eco-clays and useful components in the back produced water for IOR from conventional oil fields at relevant NCS conditions.
2. Recommendation of the potential use of optimizing composition for field scale process including improved sweep efficiency and rock consolidation.
3. Propose modelling tools for field scale for estimating IOR potential.

WP4.3
IORSim modelling for near wellbore geochemistry and geomechanics

Project Manager: Børre. Antonsen (IFE)/ Aruoture Omekeh (NORCE)
Key Personnel: J. Sagen (IFE); Y. Guo, A. Lohne, (NORCE); A. Hiorth (UiS)
Budget: 3.9 MNOK

IORSim is an IOR process simulator linkable to commercial reservoir simulators. It was developed as part of The National IOR Centre of Norway. IORSim will in this project be further matured for smart water applications combined with geochemistry. A near wellbore module will also be developed for evaluation of chemical water shut-off processes and tight rock production.

OBJECTIVE

The objective is to make IORSim into an even more useful IOR modelling tool. The pathway will be twofold, high focus on geochemical modelling for full field cases, and increased focus on the understanding and modelling of flow and geochemical reactions in the near well zone. This will include tight rock recovery.

KNOWLEDGE GAPS

Improved reservoir software regarding smart water modelling and chemical water shut-off. We want to use IORSim to obtain this goal combining it with the comprehensive geochemical module already in place.
To fulfill near wellbore modelling needs, a near wellbore simulator as part of IORSim will be developed. It is planned to use a Drift-flux model for the well flow itself.
The near wellbore model could include:

- Water shut-off chemicals injection, flow, reactions, and degradation.
- Smart water modelling and evaluation.
- Geochemistry reactions as used in IORSim today.
- Tight rock well stimulation and fracturing.
- Polymer degradation in the wellbore region.
- CO_2 injectivity development.
- Model for foam and CO_2 flow.
- Tracers of various types. Tracers for residual oil saturation estimation.
- Various completions, including ICD and AICD.
- Multibranched wells, and fishbone wells.

PLANS 2022-2023

- The smart water module in IORSim will be extended and verified to the extent possible. We will also start work for the chemical water shut-off module.
- The near wellbore module will be developed for 3d and three phases within 2022.

EXPECTED OUTCOME 2023

1. By 2023 we will deliver a new version of IORSim with comprehensive smart water capability including geochemical interaction.
2. First version water shut-off model will also be presented.
3. First version of the near wellbore simulation tool will be ready.

Work Package 5

Digital subsurface for decisions

Large amounts of subsurface data are available, but current workflows and programs for subsurface understanding are not optimal, resulting in inadequate utilization of datasets. To build a Sustainable Subsurface Value Chain and make more informed decisions, digitalization and ML are necessary to integrate the knowledge and competence building from different WPs (SO3, SO7). A digital infrastructure, Subsurface Knowledge Cloud (SKC), will be established to provide readily usable data and high-performance computing power and visualization tools. Specific targets of WP5 are:

- More robust model forecasts with feasible computational cost and better accessibility of big datasets.
- More comprehensive and reliable uncertainty quantification for multi-purpose reservoir usage.
- Develop data-driven approaches to integrate ML into subsurface-characterization, uncertainty quantification, and the decision-making process.

Six projects have been defined:

1. WP5.1 Federated Knowledge Cloud for Subsurface Digitalization across Multiple Sites (PhD)
2. WP5.2 Multi-fidelity models, scenario evaluation and probabilistic forecasts for the digital subsurface (PhD)
3. WP5.3 Reservoir-management workflows for decision-making
4. WP5.4 Hybrid ensemble algorithms applied to CO_2/H_2 utilization and storage (PhD)
5. WP5.5 Develop and support Knowledge Cloud for Subsurface Digitalization across Multiple Sites
6. WP5.6 Explore, develop, test and deploy new automated workflows that utilize cloud storage of data and cloud compute infrastructure

Lead: Geir Evensen (NORCE)
Deputy lead: Randi Valestrand (NORCE)

WP5.1 Federated Knowledge Cloud for Subsurface Digitalization across Multiple Sites

Project Manager: Chunming Rong (UiS)
Key Personnel: Y. Guo (NORCE); N. Zhang (UiS); O. Skjæraasen, Lan Liu, (IFE)
Budget: 2.5 MNOK

This project creates a Federated Knowledge Cloud that will serve as the cloud infrastructure and AI platform for subsurface digital integration in NCS2030. It aims to enable users to develop, deploy, and execute AI projects efficiently. Moreover, it brings together cloud services, federated learning, marketing, and assisting tools in enabling seamless across-silos collaborations for advanced knowledge gain, improved decisions, and efficient workflows.

OBJECTIVE

The main goal is to develop a Federated Knowledge Cloud for Subsurface Digitalization and establish a secure and privacy-preserving collaboration AI platform for industry partners and research institutes. Especially, it addresses across-silos collaborations in advanced knowledge gain, improved decisions, and efficient workflows.
This goal breaks down as follows:

1. Identify suitable, standardized data and metadata formats, and label datasets for machine learning purposes.
2. Adopt suitable schemes for subsurface data and models access, ownership, and sharing governance in cloud computing.
3. Implement federated learning in the cloud for knowledge advancement across multiple fields.
4. Coordinate digital resources in AI platforms (Open Earth Community (Landmark), DELFL (Schlumberger), etc.) and develop tools to help and enable NCS2030 researchers to develop, deploy, and execute ML models.
5. Work across work packages and enable user-defined workflows in AI platform.
6. Develop a business model for tools and knowledge exchange to incentivize data publishing and knowledge sharing.

KNOWLEDGE GAPS

The project objective is included in Research question Q5.1: How can we effectively utilize all available data from available data sources across multiple sites? How can we motivate data publishing and knowledge sharing across multiple sites? Essentially, through data governance, federated learning, and developing a business model for tools and knowledge exchange across multiple sites.

PLANS 2022-2023

- Collaborate with industry partners to connect with existing subsurface energy data and AI platforms for digital resources coordination in the cloud.
- Develop the service portal for the Knowledge Cloud.
- Educate one Ph.D. starting from 2022.

EXPECTED OUTCOME 2023

- Develop a cloud-based service portal for the Federated Knowledge Cloud.
- Demonstrate defined workflows in the federated knowledge cloud.

WP5.2 Multi-fidelity models, scenario evaluation and probabolistic forecasts for the digital subsurface

Project Manager: Kristian Fossum (NORCE)
Key Personnel: K. Fossum, A. Stordal, T. Mannseth, K. S. Eikrem, S. Aanonsen, (NORCE); R. B Bratvold, C. Rong, N. Zhang, A. Hong, (UiS)
Budget: 5.2 MNOK

Increasing model complexities and a desire to include multi-scenario models, including, e.g., various geological settings, make the problem of uncertainty quantification a daunting computational challenge. A compelling way of handling computational issues is to use a single, or multiple, computational models with reduced fidelity. Methodologies for robust probabilistic production forecasts, utilizing scenarios and fidelity models, will be developed.

OBJECTIVE

We enable multi-fidelity and scenario evaluation methodology in the digital subsurface. We will develop multi-fidelity models, and algorithms, that can be applied to efficient data assimilation (DA) workflows and for efficient decision-making under uncertainty. We also use the models in combination with methods for evaluating multiple model scenarios. We will further develop and extend Reference Class Forecasting (RCF) methods to mitigate or remove biases in probabilistic forecasts. Drawing on statistics generated based forecast and actual production data from the Norwegian Continental Shelf (NCS), we will develop calibration tables and curves which will be shared in the Federated Knowledge Cloud.

KNOWLEDGE GAPS

Standard application of DA quantifies uncertainty for a given scenario. Multiple scenarios are usually viable but posing significant methodological and computational challenges. Reliable uncertainty quantification for high-resolution reservoir models is also computationally challenging. Efficient use of multi-fidelity models allows for statistically accurate estimation of model weights, enabling uncertainty quantification accounting for multiple model scenarios. Fast low-fidelity models can enable efficient quality assurance, or validation, of multiple model scenarios. Evidence shows that operators on the NCS are both optimistic and overconfident. This suggests that statistically consistent debiasing methods, such as probabilistic reference class forecasting, can provide robust means for calibrating probabilistic production forecasts.

PLANS 2022-2023

- Classify and optimize various multi-fidelity models focusing on total computational cost and numerical accuracy.
- Develop flexible multi-fidelity algorithms for data assimilation and optimization.
- Enable Bayesian model evidence calculations via multi-fidelity models.
- Methods for automated scenario selection.
- Enhance existing data-assimilation and optimization algorithms with multi-fidelity and multi-scenarios capabilities.
- Hire one PhD student at UiS to work on methodologies for calibrating forecasts.

EXPECTED OUTCOME 2023

1. Methodologies for multi-fidelity uncertainty quantification in integrated workflow.
2. Multi-fidelity calculation of Bayesian model evidence.
3. Methodologies for calibrating forecasts.

WP5.3
Reservoir-management workflows for decision-making

Project Manager: Geir Evensen (NORCE)
Key Personnel: P. Raanes, K. Fossum, X. Luo, R. Valestrand, (NORCE)
Budget: 3.0 MNOK

In ensemble-based reservoir management, one typically runs many reservoir models in parallel. A reservoir-model workflow can include several software and scripts, and automation is essential. This project will provide the ensemble tools needed to automate the simulation of the ensemble of workflows and the ensemble updates through history matching and optimization.

OBJECTIVE

We will develop, improve, and operate closed-loop reservoir management and decision workflows. For the workflows, we will use open tools like ERT and PIPT for recursive model updating, including ensemble history matching, robust optimization, and decision-making under uncertainty. The workflows will facilitate testing and applications of new algorithms developed in WP5 on field cases and support field cases in other WPs. Furthermore, the workflows will lead to history matching, optimization, and decision-making developments.

KNOWLEDGE GAPS

We need to establish advanced and standardized tools like PIPT and ERT for ensemble-based reservoir management. The consistent formulation of the history matching problem and its solution approach requires further research and analysis. Robust optimization (taking the geologic uncertainty into account) is in its early development phase, and it is not apparent which of several solution methodologies will be the most efficient. The use of an ensemble of model predictions to support robust decision-making is in its infancy; thus, we must establish consistent decision-making methods.

PLANS 2022-2023

- We will apply and demonstrate closed-loop reservoir management workflows based on ERT and PIPT to reservoir cases.
- We will provide a framework for running and testing the new models and methods developed in the NCS2030.
- We will facilitate workflows for running the NCS2030 field cases.
- We will continue the development of methods and formulations for reservoir history matching, optimization, and decision making.
- Evaluate workflow for prototype testing for the Federated Knowledge Cloud.

EXPECTED OUTCOME 2023

- We will facilitate workflows for running the NCS2030 field cases.
- We will provide demonstration examples with ERT and PIPT that can serve as base cases for other NCS2030 projects and applications.

WP5.4 Hybrid ensemble algorithms applied to CO_2/H_2 utilization and storage

Project Manager: Xiaodong Luo (NORCE)
Key Personnel: C. Rong, N. Zhang, P. Andersen; P. Raanes (NORCE); H. Xiao (Virginia Tech.)
Budget: 3.1 MNOK

Ensemble data assimilation (DA) and optimization methods are popular approaches to subsurface characterization, development and management problems. Meanwhile, machine learning (ML) has emerged as a powerful toolset with a variety of applications in subsurface problems. The similarities and connections among DA, optimization and ML pave the way of developing advanced DA and optimization algorithms that are powered by modern ML technologies, and have the potential to go beyond the current state-of-the-art.

OBJECTIVE

The primary objective of the project is to develop a multidisciplinary digitalisation workflow with improved accuracy, efficiency and/or robustness for DA and optimization algorithms in subsurface problems, through the integrations of modern ML technologies into the state-of-the-art, ensemble-based DA and optimization algorithms. The secondary objective of the project is to apply the integrated multidisciplinary digitalisation workflow to geological CO2 and H2 storage problems, in collaboration with researchers under other relevant work packages (WP), e.g., WP1 – WP4.

KNOWLEDGE GAPS

While ensemble-based algorithms are among the most popular and powerful approaches to subsurface characterization, development and management problems, we expect that there are still potentials to further improve their performance (in terms of accuracy, efficiency and/or robustness) by combining ML technologies into the digitalization workflow. Examples in this regard include (but not limited to): New ensemble algorithms incorporating ML technologies; Machine-learning-based representations of model errors in forward numerical simulators; Improved uncertainty representation and quantification through ML; Integrated workflows for CO2/H2 storage and utilization on simplistic and realistic cases for the NCS; Connection of workflows to knowledge cloud and testing on cases/data.

PLANS 2022-2023

One focus is on the development of new ensemble-based hybrid algorithms. Another focus is on developing workflows for CO2/H2 storage and utilization. In addition, a PhD project is planned to start at UiS in 2023, which welcomes possible industry supervision and collaborations.

EXPECTED OUTCOME 2023

- Hybrid ML and ensemble-based DA/optimization algorithms;
- Workflows definition and testing for CO2/H2 reservoir management;

Development and management of micro-services, datasets, and data pipes in the subsurface knowledge cloud.

WP5.5
Develop and support Knowledge Cloud for Subsurface Digitalization across Multiple Sites

Project Manager: Rob Berendsen (Landmark)
Key Personnel: P. Sabharwal, G. Christopher, C. Badis, W. Souza (Landmark); C. Rong and N. Zhang (UiS); Y. Guo (NORCE); O. Skjæraasen (IFE)
Budget: 1.5 MNOK

Utilize Open Earth Community. Open Earth Community (OEC): Landmark Graphics to provide access to a full open development environment which includes all development tools and all Halliburton Landmark solutions. The Data Analytics platform can be utilized for building ML models. Pre-models are available that can be re-used or extended. In addition, Landmark Graphics can provide access to DISKOS data upon approval from NPD.

OBJECTIVE

- Utilize Open Earth Community; a fully open development environment which includes all development tools and all Halliburton Landmark solutions.
- Utilize DS365.ai – platform for quickly building ML models. Pre-build models are available that the Industry partners can re-use or extend. New models can be built and developed.
- Explore/build virtual data room (VDR) workflow utilizing DISKOS data.
- Collaborate in further develop the Knowledge Cloud.
- Explore possibilities on how to integrate NORCE OPM tools with Landmark analytics platform.
- Contribute with relevant Halliburton-Landmark software solutions, like DecisionSpace® Geoscience suite, iEnergy and other solutions. We can provide support, training and mentoring.

KNOWLEDGE GAPS

Landmark can provide DISKOS data and other private data required for various workflows, this will need a seamless connection of data to the tools from NCS2030.

PLANS 2022-2023

Detailed plans will be developed based on in-depth discussions and collaboration with the NCS2030 work-package leaders, in particular WP5, and industry partners. Different workshops will be setup to further discuss this.

EXPECTED OUTCOME 2023

- Developed and demonstrated agreed workflows using real data
- Training of users from both NCS2030 researchers and industrial participants

WP5.6
Explore, develop, test and deploy new automated work-flows that utilize cloud storage of data and cloud compute infrastructure

Project Manager: Pierre Le Guern (Schlum-berger)
Key Personnel: H. Garcia (Schlumberger)
Budget: 1.5 MNOK

Schlumberger will assist NCS2030 in getting trained and utilizing modern OSDU-based workflows by getting access to the DELFI Cognitive E&P Environment. DELFI has a modern OpenAPI based Developer environment and a flexible Data science and Analytics platform leveraging Dataiku and TIBCO's Spotfire. In collaboration with NCS2030 researchers, topics like Real-time Reservoir Optimization, Proxy Modelling and Data-driven Physics-based Predic-tive Modelling can be investigated.

OBJECTIVE

Schlumberger is donating core data ecosys-tem components to the Open Subsurface Data Universe (OSDU) Forum. A key obje-ctive of the project is to get NCS2030 up to speed on OSDU and work with the DELFI Data science solution, which can be used as a PhD Development toolbox. As part of the project, Schlumberger personnel will support the development of new algorithms and help organize and deploy new prototype solutions. DELFI Developer Portal provides a full-range of software development services in a scala-ble, secure and easy-to-use REST-based API developer environment. DELFI Data science is a package of AI and analytics solutions for energy workflows that enables geoscientists and engineers to build, manage, and deploy new solutions. Machine learning models are extracted from a wide range of AI libraries, evaluated automatically and ranked in order of performance. Users will be able to leverage an extensive scripting environment for furth-er extensibility and fine tuning. Machine lear-ning and analytics can thus be connected to a wide range of physics-based engines and the OSDU™ Data Platform.

KNOWLEDGE GAPS

The overall objective is to test and validate that DELFI and OSDU can be used as an open Research platform, accessing data seamlessly through OSDU. PhD work can then be valida-ted on Public data or relevant field test data. Knowledge gaps related to Real-time Reser-voir Optimization, Proxy Modeling and Da-ta-driven Physics-based Predictive Modeling will also be investigated. The focus will be on delivering acceptable run times, ensuring sta-bility and capturing the correct behavior in proxy modeling, reduced-order modeling and reduced-physics modeling.

PLANS 2022-2023

Through multiple workshops and discussi-ons, more in-depth plans will be developed in collaboration with the NCS2030 work-packa-ge leaders and NCS2030 partners.

EXPECTED OUTCOME 2023

- Setting up DELFI and OSDU to establish the backbone for a research platform
- Train PhDs/researchers
- Organize workshops
- Demonstrate new workflows on Public data or agreed/relevant field data

Work Package 6

Energy Policy, Economy and Society

The role of the Norwegian Continental Shelf (NCS) in the future energy system depends on the national and international business regulations, societal acceptance and licence to operate. The targets of WP6 are to (SO4, SO5, SO7):

- Address the competitiveness of the NCS in national and international contexts.
- Contribute to sound climate mitigation policies.
- Understand and explain the risk and uncertainty of investments related to WP1-WP5.

Four projects have been defined:

1. WP6.1 NCS, the business climate, and market characteristics (Postdoc)
2. WP6.2 Avoidance of stranded assets
3. WP6.3 Energy transition and the NCS
4. WP6.4 Acceptance evaluation

Lead: Torfinn Harding (UiS)

WP6.1
NCS, the business climate, and market characteristics

Project Manager: Torfinn Harding (UiS)
Key Personnel: Jørgen Juel Andersen (UiS)
Budget: 1.4 MNOK

Many observers expect that climate policies and alternative energy sources will put downwards pressure on the demand for fossil fuels in the coming decades. This may have important consequences for the oil sector and the oil market as we know them. First, the appetite for investments in hydrocarbon exploration and production may decline. This may result in higher risk premiums in the financial markets to finance such investments and fiercer competition from other oil producing countries to attract the remaining investments.

OBJECTIVE

The hydrocarbon markets may change, making for example the demand for fossil fuel more sensitive to price changes. Both these aspects may in turn have important implications for the effects of policies and the distribution of costs and benefits across hydrocarbon producers, consumers, and governments.

Key objectives of the project are:

- To better understand the responses to policy and price changes by firms in the hydrocarbon sector
- To study the market changes and their implications

KNOWLEDGE GAPS

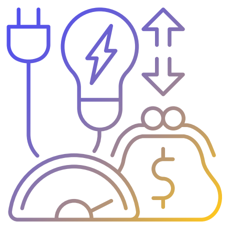
More research is required to understand how the business climate and oil price affect firms in the oil sector as well as how firms respond to changes in the business climate elsewhere, such as changing taxes in other countries. There is also a need for more research on market reactions and the sensitivity of supply and demand. Understanding both firm and market behavior is important to understand the consequences of policies.

PLANS 2022-2023

Hire post doc(s) and professor II, establish the necessary databases, start analyses.

EXPECTED OUTCOME 2023

- Hiring of post doc(s) and professor II, databases established.



WP6.2
Avoidance of stranded assets

Project Manager: Torfinn Harding (UiS)
Key Personnel: C. J. Ahi, A. Blomgren (NORCE)
Budget: 0.1 MNOK

A central challenge for governments as well as for the oil and gas sector is to balance investing in profitable projects and avoiding stranded assets. The difficulty of the tradeoffs involved is highlighted by the recent "revenge of geopolitics", a renewed interest in energy security, and the emergency of the climate crisis. A question is how to best design robust policies to deal with the risks involved. An important backstop against unprofitable projects in the Norwegian regime is the discretionary licensing system.

OBJECTIVE

- To investigate the function of the backstop mechanism in preventing projects that in expectation are unprofitable to materialize.
- To, more generally, investigate the functioning of the licensing system to the extent we are successful in obtaining the necessary data.

KNOWLEDGE GAPS

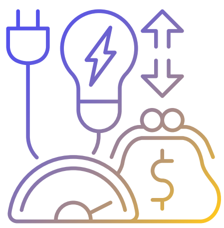
What is the right level of investments in hydrocarbons, including what is a "neutral petroleum tax system"? This has been the subject of a long-standing debate between academics, the industry, and governments. Depending on the market frictions involved, the tax system can encourage a too high, a too low, or the "right" level of investments. Some theoretical work in economics has suggested that the historical tax regime in Norway has been too generous and thus encouraged unprofitable investments, while other work in economics has found that this is not necessarily the case. The judgment by many practitioners seems to be that the system in practice has not encouraged unprofitable investments. This may be due to market frictions or backstop mechanisms in the licensing system. More research is required to better understand if and how policies may help avoiding unprofitable investments seen from the society's point of view, while at the same time allowing for profitable investments to take place.

PLANS 2022-2023

Obtain necessary data, perform analyses, draft first version of paper.

EXPECTED OUTCOME 2023

- A first draft of paper



WP6.3
Energy transition and the Norwegian Continental Shelf

Project Manager: Mari Lyseid Authen (IFE)
Key Personnel: Kristina Haaskjold (IFE)
Budget: 0.225 MNOK

The oil and gas sector may be a vehicle of transition towards new technologies. For example, there may be important complementarities between oil and gas and new technologies, such as CCS and Hydrogen. Cash flow from oil and gas may also be important to fund potentially risky new energy investments.

OBJECTIVE

- To map potential pathways for energy use at the Norwegian continental shelf.
- Study electrification from shore vs. from direct electrification from offshore wind.
- Study green hydrogen from offshore wind vs. blue hydrogen.
- Study offshore production of hydrogen vs. land-based production of hydrogen.

KNOWLEDGE GAPS

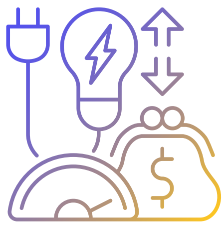
There is need for more research to understand the complementarities between petroleum and new technologies such as CCS and H2, and how the transition towards the new energy system can be facilitated. The NCS is likely to have a particularly strong potential of benefitting from such complementarities.

PLANS 2022-2023

Mobilize the team, gather data, and start performing analyses.

EXPECTED OUTCOME 2023

- Team established and first analyses made



WP6.4
Acceptance evaluation

Project Manager: Torfinn Harding (UiS)
Key Personnel: J. T. Selvik (NORCE)
Budget: 0.1 MNOK

This project will employ and develop risk principles and methods for evaluating the quality of subsurface solutions, including the use of multi-criteria decision-making approaches and prioritization of measures. The increasing scrutiny facing oil producers in politics, in the legal system and in financial markets contribute to a less predictable business climate. How to communicate risk and uncertainty to financial markets, policy makers and the wider society will be an important part of this sub-project.

OBJECTIVE

- Employ and develop risk principles and methods for evaluating the quality of subsurface solutions, including the use of multi-criteria decision making and prioritization of measures.
- Study communication of risk and uncertainty.

KNOWLEDGE GAPS

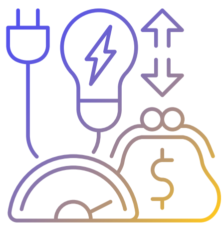
More research is required to understand how climate aware investors and constituencies will affect investments in physical and human capital in the petroleum sector. The backdrop is increasing tensions between the need for energy and the need for climate mitigation. The tradeoffs become particularly challenging due to risk and uncertainty. The risk and uncertainty are related to a range of different sources, e.g., the policy of other countries, the behavior of companies and consumers, and climate change.

PLANS 2022-2023

Mobilize team, gather data, and start performing analyses.

EXPECTED OUTCOME 2023

- Team established and first analyses made



Work Package 7

Education and Outreach

The diversification in the energy sector requires skilled professionals with subsurface competences, knowledge in the multiple energy sources, storage options, digitalization and an understanding of the NCS. However, the number of students in energy related topics at the universities in Norway has dramatically declined and the supply of people with subsurface competence is approaching a critical low level. There is a negative perception of energy-related studies because an unstable job market and this sector is not considered environmentally friendly. To address these challenges, the specific targets of WP7 are:

- Attract the next generation of scientists and skilled professionals for the energy transition.
- Educate new professionals in the future energy competences and collaboration with industry partners.
- Disseminate the NCS2030 results.

PLANS 2022-2023

The plan for the first year is to hire PhD and postdocs within the research areas of the NCS2030 and to participate in student recruiting activities focusing on bachelor students. Master and bachelor students will be involved in the centre through theses and as research assistants. We will use the digital media to disseminate the results of the centre among the scientific community, industry and society (as popular science). We will expand our research activities collaborating with other externally funded associate projects such as SUBSET, Intpart, and other PhD's projects.

EXPECTED OUTCOME 2023

- Recruited PhD's and postdocs: 9
- Participation in open days, Geologiens dag, ONS, etc.
- Posts in digital media or newspapers (e.g. newspapers, social media): 20
- Posts in social media (e.g. Linkedin, NCS2030 webpage): 20
- Industry co-mentoring theses (Master and PhD): 2
- Open-access, high-impact publications, including publications with industry: 5
- Conference presentations: 20
- Webinars: bimonthly
- Energy Norway Conference: annually
- Technical workshops: 10
- Industry visits, lunch and learn: 2

Lead: Dora Marin (UiS)

Key Personnel: Kjersti Riiber and Alejandro Escalona (UiS)

List of PhD and postdoc projects 2022/2023

Work package	Project name	Candidate	Supervisor	Research partner
WP1 (PhD)	Salt characterization and modelling for the future energy mix	Daniele Blancone	Dora Marin	UiS
WP3 (PhD)	Net-zero emission production – tight reservoir solutions	NN	Tina Puntervold	UiS
WP3 (PhD)	Optimizing CO_2 foam for EOR and CO_2 storage on the NCS	Hilde Halsøy	Zachary Alcorn	UiB
WP4 (PhD)	IORSim modelling for near wellbore geochemistry and geomechanics	NN	Ying Guo	NORCE
WP4 (PhD)	Water management – minimized water production and optimized water injection	NN	Tina Puntervold	UiS
WP5 (PhD)	Federated Knowledge Cloud for Subsurface Digitalization across Multiple Sites	Jungwon Seo	Chunming Rong	UiS
WP5 (PhD)	Multi-fidelity models, scenario evaluation and probabilistic forecasts for the digital subsurface	NN	Reidar Bratvold	UiS
WP5 (PhD)	Robust reservoir management for safe and efficient CO_2/H_2 utilization and storage	NN	Pål Andersen	UiS
WP6 (Postdoc)	NCS, the business climate, and market characteristics	NN	Torfinn Harding	UiS

The planned innovation program will form a platform for the industrial partners to quickly adopt new technologies and methods to their operations and develop new services and products both for the Norwegian Continental Shelf (NCS) and for export. This will contribute to value creation for the companies in the transition period and contribute to economic growth, job security and social welfare.

An Innovation committee (proposed to be led by industry) will be established by the Centre managment with the purpose of identifying potential innovative solutions from the Centre's research results. The Innovation committee will work closely with work package leaders and Centre management to monitor research results, which may need to be investigated further (outside the scope of the Centre) for field implementation or lead to commercial products. A PhD/Postdoc representative will be invited to be part of the committee.

The goal of the Innovation Program is to establish dedicated projects and processes for technology development, demonstration, or commercialisation with separate private or public funding to accelerate implementation. The innovation program will be built as a parallel program where in addition to the NCS2030 research partners, innovation and service companies will participate in order to facilitate and speed projects towards implementation. The innovation forum will be where the different stakeholders (see figure 3) of the innovation program interacts.

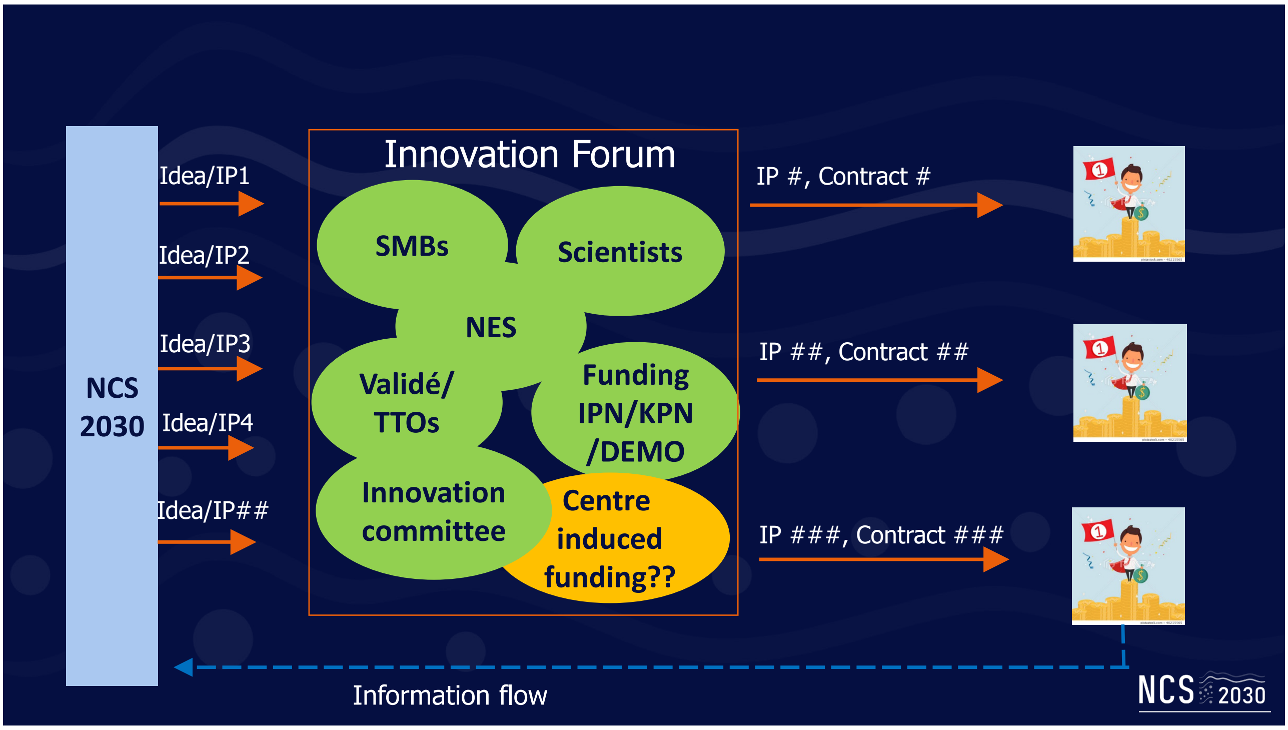


Figure 3. Tentative model for the innovation program.

Budget

WP Budget (KNOK)		TOTAL 2022-2023			
	Partner name	2022	2023	Partner	WP
WP1	UiS	600	1326	1926	7720
	NORCE	1000	1000	2000	
	IFE	847	947	1794	
	UiB	0	0	0	
	HAL/LAN	500	500	1000	
	SLB	500	500	1000	
WP2	UiS	250	250	500	5089
	NORCE	400	400	800	
	IFE	1842	1947	3789	
	UiB	0	0	0	
WP3	UiS	717	1397	2114	8399
	NORCE	1000	1400	2400	
	IFE	1000	895	1895	
	UiB	585	1405	1990	
WP4	UiS	187	1394	1581	8813
	NORCE	1800	2432	4232	
	IFE	1500	1500	3000	
	UiB	0	0	0	
WP5	UiS	466	3459	3925	16827
	NORCE	4504	4504	9008	
	IFE	394	500	894	
	UiB	0	0	0	
	HAL/LAN	500	1000	1500	
	SLB	500	1000	1500	
WP6	UiS	0	1240	1240	1865
	NORCE	0	500	500	
	IFE	50	75	125	
	UiB	0	0	0	
WP7	UiS	1712	1886	3598	4004
	NORCE	16	50	66	
	IFE	40	100	140	
	UiB	100	100	200	
WP8	UiS	1850	2673	4523	7741
	NORCE	1000	1000	2000	
	IFE	509	509	1018	
	UiB	100	100	200	
Sum:		24 469	35 990		60 459

Table 2. NCS2030 financing contribution per partner per WP for 2022-2023.

The centre budget for the total expected period of 8 years is ~295 MNOK with the public funding of 80 MNOK and the rest from the research partners and industrial sponsors. Table 2 shows the budget plan for 2022-2023 allocated to the research partners.

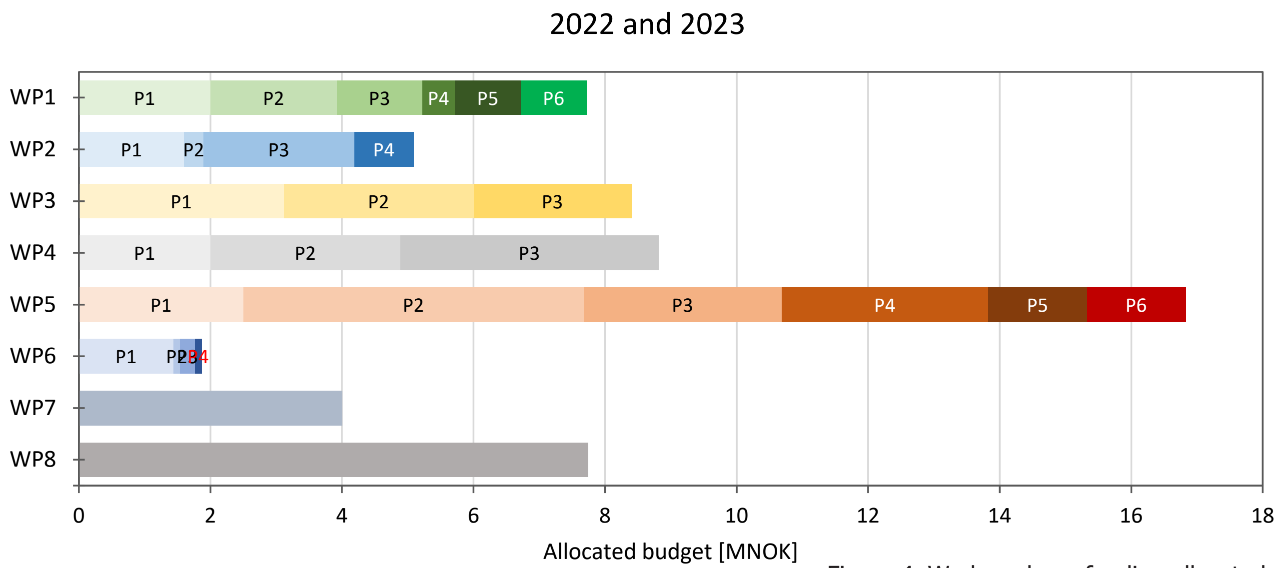


Figure 4. Work-package funding allocated to the projects. For details see table 3.

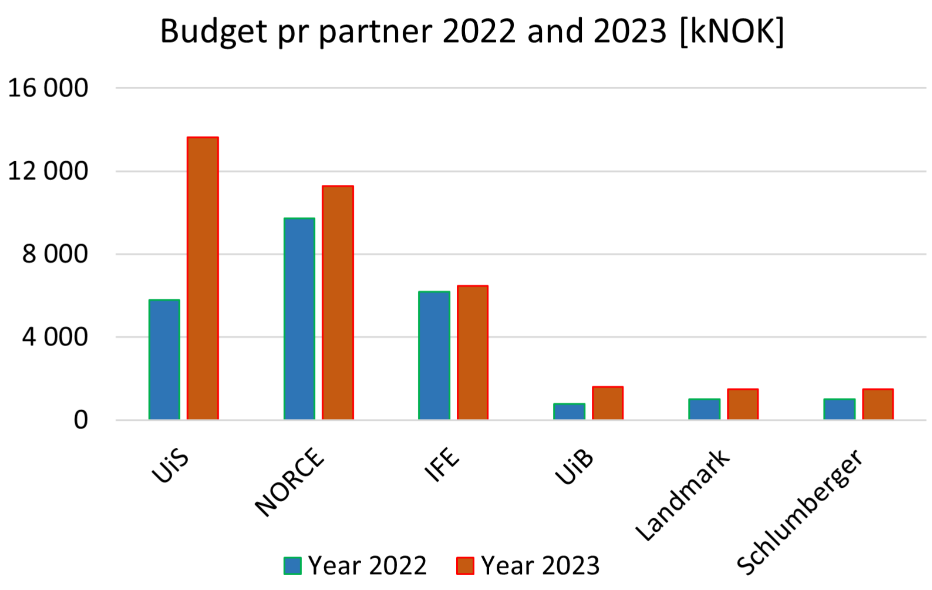


Figure 5. Funding allocated to the research partners for 2022 and 2023.

www.uis.no/en/ncs2030

NCS 2030

University of Stavanger