

2015 Annual Report:
Petroleum Research School of Norway;
Nasjonal forskerskole i petroleumsfag (NFIP)

Activities

Petroleum Research School of Norway (NFIP) includes PhD students from all of the five universities in Norway that provide PhD education within petroleum related disciplines. Education of petroleum researchers at Norwegian universities benefits from coordinated, interdisciplinary collaboration between the Norwegian universities graduating PhD's in petroleum related scientific disciplines.

The Petroleum Research School of Norway was established to provide a national tool to improve the PhD education within petroleum in Norway. This is achieved by coordinating lectures given by the different universities and providing intensive courses, seminars and conferences for all PhD students in Norway with research projects related to petroleum. The objective is also to establish discussion groups, collaborating opportunities and interdisciplinary meeting places for PhD students and their supervisors; for more information please see www.NFiPweb.org.

A database of 123 PhD students related to upstream petroleum technology at the participating universities has been established in 2014 by the Petroleum Research School of Norway; including University of Bergen, University of Stavanger, University of Oslo, Norwegian University of Science and Technology (NTNU), University of Tromsø and the University Center at Svalbard (UNIS).

Over the last three years ca 400 PhD students have participated in NFIP activities; in 2015 a total of 140 PhD- and Master Students participated in the NFIP activities.

2015 courses/seminars:

All courses and conferences provided in 2015 were in collaboration with NorTex Petroleum Cluster, due to the financial situation for NFIP in 2015.

Collaborative NFIP and NorTex Courses:

Subsea Engineering:

Four courses are being developed, while ongoing discussions with UH and the Subsea Global Alliance may offer access to several other courses as well:

- 1) At Texas A&M Corpus Christi campus a course titled: "Geochemical Assessment of Subsea Engineering", emphasizing environmental concerns during subsea operations. Lecturer is Richard B. Coffin, Ph.D. and Chair of the Department of Physical and Environmental Sciences. This course is a geochemical assessment of subsea engineering related to energy mining and carbon sequestration with a focus on

environmental impact and platform and pipeline stability. Lectures will include resource characterization.

Course will be announced in May and in August and will be offered in October 2016.

- 2) At UiB a course on Integrated Operations in Drilling and Production. This course will provide an introduction to important concepts, methods and computer tools within real-time reservoir and production management. The course will go through the principles and techniques behind the drilling, directional drilling and placement of the wellbore with respect to the optimization of production. Practical exercises are included.

Course will be announced in May and in August and will be offered in October 2016.

- 3&4) OneSubsea, in collaboration with Texas A&M, is preparing two courses in Subsea Engineering; discussions are ongoing towards including this courses within the NorTex and NFiP concepts.

Petrophysics and Well Logging:

a) Schlumberger provides an expert lecturer on Petrophysics and Well Logging: Tom Barber is semi-retired Technical Advisor at Schlumberger's Houston Formation Evaluation Center, and has worked on induction modeling, array design and environmental corrections since coming to Houston in 1978. He is author and co-author of over 50 papers and holder of 32 patents, he was awarded the SPWLA Distinguished Technical Achievement Award in 1993 for significant contributions in electromagnetic logging, and the SPWLA Gold Medal for Technical Achievement in 2011.

Statoil will provided a senior employee, Stein Ottar Stalheim, who will lecture how oil companies use the obtained petrophysical measurements to characterize the reservoir.

Course attracted 30 students at UoB Nov. 11th-14th, 2015.

It will be announced again in May and in August 2016 and offered in November 2016.

The proposed courses to be offered by Petroleum Research School of Norway (NFiP) may also be available for the NorTex collaboration. These courses are listed in the table below.

Proposed Courses and Annual Budget for NFiP [US\$]

Location	Course/Activity	No. of Participants	Cost pr. Participant	Univ. contrib.	Expenses (US\$)
<i>Existing courses already modified to be available to all PhD students within NFiP:</i>					
NTNU	Dual Porosity	20	1 000	10 000	30 000
NTNU	Advanced Gas Engineering	10	1 000	10 000	20 000
UiB	Applied Res. Modelling,	35	1 000	10 000	45 000

	External lecturer	1	5 000		5 000
<i>New Courses:</i>					
NTNU	Reservoir Char. (in negotiations)	15	1 000	20 000	35 000
NFiP location	Improving Supervisors Forum	20	3 000	10 000	70 000
UiT/UNIS	Arctic Petroleum Sciences	15	2 000	10 000	40 000
UiS/NTNU	Advanced Drilling (in negotiations)	10	1 000	10 000	20 000
UiB	Special Core Analysis	15	1 000	20 000	35 000
UiB/Web- student Int.	On-line Courses: Reservoir Physics; In collaboration with NorTex			30 000	60 000
<i>Existing Geological Field Trips already made available to all PhD students within NFiP:</i>					
DTU, Copenhagen	Chalk Field trip to Møn, Denmark, External lecturer	10 1	1 500 3 000		15 000 30 000
U. of Portsmouth	Geol. Field Trip to Devon and Dorset, UK External lecturer	15 1	2 000 5 000		30 000 5 000
U. of Barcelona	PYREX Geological Field Trip, Spain External lecturers	20 2	1 500 5 000		30 000 10 000
<i>New Geological Field Trips available to all PhD students within NFiP:</i>					
UNIS/UiO	Spitsbergen Field Trip	20	1 500	10 000	40 000
UiT	Geological Arctic Field Trip	20	1 500	10 000	40 000
<i>International Conferences and Seminars:</i>					
Norw. Petr. Museum	Annual NFiP Seminar, 6th time in 2015	70	500	10 000	45 000
Rice U., Houston	Biennial CO2 for EOR as CCUS, 2nd time in 2015	50	1 000	20 000	70 000
NFiP location	Biennial Interdisciplinary Petroleum Conf, 1st time in 2016	70	5 000	20 000	55 000
<i>Adminstration:</i>					
UiB	Expenses for Board, Leader (50%), Secretary / Coordinator (100%)				80 000
Sum Budget		420		200 000	783 000

2015 Conferences

Two conferences were provided in 2015 in collaboration with NorTex Petroleum Cluster.

1) CO2 EOR as CCUS Conference

NorTex Petroleum Cluster in collaboration with Petroleum Research School of Norway, Rice University and the Norwegian Consulate General in Houston provided the conference: "2nd Biennial CO2 for EOR as CCUS", Oct. 4-6th, 2015, at Rice U. in Houston, TX.

The conference attracted 120 registered attendees from 43 different companies, organizations and universities. A total of 60 graduate students participated; 20 from Norway and UK and 40 from 9 different universities in the USA (U. of Southern California, Rice U., UT Austin, Texas A&M, U. of Kansas, Colorado School of Mines, Stanford, University of Houston and University of North Dakota).

For 2013 conference program and published presentation: <http://nortexpetroleum.org/2013-2/>

For 2015 conference program and published presentation: <http://nortexpetroleum.org/2015-2/>

2) Petroleum Research School of Norway Annual Seminar

In a collaborative effort NorTex Petroleum Cluster and Petroleum Research School of Norway (NFIP), provided the conference: "*Petroleum Research- and Educational Collaboration with USA*", Nov. 26th, 2015, at Norwegian Petroleum Museum, Stavanger, Norway.

A total of 70 participants (36% females) from industry and academia attended the conference program, toured the Petroleum Museum and enjoyed networking during the conference dinner at the museum restaurant. A total of 41 PhD and 16 Master students from the following 5 universities in Norway participated: U. of Tromsø, NTNU, U. of Bergen, U. of Oslo and U. Stavanger.

Link to the conference: <http://nfipweb.org/NFiP-activities/annual-seminar/2015.html>

3. Student/ Researcher Exchange 2015.

During 2015 the following research exchanges and visits were funded by NorTex/NFiP:

PhD student **Shyam Panjwani**, Univ. of Houston, TX, USA – visit at UiB, Bergen, Norway

Project Name:	Robust closed loop reservoir management and optimization strategy to improve oil recovery in the water-flooded oil fields
Institution:	University of Houston, Dept. of Chemical Engineering
PhD student:	Shyam Panjwani
Project Supervisor:	Professor Michael Nikolaou
Institution Visited:	University of Bergen, Bergen
Hosted By:	Professor Arne Graue
Period:	3 months: May - August 2014

Brief Project Summary:

We propose a two-layer robust closed loop reservoir management and optimization (RCLRMO) strategy to improve oil recovery in the water-flooded oil fields. The upper layer consists of model based life-cycle optimization using net-present-value (NPV) as economic objective. In the lower layer, model predictive control (MPC) technique is used to track the production targets obtained from the upper layer. The lower layer provides the manipulated daily injection rates which are implemented in the reservoir model. Instead of highly cumbersome full-scale physics based field reservoir models, data-driven proxy models are trained and used in both the layers for optimization and control purposes. A mean-variance based multi-objective optimization scheme was proposed to counter the effect of uncertainties involved in the reservoir parameters. Sharpe ratio was used to choose the optimal injection rates from the set of optimal pareto solutions obtained from multi-objective optimization. The reservoir model was built using ECLIPSE reservoir simulator and MATLAB provided a platform for proxy model building, optimization and MPC design.

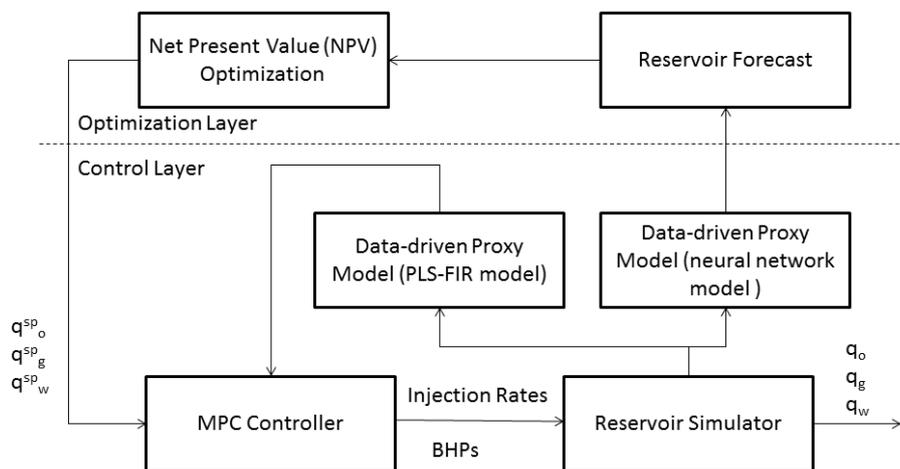


Figure 1: Structure for closed loop reservoir management and optimization

PhD student **Ryan Poling-Skutvik**, Univ. of Houston, TX, USA – visit UiB, Bergen, Norway

Project Name: Nano particle transport through porous media
Institution: University of Houston, Dept. of Chem. and Biomolecular Eng.
PhD Student: Ryan Poling-Skutvik
Project Supervisors: Professor Ramanan Krishnamoorti
Institution Visited: University of Bergen, Bergen
Hosted By: Professor Assoc. Prof. Martin Fernø
Period: From July 3rd, 2015 to July 21st, 2015

Brief Project Summary:

Ryan Poling-Skutvik travelled to Norway in a collaboration between the Krishnamoorti research group at the University of Houston and the Petroleum and Process Technology research group at the University of Bergen. The travel was initiated by the NorTex Petroleum Cluster as part of the NorTex Short Term Exchange Program to increase collaboration between universities in Texas and Norway working on petroleum related research. Ryan has experience in preparing and characterizing polymer-functionalized nanoparticles that work to increase oil recovery in oil reservoirs. He conducted experiments using silica micromodels of

porous rocks to determine the efficacy of the grafted nanoparticles on oil recovery. This trip paves the way for closer collaborations between the two research groups.

PhD student Zachary Alcorn, Univ. of Bergen, Norway – visit American Resources Inc., Houston, TX, USA.

Project Name: Reservoir Models & Simulations for Field Pilots
Institution: Department of Physics and Technology, University of Bergen
PhD Student: Zachary Alcorn
Project Supervisors: Professor Arne Graue
Institution Visited: American Resources Inc., Houston, TX, USA
Hosted By: Troy Vickers, American Resources Inc.
Period: A total of 3 months by subsequent visits

Brief Project Summary:

NorTex funding support provided a research stay in Houston to initiate work for a field pilot research program to investigate CO₂ foam for mobility control. Collaboration with industry and academic partners in Houston allowed relevant field data to be efficiently gathered and organized to begin a reservoir characterization of the multiple fields chosen for the field pilot research program. During this time, analysis of petrophysical well logs, field data, core analysis, and construction of cross sections permitted the definition of a geologic framework, reservoir characterization, and generation of geologic and reservoir models for the East Seminole and Ft. Stockton fields. Reservoir simulation cases were constructed for each field to analyze fluid flow within the reservoir. Meetings with field operators yielded identification of field well locations and provided a focus for the numerical simulation studies. Well patterns were chosen and the reservoir simulation model was subsequently history matched to actual reservoir performance in these areas. This allowed validation of the model and the use of the models to predict further reservoir performance. Collaboration with academic partners allowed the presentation of project progress and familiarization with relevant experts in their fields of study. The opportunity to work directly with partners and present project status provided invaluable insight into initiating the field pilot research program. This established a framework for the ongoing reservoir management strategy.

Prof. Arne Graue, U. of Bergen – visits to Rice University, UH and UT Austin

Project Name: CO₂ Foam EOR Field Pilots
Institution: Department of Physics and Technology, University of Bergen
Researcher: Professor Arne Graue
Institutions Visited: Department of Chemical and Biomolecular Engineering, Rice University
Department of Petroleum and Geosystems Engineering, Cockrell School of Engineering, U. of Texas, Austin
Dept. of Petr. Engineering, UH
Hosted By: Professors Ramanan Krishnamoorti, George Hirasaki and Quoc Nguyen
Period: A total of 3 months by subsequent visits

Brief Project Summary:

The primary focus of the visits were to 1) prepare for CO₂ Foam Field Tests, 2) progress meetings within CO₂ Foam laboratory studies and 3) prepare for arranging the conference: "CO₂ for EOR as CCUS", Oct. 4-6th, 2015, at Rice U., Houston, TX.

Status for the CO2 Foam Field Test:

- a. The East Seminole Field Pilot started CO2 injection October 2013. The operations will continue for at least 5 years.
- b. Collaborative research efforts between ongoing USDOE project at UT and Rice U with our Joint Research Team of 11 universities in Norway, Netherlands, UK, France and USA. Field data from previous waterflooding (70 years) has been shared among partners. Evaluation of all Five-Spots patterns are in progress to find optimum well configuration for CO2 Foam Field test. This work is performed by exchange of graduate students between UT, Rice and UoB.
- c. Negotiations for obtaining 4D seismic before during and after the field test is on-going.
- d. Negotiations with additional oil companies to participate in the test are on-going
- e. Financial support from NRC has been successful, a total of US\$ 1,25 mill has been obtained, along with cash funding from 4 oil companies.

4. Board Meetings 2015

No Board Meetings were held in 2015.

5. Chairman Activities

NFiP and NorTex was promoted by visits and presentations at: Univ. of Kansas, Lawrence, KS, Stanford Univ., CA., Lawrence Berkeley National Lab., Berkeley, CA., Univ. of Southern California, L.A., CA., and U. of Tulsa, OK, USA.

Chairman of the Executive Board of NFiP and NorTex Petroleum Cluster has participated/presented at various occasions and events:

Selected invited scientific talks by the Chairman; where NFiP and NorTex was presented:

- Presentations for the Ministry of Petroleum and Energy in Norway, March 12th, 2015.
- Russian Delegation to Univ. of Bergen; Delegation from St. Petersburg Mining U., March 27th, 2015. Title: "Research for More Sustainable Oil and Gas Production".
- USC, April 17th, 2015. Title: "Research for More Sustainable Oil and Gas Production".
- Rice University's Consortium for Processes in Porous Media, Houston, TX, USA, April 22nd, 2015. Title: "NorTex Petroleum Cluster - Update on CO2 EOR Foam Field Pilots"
- The oil company Shell: Shell Westhollow Technology Center, Houston, USA, May 12th, 2015. Title: "More Sustainable Oil and Gas Production using CO2 for EOR as CCUS - Upscaling EOR from Lab to Field Pilots".
- Norway's Consulate General in Houston: Invited talk at Lunch & Learn, May 14th, 2015:
Title: "Research for More Sustainable Oil and Gas Production"
- Florida Atlantic University (FAU), Boca Raton, FL, USA, June 5th, 2015. Title: "Climate Concern and Energy Perspectives - Research for More Sustainable Petroleum Production in CO2 EOR and Unconventional Gas Production by CO2 Sequestration in Hydrates".

- Presentations at MoU meeting on Fossil Fuels between USA and Norway at USDOE in Washington DC, June 8-12, 2015.
- Summer Seminar at Rice U., Houston, TX, USA, July 30th, 2015. Title: "More Sustainable Oil and Gas Production using CO₂ for EOR as CCUS - Upscaling EOR from Lab to Field Pilots".
- 2nd Biennial CO₂ for EOR as CCUS Conf., Houston, TX, Oct. 4-6th, 2015: Title: "CO₂ Foam EOR Field Pilots in Texas and Mississippi".
- Presentations at SPE EOR FORUM Cancun, Mexico, Oct. 18th-23rd, 2015
- Four Energy Ministers Summit; Transformational Technology to Meet Energy Security and Economic Priorities, Belgrade, November 12th, 2015. Title: "CCUS for More Sustainable Oil and Gas Production".
- NFiP Annual Seminar, Norwegian Petroleum Museum, Stavanger, Nov. 26th, 2015 Title: "NorTex Petroleum Cluster".
- Presentations at COREC Meeting ConocoPhillips, Tananger, Dec. 2nd, 2015
- Presentation at Reservoir Monitoring Consortium, USC, Los Angeles, CA, Dec. 8th, 2015

6. NFiP Web-site

The NFiP web-site is found at: <http://nfipweb.org/>

During 2015 the web-site has been improved, but will be further updated in 2016.

The NFiP secretariat, at Dept. of Physics and Technology, UiB, with Assoc. Prof. Martin Fernø as coordinator, has been of great value for the 2015 activities.

February 16th, 2016.

Arne Graue

Chairman of the Executive Board