

CURRICULUM VITAE

NAME : Bjørn Kvamme
YEAR OF BIRTH : 1954
NATIONALITY : Norwegian
LANGUAGES : Norwegian
 English
 German
POSITION : Professor at Department of Physics and Technology,
 University of Bergen, Bergen, Norway



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QUALIFICATIONS

- 1984 The Norwegian Institute of Technology:
 Dr.ing. in Chemical Engineering, 1984 Thesis: "Thermodynamic
 Properties of Polyatomic Fluids from Atom-Atom interactions".
- 1981 Siv.ing. ing Chemical Engineering
 Thesis: "Evaluation of gas-lift systems".
- 1977-1978 Bergen College of Engineering:
 Chemistry and Chemical Engineering, 1977
 Production Techniques and Economy, 1978

ADDITIONAL ACADEMIC QUALIFICATIONS

- Qualified for position as senior lecturer (1. Amanuensis) in theoretical physics. Evaluated according to application for a position in atomic physics at University of Bergen 1994. Committee consisted of Professors Rolf Manne and Jan S. Vaagen, both University of Bergen, and Prof. Anders Barany (Stockholm).
- Qualified for a position as senior lecturer (1. Amanuensis) in surface and colloid chemistry. Evaluated according to application for a position at University of Oslo 1994.
- Qualified for position as professor in increased oil recovery at University of Stavanger (Stavanger, 2006)
- Qualified for position in gas technology at Norwegian University of Science and Technology, NTNU (Trondheim, 2005)
- Qualified for position in bio process technology at Norwegian University of Life Sciences, UMB (Ås, 2005)

KEY QUALIFICATIONS:

Process Engineering, Thermodynamics, Statistical mechanics, Applied Mathematics.

PROFESSIONAL EXPERIENCE

2005-present **Senior supervisor for SINTEF with special responsibility for membranes, polymer systems and interfaces**
2000-present **University of Bergen, Dept. of Physics, Norway**
1998-2000 **University of Bergen, Dept. of Chemistry, Norway**
1988-1997 **Telemark Institute of Technology, Norway**

Main topics:

- Statistical Mechanics
- Molecular dynamics simulation and Monte carlo simulations.
- Hydrate Equilibrium.
- Initiation and kinetics of hydrate formation.
- Melting of hydrates.
- Prediction of thermodynamic properties for polar mixtures and electrolytes from atom-atom-interactions.
- Characterisation of heavy oil-components.
- Sour gas sweetening
- Carbon dioxide deposition
- Selective surface adsorption
- Metastable fluids and nucleation
- Thermostatting in canonical molecular dynamics simulations
- Grand canonical molecular dynamics simulations

- Water/oil liquid membranes (surfactants)
- 1994–1995 SINTEF
Senior consultant applied chemistry,
- Kinetic hydrate inhibitors
- 1985–1987 Bergen College of Engineering, Norway
Associate Professor of:
- Hydrate equilibrium.
 - Hydrate Kinetics.
- 1985–1986 SINTEF, division of applied chemistry,
Senior consultant with special emphasis on theoretical aspects
of hydrate formation and equilibrium.
- 1984–1985 The Norwegian Institute of Technology.
Associate Professor of:
- Statistical thermodynamics.
 - Phase equilibrium in oil/gas systems.
 - Thermodynamic models for hydrate/gas equilibrium.
- 1982–1984 Statoil. PhD Scholarship at the Norwegian
Institute of Technology.
- Equations of state for oil/gas systems and complex mixtures.
 - Characterization of heavy oil fractions.
 - Thermodynamics for polydisperse systems.
 - Group contribution equations of state.
 - Thermodynamic models for gas and fluids based on atom-atom-
interactions.
 - Activity-coefficients for water/methanol/glycol mixtures.
 - Models for kinetics of hydrate growth.

MAIN ADMINISTRATIVE DUTIES:

- 1988–1992 Leader of the committee for strategic development of the computer-
facilities at Telemark Institute of Technology
(Sivilingeniørutdanningen i Telemark).
- 1989–1997 Member of the committee for research and
doctoral studies (FUDU) at Telemark Institute of Technology.
(Sivilingeniørutdanningen i Telemark). Chairman from 1996
- 1988–1992 Member of the council for Telemark Institute of Technology
(Sivilingeniørutdanningen i Telemark).
- 1992 Member of the committee for evaluation of new studies in
environmental technology at Telemark Institute of Technology.
- 1994 Organiser of the "8th nordic symposium on simulations of liquids and

- solids" at Røros, June 1994.
- 1996–1996 Member of a the central comittee for research and development at Telemark College ("FoU-utvalget").
- 1995–1996 Organiser of the hydrate sessions at ISOPE-96 in Los Angeles May 1996.
- 1995–1996 Organiser of the hydrate sessions at ISOPE-96 in Los Angeles May 1996.
- 2001–2003 Member of the board for the program in Process technology at University of Bergen.
- 2002–2002 Organiser of the 3rd international workshop "Fiery ice from the seas", Valparaiso, Chile, November 18 - 21, 2003
- 2004– Member of "Forskerutdanningsutvalget" at UoB
- 2005–2005 Organiser of the 4th international workshop "Fiery ice from the seas", Victoria BC, Canada, May 9 – 11, 2005
- 2006–2006 In the board for the workshop "Science and Technology Issues in Methane Hydrate R&D", March 5 - 9, 2006, Kauai, Hawaii
- 2006–2006 Organiser of the 5th international workshop "Fiery ice from the seas", Ednburgh, UK, Oct. 9 – 12, 2006
- 2007–2007 Organiser of the 6th international workshop "Fiery ice from the seas", Bergen, Norway, May 13 – 15, 2008

OTHER ACADEMIC DUTIES:

- 1990 External examiner for Institute of Physical Chemistry at University of. Trondheim. Courses in statistical thermodynamics and MSc theses.
- 1997 External examiner for Chemistry Department, University of Bergen Courses.
- 1998–2001 External examiner for Proses Technology Department, University of Dar Es Salaam, Tanzania.
- 1995 Opponent to the thesis "Diffusion in dense binary fluid mixtures of dissimilar molecules" by Dag Kristian Dysthe for the degree dr.ing. NTH, Physical Chemistry Sept. the 12th 1995.
- 1996 Opponent to the thesis "Clathrate Hydrate Studied by means of Time-Domain Dielectric Spectroscopy" by Thorvald Jacobsen for the degree dr.scient. UiB, Dept. of Chemistry Dec. the 20th 1996.

- 1997 Opponent to the thesis "Diffusion in porous material" by Inge Wold for the degree dr.ing. NTNU, Physical Chemistry Dec. the 17th 1997.
- 2001 Member of a scientific committee for a professorship in thermodynamics at department of chemical process technology at NTNU in trondheim
- 2002 Member of a scientific committee for a professorship in hydrate at department of mechanical engineering at NTNU in Trondheim
- 2005 Member of the board for research education at department of Physics and Technology
- 2007 Member of a scientific committee for a professorship in Reservoir technology at University of Stavanger
- 2008 Leader for the exam commission for MSc studies at department of Physics and Technology at UoB

CURRENT ACTIVE PROJECTS AND INTERNATIONAL COLLABORATIONS.

- 1) *Novosibirsk State University. Institute of Physical Chemistry (Prof. Vladimir Belosludov) and Institute of Inorganic Chemistry (Prof. I.Y.Dyadin).*
A joint project financed by INTAS (EU) on a Russian hydrate reservoir is yet in progress. Another INTAS application is prepared for submission.
- 2) *Stockholm University. Associate Professor Aatto Laaksonen.*
Laaksonen is yet running molecular dynamics simulations in set up and premises designed and governed by Prof. Kvamme. The simulations are intended to imitate either a water in oil emulsion or an oil in water emulsion, depending on the specific set-up. The intention is to study how model membranes between the two phases (oil and gas) work and how changes in active groups will alter the effectiveness of the membranes. These simulations are part of a prestudy for another application to the INTAS program where participation from University of Bergen as well as two Russian groups are included.
- 3) *St. Petersburg State University. Theoretical Physics (Professor Pavel N-N. Vorontsov).*
Professor Vorontsov has invited to a collaboration towards an application for the INTAS program. Prof. Kvamme has designed a theoretical procedure for a new type of simulations where it is possible to keep constant chemical potential of each component in a two-phase system which may or may not be separated by a membrane. In addition

to the advantage of controlling the chemical potentials in "bulk" it has the advantage that a fairly small simulation set-up may efficiently simulate large systems to a realistic level. The group of Prof. Vorontsov will participate in one of the INTAS applications (see 2) above) with specific participation of the testing and extension of the indicated simulation-procedure.

- 4) *Texas A&M University. Petroleum Technology Department (Prof. Y. Makogan) and Department of Chemistry.*
Prof. Kvamme has been invited to an extensive collaboration with Prof. Makogan. This involves general academic collaboration on common publications that are presently being written. Also common research applications towards U.S.A., India and Japan are yet being planned.

- 5) *ENRICH (1999-2002)*
ENRICH project "NETWORK FOR COLLECTION AND EXCHANGE OF DATASETS ON GAS HYDRATES".
The project involves nine European Universities and involves the following main topics/disciplines in the evaluation of all known resources of natural gas in the form of hydrate :

- Geology
- Geophysics
- Geochemistry
- Thermodynamics
- Kinetics
- Physicochemical modeling
- Technology of exploitation of oil and gas
- Technology of gas hydrates deposits exploitation
- Ecological impact of gas hydrates exploitation.
- Modeling of ecology effects
- Economics of gas hydrates exploration, recovery, treatment, transportation and use.

- 6) *COSMOS (1999-2002)*
Bjørn Kvamme is project co-ordinator and scientifically responsible for one of four parts in the project COSMOS, which is completely financed from Japan (RITE). The aim of the project is to explore the possibilities of depositing carbon dioxide at large depths (beyond 2800 meters) with a strategy where the carbon dioxide is deposited at intermediate depths as large droplets (diameter in the order of 1 m.) covered by hydrate and ice. Keyword for some of the tasks dedicated to the group of Bjørn Kvamme

- Estimation of chemical potential in seawater, liquid carbon dioxide, ice and hydrate.
- Surface tension and mechanical strength.
- Hydrate growth rates
- Ice growth rates

- Connection between dynamics of ice growth and hydrodynamic forces as function of depth and time. Corresponding simulations of sinking scenario and successive evaluation of droplets stability

7) *Safe long terms storage of CO₂ in Aquifers (2002-2007)*

Bjørn Kvamme is project co-ordinator and scientifically responsible for one of two parts in this project, which is completely financed from The Norwegian Research Council and Norsk Hydro. The overall budget for the project is 13.5 MNOK. The aim of the project is to explore the long term stability of CO₂ storage in Aquifers, with specific emphasis on mineral reactions and effects of hydrate in cold reservoirs. The project finances 4 PhD students and a post.doc:

- Estimation of chemical potential in seawater, liquid carbon dioxide, ice and hydrate.
- Surface tension and mechanical strength.
- Mineral reactions
- Hydrate growth rates
- Characterisation of reservoir fluid parameters

8) *Storage of CO₂ in Hydrate reservoirs (2002-2006)*

This project has a budget of 6 MNOK and is divided into an experimental and a theoretical part. Bjørn is scientifically responsible for the theoretical modelling of hydrate conversion from natural gas hydrate to CO₂ hydrate. The project is financed from The Norwegian Research Council and Phillips. The overall budget for the project is 6.0 MNOK.

- Estimation of interface free energies and interface thickness between liquid carbon dioxide, water and hydrate.
- Phase field theory for estimation of hydrate conversion rates
- Magnetic resonance imaging for visualisation of hydrate formation, hydrate dissociation and hydrate reformation
- Reservoir simulation of natural gas hydrate reservoir conversion to CO₂ hydrate

9) *HipGas (2001-2005)*

HipGas is a joint venture project with several industrial partners and UoB and NTNU as the academic partners in the project. The overall budget for the project is approximately 18 MNOK and finances 5 PhD students and 2 post.doc. In this project Bjørn Kvamme is scientifically responsible for characterisation of the fluids with respect to properties of key importance in description of scrubber efficiencies.

- Measurements and modelling of viscosities
- Measurements and modelling of surface tensions
- Fluid phase equilibria

10) *Hfund (1987-2006)*

Hfund is a project dedicated to the fundamental understanding of hydrate and hydrate properties. Budget is approximately 2 MNOK. The latest candidate educated to dr.scient in this field graduated December 2002.

- Monte Carlo simulations of hydrate stability
- Molecular dynamics simulations of hydrate dissociation
- Lattice dynamics studies of hydrate stability
- Effects of different guest molecule characteristics on hydrate stability

11) *DMRISM (1987-2006)*

DMRISM is a fundamental project for development of new approaches for estimation of structure and thermodynamic properties in fluid mixtures. The project has presently no external funding.

- Integral equations for multi-atomic molecular mixtures
- Thermodynamic properties
- Molecular dynamics simulations of corresponding systems

12) *Hydrate dissociation in chemical potential gradients (2001-2003)*

This project has a budget of approximately 1.5 MNOK and finances one post.doc. The main focus of the project is the stability of hydrate that is exposed to surrounding where the chemical potential of guest molecules is significantly lower than that in the hydrate structure. The main goal is to obtain kinetic information on the main parameters that control the dissociation rate in these systems, which is particularly important for natural gas hydrate reservoirs that are exposed towards the seafloor.

- Molecular dynamics simulations of hydrate and hydrate exposed towards pure water as well as water with varying concentrations of hydrate former
- Nucleation theories

13) *Hydrate kinetics (1987-2006)*

The external funding of this project is 0.4 MNOK, which covers a guest Professor for three months in Bergen every year from 2003 to 2006. Additional efforts by allocated time from Bjørn Kvamme.

- Classical Nucleation Theory (CNT)
- Diffuse Interface Theory (DIT) and Multi-component Diffuse Interface Theory (MDIT)
- Different additional dynamics coupled to CNT or MDIT for simulation of coupled dynamics of phase transitions
- Phase field theories for estimation of phase transition kinetics involving hydrate as one of the phases

14) *Fiery ice from the seas (2001 – ongoing without determined end)*

This is listed as a project since the main purpose of this series of workshops is to initiate international interdisciplinary research collaboration on hydrate. The yearly budget is around 0.4 MNOK and covers the cost of arranging the workshop. Department of Energy (DOE) has been the major sponsor of this yearly event since the first one in 2001 in Honolulu (second in Washington 2002, third in Chile 2003, fourth in Victoria Canada 2005, fifth in Edinburgh UK 2006, sixth in Bergen Norway 2008, seventh in Wellington New Zealand 2010).

- Fluxes of hydrocarbons from exposed hydrate reservoirs and coupled dynamic systems consuming hydrocarbons (organic ecosystems, inorganic ecosystems, biological ecosystems).
- Hydrate as a future energy source
- Exploitation of hydrate reservoirs

15) *Exploitation of hydrate reservoirs using CO₂ injection (2004)*

This project is financed by ConocoPhillips and administered by Prof. Arne Graue at Department of Physics and Technology, UoB. The costs are mainly related to the use of experimental facilities at ConocoPhillips, USA, including staff. The budget for the first phase until August 2004 is 5.5 MNOK.

- Experimental studies of formation, dissociation and reformation of hydrate using Magnetic Resonance Imaging.
- Implications for hydrate reservoir exploitation strategies

16) *Microtomography of mineral dissolution (2004)*

This project is financed by ESRF, Grenoble and unpaid contribution from the group of D. Bernard, Institut de Chimie de la Matière Condensée de Bordeaux.

- Microtomographic images of minerals before and after exposure to acidic environment and corresponding effects of erosion and release of particles.

17) *Autoprecipitation of salt in hydrothermal vents(2004)*

Budget 0.4 MNOK. This project is financed by STATOIL and Forschungszentrum Karlsruhe. The results are submitted for publication and a new project is established.

- Supercritical water approaches a non-polar characteristic that is unable to dissolve significant amounts of salts. Different mechanisms of salt solubility below the out-salting regions and above the out-salting regions.

18) *Hydrate sealing (2004-2006)*

The budget of this project is 5 MNOK, which covers a post.doc at University of Bergen, experimental activities at University of Hawaii

and reservoir simulation studies in collaboration with Princeton University. Additional efforts by allocated time from Bjørn Kvamme.

- Phase field theory for prediction of phase transitions.
- Diffuse Interface Theory (DIT) and Multi-component Diffuse Interface Theory (MDIT)
- Models for biological and chemical conversion of released methane.

19) *Geomechanics and geochemistry (2005-2008)*

The budget of this project is 3.5 MNOK, which covers a PhD student at University of Bergen and some assistance from researchers. Project is partly funded by NFR program RENERGI. The remaining funding is from Carbon Capture Project, phase 2 (CCP2). This project is formally part of CCP2 and the main collaborator on these issues in the CCP2 program is Lawrence Berkeley National Laboratory

- Effects of CO₂ injection on porosity, permeability and geomechanical effects. Also effects of released particles due to dissolution of minerals.
- Corresponding effects of mineral precipitation in regions of higher pH. Including local pressure gradients caused by blocking of pores and flow channels.

20) *Precipitation of salts from boiling water and supercritical water in hydrothermal vents (2005)*

The budget of this project is 0.38 MNOK, which covers a post.doc for 3 months and some assistance from other researchers. Project is funded by STATOIL

- Rates and quantitative amounts of out-salting in natural hydrothermal vents.

21) *Stabilization of CO₂ storage through mineralization (2005-2006)*

The budget of this project is 1.5 MNOK, which covers some salary for research at UoB and the value of collaborative research done at Universite Paul Sabatier, Toulouse (Prof. Erich Oelchers) and UoB (Professor Per Aagaard).

- Dawsonite is a perfect candidate for long terms mineralization of CO₂ in natural reservoirs and is thermodynamically favourable. Will dawsonite form in natural reservoirs where CO₂ is injected?
- What other minerals are likely to create long terms storage of CO₂ in aquifers?

22) *New strategies for exploitation of hydrate reservoirs using CO₂ (2005-2008)*

The budget of this project is 15 MNOK. It includes two PhD to University of Bergen and additional staff as well as experimental facilities at ConocoPhillips in Bartlesville, USA. Ongoing negotiations.

- Phase field theory
- Diffuse Interface Theory (DIT) and Multi-component Diffuse Interface Theory (MDIT)
- Experiments using Magnetic Resonance Imaging on porous media as well as confined fluids.
- Reservoir simulation

23) *Formation of metal salt nanoparticles in supercritical hydrothermal aqueous solutions by molecular dynamics (2006-2008)*

The budget of this project is 3.1 MNOK and financed by Deutsche Forschungsgemeinschaft (DFG) in Germany). It is a personal international post.doc grant for Norbert Luemmen.

- Ab initio simulations in order to establish reliable model parameters for clustering of unlike ions
- Large scale MD simulation of salt clustering in aqueous solution at different conditions

24) *Aquifer storage and shale reactivity. (2006-2008)*

This project is a collaboration between Los Alamos National Laboratory and UoB. The budget is 4.53 MNOK and partially funded by DOE. Application towards NFR sent. Likely to get funding.

- Measurements of mineral reaction kinetics
- Rock embrittlement/fracturing
- Mobilization of trace elements and heavy metals resident in shales
- Modeling and reservoir simulation.

25) *GANS (2007 – 2010)*

This project is a national collaboration on hydrate fundamentals and identification, quantification and analyses of natural hydrate reserves. Budget approximately 16 MNOK, total. 3MNOK to Kvamme's group. It is very likely that the project gets funded.

- Hydrate stability and dynamics in porous rock matrix
- Leakage from exposed hydrate reservoirs Rock

26) *CO₂ injection for stimulated production of natural gas (2006 – 2009)*

This project is financed by the Research Council of Norway with a budget of 4.91 MNOK and is complemented by experimental efforts financed by ConocoPhillips.

- Hydrate formation and reformation kinetics
- Effects of interfaces

- 27) *Reduction of persistent organic pollutants (POPs) in fish meal (2007 – 2011)*
- The main objective of the project is to explore the use of a novel oil extraction process to reduce the POPs level in fish meal. Budget: MNOK 4.5. Financed by Fiskeriforskning and NFR
- 28) *SSC-Ramore (2007 – 2011)*
- This project is financed by the Research Council of Norway and industry. The project is a collaboration between University of Oslo, University of Bergen, IFE and NGI. The total Budget is approximately 22 MNOK, of which roughly 25% is dedicated to Kvammes group at UoB.
- Long term stability of reservoir storage
 - Approaches for remediation
- 29) *HipGLS (2006 – 2011)*
- This project is financed by the Research Council of Norway and industry. The project is located at NTNU and Kvamme has the responsibility for the theoretical modelling of interfacial tension while the experimental work is conducted at STATOIL's laboratory in Trondheim
- Molecular dynamics simulations of interfacial tension
 - Gradient theory for interfacial tension
- 30) *Involvement in the Big Sky Network for CO2 storage (2007 – 2011)*
- Big Sky International Research Exchange Program. This project is entirely funded from National Science Foundation in USA and involves a basic funding for sending 4 students per year to University of Bergen for a 8 month research project. In addition the grant contains funding for sending regular staff (Professors) to University of Bergen.
- Geochemistry and geomechanics related to aquifer storage of CO2
 - Storage of CO2 in natural gas hydrate reservoirs
 - Molecular dynamics simulations as tools for investigation the potential of storing exhaust gas directly in hydrate reservoirs without prior separation
 - Studies of interfacial properties (water/CO2 and mineral/fluids)
- 31) *Involvement in the Midwest Geological Sequestration Consortium for CO2 storage (2007 – 2011)*
- This is another of the 7 partnerships in USA dedicated to CO2 storage in aquifers. The partnership is led by Illinois Geological Survey and is tightly integrated in relevant scientific environments of University of Illinois in Champaign, with additional expertise from outside. Kvamme

has a special responsibility for modelling geochemistry and geomechanics.

- Geochemistry and geomechanics related to aquifer storage of CO₂
- Storage of CO₂ in natural gas hydrate reservoirs
- Molecular dynamics simulations as tools for investigation the potential of storing exhaust gas directly in hydrate reservoirs without prior separation
- Studies of interfacial properties (water/CO₂ and mineral/fluids)

32) *Exchange of students and staff between UoB and Montana State University (2008 – 2015)*

This is a project to support for sending students and staff to Montana State University to further develop scientific collaboration. Budget: MNOK 0.25.

33) *CCOP, Storage of CO₂ and hydrate as energy source. (2007 – 2016)*

This is a project for development of CO₂ storage and CO₂ storage combined with production of natural gas in Asia. It is supported by CCOP (Coordinating Committee for Geoscience Programmes in East and SouthEast Asia) and PETRAD. There is no present budget other than covering direct costs related to invited travels for Kvamme. Present status:

- Invited as keynote speaker at 1) CO₂ storage workshop in Brunei 7/9-07, 2) Keynote speaker at E&P R&D Forum, Kota Kinabalu, Malaysia, 16/1-18/1-08 and 3) Workshop on the Challenges of Extracting Gas Hydrates as an environmentally friendly source of energy and storing CO₂ in the gas hydrates reservoir. Kvamme was Norwegian coordinator for the scientific part of number 3) and also invited Prof. Hafliði Hafliðason and representatives from StatoilHydro to the Workshop, Hanoi June 3-6, 2008, 4) CCOP workshop on use of CO₂ for EOR, IOR and exploitation of hydrate reservoirs, Da Nang, December 8 - 10, 2009.
- Project application for hydrate exchange studies (natural gas hydrate to CO₂ hydrate) together with PETRONAS and UTP (Technological University in Malaysia) almost completed. Chances for funding is substantial.
- Discussions on collaboration with Vietnam on hydrate energy and storage of CO₂ is in progress and also involves geosciences at UoB.
- Discussions on collaboration with Indonesia on hydrate energy and storage of CO₂ is in progress and also involves geosciences at UoB.
- Scientific collaboration with Taiwan is on the way to be established and as a first step there are economic incentives for students from UoB to stay for up to 2 years of their studies in Taiwan, all paid for from Taiwan.

- 34) *Yamaguchi University and Japan Society for Promotion of Science. (2008 – 2011)*
 There has been a long term contact with Yamaguchi University in the area of hydrate and geomechanical implications. Kvamme has given several invited talks throughout Japan, including JOGMEC and different energy companies. It has proven to be very difficult to get a Norwegian PhD student to travel to Japan for the scientific part of the PhD so the grants have not yet been used.
- 35) *Subsurface storage of CO₂ - injection well management during the operational phase*
 Budget approximately 32 MNOK, of which 2/3 funded by the research council of Norway and the rest from industry. Granted December 2008 and in the early stage of starting up.
- injectivity, possible injection overpressures and geomechanical consequences and developed numerical tools for the analysis
 - Numerical tools for analyzing the geomechanical implications of hydrate formation and hydrate dissolution effects in cold reservoirs (aquifers) and hydrate reservoirs (storage of CO₂ in hydrate reservoirs)
 - Numerical tools for analyzing effects of other gases on mineral reactions and geomechanical implications. Special emphasis on H₂S, SO₂, NO_x and possible remains of amines.
 - Sensitivity analysis for consequences of possible deficiencies in shale (faults and fractures) and also well completing (holes and channels of leakage)
 - A better understanding of possible out-gassing/inversion of CO₂ from the liquid through increased temperature from geothermal gradients
- 36) *SUCCESS: SUBsurface CO₂ storage – Critical Elements and Superior Strategy*
–A Norwegian Research Centre for eco-friendly energy (FME)
 Center just granted on February 4, 2009 and details on priorities as well as total budgets will be updated as soon as all the industrial contracts as additional funding to the governmental funds are ready. The centre is funded for 8 years.
- 37) *COST action PERGAMON (2009 - 2013)*
 Network action that focus on fluxes of methane in arctic from open channels and dissociating hydrates. Special emphasis on environmental concerns and energy aspects. Also used as a network for promoting the establishment of a European Union project within this field.
- Involves key hydrate groups with expertise in hydrates around Europe and with associate members from Russia and USA.

- 38) *Combined Storage of CO₂ and hydrate reservoir exploitation (2009 and no determined end).*
 Kvamme has accepted to be mentor and scientific supervisor for UTP (Universite Technologie Petronas) and PETRONAS in their development of hydrate technology. At this stage three dedicated professors at UTP and three senior staff from PETRONAS has been pointed of as the initial core group which will only focus on hydrate for three years as a first stage of the development.
- 39) *CO₂H₂O+ (2011 - 2013)*
 Increased understanding of hydrate, water deposition and water drop-out in CO₂-streams from capture plants –enable accurate dewatering specifications for safe and economic pipeline transportation in CCS projects.
 Funded by Gassco, TOTAL and Research Council of Norway.
 Related to a planned CO₂ pipeline for bringing CO₂ from the continent to Norway for use in EOR.
- 40) *Increased energy savings in water/oil separation through advanced fundamental emulsion paradigms (2011 - 2015)*
 This project is managed by the Ugelstad Laboratory at NTNU (Prof. Johan Sjøblom) and the main objective is to optimize separation of emulsions in oil/gas processing through increased fundamental understanding from experimental and theoretical studies.
 theoretical work and a PhD student in Kvammes group
- 41) *Production of natural gas from hydrates (2013-2015)*
 This project is totally funded by STATOIL and supports one PhD student and running costs.
 The main purpose of this PhD study is to evaluate critical components of hydrate production using different methods, also including combined CO₂ storage and energy production
- 42) *Fundamentals of zeolite membrane separation for removal of water from natural gas (2013-2015)*
 This project is funded by STATOIL and covers salary for one PhD student plus partial efforts from another student. Total budget is 5 MNOK.
 The main purpose of the project is to establish fundamental understanding of separation of water from natural gas with impurities. In particular triethylene glycol content that might pollute the mebranes due to accumulation over time and limited ability to evaporate from the membrane during the regeneration. Another goal is to establish detailed data on thermodynamics and kinetics related to transport through these membranes.

- 43) *Safe long term storage sealing of co2 in hydrate (2013-2015)*
This project is funded by the Research Council of Norway and industry. It covers salary for two PhD students plus a post.doc for one year. Total budget is 7,5 MNOK of which RCN covers 6 MNOK.. The main purpose of the project is continue the development of next generation of hydrate reservoir simulator and have three main focus areas. The first PhD study is devoted to state of the art kinetic modelling of hydrate phase transitions, subsequent simplifications and implementations into the reservoir simulator. The second PhD study is applies pore scale modelling to develop new relationships for permeability in hydrate filled sediments. The post.doc project will focus on improvements in the heat transport models inside the reservoir simulator but will also assist in the implementation of results from the two other PhD projects.
- 44) *Surfactants for water/CO2/Hydrocarbon emulsions for combined CO2 storage and utilization (2014 – 2017)*
This project is funded by VISTA (STATOIL fundamental research program as administered through the Norwegian Science Academy) It covers salary a post.doc for three years from July 2014. Total budget is 3.5 MNOK
The aim of this project is to develop emulsifiers for water/CO2 which creates even more stable emulsions between water and residual hydrocarbons so that after injection in a reservoir the emulsifier will be active in releasing hydrocarbons while at the same time releasing CO2 for EOR from the water/CO2 emulsion. The kinetics of transition from a water/CO2 emulsion to the water/hydrocarbon one which decided the balance between these two extremes can be controlled by the design of the emulsifier, which is one of the goals of this project. The water/hydrocarbon emulsion will also contribute to the release of residual hydrocarbons. The combined storage and utilization aspects will be applicable even for smaller CO2 volumes normally considered feasible for EOR.
- 45) *Surfactants for water/CO2/Hydrocarbon emulsions for EOR (2015 – 2018)*
This project is funded by The Research Council of Norway It covers salary a PhD for three years from September 2014. Total budget is 3.6 MNOK
The aim of this project is, through fundamental theoretical methods like Quantum mechanics and molecular simulations, to develop next generation of emulsifiers for water and CO2 which would be even more active towards residual oil. This project is complementary to the VISTA project but on a smaller scale (nano) with more fundamental details. They integrate both in terms that this project will explore fundamental mechanisms but also provide thermodynamic properties, interface properties and transport properties to be applied in larger (micro) scale modeling under the VISTA funded project

- 46) *Capture of CO₂ in Confined Surfactant Geometries (2015 -2018)*
 This project is a collaboration with NTNU (Ass. Prof. Kristofer Paso) and is funded by NFR with 5.3 MNOK and additionally NTNU has funded one experimental PhD to the NTNU partner. The NFR fund will fund a theoretical post.doc to Kvamme's group
 The aim of this project is to develop a new concept for CO₂ capture based on selective capture of CO₂ in block co polymers. The theoretical methods will primarily be Quantum mechanics and Molecular Dynamics simulations as tools for evaluating optimum structures of block polymers with functional groups that has high selectivity for CO₂ adsorption. The experimental work is focused towards
- 47) *Marine Gas Hydrates: An Indigenous Resource of Natural Gas for Europe (MIGRATE)*
 A network program under the COST action focused on Marine hydrates and essentially European resources.

POTENTIAL NEW PROJECTS

Some new projects are either submitted for potential funding or have been submitted before and in a process of improvement for next call

- 48) *Reliability of subsurface carbon storage*
 This is an EU-project submitted by University of Oslo under FP7-ENERGY. Kvamme will participate on fundamental nano to micro scale modeling of reaction dynamics, with special focus on erosion of well completions and other aspects of close to injection geochemistry and reaction kinetics. This activity involves Kvamme as an associate professor with University of Oslo.
- 49) *EERA*
 A proposed European project on gas hydrate energy coordinated by Klaus Wallman of IFM-GEOMAR. Work is in progress on developing the application for possible EU funding.

PATENTS

- 1) Graue, A., Kvamme, B., UiB, ConocoPhillips: Production of free gas by gas hydrate conversion. US Patent 7222673. Patented in 23 countries
- 2) Kvamme, B., UoB: US Patent 8129316 : Method of creating a carbon dioxide hydrate

GRADUATE COURSES (M.Sc. level)

For courses given at Telemark college (“Høgskolen I Telemark”) credits are recalculated from the old credits to the present system based upon the size of the course relative to total credits per year.

Courses at Telemark College (1988 – 1998)

- 1) *Prosess Modelling. (15 credits)*
This course contains two main parts, dynamical modelling and thermodynamics, approximately 50% each. The thermodynamic part (Bjørn Kvamme) gives a basic introduction to first and second laws analysis, including stability analysis and the necessary bridge to dynamical balances of process equipment.
- 2) *Technical Thermodynamics I. (15 credits)*
Advanced course in applied thermodynamics. Based on previous thermodynamic courses of 2 vt. or more at University or Høgskole level and an introduction in the course *Prosess Modelling* (see above).
- 3) *Technical Thermodynamic II. (15 credits)*
Advanced course where approximately half of the course is dedicated to the basic physical understanding of fluid behaviour and the second half is dedicated to modern industrial thermodynamic models.

Course at “Senter for etter og videreutdanning” at UoB (1999 and 2000)

- 4) *Natural gas processing. (15 credits)*
This course focus on the most important processes involved in natural gas processing and involves flow sheet calculations, P&ID as well as discussion of individual processes in detail in terms of thermodynamic and hydro-dynamic issues.

Courses at UoB (from 2000)

- 5) *Fundamentals of separation Technology. (10 credits)*
This is more or less a standard “chemical engineering” course giving the the fundamental background of typical separation processes like one stage separation, distillation and other types of unit operations. The course also includes membranes and their relevance to modern separation technology.
- 6) *Separation prosesses. (10 credits)*
This is a fundamental introduction course to the basic principles of multicomponent, multistage separation as encountered in chemical engineering, with special emphasis on distillation, adsorption, extraction and membrane processes. Process dynamics, thermodynamic models, flowsheet calculations and process optimization. (Every second year – next autumn 2006)

- 7) *Fundamentals and theory for hydrate kinetics and stability. (10 credits)*
Structures and properties of hydrate, kinetic models for hydrate formation, dissociation and reformation. Practical implications. Hydrate occurrences in nature and implications of rock/fluid/hydrate interactions. Environmental aspects. (Every second year – next autumn 2007)
- 8) *Statistical mechanics and molecular modelling. (10 credits)*
This course gives a brief introduction to statistical mechanics in order to bridge molecular simulations over to evaluation of physical properties and transport properties of solids and fluids. Different approaches for molecular simulations, with special emphasis on Monte Carlo simulations, Molecular Dynamics simulations and Brownian dynamics. Design of appropriate simulation ensembles and border conditions between ensemble and surroundings. (Irregular)

GRADUATE COURSES (Ph.D level):

- 1) *Thermodynamics and structures in molecular fluids. (15 credits)*
This is an advanced course with the main focus on modern integral equation theories for complex multi-atomic molecules with special emphasis on estimation of structure and thermodynamic properties.

A number of other courses are frequently being supervised in relation to PhD-studies.

OTHER COURSES:

- 1) *Parts of the course "Olje- og gass-produksjon offshore", held as an "EEU-kurs" at NTH 1994.*
- 2) *"A brief introduction to statistical mechanics". A course held for scientific personell at NTH, Laboratory of Chemical Engineering, 1993.*

PERTINENT PUBLICATIONS

Reviewed publications in scientific journals, 5 latest years

Kvamme, B., Kuznetsova, T., Uppstad, D., "Modeling excess surface energy in dry and wetted calcite systems", 2009, Journal of Mathematical Chemistry: Volume 46, 3, Page 756 - 762

Kvamme, B., Kuznetsova, T., "Investigation into stability and interfacial properties of CO₂ hydrate - aqueous fluid system", Mathematical and Computer Modelling, 51 (2010) 156-159