SUBPRO Symposium 2023

SUBPRO SFI Closing event
SUBPRO ZERO Kick-Off

Trondheim, Monday 27 Nov. 2023

Password Britannia: **KonferanseC**

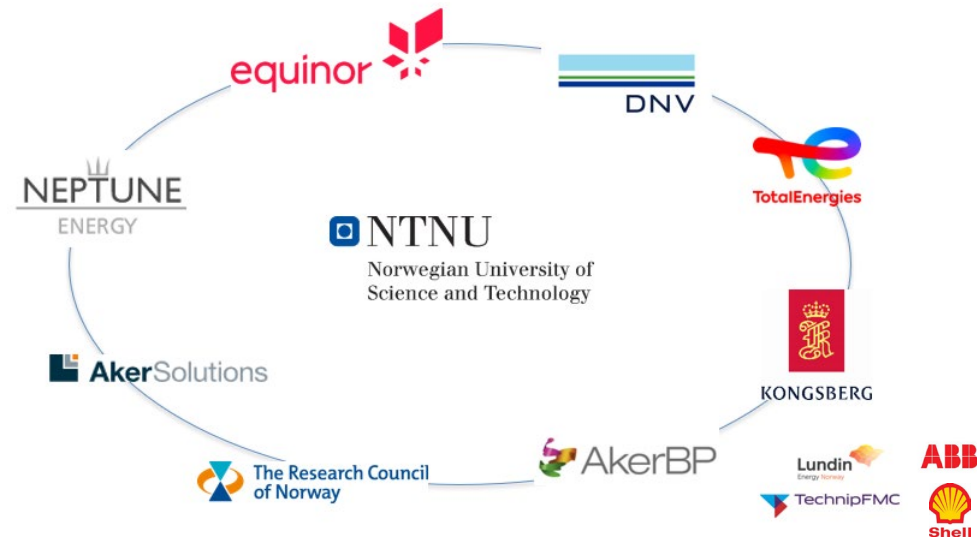# SUBPRO Symposium 2023

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Sigurd Skogestad, Director SUBPRO

Trondheim, Monday 27 Nov. 2023

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SUBPRO SFI 2015-2023

sfi SUBPRO

- Største forskningsprogrammet i Norge (og kanskje i verden) innen subsea olje og gass
- 256 millioner NOK i perioden 2015-23. Forskningsrådet (31%), partnere (54%) og NTNU (15%).
- Hvorfor? Utdanne topp kandidater og styrke den akademiske forskningen innen fem viktige fagområder:
  - **Field architecture**
  - **Reliability, availability maintenance and safety**
  - **Fluid characterization and flow assurance**
  - **Separation process concepts**
  - **Systems control**
- Forskningen skjer ved NTNU. 3 fakulteter og 4 institutter (med 25 professorer involvert):
  - **Institutt for kjemisk prosessteknologi**
  - **Institutt for geovitenskap og petroleum**
  - **Institutt for maskinteknikk og produksjon**
  - **Institutt for teknisk kybernetikk**
- Tett partnerskap med industrien som prioriterer forskningsprosjekter, følger opp, deler kunnskap, data og programvare og støtter innnovasjonsaktiviteter.
- Viktig innovasjnsoverføring: Våre kandidater 2015-23
  - **35 PhD kandidater (3 år)**
    - **Av disse: 12 med innovasjonsstipend for for overføring av resultater til partnere**
  - **11 postdocs (3 år) + 16 ett-års forskere**
  - **120 masterstudenter**
- De aller SUBPRO-kandidatene fleste har gått til relevante jobber I olje- og gassindustrien.
- Fremtid: O&G sektoren foran en stor omstilling for å bli karbon-nøytral.
- Partnerene i SUBPRO finansierer SUBPRO Zero 2023-2025. 100% industrifinansiert. 3 millioner kroner pr år fra hver operatørpartner.
- Beviser at partnerne er meget godt fornøyd med SUBPRO.
  - «The proof of the pudding is in the earing» / «Follow the money»

SUBPRO PROJECTS 2015-2023. Each box is one person in 3 years

SUBPRO

FIELD ARCHITECTURE Prof. Sigbjørn Sangesland	RELIABILITY, MAINTENANCE AND SAFETY Prof. Jørn Vatn	SEPARATION – FLUID CHARACTERIZATION Prof. Gisle Øye	SEPARATION - PROCESS CONCEPTS Prof. Hugo Jakobsen	SYSTEM CONTROL Prof. Johannes Jäschke	

Finished
Ongoing

1.1 Subsea gate box
Mariana Diaz, Postdoc
Prof. Sigbjørn Sangesland

1.1.b Optimization of subsea layout
Leonardo Sales, PhD from Jan 2020
Assoc. Prof. Milan Stanko

1.1.c Low cost subsea field development
Lucas Cantinelli Sevillano, Postdoc from Nov. 2020
Prof. Sigbjørn Sangesland

1.1.d Valves and materials – design concepts for simplifications
Mehman Ahmadli, PhD from Aug 2021
Prof. Tor Berge Gjersvik

1.2 Field development concepts
Diana Gonzalez, PhD
Assoc. Prof. Milan Stanko

1.3 Multiphase boosting models
Gilberto Nunez,
Prof. Sigbjørn Sangesland

1.4 Optimizing subsea production systems to minimize risk and cost
Haoge Liu, PhD/Researcher
Prof. Tor B. Gjersvik

Muhammad Gibran Alfarizi, associated PhD (RAMS)

3.1 New safety and control philosophy for subsea
HyungJu Kim, Postdoc
Prof. Mary A. Lundteigen

3.1.b Safety-critical systems for unmanned facilities
Tae Hwan Lee, PhD from Oct. 2019
Prof. Mary A. Lundteigen

3.1.c Digital twin for safety demonstration
Ludvig Björklund, PhD from August 2020
Prof. Mary A. Lundteigen

3.1.d Digital Twin Qualification for Maintenance
Jie Liu, PhD from Sept 2021,
Prof. Shen Yin

3.2 Reliability and availability in design
Juntao Zhang, PhD
Prof. Mary A. Lundteigen

3.3 Condition and prognostic maintenance
Yun Zhang, PhD
Prof. Anne Barros

3.3.b Optimizing condition monitoring
Himanshu Srivastav, PhD, defended in March 2021
Prof. Anne Barros

3.3.c Estimation and optimization of remaining useful life
Xingheng Liu, Postdoc from October 2020
Prof. Jørn Vatn

SPINOFF: SAFETY 4.0 – Developing framework for novel subsea concepts and technologies.
Nanda Zikrullah, PhD
Prof. Mary Ann Lundteigen

2.1 Produced water quality and injectivity
Marcin Dudek, PhD
Prof. Gisle Øye

2.1.b Influence of chemicals on produced water quality
Marcin Dudek, Postdoc
Prof. Gisle Øye

2.1.c Re-inj. of prod. water – disp. in porous media
Ilgar Azizov, PhD Aug 2019
Prof. Gisle Øye

2.1.d Gas flotation for subsea produced water treatment
Martina Piccioli, PhD from Jan 2020 Prof. Gisle Øye

2.2 Prevention of wax deposition
Jost Ruwoldt, PhD
Prof. Johan Sjøblom

2.2.b Flow improvers for waxy crudes
George Claudiu Savulescu, PhD from August 2020
Prof. Gisle Øye

2.3 Sequential separation
Are Bertheussen, PhD
Prof. Johan Sjøblom
Res. Sebastien Simon

2.8 Modeling of coalescence
Aleksandar Mehandzhiyski, PhD
Assoc. Prof. Brian A. Grimes

2.8.b Multiphase Separation and Transport Model Library
Moein Assar, PhD Oct 2019
Assoc. Prof. Brian A. Grimes

2.4 Membranes for gas dehydration (modeling)
Kristin Dalane. PhD
Prof. Liyuan Deng/
Prof. Magne Hillestad

2.4.b Membrane testing for gas dehydration
Mahdi Ahmadi, PhD
Prof. Liyuan Deng

2.4.c Natural gas dehydration with the use of membranes
Mahdi Ahmadi, Postdoc
Niloufar Rezaei, Researcher from July 2022, Prof. Magne Hillestad / Prof. Liyuan Deng

2.5 Combined H_2S and hydrate control
Eirini Skylogianni, PhD
Prof. Hanna Knuutila

2.6 Characterization of particle breakup
(Jing Shi , former Postdoc)
Nicolás La Forgia, Researcher
Prof. Hugo A. Jakobsen

2.6.b Mechanistic modeling of droplet breakage,
Hanieh Karbas, Postdoc
Prof. Hugo A. Jakobsen

2.7 Experiments on fluid particle breakage
Eirik Helno Herø, PhD
Prof. Hugo A. Jakobsen

2.9 Compact separation
Håvard S. Skjefstad, PhD
Assoc. Prof. Milan Stanko

2.9.b Subsea bulk oil-water separation
Hamidreza Asaadian, PhD from March 2020
Assoc. Prof. Milan Stanko

3.4 Dynamic simulation model library
Christoph Backi, Postdoc
Prof. Sigurd Skogestad

3.5 Modelling for control of subsea processes
Torstein Kristoffersen, PhD
Assoc. Prof. Christian Holden

3.5.b Process control algorithms
Mishiga Vallabhan, PhD
Assoc. Prof. Christian Holden

3.5.c Energy-optimal subsea prod. and processing
Asli Karacelik, PhD (3) from September 2020, Assoc. Prof. Christian Holden

3.6 Adaptive control of subsea processes
Sveinung J. Ohrem, PhD
Assoc. Prof. Christian Holden

3.7 Estimation of un-measured variables
Tamal Das, PhD
Assoc. Prof. Johannes Jäschke

3.7.b Enhanced virtual flow metering
Timur Bikmukhametov, PhD (3),
Assoc. Prof. Johannes Jäschke

3.7.c High-accuracy virtual flow metering with machine learning and first principles models
Md Rizwan, PhD from January 2021
Assoc. Prof. Christian Holden

3.8 Control for extending component life,
Adriaen Verheyleweghen, PhD
Assoc. Prof. Johannes Jäschke

3.8.b Experimental validation of methods - Remaining Useful Life (RUL)
José Matias, Postdoc
Assoc. Prof. Johannes Jäschke

3.9 Production optimization under uncertainty
Dinesh Krishnamoorthy, PhD
Prof. Sigurd Skogestad

3.9.b Field-wide production optimization
Risvan Dirza, PhD from Feb 2020
Prof. Sigurd Skogestad

3.10 Calibration of digital twins
Halvor A. Krog, PhD from August 2020
Prof. Johannes Jäschke

SPINOFF: AutoPRO
Evren Turan, PhD (SC)
Rafael Oliveira, Postdoc (SC)
Emefon Dan, PhD (RAMS)
Prof. Johannes Jâschke/Yiliu Liu

Pressemelding SUBPRO Zero

Oljeindustrien gir 47,5 millioner til NTNU for å forske på overgangen til null-utslipp offshore.

Forskningsrådet og oljeindustrien har i samarbeid finansiert et senter for forskningsdrevet innovasjon (SFI) ved NTNU innen subsea produksjon og prosessering (SUBPRO). Senteret har operert i 8 år og har hatt et budsjett på 240 millioner kroner. Fire institutt ved NTNU har vært involvert, og 35 phd-kandidater, 11 postdoktorer og mer enn 90 masterstudenter har blitt utdannet fra senteret. Prosjektet avsluttes i disse dager og resultater presenteres på et symposium i Trondheim den 27. november på Britannia Hotel.

Industripartnerne har vært så fornøyd med samarbeidet og resultatene i SUBPRO at de har bestemt seg for å gå videre med et 3-årig 100% industrifinansiert prosjekt (SUBPRO Zero) der målet er å forske på teknologi som vil bidra til null-utslipp fra olje og gassindustrien. Avslutningssymposiet for SUBPRO markerer også den offisielle oppstarten av SUBPRO Zero (*Sustainable bridge program towards Zero emissions*).   SUBPRO Zero fokuserer på følgende hovedområder: Karbonfangst og blå hydrogen (nullutslipp til luft), vannbehandling og injeksjon (nullutslipp til sjø), digitalisering, optimalisering og energieffektivitet, og feltarkitektur og pålitelighet, tilgjengelighet og sikkerhet. I tillegg til forskningen, skal SUBPRO-Zero-senteret utdanne 9 phd-kandidater, 3 postdoktorer og 20 masterstudenter som vil bidra til det grønne skiftet. Senteret ledes av professor Johannes Jäschke ved Institutt for kjemisk prosessteknologi ved NTNU og partnere er

- Equinor
- TotalEnergies
- AkerBP
- Neptune Energy
- Vår Energy
- Petrobras
- Kongsberg Digital
- Aker Solutions
- Siemens Energy

Program. Monday 27 November 2023:

09.00 Mingling
09.30 Welcome to the SUBPRO symposium (Sigurd Skogestad)
Presentation of project results:
09.45 Field Architecture (Sigbjørn Sangesland/Milan Stanko)
10.10 System Control (Johannes Jäschke)
10.35 Coffee Break
10.50 Subsea separation: Droplet Breakage and Coalescence (Hugo Jakobsen)
11.00 Subsea separation: Membranes for gas treatment (Liyuan Deng)
11.10 Subsea separation: Fluid Characterization (Gisle Øye)
11.25   Lunch Break
12.25 Reliability and safety (RAMS) (Mary Ann Lundteigen/Jørn Vatn)
12.45 **Industry partner's experience from SUBPRO** (approx. 5 min each partner)
13.20 Summary: 8 years of SUBPRO (Sigurd Skogestad)
The future:
13.30 "Technology to provide Norwegian energy to Europe during the energy transition",
Gunnar Lille, Director, Norwegian Research Council, OG21 Program
14.10 "The future as seen from NTNU", Anne Borg, Rector, NTNU
14.30 Coffee Break
15.00 "The future as seen from AkerBP", Thomas Bognø, Vice President for Business
Transformation, Aker BP
15.30 "The future as seen from Equinor", Andreas Jagtøyen, Senior Vice President for
Renewables and Low carbon, Technology Digital and Innovation, Equinor
16.00 Official opening of the new SUBPRO Zero project (Johannes Jäschke)
17.00 End of seminar

18.30 Aperitiff (Britannia Hotel)
19.15 Dinner
22.00 End

Theodor a.k.a. Akademisk bordvers

Jeg elskede sjøen ifra jeg var ung
og svømmede om som en sei,
faderiorei.
En dag da jeg badet min velskapte kropp,
kun bagenden ragede op,
faderiorei.
:/: Folk ropte: "Der svømmer en aligator!"
Så var det (bank bank) til Theodor. :/:

Bortglemte, men gjenoppdagede, ekstra vers:

Jeg rødmet og tenkte: "Nu er jeg blamert!"
og dukkede ned i en fei
faderiorei.

Men dypet det pressede tungt på min kropp
og boblene boblede opp
faderiorei.

:/:Folk ropte: "Her dufter det svovel og klor!"
Så var det (bank bank) til Theodor. :/:

Jeg tenkede: "Sjøen kan blive min grav!"
Og tanken den fengede ei
faderiorei.

Jeg stigede derfor til sjøfladens topp
med forenden ragende opp
faderiorei.

:/:Folk ropte: "Der stiger en flaggstang så stor!"
Så var det (bank bank) til Theodor. :/:
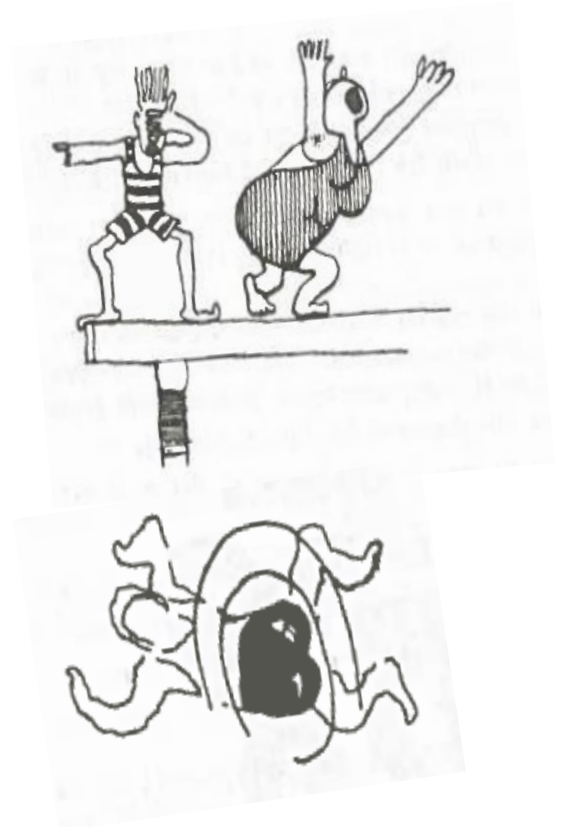
Meny 3-retter

Gravet ørret fra Garnvik

Agur, eddik gelé, sprø rug og ørretrogn Brilliant

***

Stekt andebryst

*Vinterkålvekster, bakt plomme, potetkrem
og plomme sjy*

***

Vanilje Pavlova

Marinerte multer, krokan og multeis

Survey partners

- Neptune

- Olav Dolonen

- , What is your experience with SUBPRO?
Answer; Neptune Energy has been participating in SUBPRO since start of the research project. The experience from organizing the project has been good. All TC- and board meeting has been arranged in time with sufficient information about activities and achieved results.

- 2. Can you mention a case where a result from SUBPRO research have come into practical use (in your company or others)?

- Answer; The research results from SUBPRO has in general increased the overall understanding in Neptune Energy of specific issues regarding subsea processing and hydrocarbon flowline transport.

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- AkerBP

- Edmary Altamiranda Maldonado

1. SUBPRO has been a fantastic arena for cross collaboration among operators, suppliers & academia, to define research directions for Subsea Production & Processing Systems, push state of the art in the different research areas to address industry needs with very good results.

2. See Press Release below related to OFFA (Optimal & Flexible Field Architectures)

https://eur01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fdeepseedsolutions.com%2Fmedias%2Fpress-release-optimal-flexible-field-architectures-offa%2F&data=05%7C01%7Cedmary.altamiranda%40akerbp.com%7Cc6f005f3eac54bc190cd08dbbb99df89%7C3b7e417083484aa4bfae06a3e1867469%7C0%7C0%7C638310041827956424%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTil6lk1haWwiLCJXVCl6Mn0%3D%7C3000%7C%7C%7C&sdata=MHatgp6y%2Fpdp%2BnMehnNK%2F91XBvEGs5%2BwbG%2Bh0L5fWls%3D&reserved=0

- DNV

- Frank Børre Pedersen, Vice President

1. . **What is your experience with SUBPRO?**

DNV has experienced SUBPRO to be a very professional center for research-driven innovation. The center has very actively involved the industry on multi-disciplinary topics in a way that has created large industrial value. A good balance between deep research and broader innovation has been key. This was also recognized by the mid evolution of SUBPRO.

DNV engaged primarily into the RAMS part of SUBPRO. Here we collaborated closely with the DNV funded professors, post.docs and PhD students. This close work made it possible for us to contribute to and also harvest from the scientific work at SUBPRO.

The organization and execution model of the center has also allowed industry to engage in an efficient way to both provide inputs and feedbacks, and also to learn and harvest results. The organizational structure with research areas has made it possible for DNV to engage where we can meaningfully contribute and harvest in an effective way.

2. **Can you mention a case where a result from SUBPRO research have come into practical use (in your company or others)?**

For DNV, one very valuable outcome of SUBPRO was the dialogue in SUBPRO that lead to DNV applying for a new IPN project with the Norwegian Research Council called Safety 4.0. This project built on work in SUBPRO and involved the same partners. Safety 4.0 was adapting work from SUBPRO, developing new insights and implementing this into industrial applications. This initiative would not have happened without SUBPRO.

This work again has created the foundation for DNVs new Recommended Practice called "Assurance of AI-Enabled Systems" which was released in October 2023.

Press Release – Optimal & Flexible Field Architectures (OFFA).

Media

Deep Seed Solutions, that has been dedicated to solving complex engineering problems through digital transformation, today announced a new contract with Aker BP ASA to undergo an R&D project called "**Optimal & Flexible Field Architectures**" (OFFA). This project aims to create conceptual engineering alternatives for offshore subsea decentralized processing systems, considering production potential and development cost in the screening and optimization of options in an automated way using evolutionary algorithms.

From a software perspective, the **OFFA** project will be developed based on modern codes and platforms, attending to all client's requirements for sharing and cooperation between the various business units and disciplines. It will also connect the "**Subsea Processing Module**" in **FLOCO®** with existent data repository, applications, digital platforms, and software (e.g relevant Aker BP digital ecosystem for Field Development)

"**OFFA** was initiated by **Aker BP ASA** as a Postdoctoral Research Co-Supervision initiative within **SUBPRO** *SUBPRO – Subsea Production and Processing – NTNU* and has continued the development internally in collaboration with Academia. This next development stage with Deep Seed Solutions will focus on the further development, implementation, and qualification of **OFFA** within **FLOCO®** considering the harmonization with **FLOCO®** existing capabilities. This pushes boundaries of the state of the art within Field Development, as decentralized processing can be the stepping-stone into subsea factory in the future. This can enable debottlenecking of processing capacity in legacy facilities, as well as reduce topside processing footprint for new facilities"– says Edmary Altamiranda, Controls & Systems **Engineering Lead Technology R&D at Aker BP**.

According to Leandro Basilio, **CEO** at **Deep Seed Solutions**: "Our goal is to help Aker BP achieve the maximum efficiency in its capital projects through our expert System **FLOCO®**, which combined with the disruptive approach for generating subsea layouts using an evolutionary algorithm will potentially enhance the projects' NPV calculated for each alternative generated."

At the end of the project, this feature will be available commercially as an advanced module in **FLOCO®**, allowing other Clients to take advantage of this technology.

About Deep Seed Solutions: Deep Seed Solutions is an innovative organization, targeted at developing technologies applied to complex engineering processes. With a focus on the **Energy Industry**, the company is collaborating with the efficiency of capital projects, the low carbon economy, and the energy transition, through its strong expertise in digital transformation.

About Aker BP: Aker BP is a company engaged in exploration, field development and production of oil and gas on the Norwegian continental shelf. The company operates six field centres: Alvheim, Ivar Aasen, Skarv, Edvard Grieg, Ula and Valhall, and is a partner in the Johan Sverdrup licence. **Aker BP** has made strong commitments to a wide range of digitalisation measures aimed at increasing productivity, maximise value creation and reduce emissions. Measured in production, **Aker BP** is one of the largest independent oil companies in Europe.

For more information, visit *https://akerbp.com/*

Survey PhD students etc

- Torstein Thode Kristoffersen, Equinor

- PhD with Christian Holden

- 1.What is your experience with SUBPRO?
Answer: I, as a former PhD candidate, had some fantastic years at NTNU and SUBPRO working with great minds helping me to grow as an engineer and coworker. To me, SUBPRO was not so much about the results, but more about the knowledge and competency received from completing the studies. The background I received has allowed me to work with advanced research within Equinor and being brought forward to discuss and collaborate with Contractors like Google abroad on topics like AI. I'm truly grateful for the solid, technical basis I obtained from SUBPRO. I believe this background has been an enabler for my career in Equinor.

- 2. Can you mention a case where a result from SUBPRO research have come into practical use (in your company or others)?

- Answer; , SUBPRO was to me more about the knowledge and competency received from completing the studies. As part of my research, I've among others learned about virtual flow measurements. At Johan Castberg, outlet flow measurements of cargo pumps were left out of engineering design and when observed too late to be physically installed. Currently, we (Johan Castberg Team) are now deriving a soft/virtual flow measurement based on calculation and logic for minimum flow protection and use of load sharing between cargo pumps. This is not directly linked to a result from SUBPRO, but the knowledge from such methods is a contribution to the development.

- NN (Marcin Dudek), Jotun

- PhD with Gisle Øye

1. I had a very good experience with SUBPRO. With the resource made available through the project, we were allowed to build a whole new methodology platform, which not only was continuously utilized by other SUBPRO projects, but also enabled many different projects (not necessarily oil-related) to be run in our research group. There was a lot of training and courses opportunities, as well as good support for scientific disseminations (open-access papers, conferences) and research stays for many of SUBPRO participants. The collaboration within the center was also often catalyzed by frequent group meetings and social events.

2. It is a little bit difficult to cite a real-life application case, as I was working with quite fundamental phenomena connected to separation processes. I think that for all of the results we have shown throughout the duration of the project, it was clear that separation is not only a physical phenomenon, as often it is treated from the process point of view, but it also depends on the (surface) chemistry of the main components: gas, oil, water and solids. If that would be the only lesson taken by the industrial partners from my project, I would deem it quite a success.

- Haoge Liu

- PhD with Tor Berge Gjersvik

- Looking for job

- 1.What is your experience with SUBPRO?
Answer: I started PhD in SUBPRO on Nov 9th, 2018, and successfully got the degree on Feb. 8th, 2022. Because of the good academic results during my PhD, I continued as a researcher in SUBPRO to explore the possible commecialization of my academic achievements.

- 2. Can you mention a case where a result from SUBPRO research have come into practical use? Answer: Currently, the results haven't created practical values for the industry. However, a partial result, i.e., the well trajectory design method was used by NTNU BRU21's Drillbotics team to design the optimal trajectory for consecutive targets, which contributed to the final championship of the team in the SPE Drillbotics Competition 2022.

- Besides, Equinor and TotalEnergies want to develop my academic results into a tool that can be easily used by the engineers for subsea field layout optimization. The contract from Equinor is ready and we are looking forward to the practical values that our academic results from SUBPRO can bring in the near future.

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- Mahdi Ahmadi, One Subsea

- PhD with Christian Holden

My experience with SUBPRO during my tenure as a PhD candidate and later as a Postdoc was exceptionally enriching. I worked on a research project focused on subsea dehydration utilizing membrane processes, commencing in 2017. The project progressed through my PhD tenure and extended into my two-years Postdoc position. The support and environment offered by SUBPRO were instrumental in my success. The research center, situated at NTNU, comprised experts proficient in diverse areas and subsea technologies. It provided me with an invaluable opportunity to expand my expertise in gas separation, membrane technologies, and a profound comprehension of subsea challenges.

At SUBPRO, I engaged in hands-on experimental work, actively participating in various aspects of laboratory work, including membrane fabrication and the construction of testing rigs. The research environment fostered a culture of systematic experimental design, enabling me to enhance my skills comprehensively. Moreover, SUBPRO facilitated my exploration into modeling and simulation such as design of a novel process, CFD simulation, and molecular modeling techniques, further broadening my skill set and understanding.

Beyond academic pursuits, SUBPRO placed significant emphasis on fostering social activities and team building. The center organized numerous events aimed at enhancing networking and communication skills among students and colleagues, contributing to a well-rounded professional development experience.

2. Can you mention a case where a result from SUBPRO research have come into practical use?

While membrane technology might not be widely established for subsea applications, an instance where SUBPRO's research findings were proposed for practical implementation involved addressing high CO_2 concentration in a high-flow-rate gas production field. As part of a study concept project, our team identified the challenge of elevated CO_2 levels and proposed utilizing membrane gas separation technology as a potential solution to remove CO_2 at the source, specifically in a subsea environment.

This initiative highlights the application of knowledge gained through SUBPRO's research in considering innovative solutions for subsea challenges, such as the utilization of membrane gas separation technology for CO_2 removal in high-flow-rate gas production fields.

It's worth noting that while the immediate progress might not be known, the proposal represents an attempt to leverage emerging technologies, like membrane gas separation, which may eventually contribute to the advancement of subsea gas processing methods, enhancing environmental sustainability and operational efficiency in the industry.

Survey PhD students etc

- Nanda A. Zikrullah, DNV
- PhD with Mary Ann Lundteigen

1, What is your experience with SUBPRO?

One of the highlights of my experience has been actively participating in industry conferences, workshops, and seminars, where I presented my research findings and engaged in discussions with industry professionals. These interactions have expanded my network and provided me with a broader perspective on the practical implications of our research, including the limitation that I was unaware of from the theoretical perspective. This resulted in a unique blend of academic and practical skills that I have already applied in my daily work as a consultant.

In addition, frequent meetings with other international researchers, even outside of my discipline area, allow me to integrate insights from different disciplines. During the joint seminars, I have consistently sought to convey complex ideas in a manner accessible to colleagues from diverse academic backgrounds. This experience has strengthened my communication skills and equipped me with a versatile skill set. The most obvious impact is that I am now adept at navigating the complexities of interdisciplinary collaboration, fostering inclusivity, and leveraging diverse perspectives during my daily work.

2. Can you mention a case where a result from SUBPRO research have come into practical use?

I summarise the case as follows without going into details due to confidentiality. The method I utilised and contributed to during my research is yet to be adopted as an industrial practice. Hence, I thought it may not be used anytime soon. However, I got an opportunity to participate in industry research projects in a different domain (than what I have applied it for during my study), where we concluded that the method was best fit for use during the safety design analysis of the product, though not the full method due to its complexity. My colleague adapted part of the method to a more well-known method in the industry for ease of adoption (by the industry), and I contributed to testing that in different applications and feedback on the results to him as input for improvement. Currently, the adapted method has been strongly considered to be the standard use for similar applications by the authorities, and it will lead to specific services that my company could provide to help and guide the industry stakeholders during the safety design analysis of the product. This case shows how part of cutting-edge research could be adapted further for practical industrial applications.

- **Tamal Das,** Cyient Norway,
- PhD with Johannes Jäschke

1. What is my experience with SUBPRO?

SUBPRO PhD candidature was a wonderful experience. Due to the involvement of several disciplines in the project, I could get a whole different perspective attending lectures on diverse topics. Involvement and feedback from Industry partners meant we were not as far removed from reality as academic research tends to otherwise be. For me, I got the opportunity to conduct my PhD studies and upgrade my domain knowledge at a very good university and research with the freedom to explore, yet with able guidance from professors and industry partners when needed. It was valuable and I thrived. I got a job contract from one of the former industry partners after I graduated meant that post PhD I had a smooth transition. It was also social and vibrant those three years with activities, get-togethers. I indeed learned to ski due to a course offered by SUBPRO. All in all, it was a positive experience and it made a difference in my life. It is probably due to SUBPRO, I came to Norway and I continue to live in Norway still 5 years after the completion of my PhD. It gave me some years to adapt to Norwegian culture and weather, before I embark upon a work life in the Norwegian industry. Thank you SUBPRO.

2. Can I mention a case where a result from SUBPRO research has come into practical use?

It would be difficult for me to link a specific result to fruition in practical use. In my case, the things learned/researched on did definitely help in contributing to the post-PhD work life effectively. It in some ways enabled me to work in the Norwegian oil and gas sector, which I knew nothing about beforehand. My work with the produced water treatment during my PhD helped make better judgements and interpret data better to act upon when I was working with automation systems in the north sea offshore platforms in 2021 and 2022. The knowledge gained in process control, optimization and controller tuning during PhD years was almost as is used for many of the tuning tasks. Though the direct use of the SUBPRO results in the industry is a bit subjective, the impact of SUBPRO is nonetheless paramount.

- Adriaen Verheyleweghen, Cybernetica
- PhD with Johannes Jäschke

1. What is my experience with SUBPRO?

"My experience with SUBPRO has been very positive. I really appreciated the cross-disciplinary nature of the consortium, where researchers from different fields and from industry collaborated. Not only did that improve the scientific outcomes from the project, but it also contributed to a better work environment! "

2,

"Yes! While I haven't used the results and methods developed in the project directly, In my current position as control engineer, I have on many occasions encountered problems similar to those I investigated during my PhD (optimal operation, reliability-focused operation, etc.) and have benefited from the ideas and mindset developed during the PhD."

- Dinesh Krishnamoorthy, TU Eindhoven
- PhD with Sigurd Skogestad

1. What is my experience with SUBPRO?

I had an incredibly enriching experience as a Ph.D. student in SUBPRO. The consortium played a pivotal role in expanding my professional horizons and connecting me with a diverse community of researchers. Compared to industrial research, I personally experienced that SUBPRO enabled the perfect balance between applied and fundamental research. The support and camaraderie within the network, and the social and educational events created a conducive environment for learning, collaboration, and the exchange of innovative ideas. I am truly grateful for the positive impact this experience has had on my academic journey.

Survey PhD students etc

- **Christoph J. Backi, BASF**

- Postdoc with Sigurd Skogestad

1, What is your experience with SUBPRO?

My experience with SUBPRO is very good. The project had ambitious goals to bridge the gap between academic fundamental research and practical industrial use. The industrial partners' commitment and continued interest throughout the duration of the project shows that these goals could be fulfilled (at least partially).

The important social aspects in the project were also taken care of in the shape of team building events and cross-disciplinary (social) meetings, where one had the chance to get to know colleagues from different backgrounds and disciplines.

2. Since I was employed in SUBPRO in the first three years, I have no overview over which results were commercialized and have been implemented in industry.