Project Title:	**Field-wide production optimization**	
Specifics of project (max. three lines):	Field-wide optimization of subsea wells and processing equipment to increase production while ensuring energy efficient production to reduce carbon emissions.	
SUBPRO PhD project	**Research Area:** **System & Control**	**Supervisor (NTNU):** **Prof. Sigurd Skogestad** **Co-supervisor (NTNU):** **Dinesh Krishnamoorthy**
Impact on industry goals:	**Increased production and Reduced environmental footprint**	
Selected technology:	Online process optimization using existing software infrastructure and advanced optimization tools using machine learning and data analytics	

Project period: 2019-2022

Background and motivation for the project

Daily production optimization is an important aspect throughout the production phase of any oil and gas field, where the objective is to maximize the operational profits on a day-to-day basis. With the recent focus on low carbon footprint of oil and gas operations, the daily production optimization must also aim to reduce the carbon footprint of day-to-day operations in addition to increasing production rates.

In order to take into account the carbon footprint of the subsea production network, it is important to consider not just the subsea wells, but also the subsea processing equipment such as compact separators, subsea compressors and booster pumps in the daily production optimization problem. Therefore, this project will take a holistic view of the entire field including the subsea well network and the subsea processing equipment in the production optimization problem.

Production optimization requires detailed model of the system in order to determine the optimal operation of the field. However, as the complexity of the systems increases, the models used may be uncertain or may not be able to capture the real production system accurately. In order to address this issue, we also propose to incorporate real time production data into real time decision making, by using machine-learning algorithms.

This project will build upon the work of subproject 3.9 (Production optimization under uncertainty, 2016-2019) to further mature software tools and methods in order to optimize production from a field while reducing emissions.

Research activities and deliverables

In subproject 3.9, we have developed different algorithms that can use such transient measurements efficiently in the production optimization problem in order to increase the potential of real time production data. One of the deliveries of the new project is to apply these methods to industrial cases. This project also aims to develop new machine learning based algorithms for online production optimization, which when combined with the existing first-principle models result in what is called a grey-box model. Such a model is more flexible and has potential for further savings.

In subproject 3.9, we have also developed a framework for optimal operation using simple feedback control loops that does not require complex models or additional software tools to implement, where we show that we can achieve optimal operation using simple PI controllers implemented in existing process control systems (PCS). This is especially beneficial in brownfield wells where the motivation to implement advanced optimization tools is low. This approach is also easy to implement, tune and maintain by production engineers and operators and hence are more likely to receive operator acceptance. This project aims to work closely with industrial partners to implement such simple control loops to achieve optimal operation.

The industrial case studies need to be discussed with the relevant partners before the start-up of the project

Innovation potential

- New algorithms for machine-learning based production optimization
- Easy to implement simple control structures in order to achieve optimal operation

Cooperation

- **Main partner: AkerBP or Equinor (possibly with industrial co-supervisor)**
- **Other partners: AkerBP/Equinor, Kongsberg Digital, Lundin, Aker Solutions**
- **Internal SUBPRO: Christian Holden, Dinesh Krishnamoorthy and Allyne dos Santos**
- **BRU21: Lars Imsland**
- **Universities: UFRJ and UFSC (Brazil)**

Literature references (results from previous related subproject 3.9)

Krishnamoorthy, D., Foss, B. and Skogestad, S., 2018. Steady-State Real-time Optimization using Transient Measurements. Computers and Chemical Engineering, Vol 115, p.34-45.

Krishnamoorthy, D., Jahanshahi, E. and Skogestad, S., 2019. A Feedback Real Time Optimization Strategy using a Novel Steady-state Gradient Estimate and Transient Measurements. Ind. Eng. Chem. Res., Vol 58(1), p.207-216.

Krishnamoorthy, D., Jahanshahi, E. and Skogestad, S., 2018. Gas-lift Optimization by Controlling Marginal Gas-Oil Ratio using Transient Measurements, IFAC-papers online Vol 51(8), p.19-24, IFAC OOGP, Esbjerg, Denmark.

Krishnamoorthy, D., Ryu, J. and Skogestad, S., 2019. Dynamic extremum seeking control applied to a gas lifted well network, IFAC DYCOPS-CAB, Florianopolis, Brazil (In-Press)

Krishnamoorthy, D., and Skogestad, S., 2019. Online process optimization with changing active constraint sets using simple feedback control structures. . Ind. Eng. Chem. Res. (submitted).