University teams take on the Minus CO_2 challenge at the EAGE Annual 2019

Christopher Lloyd[1], Ryan Taylor[2], Marco Aurélio[3] and Gemaque Cantuária[3], report on the main findings from the winning teams at the EAGE Minus CO_2 student challenge held at the EAGE Annual Conference in London.

Introduction

The 81st EAGE Conference & Exhibition in London hosted the final of the first EAGE Minus CO_2 Challenge, a competition between universities to develop an oil and gas field with zero net emissions. To qualify for the Minus CO_2 Challenge 2019, the EAGE invited multi-disciplinary teams of students to apply their technical excellence and innovative ideas to develop the Equinor Norne Field, with zero net emissions while maintaining a positive NPV. Out of the ten teams that progressed to round two, three teams were selected for the final based on a video presentation; The University of Manchester (UK), Dalhousie University (Canada) and Universidade Federal Fluminense (Brazil). The development plan devised by each team is summarized below.

The University of Manchester (UoM) development plan

The premise of the UoM team's plan was that the emissions from the entire life cycle of hydrocarbons, not just the upstream emissions, has to be considered for them to be considered a clean energy source. For this reason, a target of 129kg CO_2/bbl was required to be eradicated for the produced oil and gas.

To reach net zero, three emission reduction ideas were used; replace, redeposit and redistribute. Replacing out-dated technology, such as gas-turbines with onshore renewable power drastically reduced the upstream emissions, similar to the development at Johan Sverdrup. However, when considering full life cycle emissions, the addition of a carbon management scheme, such as offshore CO_2 storage is required. For this, the team selected a CCS prospect outlined in the Norwegian Sea CO_2 atlas in the vicinity of the Norne field. Finally the team faced the challenge of where to source the CO_2. This was achieved through redistribution of CO_2 from heavy industry, with a focus on point sources in the north of Norway, under the presumption that southern sources would be used for the Northern Lights Project.

To put the 'Net Zero' development plan into perspective, a business as usual (BAU) scenario was created, where the Norne Field is developed with a purpose of maximising NPV, with little effort made to reduce emissions. The main aspects of the project are summarised below, and where applicable compared to the BAU scenario:

- Onshore renewable power from the Svartisen and Rana hydroelectric plants
- CO_2 acquired from the Kjøpsvik cement plant and Mo industrial park then transported via pipeline to Norne
- 72 Mt CO_2 injected into Prospect D of the Tilje/Are aquifer from the Norwegian Sea CO_2 Atlas
- Split of CO_2 credits of 1:3 in favour of the capture industry
- Net Zero OPEX estimated as 300% larger than BAU OPEX
- 68% reduction in NPV compared to the BAU scenario
- 9% reduction in tax from 78% would result in an NPV the same as the BAU scenario

Dalhousie University (DU) development plan

To reach a goal of zero net emissions, Dalhousie University generated a plan focused on carbon capture from high CO_2 producing industries, while also reducing emissions during transportation of oil. The team used dynamic simulations to create a well placement strategy to maximize production, aiding in the reduction of both cost and CO_2 emissions.

As the main source of CO_2 for carbon capture and sequestration (CCS), a cement plant in Kjøpsvik, Norway, was chosen. Cement plants are responsible for ~5% of the global carbon emissions. Another promising source for CO_2 is waste-to-energy incinerators, which generate 33% more CO_2 than gas power stations. CO_2 is currently being captured from the flue gas at Oslo's largest waste-to-energy incinerator, with future expectations reaching 90% capture of the plant's carbon emissions making this a feasible source for CO_2 capture.

The team also looked into initiatives that reduced carbon emissions during transportation of oil from Norne. E-Shuttle tankers by 42% and consumed up to 22% less fuel than traditional shuttle tankers. Based on oil produced during dynamic simulations, this would result in 350,000 fewer tonnes of CO_2 emitted annually.

In a well to pump scenario, it was calculated that ~6 Mt of CO_2 would be emitted during this project. Therefore, to acquire net zero CO_2 emissions, only 12% of the available pore space was required for CO_2 sequestration leaving the opportunity for commercial CO_2 storage.

Main points:

- Reducing emissions from transportation vessels
- Sourcing CO_2 from industrial sources
- Attaining net zero CO_2 emissions through CCS for well to pump operations

[1] University of Manchester | [2] Dalhousie University | [3] Universidade Federal Fluminense

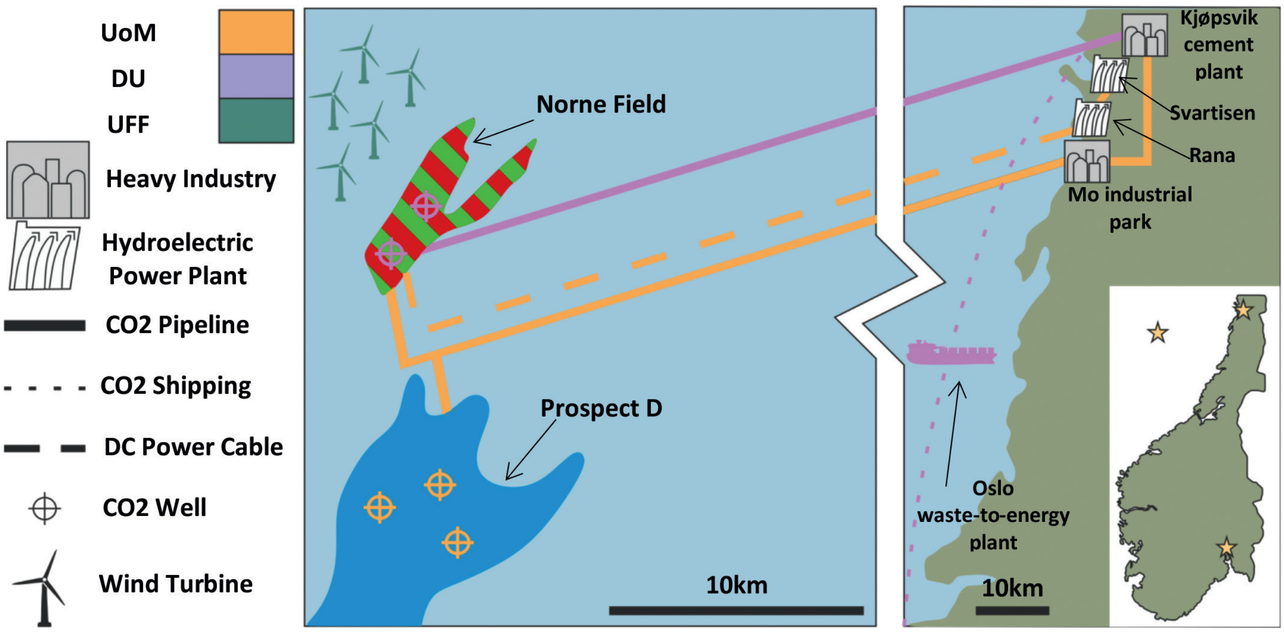

Figure 1.

- Use existing infrastructure to continue CCS in nearby depleted fields

Universidade Federal Fluminense (UFF) development plan

Universidade Federal Fluminense's Project focused on different ways to decrease the emission of CO2 during the production of hydrocarbons, with focus on energy generation and the processing system, along with efficient well planning using geophysical analysis and reservoir management.

The UFF team used a blend of advanced technology with green development such as virtual reality and drones to unman the FPSO's operation and do surveillance of equipment, also machine learning to establish a more efficient production system, creating different combination of production and injection wells that gave the greatest hydrocarbon production to gas/liquid ratio. Using the Hywind Scotland Park as a reference, the team created a strategy to generate energy for the FPSO and subsea equipment, replacing typical gas-turbine operations, reducing CO_2 emissions by more than 80%. Another innovation was the use of No-Flare Ballistic Technology, which was envisioned to keep the gas-flaring as low as possible, only activating when necessary.

Along with that vision, the team had targets for their carbon footprint in support activities, such as drilling and completion, researching rigs that had such a profile, along with decreasing the number of development wells, reaching a 50% recovery factor with 30% fewer wells than the original model. This was achieved using geophysical analysis to enhance the well placement and patterns, obtaining the greatest production possible with the least number of wells.

The main points of their project were:

- Wind Turbine Energy Generation for the FPSO
- Subsea Processing System for Gas and Liquid Separation and Gas treatment/injection
- Unmanned operation of the platform
- Virtual Reality and Drone surveillance of operations
- No-Flare Ballistic Technology
- Support activities CO_2 reduction (such as drilling and completion)

Conclusion

All three teams interpreted the problem in their own way, but all achieved the target of net zero emissions and a positive NPV. This challenge has demonstrated that sustainable field development is not only possible, but with correct economic incentives, a feasible solution that could become the norm in future developments.

Acknowledgements

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The Minus CO_2 challenge winning teams were:

- University of Manchester (Gold): Christopher Lloyd, Ross McTeir, Daniel Odjo, Dominic Skinner
- Dalhousie University (Silver): Ryan Taylor, Jennifer Lee, Sarima Vahrenkamp
- Universidade Federal Fluminense (Bronze): Marco Aurélio Gemaque Cantuária, Paula Camargos, Jackson Fonseca, Priscilla Xavier, Edmarley Costa Ramos