Fuel Cells in Offshore Oil and Gas Production

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Introduction

As global warming, our time's greatest challenge, is becoming our reality at the same time as the world's energy demand increases, there is a pressing need to accelerate the development and application of greener technology in the petroleum industry. Anthropogenic activity pushes the Earth's systems outside of natural variability. In order to address global climate change, our carbon dependent energy systems need to become more carbon neutral as fossil fuels play a key role in fueling global warming.

As the world's energy supply depends on hydrocarbons and global energy demand is set to increase by 37% by 2035, the petroleum industry will continue to extract new fossil reserves to present energy shortage as long as it is profitable. While a growing commitment to gas and oil over coal to some extent aids carbon cuts, the majority of the emission cuts needs to be facilitated by technological advancements and innovation as production is likely to continue well into the 21st century.

The ability to establish good external conditions, develop new technology, and commercialize innovations for cost efficient and competitive solutions are therefore the foundation for future, green value-creation and emission reduction. Several alternative energy solutions, including wind, hybrid, fuel cells and offshore carbon capture and storage (CCS) can be utilized in order to reduce emissions from the Norwegian Continental Shelf (NCS), which represents a quarter of Norway's total emission of greenhouse gases. As emissions from the use of gas turbines alone stands for 81% of the emissions from the NCS and reducing emissions is highly desirable, a feasible solution may be to replace gas turbines with fuel cells.

Objectives

Since fuel cells have not yet been tested in offshore oil and gas production, the main objective of this thesis is to consider the characteristics of the different fuel cell technologies in order to evaluate if fuel cell technology, and in particular which type of fuel cells that can be utilized instead of gas turbines. The thesis will look at advantages and disadvantages obtained from using fuel cell technology, and how these may affect oil and gas production. This paper will also consider the implications for climate, efficiency and money saved by using fuel cell technology as well as examine if fuel cells is a principal way in which the petroleum industry may address climate change.

SWOT analysis

A SWOT analysis is performed in order to highlight the strengths, weaknesses, opportunities and threats of the fuel cell technology. The analysis is an attempt to examine if the technology is able to meet the different technical requirements for power generating systems offshore in order to be a viable competitor to gas turbines.

Strength	**Weaknesses**
• High efficiency • High availability and reliability • Low downtime • Low maintenance	• Low OCV in a single fuel cell • Little fuel flexibility • Relatively low power output • Inrush current • DC • Life span
Opportunities	**Threats**
• Environmental friendly • Large area of application • Increased demand for green technology	• Not cost competitive • Commercial competitors • Fuel safety • Dependence of government support • H_2 production, transportation and storage

Conclusion

Up to this point, no concluding remarks have been drawn.

Working Principle

The characteristic of a fuel cell is its ability to convert chemical energy from a fuel into electrical energy without combustion and emission of greenhouse gasses. The reaction occurs directly, which gives the cell a much higher conversion efficiency than any conventional thermo-mechanical system.

A fuel cell consists of two electrodes, an anode and a cathode, an electrolyte and catalysts. The main functions of the electrodes are to bring about a reaction between the reactant and the electrolyte without being consumed or corroded. The catalyst increases the speed of the chemical reaction, causing the fuel to undergo an oxidation at the anode. This reaction releases electrons and positively charged ions. The positively charged ions move through the electrolyte at the same time as the released electrons move from the anode to the cathode through an external circuit, producing direct current. A reduction takes place at the cathode, where the negatively charged electrons react with the positively charged ions and water. The whole process is called a reduction âĂŞ oxidation reaction, and is presented in equation 1 and 2:

$$Oxidation \qquad 2H_2 -> 4H^+ + 4e^- \tag{1}$$

$$Reduction \qquad O_2 + 4e^- + 4H^+ -> 2H_2O \tag{2}$$

The working principle of a fuel cell is illustrated in the figure below, where the red arrows represent the negatively charged electrons which move in an external circuit from the anode to the cathode generating electricity. The fuel, in this case hydrogen, is represented with yellow arrows, while the oxygen injected to the cathode is represented by the blue arrows. These arrows also represent water produced as a by-product at the cathode.