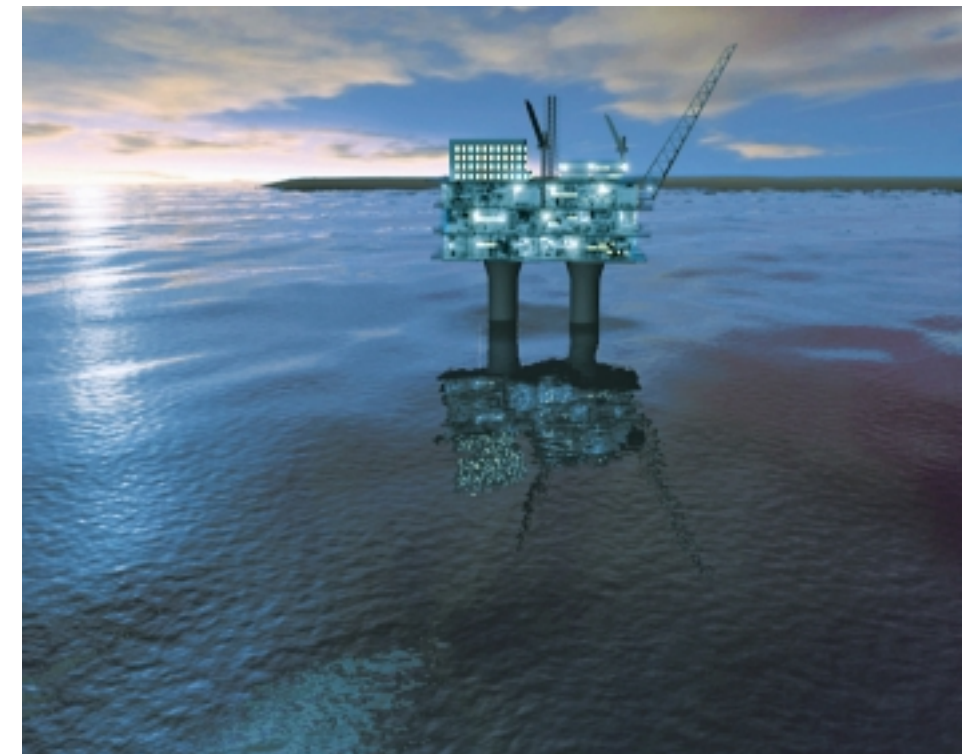


Fuel Cells - Clean Energy for tomorrow



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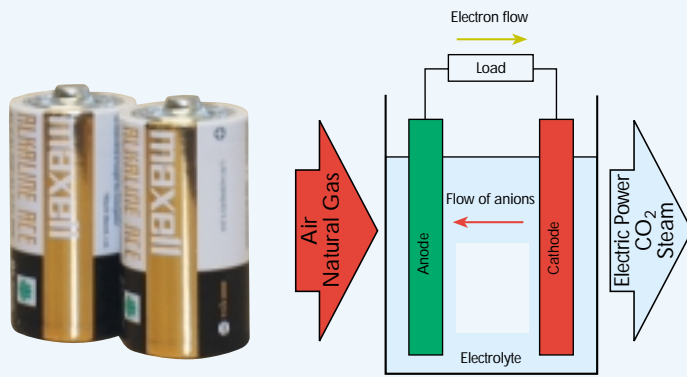


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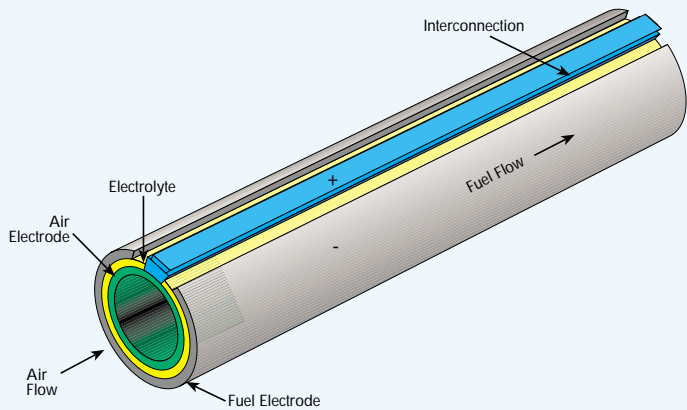
A team of researchers and engineers from Shell came up with the idea to develop power generation technology, based on natural gas, but without emissions of CO₂ (carbon dioxide) to the atmosphere. The vision was to use fuel cell technology to generate "green" electricity on offshore production platforms and make use of the produced CO₂ – something that may revolutionize the energy business in many types of applications.

What is a Fuel Cell?

The idea is simple: In many ways fuel cells are similar to batteries. They both generate power by converting chemical energy into electricity through an electrochemical process. The main difference is that a battery has the energy stored in the same container that generates the power, while a fuel cell needs continuous input of fuel and air to function.



Oxygen ions are transported through an electrolyte releasing electrons, which form an electric current. The oxygen reacts with the fuel (natural gas) to form water and carbon dioxide. In addition, the process also generates heat that can be utilised.



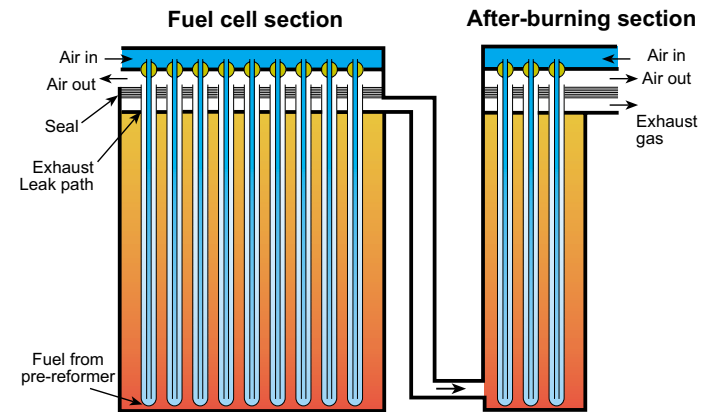
Cross section of fuel cell showing the components in the electrochemical process

The electrical efficiency of fuel cells is in the order of 50 per cent. By using the waste heat the total efficiency can be increased to more than 80 per cent.

Work is being done to examine turbine solutions, that combined with fuel cells, may result in electrical efficiency approaching 70 per cent.

What's new with Fuel Cells?

A unique concept, developed by Shell in cooperation with Siemens Westinghouse Power Corporation (SWPC), consists of a sealing system in the fuel cell and an afterburner. The CO₂ produced is virtually pure which facilitates sequestration. In addition, increased electrical efficiency is expected.



The largest fuel cell plants in the world today have a maximum capacity of a few hundred kilowatts, enough to meet the needs of an office block or a hospital. To develop the technology to a useful power range for industrial use, technical development is necessary. The units must be effectively integrated so as to reduce weight and volume, and significant cost reduction will be required to improve economics.

How can Fuel Cells be applied?

Research and development in this field has come a long way and we now have a unique window for Norwegian green technology with a potential in the world market.

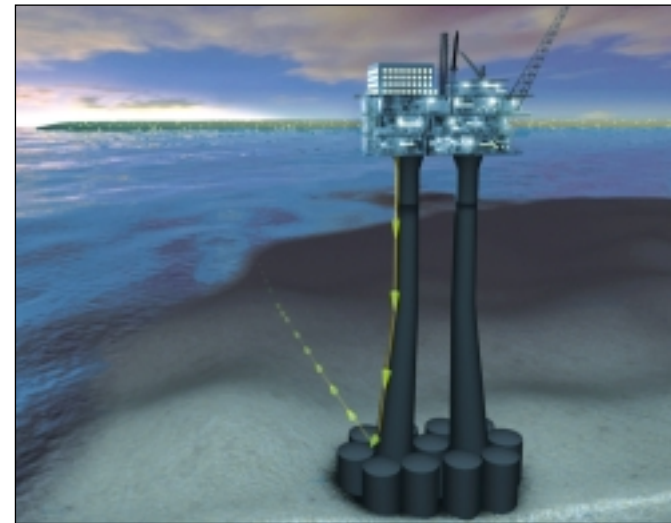
The advantages of this technology will be environment-friendly production of electricity through reduced CO₂ emissions and high-energy efficiency. The primary target is "green" power generation offshore, but many other spin-off applications onshore can be foreseen.

Partnership

In May 2002 Shell Technology Norway, Statkraft and Aker Kværner signed a partnership agreement to explore the utilisation of fuel cell technology for energy supply offshore, ship propulsion and distributed generation of power. The goal is to become the first operators in the world to commercialise large fuel cells.

A project team from Aker Kværner, Statkraft and Shell Technology Norway will perform a pilot study to explore the steps necessary to achieve this goal.

Aker Kværner is one of the world's leading suppliers of advanced products and services to the petroleum industry and has a proven track record of development and application of new technology.



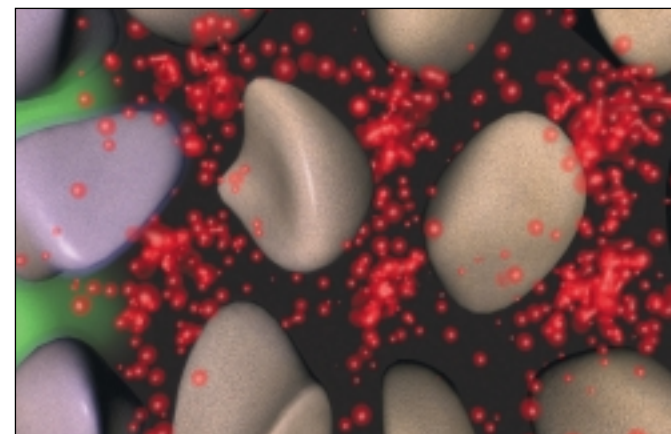
Through ongoing research we are reducing the footprint of the fuel cell plant without loss of electrical output. The aim is to produce 20 megawatts on a fuel cell plant that does not take up more space than a conventional gas turbine.

As a key technology partner Aker Kværner will have a crucial role as system integrator and system supplier through the development, testing and fabrication of complete large-scale fuel cell plants.

Commercialization

The partners will develop Norwegian technology in connection with fuel cells and thereby create new jobs in Norway. Around 50 per cent of costs of a fuel cell package are expected to come in mechanical industry.

"Power plants based on fuel cells have a huge market potential and the revenue generated in Aker Kværner can be in the region of 50 to 75 per cent, depending on choice of technology and size of plant," says Oscar Fr. Graff, head of Gas Technology in Aker Kværner.



In the future the captured CO₂ will be re-injected into the reservoir, possibly together with produced water. This leads to enhanced oil recovery because the CO₂ allows for more efficient displacement of the oil from the formation to the well.

Statkraft is Europe's second-largest producer of pure energy and will bring to the project its experience in the power business. The company will also play a key role in assessing the applications of fuel cells for power production on the mainland and possibly on disused offshore platforms.

"The days of the mighty hydro power developments are over in Norway. That is why we are looking for other environment-friendly energy solutions where our experience and competence can be tapped. The fuel cell technology we are

now about to explore has an enormous potential both at home and internationally," says Per Øyvind Hjerpaasen, who is head of Statkraft's research and development office.

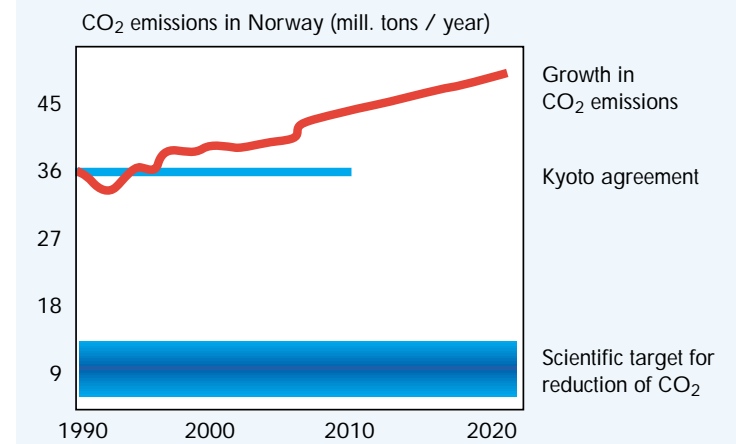
"We are very pleased that other people are recognising the potential in the new fuel cell technology. Together with Aker Kværner and Statkraft we will explore how the technology can be commercially useful. We hope to help seed a growing market for fuel cells, so that the costs of building these types of plant are reduced. Still, this is not enough to bring the fuel cell technology into profit. In order to build a multi-megawatt fuel cell plant we can say, even at this stage, that government support will be vital," declares project leader Helge Skjæveland in Shell Technology Norway.

Environmental potential

Oil and gas discoveries in Norway have given the country tremendous wealth - but also a challenge. How is Norway going to meet its commitments to CO₂ reductions i.e. reducing total emissions by 16 per cent within 6-10 years? Since oil and gas activity in Norway contributes to 30 per cent of national CO₂ emissions, the oil- and gas industry is in focus, and it was logical for Shell to set up the fuel cell project in Norway.

The Norwegian Government ratified the Kyoto Protocol May 30th 2002, stating a clear commitment to reduce the emission of greenhouse gases:

"Norway is in the forefront in the fight against climate change. We are doing our share to give life to the Protocol. Now we will follow up ratification by introducing new and innovative policies and measures to limit emissions of greenhouse gases," says Minister of Environment, Børge Brende.



Facts about the Kyoto Protocol

The Kyoto Protocol to the UN Framework Convention on Climate Change establishes legally binding commitments on limitations and reductions in emissions of six greenhouse gases. The Protocol was adopted in 1997 and commits the countries that have ratified the agreement to limit its emissions of greenhouse gases in the period 2008-12 to a maximum of 1 per cent above its emissions level in 1990.