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analyst view

Fuel Cells and Submarines

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Germany's U34 fuel cell submarine (Source: arnekiel via Flickr)

Global militaries have long been developers of, and investors in, new technologies and innovations. The level of funding available for military projects and the high price-per-unit cost that can be afforded can act as a catalyst for technology development, the benefits of which usually filter down to a consumer level over time. The versatile benefits of fuel cells are often best realised in niche applications with a specific set of demanding requirements that other technologies fail to meet sufficiently. One such example is the telecoms backup power market, discussed in another recent analyst view; another is military applications.

Unsurprisingly, fuel cells have been of interest to the military for many years. As well as offering long-lasting and lightweight power that is environmentally sound, fuel cells also offer the strategic advantages of near-silent operation, no exhaust (other than water) and low heat profiles (for PEMFC and DMFC systems, at least). The US Department of Defense (DOD) and the German Bundeswehr have been particularly notable supporters of fuel cells for soldier-borne and remote power in recent years. Marge Ryan describes the DOD's interest in fuel cells excellently in her 2011 analyst view.

Electrolyser systems from companies such as Giner and Proton OnSite are commonly used on submarines to produce oxygen to maintain breathable air. An evolution of this application is the use of fuel cell propulsion systems. Weight, runtime, noise, exhaust, heat – these are all important considerations on submarines and, as described above, these are all areas in which fuel cells can provide benefits. However, the application of fuel cells (and electrolysers) on submarines is not well known publicly. This is a product of both the inherent discretion of military projects and just how niche the market really is – the US Navy, for example, is currently home to just 53 submarines and lifecycles are lengthy.

The most notable integration of fuel cells into submarines to date has been the development of the U212 class attack submarine for the German Navy, the most recent of which was delivered in May this year. The vessels boast long-distance submerged cruising thanks to an advanced air-independent propulsion system – the key to which is a 34 kW Siemens BZM SINAVY^CIS PEM fuel cell, which has been in development with the German Navy since 1985. Other air-independent propulsion systems exist: typically closed cycle diesel engines, closed cycle steam engines, and Stirling cycle engines. These engine types vibrate and produce substantial amounts of heat – these are strategically undesirable qualities in terms of detectability. Further advantages stated by Siemens include: quick switch on/off behaviour, low voltage degradation and long service life.

The first U212 vessel, the U31, was built by Howaldtswerke-Deutsche Werft GmbH (HDW) and Kiel and Thyssen Nordseewerke GmbH (TNSW), launched in March 2002 and was commissioned in October 2005 with its sister boat the U32 (launched in December 2003). Two further submarines included in this original order were commissioned in June 2006 and May 2007. A second order for two more vessels was signed in late 2006 with delivery in November 2011 and May 2013.

Other navies have followed the Germans' lead. The Italian Navy commissioned two U212 in June 2005 (Salvatore Todaro) and February 2007 (Scire); a further two were ordered by the Italian Government in 2008 and are scheduled for delivery in 2015 and 2016. The Israeli Navy has ordered a total of six U212, the fifth of which was delivered in May this year.

Siemens is continuing to improve its SINAVY^CIS system, and offers a 120 kW version for larger submarines. To date this has been integrated into HDW's U214 submarine class – a larger variant of the U212 with an increased diving depth. Customers include South Korea (three vessels), Greece (three), Turkey (six) and Portugal (two, under the class of U209PN – a slight variation of U214).

Elsewhere, the Russian Navy's Project 677 Lada class submarines, designed by the Rubin Design Bureau for Marine Engineering, also feature an air-independent fuel cell propulsion system, although the details of the fuel cell have not been made public. The lead submarine, Sankt-Petersburg, was commissioned in May 2010 after more than a decade of development and testing. Two more Lada class are under construction with a total fleet of eight planned. An export version, the Project 1650 Amur class, has been designed with an aim to sell to Asian markets such as India and China. Navantia is currently constructing four S-80 submarines for the Spanish Navy that will include bioethanol-fed fuel cell propulsion developed by UTC Aerospace (with bioethanol reformers supplied by Abengoa); the first of the vessels is expected to launch in the 2016–2017 timeframe. UTC Aerospace was also awarded a contract by the US Office of Naval Research (ONR) in August 2012 to demonstrate a fuel cell propulsion system for undersea vehicles.

The benefits of the fuel cell propulsion system were reinforced earlier this year when the U32 set a new record for non-nuclear submarines by spending eighteen days in submerged transit without snorkelling. Although this application will always remain niche – the submarine market is unlikely to ever surge in volume – it is a testament to the versatile characteristics that make fuel cells such an exciting proposition across so many applications, both military and commercial.

Jonathan Wing Market Analyst
jonathanwing@fuelcelltoday.com
www.fuelcelltoday.com