

ENGINEERING  
TOMORROW

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Case story | VACON® NXP Liquid Cooled Drive

# Fuel savings with Danfoss Drives at the heart of electric hybrid ferries



**38%**

reduction in fuel  
consumption

As part of its commitment to supporting Scotland's target of achieving a reduction in environmentally damaging emissions by 2020, Caledonian Maritime Assets Limited (CMAL) has developed a groundbreaking diesel-electric hybrid propulsion system for its newest roll-on/roll-off (RORO) ferries. Equipped with variable speed drives from Danfoss, this system is achieving fuel savings of up to 38% with a commensurate reduction in emissions.

CMAL is the asset owner for the ferries operated by CalMac Ferries Limited, the company that provides almost all of the ferry services to Scotland's offshore islands. Following confirmation of funding from the Scottish Government and the European Regional Development Fund in 2011, CMAL embarked on a project to develop electric hybrid ferries that would create new benchmarks for fuel economy and low environmental impact.

After carrying out detailed evaluations of several alternative approaches to the project, which included high-efficiency diesel-mechanical and diesel-electric systems, the CMAL team concluded that the solution that offered the

greatest benefits would be an electric hybrid propulsion system. Essentially this comprises diesel engines driving generator sets to produce power for electric motors that drive the vessel's propulsion units, just like a conventional diesel-electric propulsion system.

A key feature of the hybrid arrangement, however, which sets it apart from traditional diesel-electric systems, is that the propulsion motors can be powered not only from the generator sets, but also from high-capacity energy storage batteries. In the CMAL vessels, these batteries are charged overnight from shore supplies while the vessels are in dock, which

means that advantage can be taken of low-cost off-peak electricity.

To turn this concept into reality in the form of an innovative ferry with high-efficiency hybrid diesel-electric-battery propulsion, CMAL worked with Ferguson Shipbuilders of Port Glasgow, ship design specialists Seatec, and electrical specialists Tec-Source. The initial contract covered the design, construction and fitting out of two ferries – the MV Hallaig, destined for use on the Sconser-Raasay route, and the MV Lochinvar, for the Tarbert to Portavadie route.



The propulsion system devised for the ferries has three diesel-driven 368 kVA three-phase generator sets operating at 400 V, 50 Hz. These feed the vessel's main switchboard, which also has provision for connection of a shore supply when the vessel is in port. The switchboard provides power for two VACON® NXP-series liquid-cooled variable speed drives from Danfoss. Each of the drives controls one of the vessels' two propulsion motors, which are rated 375 kW and have an operating speed range of 0 to 615 rpm. The motors drive Voith Schneider Propellers that combine propulsion and steering in one unit.

To make provision for pollution-free operation of the propulsion motors from batteries, each of the VACON® NXP variable speed drives has a 350 kWh

lithium-ion battery bank connected to its DC link. This arrangement is particularly convenient and cost-effective as, with NXP-series drives, no additional electronics or control circuitry is needed for the batteries.

"We had many reasons for choosing Danfoss drives for this flagship project," said John Salton, Fleet Manager and Project Director at CMAL. "They're compact, which is very important on board ship, and they combine excellent performance with an efficiency of better than 98% and a power factor of 0.99. And, thanks to the previous experience of our Director of Vessels, Jim Anderson, we knew that VACON® drives from Danfoss offer long, reliable operating lives in the toughest of shipboard environments. The drives are also well priced."

Because of the novelty of this application, extensive on-shore factory tests and trials were carried out on the new drive system before it was installed in the first vessel. This proved the concept and also enabled potential problems to be identified and addressed at an early stage. In fact, system implementation proved to be largely trouble-free, apart from some minor teething problems encountered with the integration of the battery management systems.

MV Hallaig, which was the first ferry to incorporate the new environmentally friendly hybrid drive system, accommodates 150 passengers and 23 cars or two HGVs, and has a service speed of nine knots. It entered regular service in November 2013, and is delivering impressive results.



*"We will certainly look at hybrid technology in any further new small vessels or upgrading existing vessels. And, of course, it depends for its success on the use of reliable, efficient and well-engineered components, which, as it happens, is a very good description of VACON® NXP drives from Danfoss."*

*John Salton, Fleet Manager and Project Director, CMAL*



*"We now appreciate the benefits of hybrid technology protecting the environment and reducing operating costs."*

**John Salton**

Fleet Manager and Project Director  
CMAL



Against a target of 20% reduction in fuel usage and emissions, the vessel is actually achieving a reduction in fuel consumption of 38%. It is anticipated that this will lead to a decrease in CO<sub>2</sub> emissions in excess of 5,500 tonnes over the lifetime of the vessel, with a proportionately similar decrease in sulfur and nitrogen oxide emissions.

Other benefits are that the new drive system incorporates a high level of redundancy, allowing the vessel to continue to operate even if one of its two drive systems fails. It can also operate even if no diesel fuel is available and, indeed, it regularly provides the Sunday service between Raasay and Sconser running on battery power alone, which means that the level of emissions is zero.

Just a year after the MV Hallaig entered service, its sister ship, MV Lochinvar, followed. This uses Danfoss equipment in the same configuration as that adopted for the MV Hallaig, and is consistently delivering equally impressive fuel savings and performance.

The success of these two vessels, which have achieved or surpassed all of the ambitious targets that were set for them, encouraged CMAL to order a third new vessel, the MV Catriona, once again incorporating Danfoss technology. The third vessel was built in Port Glasgow by Ferguson Marine Engineering. It was delivered to CMAL in September 2016 and, after completing sea trials, it will sail on the Claonaig to Lochranza crossing.