



TYCHO BRAHE

HYBRID FERRY CASE STORY





HENRIK FALD HANSEN

Senior Chief Engineer on the M/F Tycho Brahe, stands among hundreds of lithium batteries that power the ferry across the Øresund Strait between Denmark and Sweden.

FERRIES OF THE FUTURE SAVE 65% CO₂

In the strait between Denmark and Sweden, two ferries are leading the way to tomorrow's marine transportation.

In a major project co-financed by the European Union, the M/F Tycho Brahe and M/F Aurora are still equipped with their original diesel-powered engines, but four containers on each top deck hold the equivalent of about 4160 kilowatt hours (kWh) of electrical power: 640 lithium batteries, with 11 megawatt (MW) total. Charging is done with up to 11 MW.

The ships can run on full battery, full diesel or a combined, hybrid set-up. They are two out of four ferries running the busy route between Elsinore (Helsingør), Denmark, and Helsingborg, Sweden, a yearly total of 50,000 times – and with 7.2 million passengers. The ships' owner, HH Ferries, thus saves 65% CO₂ emissions on its battery-sailed initiative.



"We would really like to be a green shipping company, and we want to do something for the environment," says Henrik Fald Hansen, Senior Chief Engineer on the M/F Tycho Brahe. *"This is our contribution."*

The ferries charge the batteries with electricity coming from renewable-generation in Denmark and Sweden – such as wind, hydro and solar. Thus, when the ferries run on battery power alone, they are nearly 100% CO2-free, says Henrik Fald Hansen. They both use DEIF Delomatic 4 systems for power management.

"These are the ferries of the future," he says.

THREE MODES WITH DEIF

When HH Ferries was re-tooling the ships with batteries in 2017, it needed a power management system that could handle the three operating modes: diesel, battery or hybrid. Tycho Brahe was already running with a DEIF power management system since 2013, so DEIF was to upgrade that to a Delomatic 4 for diesel-electric propulsion.

"A diesel, "old-fashioned" mode simply operates gensets and main propulsion the usual way", says Per Ole Sørensen, Team Manager in DEIF's Marine & Offshore System Solutions Department. The power management system calculates and controls the load onboard the vessel, telling the main propulsion how much power is available. A battery-powered operation must work similarly but collects data from the batteries' own management system. It calculates how much discharge capacity is available and the max power needed, again making sure the main propulsion is not overloading the system.

And then the ship's operator – or the system itself – can initiate the hybrid mode. If the energy level in the batteries is low, then it must start up a diesel genset and operate in parallel with the batteries. The main propulsion can even charge the batteries until the ship reaches harbour.





*Henrik Fald Hansen, Senior Chief Engineer
on the M/F Tycho Brahe, in front of the DEIF
power management system cabinets.*



FAST & POWERFUL RECHARGE

The batteries on board can propel the Tycho Brahe 3.5 times between harbours, but the ship recharges every time.

"We are on the world's largest battery-powered ship," Henrik says. *"We recharge with 10-11 MW at harbour with high-voltage lines."* When the ship comes to dock, a robot arm carefully "plugs in" the high voltage line to the side of the ship. *"We have five and a half minutes to charge in Denmark and nine minutes to charge in Sweden – so it's got to go quickly."*

Due to the high volatility of lithium batteries in the containers, HH Ferries has installed a double (redundant) safety and emergency protection system, which includes a water-cooling system for the batteries and aerosol and water sprinkler systems for the containers, he says.

SIDE BENEFIT: QUIET

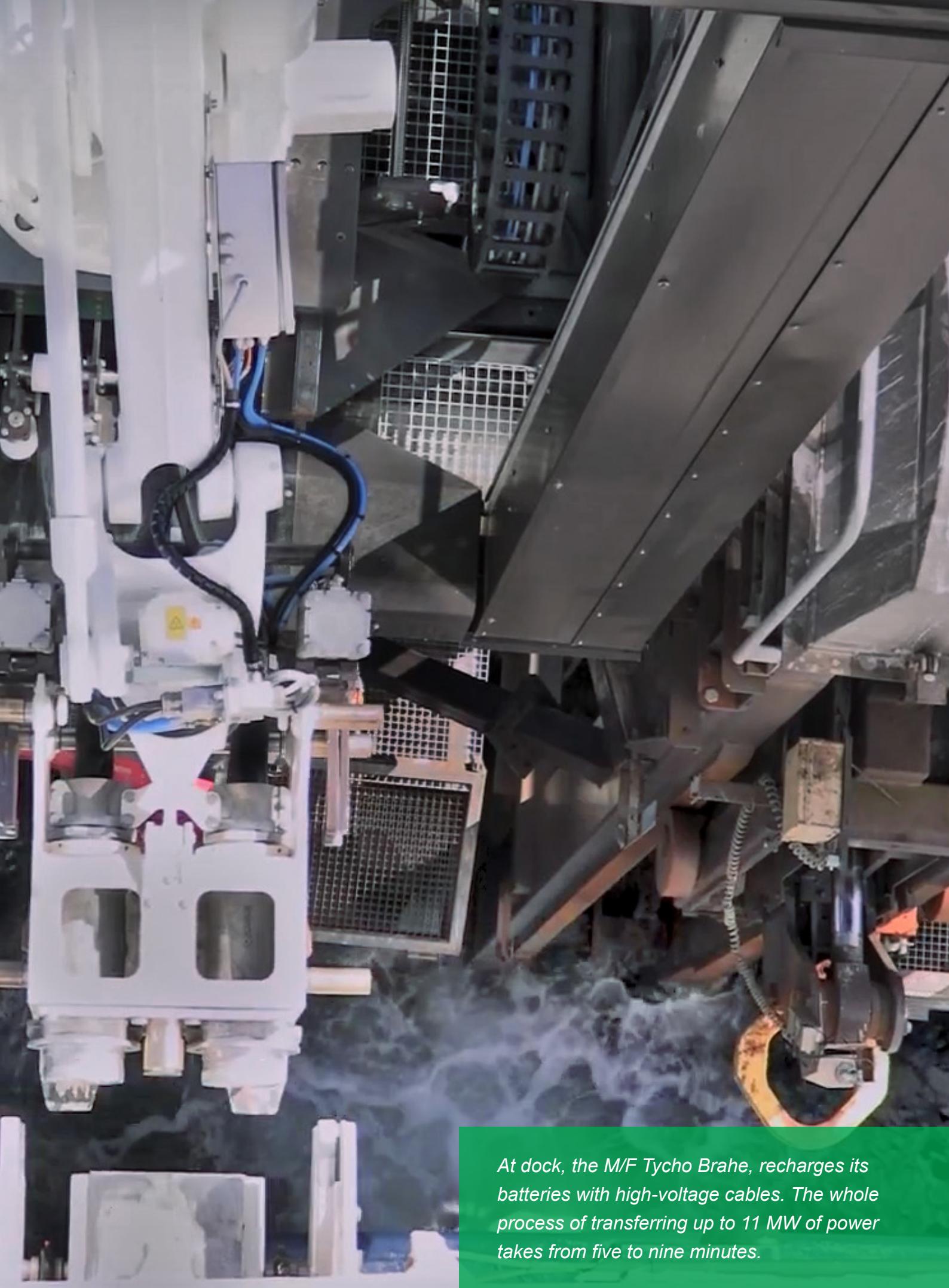
When the Tycho Brahe sails on battery power, the engine room is quiet.

"It's a completely different working environment," says Henrik Fald Hansen. *"It's a strange feeling as a mechanical engineer to have a machine room that's quiet. The first time we stopped the diesel motors and sailed on battery, the hair on my arms stood up. It's fantastic."*

"It's so impressive to see that batteries can power so large a ship. We get a completely peaceful and quiet place to work. This is an innovative project," he adds. *"Electrical propulsion is the future."*

I'm proud to be a part of the world's largest battery-driven ship, and part of such a large project. It has been a lot of work, but there are so many things we can be proud about."

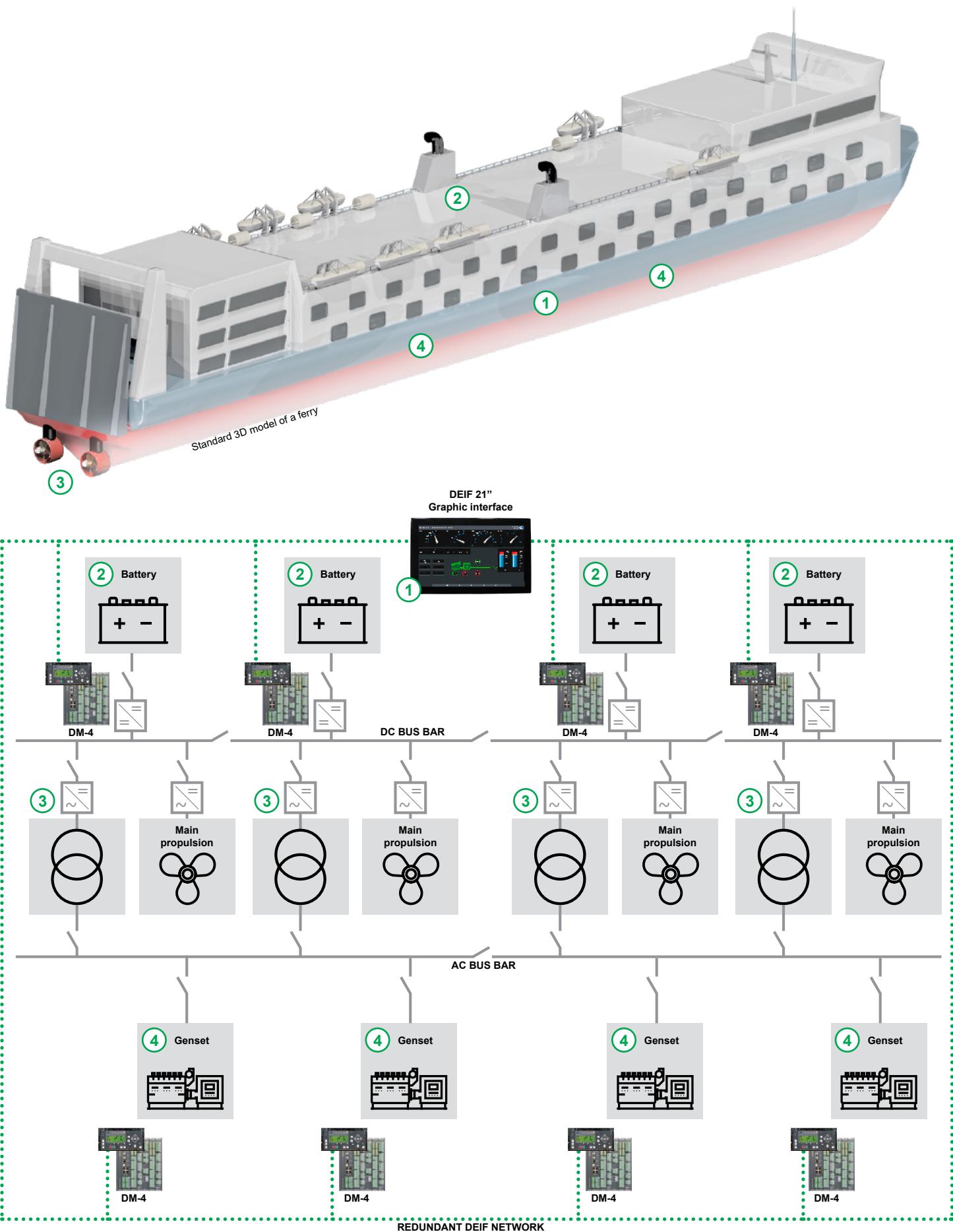




At dock, the M/F Tycho Brahe, recharges its batteries with high-voltage cables. The whole process of transferring up to 11 MW of power takes from five to nine minutes.

Diagram and technical description

From AC diesel-electrical propulsion to diesel, hybrid & battery operation



Facts

DEIF's solution installed on board M/F Tycho Brahe

Installed power supply specs

- ▶ 4 x 2.6 MW Wärtsila diesel gensets
- ▶ 11 MW batteries placed in 4 sun deck containers

DEIF power control units installed

- ▶ 8 x DM-4 power management units
- ▶ 1 x AGI monitoring and control touch screen

Features and benefits

- ▶ 4 x 2.6 MW Wärtsila diesel gensets
- ▶ 11 MW batteries placed in 4 sun deck containers
- ▶ Diesel, hybrid and battery operation possible
- ▶ Optimised genset load in hybrid mode
- ▶ Full charge/discharge battery control
- ▶ Automatic transfer from battery to hybrid
- ▶ Redundant communication – fibre-optical cables
- ▶ Thruster reduction based on battery energy status



DM-4 power management solution

- ▶ Internal system supervision
- ▶ Engine control, monitoring and protection
- ▶ 3-phase generator protections
- ▶ Automatic synchronisation
- ▶ Load sharing
- ▶ Dual ARCnet bus communication lines for redundancy
- ▶ Multiple display units and multiple Advanced Operator Panels
- ▶ Interface to the DEIF advanced graphical touch screen AGI
- ▶ 2 x Integrated RS-485 Modbus communication port
- ▶ 2 x CAN bus port for J1939 engine supervision, CANopen
- ▶ USB port for service software
- ▶ Up to 690 V AC direct AC inputs
- ▶ Alarm and event log
- ▶ Advanced load-dependent start/stop calculations
- ▶ Blackout prevention and recovery
- ▶ Priority selection
- ▶ Heavy consumer handling
- ▶ Base load function
- ▶ Trip of non essential load groups (preferential trip)
- ▶ Advanced fuel optimisation features
- ▶ One-touch auto sequences
- ▶ Dynamic positioning (DP-2) operation with closed bus tie breaker
- ▶ Fast dynamic load-share deviation protection
- ▶ Fast thruster load reduction
- ▶ Optimised load sharing
- ▶ 1 x Modbus TCP/IP
- ▶ Service software via ethernet for remote access

AGI touch screen

- ▶ State-of-the-art HMI
- ▶ Multi-touch widgets
- ▶ Advanced programming tool
- ▶ Data-logging and alarm handling
- ▶ Complimentary DEIF app templates
- ▶ Multiple remote options
- ▶ Phone/tablet compatible
- ▶ Pinch zoom
- ▶ Designed for harsh marine environments
- ▶ Available in 7", 10", 15" and 21" sizes

NOT JUST POWER. ENERGY.

"With the batteries, you have more of an 'energy management system,'" Per Ole says. "It's not only the power anymore. Your system has to be able to monitor the energy left in the batteries. Are we going to use all that energy in a moment? Then it will start up a genset and run in hybrid mode."

Henrik Fald Hansen says that when the Tycho Brahe installed the previous DEIF system in 2013, the ship's crew had to get used to it. *"Could we rely on it? We have just been really, really*

satisfied in the way the DEIF system handled problems for us. We could trust it.

If there was a generator that wouldn't start or something like that, the DEIF system took care of it. And we've had the same feeling after installing the batteries and new DEIF system.

We have definitely been confident that DEIF can handle things when there are any problems."

ABOUT HH FERRIES

HH Ferries Group owns the ferry route between Helsingborg and Elsinore, which is marketed under the trademark Scandlines Helsingborg-Elsinore. The four ferries depart every 15 minutes, transporting up to 50,000 passengers and 9,000 cars as well as 1,600 buses and trucks cross Øresund on a daily basis. 7.2 million passengers a year over the Øresund Strait.

The company has converted two of its ferries – the M/F Tycho Brahe and the M/F Aurora – to run on battery, hybrid or diesel propulsion.

That is expected to reduce the total CO₂ emissions from HH Ferries by 65%.

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"We have been really, really satisfied in the way the DEIF system handles problems for us. We trust it."

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Henrik Fald Hansen
Senior Chief Engineer
M/F Tycho Brahe



Henrik Fald Hansen, Senior Chief Engineer on the M/F Tycho Brahe, in front of the DEIF power management system cabinets.

The M/F Tycho Brahe sails into dock at Elsinore, Denmark. A robotic arm is housed in the structure on the left. It plugs the high-voltage cable into the battery recharging station on the ship.



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