Eferry

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GROUNDBREAKING, WORLD-CLASS INVENTION:

Welcome to Ærø's new electric ferry, Ellen, which has set new standards for international E-ferry operations

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Ærø Municipality aims to be CO2 neutral and self-sufficient with renewable energy by 2025, and completely fossil-free by 2030. Those targets will be reached through a combination of expanding renewable energy production, converting energy-consuming activities to use renewable energy, and through a reduction in energy consumption.

The municipality of Ærø has long been focused on renewable energy solutions. In the period from 2008 to 2017 alone, CO2 emissions from Ærø have been reduced by 44%, and the goal is to reduce this further by, among other things, restructuring transport. In order to meet this goal, the municipality, together with a number of partners, embarked on a major electric ferry project, "E-ferry", which is a five-year innovation project aimed at designing, building and testing a 100% electric, medium-sized ferry. The goal is to promote energy-efficient, CO2-neutral and pollution-free waterborne transport on island routes in and outside Europe. And in 2019, the electric ferry, named Ellen, made its first trip between Søby on Ærø and Fynshav on Als.

The development of the electric ferry is funded under the European Commission's Horizon 2020 framework program in cooperation with Ærø Municipality. The European Commission has allocated DKK 113 million to the project.

Ellen will have the capacity to sail longer distances than has been possible for fully battery-operated ferries until now. While the Norwegian electric ferry 'Ampere' on the Lavik-Oppedal route currently holds the record of 3 nautical miles, the electric ferry Ellen will sail up to 2 x 10.7 nautical miles on one charge – in other words; 7 times longer between charges. This considerably greater range means that far more ferry routes will be able to be converted to pure electricity in the future. Ærøfærgerne (Ærø Ferries) will be responsible for the operation of Ellen.

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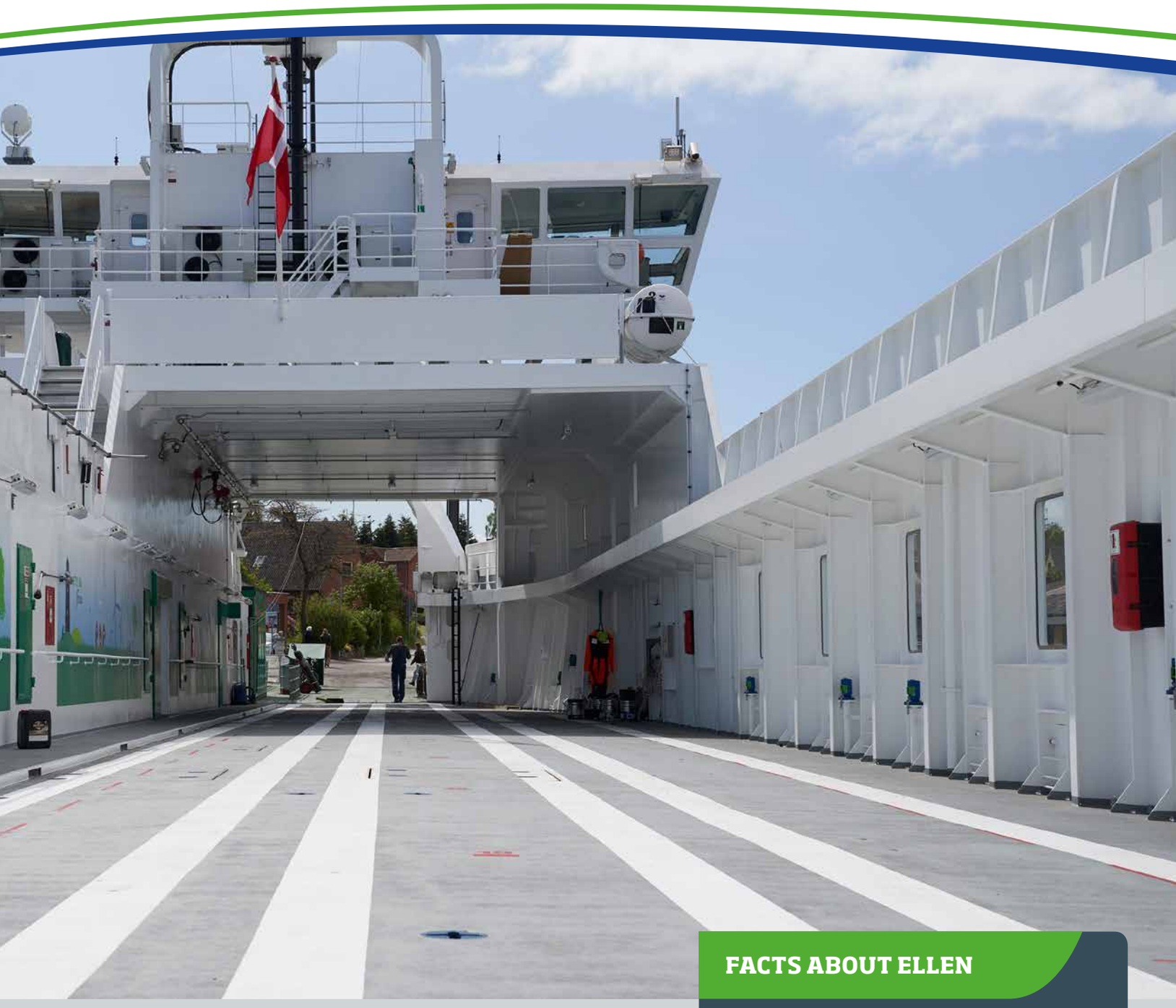
Ellen's special features

- The world's first type-approved battery pack for maritime use under DNV GL's new guidelines (energy content of 4.3 MWh).
- Capacity to sail 7 times longer than previously possible for fully battery-powered car ferries.
- Record-high peak power at charge (up to 4.4 MW).
- Minimal noise, even at high speeds.
- Expected to reduce emissions by 2,000 tonnes of CO2 and 41,500 kg of NOx annually compared to conventional ferry services on the same route.
- Certified under the shipping sector's standard for accessibility.



FACTS ABOUT ELLEN

Sailing route:	Søby-Fynshav (Søby-Faaborg)
Speed:	Up to 14 knots
Capacity:	31 passenger cars / 4 trucks + 8 passenger cars 200 people (summer) 150 people (winter)

The development of Ellen requires innovative solutions

Watch the movie about the development of Ellen.

Establishment of land facilities in Søby

It takes the building of significant facilities on land, to put an electric ferry into operation. These facilities are located in Søby, where, among other things, a completely new ferry berth has been built – adapted for the electric ferry – as well as a larger power building, which includes:

- **4 large transformers from Syd Energi, from which the power to Ellen is supplied. Each transformer can deliver up to 1.2 MW, and SE has specially developed these huge transformers for the purpose.**
- **Danfoss Editron inverters that convert power from alternating current (AC) to direct current (DC) – the type of current that Ellen's batteries are charged with.**

The cables run underground from the power building to the charging arm, located on a ramp. The charging arm was specially developed for Ellen and is now a registered trademark under the name ACDC Nector™. The charging arm is placed in a specially
built box, approx. 5 meters long, 3.5 meters high and 1.5 meters wide.

The charging infrastructure on land is a costly endeavor, which makes it even more attractive to keep the number of charging stations on a route to a minimum – and which in turn is why the longer reach demonstrated by this project really comes into its own.

A special battery system

The battery system is developed especially for Ellen and is the first battery system for maritime use that is type-approved under the classification society DNV GL's new guidelines. In terms of the battery pack's energy content, Ellen can boast of having one of the world's largest packs with a capacity of 4.3 MWh.

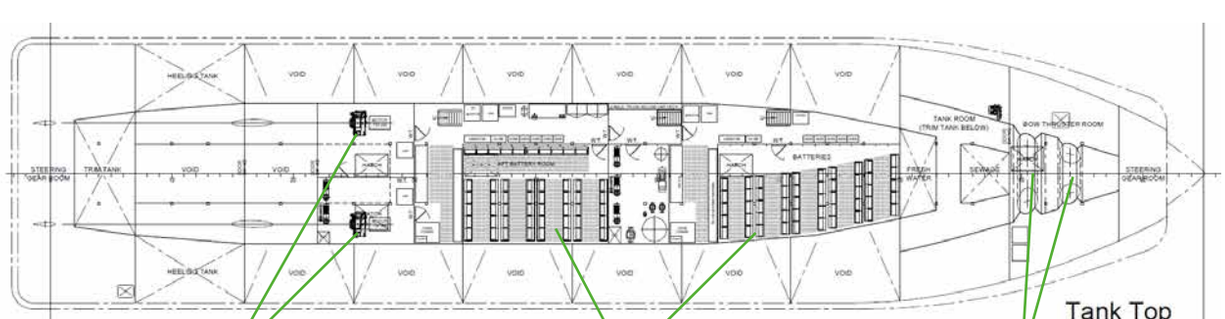
The batteries are water-cooled to keep the operating temperature stable and designed for easy replacement of single parts – and for possible scaling to other needs.

The batteries always have spare capacity for emergency preparedness and will rarely use more than 45% of the energy in normal operation. About 1/3 of the daily energy consumption on the electric ferry is charged overnight. Additional recharging takes place during the day, when Ellen is docked in Søby Harbor.

The electrical system

The charging device consists of two hydraulic arms with 16 large "male plugs", which are automatically connected to Ellen's "female plugs" when she docks in Søby Harbor.

The charger is located on the bridge flap ashore to make it easier for the automatic system to connect to the ferry.



2 propulsion engines
- 750 kW / engine
- 950 kg / engine
- 1000 K / engine

2 battery compartments
- 10 separate battery strings / compartments
- 4,3 MWh in total
- approx. 56 tonnes

2 thruster engines
- 250 kW / engine
- 465 kg / engine

Read more about the building af Ellen on the following page.

Ship design

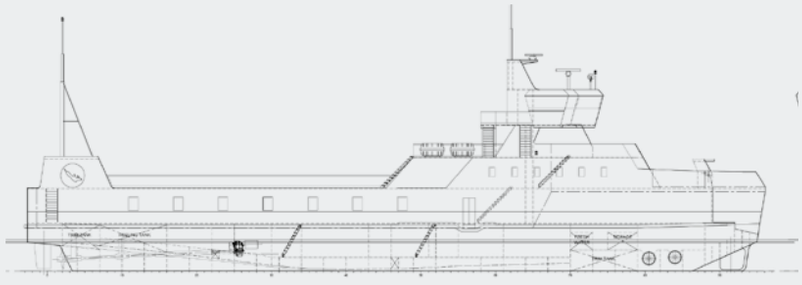
Nothing is left to chance – that goes for the ship's layout and design, too. The passenger lounge, for instance, is located at the same level as the car deck, allowing us to:

- **avoid elevators and stairs**
- **ensure easy search of passengers in case of emergency**
- **ensure that passengers are close to the disembarkation point with direct access to liferafts**
- **ensure weight saving**
- **ensure less wind area, which provides better maneuverability and stability**

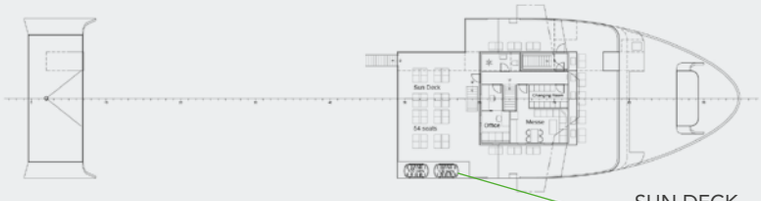
The bow thruster is designed for lower energy consumption when maneuvering in port. Hull shape with full midship and slim ends minimizes propulsion resistance and ensures high energy efficiency.

Increased safety and comfort

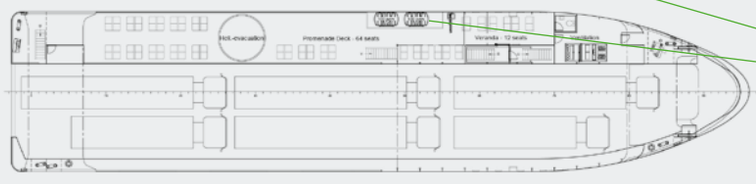
- **Double hull with U-shaped tanks ensure very high survivability in case of leakage**
- **No noise, vibration and smoke makes the crossing comfortable for passengers and crew**
- **So-called double redundancy in that the batteries are distributed in two separate compartments connected to seperate propulsion systems, and in each compartment the battery packs are distributed in 10 separate strings**



PROFILE



SUN DECK



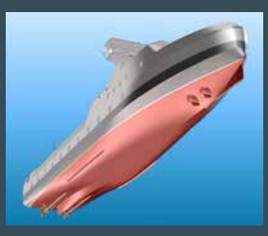
PROMENADE DECK

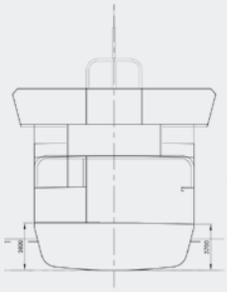
MAIN DECK

TANK TOP

FACTS ABOUT ELLEN

Length:	**59,50 metres**
Width:	**12,80 metres**
Draft:	**2,50 metres**
Deadweight:	**192 tonnes at 2,50 metres draft and straight trim**
Lightweight:	**747 tonnes**





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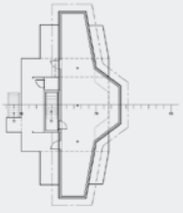

BRIDGE DECK

Possibility of full evacuation from both sides of the ship.

Dry-shod evacuation via passenger lounge and car deck.

2 separate battery compartments ensure independent propulsion.

Partners

DBI - The Danish Institute of Fire and Security Technology (Denmark) advises and tests in relation to fire safety.

Hellenic Institute of Transport (Greece) is in charge of mediation and market development.

The Danish Maritime Authority (Denmark) advises on security and approvals.

Tuco Yacht Shipyard Ltd. (Denmark) has investigated the possibility of composite elements.

Danfoss Editron (Denmark) has developed and supplied the electric propulsion system as well as the charging system.

Leclanché GMBH/SA (Germany/Switzerland) has developed and delivered the battery pack.

Consulting Naval Engineer Jens Kristensen ApS (Denmark) has designed the ferry.

Søby Shipyard (Denmark) has built, fitted, mounted and equipped the ferry.

Ærø Municipality including Ærø Ferries (Denmark) coordinates the project, ensures the development of the port structure and performs the actual demonstration of the ferry. In addition, the municipal-owned ferry company is responsible for the operation after the end of the E-ferry project.

The E-ferry project has received funding from the EU's Horizon 2020 research and innovation program under grant agreement no. 636027.

New technology requires new skills

Because electric ferries are still new and only available in limited numbers worldwide, there are no specific guidelines in the field and not yet any requirements for training from the IMO (International Maritime Organization). Therefore, there was also no training course in maritime electrical operation when the E-ferry project started.

However, safety for passengers and crew must be ensured also when sailing with electric ferries. The new properties of electric propulsion and especially the battery systems require special skills of the crew. Based on the extensive knowledge of electric ferries that Marstal Maritime Academy has aquired through their involvement in the E-ferry project as advisors, the Maritime Academy has developed a training course where crews on electric vessels get the right skills to operate this type of vessel.

Marstal Maritime Academy has, as the first in the world, developed a series of specialized training courses that have been tested with great success on Ellen's crew. In addition, a simulator model of the electric ferry has been developed for the school's full-mission simulator, so that the crew can practice sailing with a fully electric ferry before they actually set sail.

Myths and misconceptions

The transition to electric ferries is slower than expected, and part of the reason can be found in a number of myths and misconceptions that continue to circulate. Examples of this could be that batteries are dangerous, that they will deplete completely while at sea, or that it is more expensive to operate an electric ferry.

A course specifically aimed at ship-owners and ports deals specifically with such myths. Based on data and experience from the design and demonstration phase of the E-ferry project, the course will help participants access accurate information. Whether confronting myths and misunderstandings can push the green change in ferry operations, or not, it can ensure that a decision is made on the right foundations.

Ærø – a sustainable island

The renewable energy sources that are utilized on Ærø are primarily solar, biomass and wind. However, on a non-bridged island like Ærø, some of the biggest CO2 emitters are the ferries, and it is of great importance for the energy balance to use electric ferries on the sailing route between Søby on Ærø and Fynshav on Als – and in the long term from Ærø to Faaborg on Funen.

The massive renewable energy investment is expected to give Ærø a positive spin-off in the form of more green jobs, more visitors to the island, as well as a green and sustainable island to live on.

“There are several benefits to an electric ferry - such as reduced pollution, reduced noise, as well as economic factors. An electric ferry costs more up front, but is cheaper to operate in the long run, for example because of reduced fuel and maintenance costs.”

Cecilie Larsen, project manager, renewable energy, Ærø Municipality


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100% electric

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Faaborg

Limited need for continuous maintenance of propulsion unit (electric engines, etc.) compared to conventional diesel operation.

DISTANCE: **Ellen can sail**

22 nautical miles / 40 km

between each charge, which is 7 times longer than any other electric ferry

Fynshav

Speed up to 14 knots

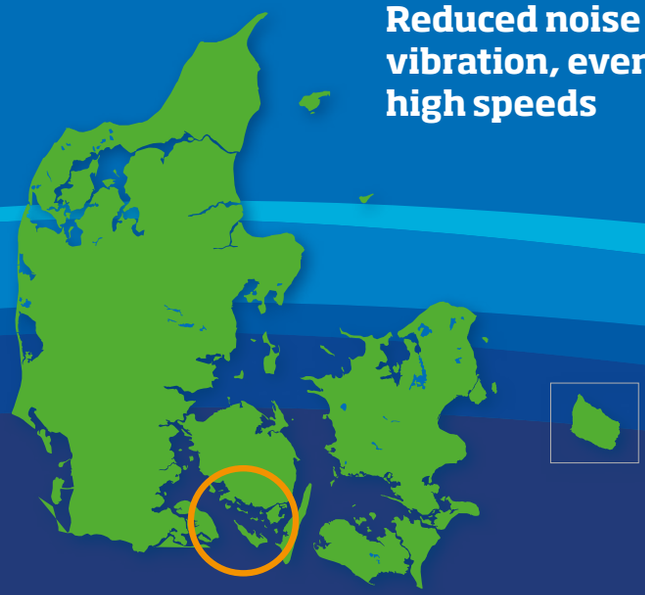
Søby

7 out of 10 routes

in Denmark alone would be profitable with pure battery operation

Source: Siemens report, 2016

Reduced noise and vibration, even at high speeds



CHARGING POWER: Ellen can charge up to 4.4 MW, battery size is 4.3 MWh, equivalent to 50 Model S Teslas or 28,000 electric lawn mowers in power, and 10 full-grown African elephants in weight.

Record-high peak power at 4.4 MW allows short stays (estimated to take about 20-30 minutes) in port.

65-80 %

of Nordic ferry routes are suitable for electrical operation.

Source: Green Ferry Vision report, 2014

An electric ferry makes up for the CO2 pollution in battery production in just

1,4 months

According to the NOx Fund's paper, 2016

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