In search of the Holy Grail of electric ferry operation!

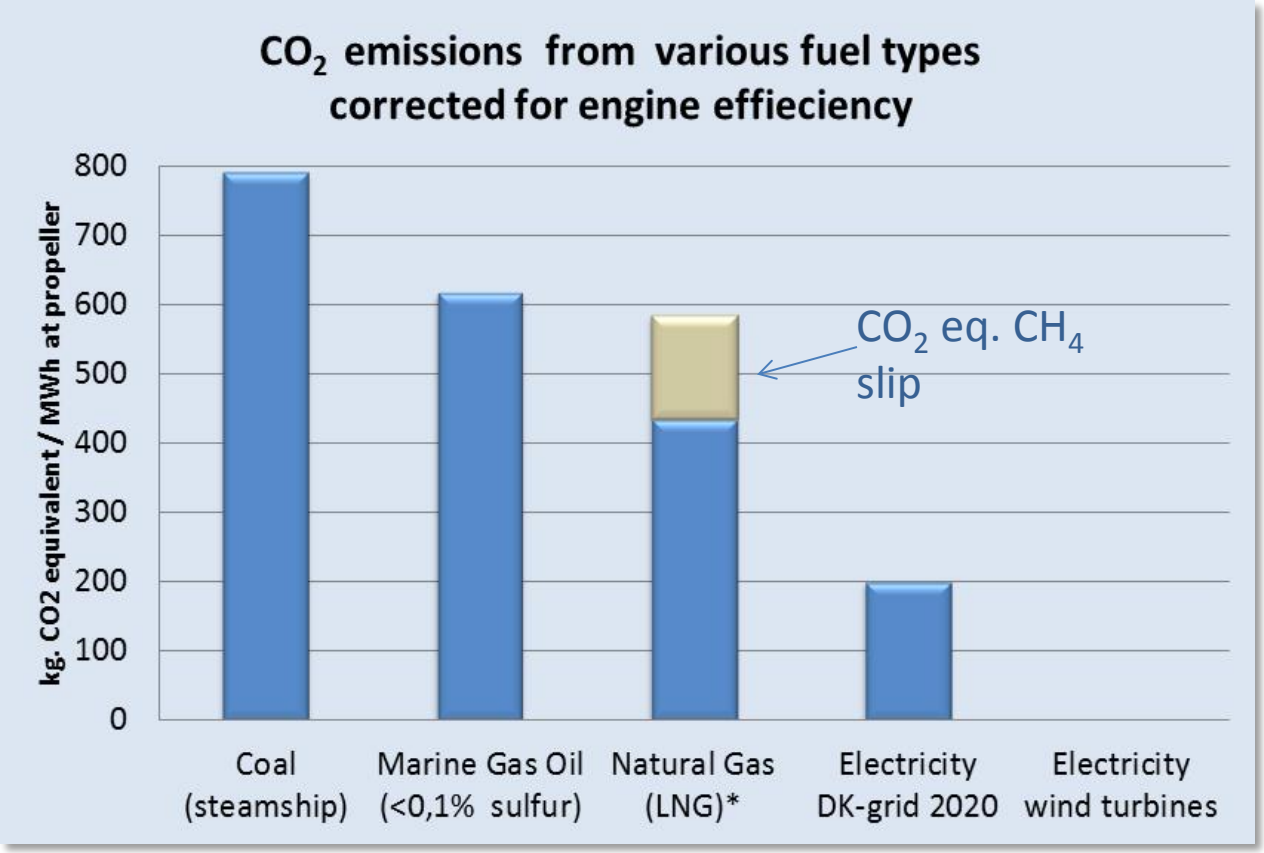
Green Ferry Vision Seminar

5th of September 2014

Motivation factors

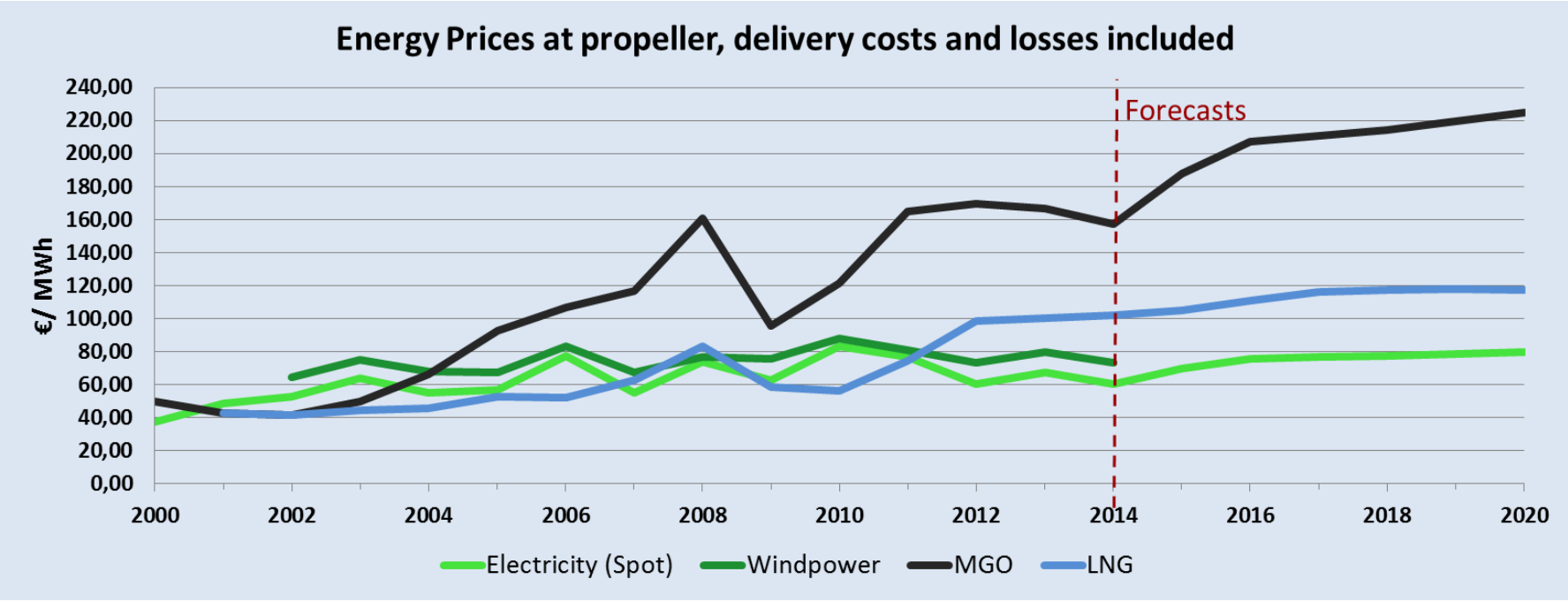
Comparative analysis of CO_2 equivalent emissions from five types of fuel including methane emissions and loss due to various engine efficiencies based on "well-to-propel" methodology.

Source: Green Ferry Vision compiled from various studies, see WP 4 analysis



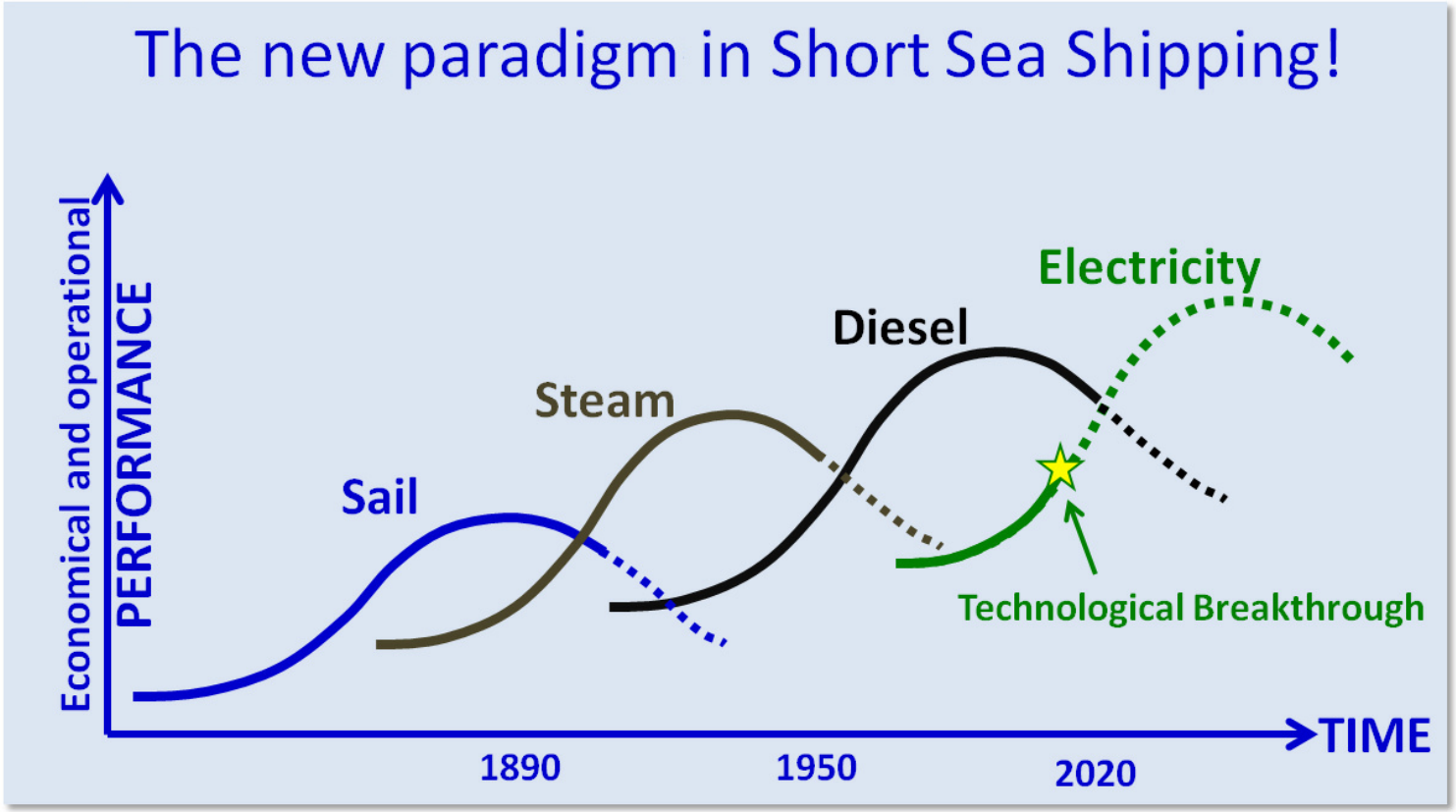
*LNG is based on a Dual Fuel engine (Wärtsila W6L20DF) with a methane slip of 6 g/kWh at optimal load

Another motivation factor



Energy price measured at propeller for four important fuel types of the future ex. tax. CO_2-quotas not included which disfavors wind energy. Source: Green Ferry Vision, Nordpool, Pace Global, Dansk Energi, Energinet.dk, Joachim Grieg, DNVGL, DMA (Danish Maritime Authorities).

The potential



The innovation S-curves of ship propulsion adapted from Everett Rogers, Diffusion of Innovations

Will higher investment cost be repaid by lower running cost?

Key figures for the cost of energy at propeller 2014

	HFO	MGO	Hybrid	LNG	Electricity
€/MWh*	115	160	135	100	60

*Distribution cost included. For LNG pilot fuel is included. Tax and CO_2-quotas excluded.

Five different propulsion systems compared. Source: Green Ferry Vision, Scandlines, Danske Færger, DNVGL, MAN-Diesel & Turbo.

Added cost of newbuilding approximately 33 % plus another 15 % for land installations.

(According to case study of total E-ferry service for Aeroe with four units)

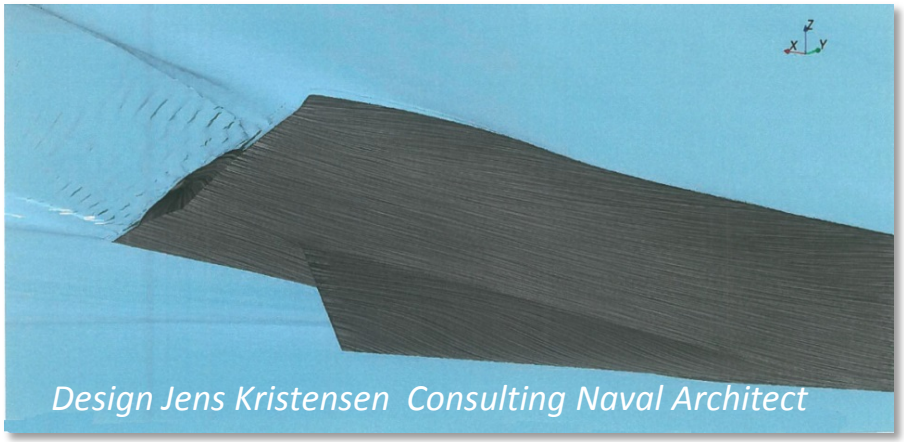
Barriers to be discussed

Feasibility case study defined 6 challenges:

1. **Design af extremely energy efficient E-ferry**
2. **Battery layout ensuring full working day**
3. **Ample charging power at berth(s)**
4. **Energy tax equivalence to fossil fuels**
5. Approval of safe manning and safe management
6. Approval of lightweight equipment and materials

(5 and 6 to be investigasted further)

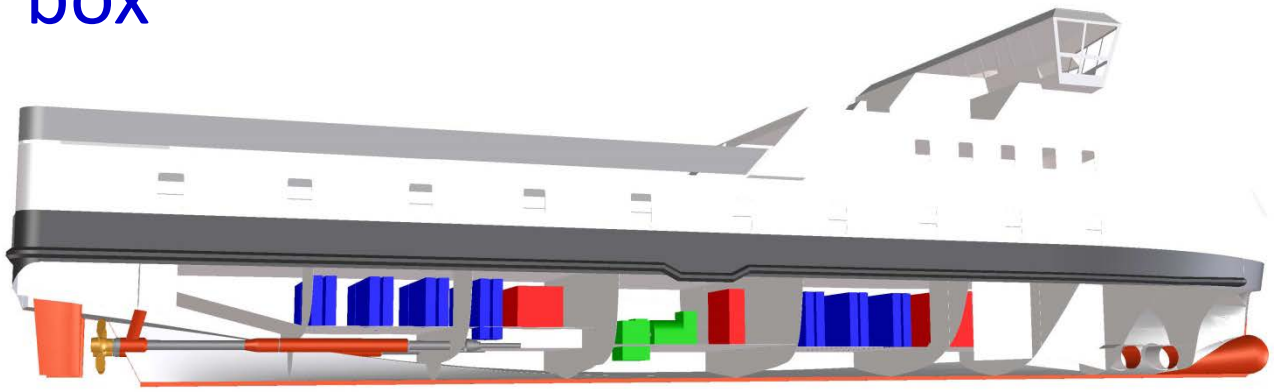
Design of energy efficient hull



Ambition 50 % savings compared to existing ferries and better performance at shallow water depth.

Electric drive train strategy

- Record-breaking 4,000 kW shore charging facility
- Record-breaking 3,800 kWh Li-NMC battery pack
- Only discharge to 40 % equals 10 year life-span
- Charging at port calls on Aeroe with ”one-hour lunch box”



Operational strategy

Ferry A Sailing time around 50 minutes. Docking time Aeroe 13 min / mainland 7 min.

Dep. Aeroe	0530	0730	0930	1230	1430	1630	1930	
Dep. mainland	0627	0825	1027	1327	1527	1727	2027	

1st crew watch

2nd crew watch

3rd crew watch

Ferry B

Dep. Aeroe	0630	0830	1030	1330	1530	1730	2130	
Dep. mainland	0727	0927	1127	1427	1627	1827	2227	

- Two E-ferries provides hourly service on routes up to 11 nautical miles (at 14 knots)
- Two E-ferries sharing three crew watches to avoid idle manning hours in port during ”lunch box” breaks
- Two E-ferries sharing the relatively expensive shore charging facilities

What about the engineer?

- Little maintenance on main and auxiliary power systems
- 2x750 KW and redudant systems
- Safe manning for 98/147/198/245 PAX?