



Sjøfartsdirektoratet
Norwegian Maritime Authority

Green shipping – alternative marine fuels, battery power and hybrids

- Regulatory and safety-related issues

Lasse Karlsen
Technical Director





Green Shipping: ECO-efficient options

- Diesel engines w/scrubbers/SCR/EGR
- LNG/gas engines single/dual fuel
- LNG/gas generators and electrical propulsion
- Electrical propulsion – battery only
- Diesel or LNG/gas battery hybrids
- LNG/gas electrical propulsion with fuel cells and battery
- Hydrogen



Development in Norway – focus on gas/LNG

- Experience from large scale shipping
- Development of gas-fuelled engines
- Availability of gas/LNG
- Political decisions
- Environmental requirements



Experience from shipping of LNG – very good

- 52 years of experience!
- Started in 1963
- 179 recorded LNG accidents on ships
- **No fatalities** related to ship operations
- Excellent safety record

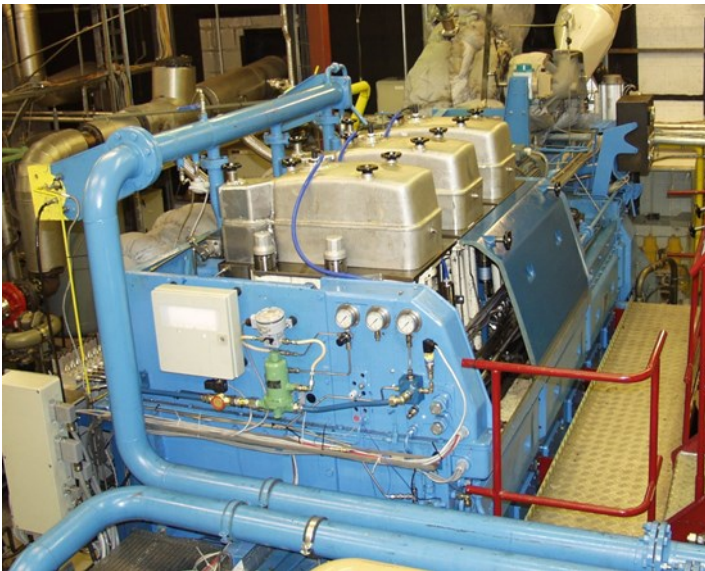
(Ref: IMO-FSA: Ship only,
LNG terminals excluded)





Norway – Leading on use of LNG in shipping

- Research on modern gas engines since 1980 for IGC tankers and power generation





Availability of LNG

HAMMERFEST,
Barents Naturgass
Bunkringsportal 100 m3

LØDINGEN
MOSKENES
BODØ
Barents Naturgass
Terminaler 150 – 250 m3
(ferdig 2012)



ÅLESUND,
Naturgass Møre
Terminal 1366 m3



ÅGOTNES (CCB),
Gasnor
Terminal 450 m3

HALHJEM,
Gasnor
Terminal 1000 m3



RISAVIKA (Stavanger)
Skangass
Fabrikk/Terminal 30 000 m3

Fredrikstad
Skangass
Terminal 6 500 m3



Political decisions in Norway

- In 1996 the Norwegian Parliament decided to:
 - develop technology for ferries utilising natural gas as energy for propulsion

First ferry
Glutra
Year 2000





Driving forces in Norway

- Environmental effects are the main incentives, implemented by:
 - Emission reduction requirements
 - Emission tax on NOx ~ NOK **19.1 pr. kg**, or;
 - Alternatively: Owners can join the private NOx **fund** and only pay NOK **4.00 pr. kg** and be able to re-allocate **funds** when investing in low NOx emission technology.
 - Charterer agreements – NOx reduction exchange (supply ships)



46 LNG-fuelled ships flying Norwegian flag

Year	Name	Type	DWT	Year	Name	Type	DWT
2000	Glutra	Ferry	659	2011	Tresfjord	Ferry	200
2003	Stril Pioner	PSV	6013	2012	Viking Prince	PSV	5380
2003	Viking Energy	PSV	6013	2012	Viking Princess	PSV	5380
2006	Bergensfjord	Ferry	1025	2012	Olympic Energy	PSV	5066
2007	Fanafjord	Ferry	1025	2012	Høydal	Cargo	2692
2007	Mastrafjord	Ferry	1025	2012	Norman Arctic	PSV	5265
2007	Raunefjord	Ferry	1025	2012	Island Crusader	PSV	4750
2007	Stavangerfjord	Ferry	1025	2012	Island Contender	PSV	4750
2008	Viking Queen	PSV	6200	2012	Landegode	Ferry	2455
2009	Viking Lady	PSV	6200	2012	Værøy	Ferry	2455
2009	Tidedronningen	Ferry	150	2012	Barøy	Ferry	2455
2009	Tidekongen	Ferry	150	2013	Lødingen	Ferry	2455
2009	Tideprins	Ferry	150	2013	Rem Leader	PSV	5335
2009	Barentshav	Costgard	2100	2013	Eidsvaag Pioner	Cargo	2145
2009	Moldefjord	Ferry	857	2013	Ryfylke	Ferry	3999
2010	KV Bergen	Costgard	2100	2014	Borgøy	TUG	675
2010	Fannefjord	Ferry	857	2014	Bokn	TUG	675
2010	Romsdalsfjord	Ferry	857	2014	With Harvest	Cargo	3250
2010	Korsfjord	Ferry	857	2014	With Marine	Cargo	3250
2010	Selbjornsfjord	Ferry	900	2014	Hardanger	Ferry	3999
2010	Sortland	Cargo	2100	2014	Rem Eir	PSV	5900
2011	Scandi Gamma	PSV	5000	2015	Stril Barents	PSV	5938
2011	Boknafjord	Ferry	1300	2015	Kvitebjørn	Ro-Ro	



Operational experience - dual fuelled PSV

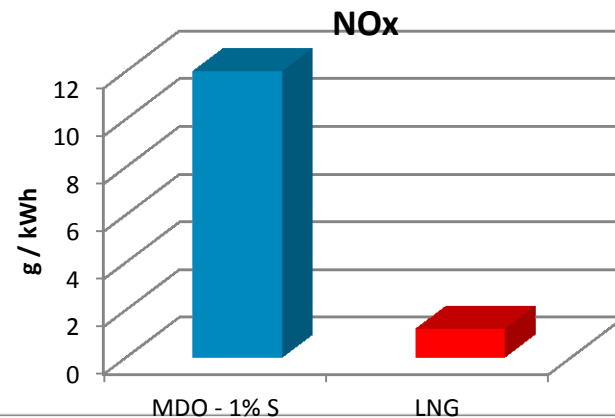
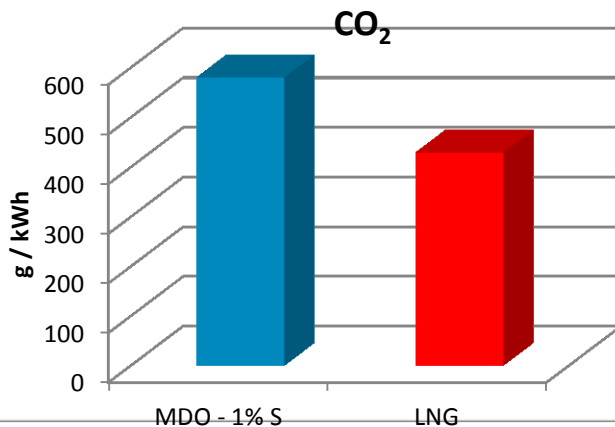
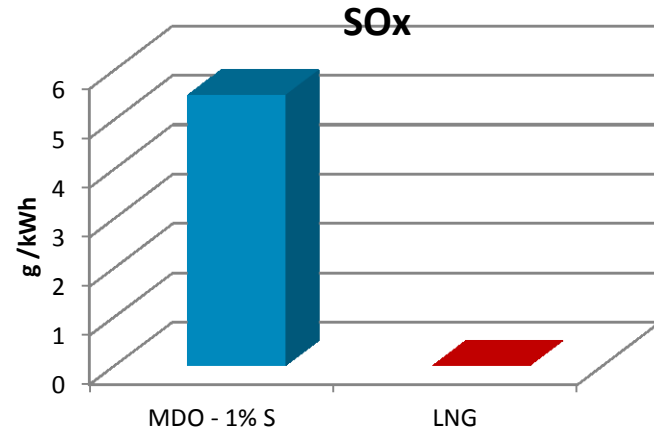
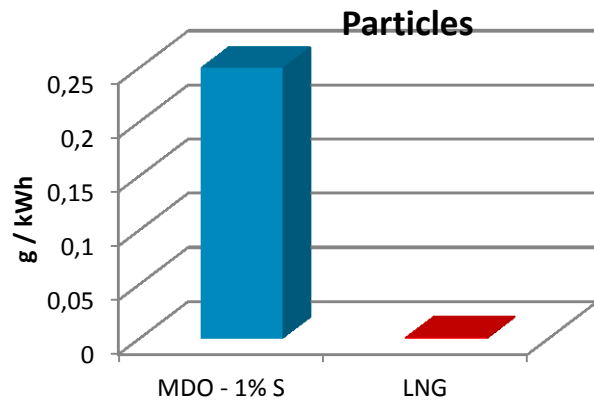
Viking Energy – Eidesvik

- Viking Energy: 13 years of operation without off-hire caused by the gas system
- Gas mode in 97% of total energy production time
- ~18% reduction in operational and maintenance costs





Experience on emission





Norwegian regulations on LNG-fuelled ships

- Regulations in force
 - Reg. of 17 June 2002 No. 644 on cargo ships with natural gas fuelled internal combustion engines
 - Reg. of 9 September 2005 No. 1218 on the construction and operation of gas-fuelled passenger ships



International regulations – the IGF Code

- 2004 Proposal from Norway to develop Gas Code
- 2009 Interim Guidelines adopted in June 2009
Resolution MSC.285(86)
- 2009 The development of the IGF Code started
- Approval in principle at MSC 94 November 2014
- Adoption at MSC 95 June 2015?
- Entry into force on 1 January 2017?



IMO



HTW - Training for gas-fuelled ship crew

Human Element, Training and Watchkeeping developed Feb 2014

- Training requirements for officers and crew on board ships using gases or other low flashpoint fuels
- Adoption at MSC 95?



A new International Bunker System standard – must be harmonised with the IGF Code

- Nordic co-operation on bunkering regulations:
 - Denmark
 - Faroe Islands
 - Finland
 - Sweden
 - Norway





Battery propulsion also has a relatively long history

In 1886 Siemens delivered the 11m long and 2m wide vessel ELEKTRA for 30 passengers with a 4.5kW electric propulsion engine and batteries. 200 units of this type were delivered.





MF Ampere: First fully battery-driven ferry in Norway

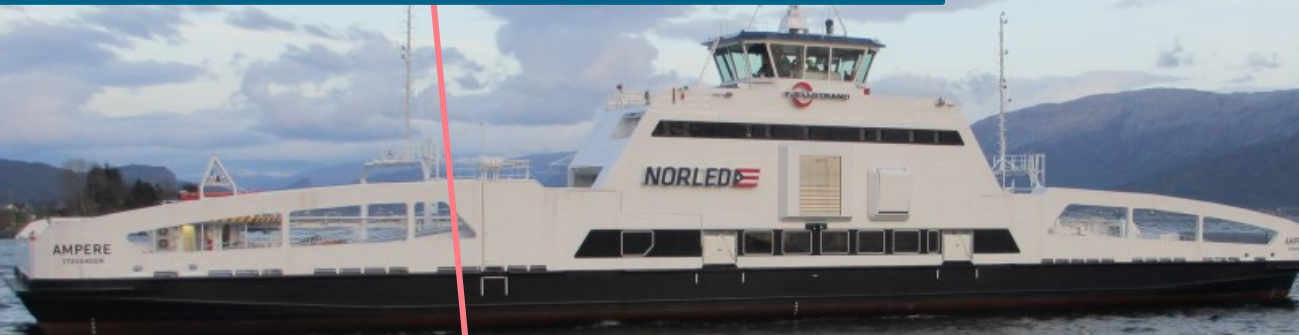


ECO-efficient ferry by Fjellstrand shipyard

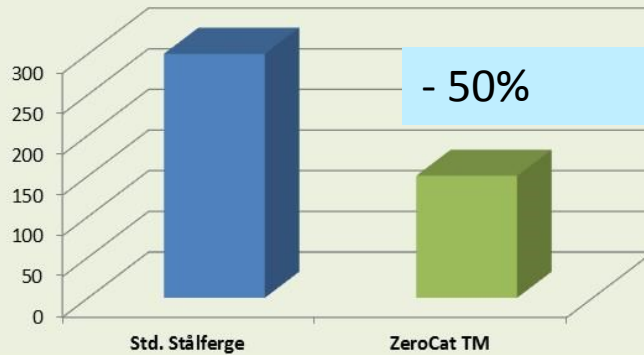
Norwegian low weight technology by Fjellstrand

Norwegian high efficient propellers by Rolls Royce

Norwegian low drag hull technology by Marintek

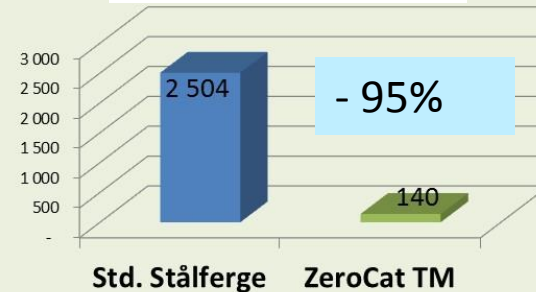


Energy consumption in kWh / trip



2.69kg CO₂/litre diesel
0.075 kg CO₂ /kWh electricity

Tons of CO₂/year



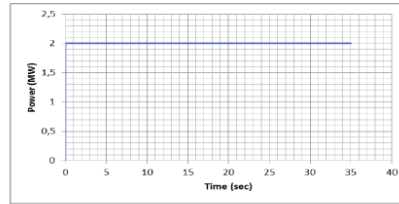
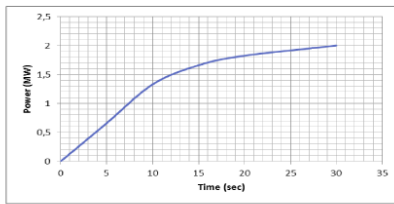
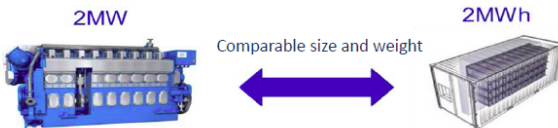
Diesel hybrid with battery power support

Edda Ferd

Østensjø



Performance – Load Response



- Optimizing fuel consumption by damping transient loads
- Instant standby power available
- Enable utilization of shore power facilities



50.000 dwt Product tankers utilising Methanol as fuel

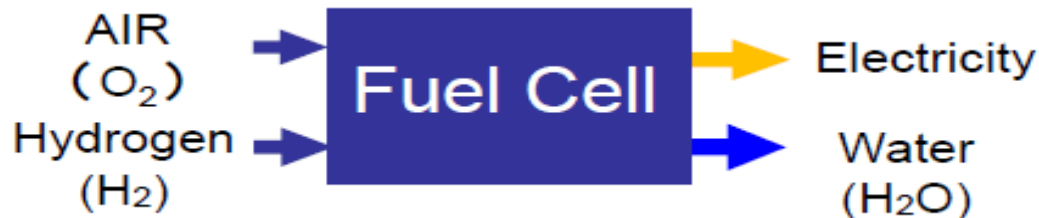
The ships are equipped with MAN B&W ME-LGI 2-stroke Diesel Dual Fuel Engines. The engine platform can be delivered for different types of Low Flashpoint Liquids, including methanol, ethanol and DME





ECO-efficient shipping - NEO

- Challenging but possible future zero emission fuel:
 - H₂ produced by electrolysis of H₂O
 - H₂ from Methane with CO₂ separation
 - Calorific value H₂ = ~ 2,9 X HFO (J/kg)





The GreenTech Frontier Ship

- LNG/gas electrical propulsion
- Fuel cell auxiliary power
- Li-ion battery energy storage





To the future: Green Shipping



Awaiting the IGF Code - Owners are invited to build Green fuelled ships to Norwegian regulations!

Thank you for your attention!