Presentation of ‘Green Ship of the Future’

by

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Green Ship of the Future

'Green Ship of the Future' is a Danish joint industry project aiming at developing and demonstrating technologies and methods that makes shipping more environmental friendly.

With respect to airborne emission the aim of the project is to provide the necessary technologies and operational means to reduce emissions as follows for newbuildings:

- 30 % reduction of CO_2 emissions
- 90 % reduction of NO_x emissions
- 90 % reduction of SO_x emissions

The base case is the emission level of the average global fleet in 2007 with a time frame of 10 years.

How to Join . . .

Green Ship of the Future is a joint industry project aiming at developing or demonstrating technologies and methods that makes shipping more environmental friendly. The project is open for all companies and organisations with a project meeting the following conditions:

- The project must aim at demonstration of a technology and methods that makes shipping more environmental friendly.
- One of the partners must be Danish or must have a Danish affiliated company
- The project partners must be willing to join and actively cooperate with the Green Ship working group (i.e. the group of GSF partners) in order to meet the overall goal for reduction of emissions from ships

'Green Ship Project Partners

Odense Lindø
Odense Steel Shipyard Ltd.

DANSK TEKNOLOGI

NORDIC TANKERS

DESMI A/S

AALBORG INDUSTRIES

MAN
MAN Diesel

MAERSK

APV
AN SPX BRAND

Grontmij | Carl Bro

DFDS

Lloyd's Register

NanoNord A/S

LR-MARINE
MARINE & OFFSHORE SOLUTIONS PROVIDER

GREENSTEAM

Danish Defence Acquisition and Logistics Organization

TORM

Mols-Linien
Din genvej i Danmark

ABB

FORCE TECHNOLOGY

NORDEN

Lauritzen Bulkers

HEMPEL

DTU

Network Partners

Green Ship of the Future has established a network partnership agreement with the following Danish maritime organisations:

- Danish Maritime Authority
- Danish Shipowners' Association
- Danish Maritime
- Danish Marine Group
- Transport Innovation Network
- Danish Ministry of the Enviroment

The role of the network partners is to provide a network and to communicate events and project results to their respective members.

Green Ship of the Future

To meet the reduction targets, the following four working groups are considered:

- **Machinery** WHR, scrubbers, EGR, etc.
- **Propulsion** Propellers, rudders, trim optimization, etc.
- **Operations** Route planning, performance monitoring, etc.
- **Logistics** Better interaction between transport forms, development/modification of existing ship types etc.

Currently nearly 20 projects are active all with several partners. The project is coordinated by FORCE Technology.

’Green Ship of the Future’

Machinery

- Waste heat recovery system (A. P. Moller – MAN, Aalborg Industries, Odense Lindoe Shipyard)
- Exhaust Gas Recirculation system (MAN, A.P. Moller)
- Water in fuel emulsion (WIF) (MAN and A. P. Moller
- Scrubbers (Aalborg Industries and DFDS)
- Selective Catalytic Reduction (Dansk Teknologi and Danish Navy)
- Turbo charging with variable nozzles (MAN and ABB)
- Automated engine monitoring (MAN and A. P. Moller)
- Optimization of pump system systems (DESMI, APV, Odense Lindoe, Grontmij Carl-Bro)
- LNG for aux. engines and gas turbines (Mols Line and DTU)

’Green Ship of the Future’

Propulsion

- New paint systems (Hempel and FORCE Technology)
- Trim optimization (NORDEN/Green Steam, and Nordic Tankers/FORCE Technology)
- Real-time analysis of bunker quality and emissions with LOAS (Lauritzen, NanoNord and Lloyds Register)

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Operations

- Voyage planning (DFDS and FORCE Technology)
- SIMAC (nautical college) has established a Student Forum with focus on Green Ship technologies
- Cooperation with other nautical education institutions, to introduce ‘Green shipping’ in the working procedures onboard
- Constant focus on energy saving possibilities on the ships

’Green Ship of the Future’

Logistics

- Better transport planning
- Better tools for evaluation of the most
- energy efficient transport forms
- Better cooperation between the transport providers

‘Low emission concept ships’

SEAHORSE 35
35.000 DWT Bulk Carrier
By Grontmij Carl Bro

A-Class
8500 TEU Container Ship
By Odense Lindoe Shipyard

Technologies Applied

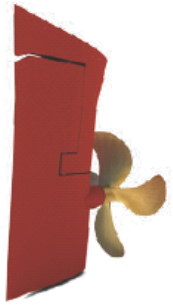
Technologies applied

1

Advanced rudder and propeller system

A well-designed propeller and rudder system can save up to approximately 4% of the fuel oil consumption. Such a system could be a modern propeller combined with an asymmetric rudder and a so-called Costa Bulb.

With new propeller design methods modern propellers becomes more and more efficient. The Costa Bulb creates a smoother slipstream from the propeller to the rudder. With an asymmetric rudder, the rotational energy from the propeller is utilised more efficient compared to a conventional rudder.



2

Speed Nozzle

Normally, nozzles are used to improve the bollard pull on tugs, supply vessels, fishing boats and many other vessels which need high pulling power at low speed.

This new kind of nozzle, called a speed nozzle, is developed to improve the propulsion power at service speed. Using the new speed nozzle concept has a saving potential of approximately 5%.

3

Exhaust gas scrubber system

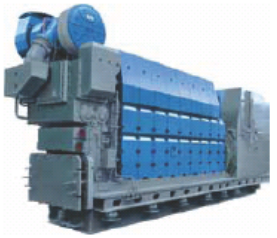
One way to fulfil the future regulations on sulphur emissions is to install an exhaust gas scrubber. This scrubber system use water to wash the sulphur out of the exhaust gas. Measurements have shown that SOx emissions are reduced with up to 98%. It is not only the sulphur which is reduced, also the content of harmful particles are reduced by approximately 80%.

4

LNG auxiliary engines

Normally, the electrical power in harbour condition is supplied by using auxiliary engines running on heavy fuel or marine diesel. By using auxiliary engines running on LNG (liquefied natural gas) instead of conventional fuel, significant emission reductions can be achieved.

Emission reductions in the magnitude of approximately 20% on CO_2, approximately 35% on NOx and 100% on SOx are the potential of switching from diesel to LNG.



5

Hull Paint

The choice of the right hull paint is essential to keep the resistance at a minimum. Modern anti-fouling hull paint with a low water friction has a fuel saving potential in the region of 3 to 8%. The reduction of emissions is proportional to the fuel savings.

6

Waste Heat Recovery system (WHR)

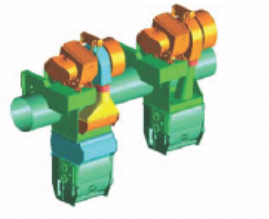
The waste heat recovery system utilises the heat in the exhaust gas from the main engine. The exhaust gas contains a lot of heat energy which can be transformed into steam. The steam can then be used for heating of the accommodation, cargo areas and fuel oil. The steam can also be used for power generation in a turbo generator. Depending on the configuration, a waste heat recovery system can reduce the fuel consumption by 7 – 14 %.

Technologies applied

7

Water In Fuel system (WIF)

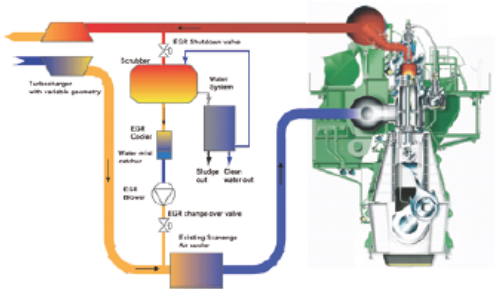
The formation of NOx is dependent of the temperature in the cylinder liner. By lowering the temperature the NOx emissions are also lowered. By adding water to the fuel before injection, the temperature in the cylinder will be lowered. This will result in a reduction of NO_x by 30-35%.



8

Exhaust Gas Recirculation system (EGR)

The formation of NO_x emissions can be reduced by lowering the temperature in the cylinder liner of the main engine. One way of lowering the temperature is to recirculate some of the exhaust gas. Some of the exhaust gas is mixed with the scavenge air so that the oxygen content is reduced together with a lower temperature in the combustion chamber. Measurements have shown that this technology have a potential of NO_x reductions of approximately 80%.



9

Pump and cooling water optimisation

By using an optimised cooling water system it is possible to save up to 20% of the electrical generated power, corresponding to approximately 1.5% reduction of the total fuel consumption.

Studies show that the resistance in the cooling water system often can be reduced. When the resistance is reduced smaller pumps can be used and thereby saving up to approximately 90% of the power needed for pumps.

Conclusion from Study

SEAHORSE 35 Bulk carrier, optimised with:

- Speed nozzle / optimized propeller
- Twisted spade rudder with Costa bulb
- Water in fuel (WIF)
- Exhaust gas recirculation (EGR)
- Waste Heat Recovery system (WHR)
- Exhaust Gas Scrubber
- Ducted / direct air intake for main engine
- Optimised coolers and cooling pumps
- Auxiliary engine operation on marine diesel oil (MDO)
- High capacity fresh water generator

Extra costs 5 mill USD (Corresponds to approx 20 % of newbuilding costs)

Goals	Results
-30 % reduction of CO_2 emissions	- Achieved 7 %
-90 % reduction of NOx emissions	- Achieved 90 %
-90 % reduction of SOx emissions	- Achieved 79 %

Conclusion from Study

8500 TEU container vessel, optimised with:

- Water in Fuel technology (WIF)
- Exhaust gas recycling (EGR)
- Waste heat recovery exhaust boilers
- Power and Steam turbine technology
- Exhaust gas Scrubber

Extra costs 10 mill Euro (Corresponds to approx 10 % of newbuilding costs)

Goals	Results
-30 % reduction of CO_2 emissions	- Achieved 11 -14 %
-90 % reduction of NOx emissions	- Achieved 80 %
-90 % reduction of SOx emissions	- Achieved 90 %

Main Conclusions from Concept Studies

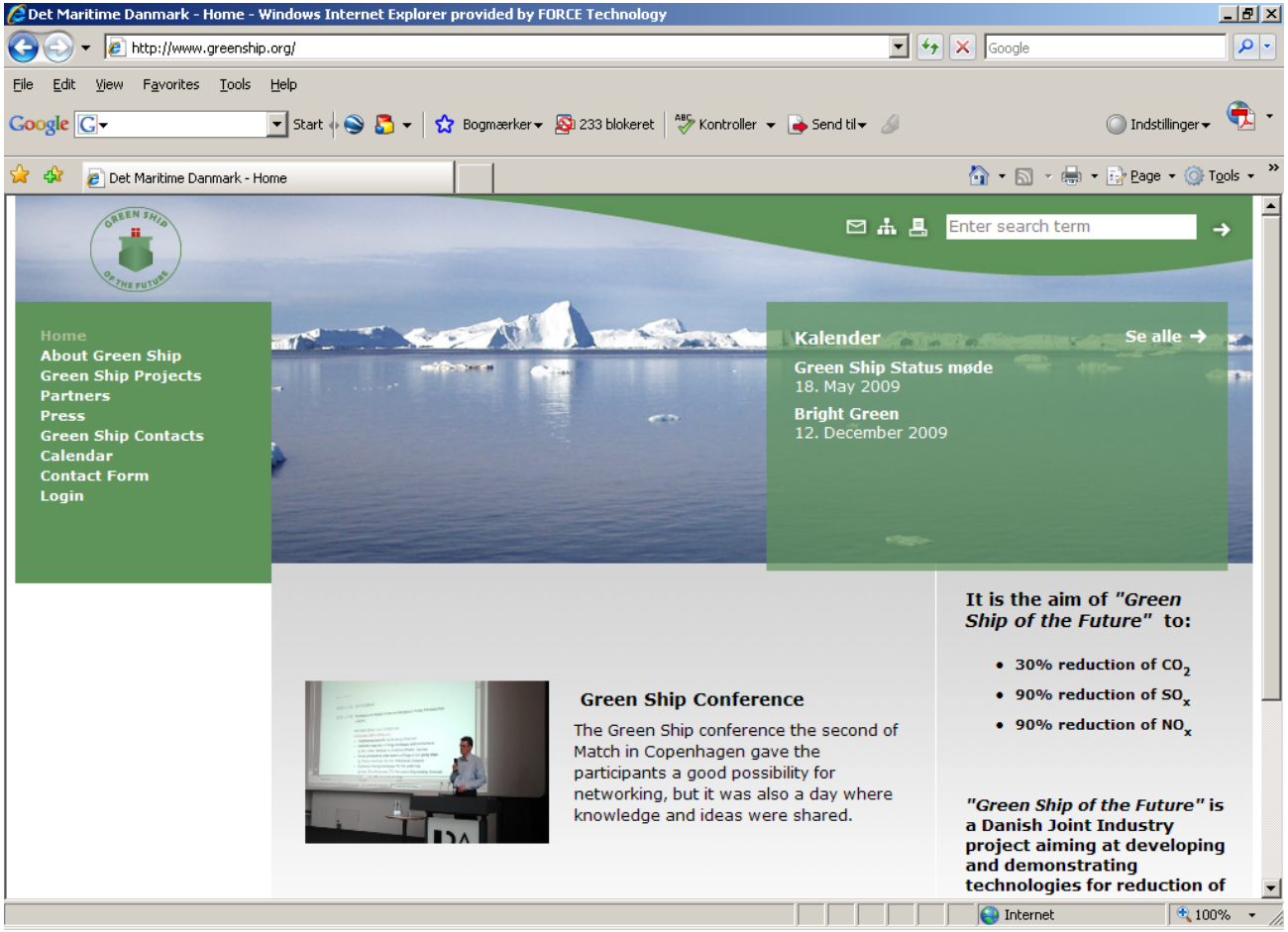
- With respect to NOx and SOx we have reached our goals
- Reducing NOx and SOx will in some case cost increased CO2 emission
- With respect to CO_2 the study shows that we still need to work with technical solutions and operation to meet goal
- Further reduction in CO_2 must be obtained through continued efforts to reduce vessel resistance, optimised operation, more effective propulsion systems, more fuel efficient engines, alternative fuel (LNG, Biofuel etc.) and addition of alternative green means of propulsion (fuel cells, wind, solar etc.) etc.
- Further reductions in CO_2 will also reduce NOx and SOx emissions
- Retrofit challenges

- **The challenge continues !!!!!**

The future of Green Shipping ?

- Depends on the economic climate
- Depends on the real climate
- Depends on future legislation (from IMO, EU..)
- Depends on the commitment of each partner

www.greenship.org



Invitation ...

All companies, Organisations and Educational institutions are invited to join 'Green Ship of the Future'

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