# LNG Vessels and innovations in hydrodynamics on the Danube and a practical experience: Damen LNG Ecoliner

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# Damen Shipyards Group at a "glance"

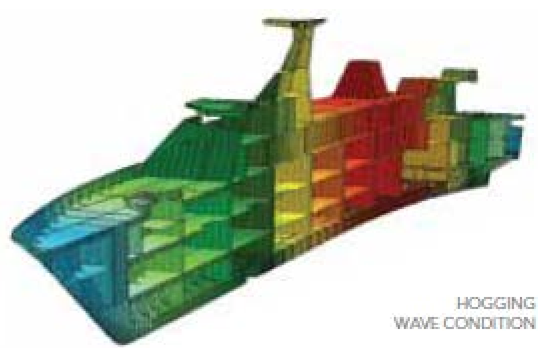
- Family Company started in 1927
- Annual turnover: 1.3bn EURO
- 35 yards worldwide
- Over 6,000 employees
- Annual deliveries: 120 – 150 vessels
- More than 5,000 vessels delivered since 1969
- Over 1,000 repair jobs per year

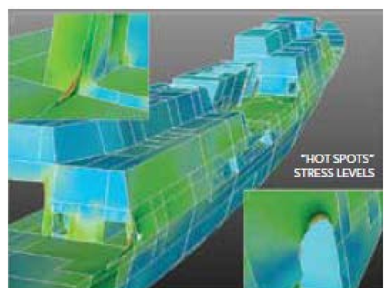
# Research & Development
# Damen's Backbone

TU Delft · MARIN · TNO innovation for life

DUTCH MARITIME KNOWLEDGE

All Damen vessels benefit from knowledge gathered during ongoing research programmes within the Group. Damen works alongside world-renowned research institutes like Delft University of Technology, Maritime Research Institute Netherlands (MARIN) and the Netherlands Organisation of Applied Scientific Research (TNO), as well as other reputed universities and leading maritime companies.




FINITE ELEMENT METHOD

By using the Finite Element Method, the actual behaviour of the ship can be simulated. Undesired effects can be found and corrected.

THE AXE BOW CONCEPT SEA AXE

Since the eighties, Damen and Delft University of Technology have cooperated in a research programme aimed at improving the seakeeping characteristics of high speed vessels. In the nineties, this cooperation produced the "Enlarged Ship Concept" on which the highly successful Stan Patrol 4207 and 4708 are based. In the beginning of the 21st century, the "Axe Bow Concept" was developed, a hull shape with unparallelled sea-keeping characteristics. Based on this concept, Damen has developed the "Sea Axe" Patrol Vessels and Fast Crew Suppliers.

# Damen Ships in General

High Speed Craft

Cargo vessels

Tugs

Offshore & Transport

Ferries

Naval & Patrol

Pontoons & Barges

Workboats

Yachting

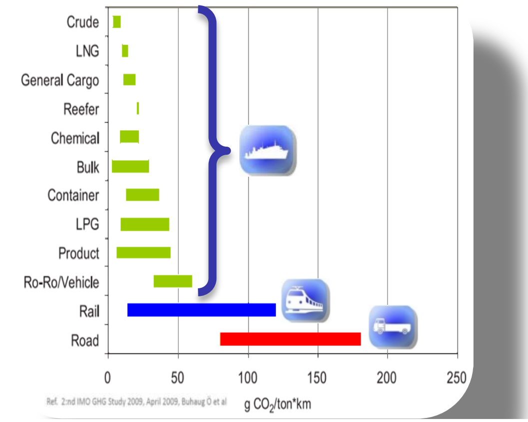
Dredging

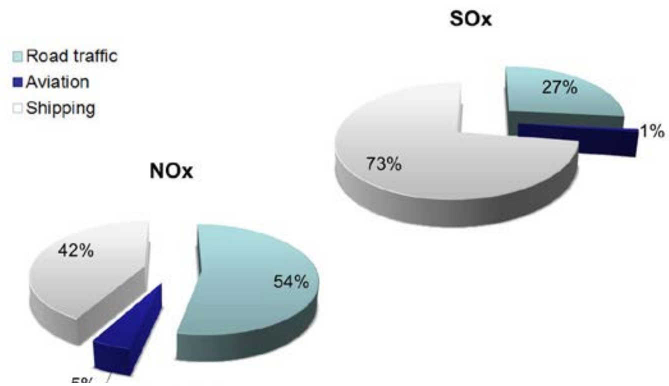
Fishing vessels

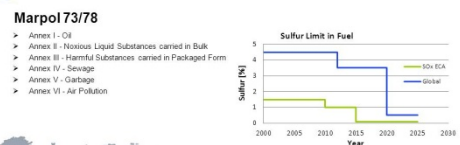
# Damen Inland Vessels

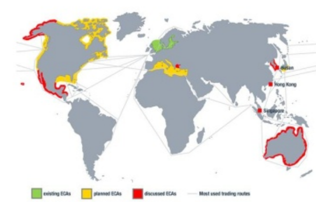

# WHY Green Ship R&D?

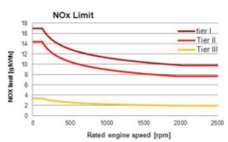
- Greenhouse gas emissions
- Harmful emissions
- Rules and regulations
- Customer requirements

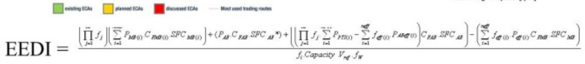




**Energy and emission reduction; options**

- Reducing Energy Consumption
  - Design for operations approach **2 Examples**
  - Resistance reduction **ACES**
- Improving the efficiency of energy conversion
  - Improving engine efficiency and matching engines to Operational Profile
  - Efficient propulsors
  - Fuel Cells
- Pre-, while- and aftertreatment of fuel and emissions
- Alternative fuels (LNG) **IWT application**
- Crew behaviour and operational strategy with a focus on fuel saving.

# Energy and emission reduction
# Design for Operations (1)

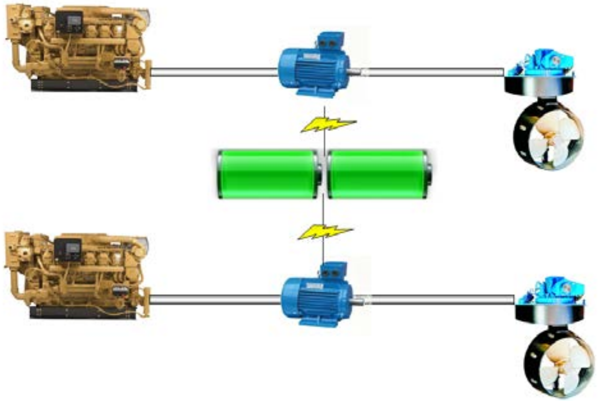
**The SEA AXE Development**

- **Ship motions optimised for crew comfort and safety**
- **Significantly reduced resistance in a seaway**
- **20% fuel consumption reduction in operational conditions**

# Energy and emission reduction
# Design for Operations (2)

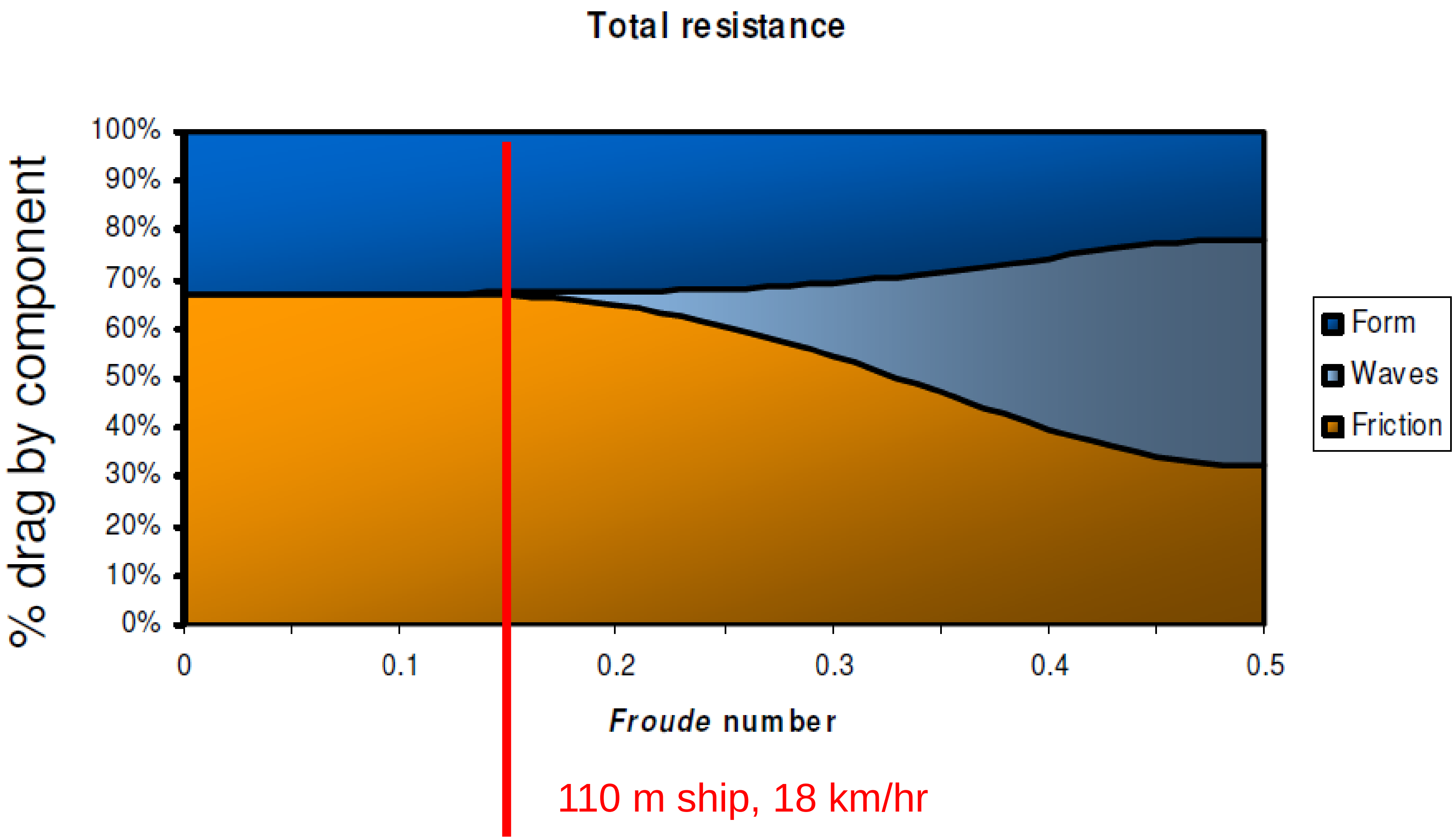
**The E3 – Tug**

- **Design optimized for operational profile**
- **Hybrid E&P configuration**
- **35% environmental impact reduction**



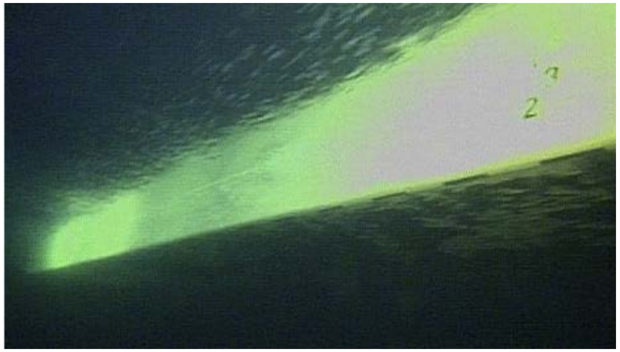
# The development of the Ecoliner

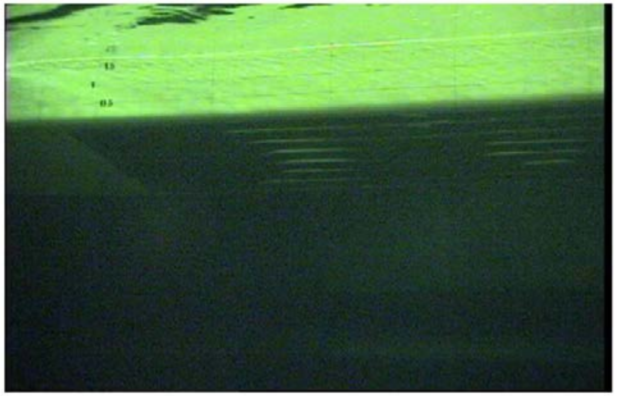
# Resistance Reduction



# Reducing frictional resistance

- An (enduring) sleek surface
  - Anti-foulings
  - maintenance
- Air lubrication
  - By airbubbles
  - By airsheet
  - By air cavity chambers





# Research Goals

- Insight in physics
  - Resistance reduction of two-phase flows and stability thereof
  - Resistance reduction by airfilms and air cavity chambers
  - Scale effects
  - Numerical modeling
- Design knowledge
  - Insight into the design consequences of airlubrication

# Air Lubrication Concept

Patented Air Chamber Energy Saving System

Cost effective combination of air chamber concept and structural design

# Desk and Lab studies

RESISTANCE TEST No. : 9809051
SHIP MODEL No. : 8910

DRAUGHT FWD : 1.700 m
DRAUGHT AFT : 1.700 m

SHIP SPEED $V_s$ : 13.00 KM/H

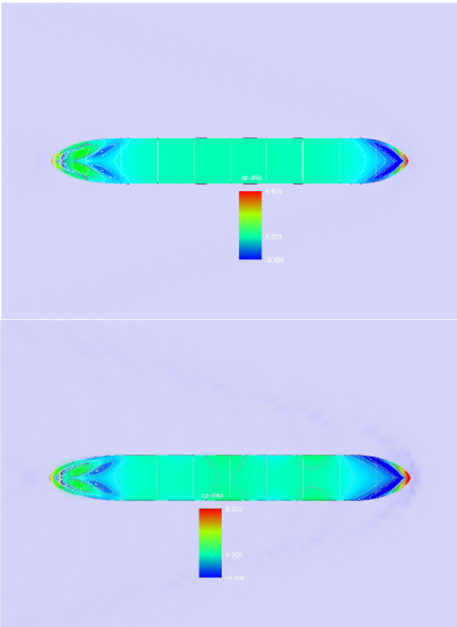
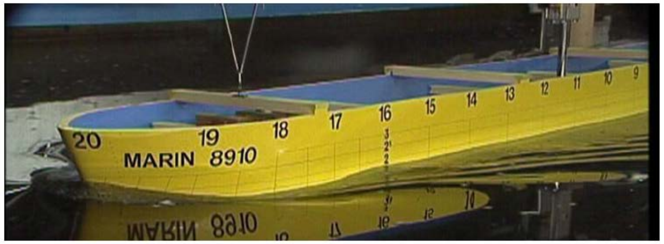
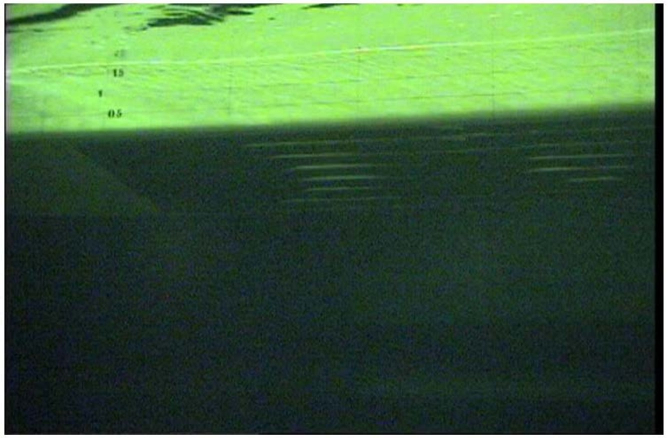


*Figure 2 Dimensionless pressure distribution on the ship hull at 13 and 19 km/h. The pressure distribution is reasonably flat between frames 4 and 16¼ where the air cavities are situated. As the ship speed increases, transverse waves are formed that visibly influences the pressure distribution on the hull.*





WAVE PROFILES



*13 km*

| | | |
|---|---|---|
| Length between perpendiculars | 62.200 | m |
| Breadth moulded | 7.740 | m |
| Design draught moulded | 1.700 | m |
| Displacement volume moulded | 685.0 | m3 |

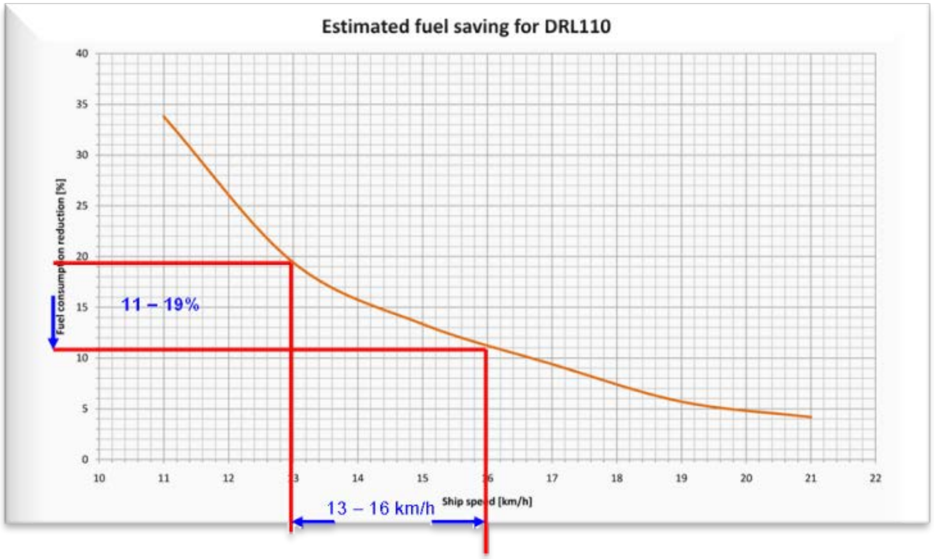
CFD calculations and modeltests with a number of air chamber configurations: Resistance reductions in excess of 10% predicted for full scale

# Full Scale Testing

- Cleaning (original) hull and propulsors
- Full scale reference tests
- Refit of air chambers to ship
- Full scale air chamber tests


# Results

Depending on speed and loading condition a power reduction of 15%



# Environmental Effects

What does this mean for the environment?

| | |
|---|---|
| 5.000 | Dutch inland ships |
| 800 | kW average installed power per ship |
| 80.00% | load |
| 180 | g/kwh specific fuel consumption |
| 4.500 | Sailing hours per year |
| | |
| 2.592.000 | ton fuel per year |
| 8.084.448 | ton CO2 |
| 121.266,2 | ton CO2 savings at 15% resistance reduction |
| 700 | g/vkm HGV (CE Delft) |
| 1.732 | mln equivalent Heavy Goods Vehiclekm's |

# Economic Effects

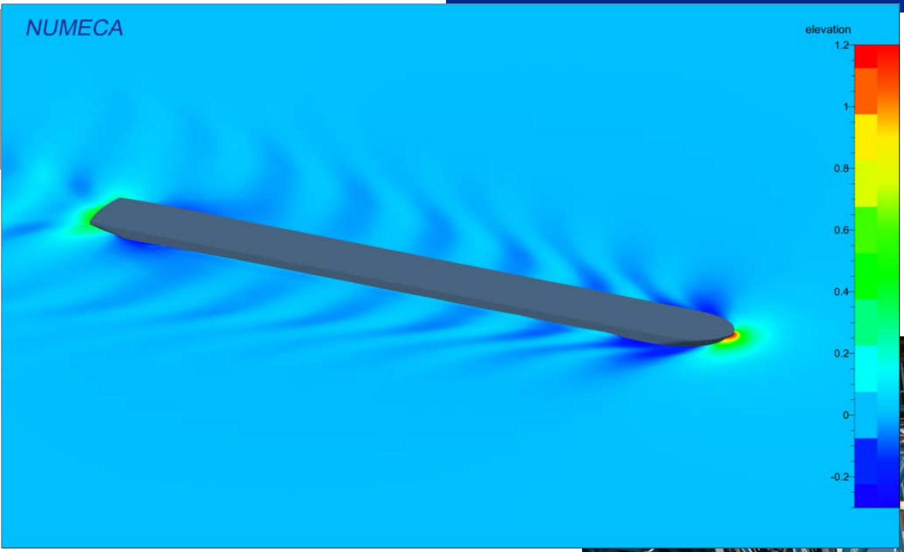
What does it mean for the inland shipping operator ?

| | |
|---|---|
| 800 | kW average installed power per ship |
| 80.00% | load |
| 180 | g/kwh specific fuel consumption |
| 4.500 | Average sailing hours per year |
| | |
| 612.748,8 | liter fuel per year |
| 775 | €/ 1000 liter |
| 474.880 | €/year |
| 71.232 | € fuel cost savings |

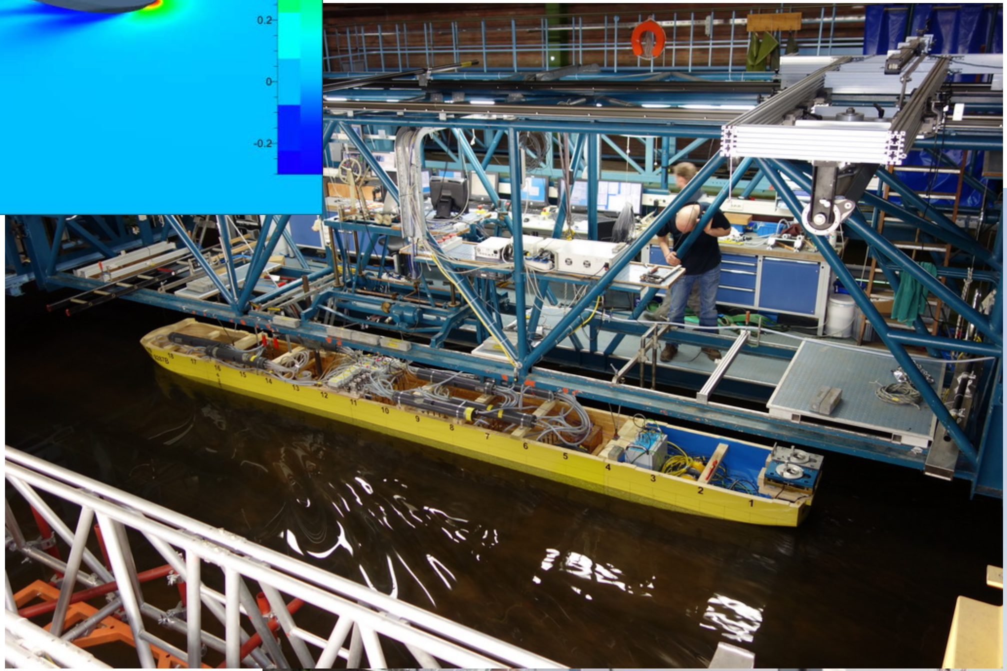
# 2nd full scale measurement campaign
## Operational performance and system development

1. Shallow water effects research – Confirmation of savings
2. Prototype air supply system development and validation of power requirement

# Application to the new standard Ecoliner



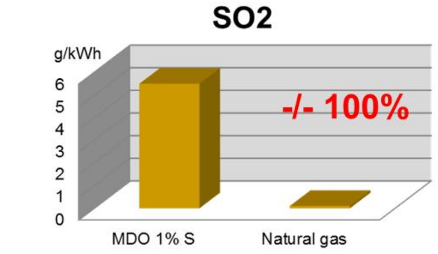

CFD hullform optimisation

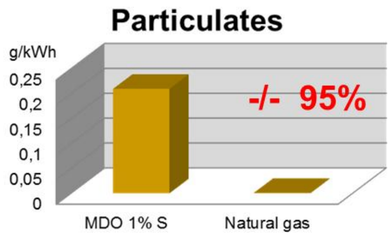


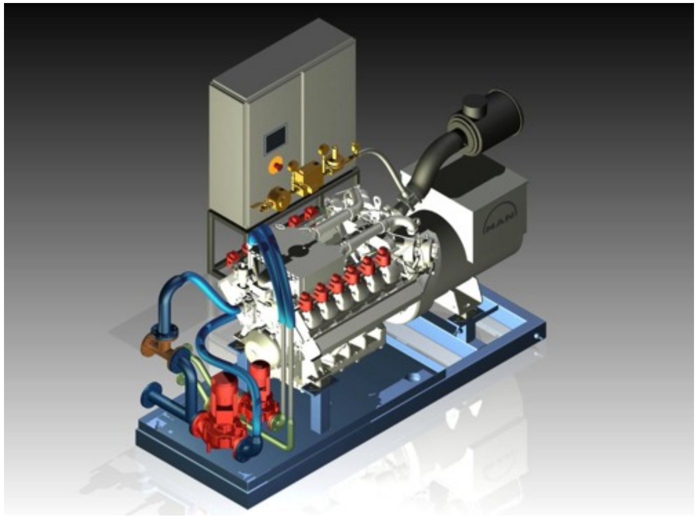
ACES optimisation

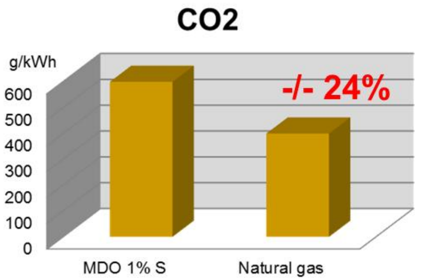

System integration & product development

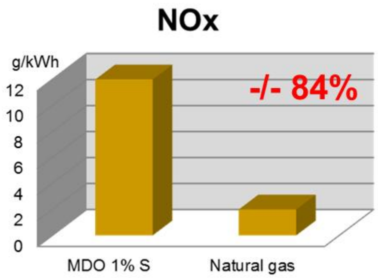
# Ecoliner LNG-Electric propulsion plant

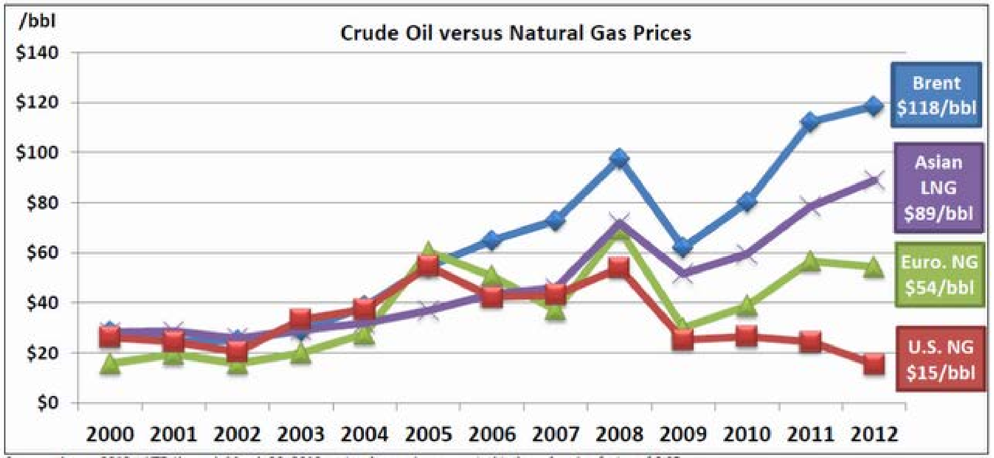




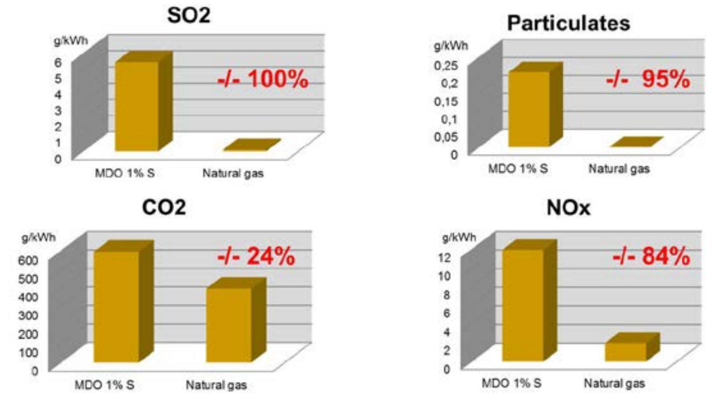



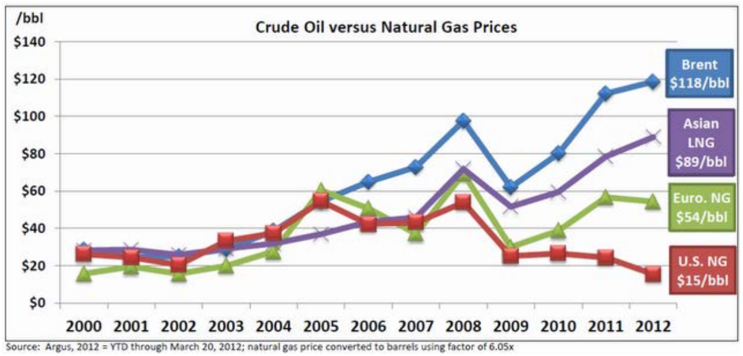




Source: Argus, 2012 = YTD through March 20, 2012; natural gas price converted to barrels using factor of 6.05x

# Factors influencing the introduction of LNG

1. Fuel price development (relative to oil) 
2. Higher investment and associated financing
3. Uncertainty in rules and regulations regarding LNG as a fuel
4. Uncertainty in LNG supply infrastructure



# Ready to sail into a cleaner future:
# The Ecoliner

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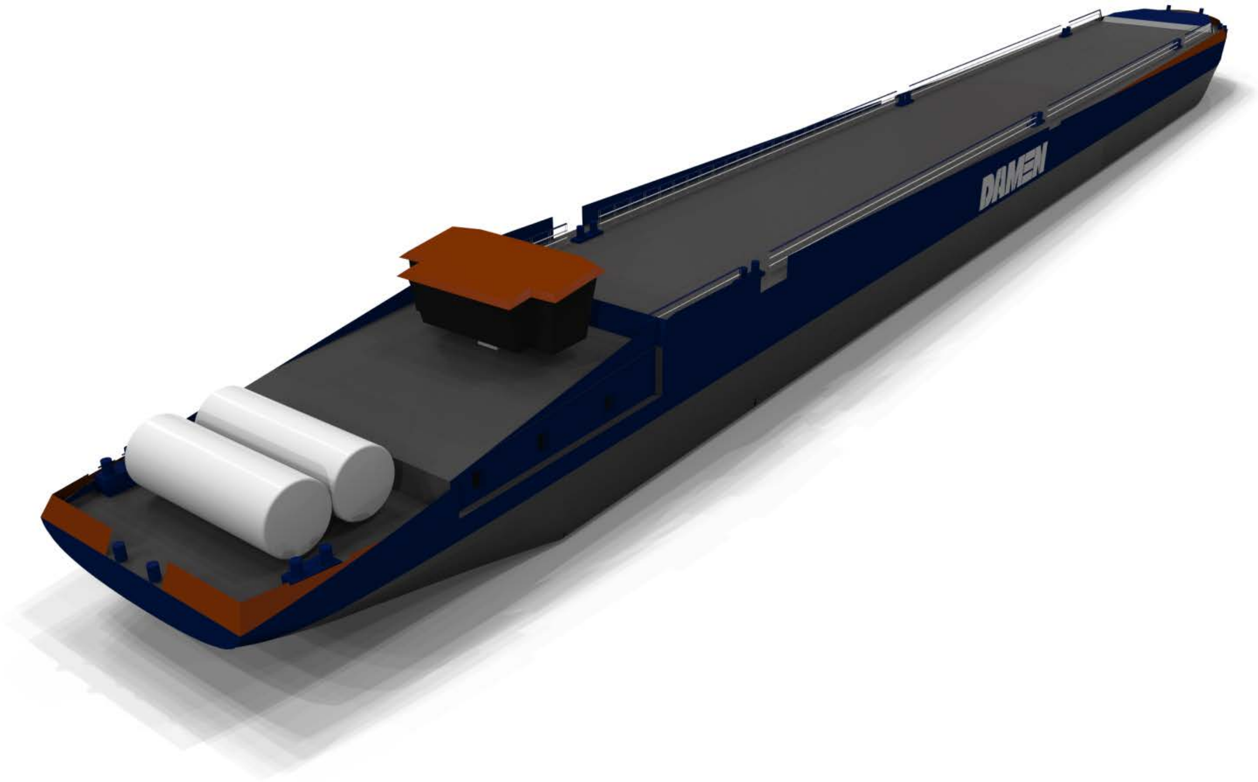
# Thank you for your attention

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