University of Applied Sciences
HOCHSCHULE EMDEN·LEER

GreenShipping Niedersachsen

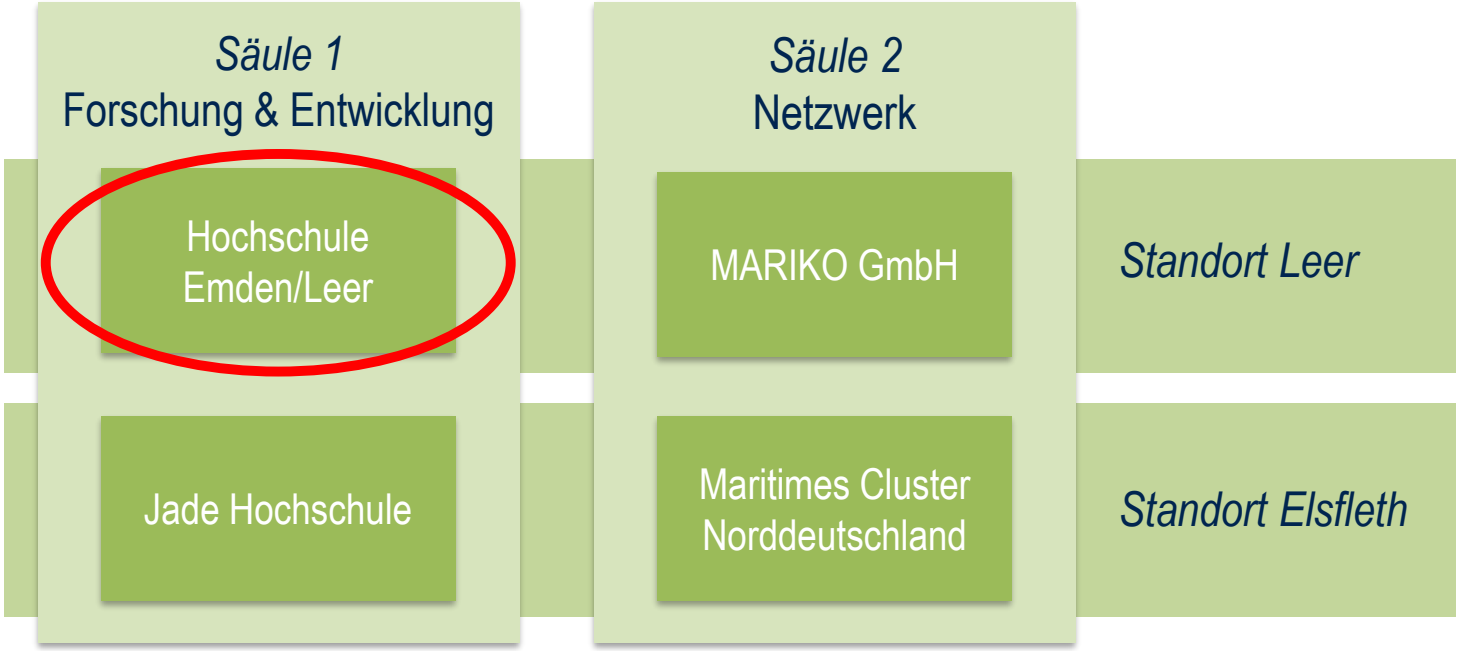
GreenSailer

Prof. Marcus Bentin
Prof. Michael Vahs
David Elger
Christian Schnabel

University of Applied Sciences
HOCHSCHULE EMDEN·LEER

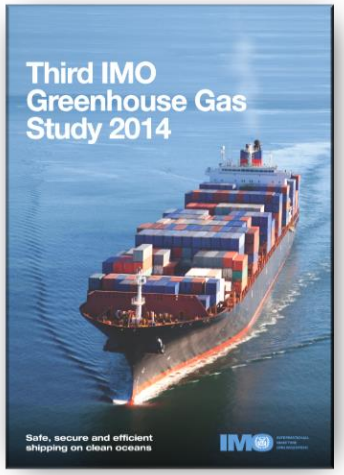
GreenShipping Niedersachsen

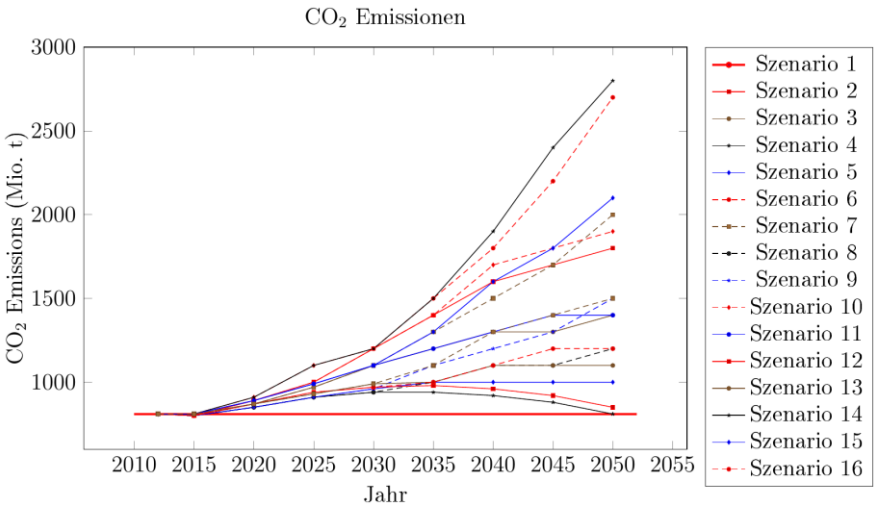
GreenSailer



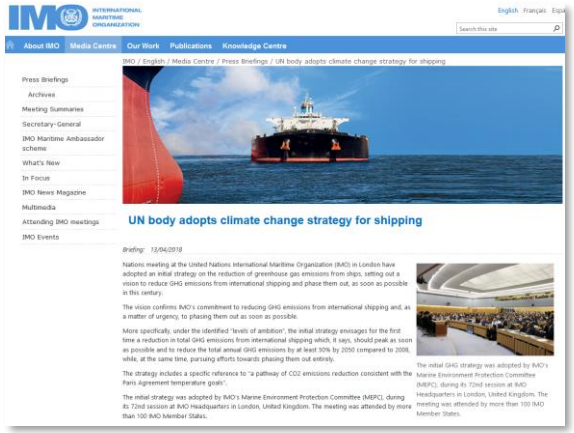
GreenSailer – Motivation & Ziel

- **Prognose: CO_2-Anstieg bis 2050 zwischen +50% bis +250%**
- **„Gute“ Prognosen setzen dabei noch nicht vorhandene Innovation voraus!**
- **IMO-Ziel: -50% (gegenüber 2008) im Jahr 2050**

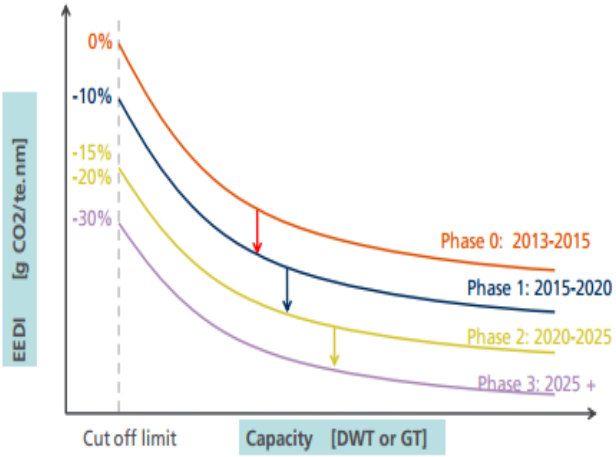


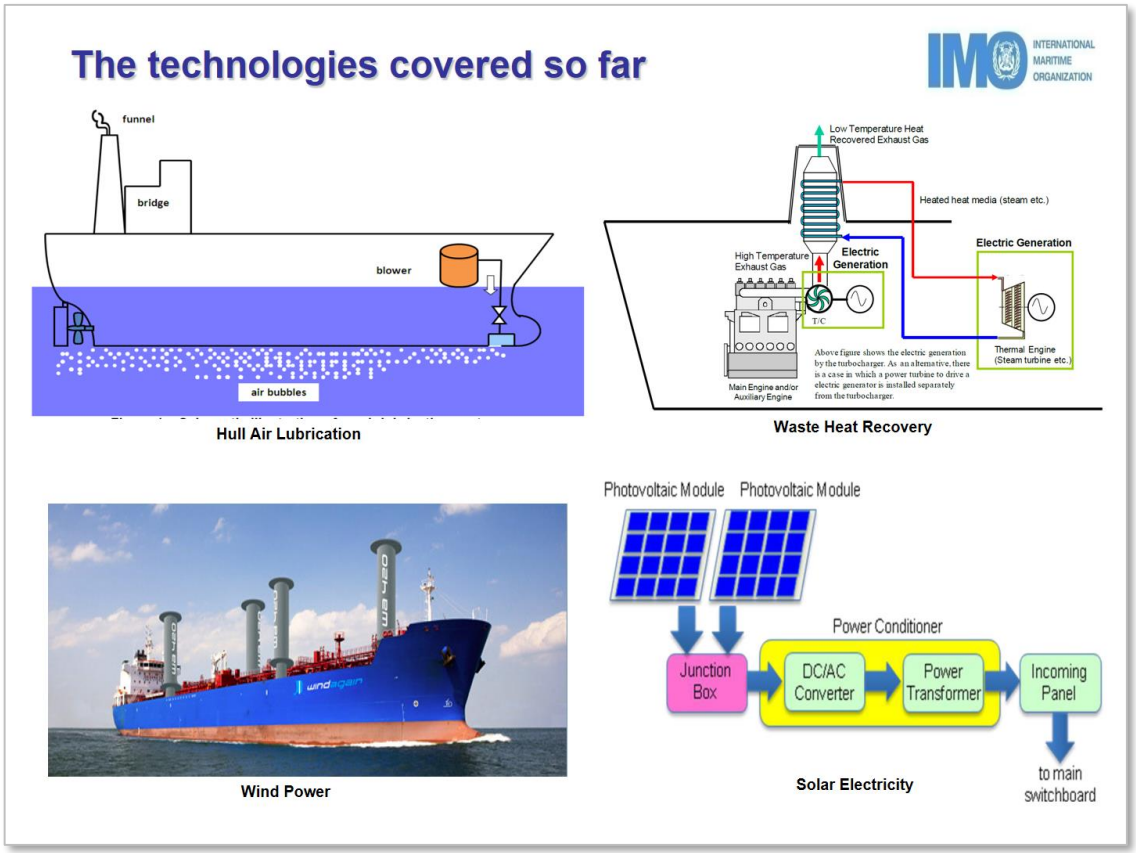


Prognose des maritimen CO2 Ausstoßes. *Darstellung nach IMO.*



EEDI


EEDI [g CO2/te.nm]
0%
-10%
-15%
-20%
-30%
Phase 0: 2013-2015
Phase 1: 2015-2020
Phase 2: 2020-2025
Phase 3: 2025 +
Cut off limit
Capacity [DWT or GT]


The technologies covered so far
IMO INTERNATIONAL MARITIME ORGANIZATION
funnel
bridge
blower
air bubbles
Hull Air Lubrication
Low Temperature Heat Recovered Exhaust Gas
Heated heat media (steam etc.)
High Temperature Exhaust Gas
Electric Generation
Electric Generation
T/C
Thermal Engine (Steam turbine etc.)
Main Engine and/or Auxiliary Engine
Waste Heat Recovery
Photovoltaic Module
Photovoltaic Module
Power Conditioner
Junction Box
DC/AC Converter
Power Transformer
Incoming Panel
to main switchboard
Solar Electricity
Wind Power

GreenSailer – Motivation & Ziel

- Geringer Energiebedarf pro t/km
- Gewicht / Platz weniger kritisch (Speicher, Energiegewinnung, Abgasreinigung, etc.)
- Energie unterwegs ergänzbar (Wind, Solar, Strömung,…)
- Anstehende internationale Regulierungen
- Potentiale für lokale und bundesweite Industrie

Abb. Illustration „GreenSailer“, *HS Emden/Leer*

Wenn „Zero-Emission“ realisierbar ist, dann auf dem Wasser!

→ Technology-Transfer auf andere Verkehrsträger

Funktionen des GreenSailers

- **Forschung**
  - GreenShipping
  - Innovative Schiffsantriebe
  - Meeres- und Klimaforschung
- **Ladung**
  - Carbon free Transport and zero emission
  - Küstenverkehr und Inselversorgung
  - Fair Trade and Transport
- **Ausbildung**
  - Praktika & Studienfahrten
  - Nautik & Schiffsbetriebstechnik
  - Meereswissenschaften
- **Passagiere**
  - Nachhaltiger Seetourismus
  - Bildungsreisen, schwimmende Universität

Technologieplattform
und
Aufdeckung zusätzlicher Potentiale durch Gesamtentwurf

GreenSailer – Der Weg

Existierende Entwürfe

(IndoSailer, Greenheart, …)

Vergleichsentwürfe

(Transformation)

GreenSailer

(Varianten-Baukasten)

Was nutzen wir

- **Reale Betriebsprofile als Vergleich**
- **Analyse bestehender Frachtsegler**
- **Retrofit**

UB/TIB Hannover

RO 203
(72/85)

Hamburgische Schiffbau-Versuchsanstalt
G. m. b. H.
Hamburg

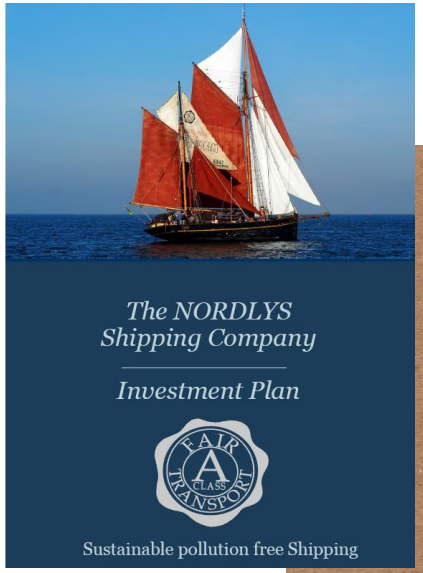
HSVA

REPORT WP 72/85

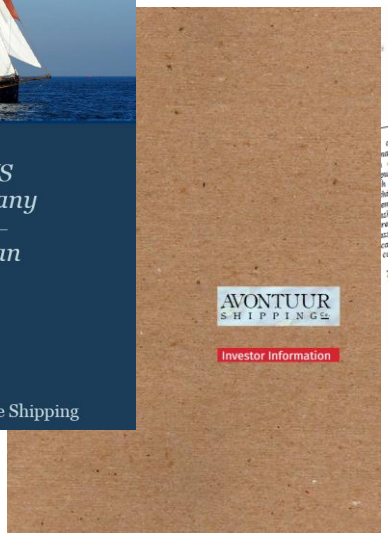
DEVELOPMENT OF SAILING VESSELS FOR THE INDONESIAN INTER-ISLAND TRADE

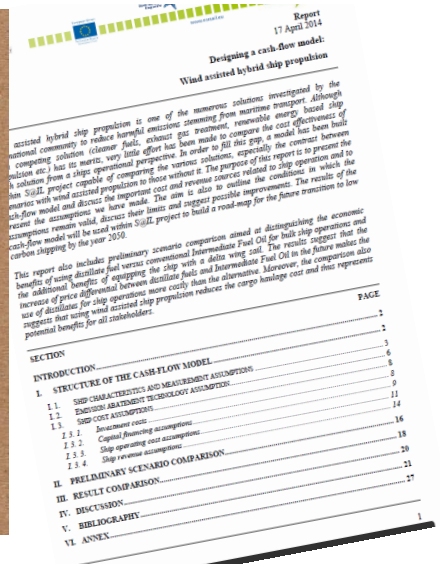
Executive Summary on Phase 3 A

Sponsered by:
FEDERAL MINISTER FOR RESEARCH AND TECHNOLOGY
Bonn 524- 3892- MTK 0280 5



The Caribbean Sea: overlooking the coastal waters of Barbados during the build of sailing cargo schooner Ruth.




Report
17 April 2014

Designing a cash-flow model:

Wind assisted hybrid ship propulsion

assisted hybrid ship propulsion is one of the numerous solutions investigated by the national community to reduce harmful emissions stemming from maritime transport. Although competing solution (cleaner fuels, exhaust gas treatment, renewable energy, based ship propulsion etc.) has its merits, very little effort has been made to compare the cost effectiveness of h solution from a ships operational perspective. In order to fill this gap, a model has been built hen SAIL project capable of comparing the various solutions, especially the contrast between enarios with wind assisted propulsion to those without it. The purpose of this report is to present the ash-flow model and discuss the important cost and revenue sources related to ship operation and to resent the assumptions we have made. The aim is also to outline the conditions in which the assumptions remain valid, discuss their limits and suggest possible improvements. The results of the cash-flow model will be used within SAIL project to build a road-map for the future transition to low carbon shipping by the year 2050.

This report also includes preliminary scenario comparison aimed at distinguishing the economic benefits of using distillate fuel versus conventional Intermediate Fuel Oil for bulk ship operations and the additional benefits of equipping the ship with a delta wing sail. The results suggest that the increase of price differential between distillate fuels and intermediate Fuel Oil in the future makes the use of distillates for ship operations more costly than the alternative. Moreover, the comparison also suggests that wind assisted ship propulsion reduces the cargo haulage cost and thus represents potential benefits for all stakeholders.

PAGE

SECTION

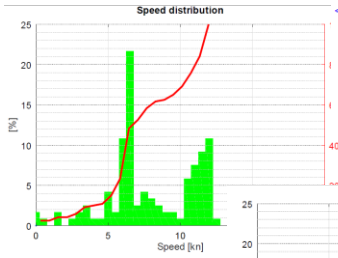
INTRODUCTION 2
I. STRUCTURE OF THE CASH-FLOW MODEL 2
1.1. SHIP CHARACTERISTICS AND MEASUREMENT ASSUMPTIONS 3
1.2. EMISSION ABATEMENT TECHNOLOGY ASSUMPTION 6
1.3. SHIP COST ASSUMPTIONS 8
1.3.1. Investment costs 8
1.3.2. Capital financing assumptions 9
1.3.3. Ship operating cost assumptions 11
1.3.4. Ship revenue assumptions 14
II. PRELIMINARY SCENARIO COMPARISON 16
III. RESULT COMPARISON 18
IV. DISCUSSION 20
V. BIBLIOGRAPHY 21
VI. ANNEX 27

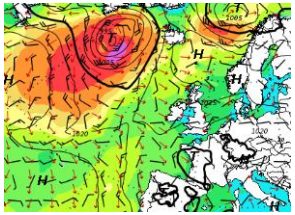
1

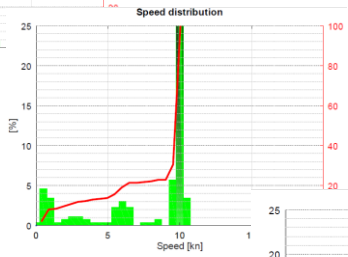
GreenShipping Niedersachsen

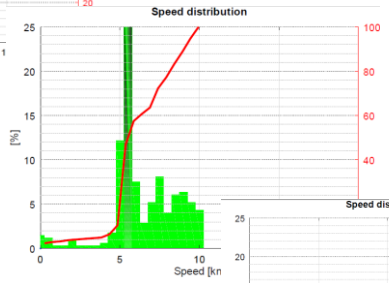
Basis: Reale Routen für Auslegung und Benchmark

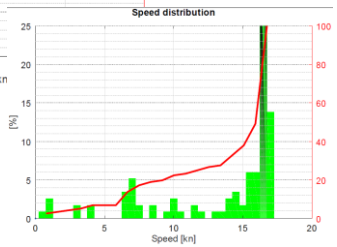
```
<trkpt lat="53.7073662" lon="7.5196438">
  <ele>6.24</ele>
  <time>2018-06-09T08:58:10Z</time>
  <hdop>9</hdop>
  <extensions>
    <speed>6.09</speed>
  </extensions>
</trkpt>
<trkpt lat="53.7080597" lon="7.5188432">
  <ele>7.24</ele>
  <time>2018-06-09T08:58:26Z</time>
  <hdop>9</hdop>
  <extensions>
    <speed>5.89</speed>
  </extensions>
```









GreenShipping Niedersachsen

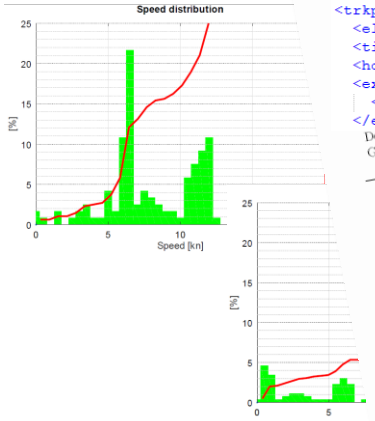
Basis: Reale Routen für Auslegung und Benchmark

Messreisen
AIS-Daten
GPS-Tracks

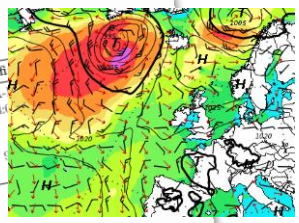
Wetter-Daten
Statistik

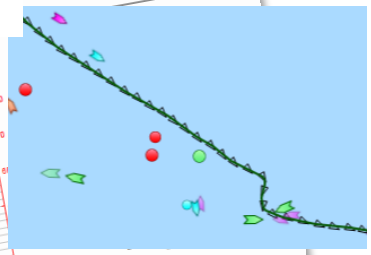
Auswertung

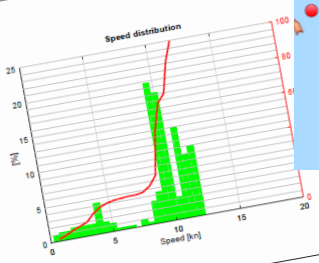
Reise-Profil +
Perfomance

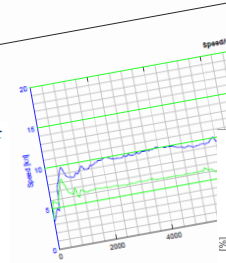


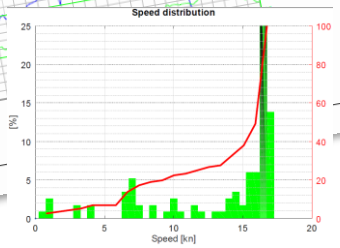

```
<trkpt lat="53.7073662" lon="7.5196438">
  <ele>6.24</ele>
  <time>2018-06-09T08:58:10Z</time>
  <hdop>9</hdop>
  <extensions>
    <speed>6.09</speed>
  </extensions>
</trkpt>
<trkpt lat="53.7080597" lon="7.5188432">
  <ele>7.24</ele>
  <time>2018-06-09T08:58:26Z</time>
  <hdop>9</hdop>
  <extensions>
    <speed>5.89</speed>
  </extensions>
```





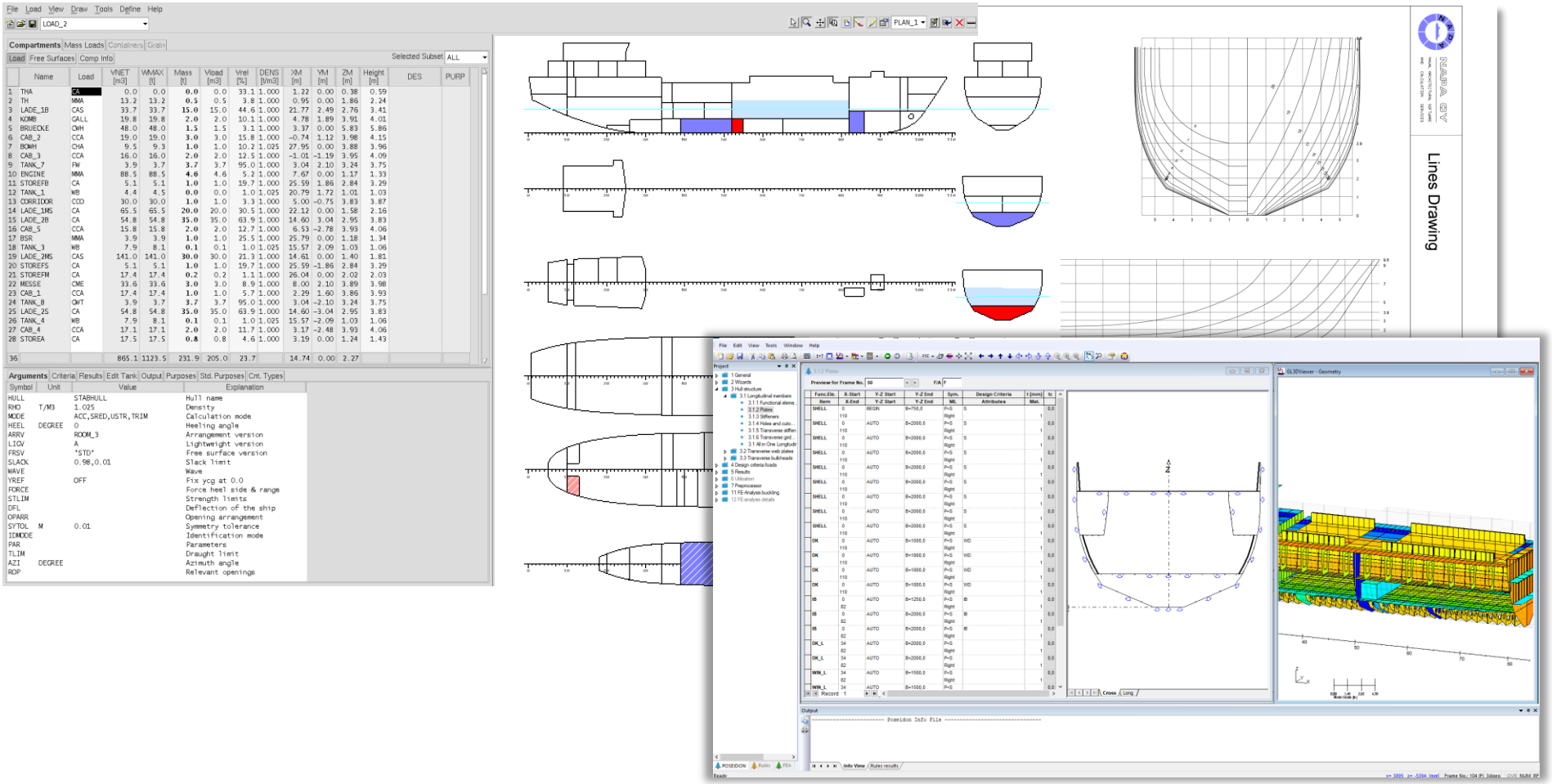




Wind Sp	Wind Dir	- - -	Result	Performance Faktor
8.00000	25.00000	0.00000	18993.31576	0.85555
10.00000	25.00000	0.00000	16341.63266	0.73611
12.00000	25.00000	0.00000	14451.93916	0.65099
8.00000	90.00000	0.00000	24869.30894	1.12024
10.00000	90.00000	0.00000	21524.66293	0.96958
12.00000	90.00000	0.00000	19145.78548	0.86242
8.00000	135.00000	0.00000	65689.18627	2.95897
10.00000	135.00000	0.00000	59605.12857	2.68492
12.00000	135.00000	0.00000	55298.68186	2.49093

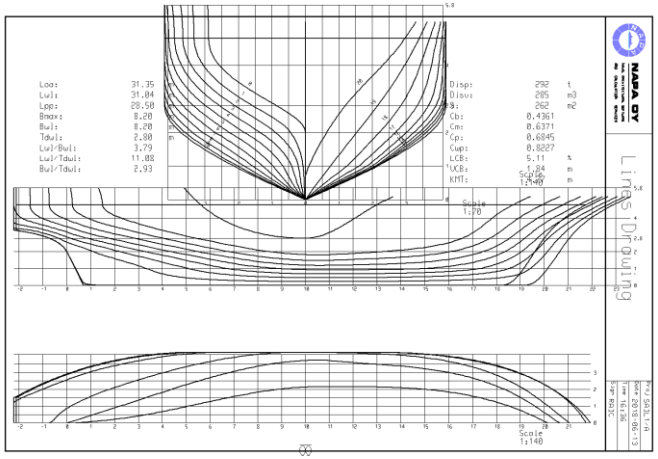
GreenShipping Niedersachsen

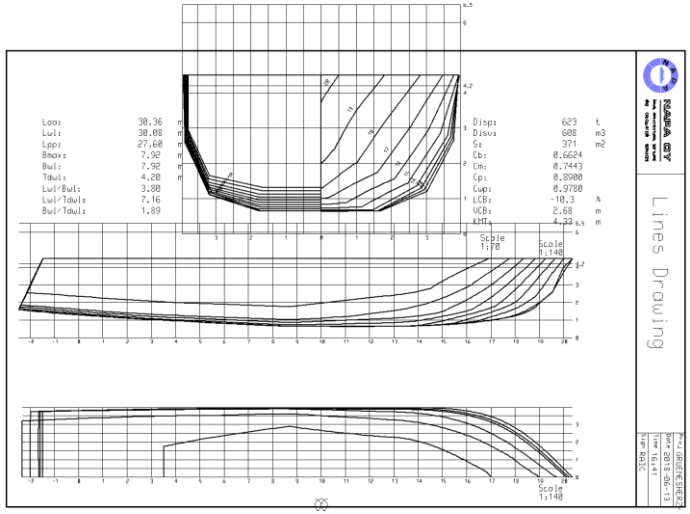
GreenSailer: Basic Design Phase

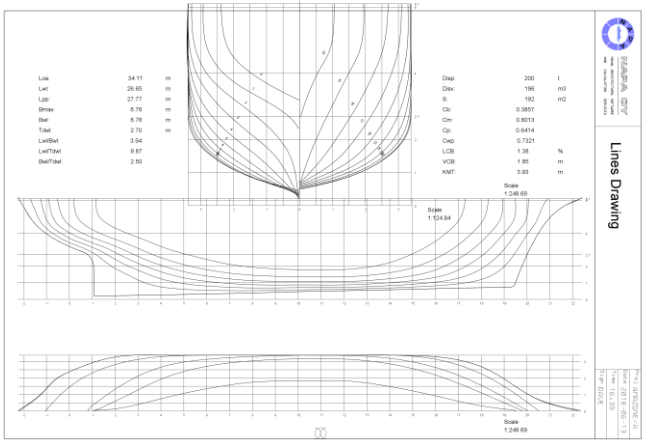


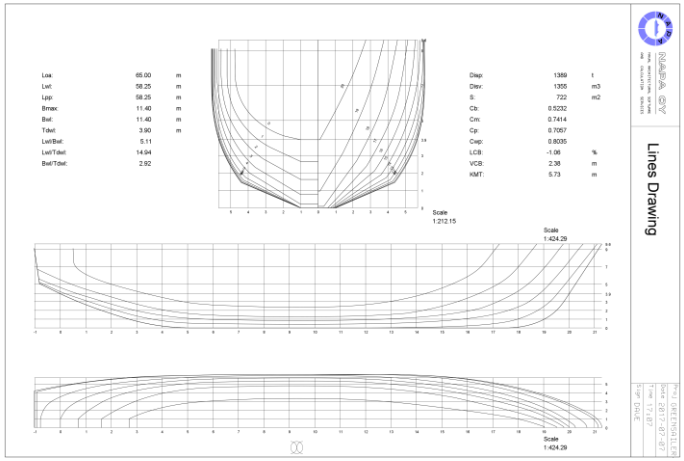
GreenShipping Niedersachsen

Vergleich von Rumpfkonzepten

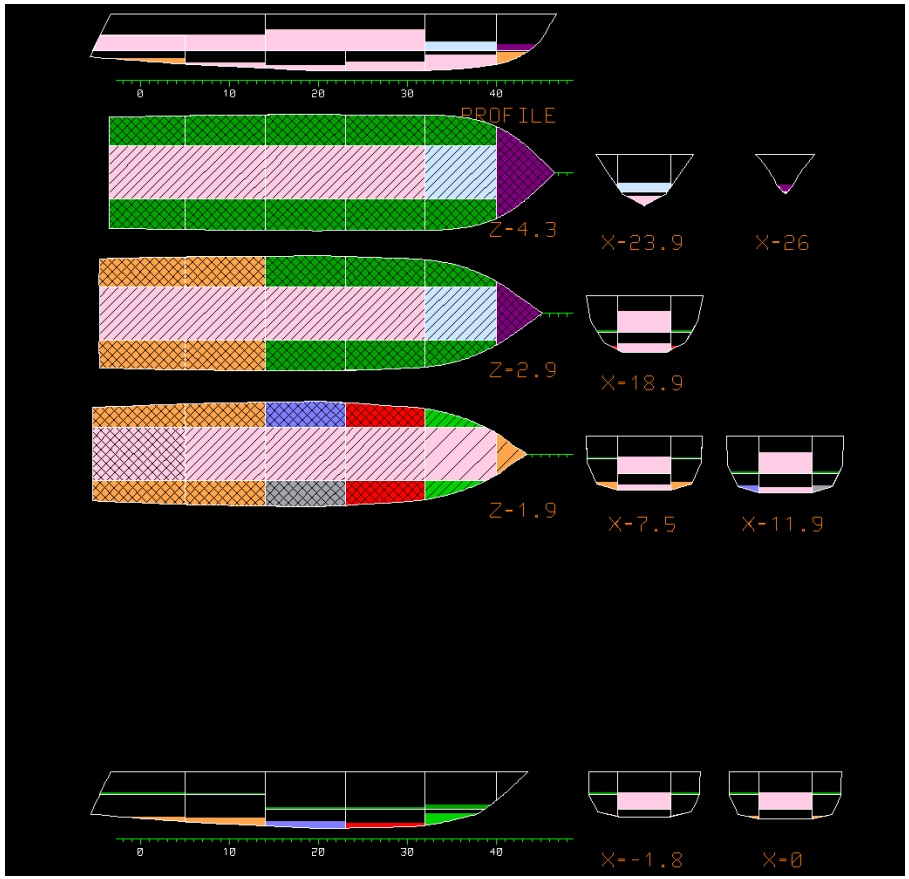


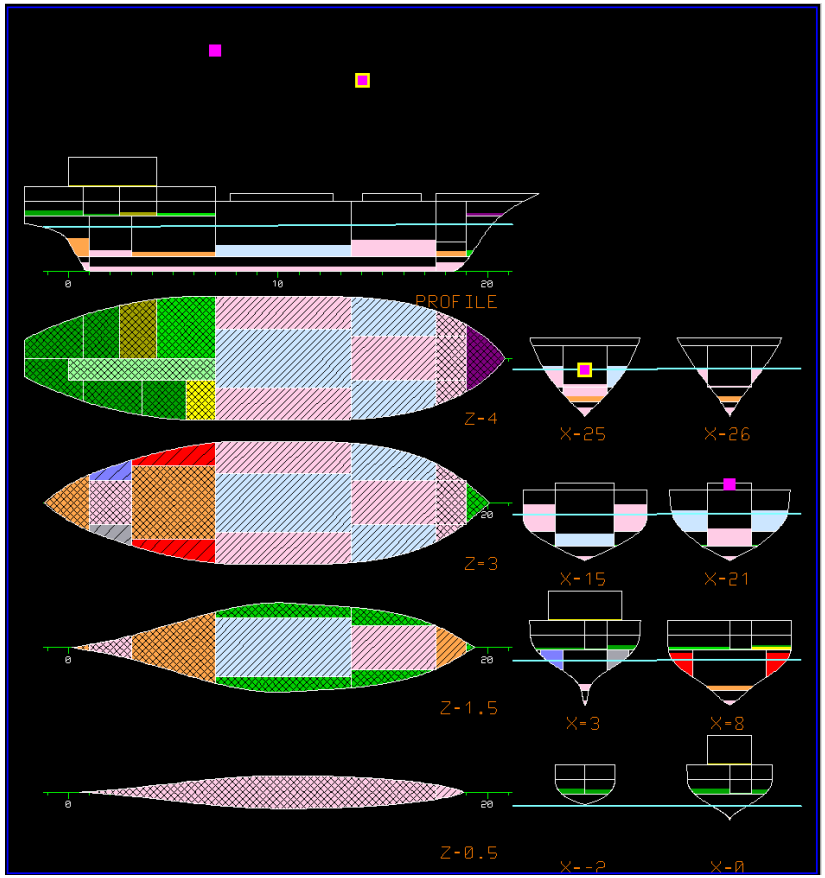






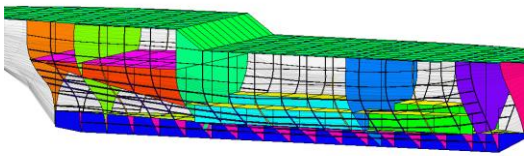
Vergleich von Rumpfkonzepten

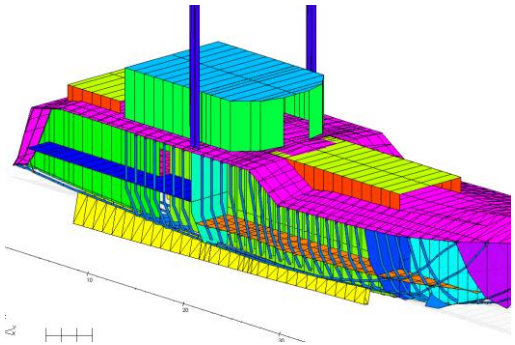


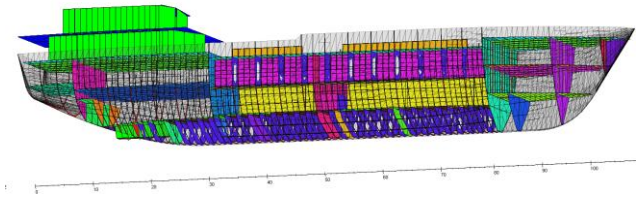


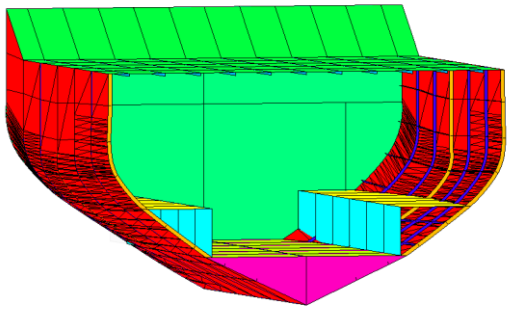
GreenShipping Niedersachsen

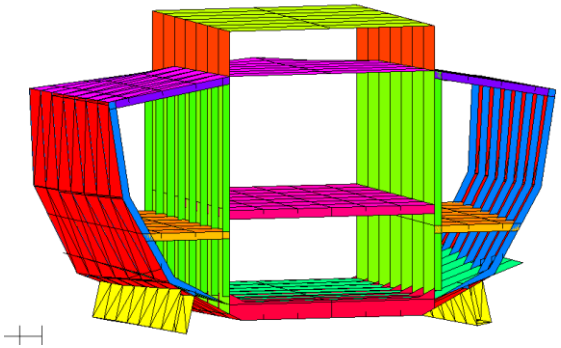
Konstruktion: Analyse und Bauvarianten

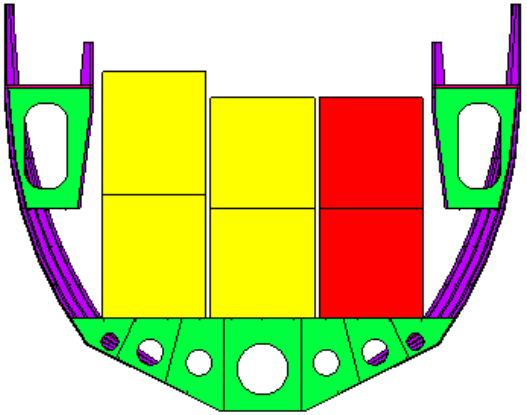






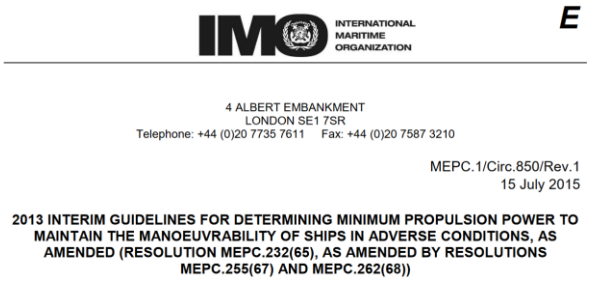






Nächste Schritte:

- **Fokus auf die Schiffstechnik**
  - Hybrid-Antriebe
  - Antriebsunterstützung
  - Minimum-Save-Power



IMO INTERNATIONAL MARITIME ORGANIZATION

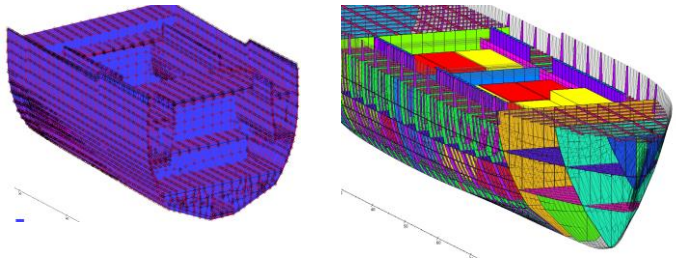
E

4 ALBERT EMBANKMENT
LONDON SE1 7SR
Telephone: +44 (0)20 7735 7611 Fax: +44 (0)20 7587 3210

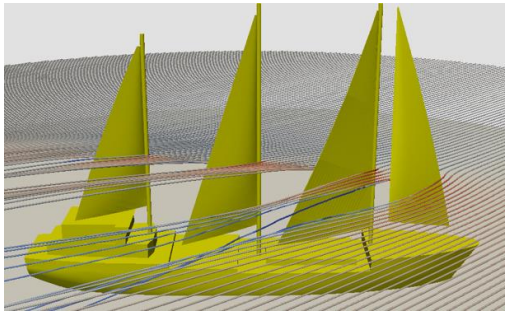
MEPC.1/Circ.850/Rev.1
15 July 2015

2013 INTERIM GUIDELINES FOR DETERMINING MINIMUM PROPULSION POWER TO MAINTAIN THE MANOEUVRABILITY OF SHIPS IN ADVERSE CONDITIONS, AS AMENDED (RESOLUTION MEPC.232(65), AS AMENDED BY RESOLUTIONS MEPC.255(67) AND MEPC.262(68))

- **Detailkonstruktion**
  - Gewichtsoptimierung
  - Leichtbau (GFK, Alu vs. Stahl)
  - Vereinfachung für Low-Budget-Fertigung



- **Windantrieb**
  - Optimierte Auslegung
  - Rigg-Kosten vs. Bedienung vs. Performance



Zusätzliche Anforderungen / Stabilitätsbedingungen

IMO

„Code on Intact Stability“

DNVGL

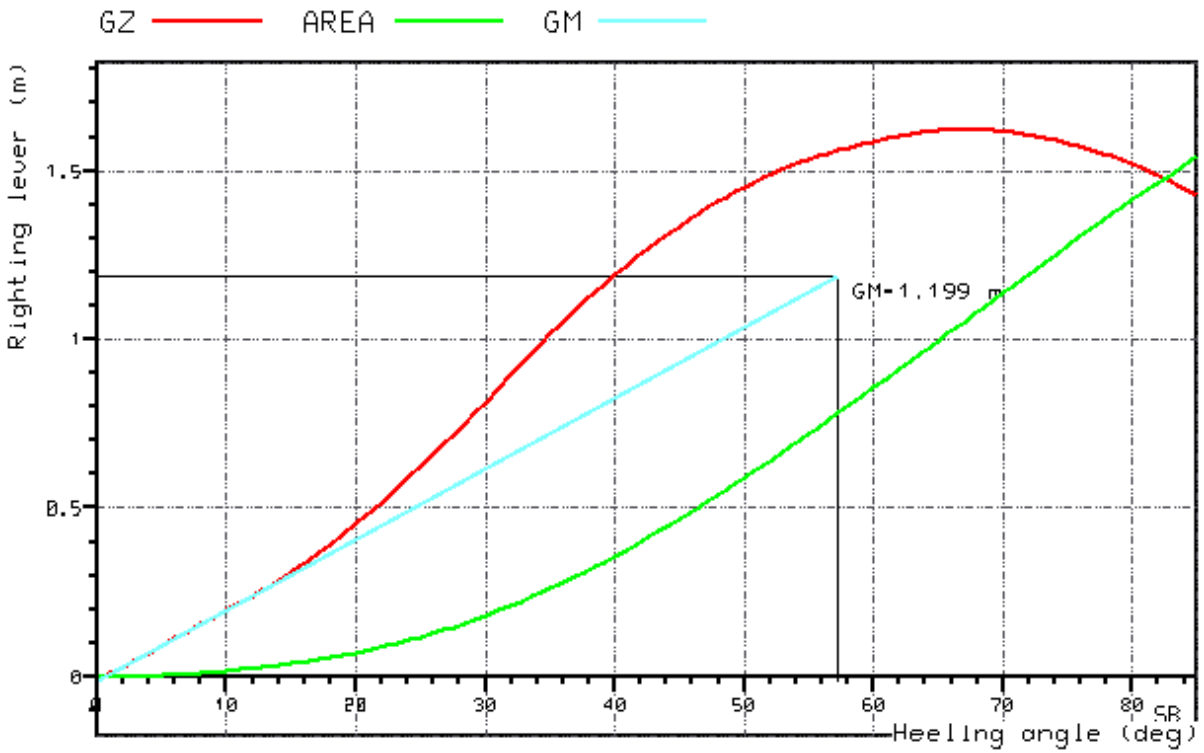
Yachts — DNVGL-RU-YACHT-Pt3Ch10

MCA

The Large Commercial Yacht Code

USCG

„Intact stability requirements for a monohull sailing vessel or a monohull auxiliary sailing vessel“



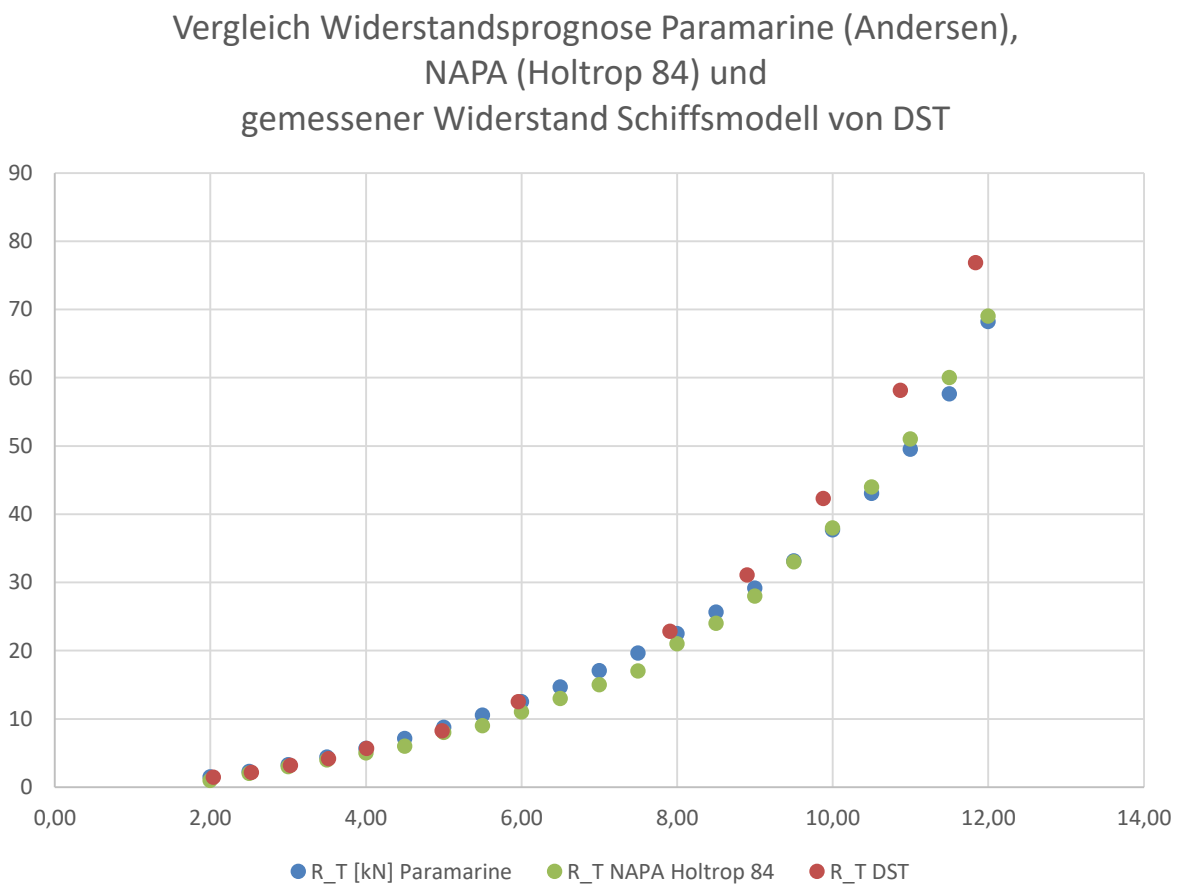
GreenShipping Niedersachsen

Modellversuche unter Drift und Krängung sowie Seegang

10 kn bei 0,5 Hz, 30 mm Amplitude (6,60 m), 6° Drift

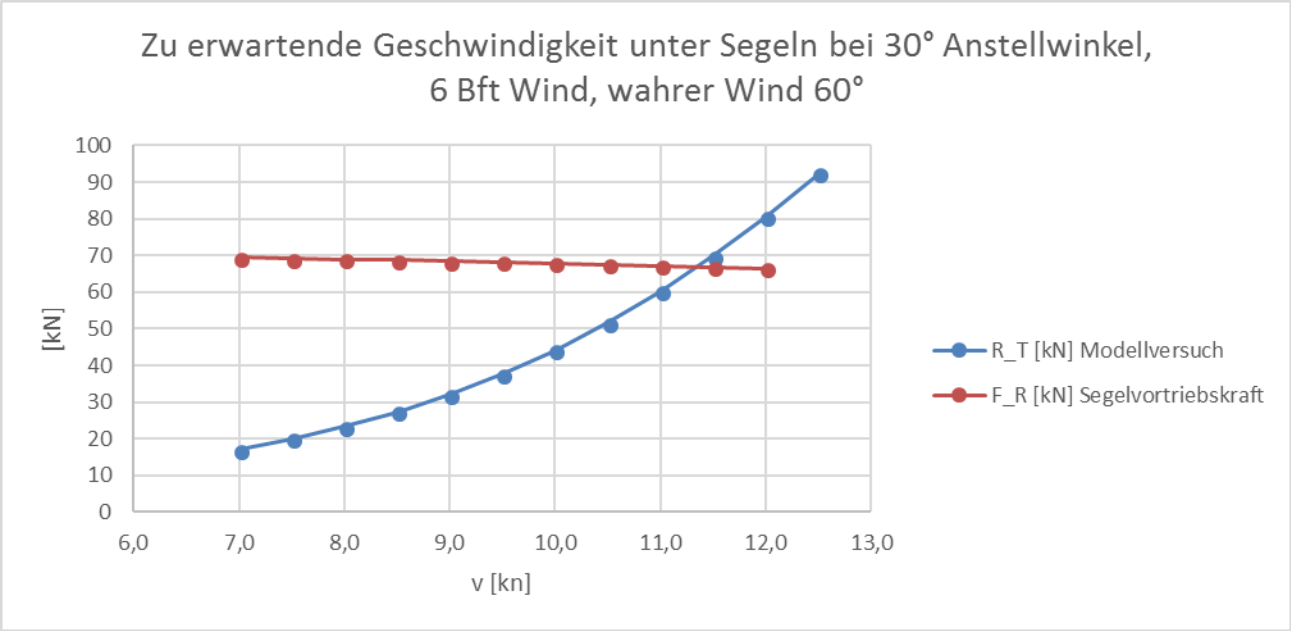
GreenShipping Niedersachsen

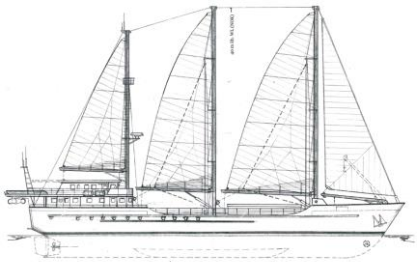
Vergleich prognostizierter und gemessener Widerstand



GreenShipping Niedersachsen

Segelkräfte-Berechnung mit Beiwerten eines Hochsegels von Marchaj



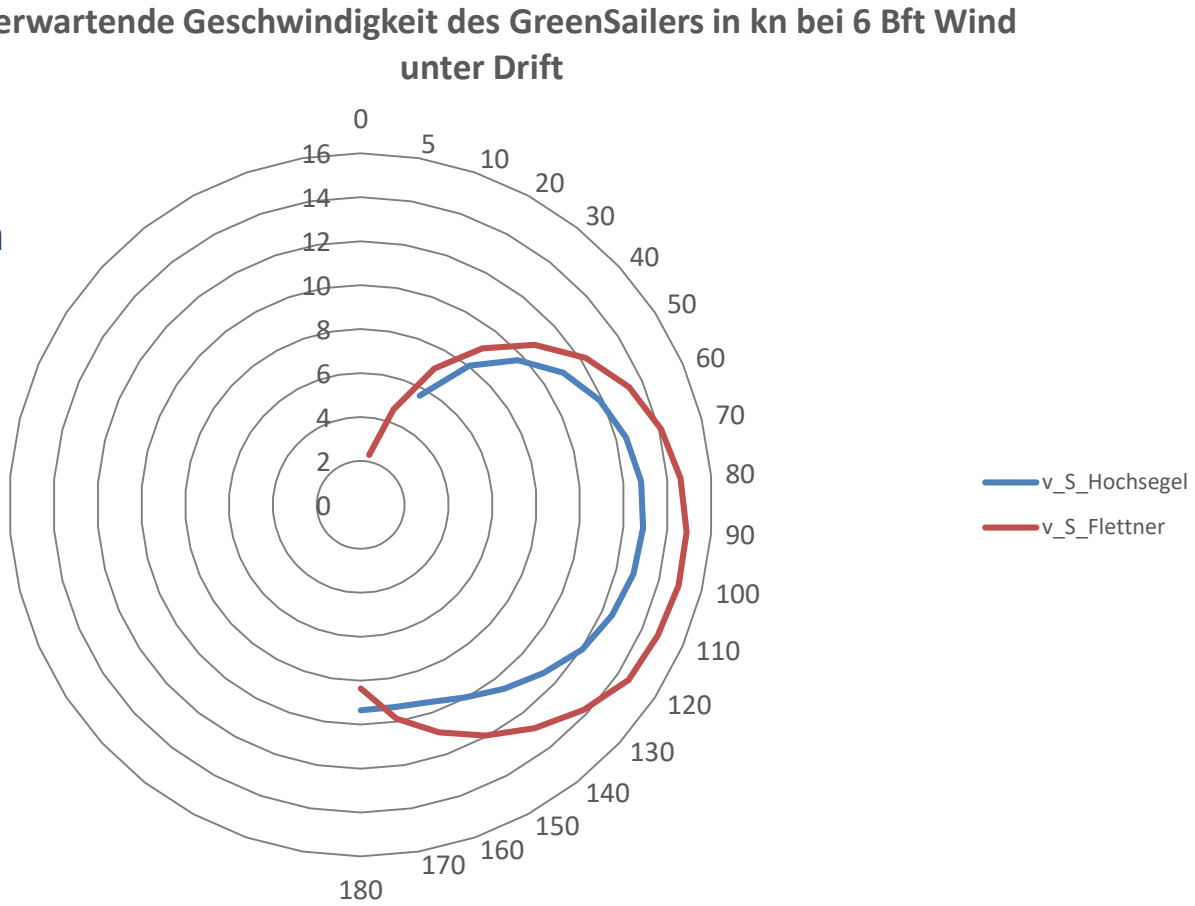


GreenShipping Niedersachsen

Vergleich von Hochsegel und Flettner-Rotor

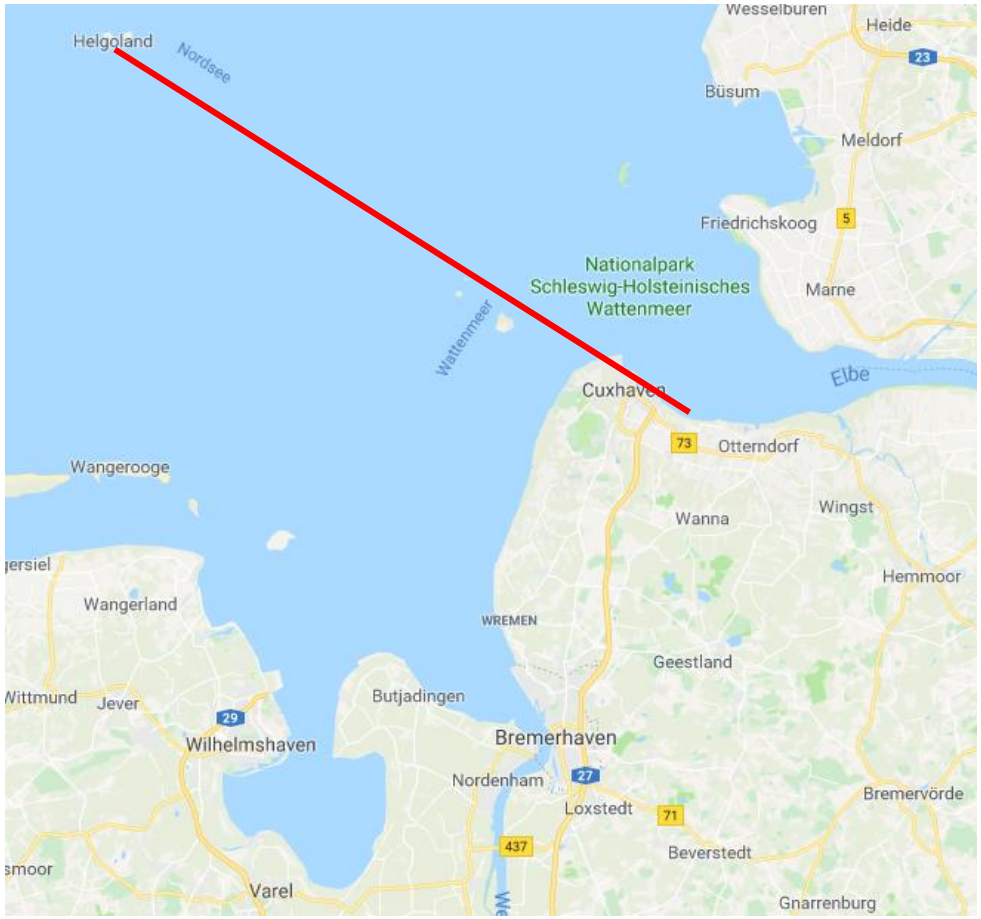
4 Hochsegel 890 m²

2 Flettner-Rotoren á 4 m x 24 m



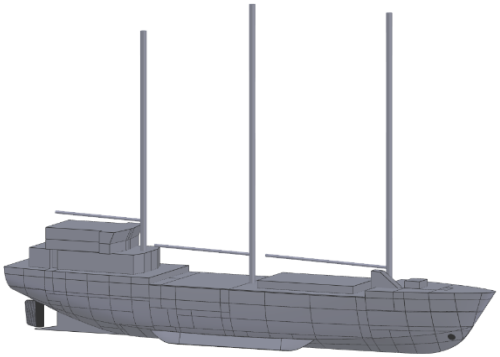
Routensimulation

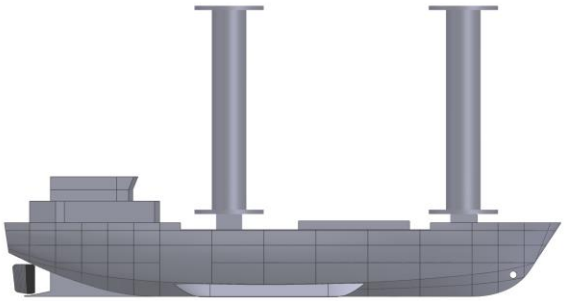
Cuxhaven - Helgoland

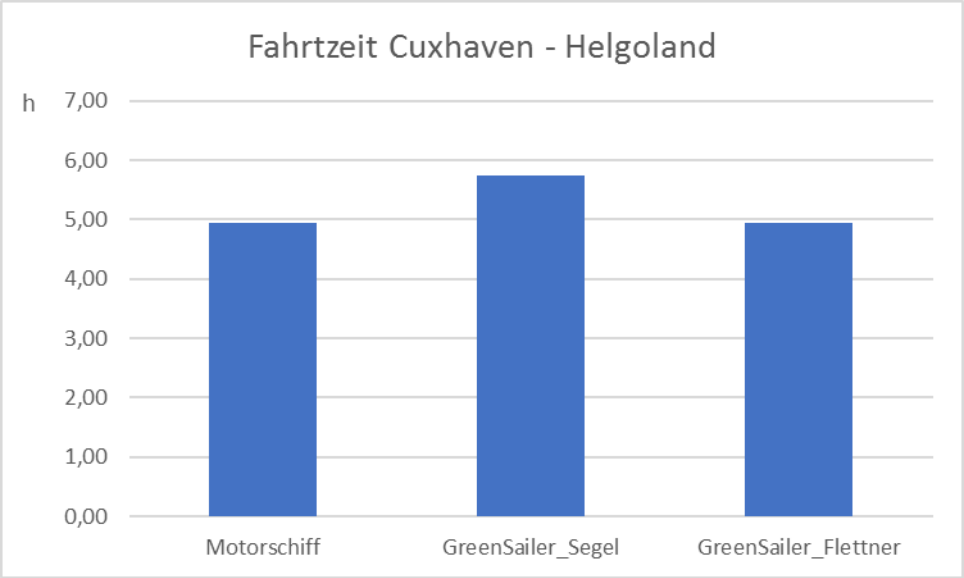


GreenShipping Niedersachsen

Routensimulation bei Windstärke 4 Bft aus Ost





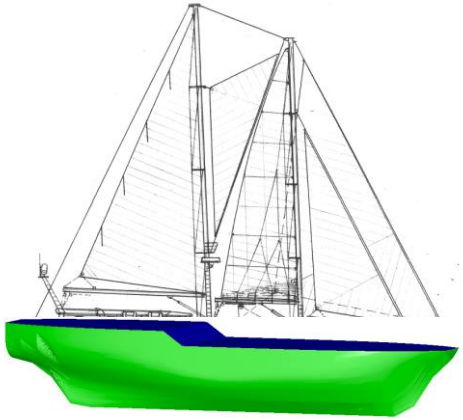


GreenShipping Niedersachsen

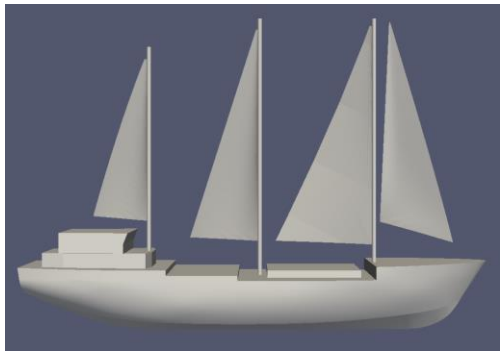
Ausblick: Transition to Low Carbon Shipping

2018: ☆ Early Movers	2030 Wind-Hybrid	2050 Wind + H2?

Ausblick: Green Sailer Concept



- **Green Sailer 100 dwt**
  - Existierende und neue kleine Nischenmärkte
- **Green Sailer 500 dwt**
  - Kleine Insel-/Küstenverkehre
- **Green Sailer 1000 dwt**
  - Kleine bis mittelgroße Insel-/Küstenverkehre



GreenShipping Niedersachsen

Ausblick: Green Sailer Concept

- **Flaggschiff:**
- **Green Sailer Research**
  - **Minimal invasive Forschungsschifffahrt unter Segeln**
  - **Praxisausbildung für marine/maritime Hochschulen und Universitäten**
  - **Europäisch - international**

GreenShipping Niedersachsen

Vielen Dank

www.greenshipping-niedersachsen.de

GreenSailer

University of Applied Sciences
HOCHSCHULE EMDEN·LEER

EUROPÄISCHE UNION
Europäischer Fonds für regionale Entwicklung

EUROPA FÜR NIEDERSACHSEN
EFRE Förderung für die niedersächsischen Regionen