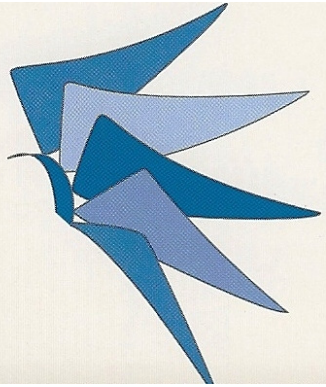


SHIP EFFICIENCY 2009

by STG

2nd International Conference

Hamburg, 28 – 29 September 2009

Fuel- and Cost-Savings by Hydrodynamic Measures

by

Jan Øivind Svardal, **Grieg Shipping Group, Bergen, Norway**

Friedrich Mewis, **Mewis Ship Hydrodynamics, Dresden, Germany**

Fuel- and Cost-Savings by Hydrodynamic Measures

Contents

The Grieg Group

- **Established in 1884**
- **Family owned (4th generation)**
- **Ship owning (incl. operation and ship management), seafood, ship broking, logistics, insurance broking, wind mills, navigation equipment and asset management**
- **Headquarters in Bergen. Several offices in Norway and abroad**

Grieg Shipping Group - Grieg Star Shipping - Grieg International

Grieg Seafood - Grieg Logistics - Joachim Grieg & Co. - Aon Grieg

Grieg Investor- MARIS - NORWIND

Grieg Foundation

- Registered charity
- Holder of 25% of the shares of the Grieg Group operating companies
- Primary objective is to support SOS Children's Villages, in addition substantial contributions are given to aid medical research, humanitarian causes and cultural activities.

Newbuilding K-class vessel (built 2009 - 2010)

Main particulares:

Lpp = 197.40
B = 32.20
Tdes = 12.00
V = 16.0 kts
P_D = 9,313 kW
DWT = 49,900 t

Open Hatch General Cargo Carrier:
- 2x70 tons Gantry cranes,
- 11 box shaped holds,
- Dehumidification system for cargo

Target: 20 % energy reduction of the whole fleet through hydrodynamic and other measures by 2015!

K-class vessel

Improvement by hydrodynamic measures:

Result of collaboration with MSH

Measure	Remark	Power reduction	Costs reduction
		%	%
Improvement of bow lines	-	2.0	0.9
Trim optimisation	average	(3.0)	(1.4)
50%	realizable	1.5	0.7
Speed reduction	calculated	(30.0)	(3.0)
50%	realizable	15.0	1.5
Power saving device	PBCF	3.0	1.4
Total reduction	absolute	21.5	4.5
Total reduction	approximate	20 - 23	4 - 5

Note: All figures are approximate only

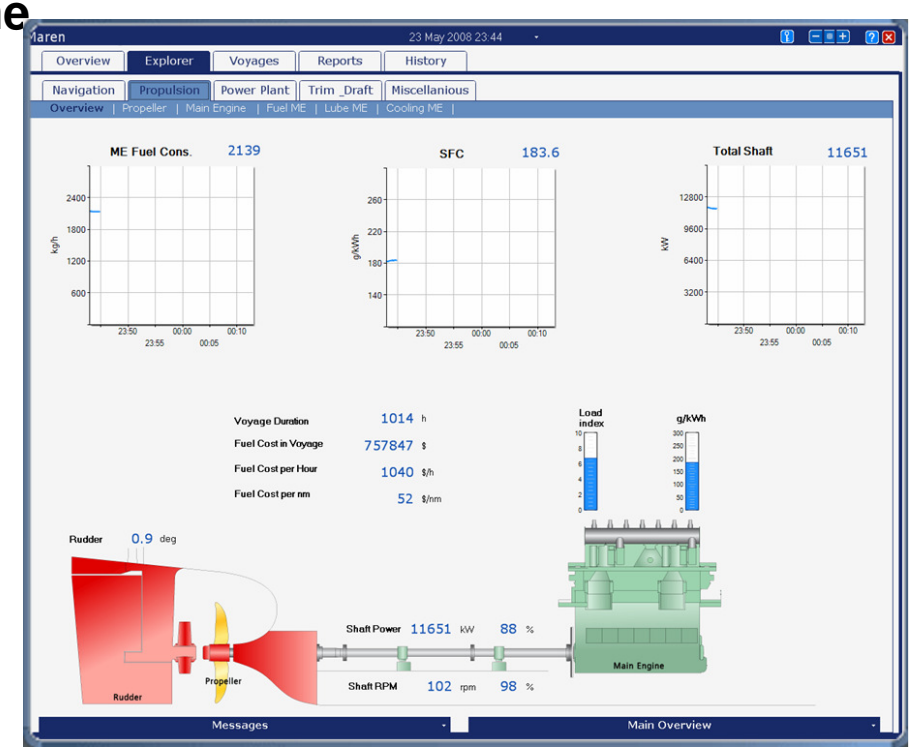
These figures will be checked permanent by an " Energy Monitoring System"

K-class vessel

Energy Monitoring System

Interfaces:

- Fuel oil module (Density and Viscosity measurements). M.E. and Aux. Eng.
- Torque meter on tail shaft – Main Engine
- Generator power
- Alarm and Monitoring system
- VDR (examples: speedlog, GPS, wind)
- ECDIS information – route planning
- Loading computer



K-class vessel

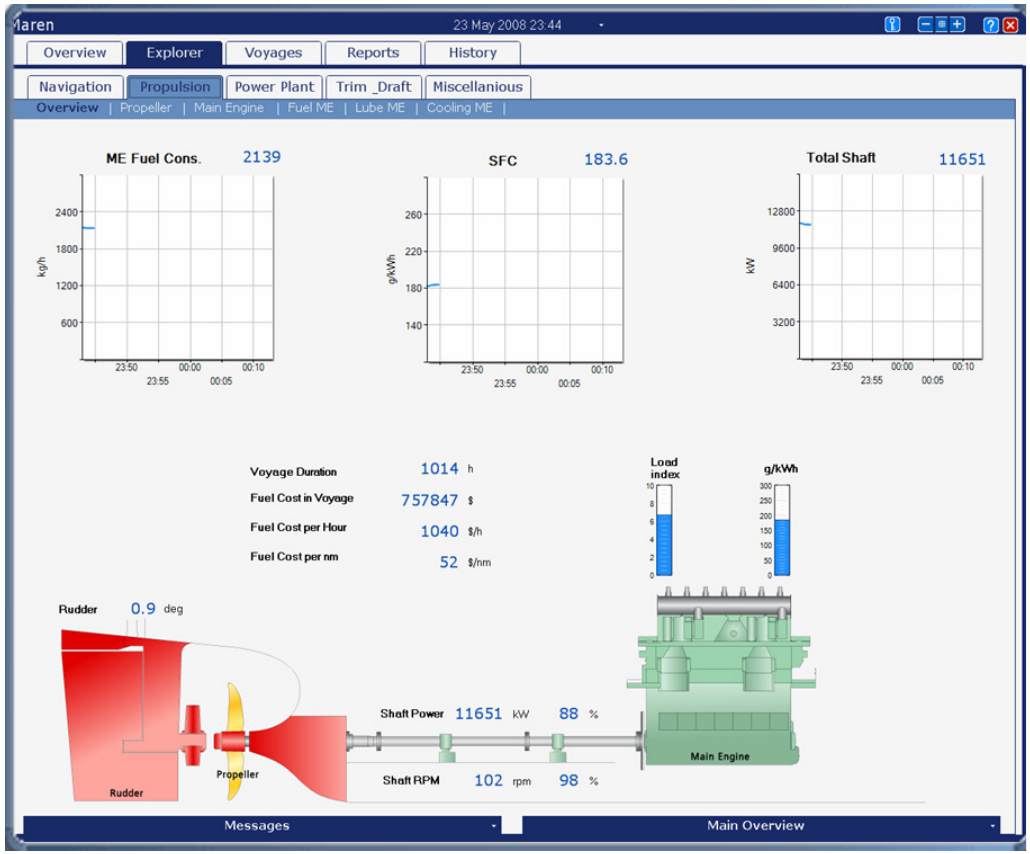
Energy Monitoring System – Marorka (Iceland)

Software modules:

- Propulsion plant
- Trim optimisation
- Power plant (partly)

Results:

- Monitoring energy efficiency
- History trend logging
- Trim optimisation guiding
- Report generator – user defined
- Higher energy awareness for the ship crew



J-class vessel (built 2004 - 2006)

Main particulars:

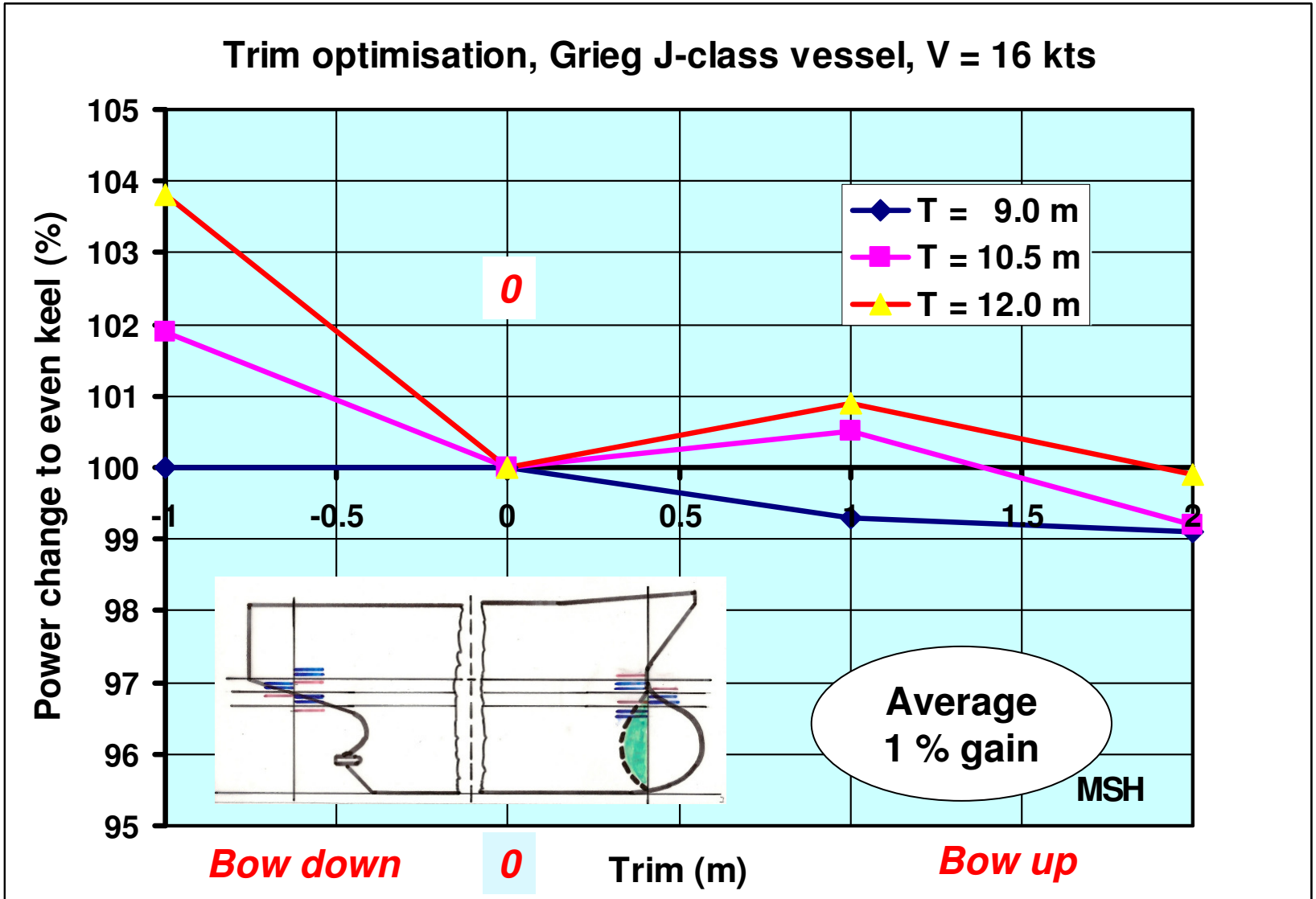
Lpp = 187.00
B = 31.00
Tdes = 12.02
V = 16.0 kts
P_D = 8,151 kW
DWT = 46,200 t

Open Hatch General Cargo Carrier:
- 2x70 tons Gantry cranes,
- 11 box shaped holds,
- Dehumidification system for cargo

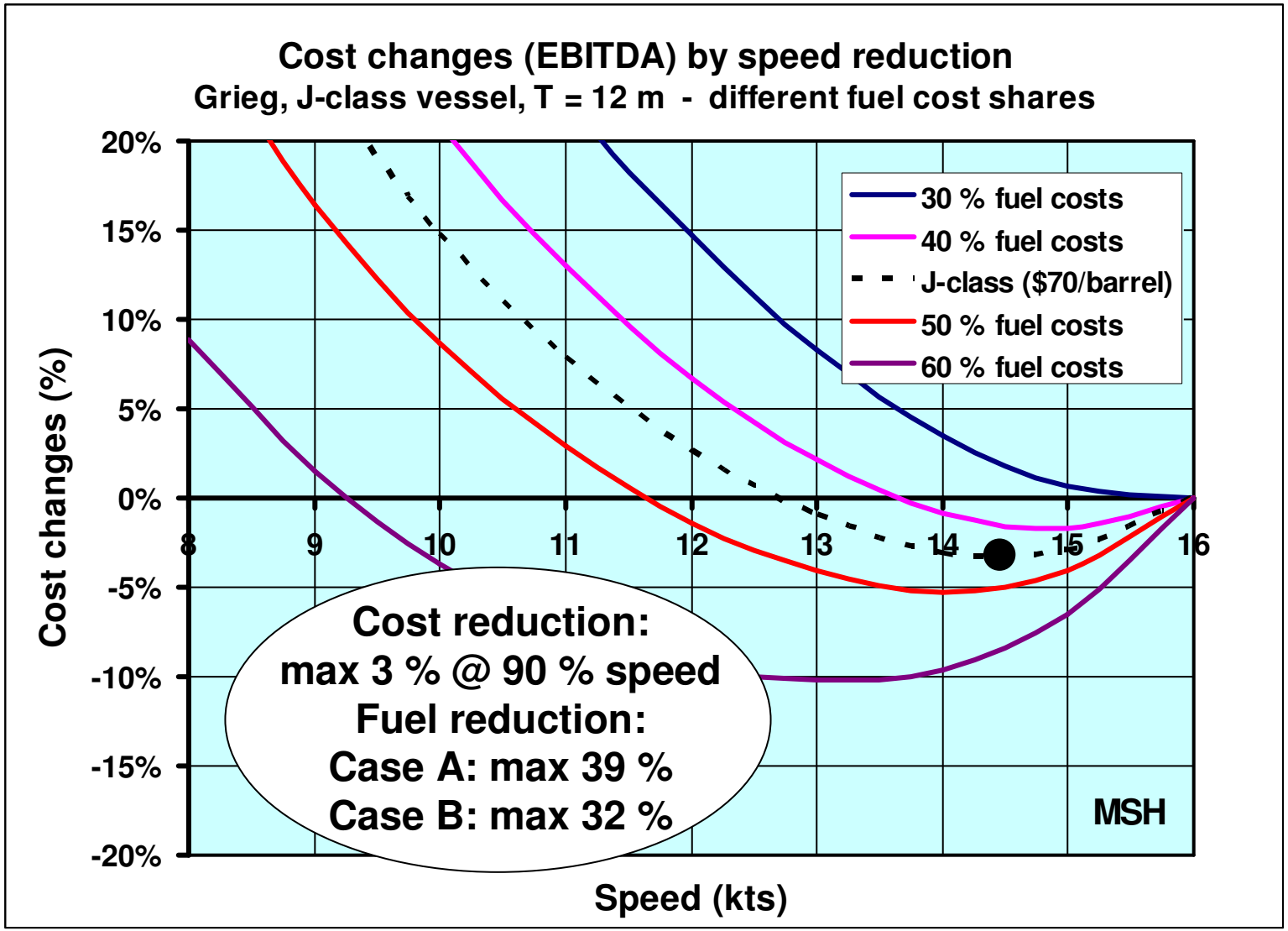
Examinated measures for cost and fuel reduction:

- Trim optimisation, model tests
- Speed reduction, calculations
- Power saving device, retrofit of a Mewis Duct®

J-class vessel, trim optimisation



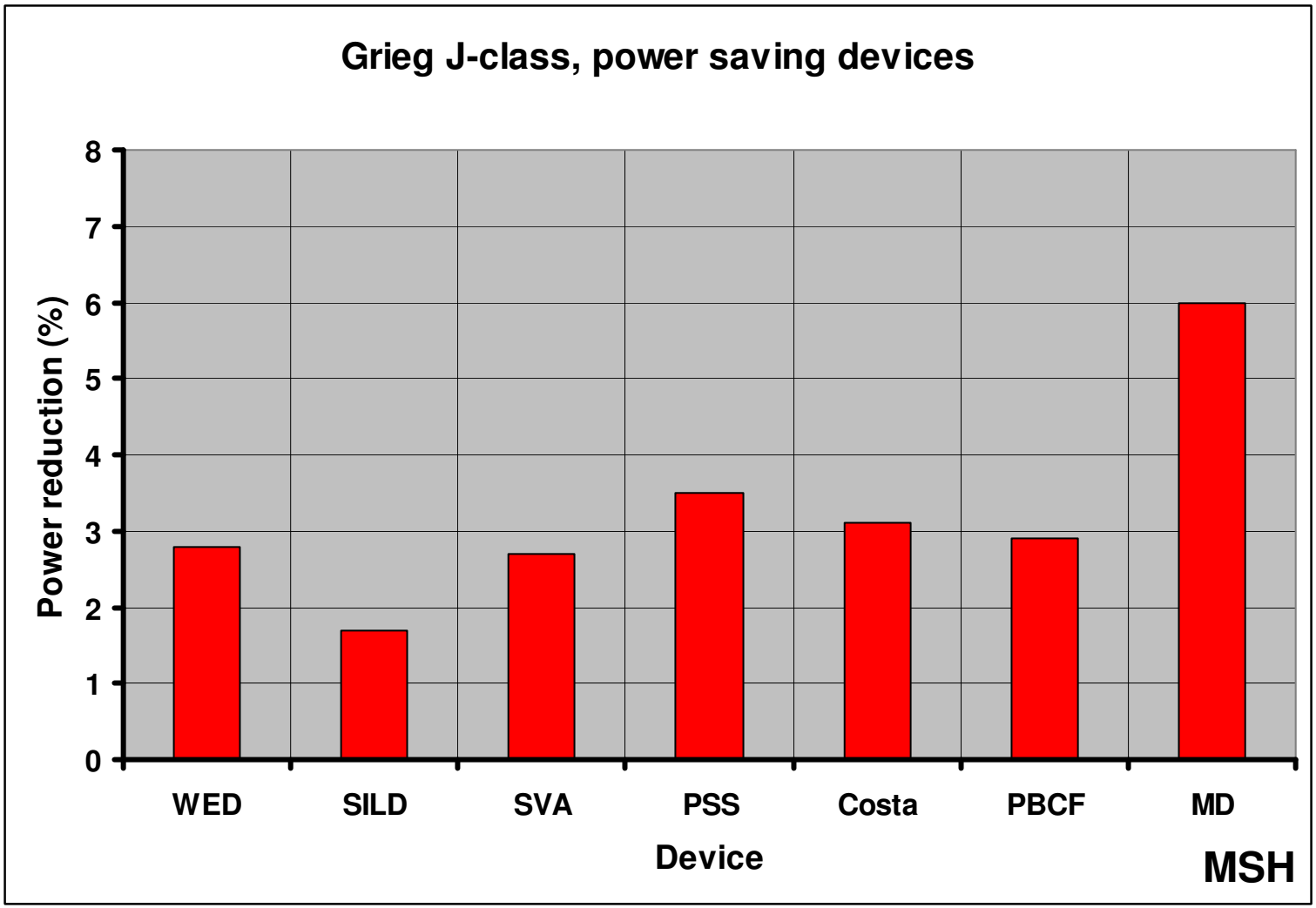
J-class vessel, speed optimisation



Case A: slow speed

Case B: adjusted fleet

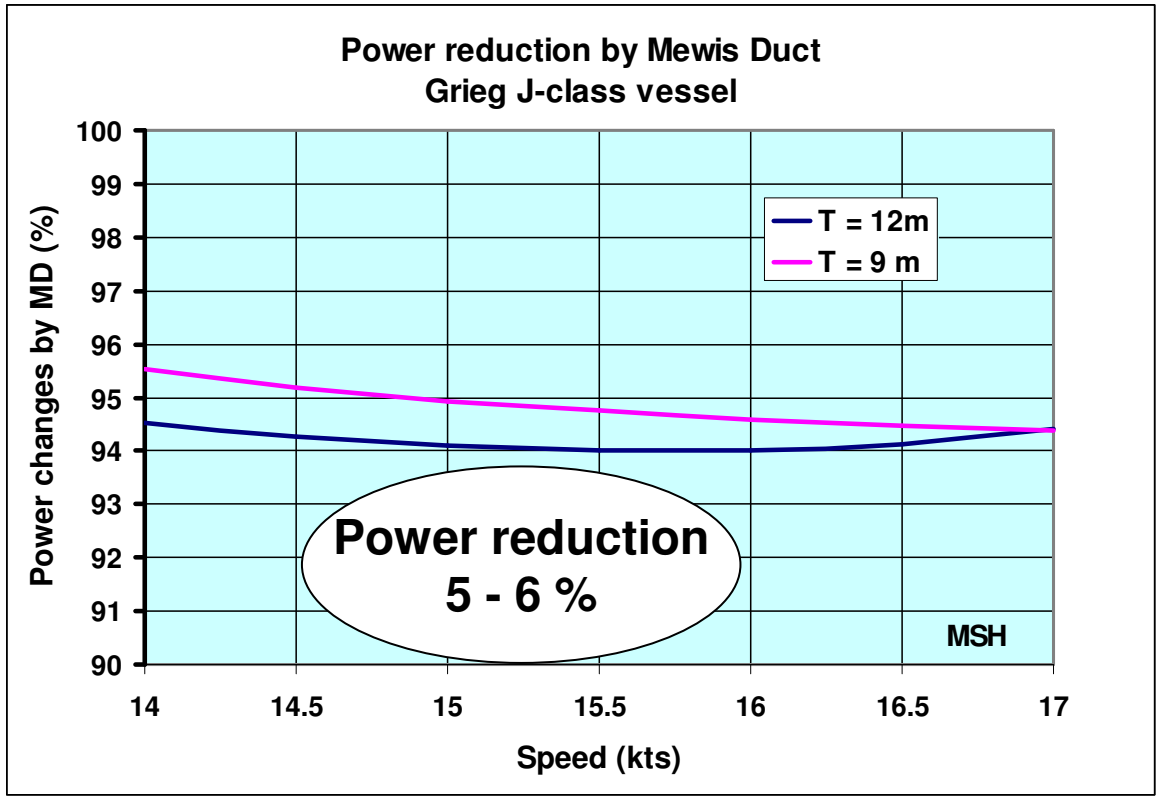
J-class vessel, power saving devices



J-class vessel, power saving devices

As power saving device was selected the Mewis Duct®
(Mewis Duct® is offered by Becker Marine Systems, Hamburg)

CFD- calculations and model tests show more than 5 % power reduction!



Model test result:
T = 12 m
V = 16 kts:
6 % power reduction
or 0.27 kts higher speed

Summary J-class vessels achievable power and cost reductions

Ship type	J-class Ship in service	
Measure	Reduction	
	Power	Costs
	%	%
Improvement of ship lines	-	-
Trim optimisation (50%)	0.5	0.2
Speed reduction (50%)	16.0	1.5
Power saving device	6.0	2.7
Total reduction	22.5	4.4

Note: All figures are approximate only

Summary K- and J-class vessels achievable power and cost reductions

Ship type	J-class Ship in service		K-class Newbuilding	
Measure	Reduction			
	Power	Costs	Power	Costs
	%	%	%	%
Improvement of ship lines	-	-	2.0	0.9
Trim optimisation (50%)	0.5	0.2	1.5	0.7
Speed reduction (50%)	16.0	1.5	15.0	1.5
Power saving device	6.0	2.7	3.0	1.4
Total reduction	22.5	4.4	21.5	4.5

Note: All figures are approximate only

Summary, achievable power and cost reductions

K-class vessel
built 2009 - 2010

J-class vessel
built 2004 - 2006

Achievable savings:

Fuel	**20 - 23 %**	**21 - 24 %**
Costs	**4 - 5 %**	**4 - 5 %**

Study for 4 very varying ships:

- Trim optimisation
- Speed reduction
- Power saving device

1. Heavy Lift Multipurpose Dry Cargo Vessel 12,700 DWT

2. Very Large Crude Oil Carrier 300,000 DWT

3. Container Feeder Vessel 1,700 TEU

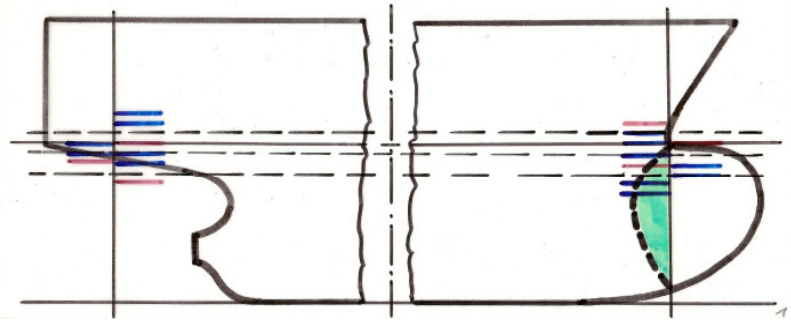
4. Very Large Container Vessel 13,500 TEU

Main particulars, ships in study

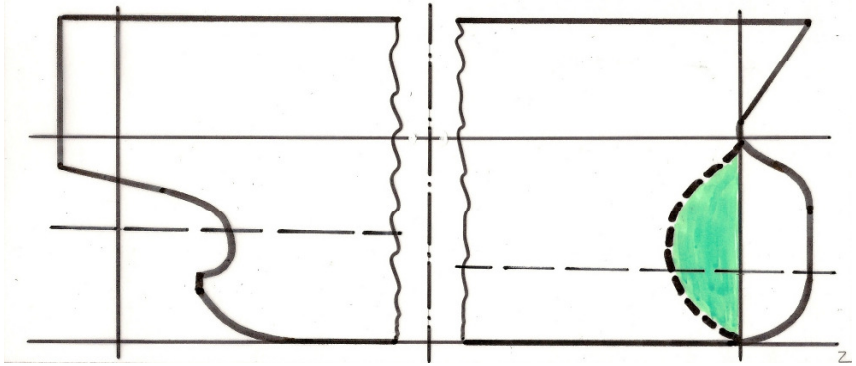
Case No		1	Grieg J	2	3	4
Ship type Size		Bulker 12k	J-class 46k	Tanker 300k	Container 1,700TEU	Container 13,500TEU
Lpp	m	130.00	187.00	324.00	165.00	350.00
B	m	21.00	31.00	60.00	27.90	51.20
T	m	7.50	12.00	20.00	8.50	14.00
CB	-	0.79	0.80	0.81	0.65	0.69
DP	m	4.90	7.00	9.70	6.60	8.90
PD	kW	4,464	8,151	22,450	12,250	56,000
n	rpm	130	91	73	101	100
VD	kts	15.20	16.00	15.50	20.00	24.60
Fn	-	0.21	0.19	0.14	0.26	0.22
CTh	-	1.60	1.31	2.32	1.00	1.25

Trim optimisation

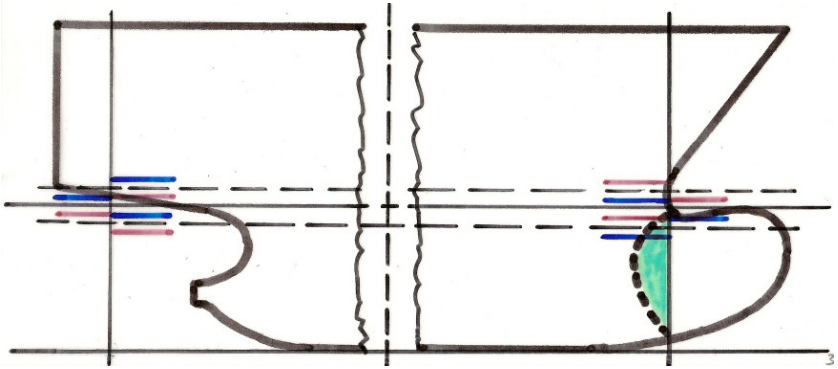
1. Bulker 12k, T = 7.5 m



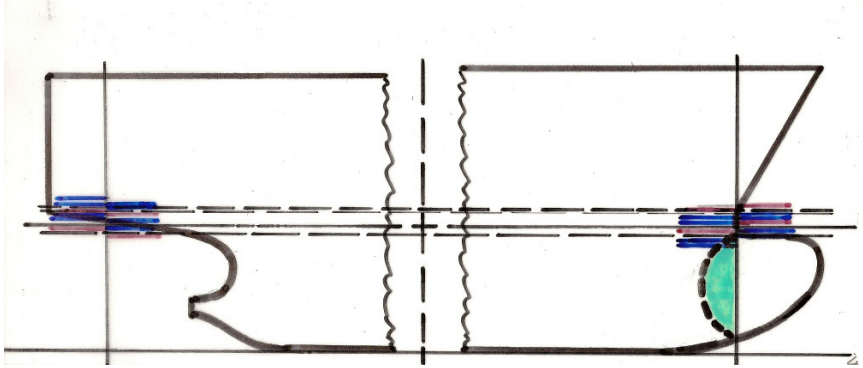
2. Tanker 300k, T = 20.0 m



3. C/V 1,700 TEU, T = 8.5 m



4. C/V 13,500 TEU, T = 14.0 m



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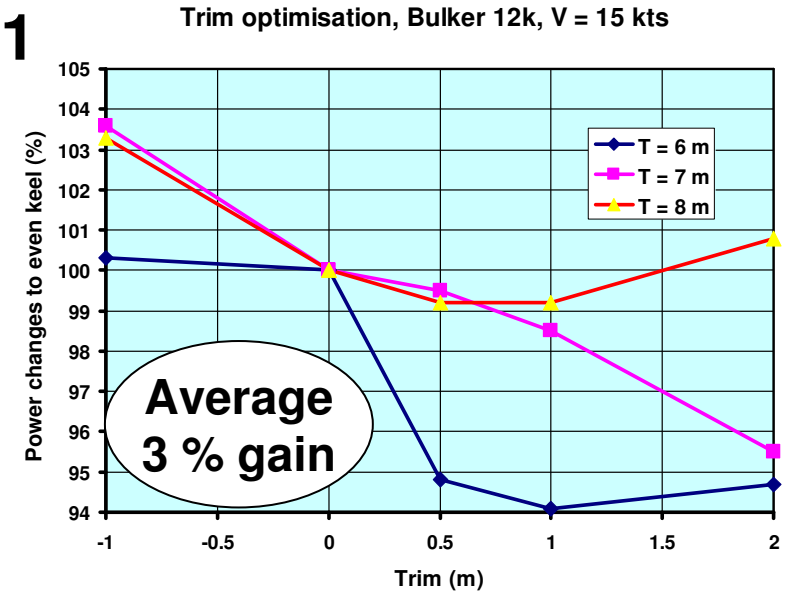


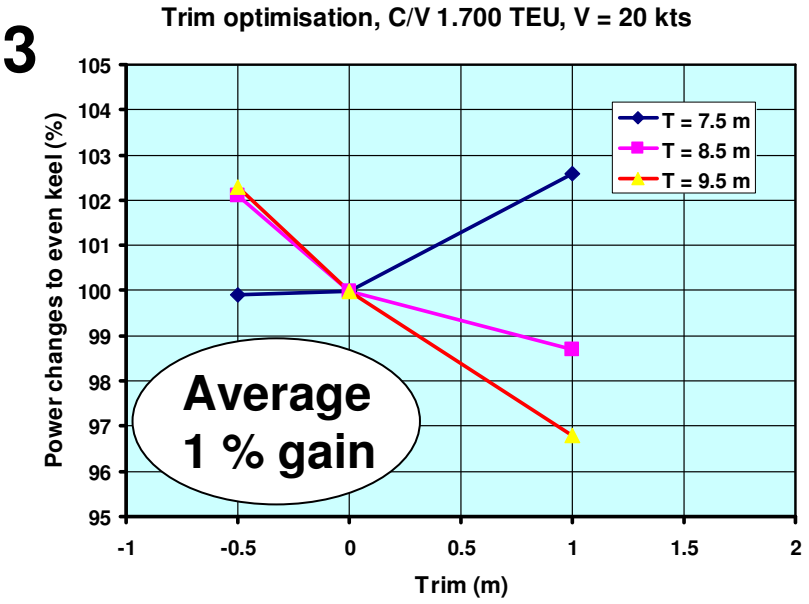
2

Trim optimisation

VLCC, 300k
Change of trim not possible!

No gain

3



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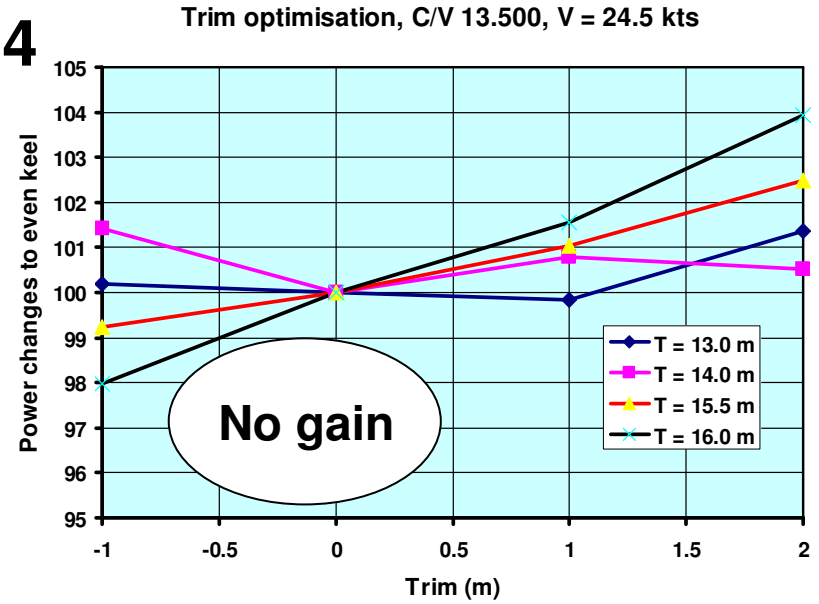


Trim optimisation

Summary

Case No		1	Grieg J	2	3	4
Ship type Size		Bulker 12k	J-class 46k	Tanker 300k	Container 1,700TEU	Container 13,500TEU
VD	kts	15.20	16.00	15.50	20.00	24.60
Fn	-	0.21	0.19	0.14	0.26	0.22
CTh	-	1.60	1.31	2.32	1.00	1.25

Trim optimisation, averaged power reductions:

ΔPD	%	3.0	1.0	0	1.0	0

Note: About 50 % of the these averaged power reductions are realizable only

Speed optimisation

Mathematical model takes into consideration:

- speed power curve of the ship
- engine behaviour at low load operation
- monetary losses due to later arrival
- cost share value = fuel costs / total costs

(the presented cost share figures are valid for 100 % speed)

Two cases: A – the vessel simply operate at slower speed
B – adjusted fleet with constant transport capacity

The actual amount of cost share value depends mainly on:

- fuel costs

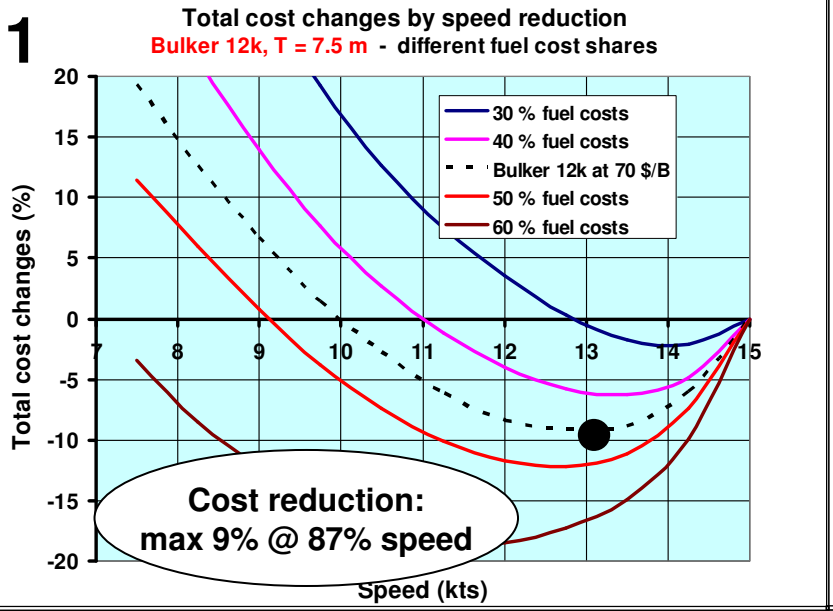
But also on:

- operation costs
- capital repayment
- interest repayment
- cargo handling costs
- maintenance costs

total costs

2nd Ship Efficiency Conference, Hamburg 28 – 29 September 2009

1



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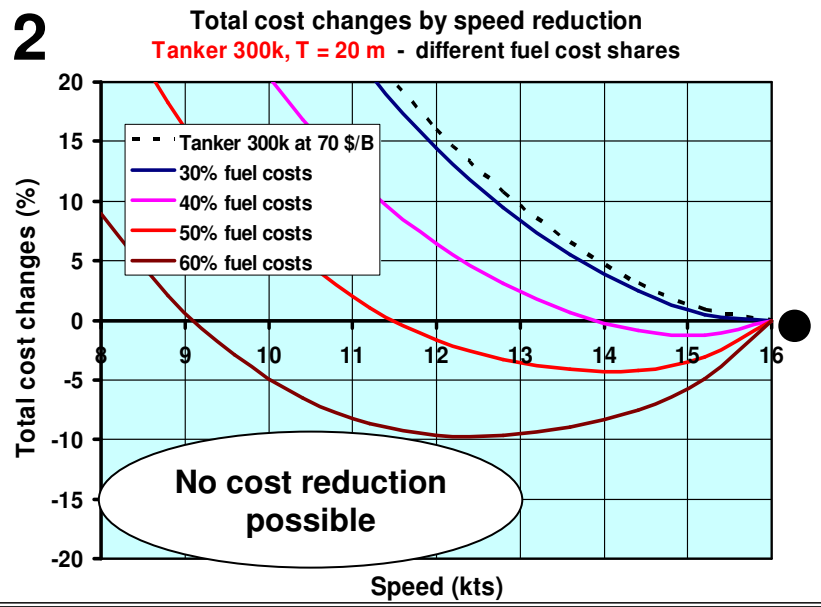

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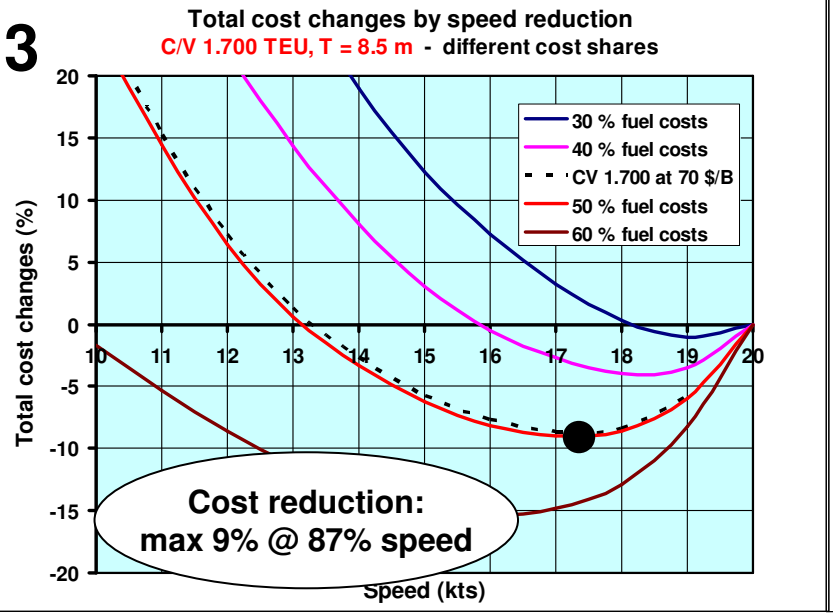

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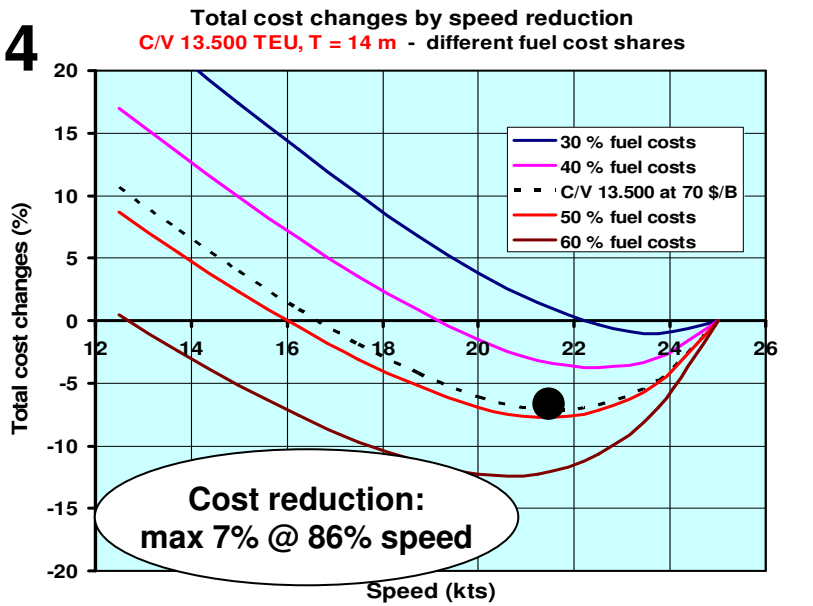
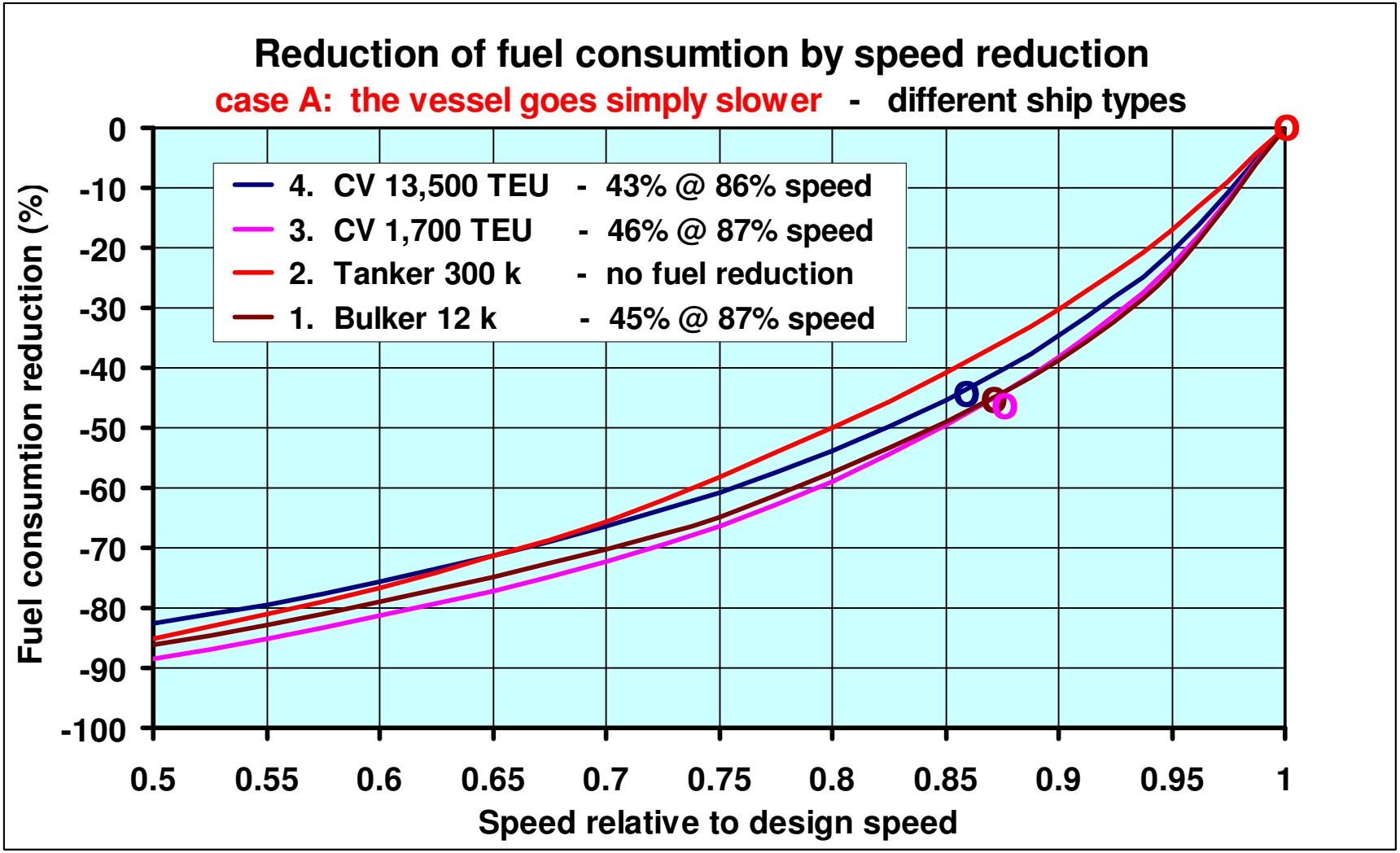
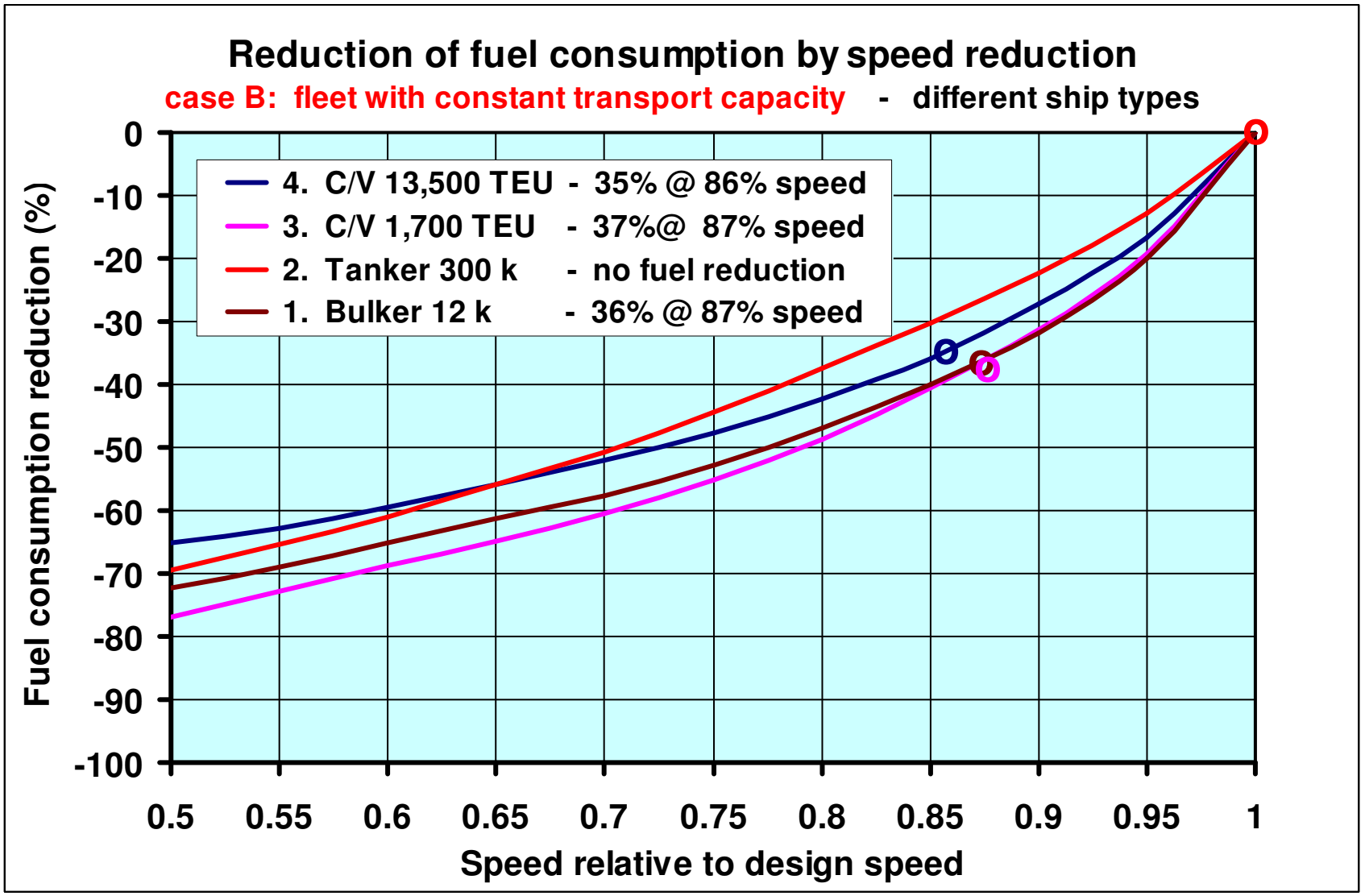


Speed optimisation



Speed optimisation



Speed optimisation, summary

Case No	1	Grieg J	2	3	4
Ship type	Bulker	J-class	Tanker	Container	Container
Size	12k	46k	300k	1,700TEU	13,500TEU

Speed optimisation, Δ costs at optimum speed:

VD	100%	15	16	16	20	25
Vopt.	kts	13.1	14.5	>16	17.4	21.5
Δ Costs	%	9	3	0	9	7

Speed optimisation, Δ fuel consumption at optimum speed:

Case A	%	45	39	0	46	43
Case B	%	36	32	0	37	35

positive % are reductions at costs & fuel consumption

Note: About 50 % of these averaged power reductions are realizable only

Power saving devices (PSD)

"Power Saving Devices"
denote additional components positioned close to the propeller

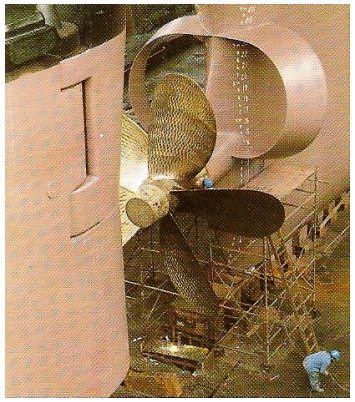
For all vessels the following are compared:

- Pre ducts	1. WED	Schneekluth Duct
	2. SILD	Sumitomo Integrated Lammeren Duct
- Pre swirl fin systems	3. SVA	SVA - fin system
	4. PSS	DSME - Pre Swirl System
- Hub vortex optimiser	5. Costa	Bulb (rudder bulb)
	6. PBCF	Propeller Boss Cup Fin (Mitsui)
- Combined system	7. MD	Mewis Duct® (Becker Marine Systems)

Power saving devices (PSD)

Pre ducts

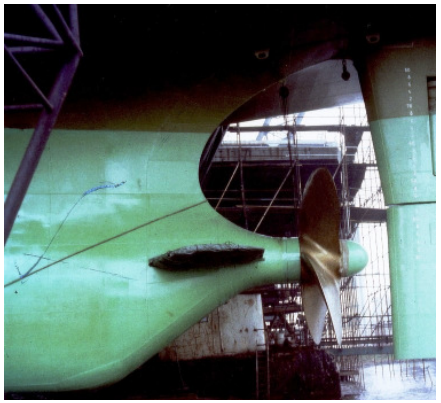
1. WED



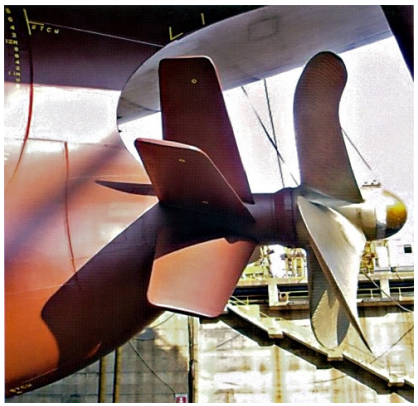
2. SILD

Pre fins

3. SVA



4. PSS



Hub devices

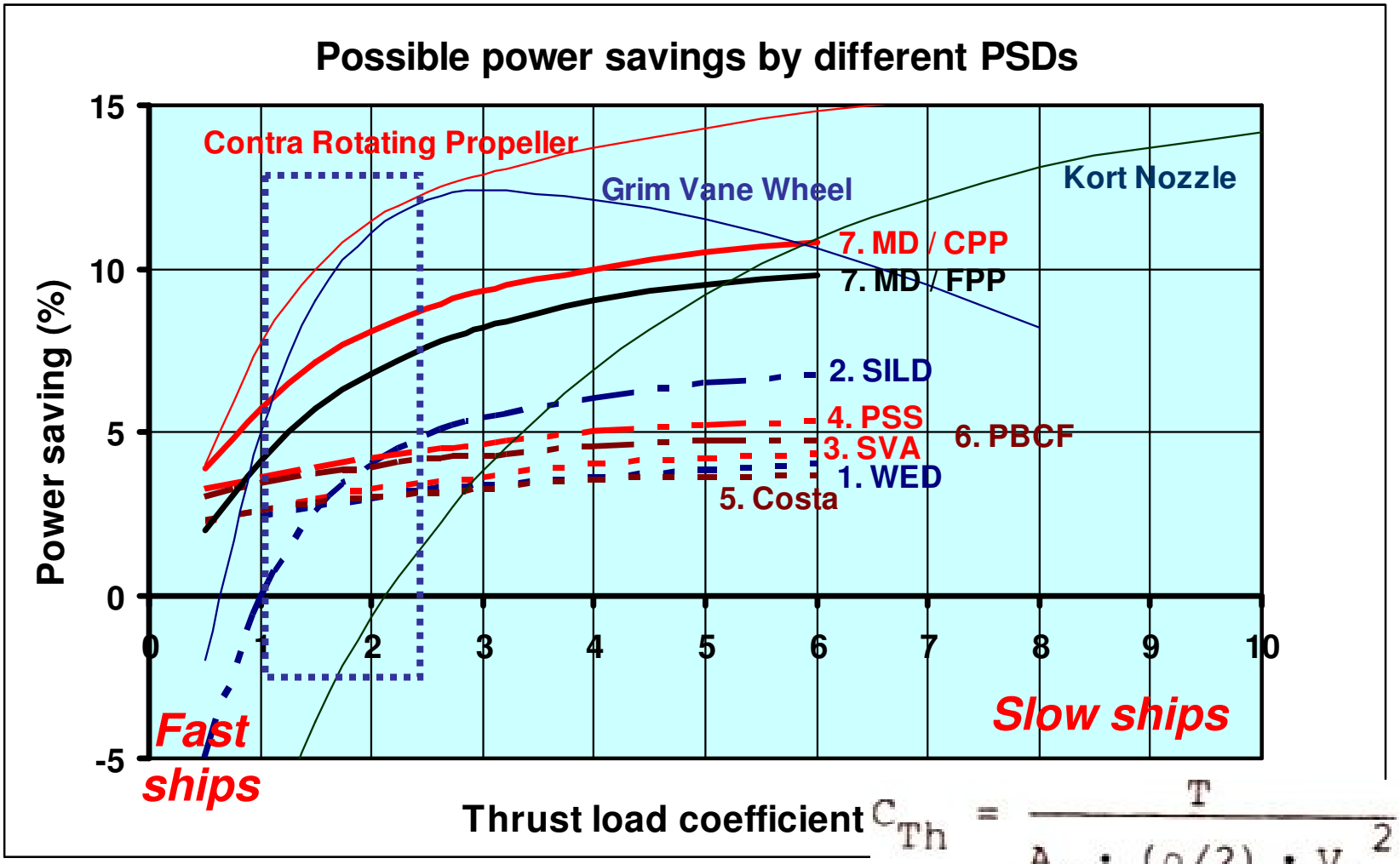
5. Costa

6. PBCF

Combined device

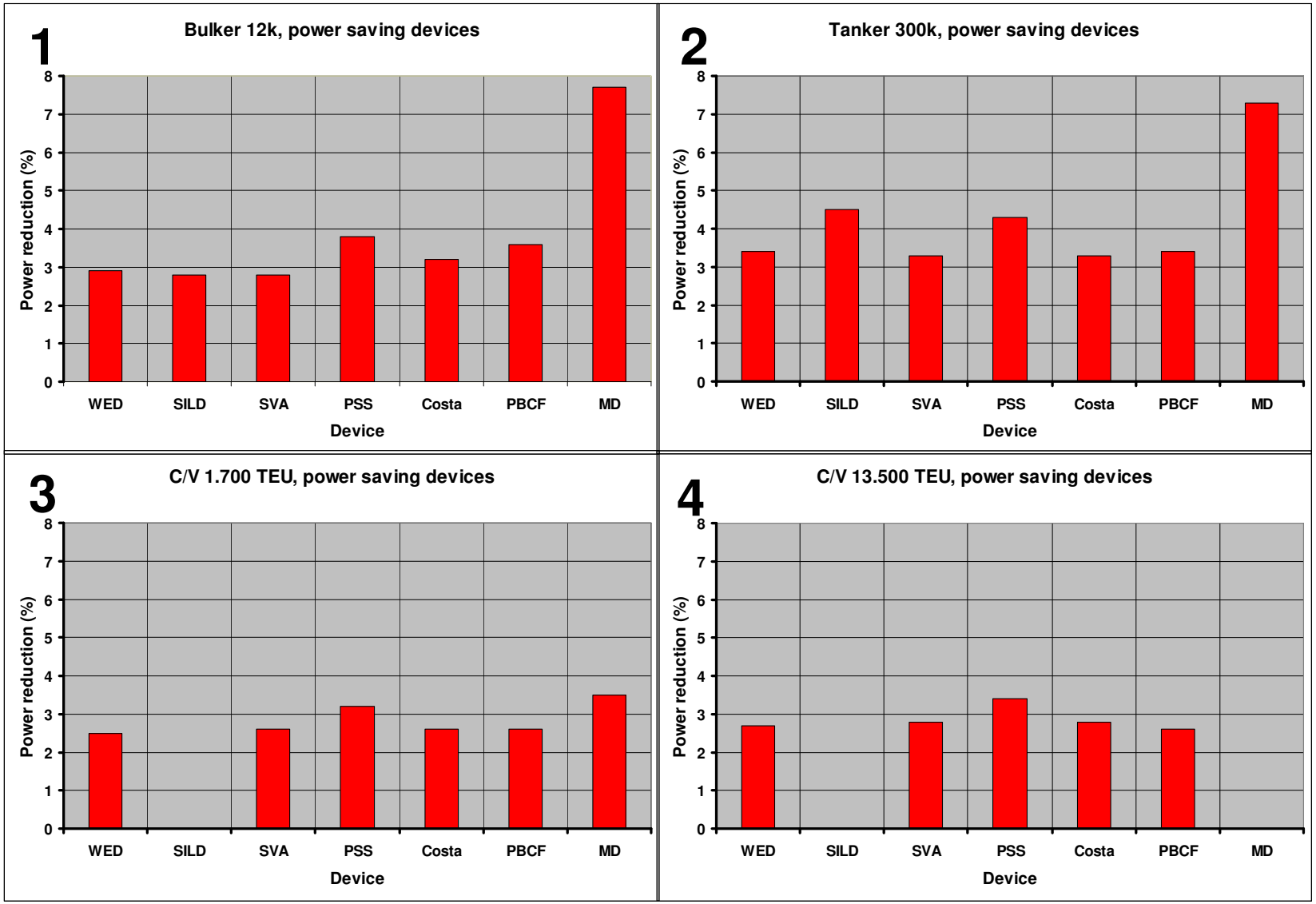
7. MD

Power saving devices (PSD), possible power reductions



Note: These curves can vary from ship to ship

Power saving devices (PSD), possible power reductions



Power saving devices (PSD), possible power reductions

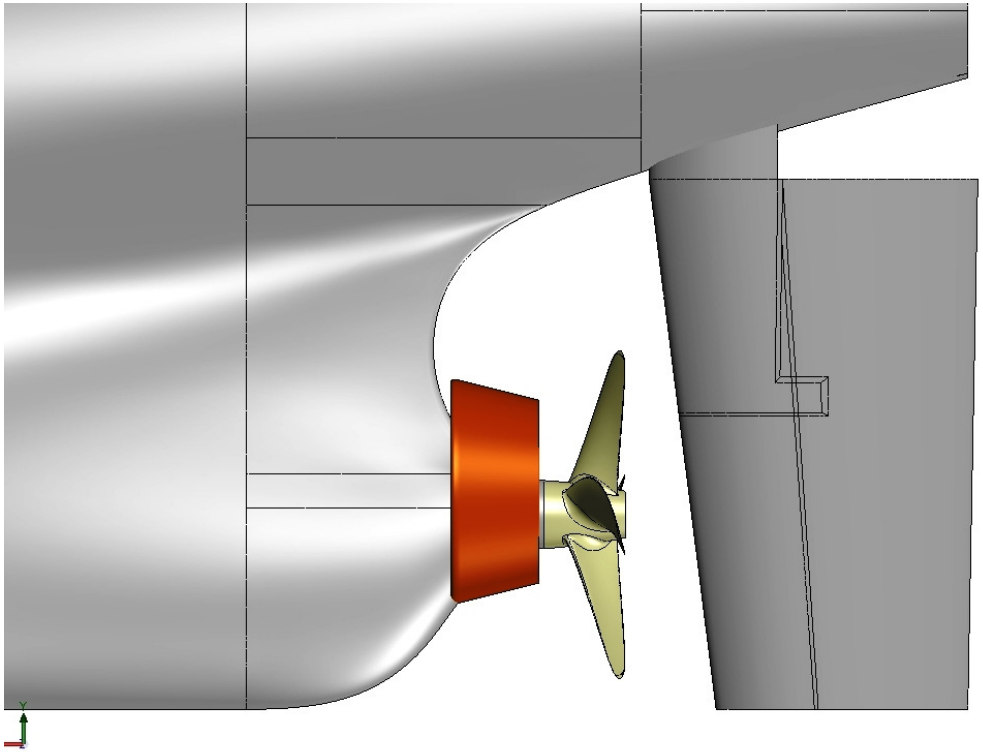
Case No		1	Grieg J	2	3	4
Ship type Size		Bulker 12k	J-class 46k	Tanker 300k	Container 1,700TEU	Container 13,500TEU
VD	kts	15.20	16.00	15.50	20.00	24.60
CTh	-	1.60	1.31	2.32	1.00	1.25

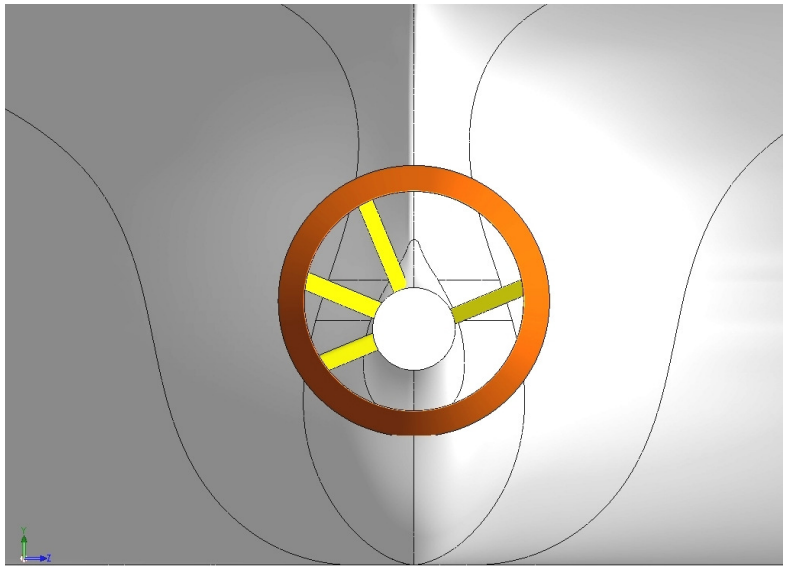
Power saving devices, possible power reductions

WED	%	2.9	2.8	3.4	2.5	2.7
SILD	%	2.8	1.7	4.5	-	-
SVA	%	2.8	2.7	3.3	2.6	2.8
PSS	%	3.8	3.5	4.3	3.2	3.4
Costa	%	3.2	3.1	3.3	2.6	2.8
PBCF	%	3.6	2.9	3.4	2.6	2.6(?)
MD	%	7.7	6.0	7.3	3.5	-

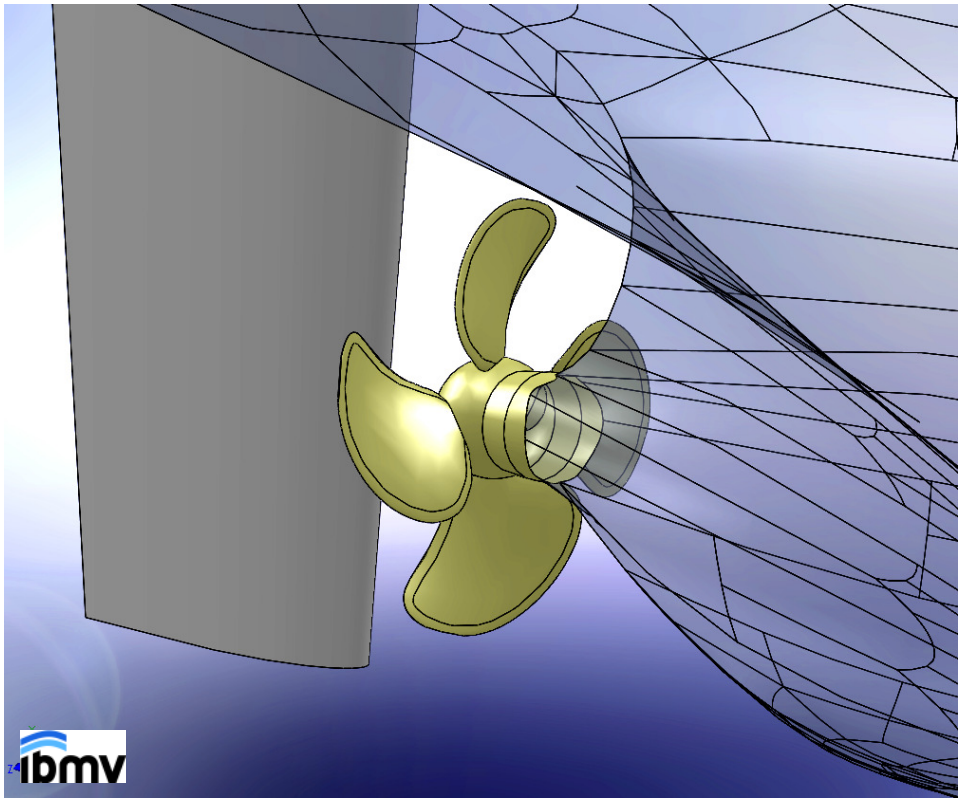
Mewis Duct®

Principle arrangement



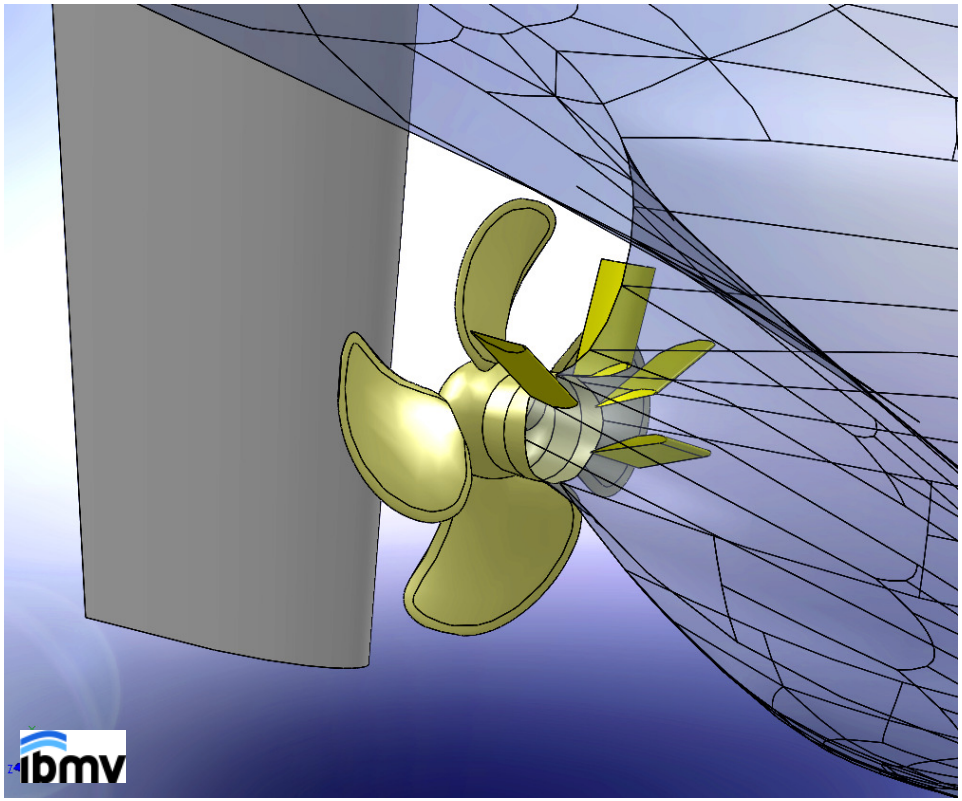


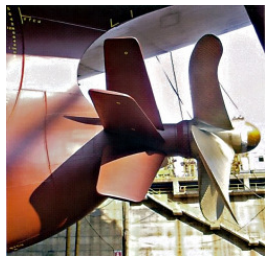
Mewis Duct®



Aft-body with propeller and rudder, no power saving device

Mewis Duct®

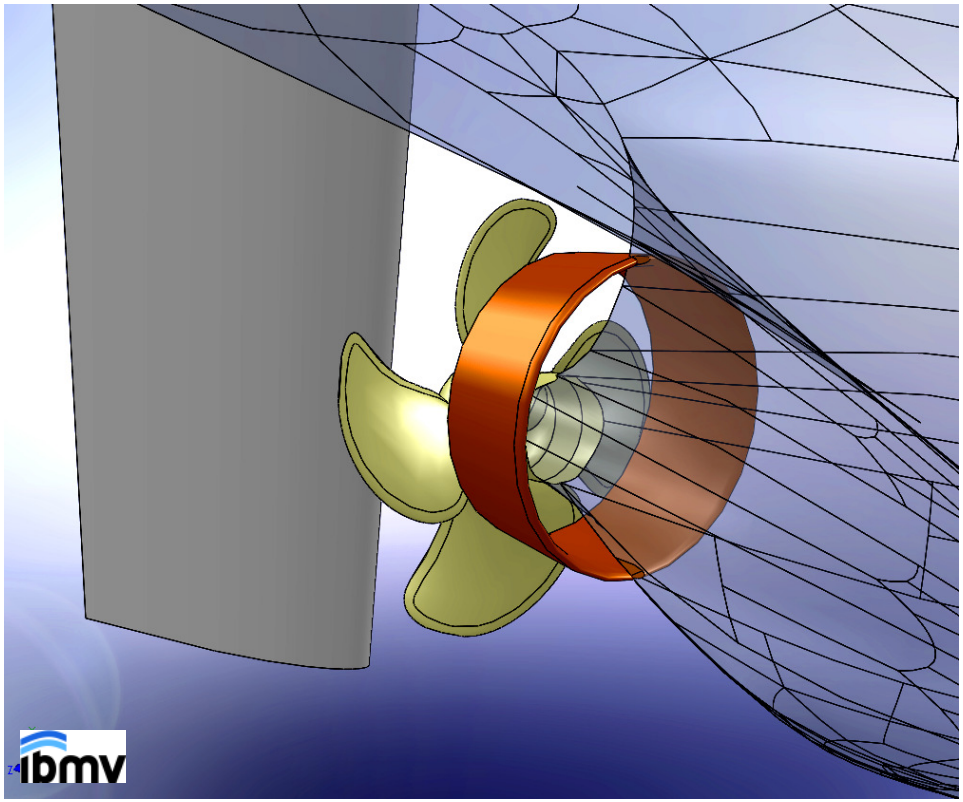




PSS

1. Fins ahead the propeller Generation of pre-rotation

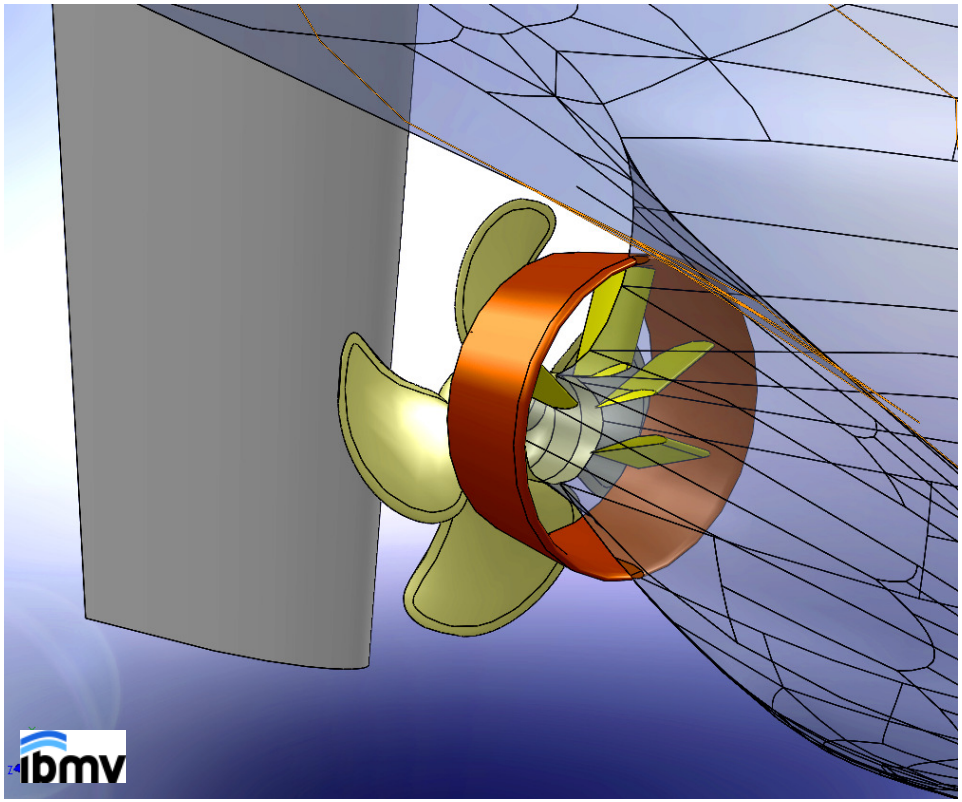
Mewis Duct®

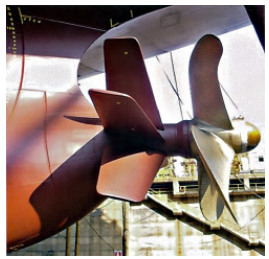


SILD

2. Duct ahead the propeller **Direct flow to the inner radii, own thrust**

Mewis Duct®





PSS

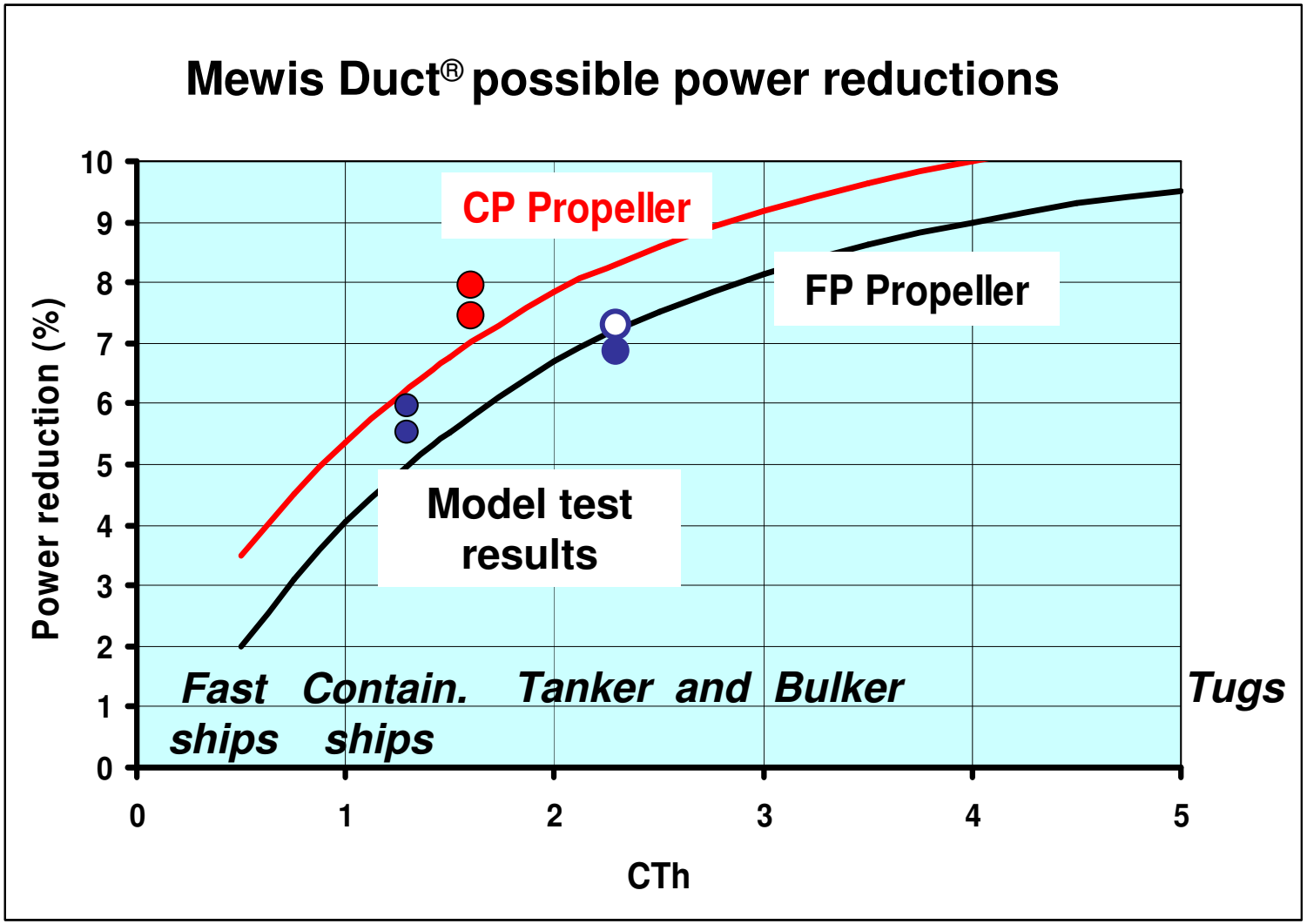
SILD

PBCF

1. Fins ahead the propeller — Generation of pre-rotation
2. Duct ahead the propeller — Direct flow to the inner radii, own thrust
3. Pre-swirl mainly inwards — Reduction of hub vortex losses

Mewis Duct® = Combination of these three components

Mewis Duct®


Mewis Duct® possible power reductions
Power reduction (%)
10
9
8
7
6
5
4
3
2
1
0
CP Propeller
FP Propeller
Model test results
Fast ships
Contain. ships
Tanker and Bulker
Tugs
0
1
2
3
4
5
CTh

Mewis Duct®

STAR ISTIND
Grieg Star Shipping

the vessel with
the first Mewis Duct®

Summary, Possible fuel and cost savings, all measures

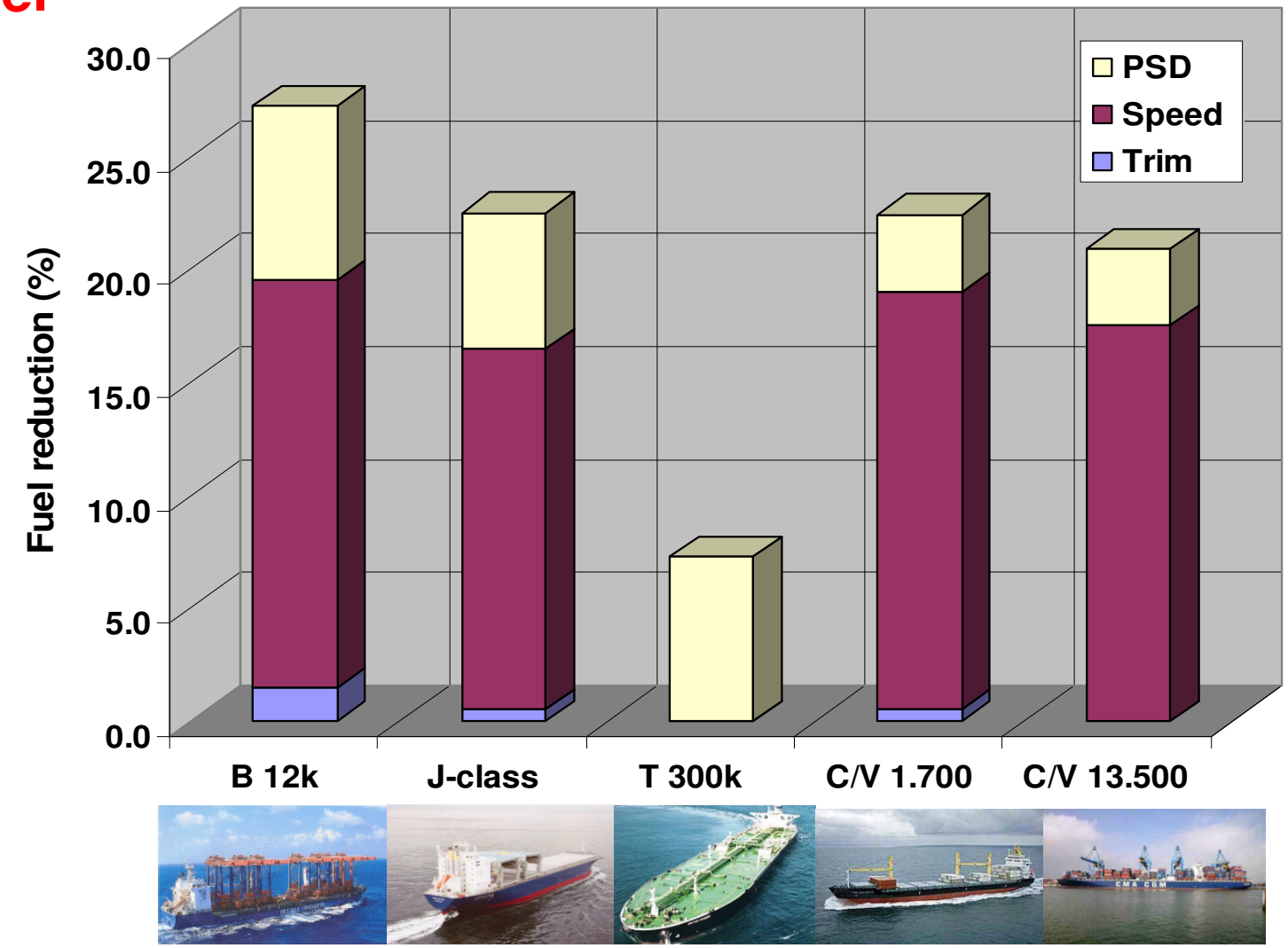
Case No		1	Grieg J	2	3	4
Ship type		Bulker	J-class	Tanker	Container	Container
Size		12k	46k	300k	1,700TEU	13,500TEU
Possible power reduction by different measures, % power						
Trim (50%)		1.5	0.5	0	0.5	0
Speed (50%)		18	16	0	18.5	17.5
PSD		7.7	6	7.3	3.5	3.4
Sum power	%	27.2	22.5	7.3	22.5	20.9
Possible cost reduction by different measures, % total costs						
Trim (50%)		0.7	0.2	0	0.3	0
Speed (50%)		4.5	1.5	0	4.5	3.5
PSD		3.5	2.7	2.1	1.7	1.7
Sum costs	%	8.7	4.4	2.1	6.5	5.2

Note: Trim optimisation and Speed reduction: 50 % of estimated gain is realizable only!

Summary fuel

Possible fuel reductions, summary

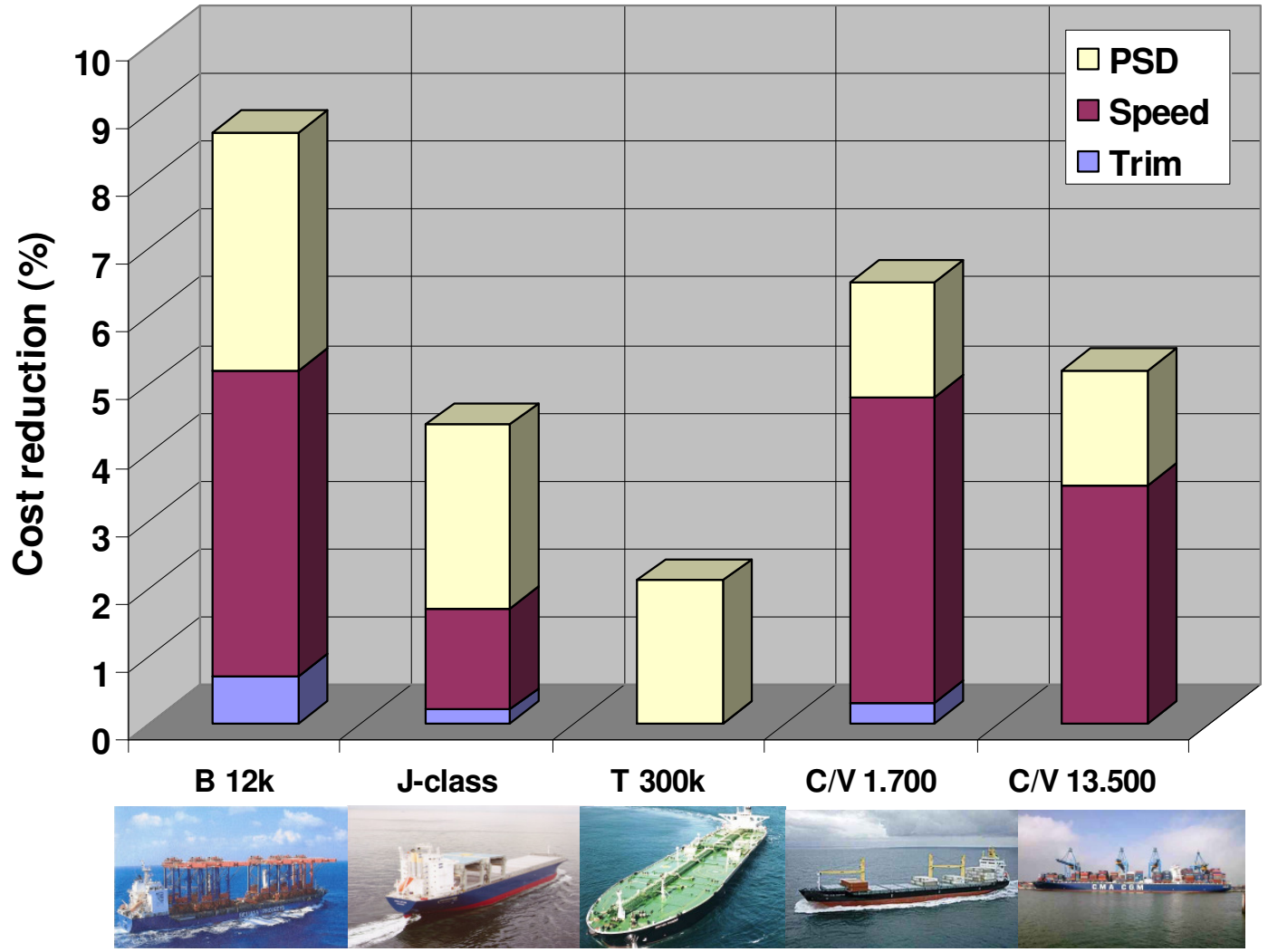
Case B: fleet with constant transport capacity



Summary costs

Possible cost reductions, summary

Case B, fleet with constant transport capacity



We thank you very much for your attention!