KNUD E. HANSEN A/S

Defining the path to Energy saving

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OVERVIEW OF PRESENTATION

1. SHORT INTRODUCTION OF KNUD E. HANSEN A/S

2. WHAT SHALL WE GO FOR ?
   - ¤ New buildings
   - ¤ Retrofit

3. WHAT IS OUR OPTIONS ?

4. WHERE SHOULD WE START ?

5. CASES/ESTIMATES
   - ¤ Duct on VLCC and Mid size Tanker
   - ¤ Energy Saving Devices : Retrofit Vs. New building

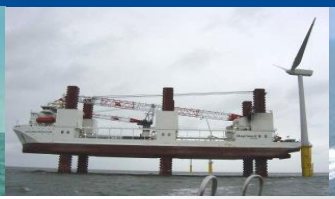
6. QUESTIONS

*"Since 1937, **Knud E. Hansen A/S** provides **tailor made** consultancy and design services to the global maritime industry.*

KNUD E. HANSEN A/S – World Offices

VESSELS TYPES






- TANKER VESSELS
- RO-RO & RO-CON
- CONTAINER VESSELS
- CRUISE VESSELS
- MULTI PURPOSE VESSELS
- MILITARY VESSELS
- OFFSHORE WIND
- OFFSHORE OIL & GAS
- YACHTS
- FERRIES (RO-Pax)





TANKER PROJECTS CURRENTLY ON OUR TABLE

- 6.300 DWT IMO 2 (Internal project)

- 14.000 DWT ASPHALT/BLACK PRODUCTS
- 14.250 DWT IMO 2
- 19.999 DWT IMO 2 (pending)
- 24.000 DWT IMO 2
- OPTIMIZING VLCC

WHAT SHALL WE GO FOR ?

NEW BUILDING

UPGRADE
EXISTING FLEET

NEWBUILDING-Energy Saving Devices

NEW BUILDING

- Anticipate new fuel regulatory changes now and in the coming years.
- Generally it is cheaper to add fuel saving technologies on newbuilding.
- Allmost all fuel saving technologies is economical feasible on new buildings.
- Coorperate with proven design house ensure high overall efficiency.

[**Generally, Yards main focus is on optimized production**]

- If a fuel saving solution is found economical feasible on an exsisting Vessel then it would most likely also be it on a newbuilding.

UPGRADE EXISTING FLEET

UPGRADE
EXISTING FLEET

- OLD OR BAD DESIGN = MANY SOLUTIONS
- LARGE VESSEL = MANY SOLUTIONS
- SMALL VESSEL = FEW SOLUTIONS
- NEW / GOOD DESIGN = FEW SOLUTIONS

THE CHEAP & PERFECT SOLUTION DOESN'T EXIST !

ENERGY AWARENESS IS THE KEY WORD

WHAT IS OUR OPTIONS ?

There are basically four ways to be improve the fuel efficiency of a ship.

- Reduce the hull resistance in Loaded/Ballast condition
- Increase the propulsion system efficiency
- Improve the power plant efficiency
- Improve the Crew behavior & operational efficiency

- For New buildings a fifth way exists **OPERATION PROFILE…**Draft, speed, laden/ballast, operation area

Reduce the hull resistance in Loaded/Ballast condition

Hull Resistance:

General characteristics of a full-form/high block coefficient vessel such as Tankers;

- 60-80% of the hull resistance is in the form of viscous resistance.
- 10-20% can be attributed to wave resistance
- 5-10% to hull roughness
- Up to 5% to air resistance.

The largest areas for improvement here lie in optimizing the hull form (optimize carry capacity), applying smooth coatings and KEEP the hull and propeller clean. **For Tanker vessels already in operation hull form optimization has very limited applicability. BUT on new building it has high Value**

Increase the propulsion system efficiency

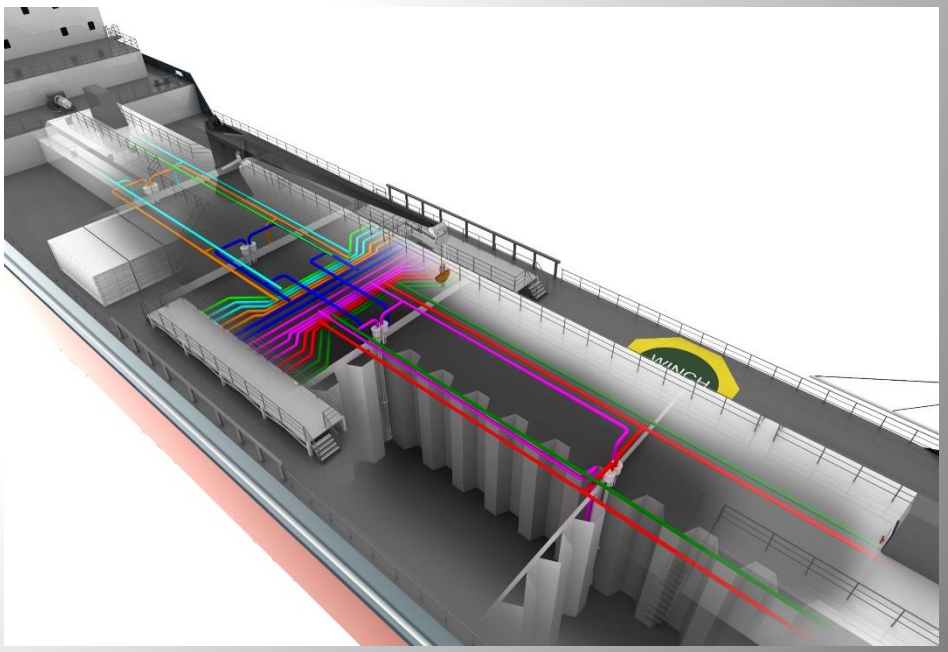
Propulsion System Efficiency

There are a range of options Energy Saving Devices (EDS) on the market for systems which improve the propulsion efficiency. These include:

- Nozzles / Ducts (i.e. Mewis ducts,)
- Novel propellers (i.e. Kappel, NPT)
- Pre-swirl Stators / Fins
- Twisted Rudders/ Asymmetric Rudder Technology
- Flap rudder
- Rudder Bulbs
- Boss cap fins
- Combinations (i.e. Mewis ducts)
- "De-rating Main Engine"
- Modern Hull coatings
- Optimum match between Propeller and Main Engine

Propulsion System Efficiency

- All of these systems are highly customized and designed specific for each vessel. Each system has advantages and disadvantages, and in some cases combining different devices has been shown to give good improvement, such as the Mewis Duct which combines a duct and pre-swirl fins. In general the efficiency improvements to be gained are highly dependent on the geometry of the vessel in question.



Improve the power plant efficiency

Improve the power plant efficiency

Generally the VFD, recover waste heat and automation is the key! There are a range of options on the market for systems which improve the plant efficiency. These include:

- Cargo heating
- Generation of N2
- Ventilation systems and Air intakes
- SW/FW Cooling Water system
- Light installations
- HT water waste heate recovery
- HVAC
- Main Engine - Autotuning
- Exhaust gas Waste heat recovery (feasible for VLCC)

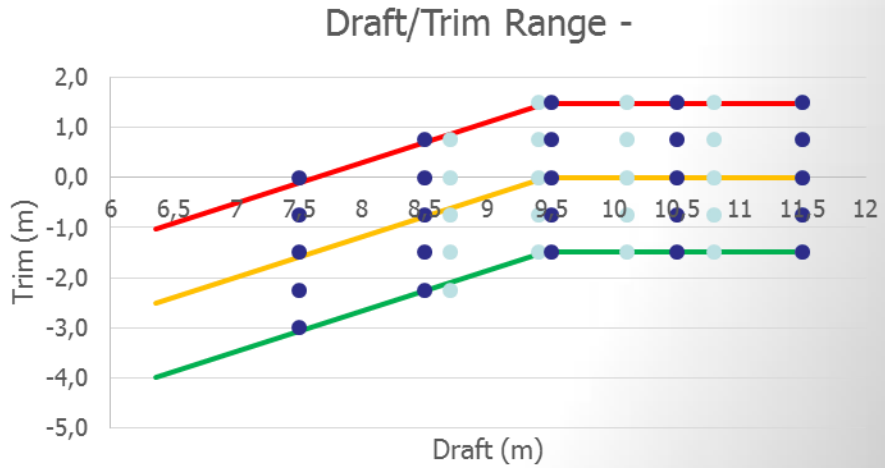
In few cases, mainly on larger Vessels and for Bad designs; Larger conversions could be done with large savings / Quick return of Investments.

- Replace propeller
- Change Main Engine layout.
- Change bulbous bow design

Improve the operational efficiency

Improve the operational efficiency

- Trim optimization can offer reductions in fuel consumption in the range of 1-5% Done either by model test or CFD – depending on whether a model is available or not).



- Route planning (weather, adjust speed according to ETA.)

- Crew training / awareness
  - -Do the Vessel systems operate in most efficient mode ?
  - -Lack of maintenance / overhaul is increasing energy consumption
- Slow steaming, take advantage of current and avoid bad weather.
- **Hull & propeller fouling**

WHERE SHOULD WE START ?

DECISION TOOLS

- **DETAILED APPROACH…….**KEH has a very detailed/strong calculation tool which take almost all the variables and risks into account and gives a good support to the decision process.

- **SIMPLIFIED APPROACH…..** Another approach is to simplify the decision process; Before starting on each individual Fuel saving devices on a Vessel a general/quick analysis of the fleet is carried out.

DETAILED APPROACH

MAKE "GUESTIMATES" FOR A GREENER and MORE EFFICIENT FLEET:
Estimated assumptions based on history, experience and the vision of the owner regarding the type and condition of the fleet that will be examined.

- New-building or Retrofitted ships or combinations
- Potential investment scenario
- Fuel price
- Variations of fuel price in the future
- Life Cycle period
- Type of market-Freight rates

	4 Cases	Ships number	
		Retrofits	New
1	All Eco friendly Newbuildings	0	10
2a	All Retrofits-to become eco-friendly-5 yr old	10	0
2b	All Retrofits-to become eco-friendly-10+15 yr	10	0
3a	Mix New-Retro(5 yr old)	5	5
3b	Mix New-Retro(10+15 yr old)	5	5
4	Totally Non Eco-friendly	0	10

Ship:	
Total nr.ships:	10
Type of ship:	Tanker
Enter DWT:	60000
Enter LWT:	10000

Fuel:	
Fuel consumption(t/day):	30
Working days/year:	250
Fuel consumption/year(t/year):	7500
Fuel Price($/MT):	730

Life study period (years):	25
Select of bulk carrier:	Supramax
Select Route:	Atlantic
Enter T/C rate ($/day):	10000
Enter Sale price of 5yr old ship($):	15000000
Enter Newbuilding price ($):	20000000

DETAILED APPROACH

- Green technologies that will be applied

Fuel saving Design Technologies

Impoved hull design:		
Hull form optimisation (assymetric body design)	1	0.08
Bulb modification (bulbous bow)		0.04
Design for both calm &seaway operations	1	0.01
Evaluation of added resistance		0.01
Propeller & Rudder design:		
High performance propeller series		0.06
Contra-Rotating podded propulsion concept		0.1
Thruster/Vortex Fins		0.04
Pre-Duct-Mewis Duct		0.06
Pre-Duct-Schneekluth		0.05
Boss-Cap Fins	1	0.03
Rudder Bulbes-Twisted rudders		0.04
Propeller coatings	1	0.04

Eco-friendly Operational Technologies

MARPOL VI	Air-pollution:		
	Operational aspects		
	Slow streaming (5% speed reduction)	1	0.13
	Hull cleaning		
	Course keeping ability		
	Manouvering ability		
	Weather Routine		
	Optimum dynamic trim		0.02
	Cold ironing		
	Crew Training		
	On board monitoring for energy efficiency		

Technologies to protect the environment and compliance with future legislations

Ballast Water Convention		
	Ballast water treatment systems(minimum ballast)	1
	Ballast water free design	
MARPOL I	Oil:	
	Dipose off at shore	
	High speed centrifuges	1
	Biodegradable fuels and oils(biodiesel)	
	Water lubed stern tube	
MARPOL IV	Sewage:	
	Dipose off at shore	
	Sewage treatment system	1
	Membrane bioreactors	
	Vacuum toilets	
MARPOL V	Garbage:	
	Dispose off at shore	
	Waste compressors	
	Incinerators (also for heat recovery)	1

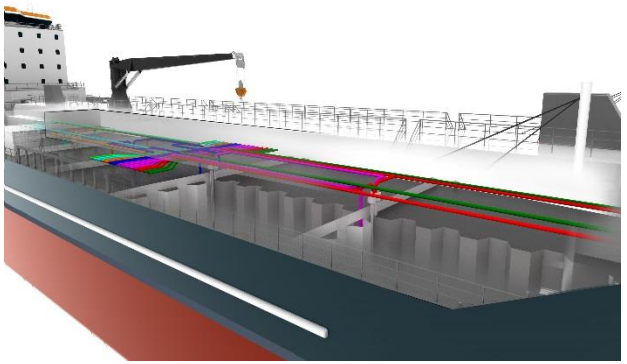
SIMPLIFIED APPROACH

List following for your Fleet.

- Quantify amounts of USD equal to x % saved
- New building year, Yard and Design house
- VFD's and automation systems installed on board
- Propeller & Engine type
- Consumption compared to Sea trial data
- Operation Profile such as operation data in Ballast, partial and full loaded condition
- Company policy regarding return of investment

Quantify amounts of USD……examples

VLCC 300.000		
SFOC-Sea	175	g/kWh
SFOC-Harbour	200	g/kWh
Power cons. At Sea	22.050	kW/hr
Power cons. Harbour	500	kW/hr
Days in Sea	295	days
Days in Harbour	70	days
Fuel cost-HFO	650	USD/ton
Fuel cost-Lo-S	950	USD/ton
Avg. daily Cons	92,61	ton/day
Basis cost-Sea	17.757.967	USD/year
Basis cost-Harbour	159.600	USD/year
Total cost	17.917.567	USD/year
Design optimize-2%	**355.159**	**USD/year**
Design optimize-6%	**1.065.478**	**USD/year**
Design optimize-10%	**1.775.797**	**USD/year**



Aframax 110.000		
Design optimize-2%	224.693	USD/year
Design optimize-6%	674.078	USD/year
Design optimize-10%	1.123.463	USD/year
Handymax 50.000		
Design optimize-2%	115.970	USD/year
Design optimize-6%	347.911	USD/year
Design optimize-10%	579.852	USD/year
Handysize 30.000		
Design optimize-2%	86.978	USD/year
Design optimize-6%	217.445	USD/year
Design optimize-10%	434.889	USD/year
Handysize 19.999		
Design optimize-2%	50.737	USD/year
Design optimize-6%	152.211	USD/year
Design optimize-10%	253.685	USD/year
6.500		
Design optimize-2%	36.241	USD/year
Design optimize-6%	108.722	USD/year
Design optimize-10%	181.204	USD/year

Case story 1 – Retrofit DUCT on VLCC

VLCC – Simplified approach

Client require

- Min. 5 % saved – 6 Vessels – ROI max. 1 Years – Vessel must not be taken out of Service

- Quantified amounts of USD equal to 5 % saved = approx. 900 kUSD/Year
- Which ESD option may be available for retrofit during scheduled dry docking or in-service:

-Waste heat recovery would technical be feasible but did not comply with ROI request

-Duct considered feasible

Preliminary budget: Duct maker Design fee 175k USD

Duct – Materials	500k USD/Vessel
Project handling	25k USD
Finance cost	20k USD/Vessel
Total cost/Vessel	555k USD/Vessel → Retrofit case valid

Model test results has shown 6-10% saving (depending on speed and trim)

Fitting duct would also be applicable for New buildings same as waste heat recovery (ROI >1 year)

Case story 1" – Retrofit DUCT on 24k-30k Tanker

24k-30k Chemical Tanker– Simplified approach

Client require

- Min. 5 % saved – 6 Vessels – ROI max. 1 Years – Vessel must not be taken out of Service

- Quantify amounts of USD equal to 5 % saved = approx. 215k USD/Year
- Which ESD option may be available for retrofit during scheduled dry docking or in-service:

Duct considered feasible in current case

Preliminary budget: Duct maker Design fee 175k USD

Duct – Materials	200k USD/Vessel
Project handling	25k USD
Finance cost	20k USD/Vessel
Total cost/Vessel	242k USD/Vessel → Retrofit case valid to investigate

Estimated results has shown 3-6 % saving (depending on speed and trim) (ROI >1 year)

Fitting duct would also be applicable for New buildings

Case story 2 – Retrofit Vs. New build 24k-30k Tanker

Example 24k-30k – Chemical Tanker Simplified approach using conservative estimates. What would be the approximated picture if considering following ESD package.

							One time investment	
		Rough estimate of cost for implement energysaving devices, **24k-30k DWT Chemical Tanker**					Cost per Vessel	
		Based on serie of 6 Vessels						
Saving pot. %	ROI Mth(s)	Optimize **exsisting** Vessel	**USD**		**USD**	Optimize **New** Vessel	ROI Mth(s)	Saving pot. %
		Hull Resistance:				**Hull Resistance:**		
3,0	33	Optimize bulbous bow [CFD+Design]	86.000		28.000	Optimize bulbous bow [CFD+Design]	3	2,6
		Optimize bulbous bow [Materials]	270.000		0	Optimize bulbous bow [Materials]		
		Propulsion System Efficiency			**Propulsion System Efficiency**			
4,0	16	Nozzles / Ducts incl .design+test (NCNP)	180.000		162.000	Nozzles / Ducts incl .design+test (NCNP)	16	4,0
		Nozzles / Ducts - materials	200.000		200.000	Nozzles / Ducts - materials		
6	55	Novel propellers + chg. Rating of Main Engine	1.200.000		200.000	Novel propellers + de-rating of Main Engine	11	5
		power plant efficiency			**power plant efficiency**			
	13	Cargo heating	62.500		20.000	Cargo heating	4	
	17	Generation of N2 (depend of install type)	60.000		0	Generation of N2	(-)	
	6	SW/FW Cooling Water system	70.000		25.000	SW/FW Cooling Water system	2	
		Total Cost	**2.128.500**		**635.000**			
		Total saved "fuel cost" per year	**814.742**		**760.466**			
		Break even Year's without financing	**2,6**		**0,84**			

Above is illustrating a few of the ESD which is considered applicable for both new building and/or retrofit.

Case store 3: Daily Consumption

Buying daily consumption???

Below are some figures that have been seen for variously full body Vessel designs, approx. same block

Loa 185 m
B 28.4 m
d_{design} 10.3 m
CSR incl. 15% SM…. 14kn
SFOC(10,200kcal/kg) abt. **17.5 t/day**

Loa 180 m
B 30.4 m
d_{design} 9.5 m
CSR incl. 15% SM…. 14kn
SFOC(10,200kcal/kg) abt. **17.9 t/day**

Loa 175 m
B 27.0 m
d_{design} 8 m
CSR incl. 15% SM…. 14kn
SFOC(10,200kcal/kg) abt. **16.6 t/day**

Loa 180 m
B 30 m
d_{design} 10.1 m
CSR incl. 15% SM…. 14kn
SFOC(10,200kcal/kg) abt. **20.1 t/day**

Remember to add all tolerances

"Sales" figure..... 16.3 t/day
Actual figure considering "tol"... 20.7 t/day

Loa 163.5 m
B 27.0 m
d_{design} 9.2 m
CSR incl. 15% SM…. 14kn
SFOC(10,200kcal/kg) abt. **19.7 t/day**

Loa 171.2 m
B 27.4 m
d_{design} 9.75 m
CSR incl. 15% SM…. 14kn
SFOC(10,200kcal/kg) abt. **18.6 t/day**

Closing Comments & "Conclusion"

There is NO UNIQUE PATH…Each Vessel series has its own optimum solution as the technical configuration, financial aspect are different for each Vessel/Owner; purchase price, debt secured against the vessel and the cost of financing the vessel such as financing interest or required rate of return of the owner/ investor.

Duct & Prop. manufactures offer normally **"no-cure no-pay"**

Owners should be ready to **make minor investment** for Vessel ESD review

Financing of ESD is better for New Buildings then retrofit

Owners may be obligated to pay for expensive retrofitting to **keep vessels compliant** and could face having non-compliant

Eco-ship ??? If you are buying a new building, you should get Vessel(s) with the latest technological improvements IF you **technically manage to push the Yard** during negotiating of Building Specification.

THANK YOU FOR YOUR KIND ATTENTION

Any Question?