Workshop
Inland Navigation CO2 emissions
April 12th, 2011
Strasbourg, Palais du Rhin

Super Eco Inland Vessels

Line –Shaft Contra Rotating Propellers with Diesel Electric Propulsion System

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Summary

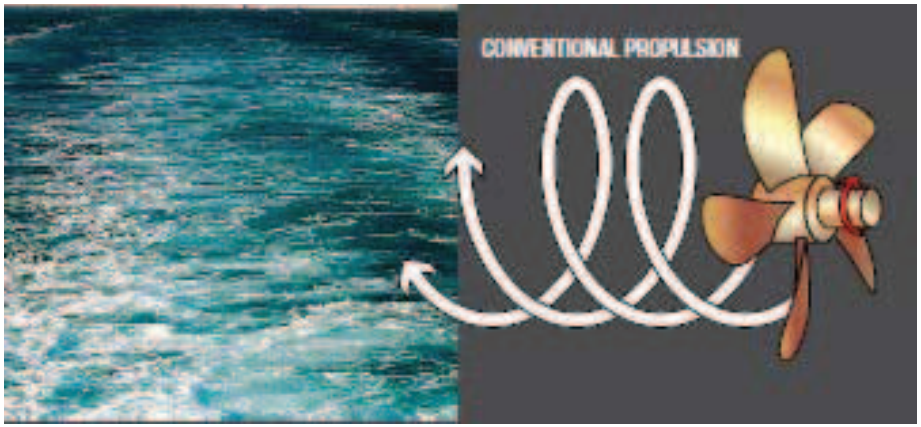
IHIMU is promoting **Contra Rotating Propeller** combined with **Diesel Electric System** to the **Inland Vessels**.

- IHIMU have delivered **14 vessels** with CRP combined with diesel electric system.
- CRP efficiency of **10%** is expected.
- Additional fuel saving by diesel electric system is expected

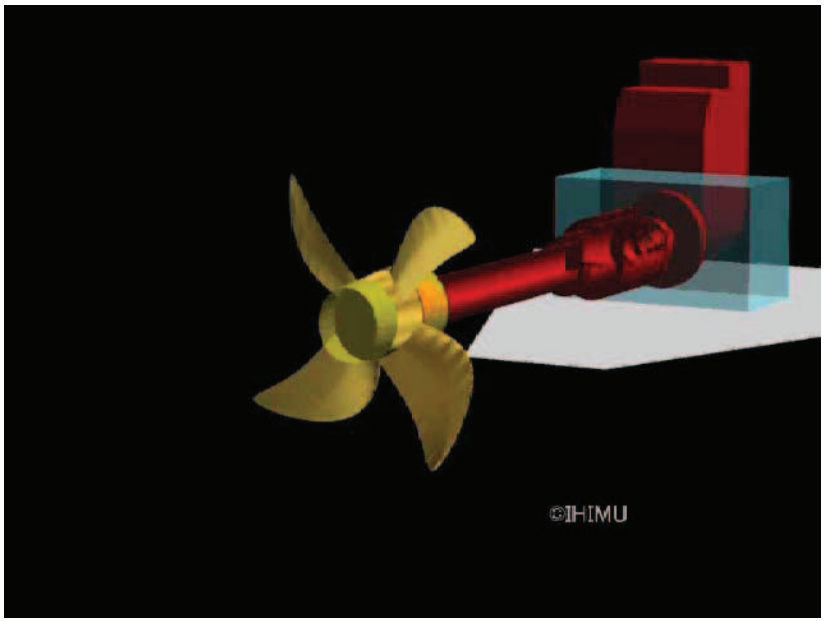
What is In-line Contra Rotating Propeller (CRP) system?

Principle of Contra Rotating Propeller

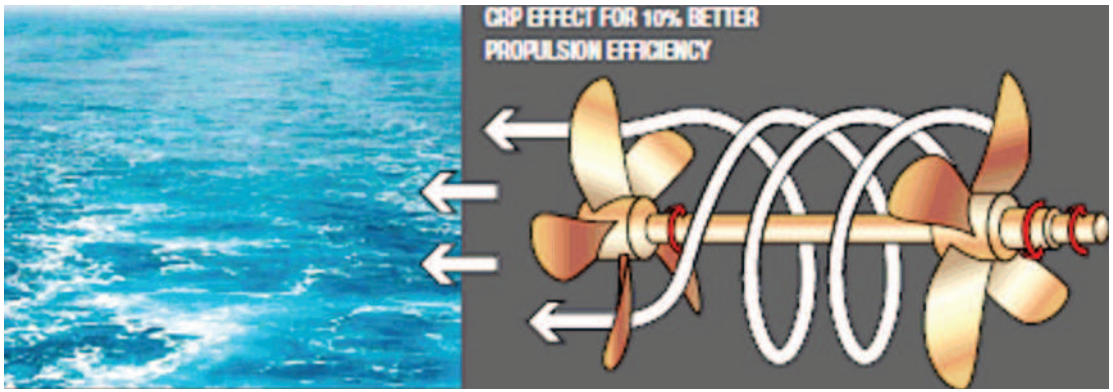
Single Propeller



Rotational stream energy after propeller doesn't work for propulsion



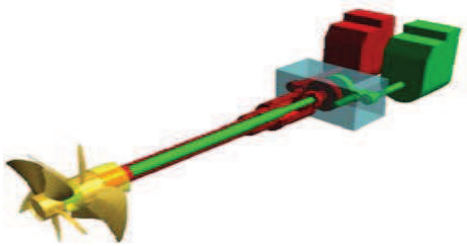
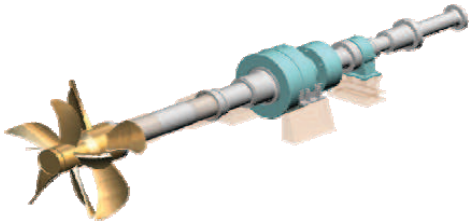
CRP



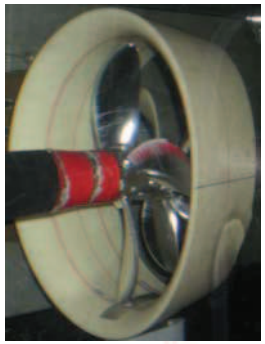
Improve
10% Efficiency

Rotational stream energy is recovered by aft propeller

CRP Application

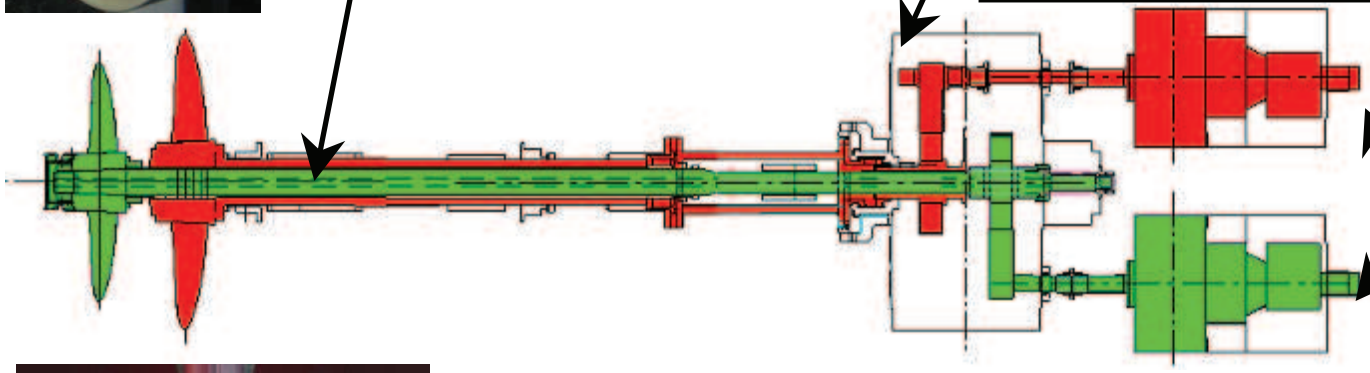
Environmental Footprint Fuel	**Current** CO2 △10% NOx △10% EN590	Convert → **Future** CO2 △20～30% NOx △90% PM △90% LNG
 **Twin Drive for Diesel Electric System** **Delivered 14 vessels**	**Motor** **Motor** **Driven by Two electric motors**	Displace the generator engines to gas engines. Constant speed engine is more reliable for gas fuelled
 **Single Drive for Mechanical System** **Delivered 3 vessels**	**Diesel Engine** **or** **Dual Fuel Engine** **Driven by One diesel engine**	Displace the main engine to gas engines. No engine displacement. Further investment for gas engine is necessary in case direct coupling with FPP

Inline Contra Rotating Propeller

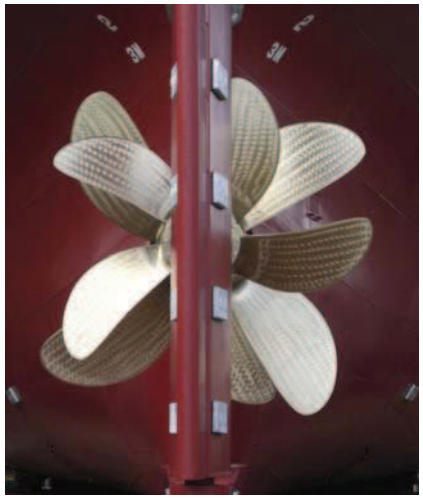


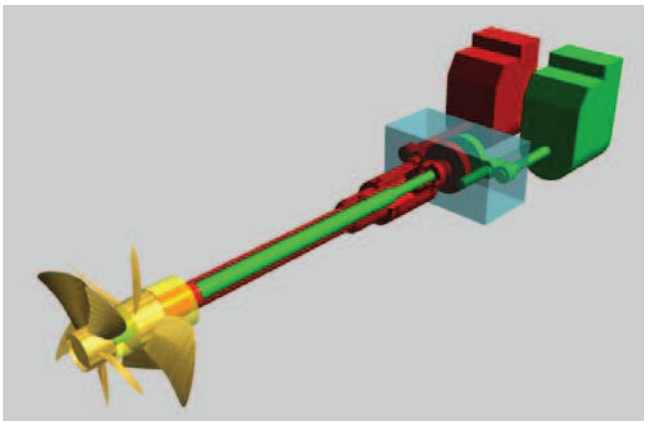
Inner prop. shaft→drive to aft propeller
Outer prop. shaft→drive to fwd propeller

Contra Rotating Gear
(Parallel Shaft Type Reduction Gear)



Electric Motor
(2sets)





Reference of similar size

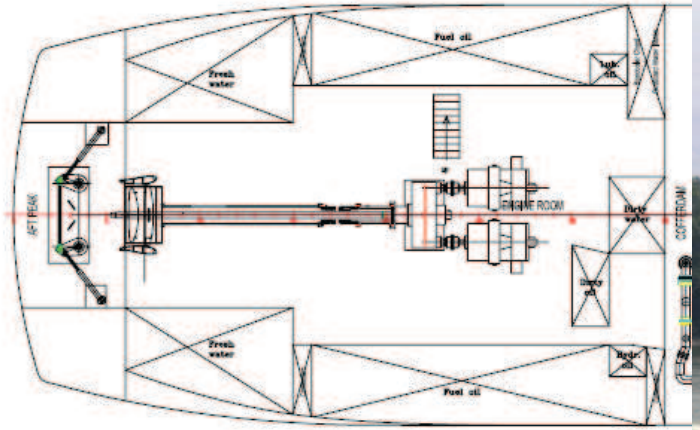
Name	Nadeshiko-Maru	Kokuho-Maru
L × B × D	69.95x11.5x5.25m	76.9x12.2x5.80m
Cargo Volume	abt. 2,200m^3 Product	abt. 2,500m^3 Chemical
Service Speed	12.0kt	13.0kt
Propulsion Motors	600KW × 2sets (Inverter)	745KW × 2sets (Inverter)
Main Generators	410KW × 4sets	700KW × 3sets

Super Eco Ships in Japan

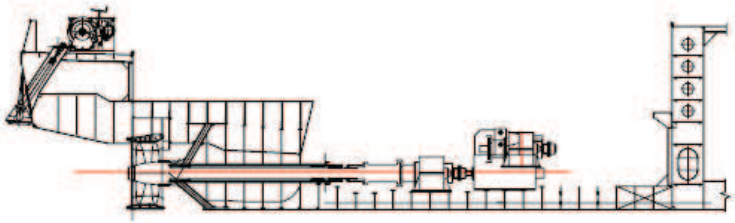
CRP with Diesel Electric

Application to Inland Navigation

110m size Chemical Tanker



Aft machinery room

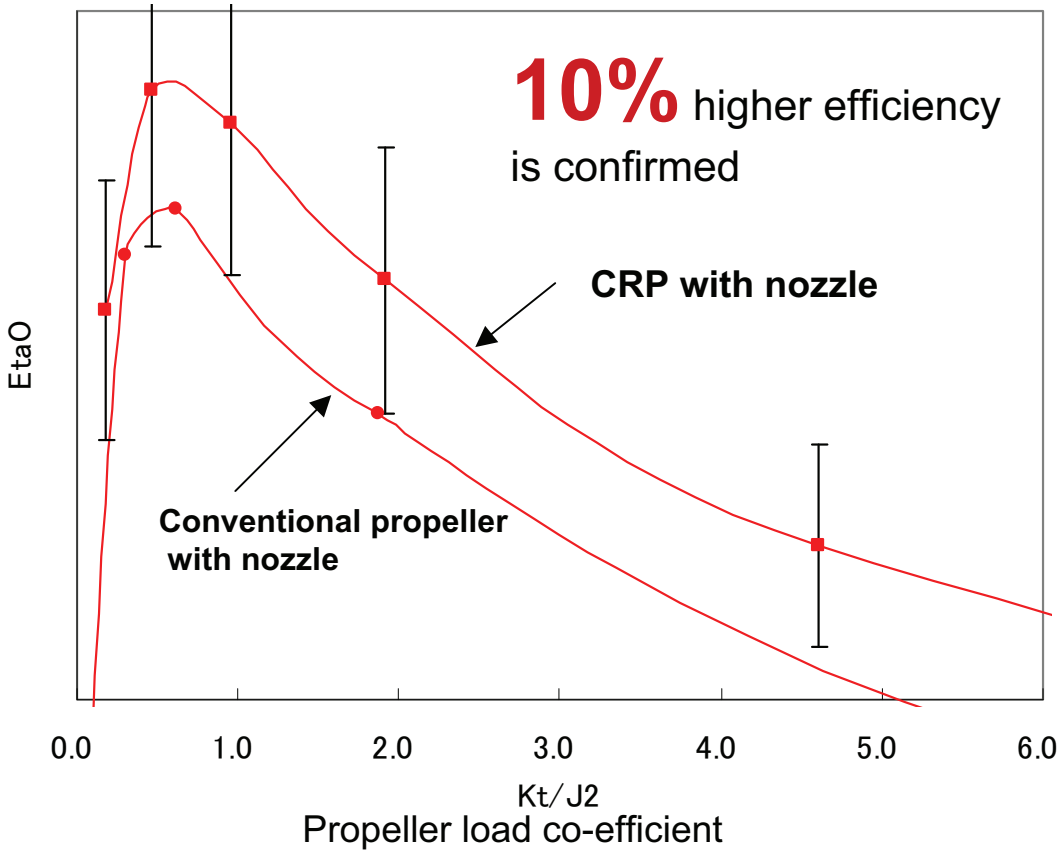


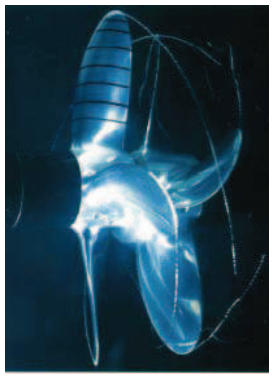
Nozzle is applicable for low speed operation

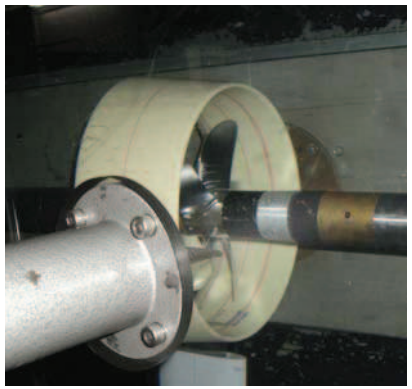
Conventional space is enough

Tank Test Result -CRP Efficiency with Nozzle-

CP(MP408) vs. CRP2 (fore prop.: MP5053, aft prop.: MP5057)
– improvement of efficiency by CRP

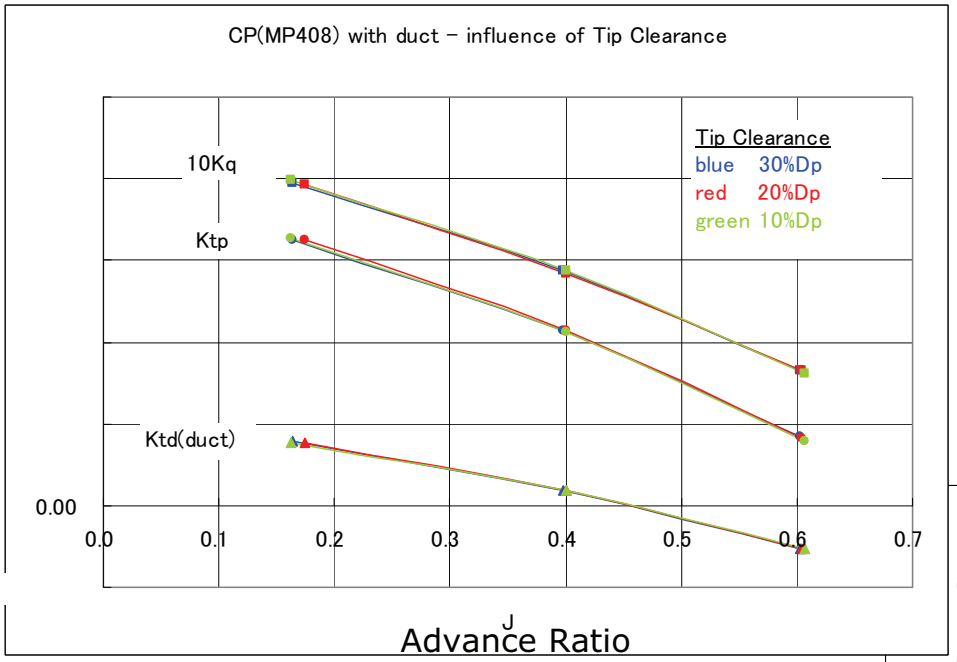




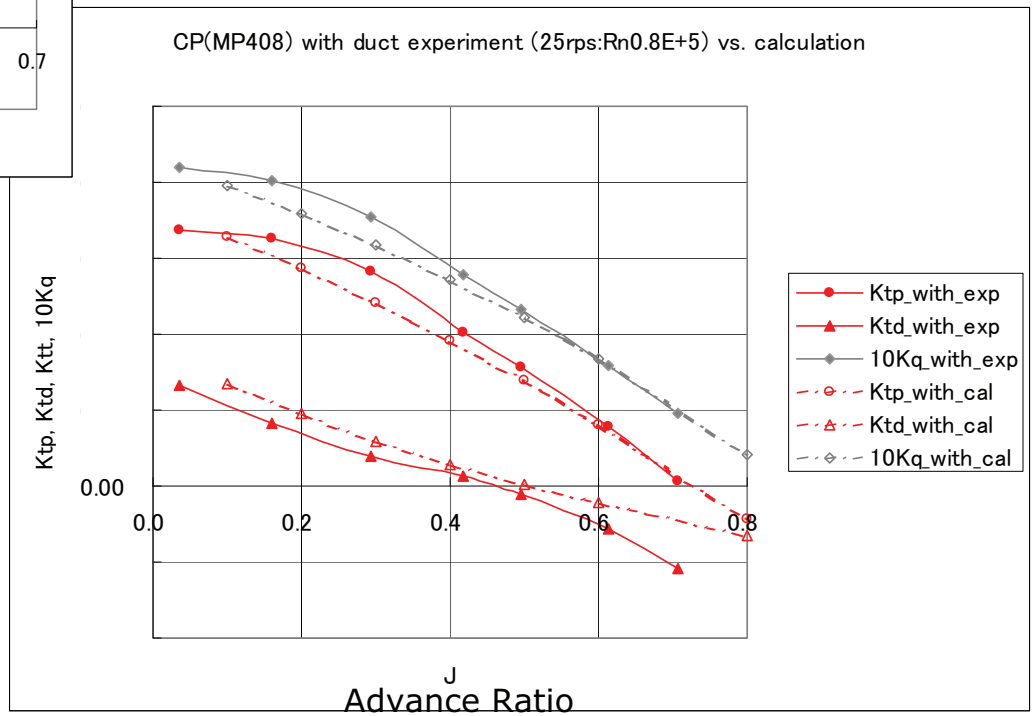


This tank test was carried out to confirm the CRP efficiency with nozzle using the existing CRP for coastal vessel, which is not optimized for duct application.

Tank Test Result -Shallow water & Nozzle-



Efficiency of CRP and nozzle is not influenced by shallow water.



Performance of the nozzle propeller can be predicted by the present design tool accurately

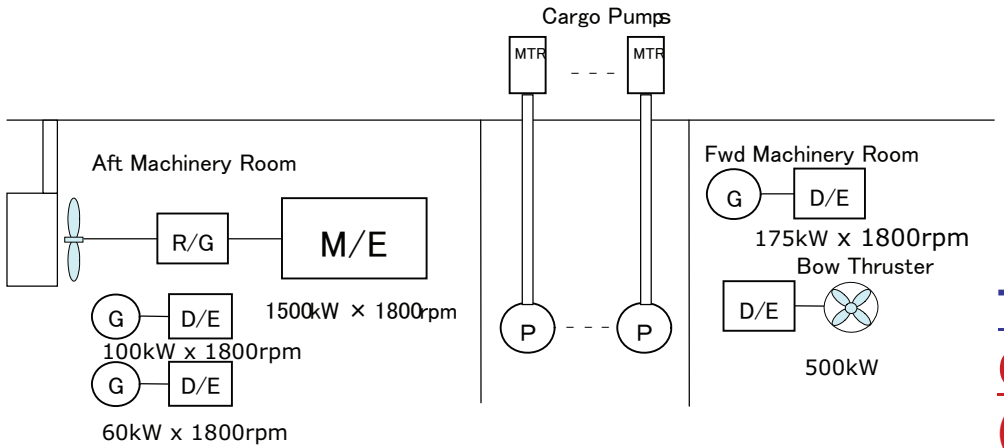
Benefits of Super Eco Inland Vessel (SEIV)

Why CRP with Diesel Electric Propulsion System?

Comparison with conventional plant

Plant Comparison with conventional Single Shaft

Conventional



Total Diesel Engine Power; 2,360kW

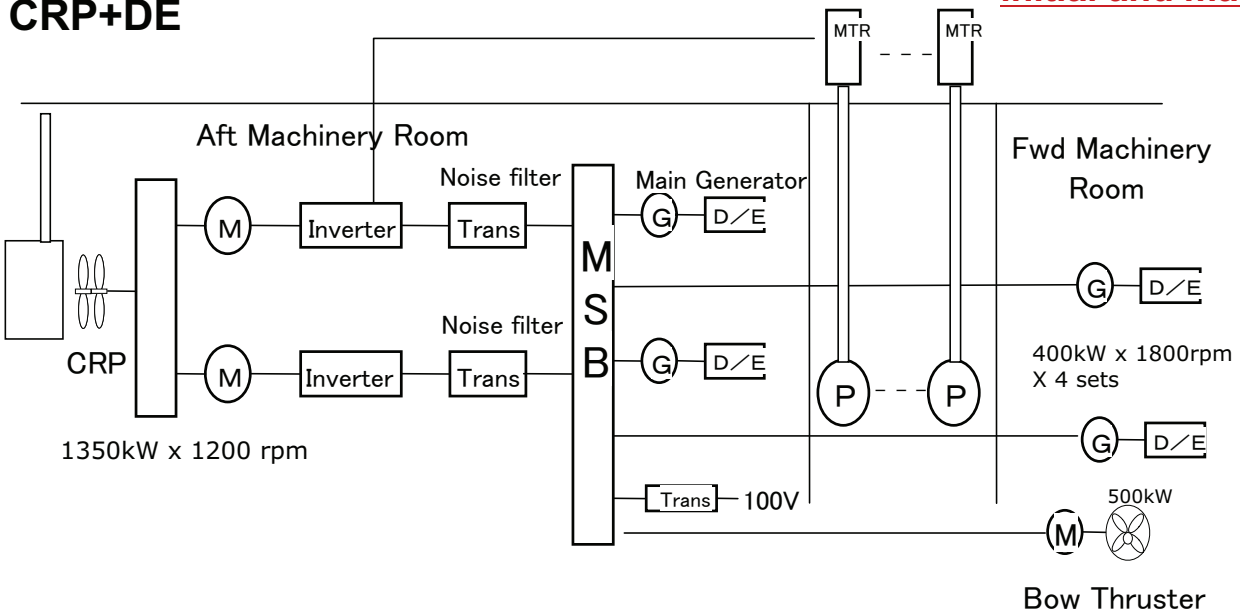
5 Types of Engine

Total Diesel Engine Power; 1,720kW

Only 1 Type of Engine

(27% less power and unified engine type saves initial and maintenance cost)

CRP+DE



Plant Comparison with conventional Single Shaft

For Environmental Economy

- **Less FO Consumption**
  by CRP with power management
- **Less Emission(NOx, CO2, SOx,PM)**
  by Less SFC

60kW x 1800rpm

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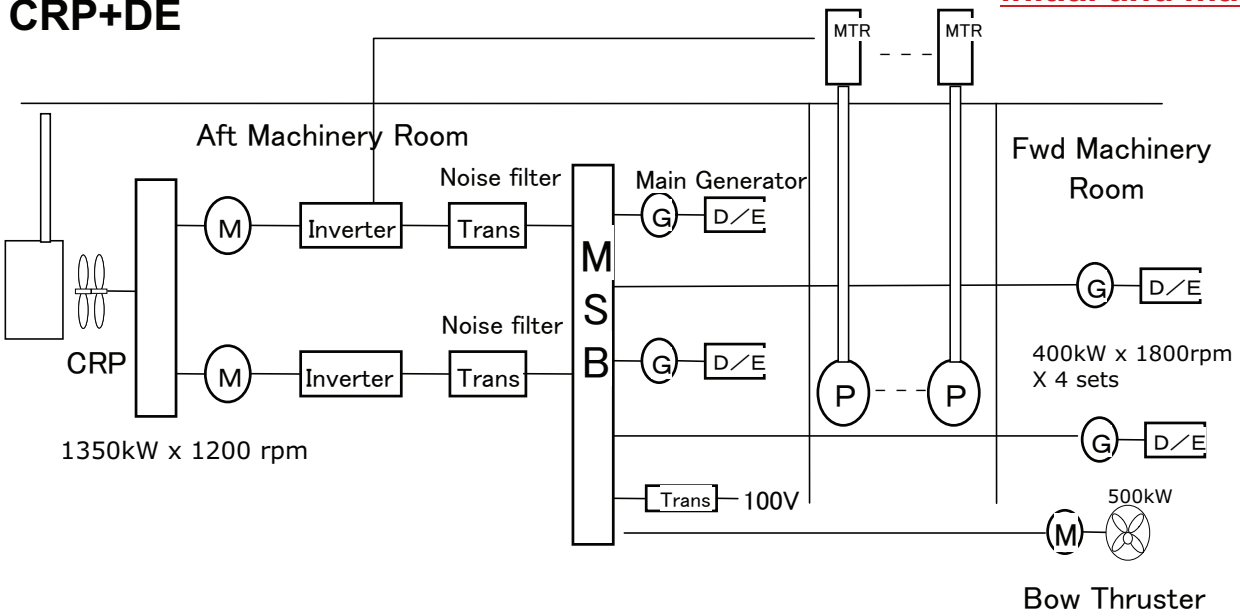

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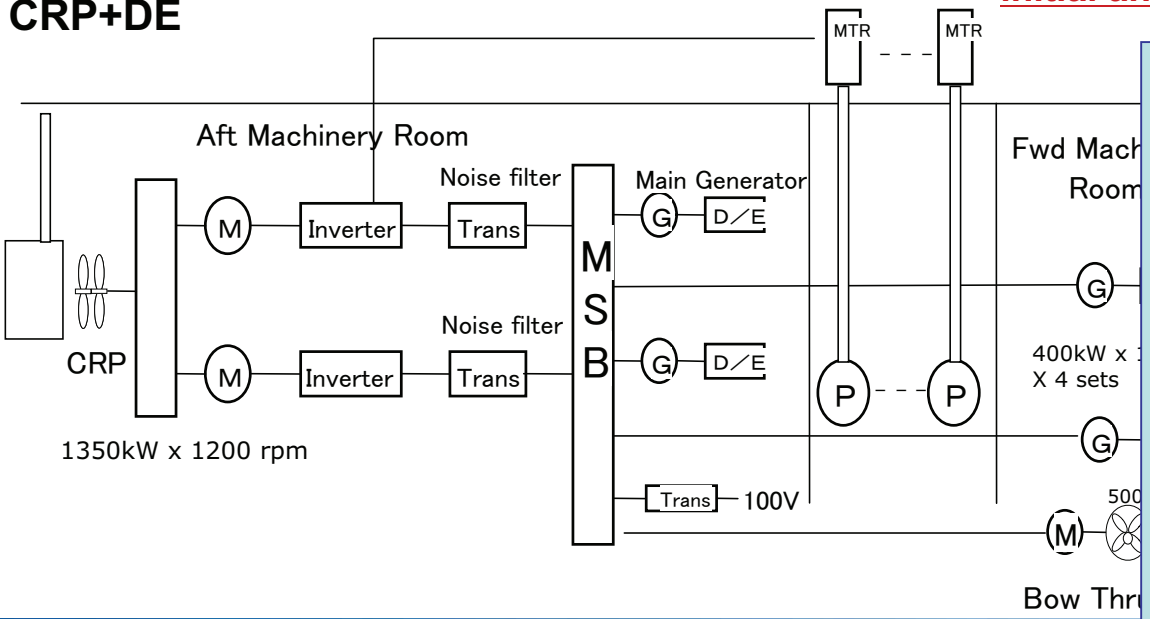


For Safety

- **Higher Redundancy**
  by DE(Power Plant)+ CRP(Propellers)
- **Better Maneuverability**
  by Rich Torque Operation
  at Low Speed+Bigger Thrusters
- **Flexible Arrangement**
  for reliability by multi location

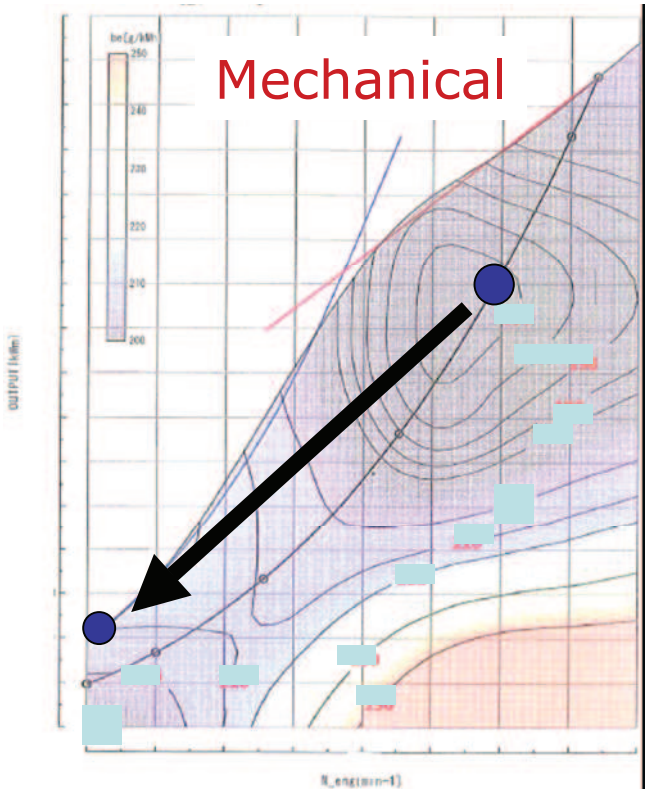
Why Diesel Electric for Inland Vessels?

110m Chemical Tanker

Source: Inland Navigation Europe

Operation

	Mechanical	Diesel Electric
Going Up Stream		
Navigation	No control	Power Management
Shallow water	Poor Torque	Rich Torque
Cargo Handling		
Pump operation	Load Control	Inverter Control
Going Down Stream		
Min. load operation	30%	10%



Diesel Electric

Keep good fuel consumption to control no. of running D/G

FOC Simulation for example

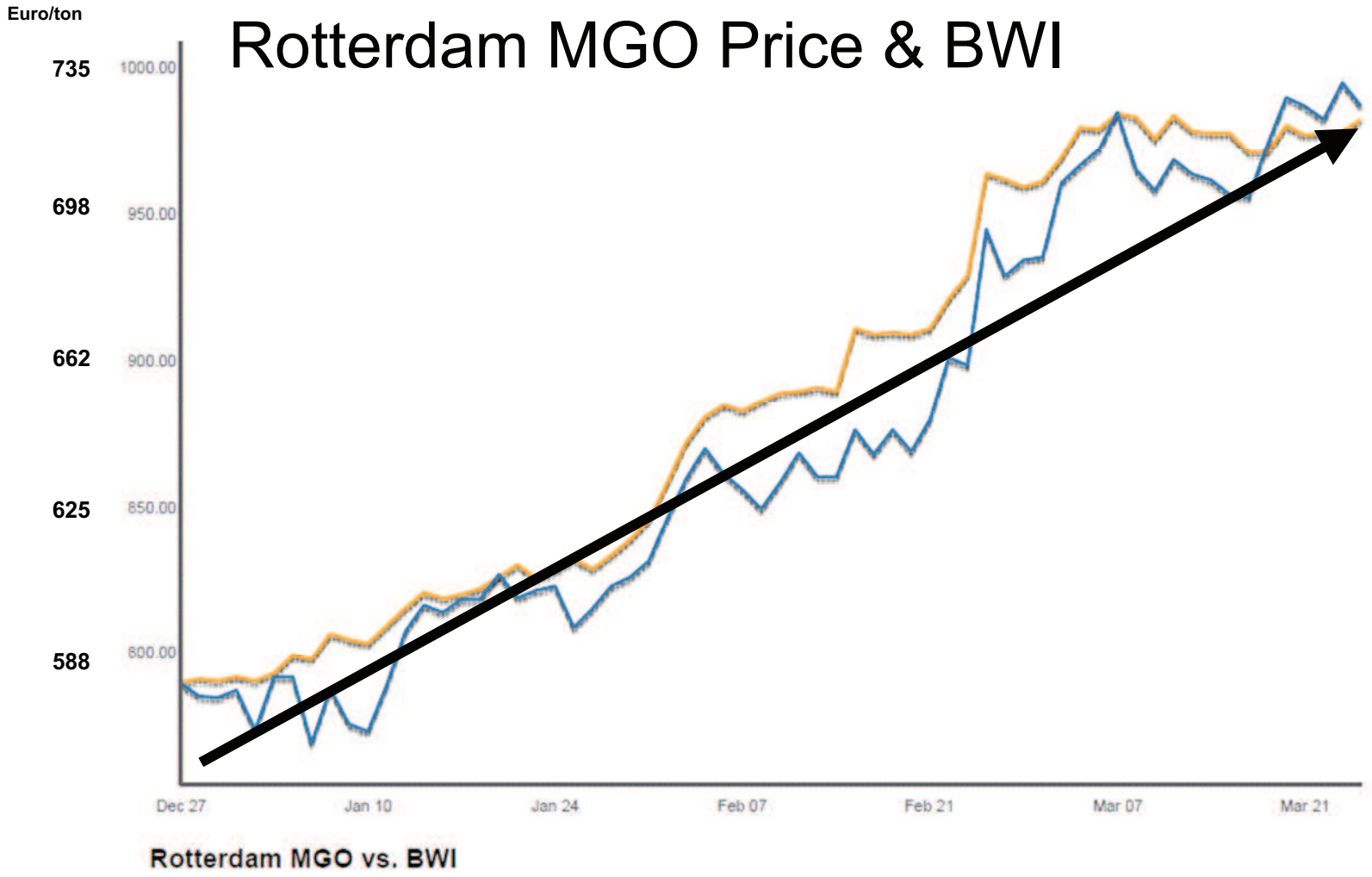
			Navigation			Maneuvering	Total (1round trip)
			Up Stream		Down Stream		
	Item	Unit	Normal	T. Rich			
Mechanical	Main Engine	kW	1350 (90%)	750 (50%)	450 (30%)	450 (30%)	
	SFCR	g/kWh	203	255	222	222	
	Time	Hr	41	29	70	4	6 days
	FO Cons	ton	11.2	5.5	7.0	0.4	24.2
CRP + Diesel Electric	D/G Engine	kW	1276 (90%)	567 (50%)	284 (20%)	284 (20%)	
	SFCR	g/kWh(e)	225	226	226	226	
	Time	Hr	41	29	70	4	6 days
	FO Cons	ton	11.8	3.7	4.5	0.3	20.2

CRP efficiency : 10%
Energy loss (Inverter-Motor) : 5%

△16.5%

Evaluation

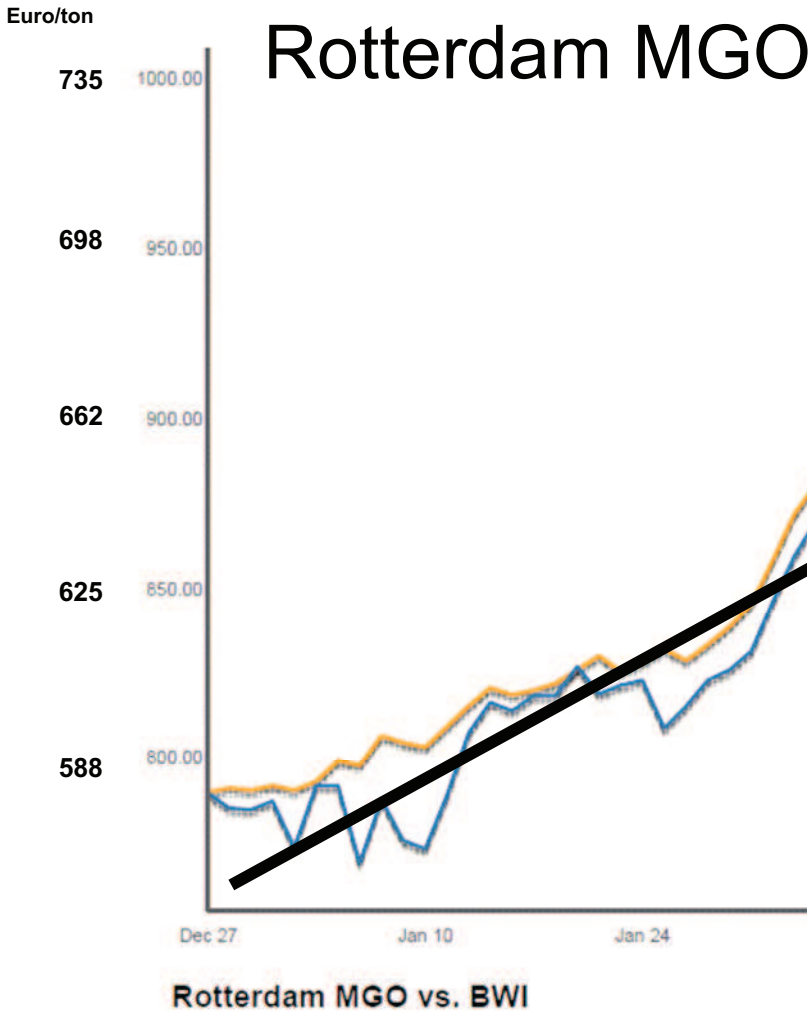
Bunker Price



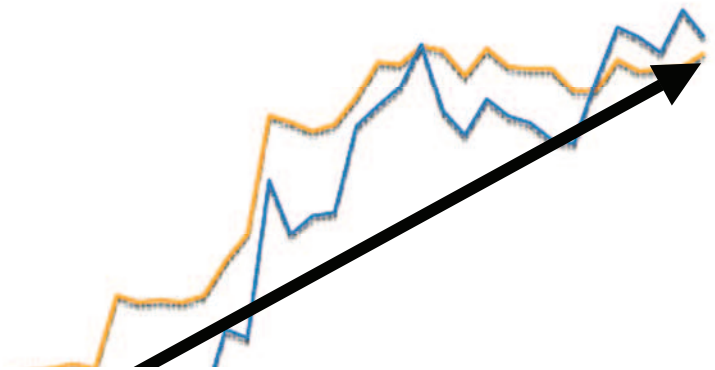
SOURCE:Bunkerworld

Bunker Price

Rotterdam MGO Price & BWI



Rotterdam MGO vs. BWI



Current EN590(Sulfur <10ppm) Price

750～950EUR/ton

–Fuel Consumption 860 ton / year

–Fuel Cost 645,000～817,000 EUR / year

–Fuel Cost Saving by CRP

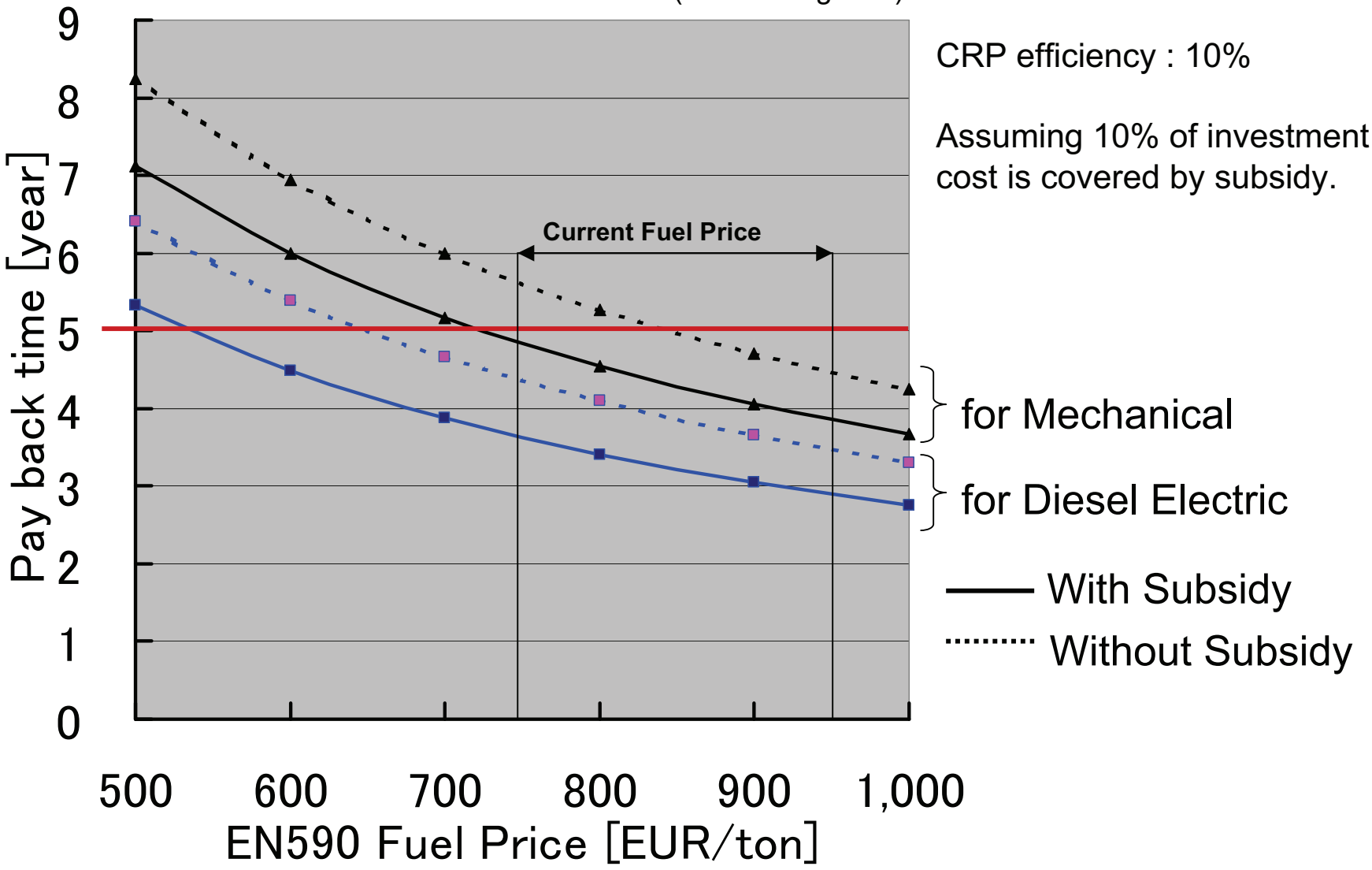
64,500～81,700 EUR / year

In case of 110m Chemical Tanker

SOURCE:Bunkerworld

Pay Back Calculation

$$\text{Pay back time} = \frac{\text{(CRP price-Initial saving-subsidy)}}{\text{(Fuel saving cost)}}$$



Cash flow for 110m class

Annual cost

Vessel	Tanker			Dry Cargo	
Case	Base	DE CRP	ME CRP	Base	ME CRP
Labor	Same condition				
Capital	100%	+11%	+6%	100%	+10%
Other	Same condition				
Fuel	100%	-(10+α)%	-10%	100%	-10%
Total	100%	**＜97.9%**	**97.9%**	100%	**98%**
NPV[MEUR] For 20yrs	100%	**1.0＜**	**1.0**	100%	**1.0**

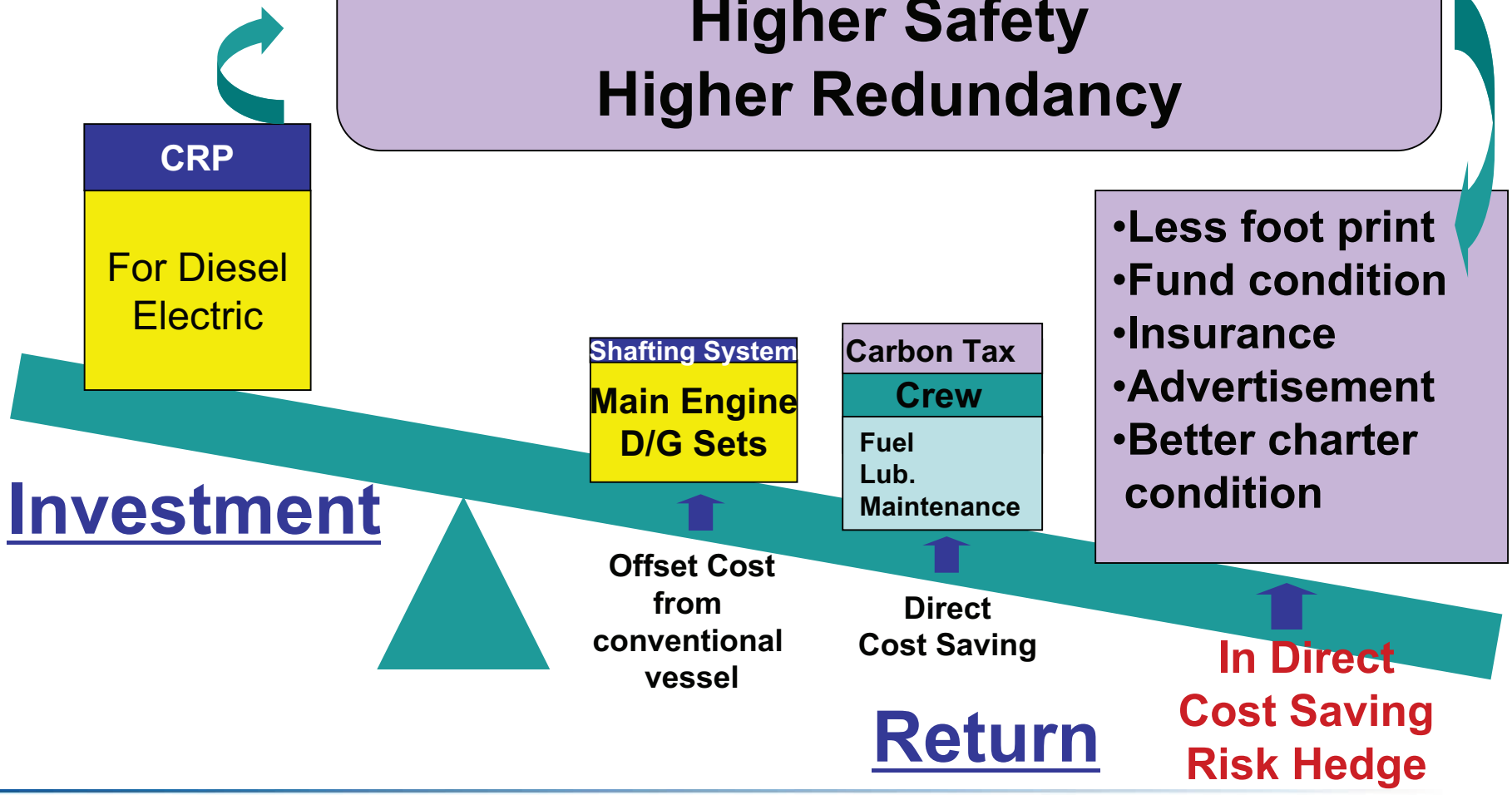
Conditions: Fuel Price : 750 EUR/ton
With subsidy (10%)

Source:INLANDSHIPPING AN OUTSTANDING CHOICE

Return on Investment

Corporate Social Responsibility Appeals

Less Environmental Footprint
Higher Safety
Higher Redundancy



Business Paradigm Shift

Economy
Business

New Market
Fundamentalism

→ **Green Economy**
Modal Shift

Issues

Earth Warming, Low Carbonize
Growth of Developing Countries(Energy/Foods)

Mechanism

Carbon Tax, Cap & Trade
ISO 26000(Social Responsibility)

Competence
Competitiveness

Reduce CO2 Emissions
Corporate Social Responsibility

Conclusion

- IHIMU have been delivered **14 vessels** with CRP combined with diesel electric system.
- CRP efficiency of **10%** is expected.
- Additional fuel saving by "Diesel Electric System "should be studied and validated on board.

IHIMU will help to realize Super Eco Inland vessels for the inland navigation with sustainable competence.

Thank you very much for your attention!

Hartelijk Dank

Vielen Dank

Je vous remercie beaucoup

ありがとうございました。

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