Vessel Efficiency Improvements for Reducing CO2 Footprint

+ LNG … A Better Way to Cold Iron

American Association Port Authorities
Harbors, Navigation, & Environmental Seminar
and Green Port Americas
Charleston, SC
4 - 6 May 2010

John F. Hatley PE
Americas Vice President Ship Power
Wartsila North America, Inc.
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www.wartsila.com

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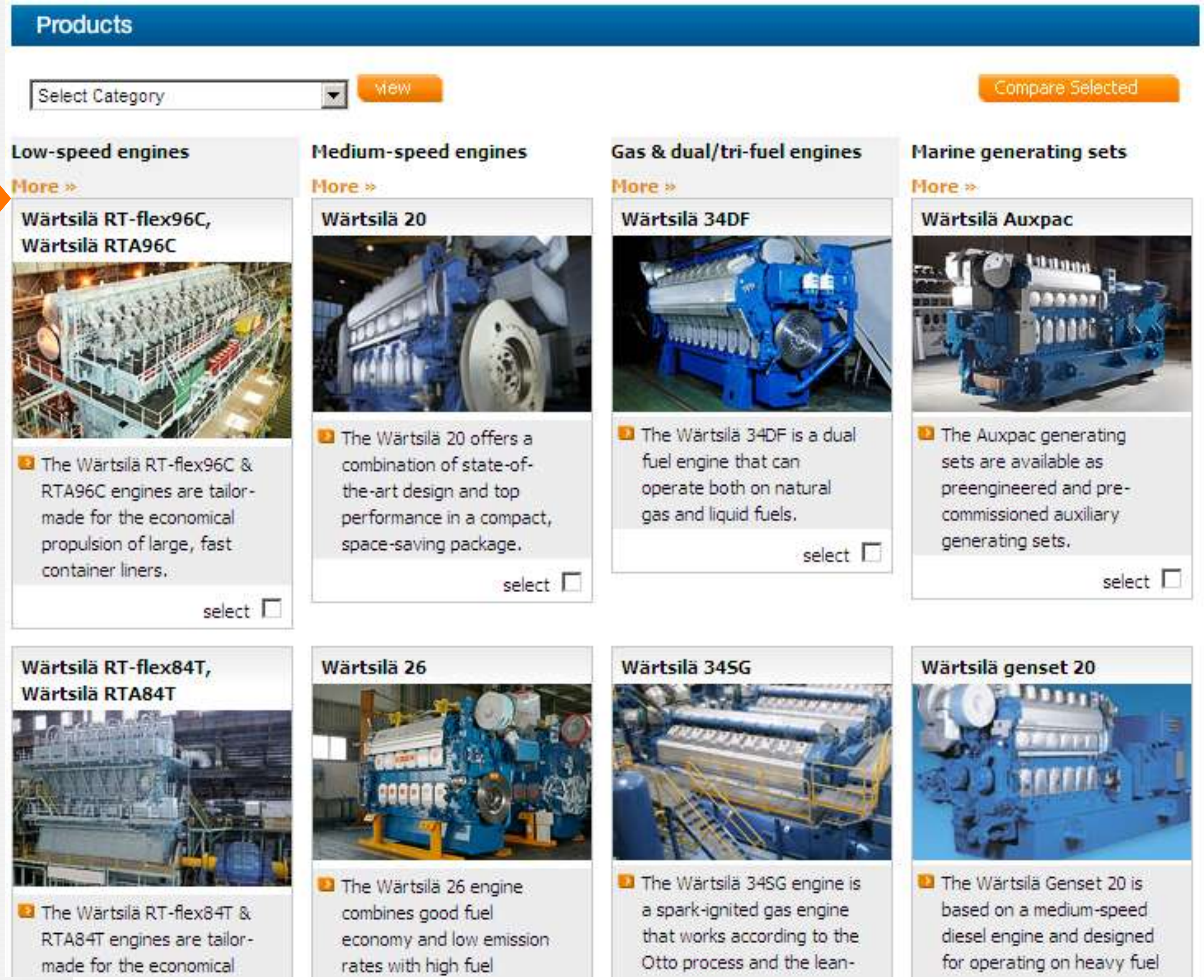
Not just Engines

Products

- Low-speed engines
- Medium-speed engines
- Gas & dual/tri-fuel engines
- Marine generating sets
- Power plant generating sets
- Mechanical drives
- Propulsors
- Seals
- Bearings
- Propulsion packages
- Automation
- Ship design
- Engine auxiliary systems
- Environmental technologies, Marine Industry
- Environmental technologies, Power Industry
- Fuel cell technology



Wartsila Power Range 800 - 80,000 kW

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But also … Matched Propulsion Systems

Products

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- Environmental technologie Power Industry
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Propulsors

Propulsors ▾ view Compare Selected

Wärtsilä CP propellers

Controllable pitch propellers are the ideal choice for ships with frequent port calls as they provide excellent manoeuvrability.

select ☐

Wärtsilä FP propellers

Wärtsilä FP propellers guarantee superior propeller efficiency, reliability and minimum noise and vibration levels.

select ☐

Wärtsilä CIPS

Tailor-made propulsion systems suitable for inland navigation vessels, fishery vessels, coasters and luxury yachts.

select ☐

Wärtsilä nozzles

A nozzle increases the thrust at relatively low ship speeds and significant savings in fuel consumption can be achieved.

select ☐

Wärtsilä rudders

This is an integrated concept that reduces fuel consumption, vibration and noise level compared to traditional design.

select ☐

Wärtsilä steerable thrusters

Propulsion solutions with steerable thrusters are provided for offshore, offshore support, sea-going and tug applications.

select ☐

Wärtsilä jets

Waterjets propulsion is the most successful and efficient method of propulsion for high-speed applications.

select ☐

Wärtsilä transverse thrusters

Wärtsilä transverse thrusters can be equipped with fixed pitch propellers or controllable pitch propellers.

select ☐

Wartsila propels Wet End as well

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+ Wartsila Environmental

Products

- Low-speed engines
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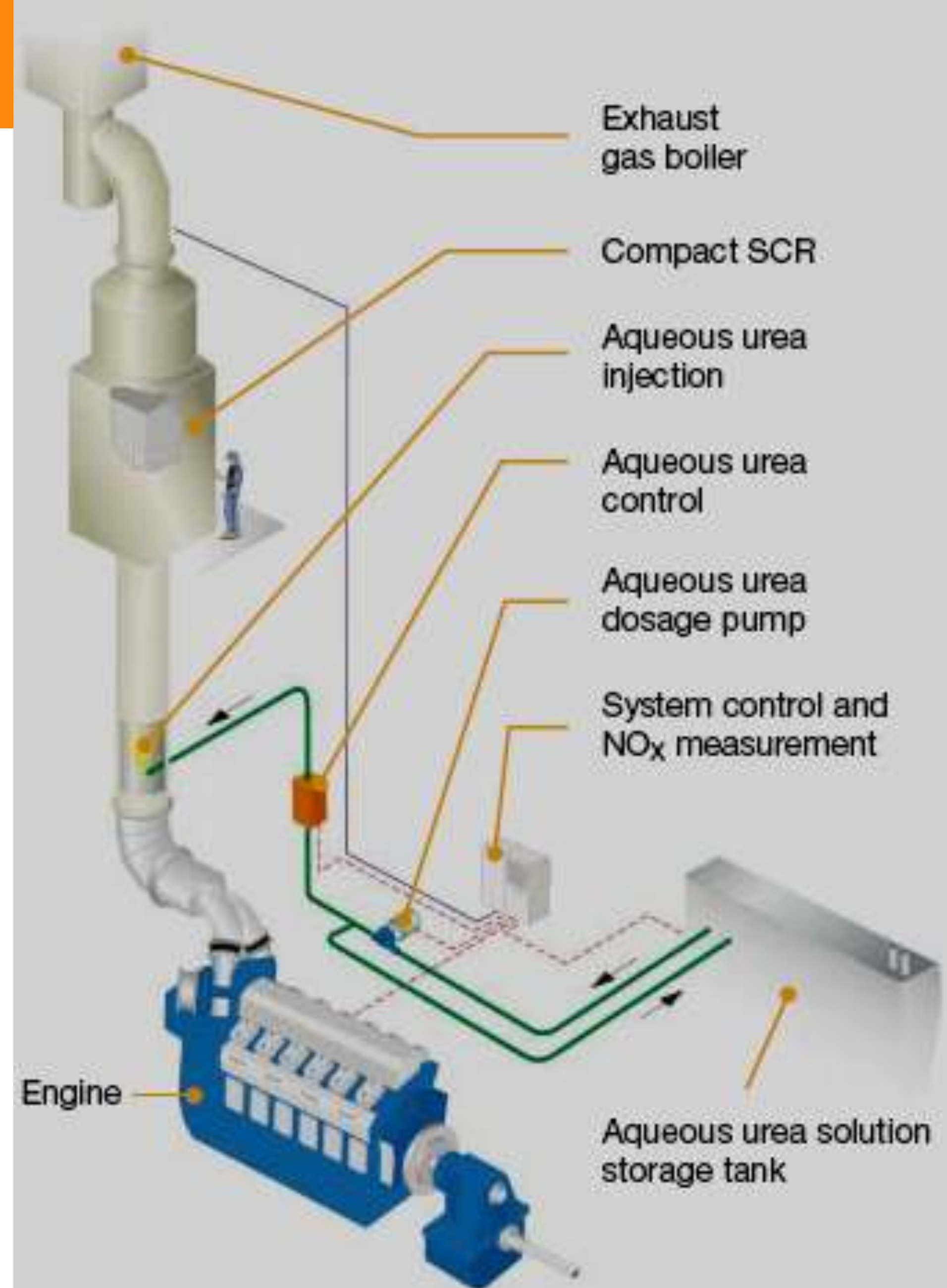

Wartsila SCR in 100+ Vessels

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Agenda

Efficiency Technologies & Energy Savings

Evolving Developments

- Ship Design
- Propulsion
- Machinery
- Operations & Maintenance

Why Clean Natural Gas

LNG Improves Cold Ironing

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Environment Drives Ship Design

Emission reduction

- NO_X emissions
- SO_X emissions
  - SECA areas
  - North American ECA

Climate change

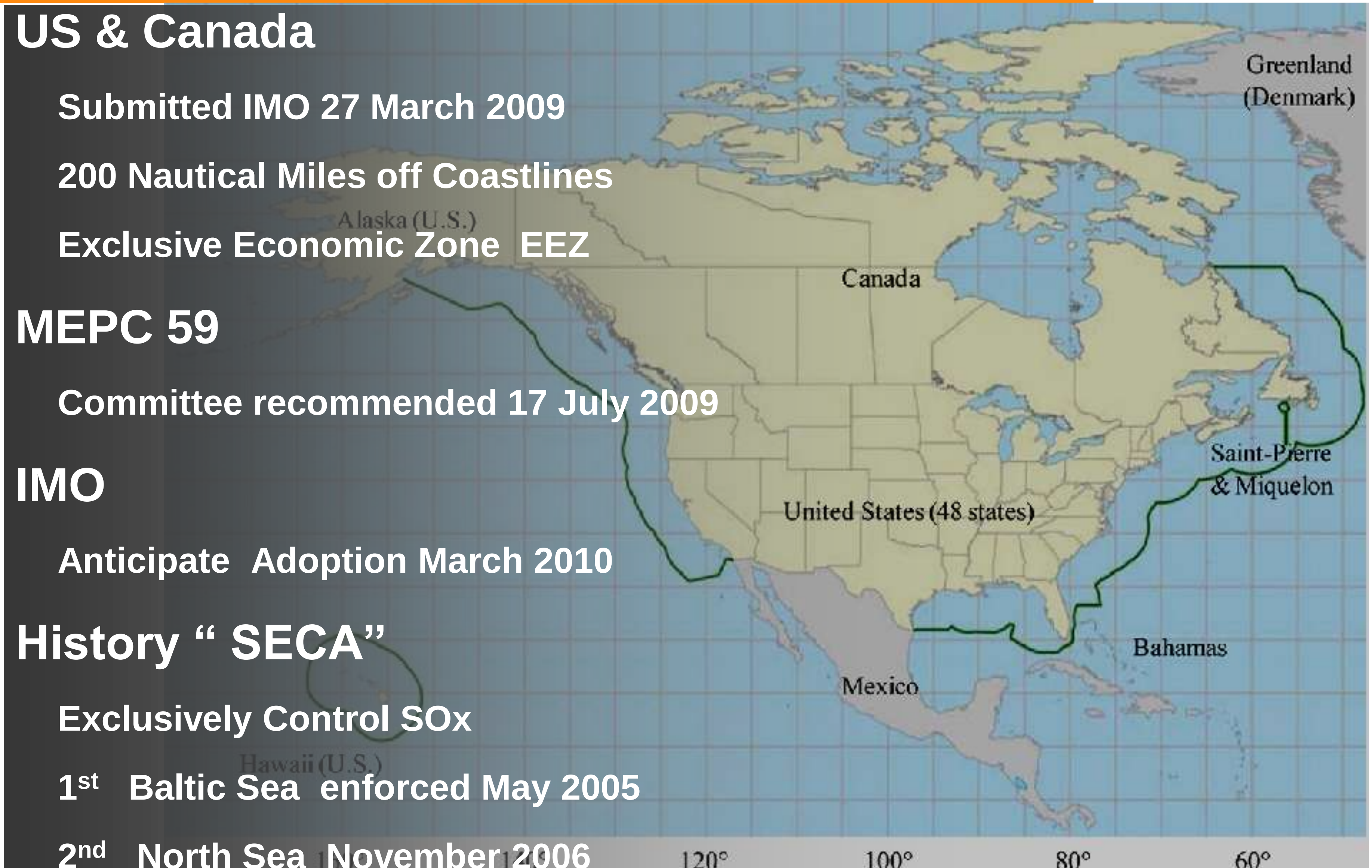
- Greenhouse gases
- Focus on CO_2 emissions

Fuel cost

- Scarcity escalates prices
- Tighter Sulphur requirements

Good Stewards today for future generations

US / Canada Emission Control Area “ ECA ”



US & Canada

- Submitted IMO 27 March 2009
- 200 Nautical Miles off Coastlines
- Exclusive Economic Zone EEZ

MEPC 59

- Committee recommended 17 July 2009

IMO

- Anticipate Adoption March 2010

History “ SECA”

- Exclusively Control SOx
- 1st Baltic Sea enforced May 2005
- 2nd North Sea November 2006

CO_2 emission reduction

Reduce power demand

- Ship and propulsion design
- Operation profile

Improve efficiency

- Propulsion optimisation
- Engine technology
- Waste energy recovery

Use alternative fuels

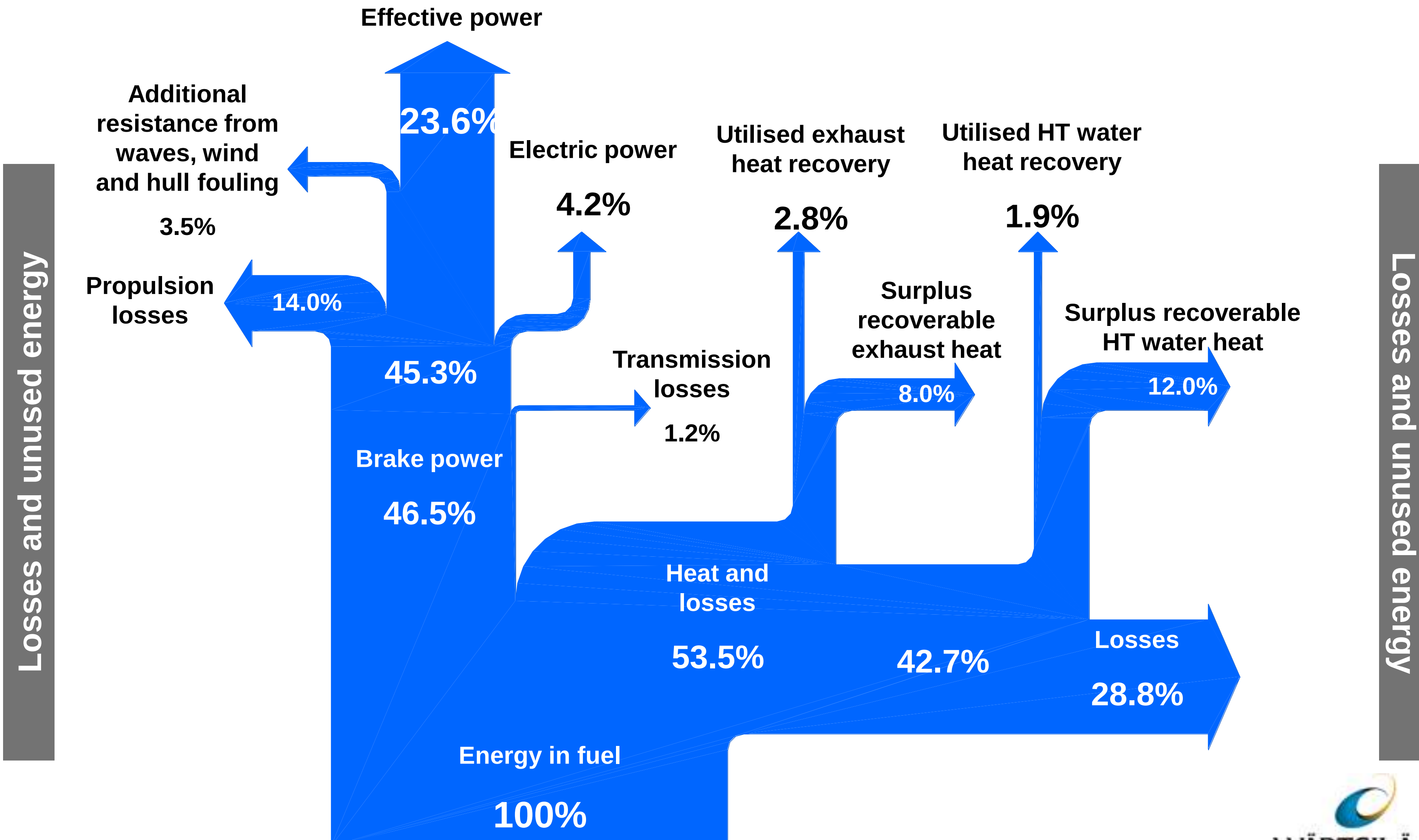
- Lower carbon content fuels

Vessel Energy Efficiency

30 000 gt

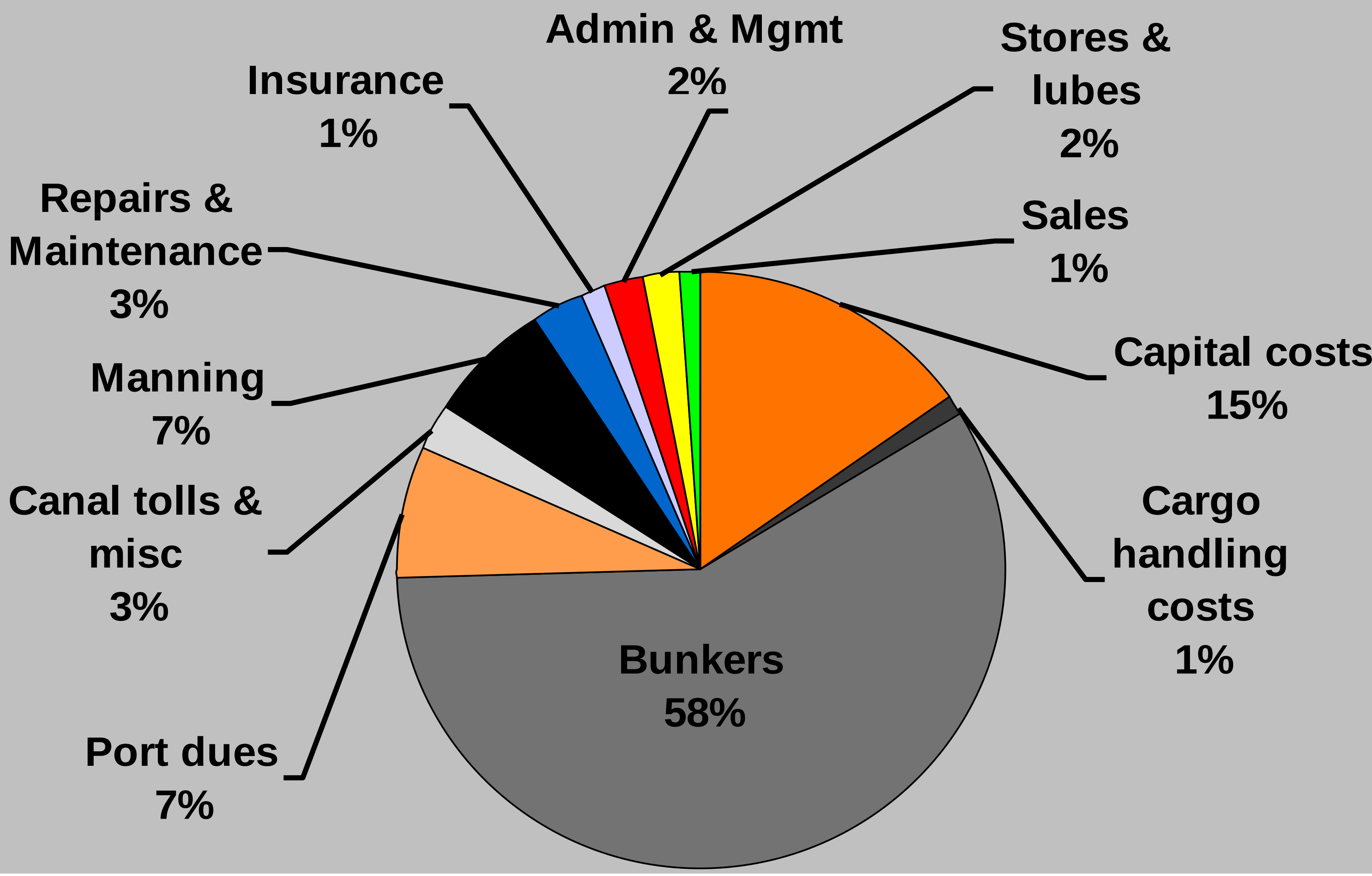
Estimation for service speed mode

Useful Energy 32.5%



Typical Annual Costs

15 years , 6% interest
HFO = 400 € / ton



Annual CAPEX + OPEX = 13,000 K € … Fuel Dominates 2/3 Costs

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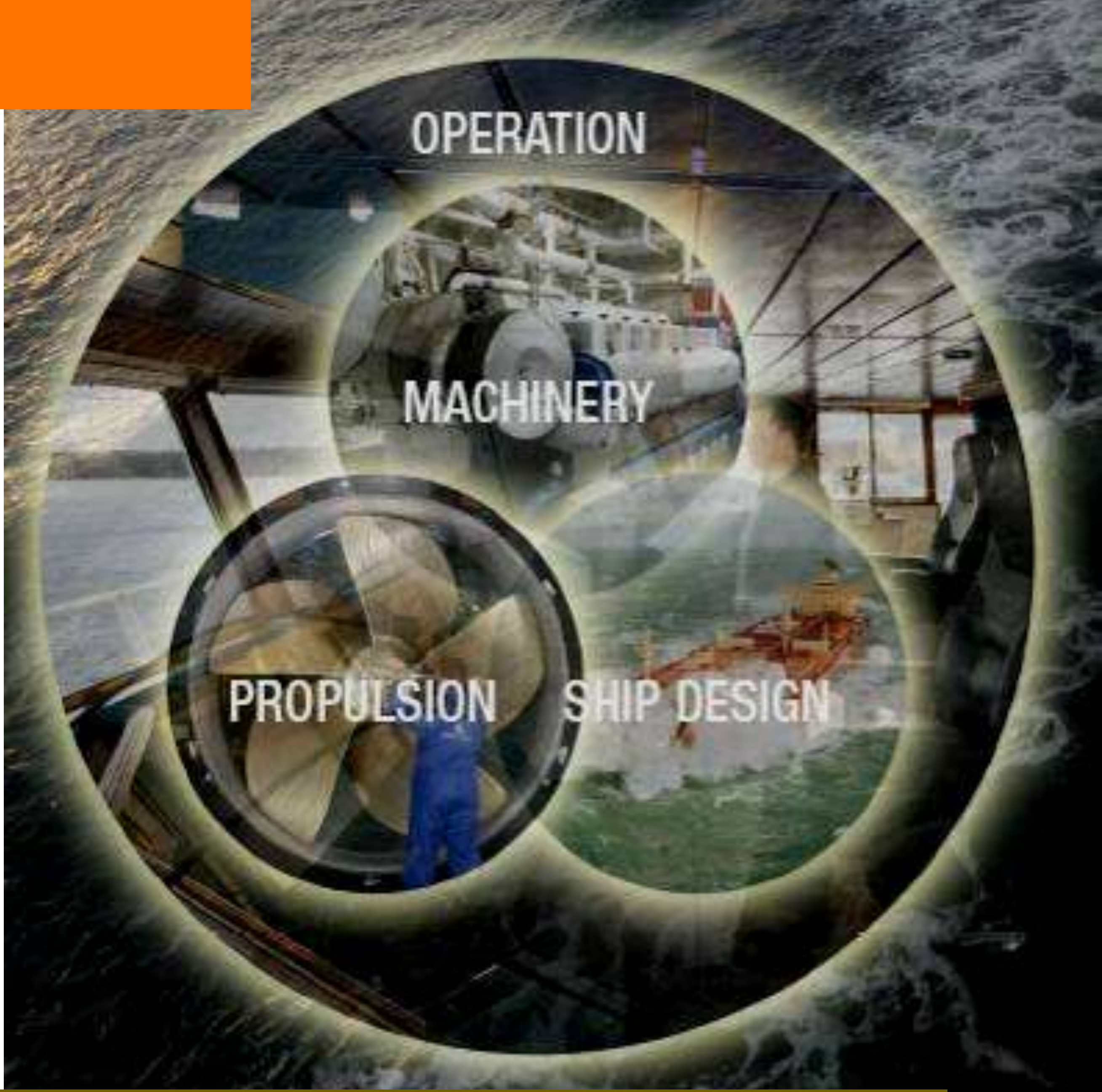
Efficiency Areas

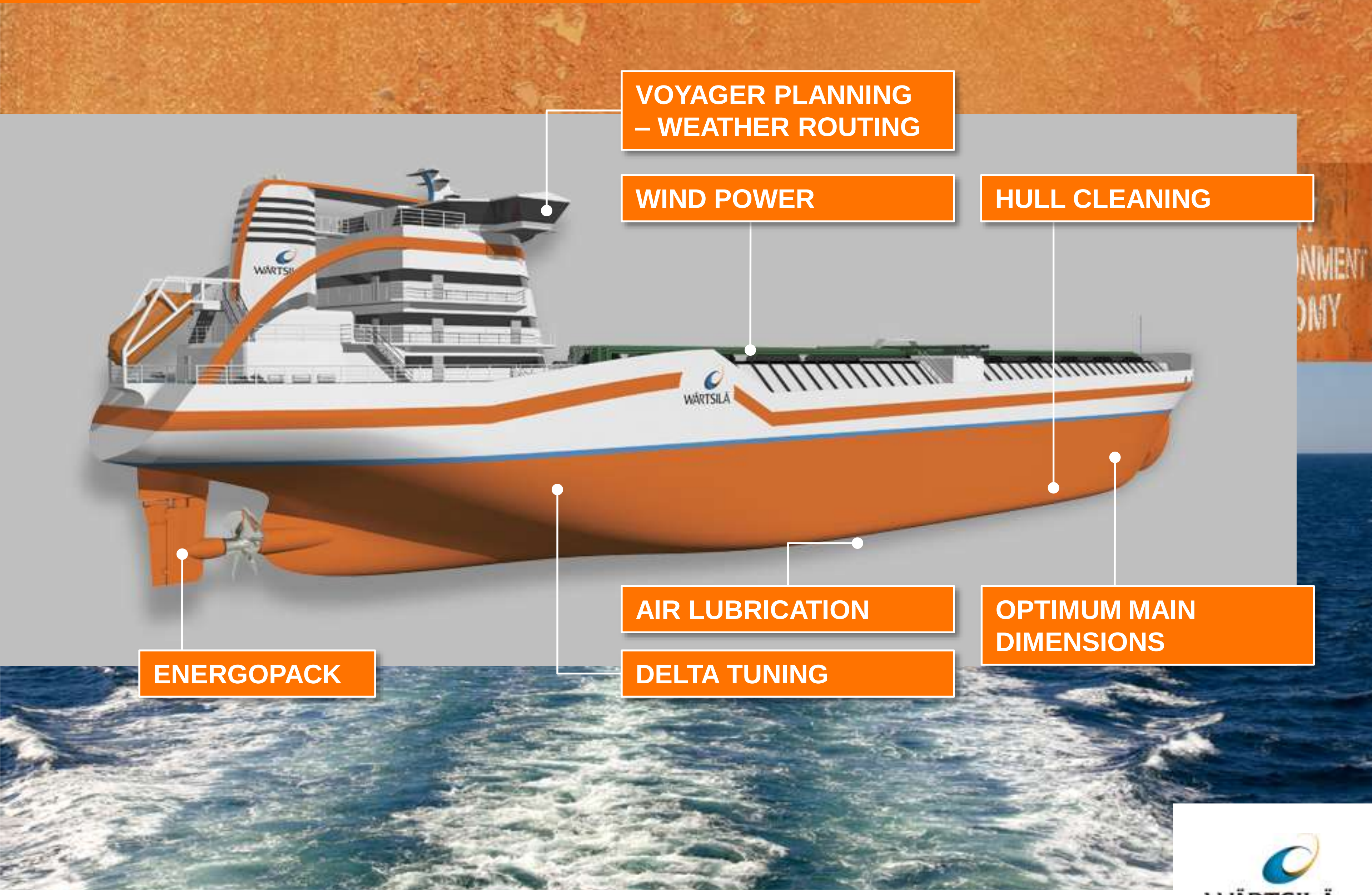
Technologies

- Ship design
- Propulsion
- Machinery
- Operation & Maintenance

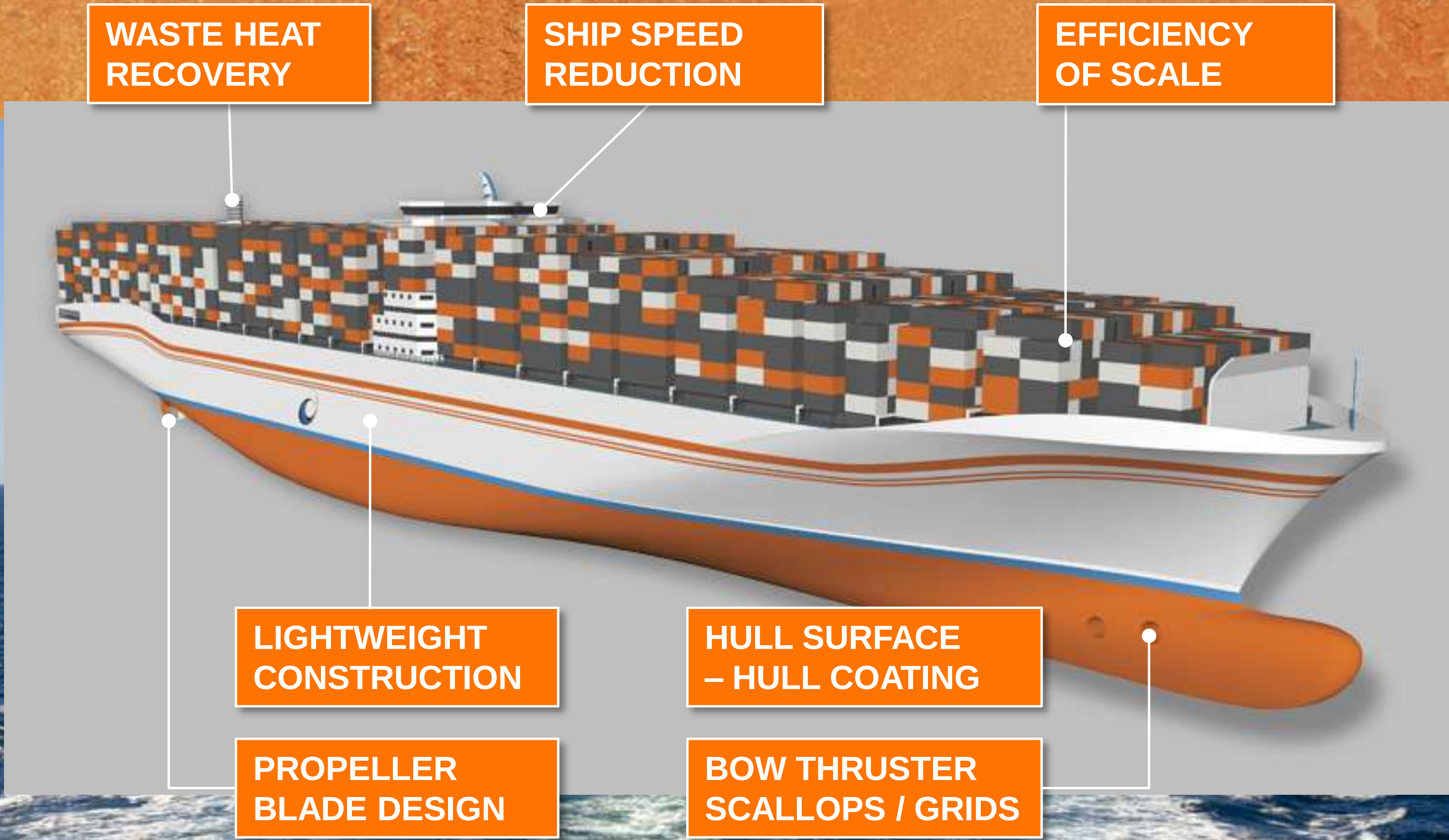


Engineered & operational integration of these principles yields optimal overall ship efficiency

Tanker, Bulker Efficiency Improvements



Container Efficiency Improvements



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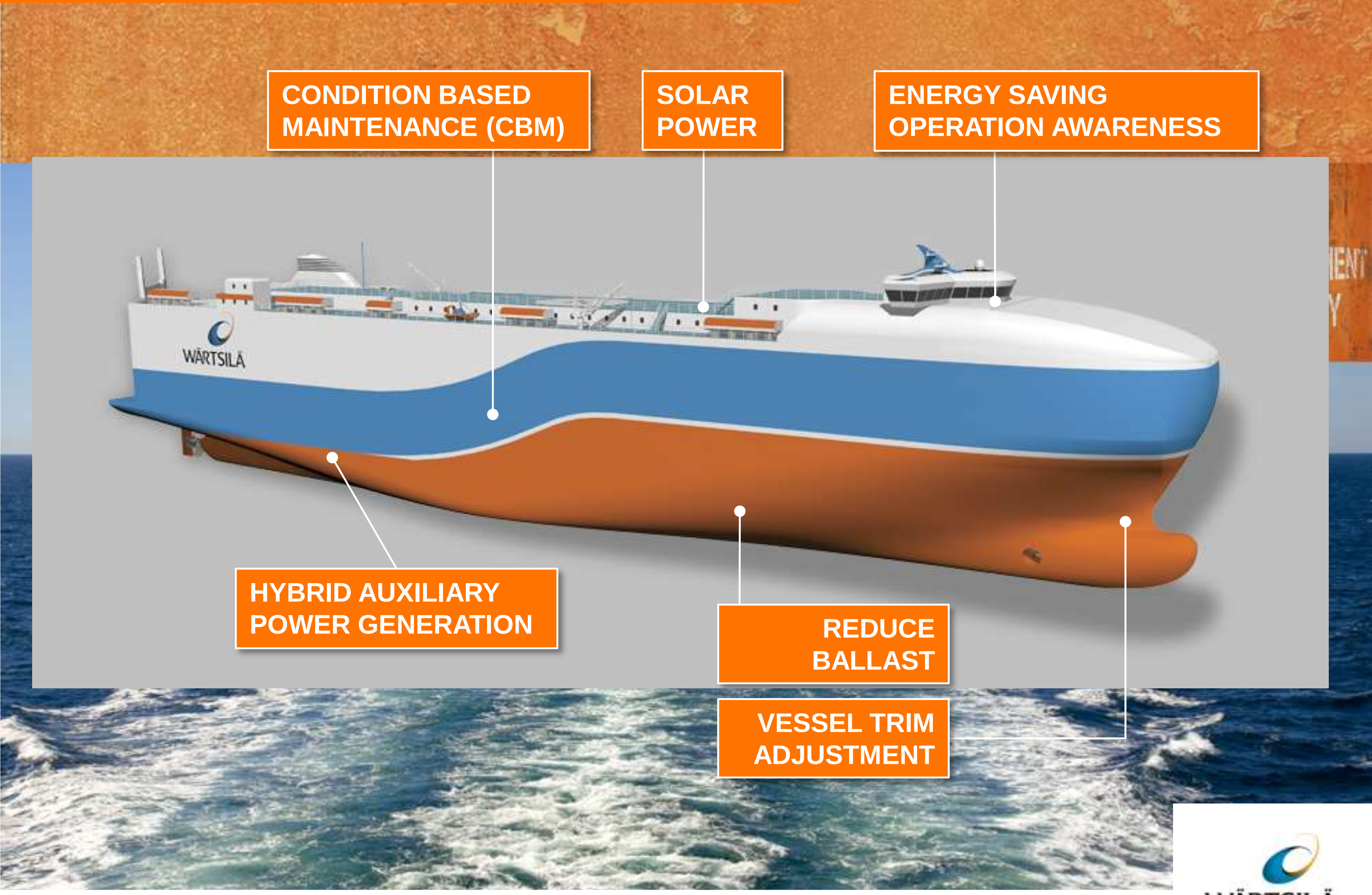
Ro-Ro Efficiency Improvements



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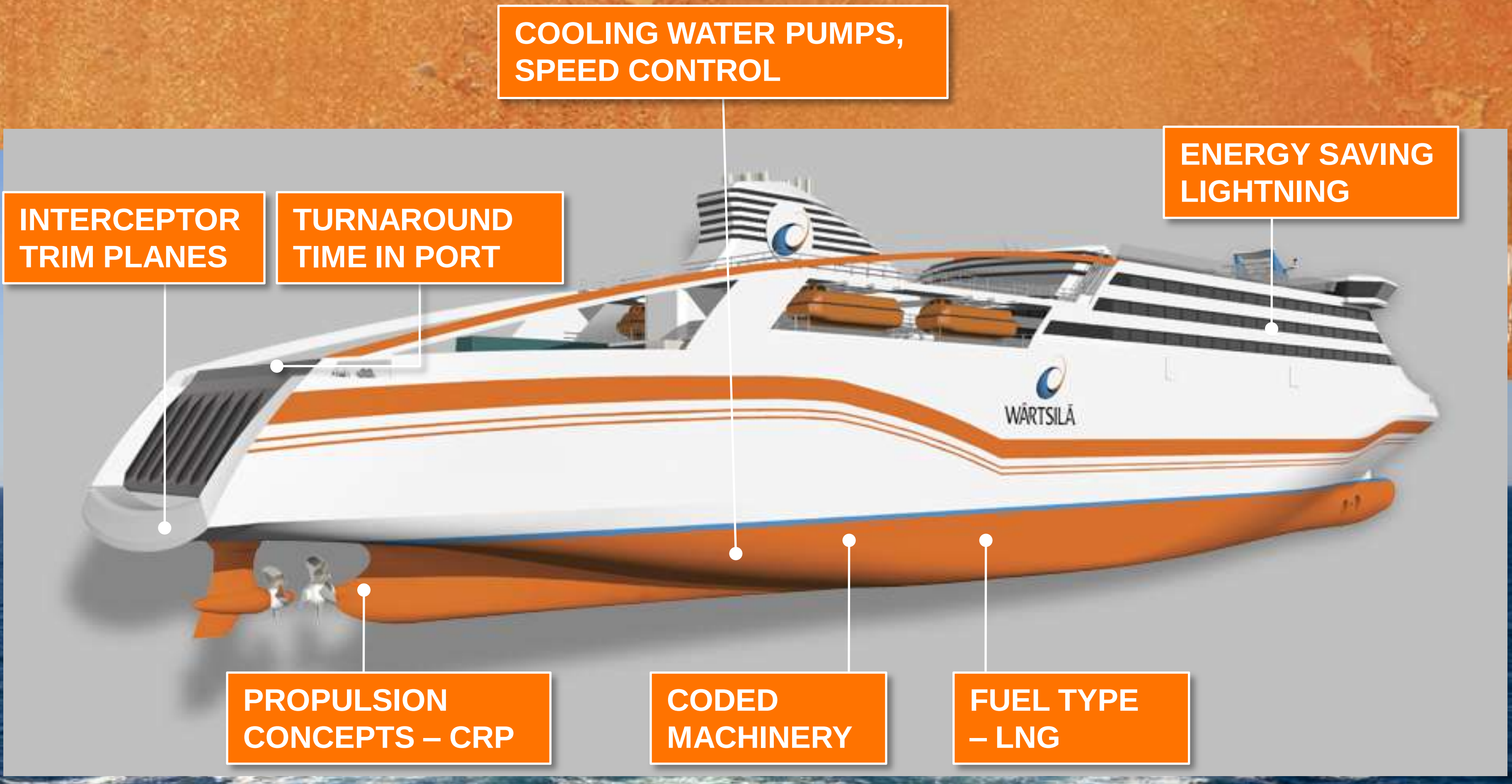
Ferry Efficiency Improvements



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Why Clean Natural Gas

LNG Improves Cold Ironing

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Symbols

< 4%

Potential upper range of vessel overall annual fuel savings, not a specific power mode

Retrofit Measures likely for existing vessels

Operational measures

Methods suited for new buildings

Payback timeframe

Short < 1 year to Long > 15 years

Ship types for which the energy efficiency improvement suits best

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Ducktail Waterline Extension

< 7%

Ducktail reduces wetted transom and lengthens effective waterline resulting in reduced hull resistance

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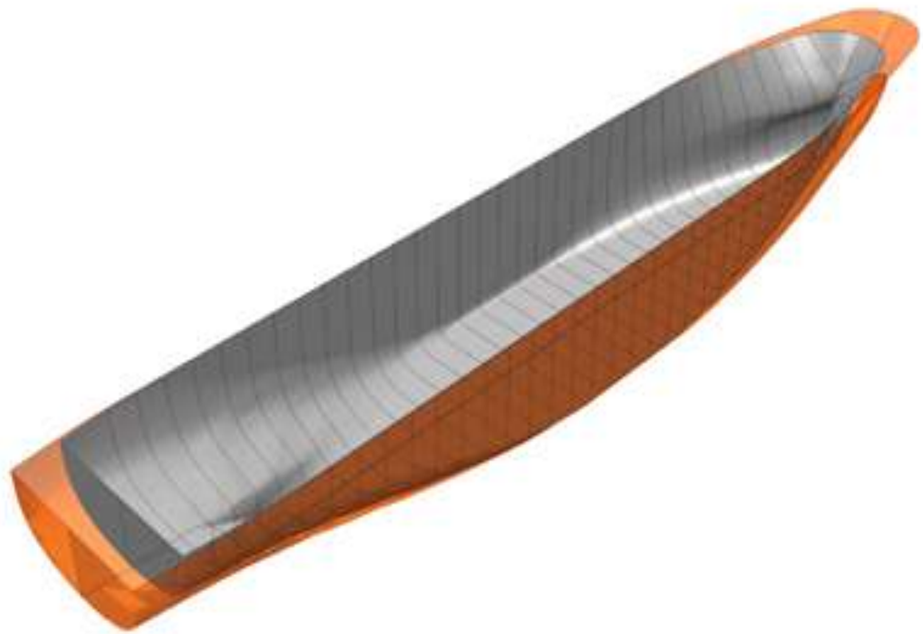
Optimum Hull Dimensions

< 9%

Finding optimum length and hull fullness ratio Cb exponentially impacts ship resistance

Large Length to Beam L/B ratio means ship has smooth lines, narrow entry and exit, brings benefit of lower wave making resistance

High block coefficient Cb blunts hull lines and negatively increases resistance.



A vessel with 10-15% extra length may achieve powering reduction near 10%.

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Scale Efficiency

< 4%

Regression analysis shows 10% larger ship achieves a 4 - 5% higher transport efficiency all other things equal

Larger ships usually achieve greater transport efficiency

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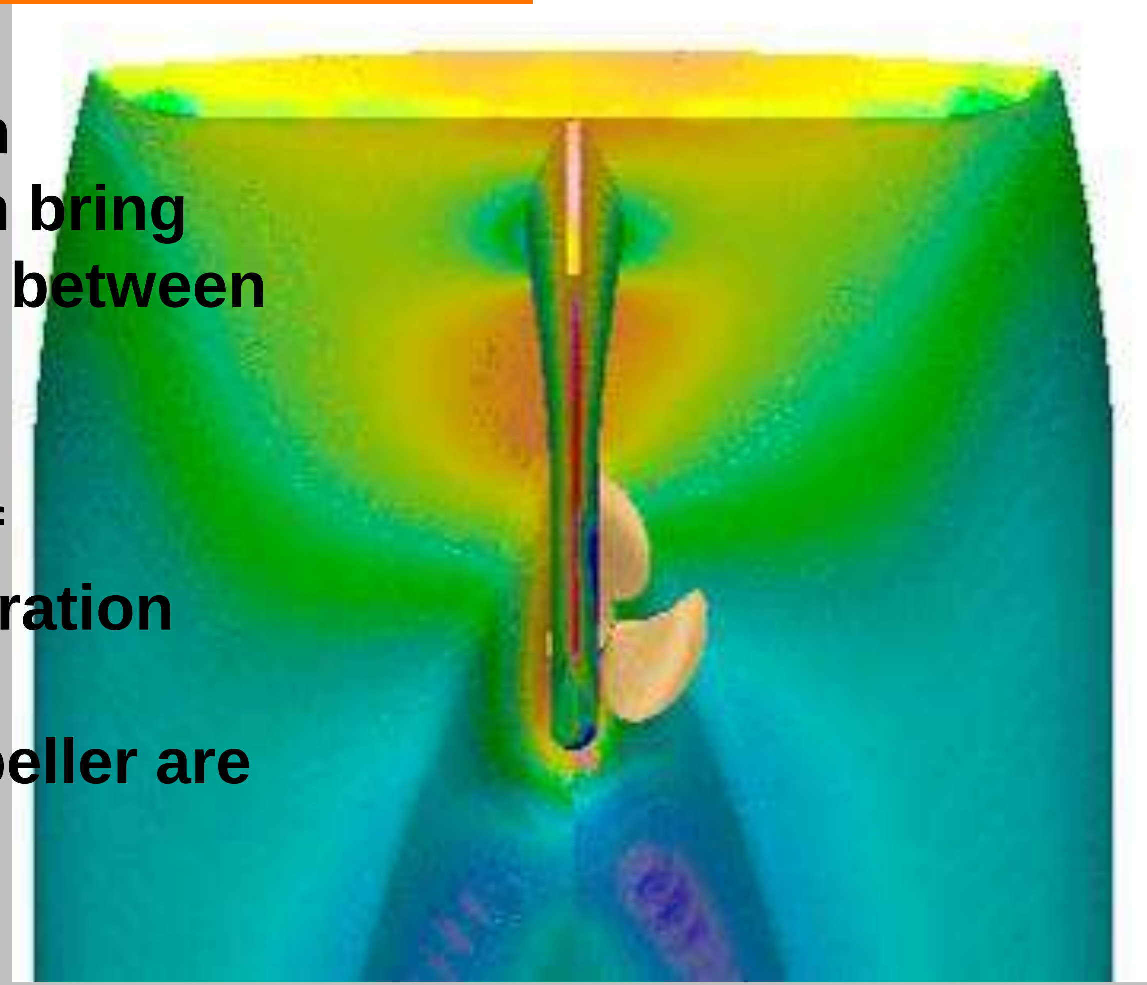
Propeller Hull Interaction optimization

< 4%

Computer advances in Hydrodynamic design bring improved interactions between hull and propeller

Negative resistance of propeller water acceleration actions amongst hull, appendages, and propeller are minimized improving performance



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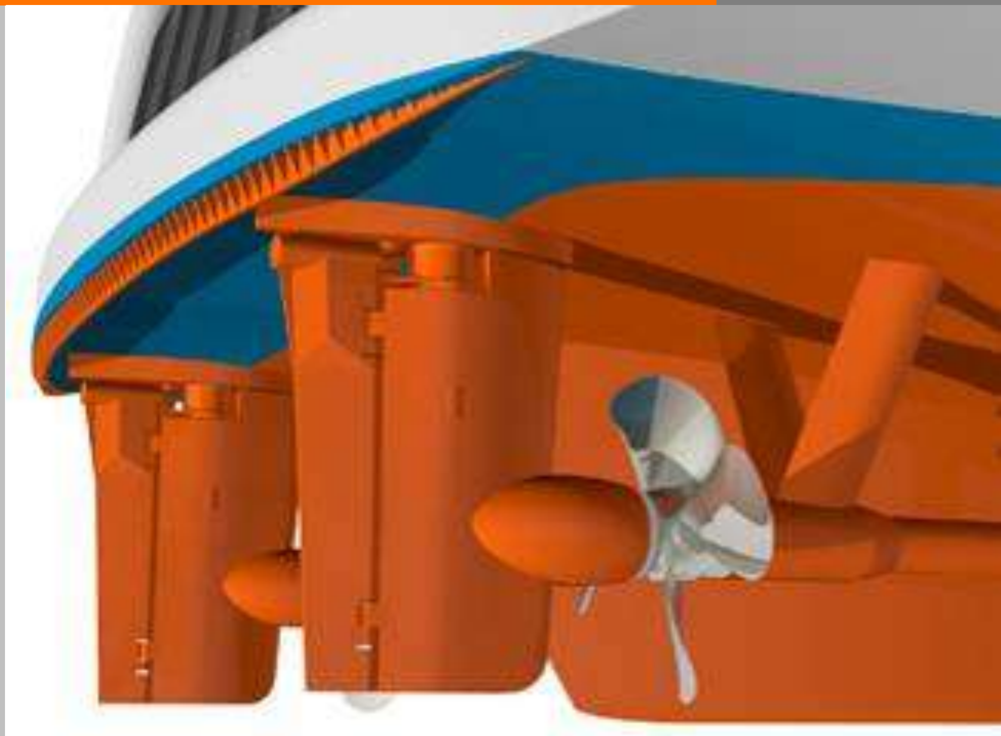
Interceptor trim planes

< 4%

The transom mounted interceptor plate deflects flow downward across stern which creates lift and reduces hull resistance reducing power demand



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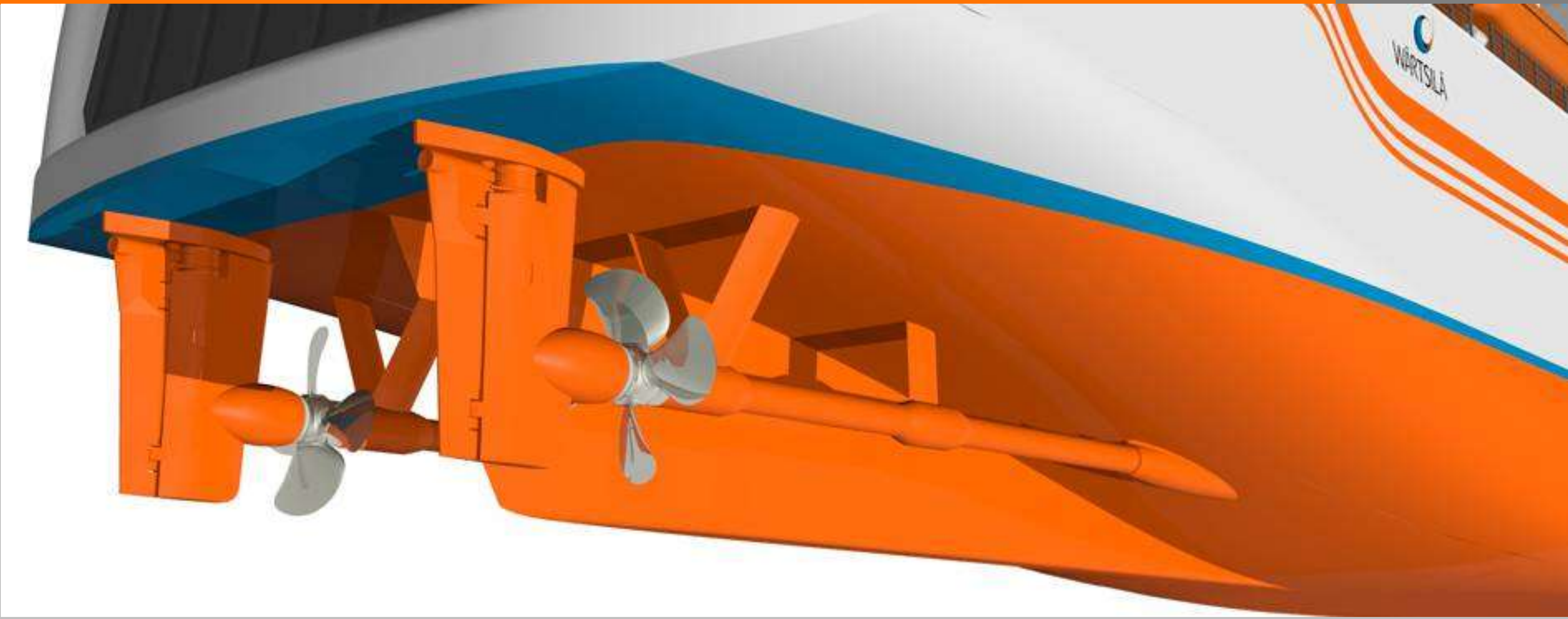
Shaft line arrangement

< 2%



Streamlining shaft lines and brackets lowers flow disturbances = reduced resistance.

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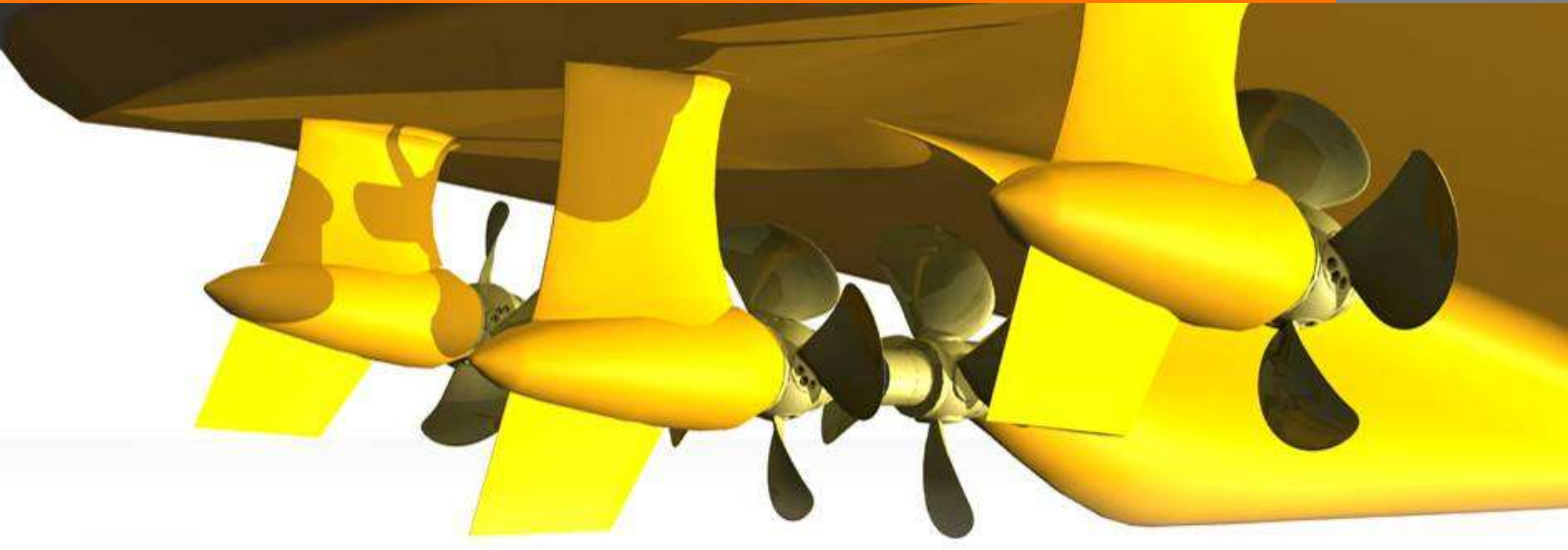
Pulling thrusters

< 10%



Pulling steerable thrusters combined with center Contra Rotating Propeller or Wing Thrusters improve propulsion efficiency.

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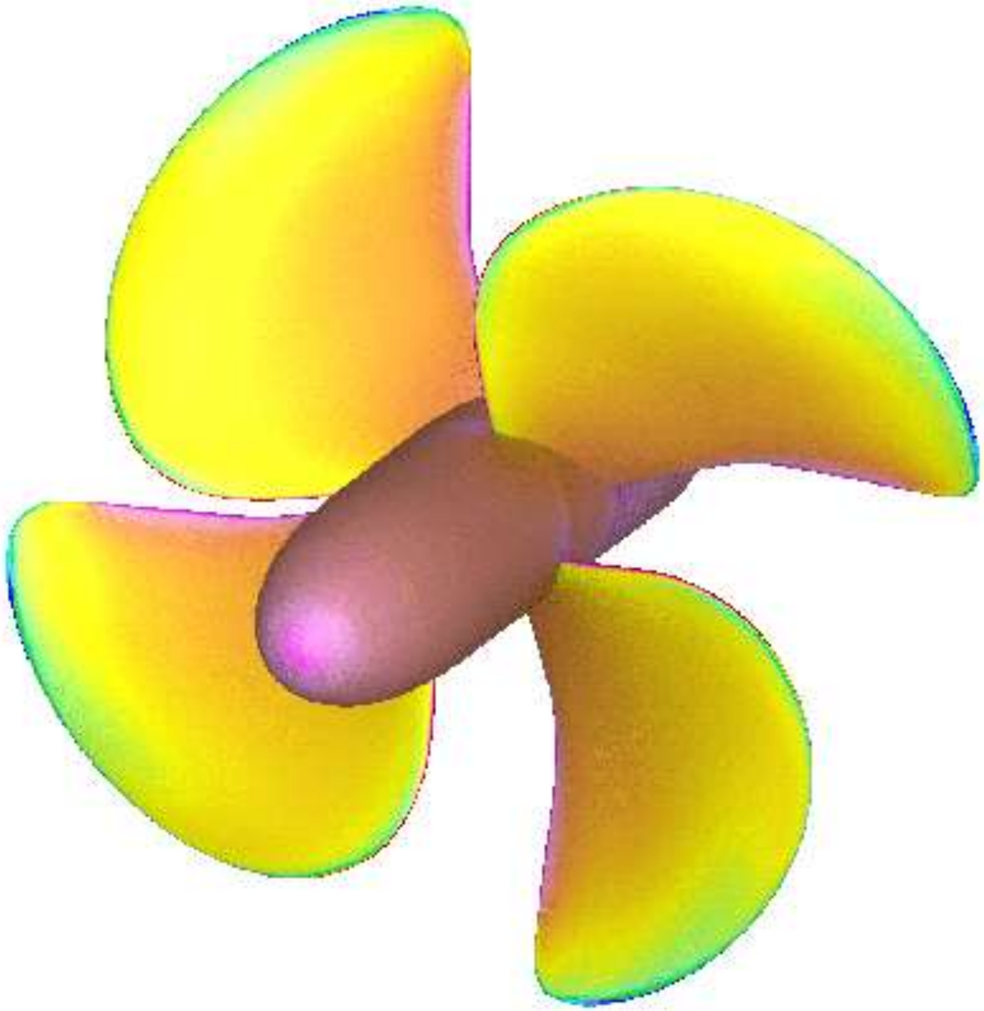
Advanced propeller blade sections

< 2%



Advanced improvements in blade sections reduces cavitation and frictional resistance.

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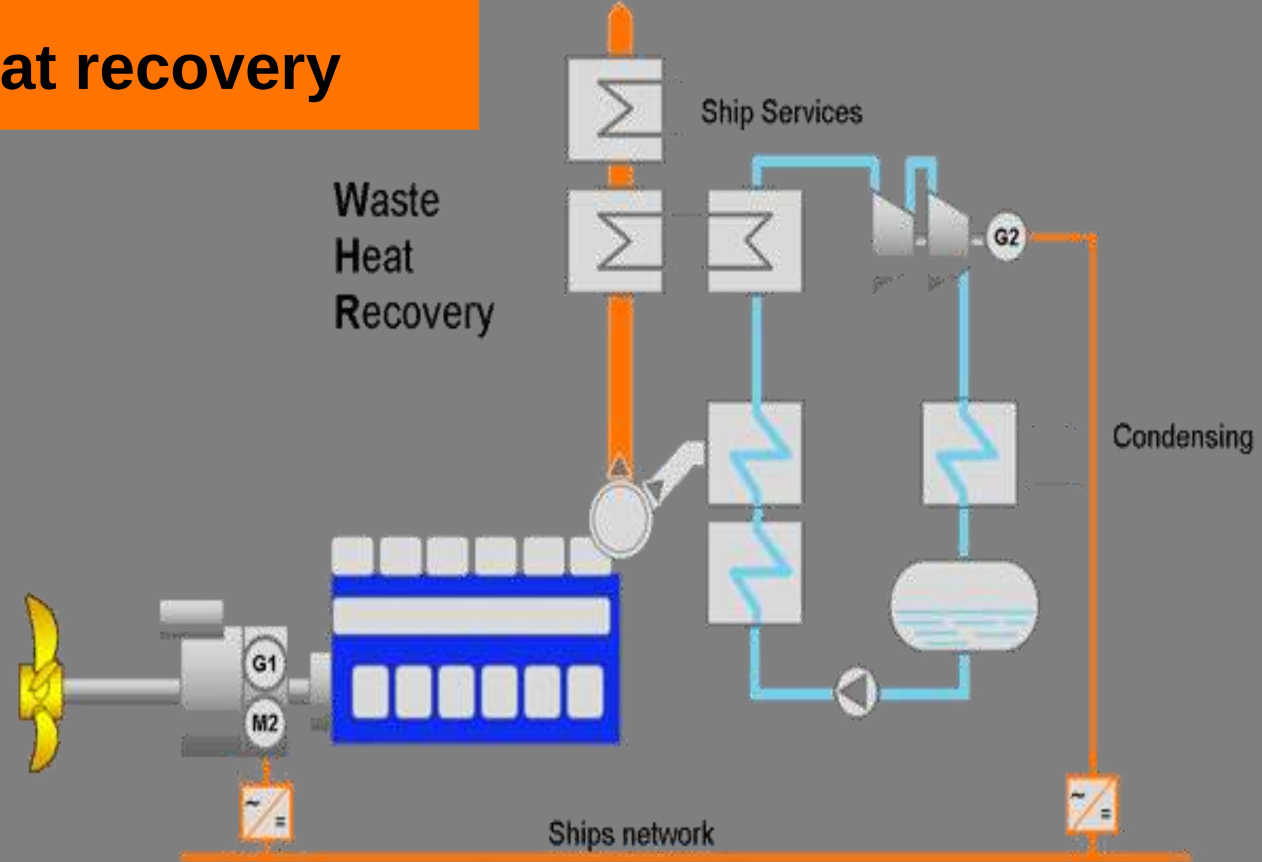
Waste heat recovery

< 15%



Waste heat recovery (WHR) recovers thermal exhaust gas energy and converts to electrical energy employing a steam boiler and turbine alternator

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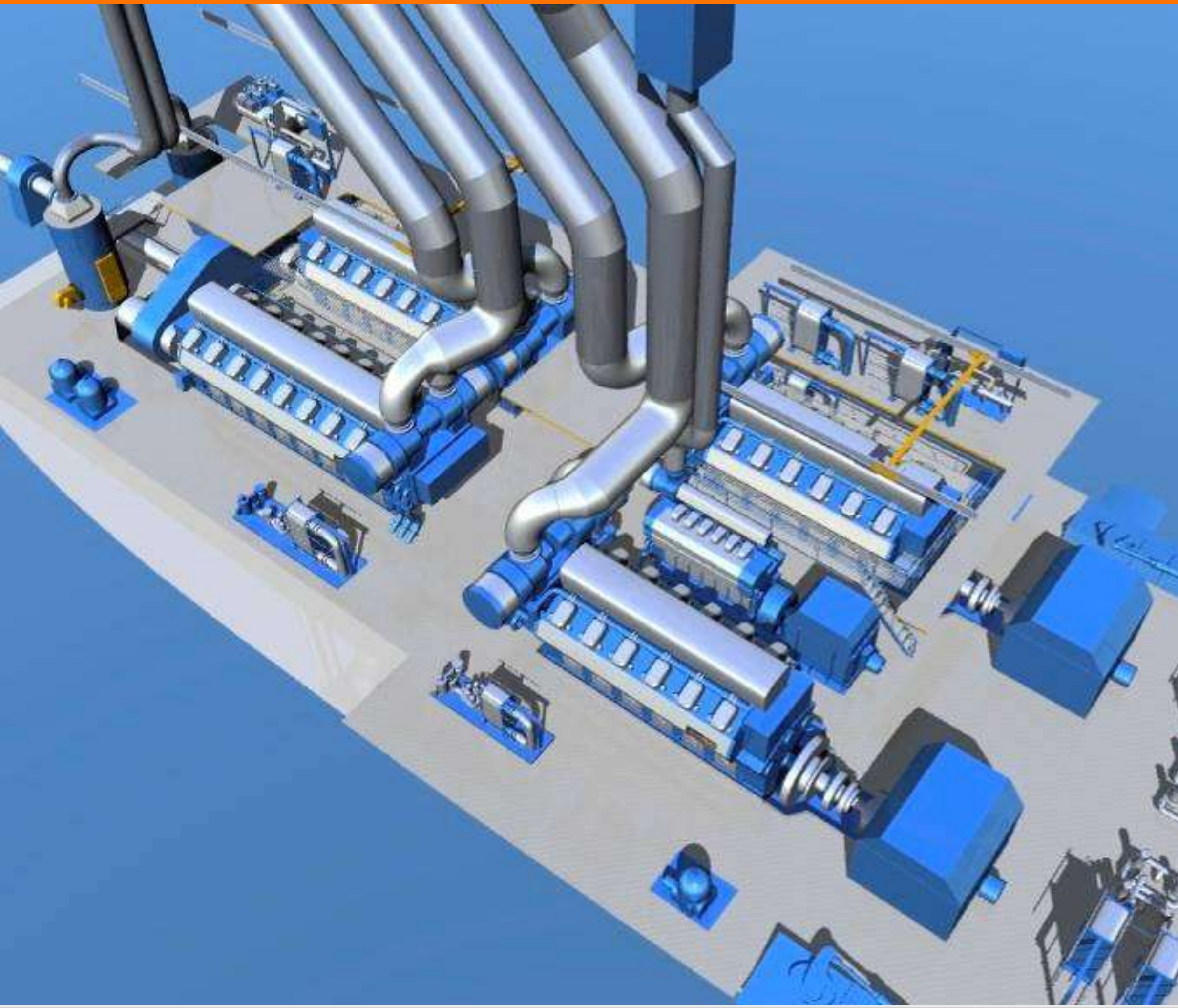
CODED machinery

< 4%



Combined Diesel-Electric and Diesel-Mechanical (CODED)machinery provide broad range of modal efficiency gains; at part load electrical efficiency benefits are achieved while at high power the mechanical drive system loss transmission losses achieve efficiency

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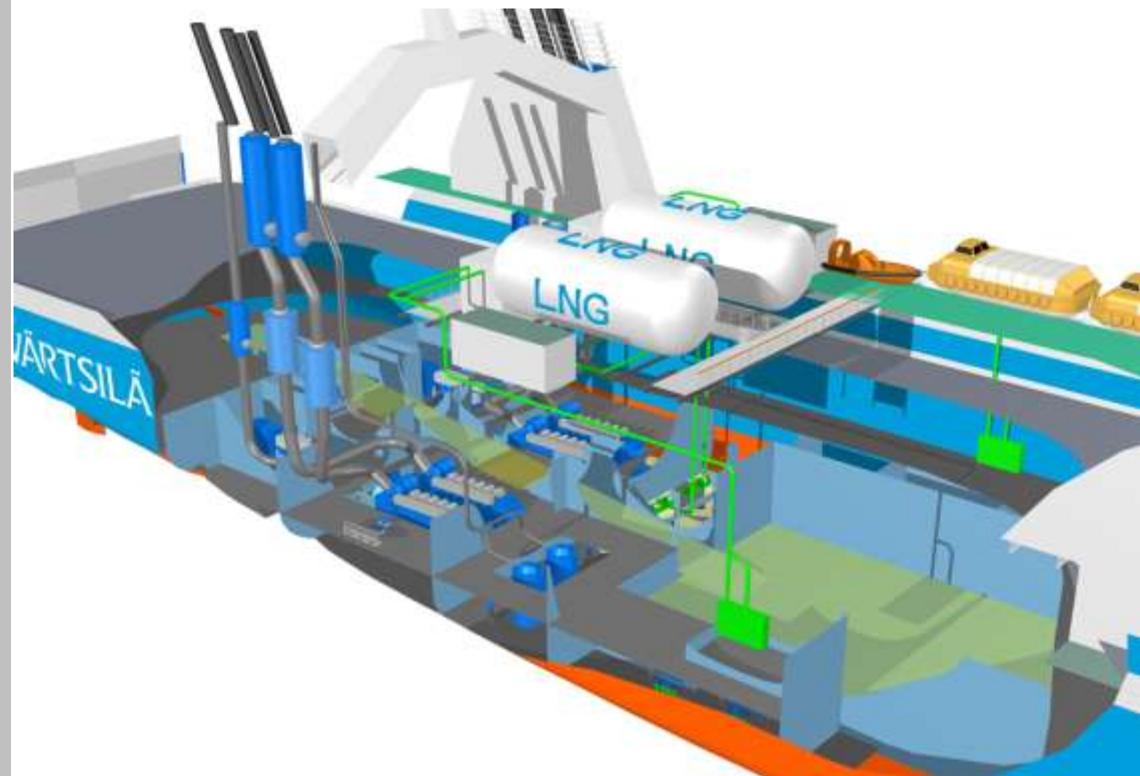
LNG as fuel

< 4%

LNG as a fuel reduces energy consumption onboard

- No HFO heating
- Cold LNG (-162 °C) can be utilized in HVAC cooling to reduce compressor power



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Hull cleaning

< 3%

Algae and marine organism hull growth negatively increases ship resistance

Frequent housekeeping with hull cleaning reduces drag influence

Fuel reductions vary by ship type and operational speeds; Tankers 3% ….. OSV 0.6%

Hull surface coatings

< 5%

Modern paint coatings possess hard smooth surfaces which reduce hull friction and deter fouling

Fuel savings vary by ship type and operational speeds; Tankers 9% ... Ferry 3 %

Ship speed

< 23%

Speed reduction efficiently cuts energy consumption

Reductions

0.5 kn	-->	- 7% energy
- 1.0 kn	-->	- 11% energy
- 2.0 kn	-->	- 17% energy
- 3.0 kn	-->	- 23% energy

Reduce ballast

< 7%

Minimal ballast results in lighter displacement and thus lower resistance

Removing 3000 ton of permanent ballast from a PCTC and achieving similar stability by increased beam 0.25 m reduces propulsion power by 8.5%

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Propeller surface finish/polishing

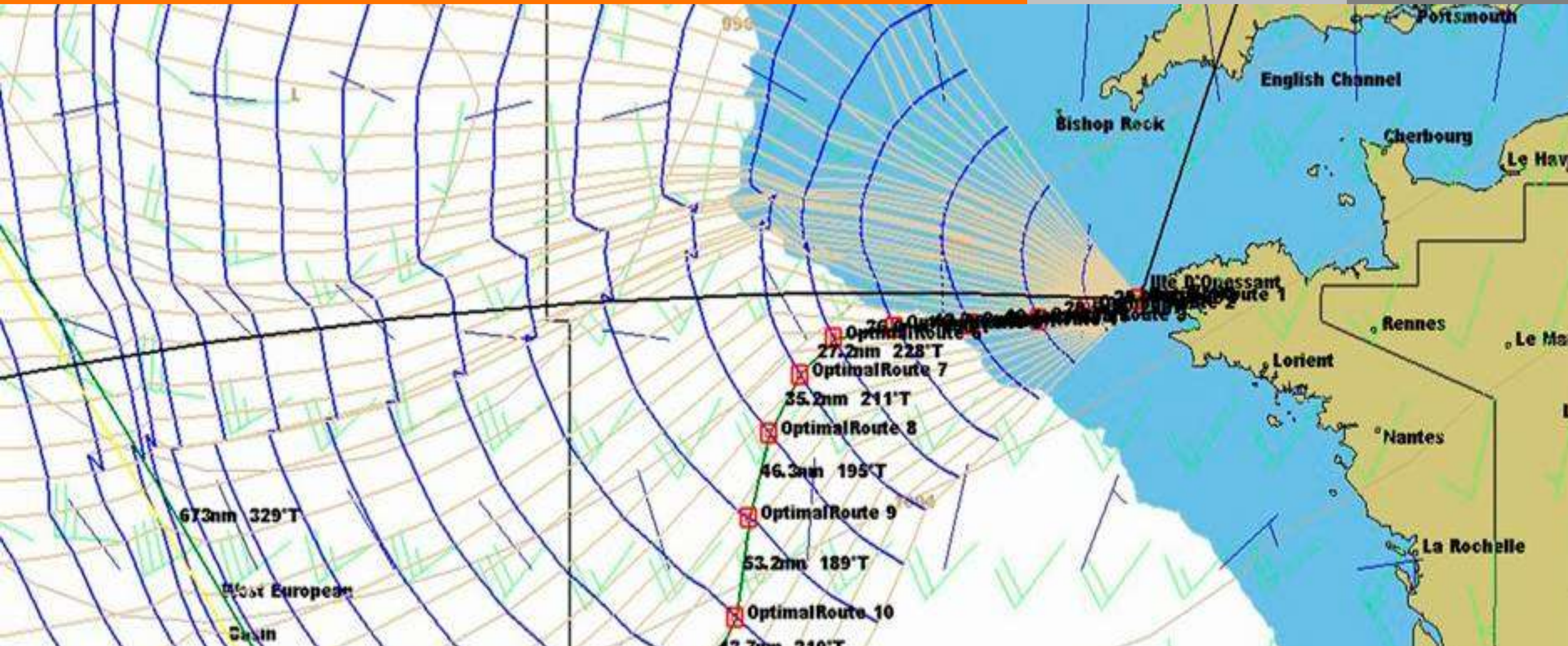
< 9%

Regular in service polishing off organic growth and fouling reduces surface roughness on propellers

Efficiency gains up to 10% compared to a fouled propeller

Voyage planning – weather routing

< 10%



Updated satellite climatic data allows optimal voyage tracks to follow best weather route

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Condition Based Maintenance (CBM)

< 5%

Satellite communication allows

- real time remote monitoring
- trend analysis
- smart systematic diagnosis
- expert personnel observation

Main benefits

- lower fuel consumption
- lower emissions
- longer interval between overhauls
- higher reliability

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Energy saving lighting

< 1%

Use efficient lighting wherever possible and optimized lighting use reduces electricity and air conditioning demand

Fuel consumption saving for a vessel: ~1%

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Energy saving operational awareness

< 10%

A culture of fuel saving and reward or bonus system based on fuel savings encourages internal competition amongst vessels in fleet

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Turnaround time in port

< 10%

Quicker port turnaround time allows transit speed reduction while maintaining schedules

Turnaround time is reduced by improved maneuvering performance or enhancing cargo flows through innovative ship and terminal design

Reducing ferry port time:

Port time		Energy
2 h	-->	100%
-10min	-->	97%
-20min	-->	93%

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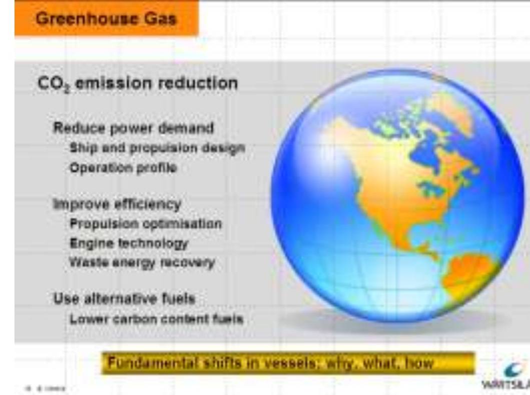
Why Clean Natural Gas

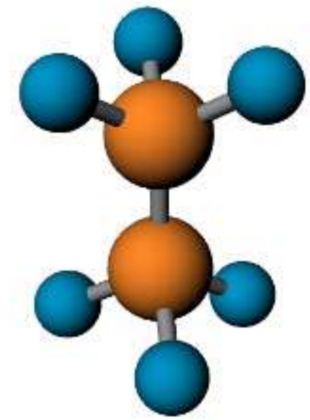
LNG Improves Cold Ironing

What is natural gas?



Natural gas … mostly methane (CH_4)

Methane has highest hydrogen content energy of any fossil fuel

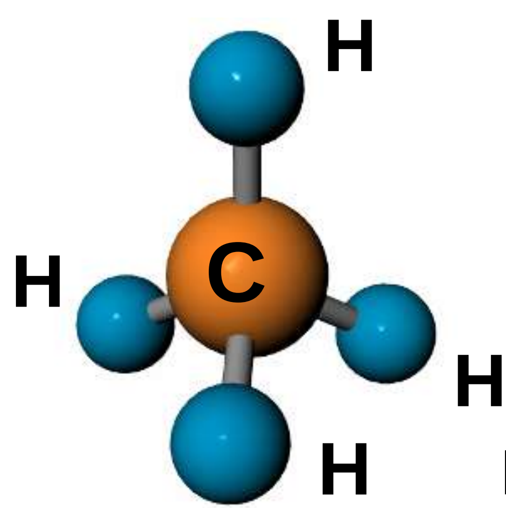


Ethane (C_2H_6)

Carbon to hydrogen ratio 1 / 4 (gasoline: 1 / 2,25)

Natural gas is:

- **Non-toxic**
- **Colourless**
- **Odourless**
- **Lighter than air**



Methane (CH_4)

Natural Gas has least Carbon content = Low CO2 Emissions

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Low Natural Gas Emissions

25-30% lower CO_2

- **Low Carbon to Hydrogen ratio of fuel**

85% lower NO_X

- **Lean burn concept (high air-fuel ratio)**

No SO_X emissions

- **Sulphur is removed from fuel when liquefied**

50% lower PM Particulates

- **Particulates vary across operating range**

No visible smoke

No sludge deposits extends engine life and time between overhauls achieving maintenance savings

ULTRA CLEAN COMBUSTION

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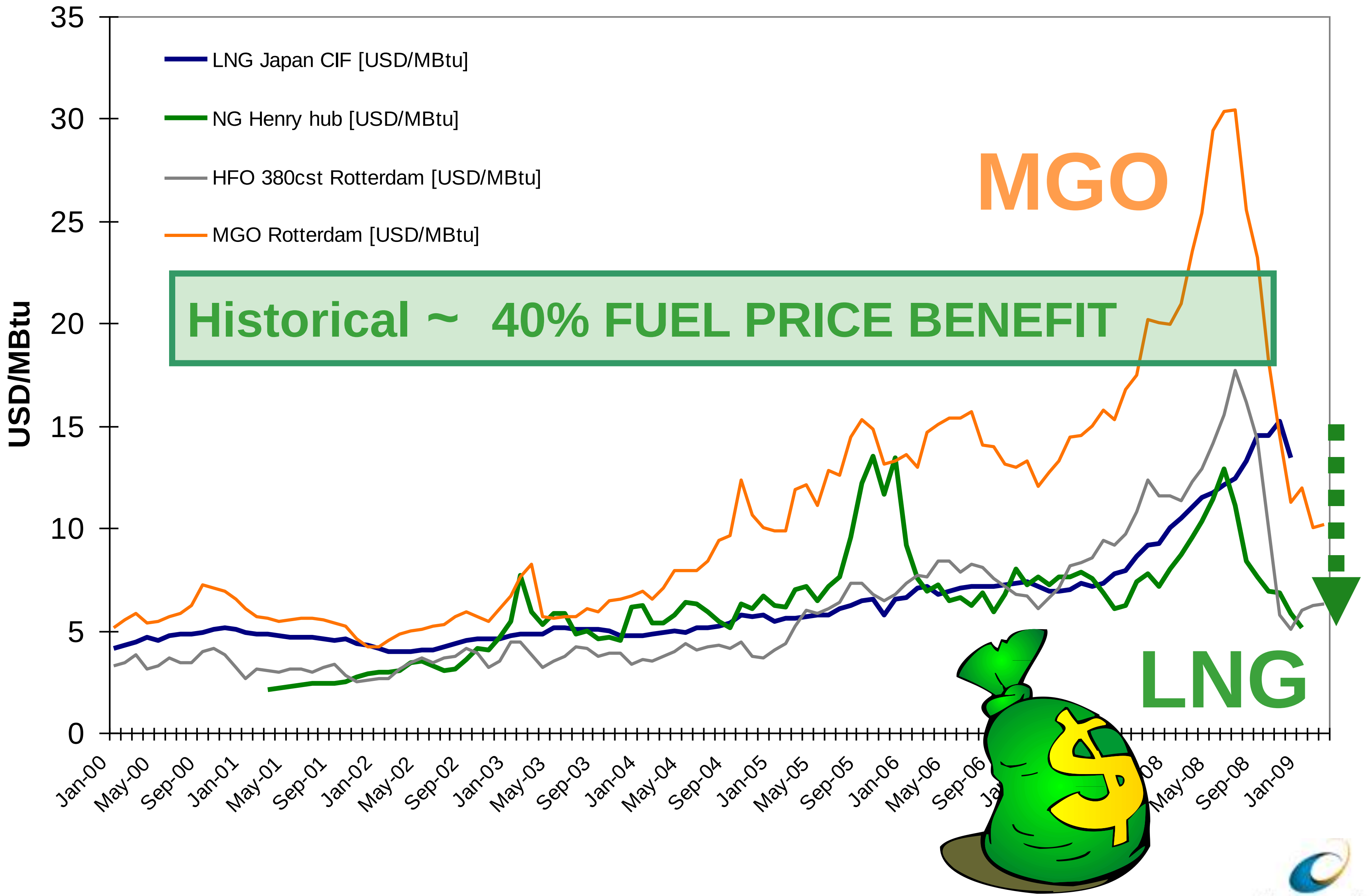
Win Win : Emissions Reduction & OPEX Savings



Sources: www.lngoneworld.com, www.bunkerworld.com, LR Fairplay

Agenda

Efficiency Technologies & Energy Savings

Evolving Developments

Ship Design

Propulsion

Machinery

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10 July 2009

SignOnSanDiego.com
BY THE UNION-TRIBUNE

New ship rules strike a blow for clean air

Digg
submit

State, local rules to cut ships' diesel pollution

By Mike Lee
UNION-TRIBUNE STAFF WRITER
2:00 a.m. July 10, 2009

San Diego's skies are about to get cleaner thanks to state and local programs designed to reduce diesel pollution from ships, which have long been a major cause of sooty air in port cities.

The Unified Port of San Diego approved $7.6 million this week to install giant electrical plug-ins at its cruise-ship and 10th Avenue terminals so visiting vessels can shut down their diesel engines while in port. The agency also will tap about $5 million in grants for the work, which should be completed in August 2011 – more than two years ahead of California's mandate.

Another coastal pollution measure took effect statewide July 1. The regulation forces all oceangoing ships to use cleaner-burning

UCSD's Mark Thiemens found that ships account for a large

San Diego approves $7.6 M for giant electrical plugs… so vessels can shut down diesel generators while in port.

Definition Cold Ironing

WIKIPEDIA
The Free Encyclopedia

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Cold Ironing

From Wikipedia, the free encyclopedia

Cold Ironing[1] is the process of providing shore-side electrical power to a ship at berth while its main and auxiliary engines are turned off. Cold ironing permits emergency equipment, refrigeration, cooling, heating, lighting, and other equipment to receive continuous electrical power while the ship loads or unloads its cargo.

Source: http://en.wikipedia.org/wiki/Cold_Ironing

Cold ironing at berth substitution of "preferred" shore power over traditional undesirable ship genset fuels misses LNG benefits !

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Ship Port Transit Steps

Ship approaches coastline

Ship maneuvers to pier

Cold Ironing limits emissions only during dockside cargo efforts while missing majority of vessel activities

Cargo load / unloading ops

Sources:

1. http://www.oldsaltblog.com/tag/container-ship
2. http://www.ports.co.za/images/MAERSK-BOSTON.jpg
3. news.xinhuanet.com/.../09/content_11154169.htm
4. http://www.ports.co.za/images/MAERSK-BOSTON.jpg
5. flickr.com/photos/77759596@N00/2063547505 /

Ship departs berth

Ship heads to sea

Suboptimal Cold ironing focus at berth … is there a better approach?

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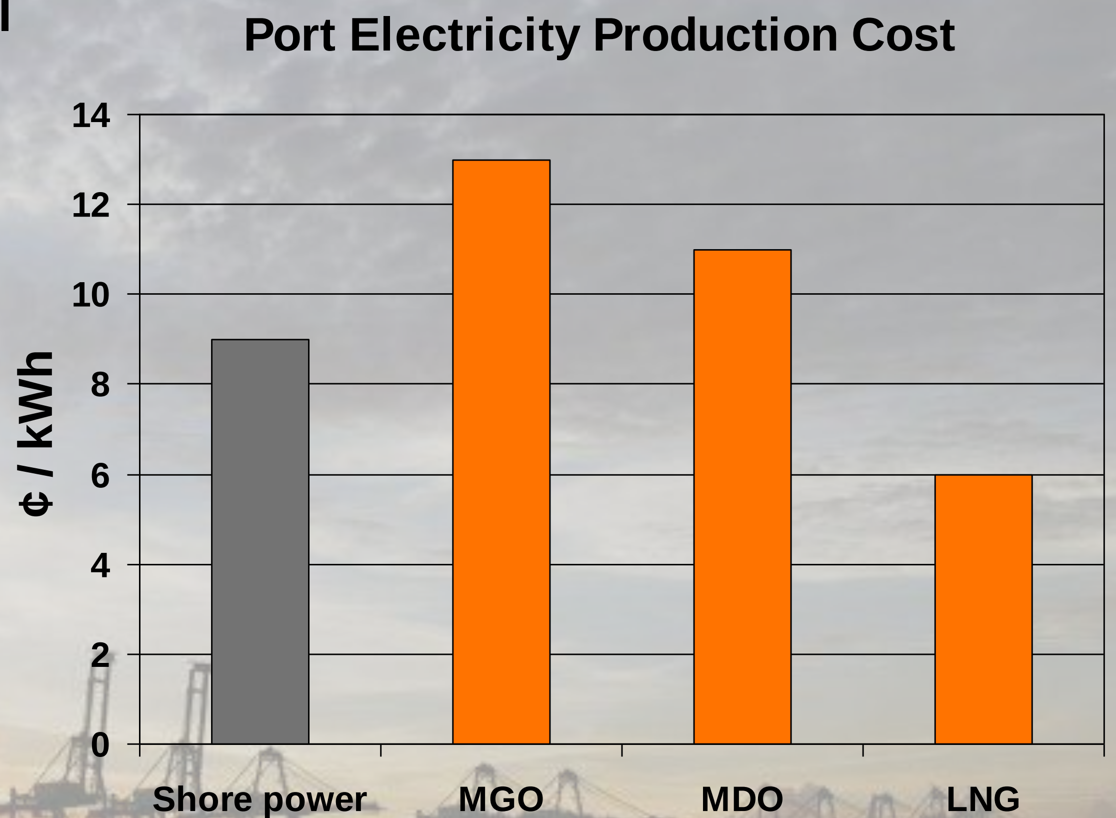
LNG Onboard Gensets

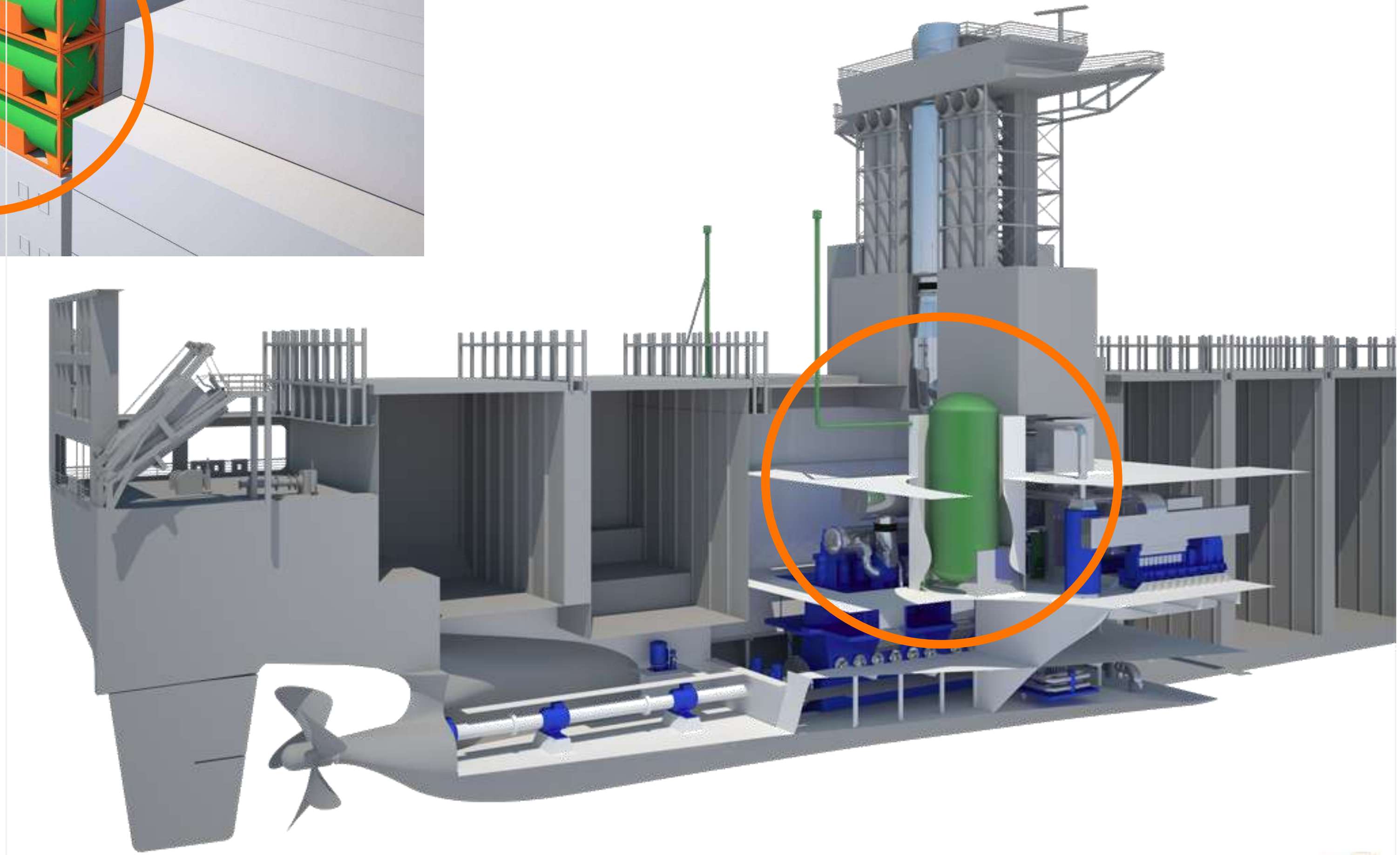
LNG auxiliary gen set electrical power for container vessels

- Onboard units power vessel's entire coastwise transit & port stay
- Economically feasible
- Significant emissions reduction
- Available Technology



LNG = Superior solution to coastal and port emissions over dockside Cold Ironing… best duration, costs, stakeholder needs

LNG Storage Possibilities



Topside ISO Containers or permanent below deck LNG fuel tankage

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LNG Gensets Case Study

Containership

Length over all	322.34	m
Breadth	40.00	m
Draught	14.00	m
Deadweight	84 500	ton
Main engine	Wärtsilä 11RT-flex96C	
Propulsion power	62 920	kW
Speed (trial)	25.5	kn
Cargo capacity	7 300	TEU
Reefer plugs	1 300	FEU

Trans-Pacific Voyage Route

Los Angeles – Oakland – Dalian – Busan – Nagoya – Yokohama – Los Angeles

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Operating US west coast

Coastal Zone … fuel with very low sulfur to reduce S0x … was 24 miles soon 200 miles ECA

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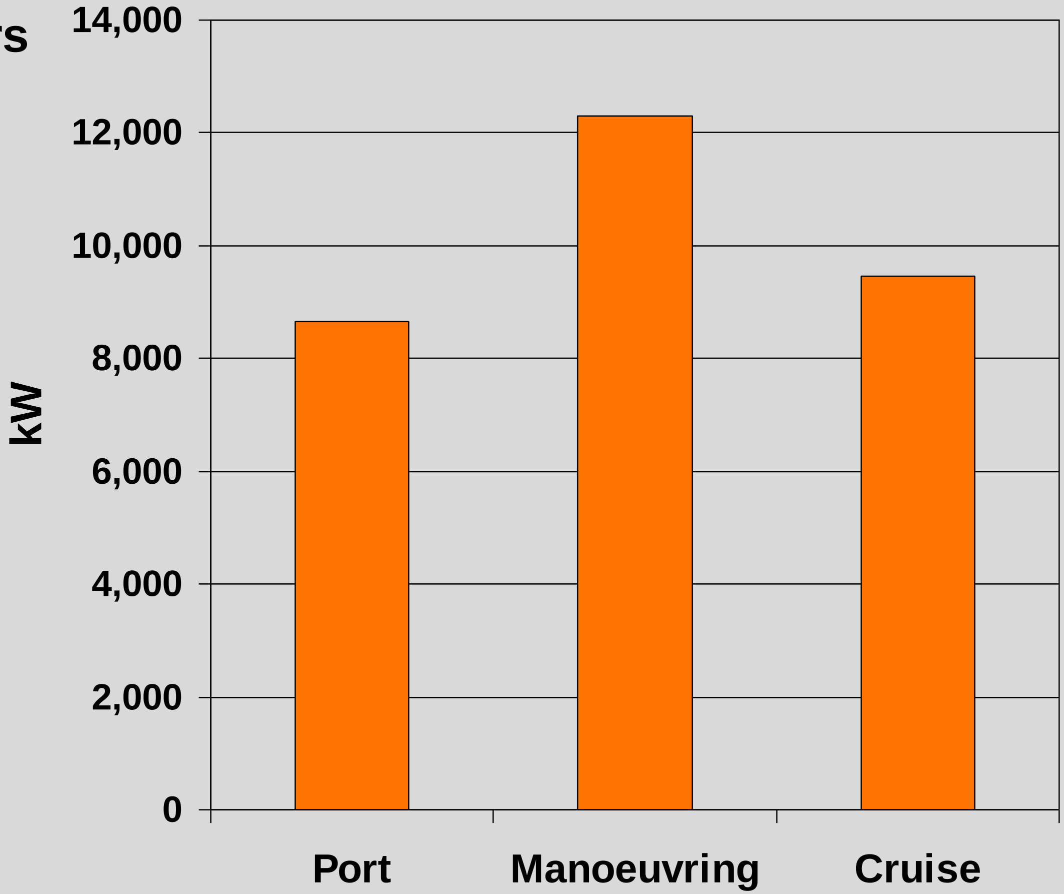
Container Cargo Electrical Load

1,300 refrigerated cargo containers consume high electrical power to maintain cold storage.



Large electrical cargo loads demand > 8,000 kW (10,800 HP)

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Operating Profile LNG Consumption

	LNG consumption	Run Time per round trip	Consumption per round trip
	Ton / hour	hours	tons
Cargo Loading & Unloading	1.5	138	207.0
Maneouvering	2.1	6	12.6
Coastwise slow transit with clean low sulphur diesel*	1.6	10	16.0

236 Tons LNG = 523 m3

2 Fixed tanks @ 190 m3 ... Bunker twice (1.4 x) each voyage

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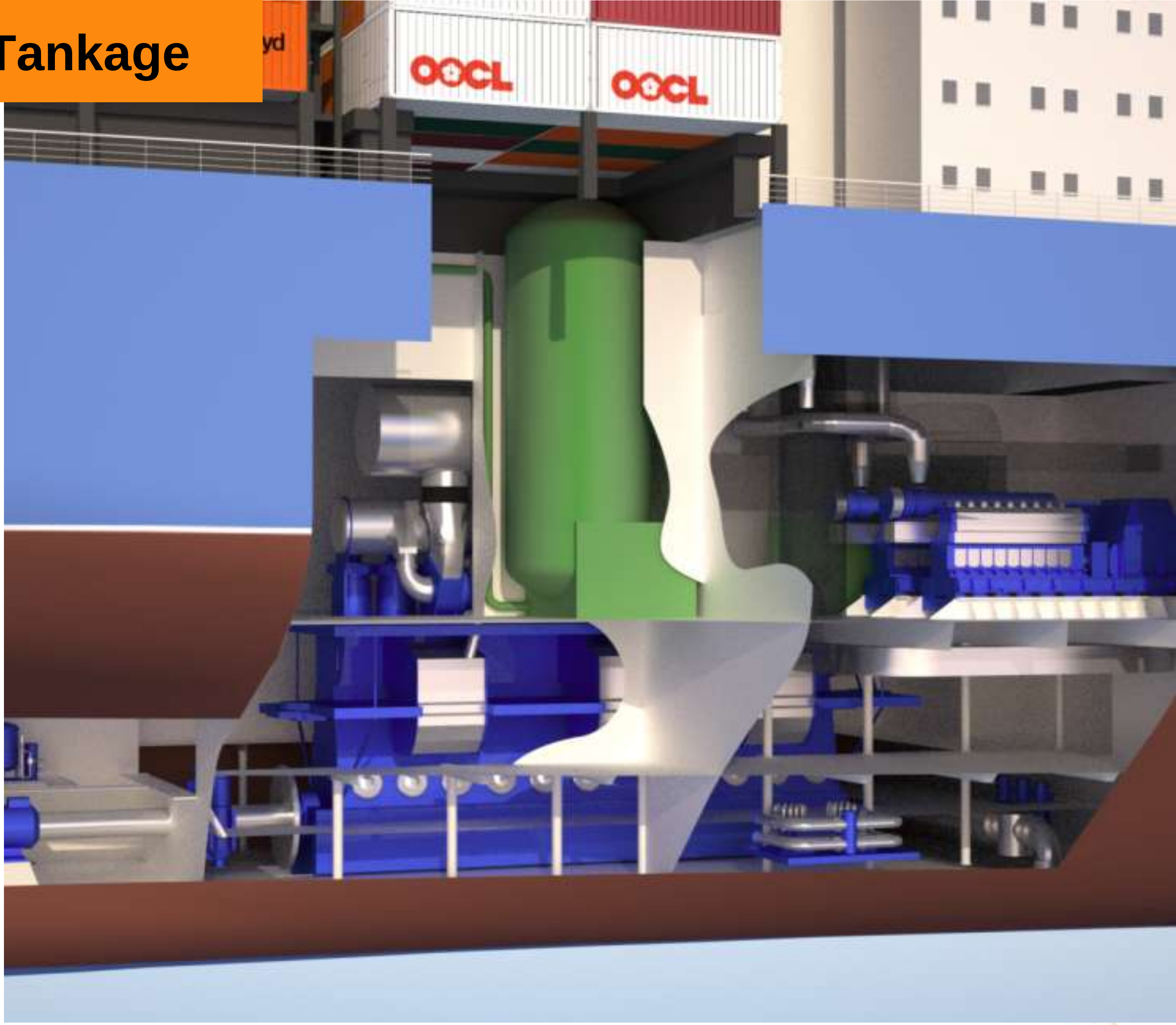
Fixed LNG Tankage



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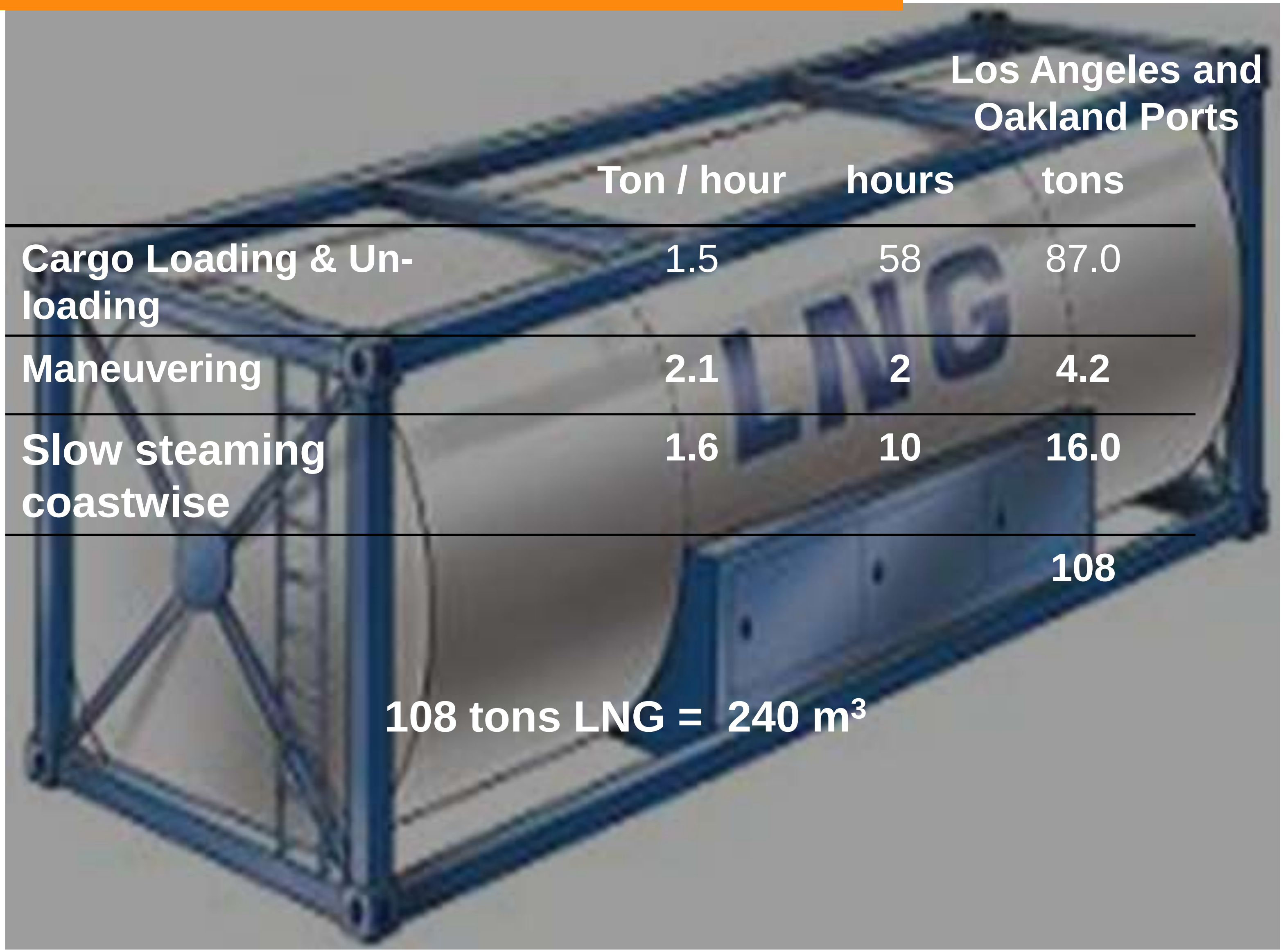
Or Containerized Above Deck LNG Storage

Topside ISO Containers provide flexibility and capacity

LNG consumption – West Coast Ports



Los Angeles and Oakland Ports

	Ton / hour	hours	tons
Cargo Loading & Un-loading	1.5	58	87.0
Maneuvering	**2.1**	**2**	**4.2**
Slow steaming coastwise	**1.6**	**10**	**16.0**
			108

108 tons LNG = 240 m^3

Tankage Need 8 units 40ft ISO LNG containers @ 31.5 m^3 = 240 m^3

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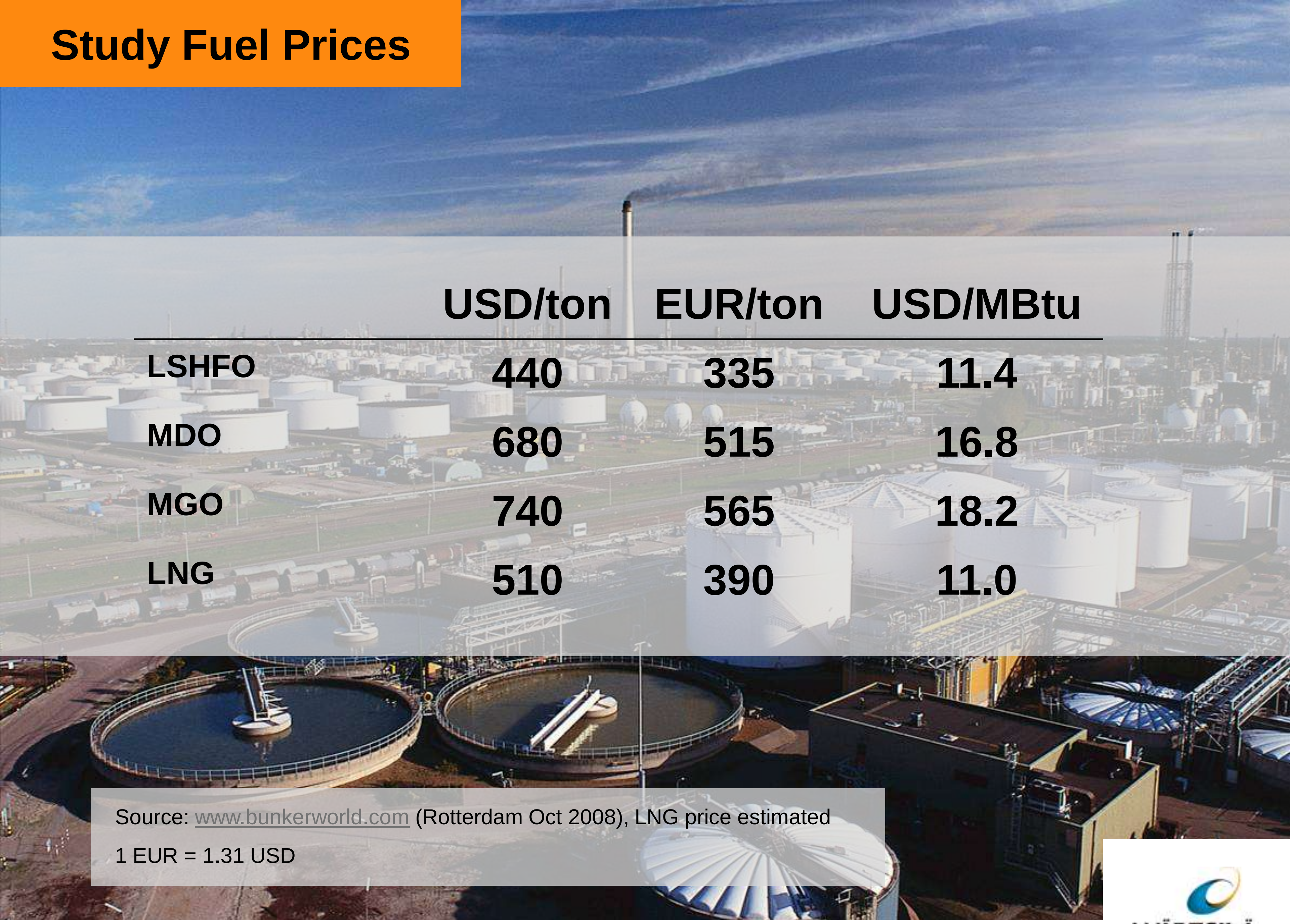


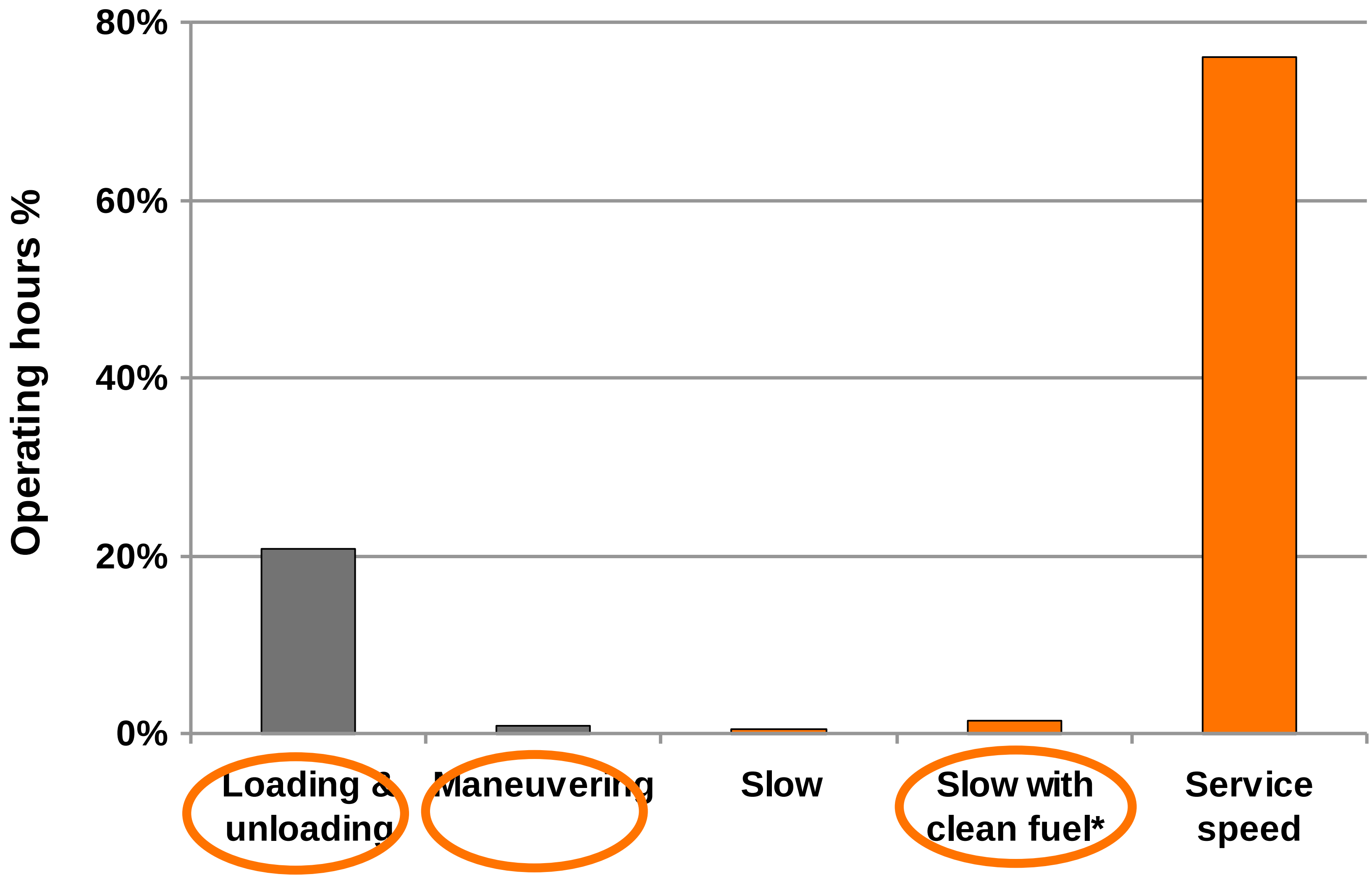
Study Fuel Prices

	USD/ton	EUR/ton	USD/MBtu
LSHFO	**440**	**335**	**11.4**
MDO	**680**	**515**	**16.8**
MGO	**740**	**565**	**18.2**
LNG	**510**	**390**	**11.0**

Source: www.bunkerworld.com (Rotterdam Oct 2008), LNG price estimated

1 EUR = 1.31 USD

Ship Operating Profile



Clean fuel is to be used in aux engines in all these time phases

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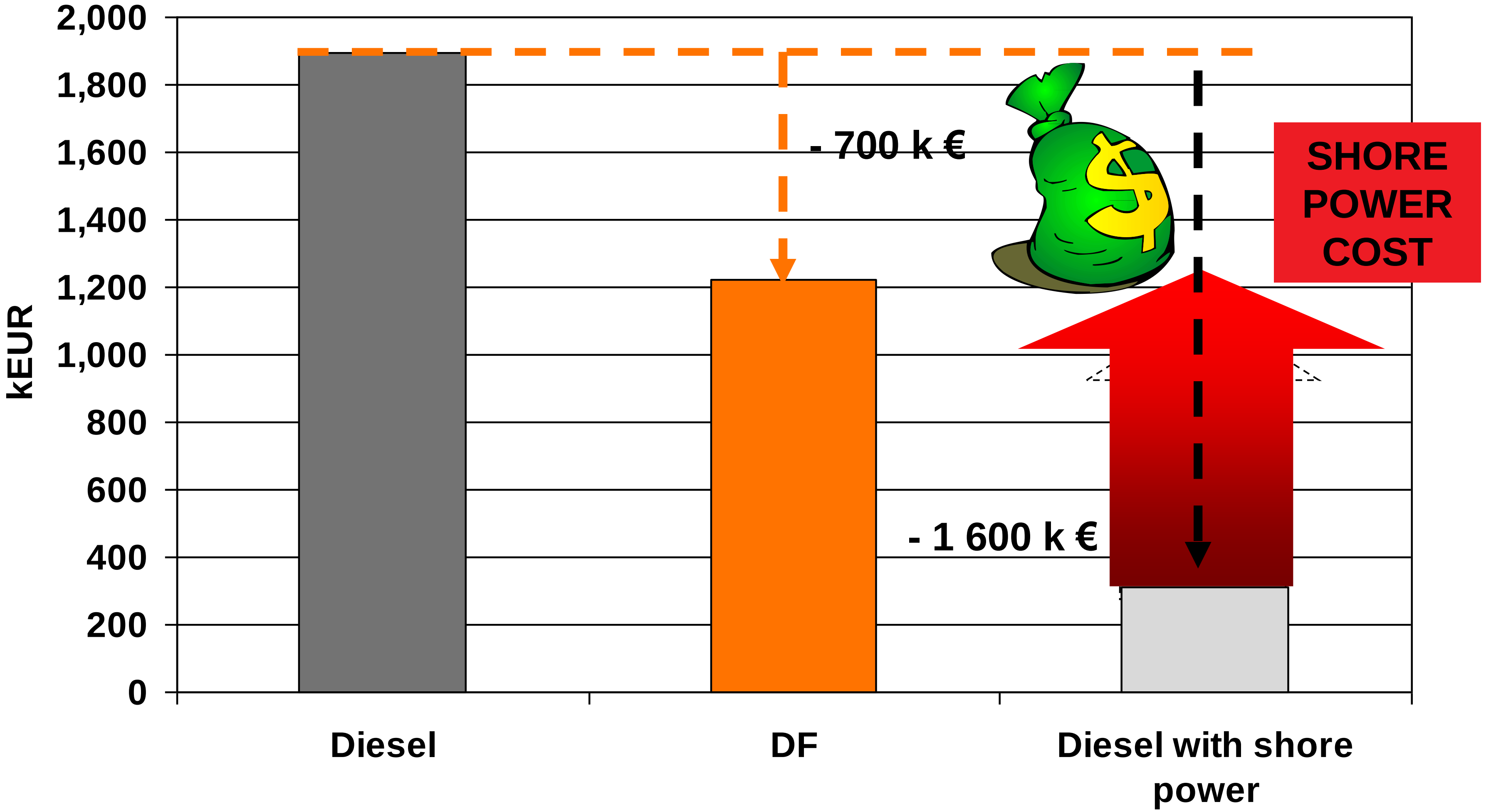
Annual Aux Gen Set Fuel Cost

LNG Win + Win = Emissions & Cost Reduction



LNG Lowest emissions & Annual Cost Savings 700 K €
Shore Power similar costs but hosts emissions achievement short fall

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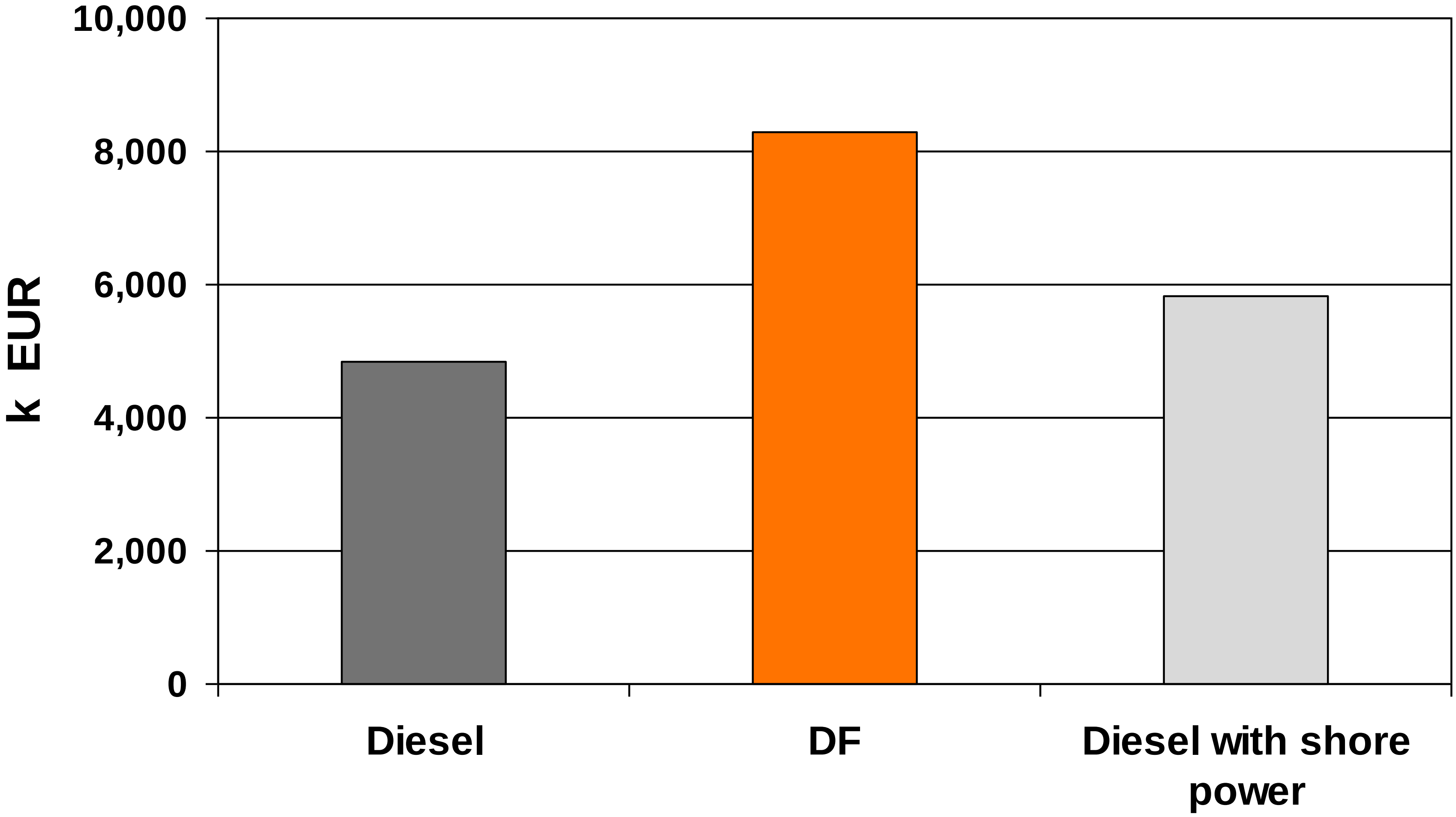
Auxiliary Engine CAPEX



Investment cost for aux engines includes
Engines + Generators … LNG System … Shore Power Connection

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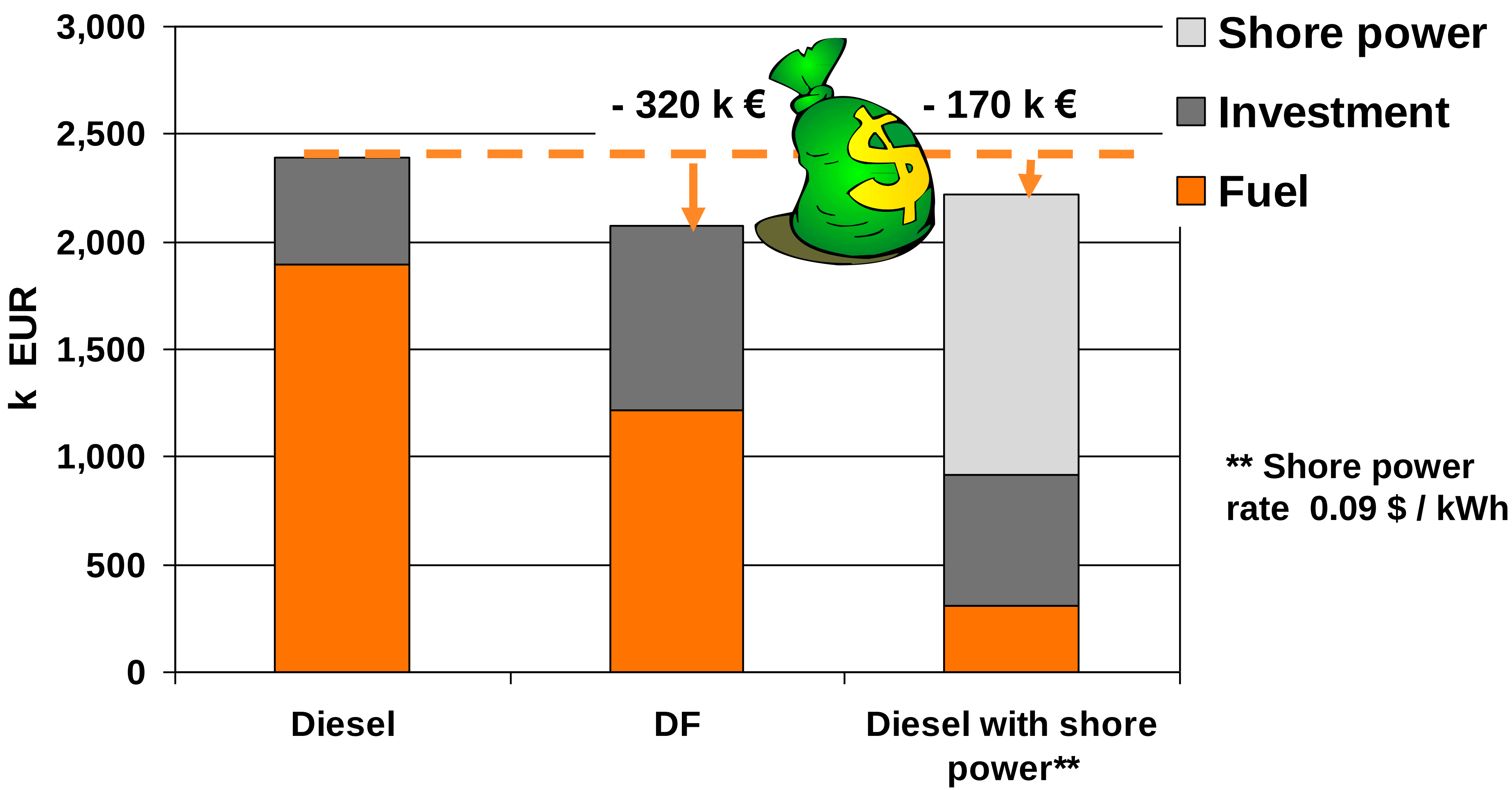
Annual CAPEX + OPEX "All In" Costs



** Shore power rate 0.09 $ / kWh

LNG Genset Financial Payback 15 Years at 6 %
LNG Genset Emissions Environment Payback immediate

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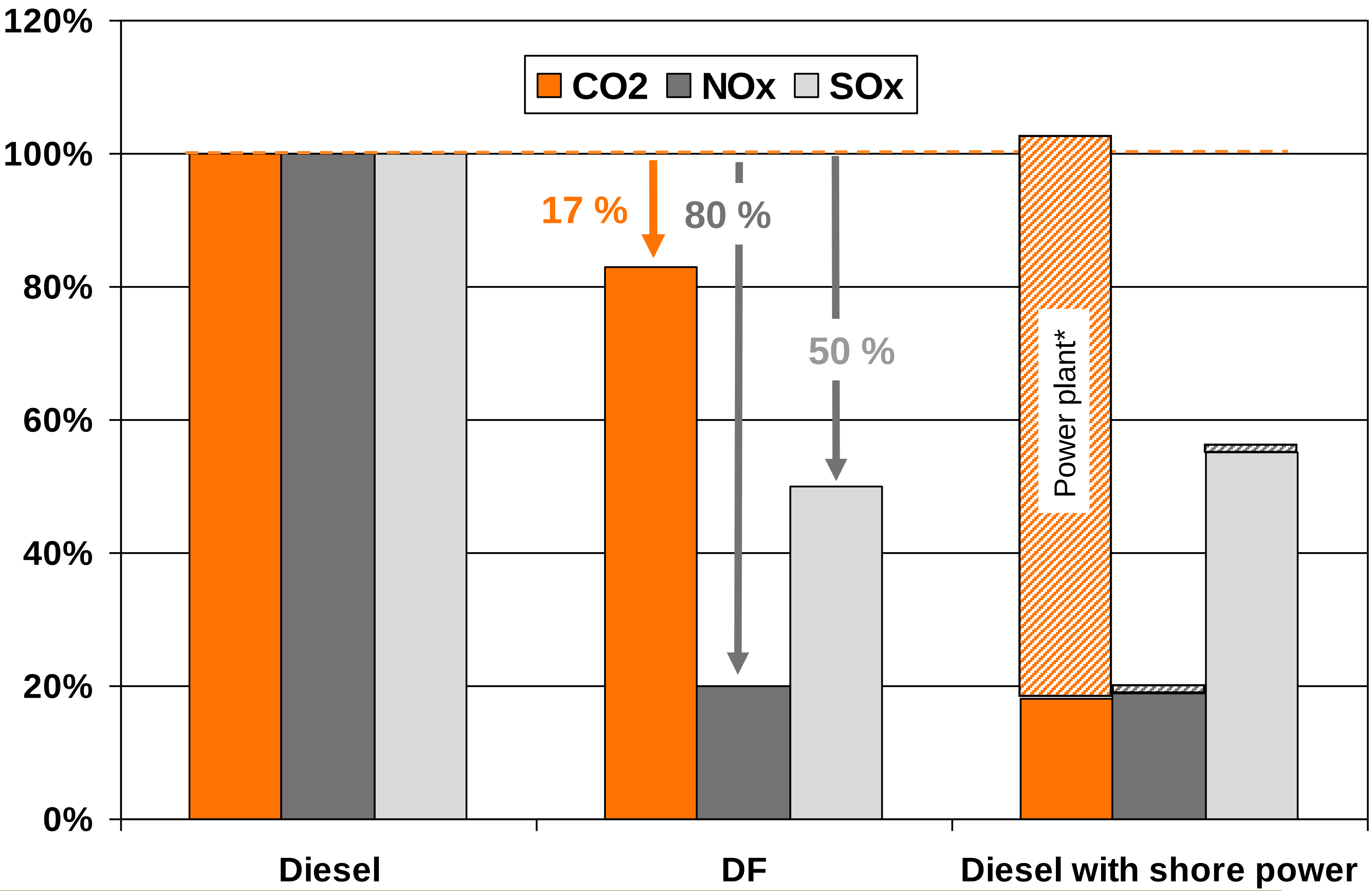
LNG Emissions Reductions



LNG DF Reductions = 1900 Tons CO_2 190 Ton NOx 7 Ton SOx
Shore Power Plant … uncertain ????

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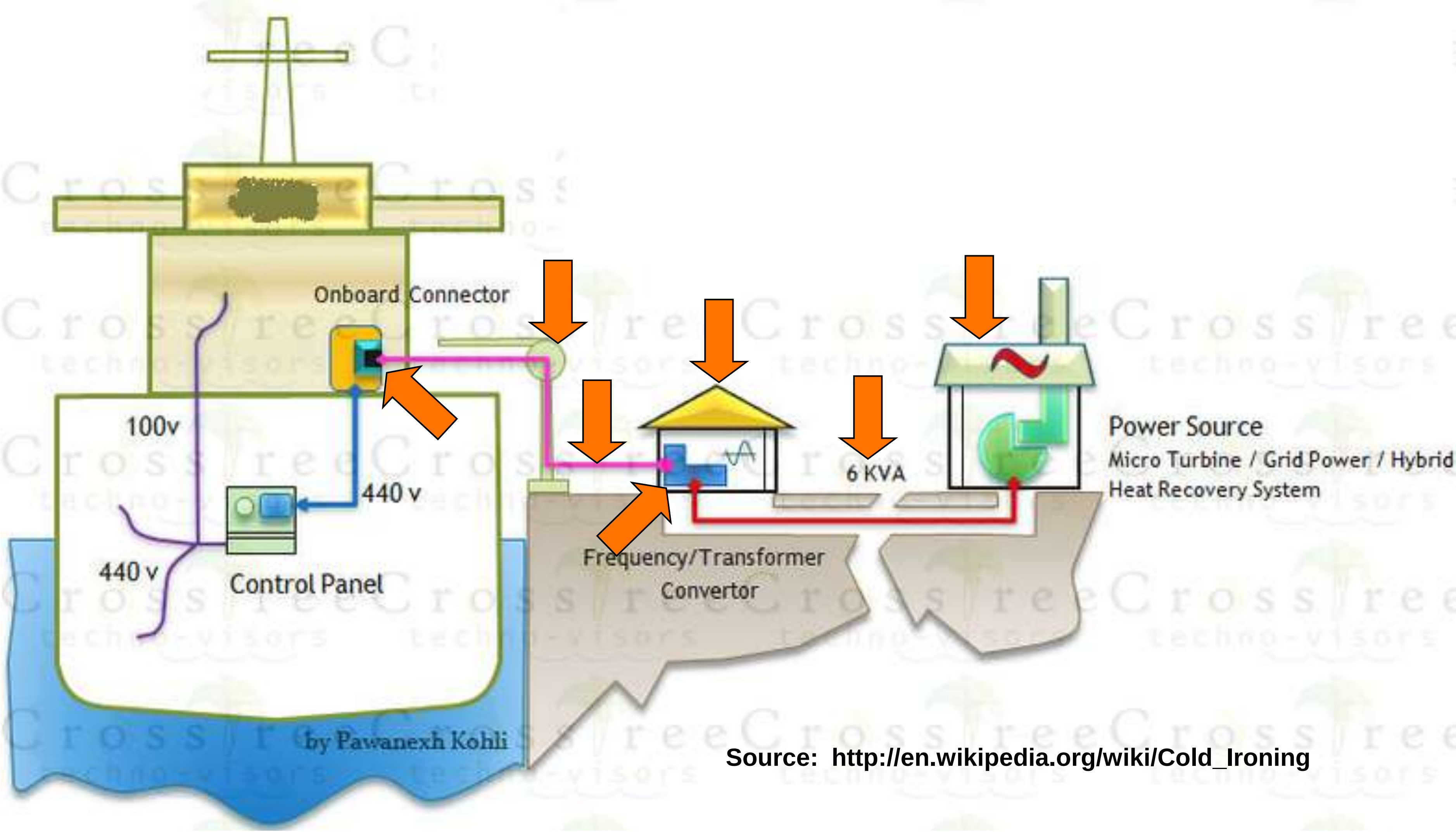
Shoreside Cold Ironing



Source: http://en.wikipedia.org/wiki/Cold_Ironing

Several shore-side linkages bring power to ship from land … multiple interfaces pose match challenges

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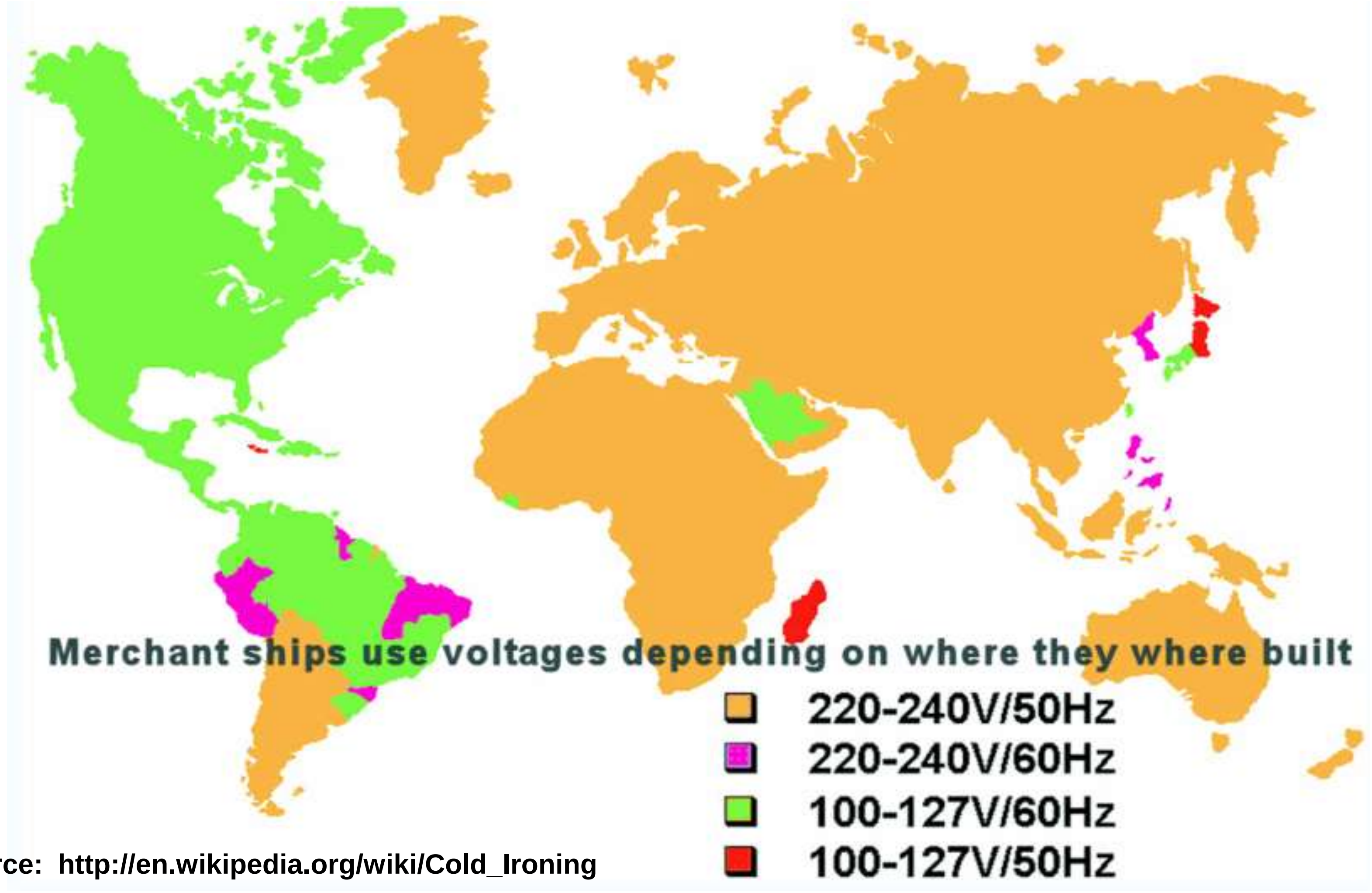
Shipboard Electrical Systems



Source: http://en.wikipedia.org/wiki/Cold_Ironing

Several different ship electrical systems complicate smooth integration with cold ironing port infrastructure

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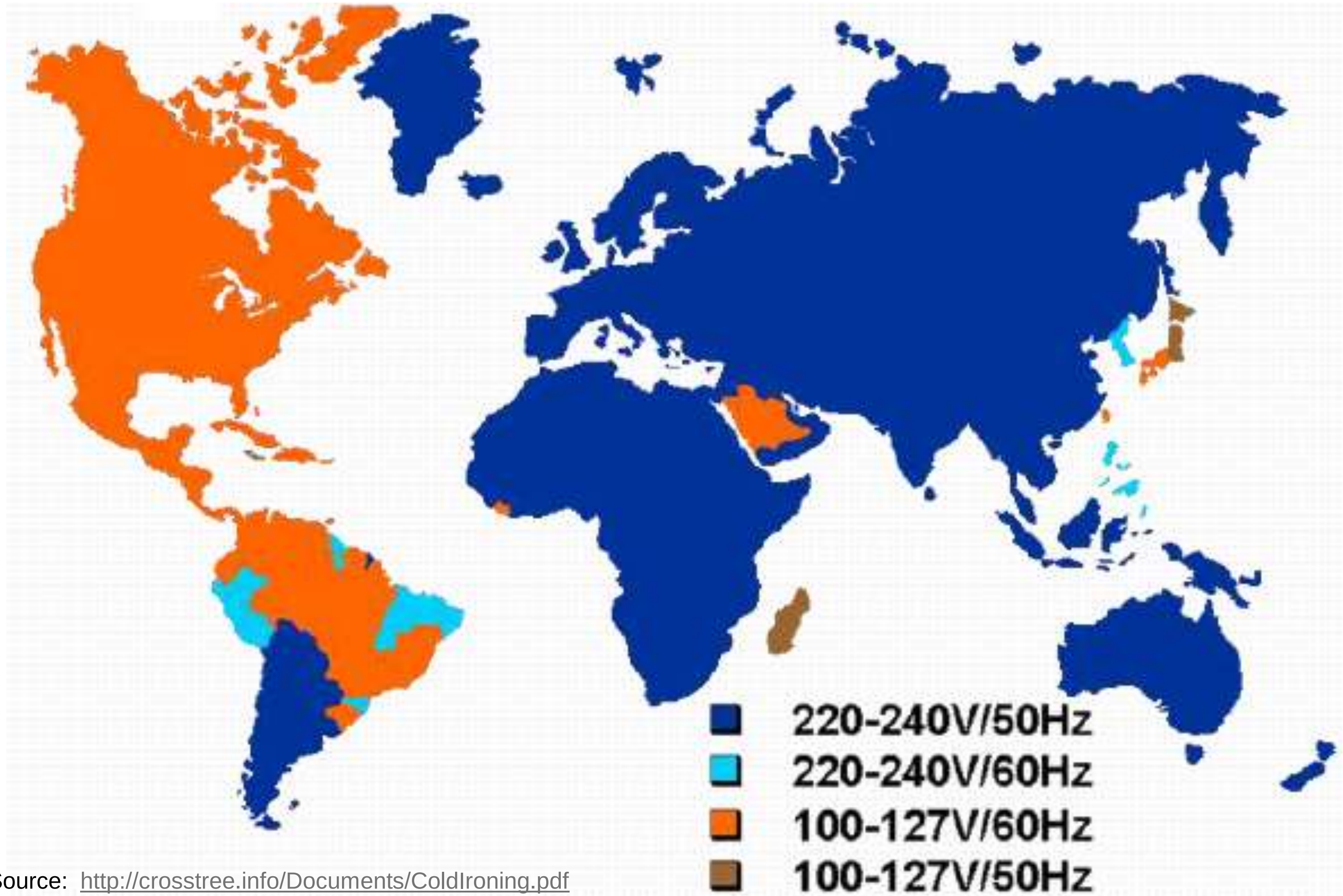
Land Electrical Systems



Source: http://crosstree.info/Documents/ColdIroning.pdf
Fuel- Energy in Ports: Maritime Industry Cold Ironing An Overview, Capt. Kohli, Cross Tree Techno-visors

Utility frequencies miss ship needs… result employ shore transformers @ 3% inefficiency = costly CO2 increase

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What size connection Plug ?

Source:http://www.coldironing.us/unitedstates coldironing.htm

Source:
http://crosstree.info/Documents/ColdIroning.pdf Fuel- Energy in Ports: Maritime Industry Cold Ironing An Overview, Capt. Kohli, Cross Tree Techno-visors

Variety of ships shore-bus connection types present “plug & play” challenges

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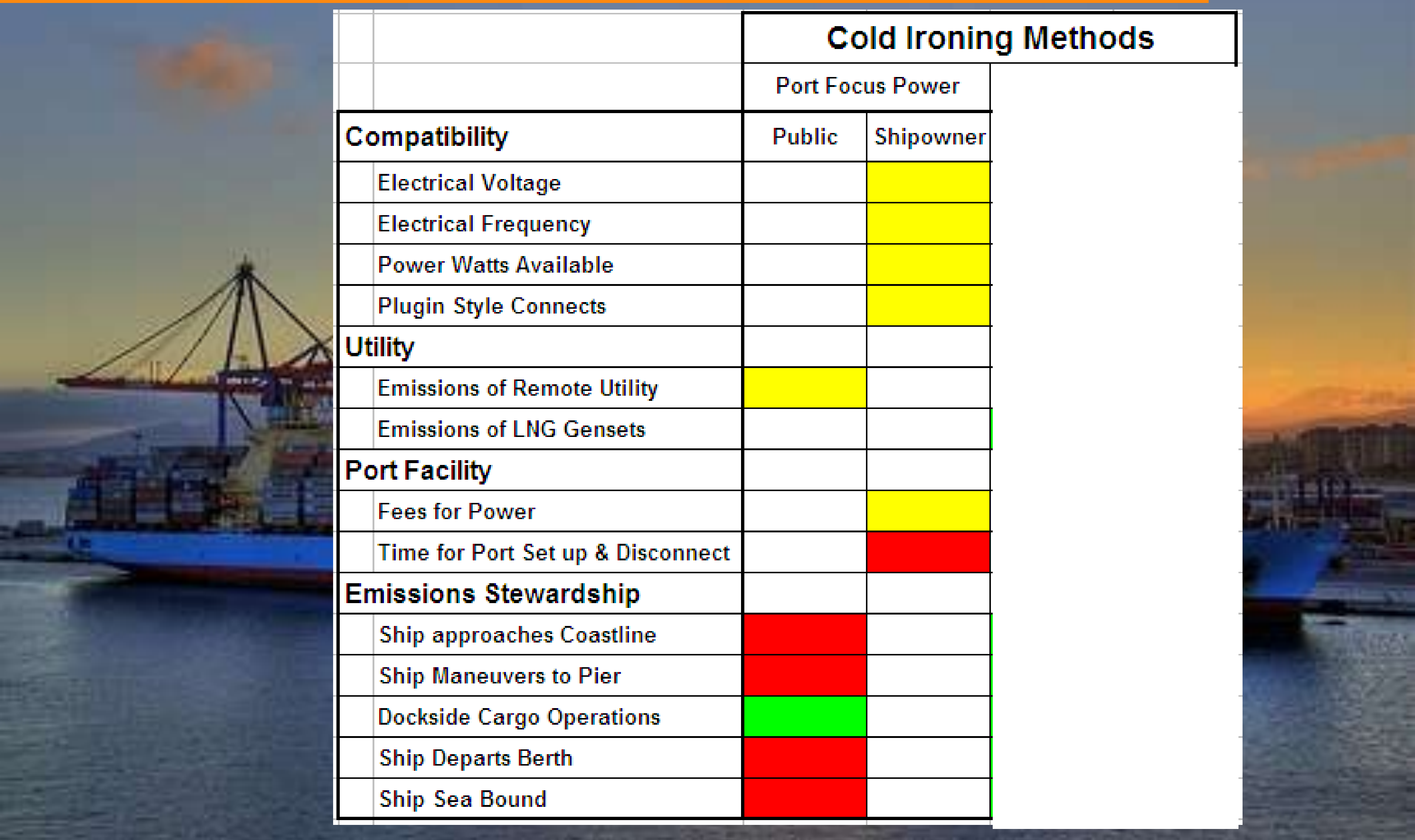
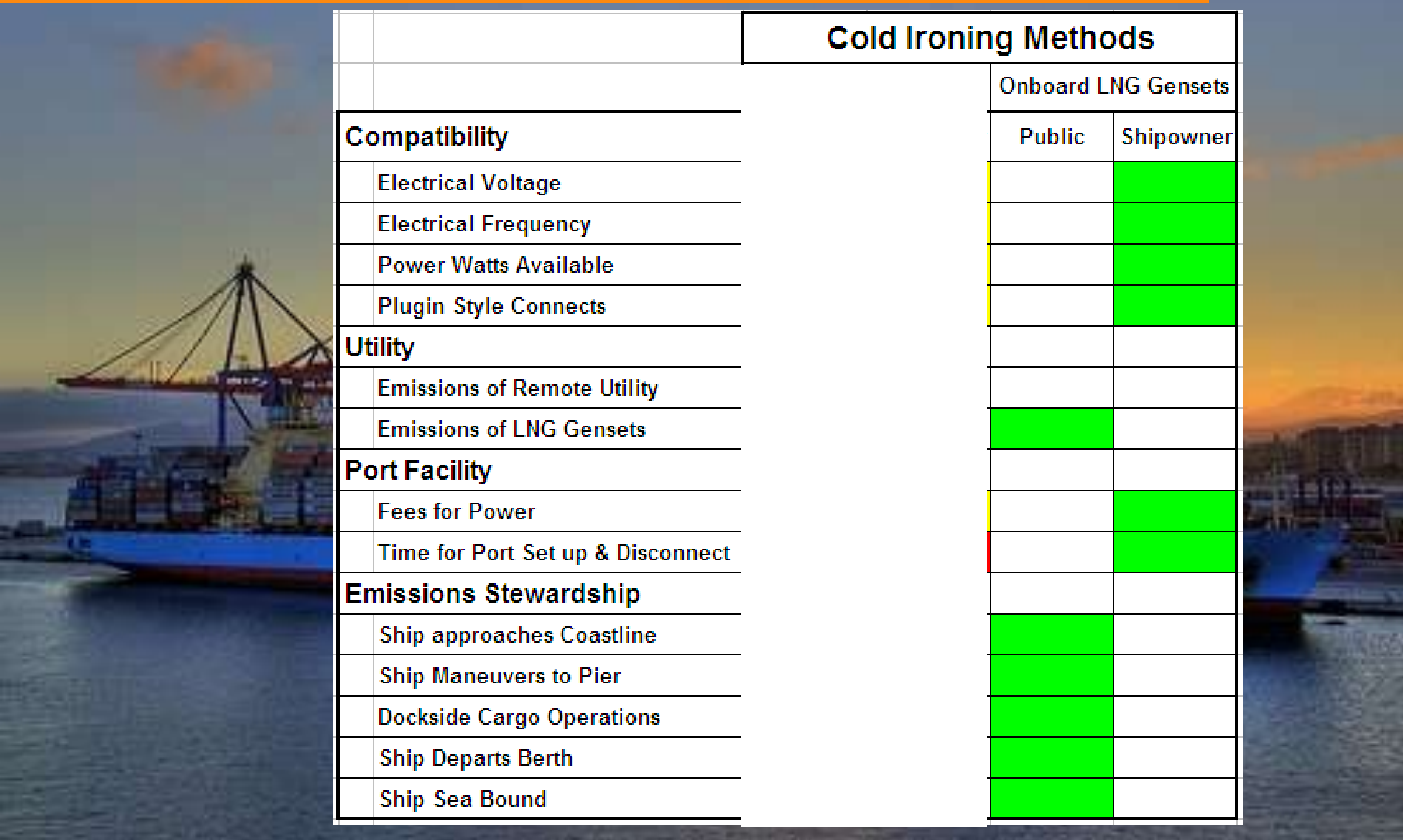
Scorecard: Port Cold Iron Vs. LNG Ship Gensets



	Cold Ironing Methods	
	Port Focus Power	
Compatibility	Public	Shipowner
Electrical Voltage		
Electrical Frequency		
Power Watts Available		
Plugin Style Connects		
Utility		
Emissions of Remote Utility		
Emissions of LNG Gensets		
Port Facility		
Fees for Power		
Time for Port Set up & Disconnect		
Emissions Stewardship		
Ship approaches Coastline		
Ship Maneuvers to Pier		
Dockside Cargo Operations		
Ship Departs Berth		
Ship Sea Bound		

Scorecard: Port Cold Iron Vs. LNG Ship Gensets



	Cold Ironing Methods		
		Onboard LNG Gensets	
		Public	Shipowner
Compatibility			
Electrical Voltage			
Electrical Frequency			
Power Watts Available			
Plugin Style Connects			
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Scorecard: Port Cold Iron Vs. LNG Ship Gensets

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Scorecard: Port Cold Iron Vs. LNG Ship Gensets

	Cold Ironing Methods			
	Port Focus Power		Onboard LNG Gensets	
Compatibility	Public	Shipowner	Public	Shipowner
Electrical Voltage				
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Onboard LNG Gensets superior win for environmental protection …
optimal stakeholder solution serving both Public & Shipowner

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Conclusions

LNG provides OPEX savings and Emissions reduction in port

DF achieves portside goal of lower emissions and uniquely extends reductions to / from horizon

DF independence from port facilities eliminates many concerns and brings timely efficiencies

LNG system + DF gen sets
Investment Payback Less Than 3 years

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