CARNIVAL CORPORATION & PLC

Energy Consumption and Alternative Fuels

SEATRADE 2017

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Holland America Line P&O CRUISES P&O AUSTRALIA PRINCESS CRUISES SEABOURN

Energy Savings

New ships are more efficient

- Our new generation of ships are more efficient than those previously delivered
- This is demonstrated by the Energy Efficiency Design Index (EEDI) *

Ship	Required EEDI Reduced CO2 emissions	Attained EEDI Reduced CO2 emissions
A	13.7 g (CO2)/(t.nm)	9.81 g (CO2)/(t.nm)
B	14.6 g (CO2)/(t.nm)	9.75 g (CO2)/(t.nm)
C	13.9 g (CO2)/(t.nm)	7.89 g (CO2)/(t.nm)

- But what about existing ships? Saving fuel comes directly off the bottom line
  - Low fuel price means that return on investment is longer – but is still worth doing
  - Prototype energy saving project capital budget over last 3 years > 200 MUSD
- Pioneering LNG for cruise ships

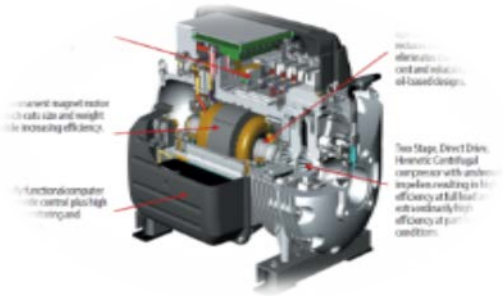
* Still voluntary for most of our ships but when calculated shows what can be achieved by good design.

Examples of investment in energy-savings initiatives (1 of 2)

1. Designing ships for greater efficiency
   - Hull form optimization to enhance performance
   - Installation of Air Lubrication Systems which create bubbles between the ship's hull and water to reduce friction
   - Fitting high efficiency propellers and propeller appendages
   - Use of steam turbines to generate electricity from waste heat
   - Use energy-efficient equipment such as LED lighting and advanced reverse osmosis plants for production of fresh water
   - Introduction of next generation HVAC systems such as active chilled beam technology and adsorption chillers

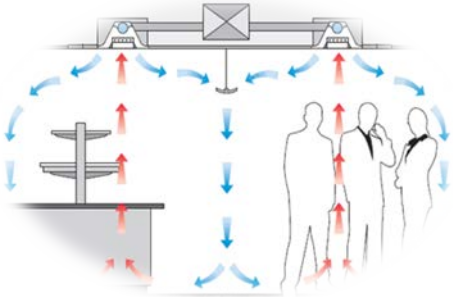
2. Executing ship operation and maintenance initiatives
   - Upgrade to high efficiency waste heat evaporators
   - Utilize state of the art automation for control of HVAC systems including CO_2 sensors to control recirculation flow
   - Introduction of differential blasting and coating strategies on underwater areas to improve hull efficiency
   - Use of hull and propeller performance monitoring to determine effective cleaning intervals to reduce resistance in service
   - Introduction of low temperature heat recovery systems to increase the use of waste heat from engine exhaust

HVAC
High Efficiency Chillers



HVAC
Advanced Automation

Active Chilled Beam Technology

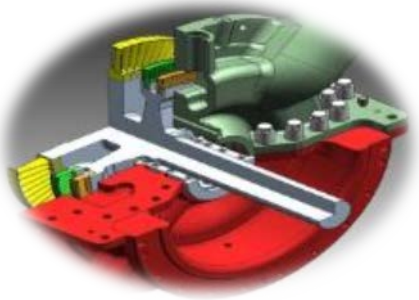


Examples of investment in energy-savings initiatives (2 of 2)

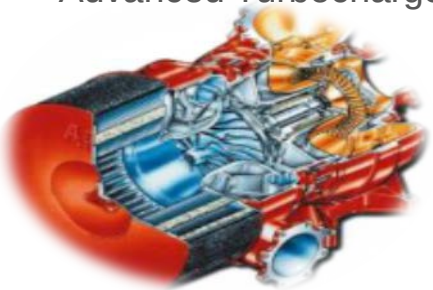
3. Minimizing fuel use and engine emissions
   - Optimize diesel generator loading to minimize emissions
   - Modification of fuel systems to allow for operations at optimal efficiency under port load conditions
   - Introduction of condition and performance monitoring systems to improve effective ness of maintenance
   - Use of advanced turbochargers to enhance performance
   - Use of variable speed drives on fan and pump motors to allow the implementation of on-demand control logic to reduce power consumption

4. Implementing other energy-saving initiatives
   - Design more fuel-efficient itineraries.
   - Use voyage optimization tools
   - Increase energy use awareness through education
   - Introduce ‘energy monitoring’ for on-board systems to provide transparency into energy consumption
   - Implementation of energy efficiency management training courses for engineers

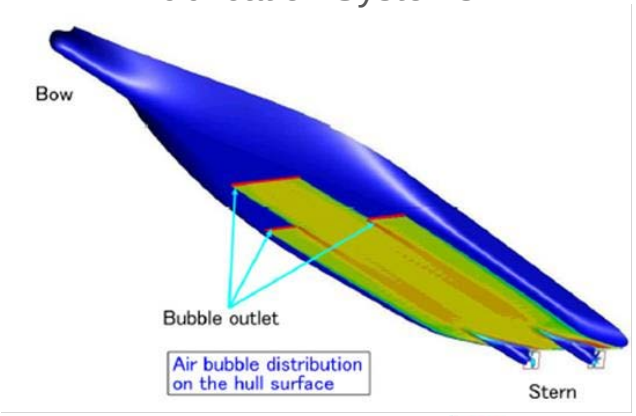
Waste Heat Recovery Steam Turbines using exhaust gases



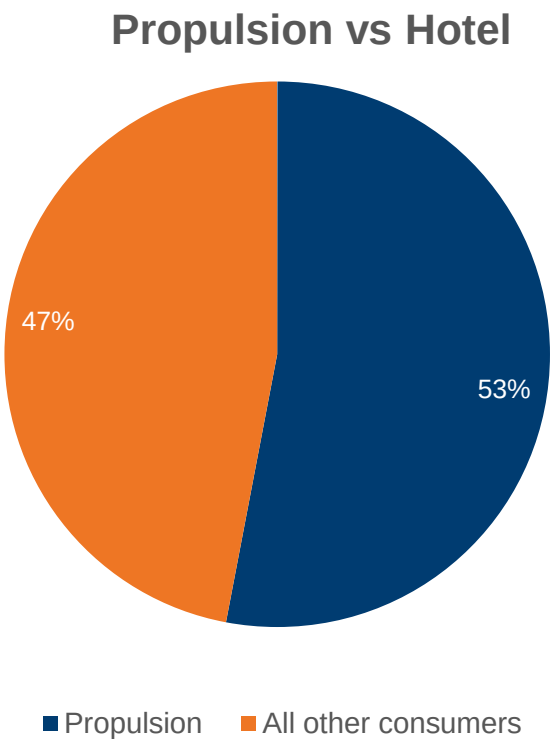
Advanced Turbochargers

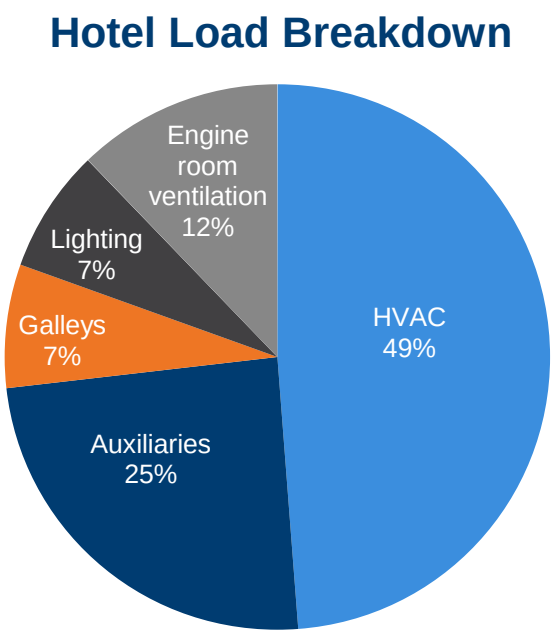


Air Lubrication Systems



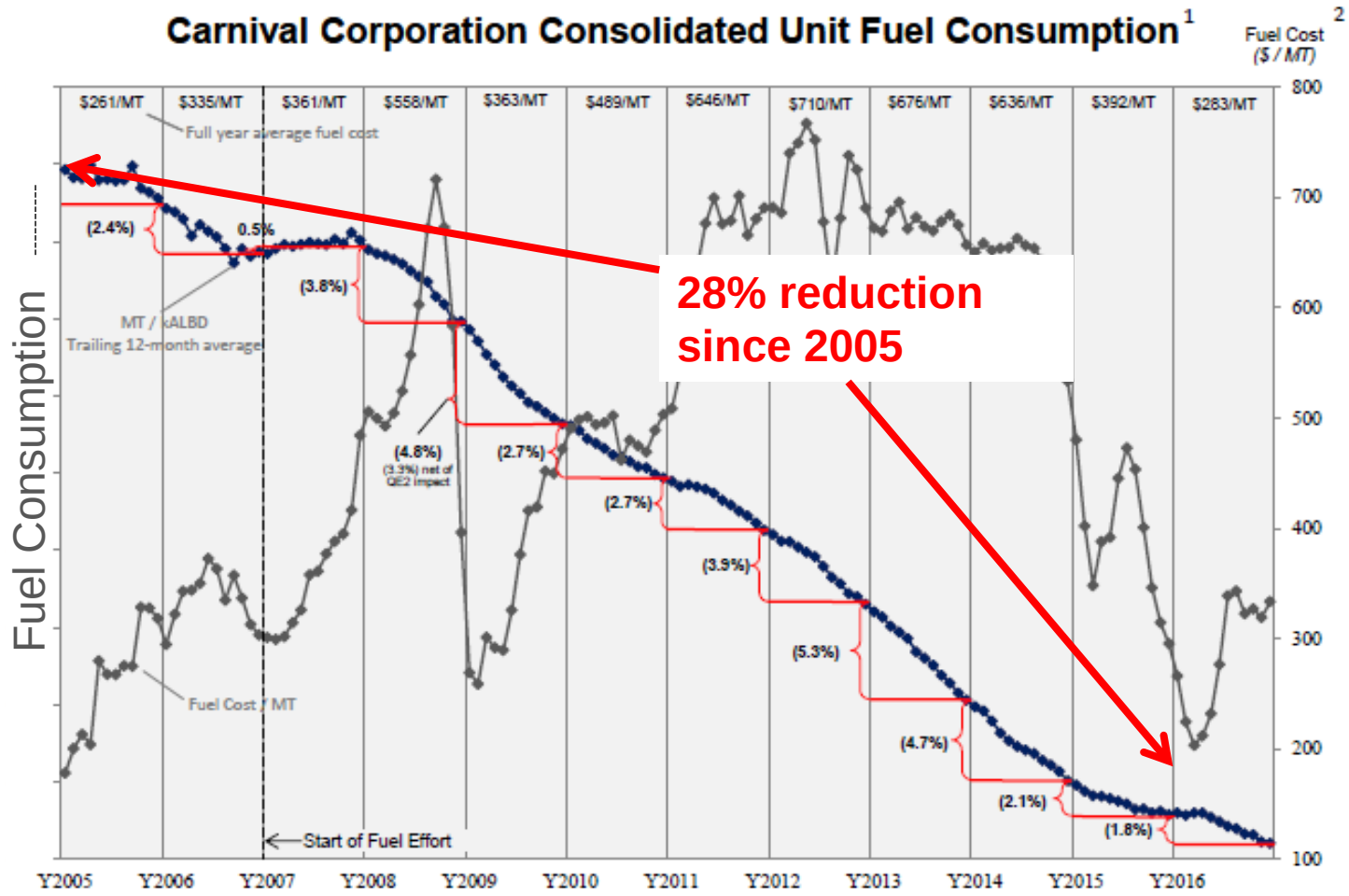
2016 Projects





Energy Savings Initiatives cover both improvements in the efficiency of energy generation and savings in the consumption of energy to cover the requirements for both propulsion and hotel

Fuel Performance Across the Whole Group



Note 1: Trends represent consolidated-level performance, without any brand/ship exclusions.
Note 2: Weighted

Alternative Fuels

2020 is not far away and what alternatives are there?

- 0.5% HFO
- MGO
- HFO + EGCS + SCR
- Methanol
- LNG
  - AIDAprima and AIDAperla operating on LNG in port
  - 7 new ships on order from Meyer Werft that use LNG all the time
  - Best option for emissions
- Future …..
  - Batteries, fuel cells, hydrogen….

AIDAprima supplied directly with LNG by truck in Germany – May 2016.

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Thank you