



CARNIVAL CORPORATION & PLC.

Green Cruising

Energy efficiency improvements

June 14th 2018



Carnival Corporation

105 ships ...

**sailing 10 million
nautical miles per
year...**

**carrying 12 million
passengers per year...**



Summary of agreed initial IMO GHG reduction strategy

Two Targets:

1. Reduce international shipping average **unit CO₂ emissions** (per transport work) by at least **40% by 2030**, pursuing efforts toward **70% by 2050 compared to 2008**
2. Reduce **absolute** international shipping GHG emissions...to peak as soon as possible and then reduce the total annual GHG emissions by at least **50% by 2050 compared to 2008** and pursue efforts to phase them out (consistent with the Paris Agreement temperature goals)

The Initial Strategy identifies levels of ambition for the international shipping sector noting that technological innovation and the global introduction of alternative fuels and/or energy sources for international shipping will be integral to achieve the overall ambition.

In other words it is recognized by the IMO that the 2050 decarbonization target is probably unachievable with current technology.



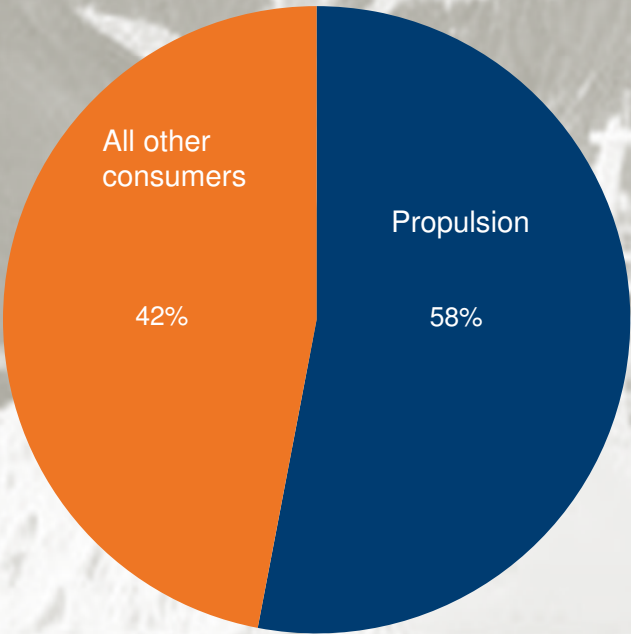
The scale of the challenge

- At sea the average power requirement is around **22,000 KW**
- Maximum power requirement at sea approximately **50,000 KW**
- Average power requirement in port is around **7,000 KW**

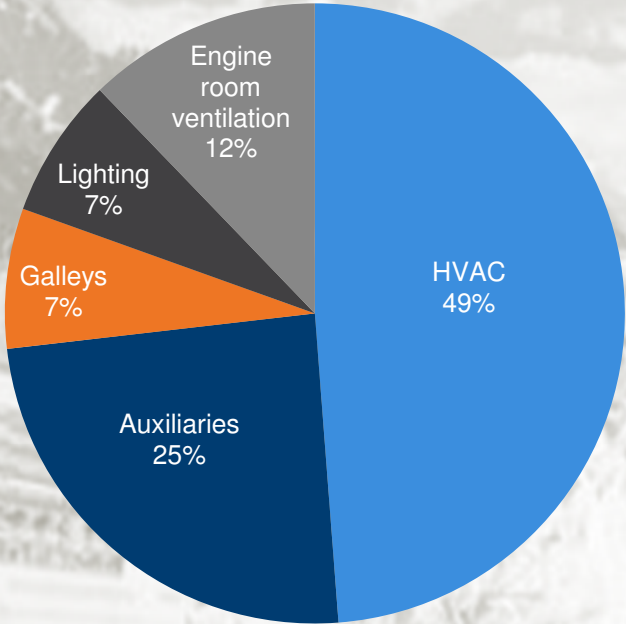


How does the energy get used?

Propulsion vs Hotel

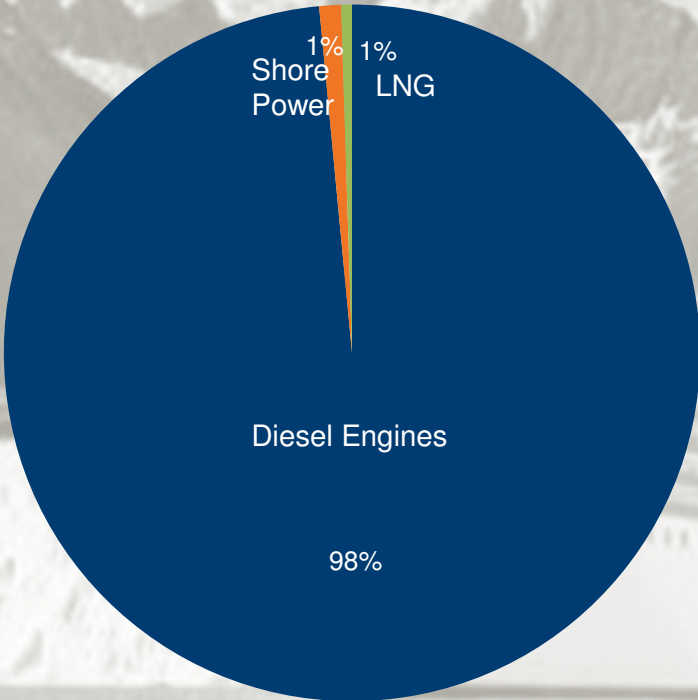


Hotel Load Breakdown

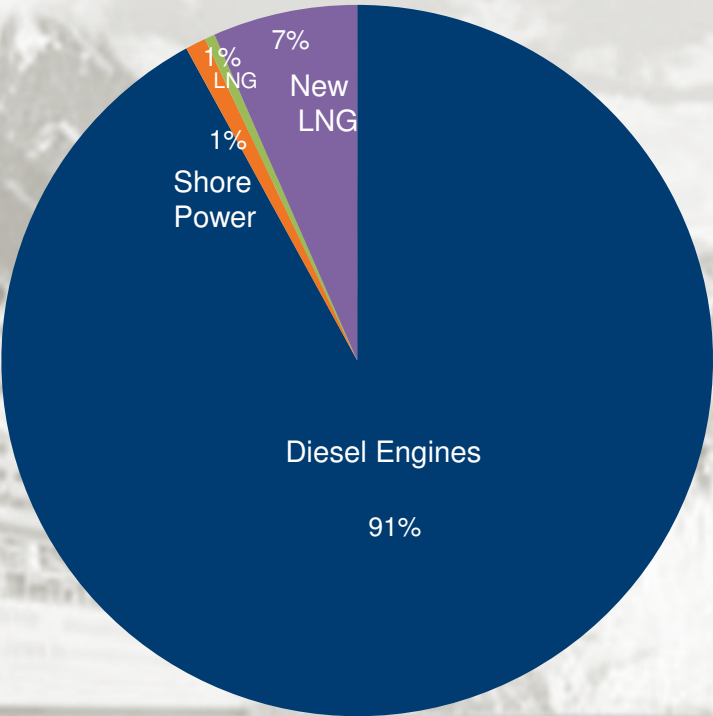


How does the energy get generated ?

Current Fleet



Fleet with New Builds



What are we doing ?

- **Investing in energy efficiency**

Carnival Corporation is currently spending around \$75m annually on energy efficiency improvements for the fleet

- **Prioritizing energy efficiency**

Energy efficiency commands a high priority within the company and forms an integral part of our corporate sustainability goals

- **Exploring new technology**

Currently running 146 different R&D or 'technical prototype' projects

- **Implementing new technology**

Carnival corporation has been at the forefront of investment in new energy efficiency technologies and is leading the way with LNG powered ships – 2 currently operating and 7 new LNG ships on order



Power Generation

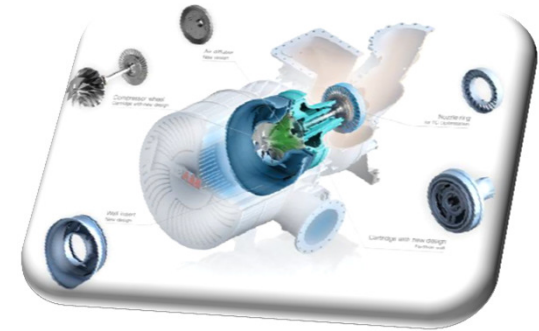
ENGINES



Some examples of Engine Efficiency Projects

- **Dual Fuel engines**

On our recent ships we have fitted dual fuel engines that allows us to run on LNG whilst alongside – we have the world's first large cruise vessel fully powered by LNG being delivered in November 2018



- **Turbocharger Upgrade & Valve Timing**

We have installed high efficiency turbochargers and new camshaft with Miller inlet valve timing to improve engine performance at port load.



- **Receiver Temperature Dew Point Control**

We installed systems to improve the efficiency of the engines by keeping charge air at the optimal temperature.

- **Engine Performance Monitoring**

We have installed equipment that allows us to combine the power and fuel measurements and transmit this data ashore so that we are able to monitor the performance of every engine in the fleet (≈ 500) in real time.



Power Consumption

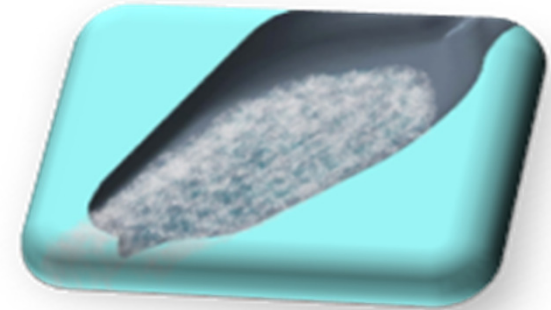
Propulsion



Some examples of Propulsion Efficiency Projects

- **Air Lubrication system**

Air lubrication systems have been fitted to several vessels to provide a bubble carpet to reduce hull resistance.



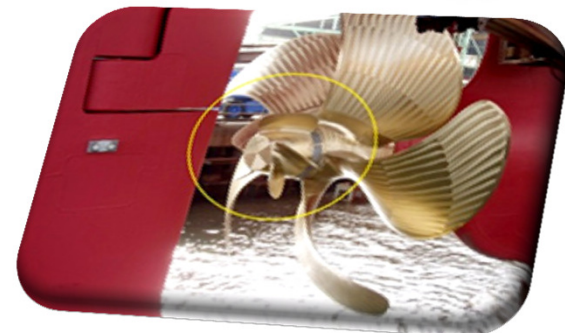
- **Hull Coating**

We are working with all of the major paint manufacturers on analyzing paint performance and constantly trialing new paint schemes.



- **Propeller Boss Cap Fins**

We have 208 propellers across our fleet and we are obviously keen to make them as efficient as possible – one way to improve efficiency has been to fit boss cap fins to 'recover' wasted propulsive energy from the flow.



- **Hull performance monitoring system**

We have a range of hull performance monitoring systems fitted across our fleet that allow us to collect data on propulsive efficiency

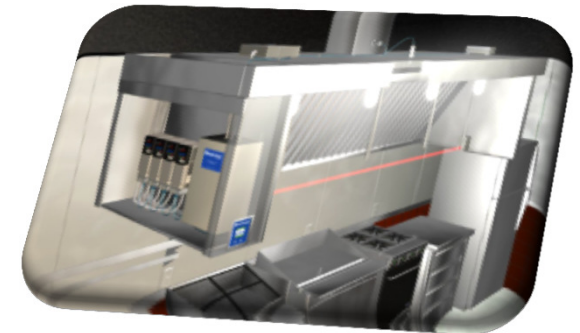
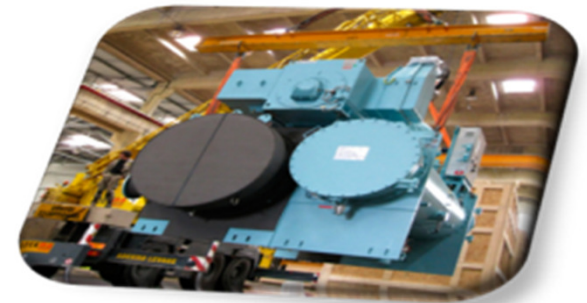
Power Consumption

HVAC



Some examples of HVAC Efficiency Improvement Projects

- **HVAC Automation – Re-circulation mode**
We been fitting advanced HVAC automation with an energy savings feature that allows us to exploit is 'on demand' air flow for public spaces.
- **Chiller Upgrades**
We have had a number of chiller upgrades to improve the efficiency and we have recently been fitting absorption chillers running off waste heat
- **Galley Ventilation system**
Galleys consume large quantities of conditioned air and we have fitted systems that detect smoke, steam, and temperature caused by cooking activity and adjust the fan speeds accordingly
- **Air Handling Units & Chilled Water Pumps**
We have developed a system for remote monitoring of power consumption from all of the air handling units and chilled water pumps on-board which let us continually assess the energy efficiency of the HVAC system



Power Consumption

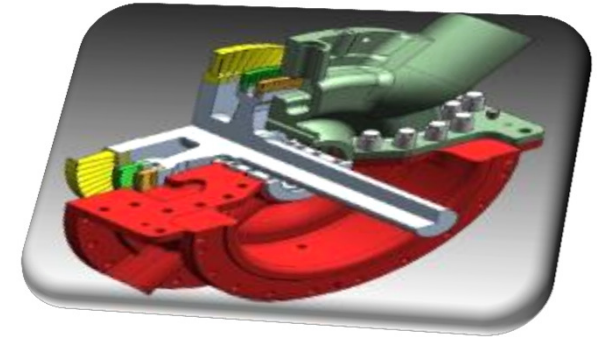
Auxiliaries



Some examples of Auxiliaries Efficiency Improvement Projects

- Waste Heat Recovery

We have fitted some of the most sophisticated waste heat recovery systems in the industry which include exhaust heat recovery steam turbines



- LED lighting

On board our ships we typically have in the region of 50,000 light bulbs and of course lighting is a major power consumer. We have been fitting LED lighting across both public and technical areas to make considerable savings in both lighting power and in HVAC load.



- Fresh water

On board a typical ship we use over 1,000,000 litres of fresh water every day we have a wide variety of measures designed to both improve the efficiency of our fresh water production as well as reducing consumption



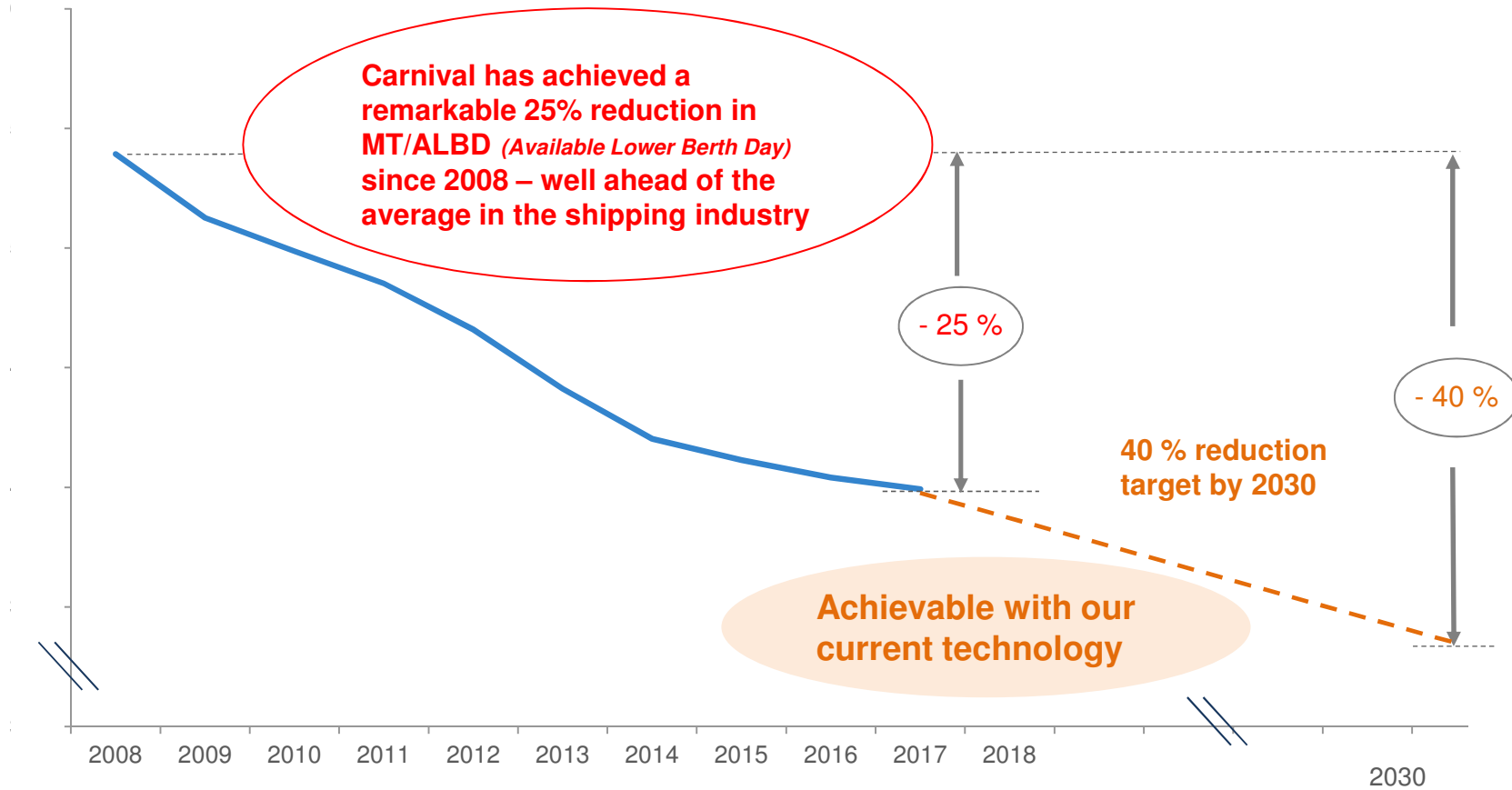
- Consumption Mapping

We have fitted instrumentation for mapping of on-board consumption of electrical power, fresh water and steam which allows us to both influence operational behaviour and target our energy savings capital investment.

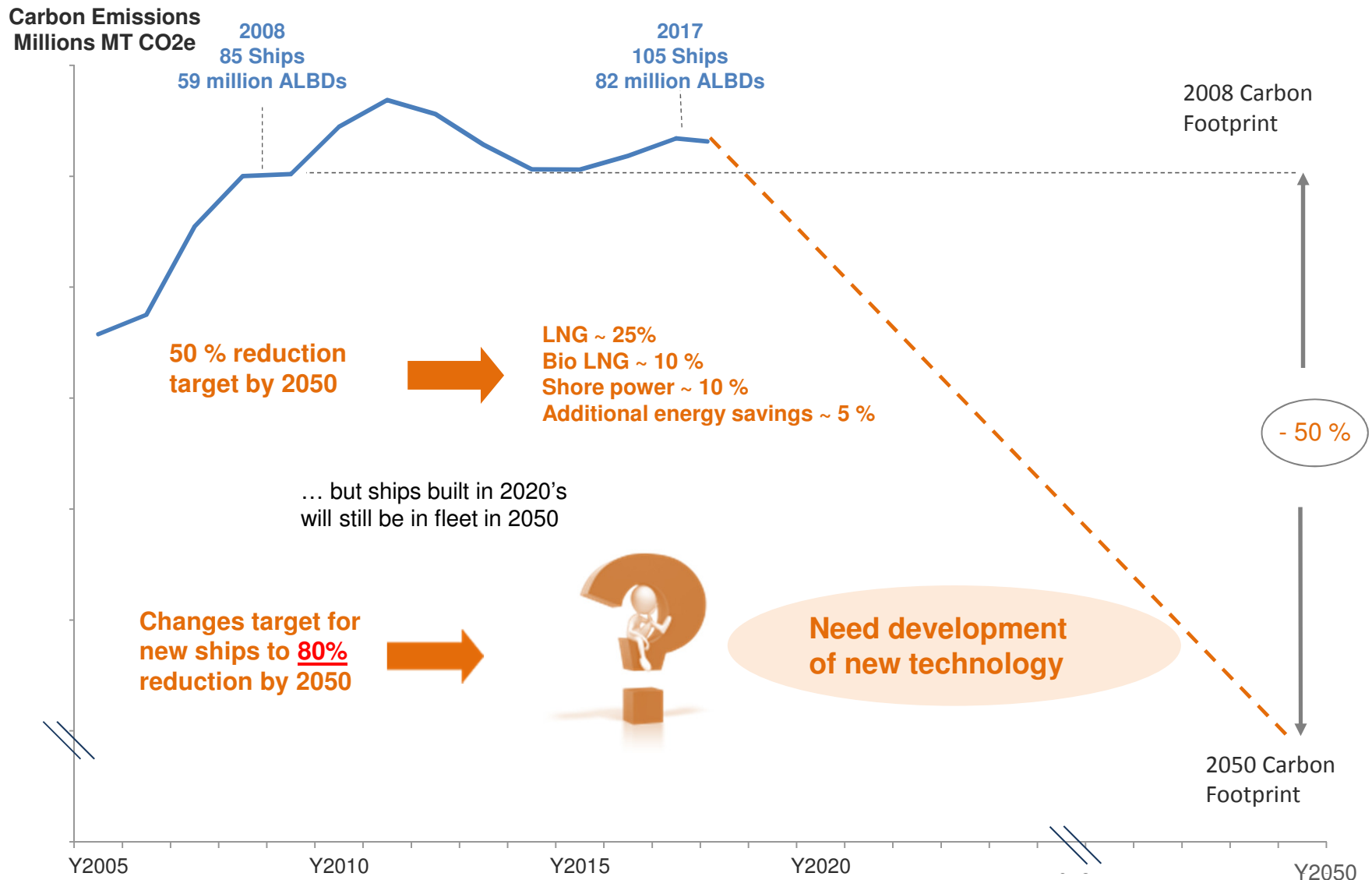


Target 1 : Reduce average unit CO2 emissions (per transport work) by at least 40% by 2030

Fuel Consumed
MT / KALBD



Target 2 : Reduce absolute GHG by at least 50% by 2050 compared to 2008



Research & Development

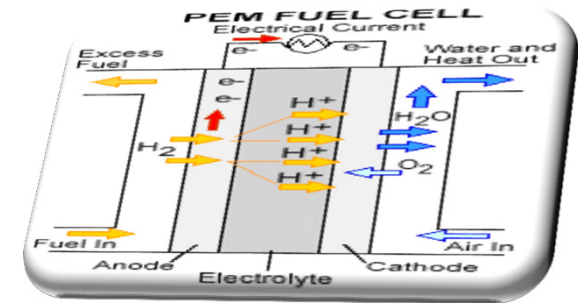
Future Technologies



Some examples of Future Technologies we are exploring

- Fuel Cells

We have a range of on-going projects assessing the feasibility of different technology fuel cells including trial installations



- Batteries / Hybrid

We are currently working with several different equipment suppliers providing feasibility studies and concept designs for potential battery installations on-board our vessels.



- Renewable Energy

We are assessing the viability of possible renewable energy solutions both in the fuel supply chain and on-board our vessels

- Alternative Fuels

In addition to our pioneering work on the use of LNG as a marine fuel in the cruise sector we are continuing to work with major fuel suppliers on feasibility assessments for next generation alternative fuels solutions.



... our most efficient ship



... to date

