

CARNIVAL CORPORATION & PLC'S LIQUEFIED NATURAL GAS VISION

VISION

We at Carnival Corporation & plc are continuously working to reduce our air emissions and improve air quality by evaluating both established and emerging technological solutions.

With less carbon and cleaner emissions, Liquefied Natural Gas (LNG) is one of our solutions. It has zero emissions of sulfur dioxides, and compared to marine diesel oil, has a 95 to 100 percent reduction in particulate matter, an 85 percent reduction in nitrogen oxides and a 25 percent reduction in carbon emissions.

When we considered the environmental benefits of LNG in combination with recent changes in regulatory and supply chain factors, it all aligned in favor of building the world's first LNG-powered cruise ships.

OUR STRATEGY

We began the implementation of our vision by using LNG in port. In 2015, *AIDA Sol* was the first cruise ship in the world to be supplied with power by an LNG Hybrid barge while in Hamburg, Germany. The LNG Hybrid Barge, a unique pilot project with Becker Marine Systems, was designed, constructed and commissioned in three years.

Now we are expanding our LNG capabilities to supply LNG directly to two ships, each with a dual-fuel powered engine. These ships will use LNG while in port drawing fuel directly from trucks alongside the ship.

By the end of 2018, we will be the first cruise company to use LNG on the open sea and in port. We are building four LNG-powered next-generation cruise ships with the first two operated by our European Brands (AIDA Cruises and Costa Cruises). The first of these ships will be in service in late 2018.

SWITCHING FROM MARINE DIESEL TO LNG



Sulfur Dioxide Emissions

95-100%

Reduction in Particulate Matter

85%

Reduction in Nitrogen Oxides

25%

Reduction in Carbon Emissions



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

LNG TECHNOLOGY ON BOARD

Natural gas is converted into liquid by cooling it to -162°C , which shrinks its volume by a factor of 600 and allows it to be transported both efficiently and safely. LNG is odorless, nontoxic and non-corrosive and it is considered the world's cleanest-burning fossil fuel. The fuel will be stored in type C tanks at a working pressure of 0.7 bars. The tanks are located in their own hold spaces and the engine room spaces will be inherently safe, with double-wall pipes used for gas lines and gas control valves located in their own safe spaces. On our LNG fuelled ships, the LNG will be used to power dual fuel, medium-speed, four-stroke engines to run the ship in port and at sea.

One key element was deciding upon the total volume of LNG needed to be stored on board. LNG, when liquefied, has a density that is about half that of conventional fuels; therefore, it does require a larger tank volume than conventional fuel. Consequently, when designing the vessel we needed to analyze the likely itineraries to ensure the optimum arrangements on board. For our first vessels we will be designing the vessel to be able to operate for 14 days between refueling with a combined volume of approximately 3,600 cubic meters of LNG stored on board.





TOM STRANG
Senior VP
Maritime Affairs

REGULATORY FRAMEWORK

As result of regulations recently adopted by the International Maritime Organization, there is a greater push in the maritime industry to build ships that can utilize cleaner burning fuel, such as LNG. The European Union is investing heavily in infrastructure and today we are seeing gas bunkering facilities and terminals being developed in Europe.

With the emphasis on emissions regulation in Northern Europe it is natural to see the drive towards LNG centered in the region and we expect Europe to continue to lead in infrastructure development particularly as the 2014/94/ EU directive comes into force. This directive sets out a program for the building of alternative fuel infrastructure – not only related to LNG – and asks that member states submit their program plans by November of 2016. Mediterranean ports in particular have taken proactive steps based on this directive, and many are looking into the rapid development of LNG-bunkering facilities with a view to catching up with the north. This is helped by the European Union being clear that in 2020, ships will be required to utilize fuel with a maximum of 0.5 percent sulfur in European waters. In the U.S., the LNG-bunkering process is just beginning; low natural gas prices will offset logistics costs and will likely boost sales of LNG bunker fuel in North American ports. In the Asia Pacific region there are currently few sulfur emission regulations to drive the adoption of LNG and the uptake of LNG as a marine fuel is limited. However with Singapore recently awarding licenses for LNG bunkering; the actions being taken in China to reduce emissions by encouraging

significant portions of the inland waterway fleet to change to LNG fuel; and with the renewed interest in emissions regulations seen elsewhere in the region we can expect to see renewed interest in LNG marine fuel usage.



ERIC EVANS
VP Strategic
Sourcing

SUPPLY CHAIN INFRASTRUCTURE

While worldwide natural gas is plentiful and all projections are that this will remain the case for the foreseeable future, it is not however, available everywhere in liquid form. We will need LNG and suitable infrastructure and logistics available in specific locations and with specific quantities.

This is true today, for example, in South Florida, where natural gas is available, but not in liquid form or in the quantities that we will need.

There also remain a number of regulatory hurdles to overcome, as there are no internationally agreed rules for fueling cruise ships with LNG. Overcoming the infrastructure challenges will be essential for our team to be able to deliver LNG to our ships. We are working together with the various stakeholders including local authorities, ports, flag states, classification societies and suppliers to ensure that we have a secure and reliable supply of LNG for the future and to ensure the benefits of LNG are clear to all. To be successful, we will need to take a partnership approach.

LEADING THE WAY

We know that the transition to LNG is no simple task, and the demands – technical or otherwise – associated with its implementation make it something of a milestone both for Carnival and the wider cruise industry. Having delivered on our vision of using LNG in port, we now look forward to launching our first next-generation cruise ships to be powered by LNG on the open sea starting in late 2018.



*AIDAsol and LNG-Hybrid Barge
in Germany 2015.*