# NORWAY: A Look at Recent LNG Marine Fuel Developments


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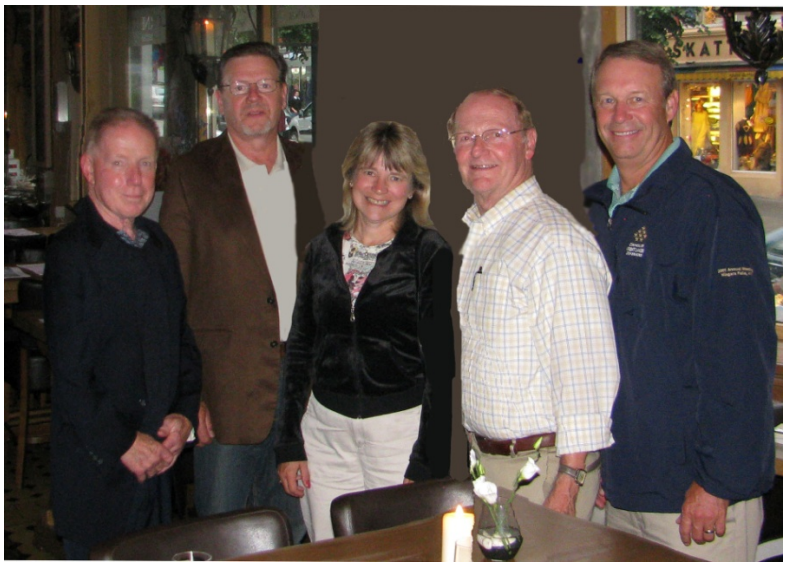
## with support from Randolph Helland and Carol Wolosz


On August 12-18, 2012, a team of five representatives from the Great Lakes Maritime Research Institute (GLMRI) were able to visit Norway to observe the development and use of Liquefied Natural Gas (LNG) as a marine fuel in non-LNG cargo vessels. Since the use of LNG as maritime fuel is new in the United States, it was important to learn from countries that have successfully implemented this technology. Over the past decade, Norway has built natural gas powered ferries and are currently building additional natural gas powered vessels to support the North Sea oil and gas industry. This initiative was undertaken in part because of the strict emission standards in Europe and the establishment of Emission Control Areas. Further, the European Union (EU) has embarked on an approximately $14 million study on converting vessels operating in the Baltic and other Emission Control Areas to using natural gas as a primary fuel.

While the supply chain infrastructure for LNG is a concern to the Norwegians, it has grown substantially over the past decade. The maturity of the supply chain infrastructure along with an abundant source of natural gas positions them well to expand this technology.



GLMRI LNG Team (from left to right): Steam Conversion Project Consultants Richard Harkins and Patrick O'Hern, GLMRI Executive Director Carol Wolosz, Steam Conversion Project Principal Investigator Michael Parsons, and GLMRI Consultant Randolph Helland (CAPT, USCG, ret).

The goals of the GLMRI visit were to observe the propulsions plants of vessels with both single fuel LNG and dual fuel LNG and Marine Diesel Oil (MDO) gas engines and discuss LNG marine fuel developments with representatives of the building shipyards, operating companies, engine manufacturers, classification society and national regulators. The trip was based in Bergen, Norway, and included side visits to Halhjem, Alesund, Ulsteinvik, Haugesund and Oslo. Members of the team were able to accomplish the following:

- Tour the Rolls-Royce factory building and testing single fuel LNG gas engines in Bergen, Norway
- Tour the single fuel LNG engine propulsion plant onboard the operating Fjord1 ferry *MV Raunefjord*
- Observe refueling of the LNG supply tanks at the Halhjem, Norway ferry terminal from truck
- Observe the LNG bunkering of the *MV Raunefjord* at the Halhjem, Norway ferry terminal
- Tour the dual fuel LNG engine plant onboard the nearly completed Eidesvik platform supply vessel *Viking Princess*
- Meet with Norwegian Maritime Authority personnel who regulate Norwegian LNG vessels in Haugesund, Norway
- Visit the Kleven Verft shipyard, Ulsteinvik, Norway, during the final weeks of building the *Viking Princess*
- Visit the Fiskerstrand shipyard, near Alesund, Norway, builder of the latest Fjord1 single fuel LNG ferry *MV Boknafjord*
- Meet with Det Norske Veritas classification personnel involved in LNG vessel development and approval in Oslo, Norway.

The Norwegian hospitality and openness was outstanding and the visit was able to accomplish all goals and exceed expectations. The team is indebted to the U.S. Maritime Administration (LNG Study project sponsor), the many organizations and individuals who assisted in the planning of this visit and those who met with the team during the visit.

The team was able to ride and tour the propulsion plant of the ferry *MV Raunefjord* operated by Fjord1during transits between Halhjem and Sandvikvag, Norway. Three LNG fueled ferries delivered in 2006 and 2007 now operate on this critical link along Norwegian highway E39 between Bergen and Stavanger. These double-ended ferries are 129.8 m long with a capacity of 212 cars, 22 trailers, and 587 passengers. They are equipped with integrated electric plants with a dual propeller (pusher and puller) rotating thruster located at each corner of the hull. They can make 21 knots on three thrusters and 23 knots maximum using all four. The ferries have Rolls Royce Bergen single fuel LNG gas engine generator sets with a total capacity of 6180 ekW. They are built using the classification society Det Norske Veritas emergency shut-down safety design concept since these early engines did not have double-wall piping all the way the cylinder heads.

Single fuel LNG ferry *MV Fanafjord*, sister ship of the *MV Raunefjord*, underway


Dual fuel LNG Platform Supply Vessel *MV Viking Princess* at Kleven Verft shipyard

Vessels toured during GLMRI LNG visit to Norway

Team members were able to observe the transfer of LNG from a road truck to the two 500 $m^3$ dedicated shore storage tanks at the Halhjem ferry terminal. It was note worthy that these tanks were located only a few feet behind a resort marina. Transfer was accomplished during normal daytime hours. They were also able to observe the bunkering of the *MV Raunefjord* from these tanks later that night. Bunkering was undertaken at night so that no vehicles or passengers would be onboard at the time.

Dedicated 500 $m^3$ LNG storage tanks at ferry terminal in Halhjem, Norway


Resupply of LNG storage tanks from a road truck

The steam conversion project team members were also able to tour the propulsion plant of the nearly completed Eidesvik Platform Supply Vessel *Viking Princess* in the Kleven Verft shipyard. The vessel was christened by the Crown Princess of Norway in Bergen September 14, 2012, five weeks after the visit, and is now supplying platforms in the North Sea. The vessel is 89.6 m long with an integrated electric plant supplied by two Wärtsilä dual fuel 6L34DF generator sets and two smaller Wärtsilä dual fuel 6L20DF generator sets. These four generators produce a total output of 7332 ekW. The vessel already had LNG onboard and was operating one of its smaller dual fuel generators on MDO for shipboard power at the time of the visit. The ship is equipped with two rotating dual propeller thrusters aft and two bow thrusters and an azimuthing thruster forward for use in dynamic positioning. The *MV Viking Princess* was built using the Det Norske Veritas inherently safe engine room design concept since these engines have double-wall piping all the way the cylinder heads.

The primary government agency that has jurisdiction over commercial shipping is the Norwegian Maritime Authority (NMA). NMA has similar authorities to the U.S. Coast Guard in that they are responsible for ensuring Norwegian vessels meet the highest level of safety and environmental standards, that mariners are properly qualified (licensing), and that foreign ships that enter Norwegian ports and territories meet applicable international rules.

Norway adopted IMO Resolution MSC 285(86), Interim Guidelines For Gas-Fuelled Engine on Ships and all Norwegian flagged ships must comply with those standards. Specifically, regulation No.1218 of 9 September 2005 addresses construction and operation of gas-fueled passenger ships (more than 12 passengers) and Regulation No. 644 of 17 June 2002 addresses cargo ships with natural gas fueled combustion engines. For other ships (entitled Unclassified ships), gas related matters not regulated by NMA are to comply with Det Norske Veritas (DNV) rules currently in force for gas-fueled engine installations.

Wärtsilä dual fuel 6L34DF generator set onboard the PSV *Viking Princess* with double-walled gas supply line in yellow

Steam Conversion Project Consultant Richard W. Harkins in LNG storage tank room in the *MV Viking Princess*

The agency responsible for LNG facilities (storage tanks and liquefaction plants) as well as the bunkering process from shore to ship (or barge) is the Directorate for Civil Protection and Emergency Planning (DSB). Recognizing that two government agencies have jurisdiction over the bunkering process, there has been significant coordination between NMA and the DSB to standardize the requirements for LNG bunkering since both agencies have regulatory jurisdiction. Both agencies are looking at developing a standardized risk assessment process and implementing a safety work permit (similar to the Coast Guard Declaration of Inspection for transfer operations).

Norway has been very successful in encouraging the maritime industry to invest in NOx reducing technology. The main driver for this initiative is the environmental requirements mandated by MARPOL as well as the Baltic/North Sea limitations on nitrogen oxide emissions. Starting in August 2012, the Baltic Sea and North Sea as well as North American coasts and Great Lakes are regulated as Emission Control Areas (ECA), limiting the amount of nitrogen oxide emissions. MARPOL Annex VI requires NOx reduction to meet Tier II requirements (20% reduction) by 2011 and Tier III requirements (80% reduction) by 2016.

While the use of LNG fuel involves new, higher technology and additional safety considerations, the use of LNG as a marine fuel for non-LNG cargo vessels is now part of normal marine practice in Norway following the introduction of the ferry *MV Glutra* 12 years ago.

Note: Adapted from an initial, shorter version that appeared in *Great Lakes/Seaway Review*, Vol. 41, No. 2, Oct.-Dec. 2012.