GASVESSEL Project

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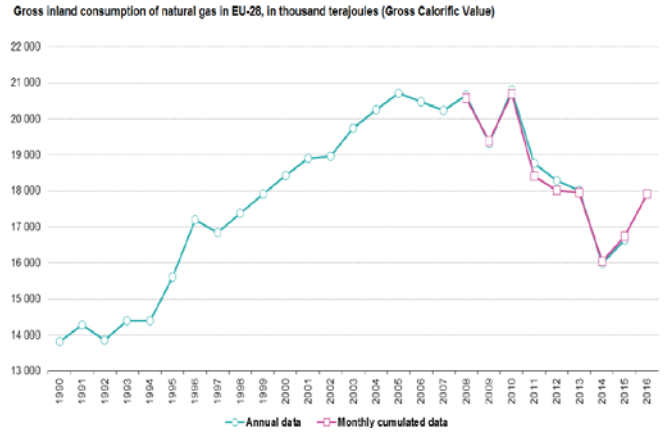
Preamble

- EU consumption of Natural gas is increasing



- EU dependency on imported Gas in 2014 was 70% (40% by one single supplier)

- There are huge amounts of stranded* gas and associated** gas which is not used or wasted (flared)

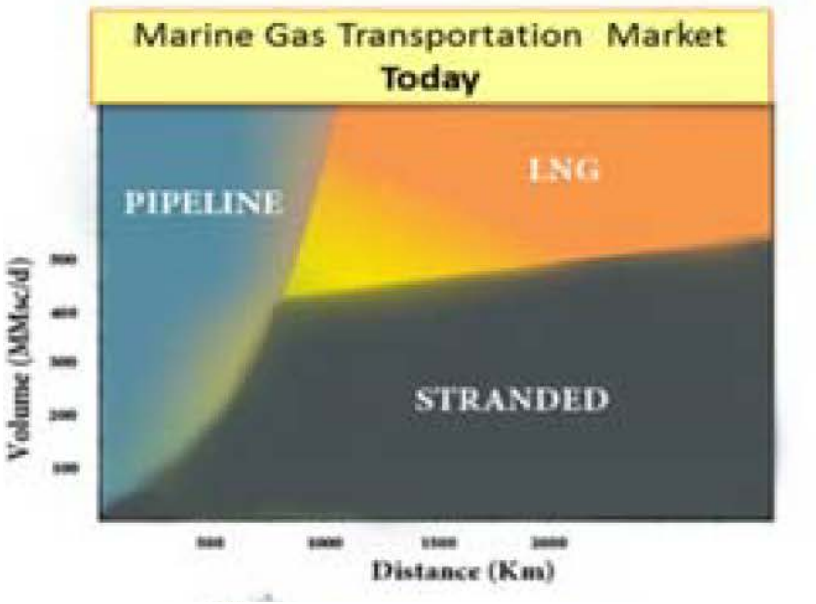
*natural gas field that has been discovered, but remains unusable for either physical or economic reasons

**natural gas found extracted together with oil as a byproduct

Flaring in Russia, Nigeria, Iran, etc.

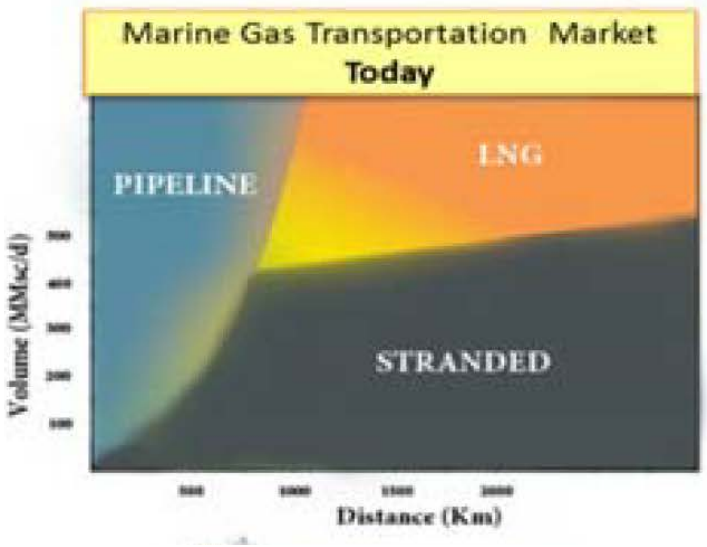
Scenario 1 / 4

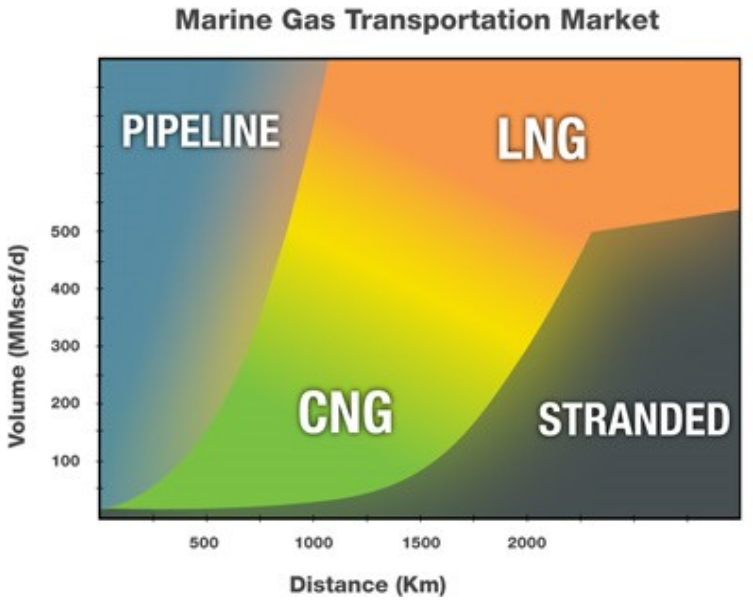
- 30% to 60% of the world's natural gas is "stranded"



- Abscissa: distance between gas reservoir and the end user
- Ordinate: volume of recoverable gas

Scenario 2 / 4

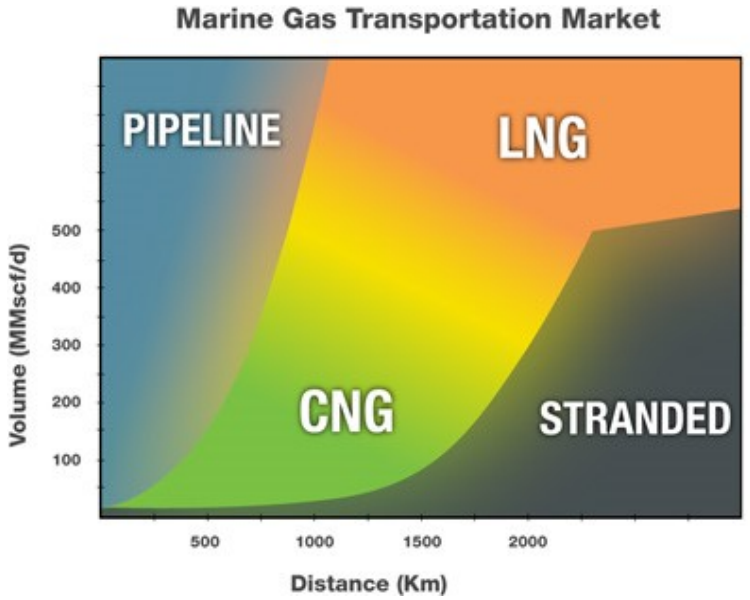




- Big reservoir / distance LESS than 1000 km → pipeline
- Big reservoir / distance MORE than 1000 km → LNG carrier

- Limited reservoir / distance less than 1000 km → no proven technology economically viable at the moment
- Containment vessels too small and too heavy

Scenario 3 / 4



The scope of the GASVESSEL Project it to remove the technological barriers that prevented the Operators from putting in place an organized and cost-effective transport of the stranded, associated and flared gas.

The new technology is based on very large cylinders (ID 2-3 m, LOA=11.5-30m, pressure 300 bar)

Very small weight / Very high capacity → economically interesting

- A new class of CNG ships (new or converted)
- Loading/unloading facilities
- Transported gas → pressure reduced to existing onshore gas distribution net

Scenario 4 / 4

The GASVESSEL solution is a ‘gas ferry’ concept where ships will sail back and forth between the offshore supply site and the harbour site thus providing a stable gas supply solution.

GASVESSEL technology mature → everyone benefits

- Gas Producers: monetize underdeveloped fields by eliminating or reducing flaring and sell the gas

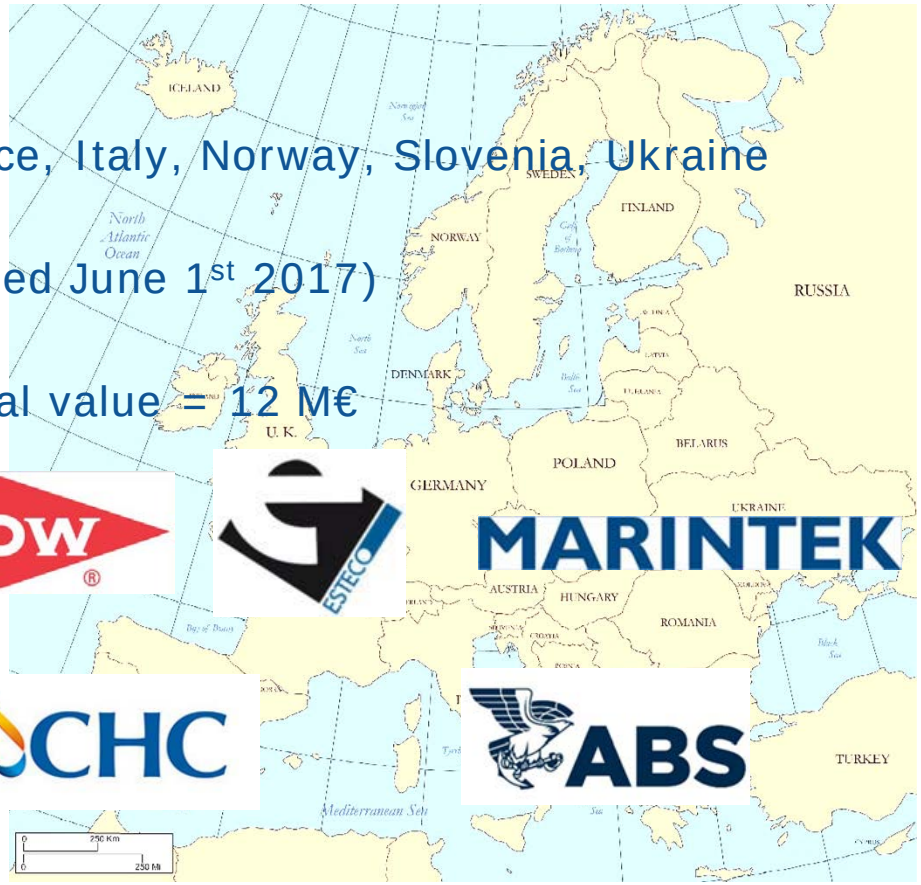
- Countries: reduced dependency on oil, convert old power plants to gas-fired power generation

- «Home» users: reduced energy costs and reduced CO2 emissions

European Commission

General Info 1/2

- CONSORTIUM formed by 13 Partner Companies
- 8 Countries represented:
  Belgium, Cyprus , Germany, Greece, Italy, Norway, Slovenia, Ukraine
- Project duration: 48 months (started June 1st 2017)
- EU contribution = Project's financial value = 12 M€



Research and Innovation

General Info 2/2

- Project coordinator NAVALPROGETTI SRL – Trieste – Italy

Research activities Coordinator and Project Manager.
Design of the prototyping pilot line and ship design.
Interface with the European Commission.

- CNGV doo – Izola – Slovenia.

Designer of the gas cylinders

Designer of the equipment and machinery required to fabricate and test the prototypes.
Holder of the national and international patent of the gas cylinders technology.

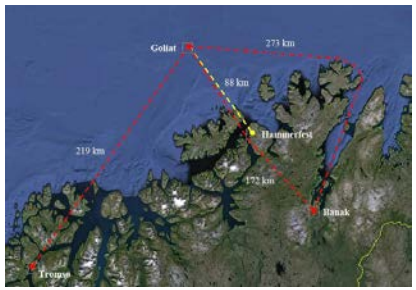
- AMERICAN BUREAU OF SHIPPING (ABS) – Greece.

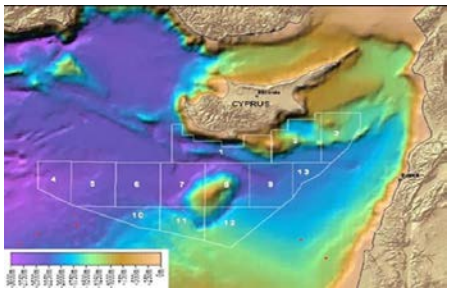
Authority for the approval and certification of the CNG cylinders and ship design package.

Reference body ruling the processes of risk analysis, HAZID, HAZOP, Quantitative Risk Assessment (QRA) and General Design Approval (GDA)

Project development 1 / 5

- Analysis of 3 real-life geo-economical gas exploitation scenarios (East Mediterranean, Goliat Barents Sea, Black Sea)





- Mathematical model to optimize
  - Ship carrying capacity
  - Nr of ships
  - Ship main design parameters
  - Pressure vessels dimensions (diameter and length)
  - Transportation tariff

Project development 2 / 5

- Design of Pressure Vessels

  PATENTED+ABS AIP ultra-thin stainless steel+carbon/glass

  300 bar (70% lighter than any other previous technology)

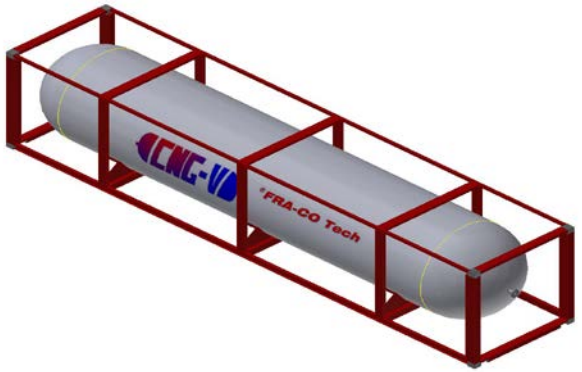
  Optimization process

- Pre-industrial Prototyping Pressure Vessels

Custom built/self designed facility in Italy

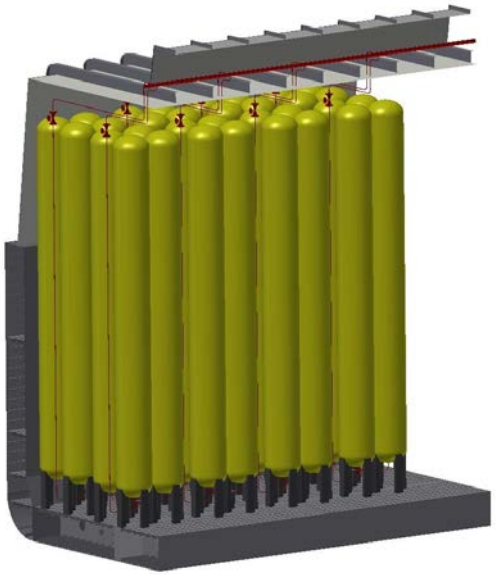
Tests on LOA= 8.0 m, diameter 2.5 m

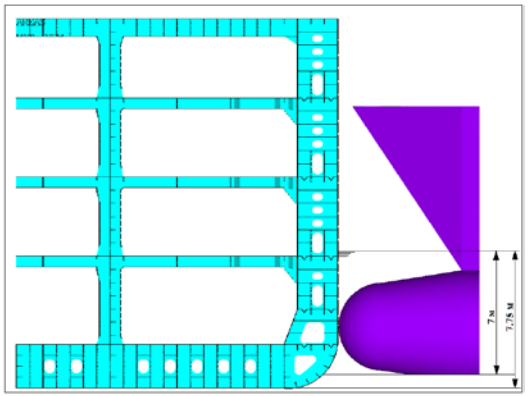
Results valid for LOA=11 m (40' Container)



Project development 3 / 5

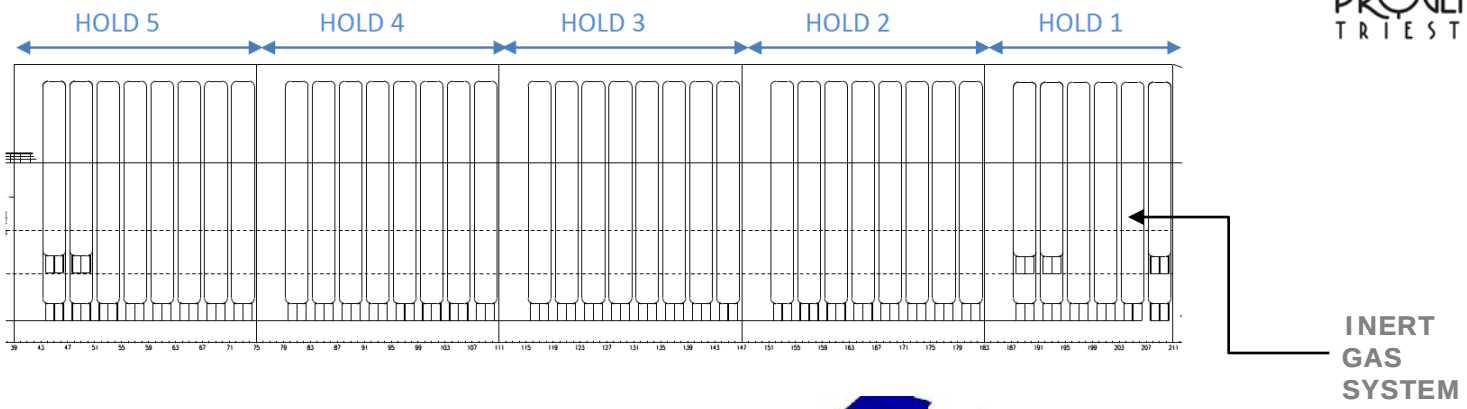
- CNG Ship Design (AIP from ABS covering concept and safety)

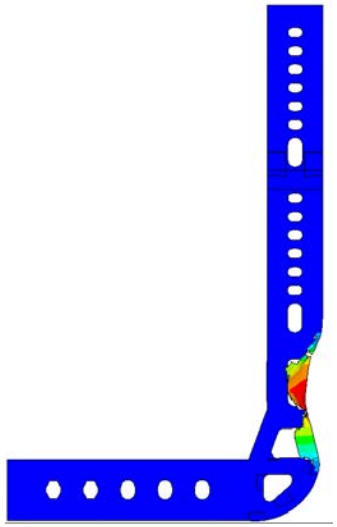


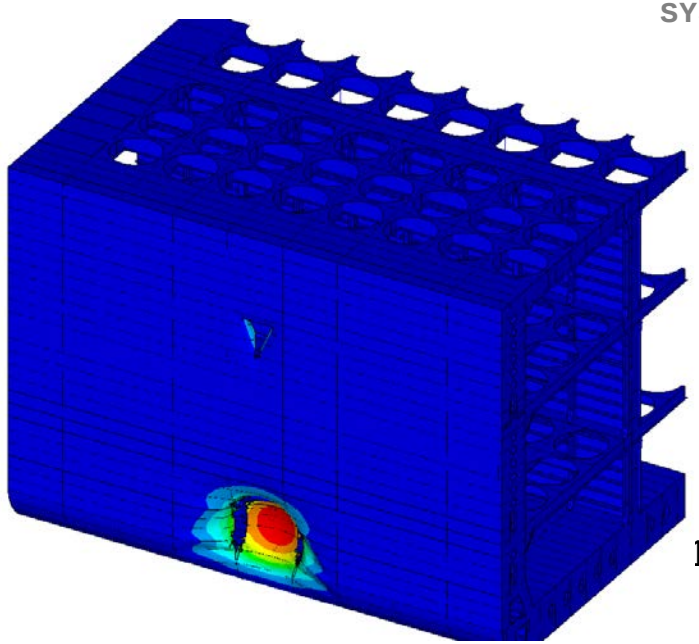


Project development 4/5

- CNG Ship Design (AIP from ABS covering concept and safety)







Project development 5 / 5

- Environmental assessment and safety assessment

  Assessment of Life-cycle flows (economic and environmental flows)

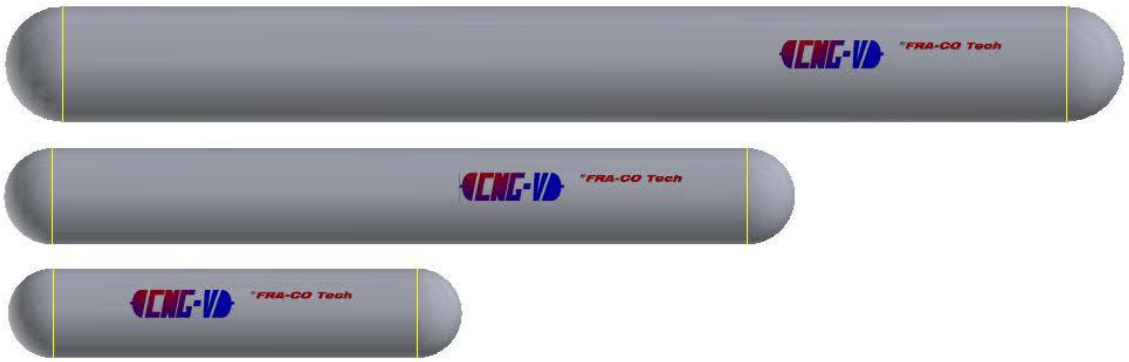
  Reductions of emissions vs new emissions vs non-exploitation of the identified stranded and associated gas

- Class design review - Safety Assessments (ABS)

  Support on the development of a safe and efficient design

  Surveyors will attend the construction and the testing of the cylinders for certification.

The CNG vessel



- Austenitic stainless steel liner (very thin)

externally reinforced with a composite made of carbon and glass fiber, impregnated with epoxy resin.

- DOW/ DOW AKSA are into the Consortium

- Characteristics: 250/350 bar / ID=2-3 m / LOA=11.5-30 m

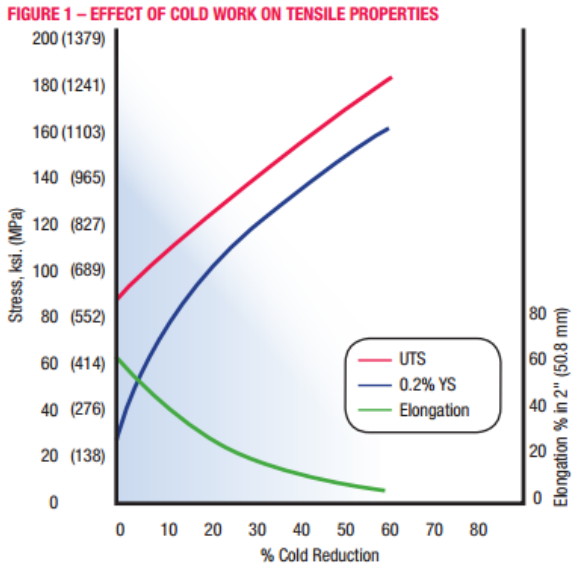
The CNG vessel

AUSTENITIC STAINLESS STEEL LINER

most common and familiar types of stainless steel / 16-25% chromium

extremely formable (low yield strength compared to carbon steel, 200 MPa)

extremely strong by cold work (up to 2000 MPa)

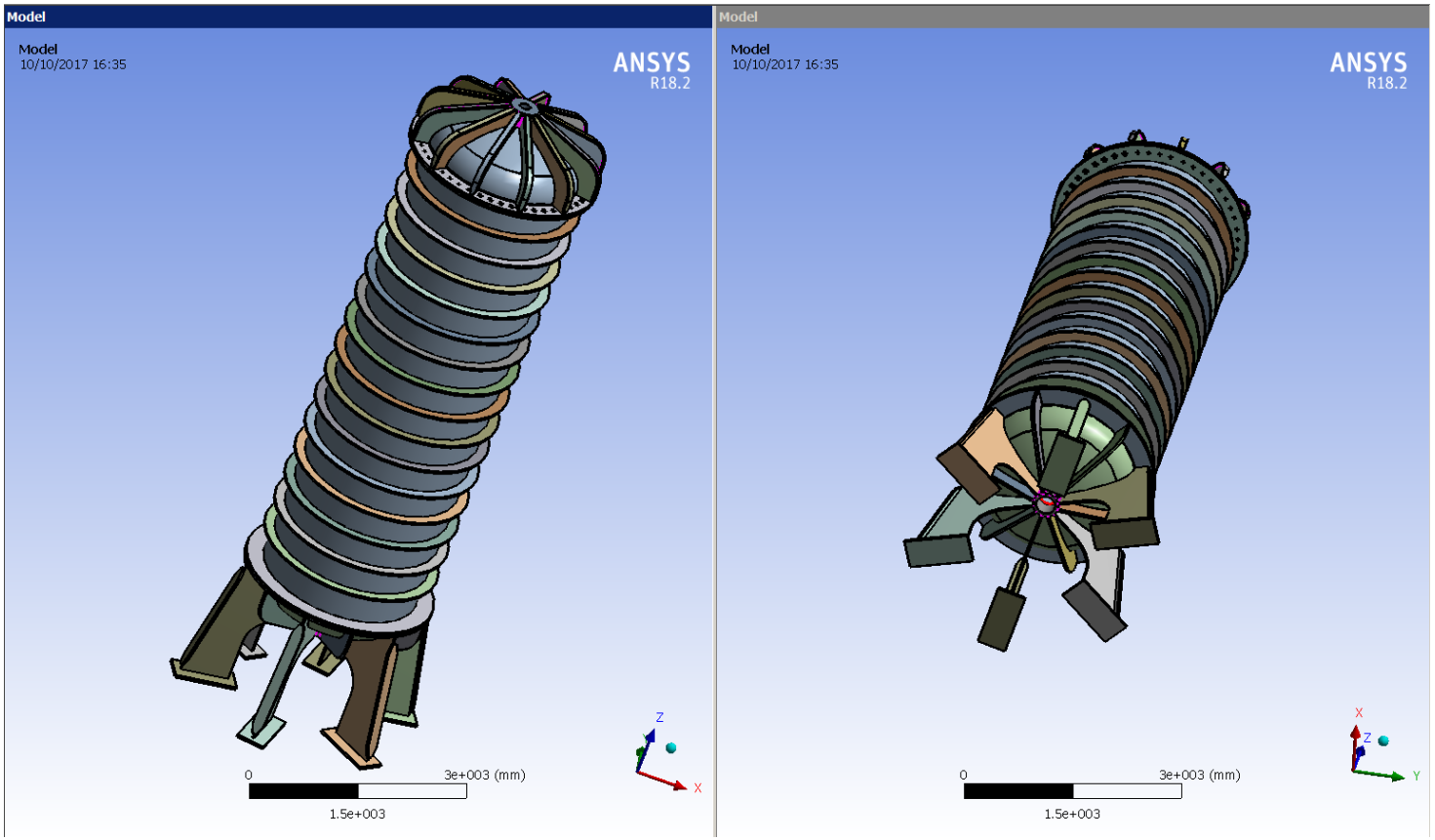


- Cold forming is achieved through hydroforming
- Liner inserted into a mold, high pressure water pumped inside the liner, liner leans against the mold
- Innovation reduced thickness of liner. Lower production cost, lower weight and increased capacity.

The CNG vessel

AUSTENITIC STAINLESS STEEL LINER

Design of the mold



The CNG vessel

AUSTENITIC STAINLESS STEEL LINER

- Hydroforming increases fatigue resistance
- Material tests in progress: tensile, fatigue and resilience (welded and un-welded areas)
- Excellent weldability
  Mechanical characteristics maintained also in the areas interested by the welding
- Great resistance to corrosion
- Great behavior in extremely cold or hot environments
- The relatively low Young's modulus is beneficial when the steel is used in combination with carbon fiber glass and resin

The CNG vessel

AUSTENITIC STAINLESS STEEL LINER

- FEM analysis

300 bar

- Patented Technology PCT/IB2015/050668

- Approval in principle from ABS

ABS

Ref.: TASK#: T1265825
Project# 3374211
Date: 15 April 2015

Certificate of Approval in Principle

As requested by:

NAVALPROGETTI SRL, Italy

ABS has reviewed documentation as specified in ABS letter dated 15 April 2015 for:

New Compressed Natural Gas (CNG) Containment System

and found the system to be satisfactory with respect to the intent of the following:

1- ABS Guide for Vessels Intended to Carry Compressed Natural Gases in Bulk, April 2005 (Updated Feb. 2014)
2- ABS Guidance Notes on Review and Approval of Novel Concepts , June 2003
3- International Standard for Gas cylinders – Refillable composite reinforced tubes of water capacity between 450L and 3000L – Design, construction and testing (ISO 11515:2013)

subject to compliance with the comments in the above letter and the Rules. All drawings, calculations, test reports, and certificates for components are to be found acceptable to ABS for issuing this certificate.

Dimitrios G. Kostaras
Vice President of Engineering
ABS Europe Division

By:
Lucio Trevisan
Senior Managing Principal Engineer

ABS CORPORATE, Technology

Yung S. Shin,
Head of Cargo Containment Systems Group

Note: This certificate evidences compliance with one or more of the rules, Guides, standards or other criteria of American Bureau of Shipping or a statutory, industrial or manufacturer's standards and is issued solely for the use of the Bureau, its committees, its clients or other authorized entities. Any significant changes to the aforementioned product without ABS approval will result in this certificate becoming void. This certificate is governed by the terms and conditions in the ABS Rules.

Expected Achievements

- Main goal:
  prove the viability of the CNG concept
  offer to the market a customizable technology package composed by the pressure vessel and the ship design

- Introduction of CNG transport at competitive costs where pipeline and LNG is not economically attractive

- Secure and affordable energy supply for Central and South East Europe (Southern Gas Corridor)

- Europe less dependent on gas import

- Supply natural gas to places where natural gas is not part of the energy supply (regassifiers not feasible or internal area [ex. Russia])

…after the project

- GASVESSEL concept is expected to open-up important business opportunities for European industry from shipbuilding, shipping, pressure vessels manufacturers, epoxy resin and carbon fiber manufacturers as well as oil and gas and energy production companies
- Perspective of initially 1 – 2 fully operational CNG ships by 2025
- GASVESSEL project will reduce or stop the flaring of associated gas
- Substitution of coal by natural gas would help to further reduce air pollution, providing immediate public health and environmental benefits

Thanks for Your Attention

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