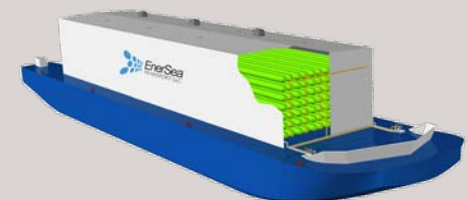


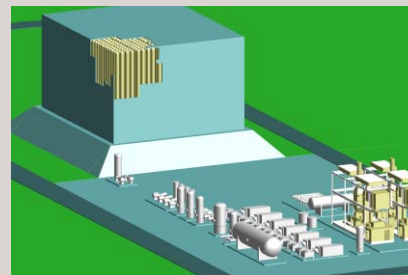
# Solutions for Flaring & Venting CNG Marine Transportation

Paul BRITTON



# EnerSea Introduction

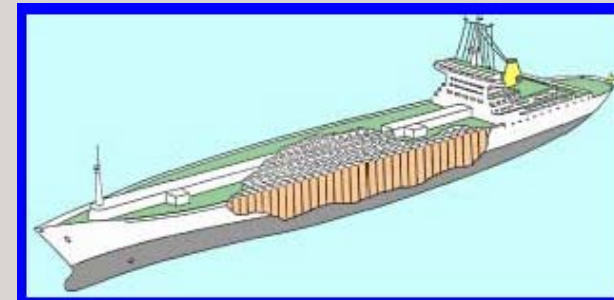
- Gas Transport and Storage service provider
- Proprietary CNG system
- World class partners & business relationships
- Access to capital for large projects



# CNG – Proven Technology

- 1967-70
  - Initial CNG Ship Service
- Since 1970's
  - CNG Land Transport
- Since 1980's
  - Public & Commercial Vehicles

Columbia Gas



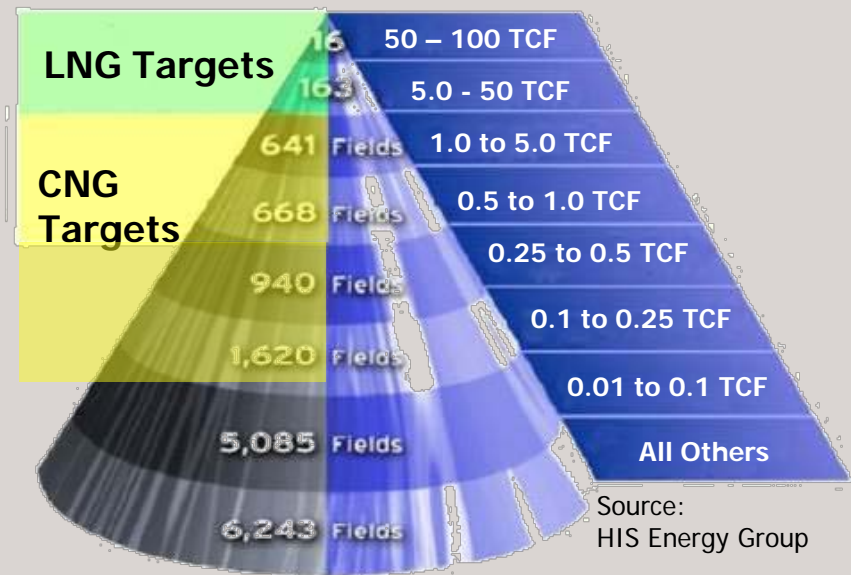
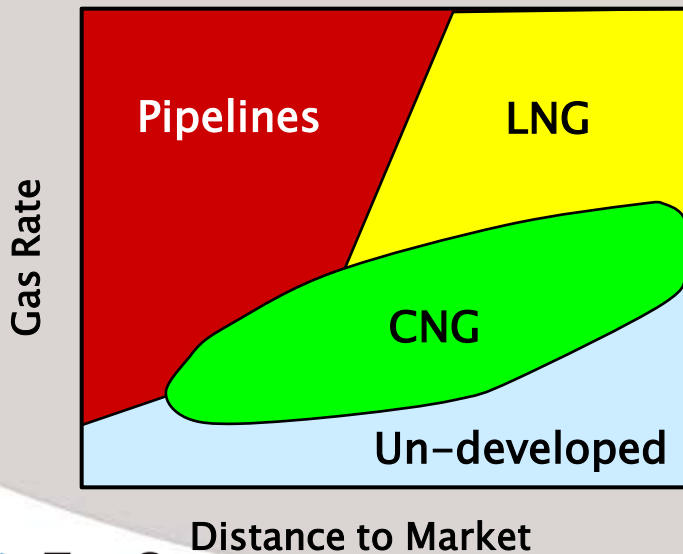
CNG Trucking



CNG Vehicles – Worldwide

# Resource Sector for Marine CNG

- Develop smaller undeveloped reserves
- Highly Scalable solution to suit variable gas profiles
- Market solution for power generation currently burning diesel or fuel oil
- Create value from flared gas as supplemental LNG feedstock



Distribution of World's Gas Fields by Size

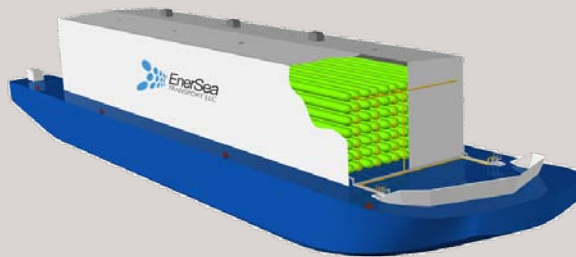
# Certified for Project Deployment

250 – 1,000 MMscf

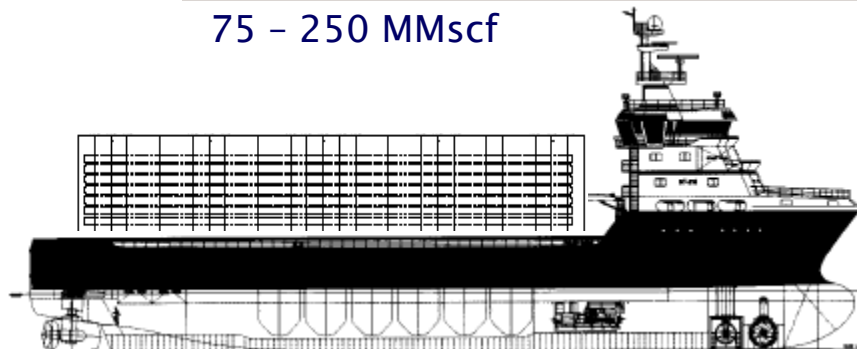


Developed design & operating plans with "K"Line and HHI

25 – 75 MMscf



75 – 250 MMscf



April 16, 2003

EnerSea Transportation LLC  
3555 Timmons, Suite 650  
Houston, Texas 77027

**Attn:** Mr. Charles White  
Vice President - Technology

**Subject:** Class Approval in Principle for:  
75,000 CBM CNG Carrier  
291x 50x 27.4 M

ABS has reviewed documentation on CR-ROOM provided by EnerSea on 28 February 2003 for a Compressed Natural Gas (CNG) Carrier. This has been provided for review in accordance with ABS proposed work scope by ABS in "A Program to Establish 'Class-Approval in Principle (AMP)' for New CNG Vessel Design dated 25 February". All elements requested for review are in the proposed work scope. Key elements evaluated for the CNG concept are:

- 1) CNG pipe tank including nozzle (up to first welded joint)
- 2) CNG cargo tank (24 pipe tanks with header assembly)
- 3) Cargo containment system (100 cargo tanks)
- 4) CNG cooling and warming system and process equipment
- 5) Loading and unloading of CNG
- 6) Structure in cargo block
- 7) Insulation for Z-Pack, cargo piping, and heating system if necessary for ball structure
- 8) HAZID, HAZOP and other special studies.

ABS Approval in Principle is a process by which ABS issues a statement that the proposed novel concept design complies with the intent of ABS Rules and IGC code as applicable, subject to a specified condition. In order to achieve the Class-AP, the proponent must identify all hazards related to the concept and compare them with existing marine practice to show that the risk created by novel concept is comparable to existing marine practice and would not pose any additional hazards.

The proposed CNG Ship design must be considered novel in that it differs in several key areas from any of the conventional LNG, LPG Carriers that are trading today. These key areas include but are not limited to, the following:

- ◆ Pressure and Temperature of the Gas Carried
- ◆ Cargo in Gaseous state
- ◆ Method for loading and off-loading the cargo
- ◆ Extent of gas handling equipment on board
- ◆ The type C containment system

ABS PLAZA 1000 NORTHCHASE DRIVE, HOUSTON, TX 77060 USA  
TEL: 281 871 6000 FAX: 281 871 6001 EMAIL: abs@abs.org

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3. HAZARD Register is to be maintained to confirm that any necessary mitigation provided will satisfy the intent of the International Maritime Organization (IMO) Formal Safety Assessment Guidelines, the terms of the International Gas Code, and ABS Rules and Guides. This is to include hazards identified by current studies and those requested.

4. EnerSea performs and ABS is to witness Pipe Tank tests as well as material fracture toughness tests and pressure tests to support the Pipe Tank design. The results are to confirm the limit state assessment of the Pipe Tank. ABS requests documentation of all the special equipment for NDE, and any special fabrication techniques.

5. EnerSea performs and ABS is to witness model tests to demonstrate the instrumentation and flow of fluids. Full scale gas trials are required for classification of the ship.

The CNG Carrier could be classed in accordance with ABS Rules and receive a class certificate when built. ABS recommends that the concept be discussed with administrations to assure that any special concerns that they may have are properly evaluated and incorporated in the final design.

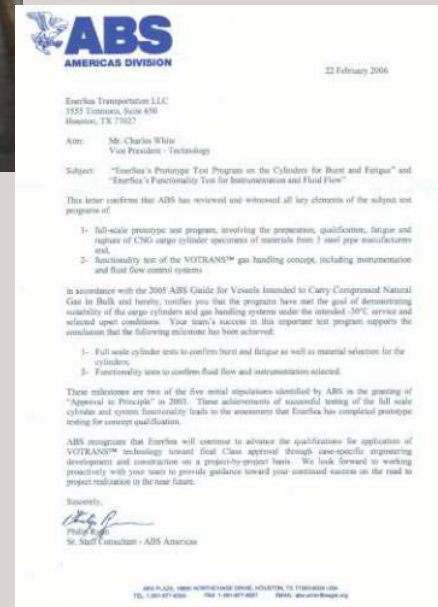
cc: K. Richardson, B. Lind, P. Rym, H. Patel

# Prototype Testing: ABS Approved

- 10 full-scale cylinders tested:
  - Nippon Steel, JFE and Sumitomo qualified
  - Burst pressures > 2 x operating pressure
  - Fatigue cycles > 3 x vessel life
  - Temperatures at -30°C and -50°C

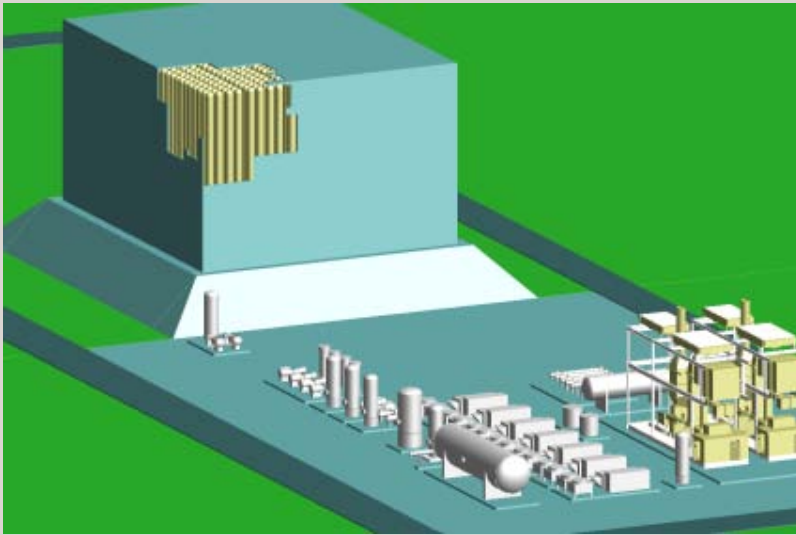


- Gas handling system tests:
  - Loading
  - Unloading
  - Abnormal and Upset conditions
  - Programming logic & controls



# VOLANDS Storage: Market

- High cyclability to meet daily demand
- High volumetric storage and delivery efficiency
- Provides ratable deliveries for power generation



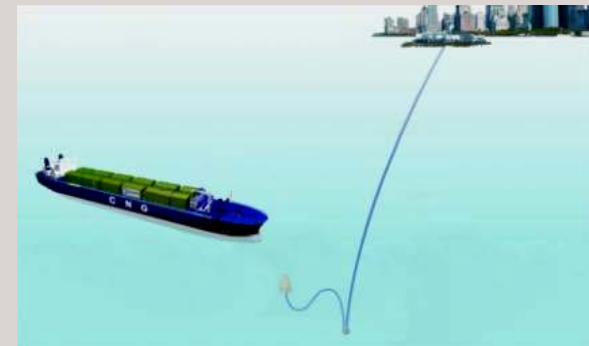
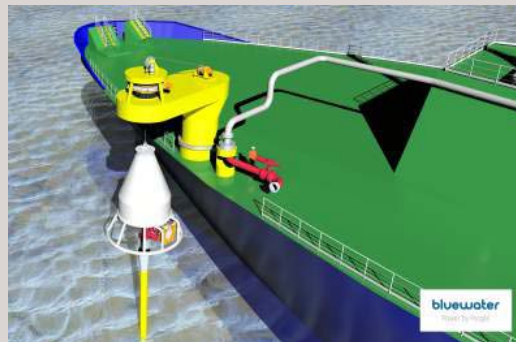
Vertical Configuration



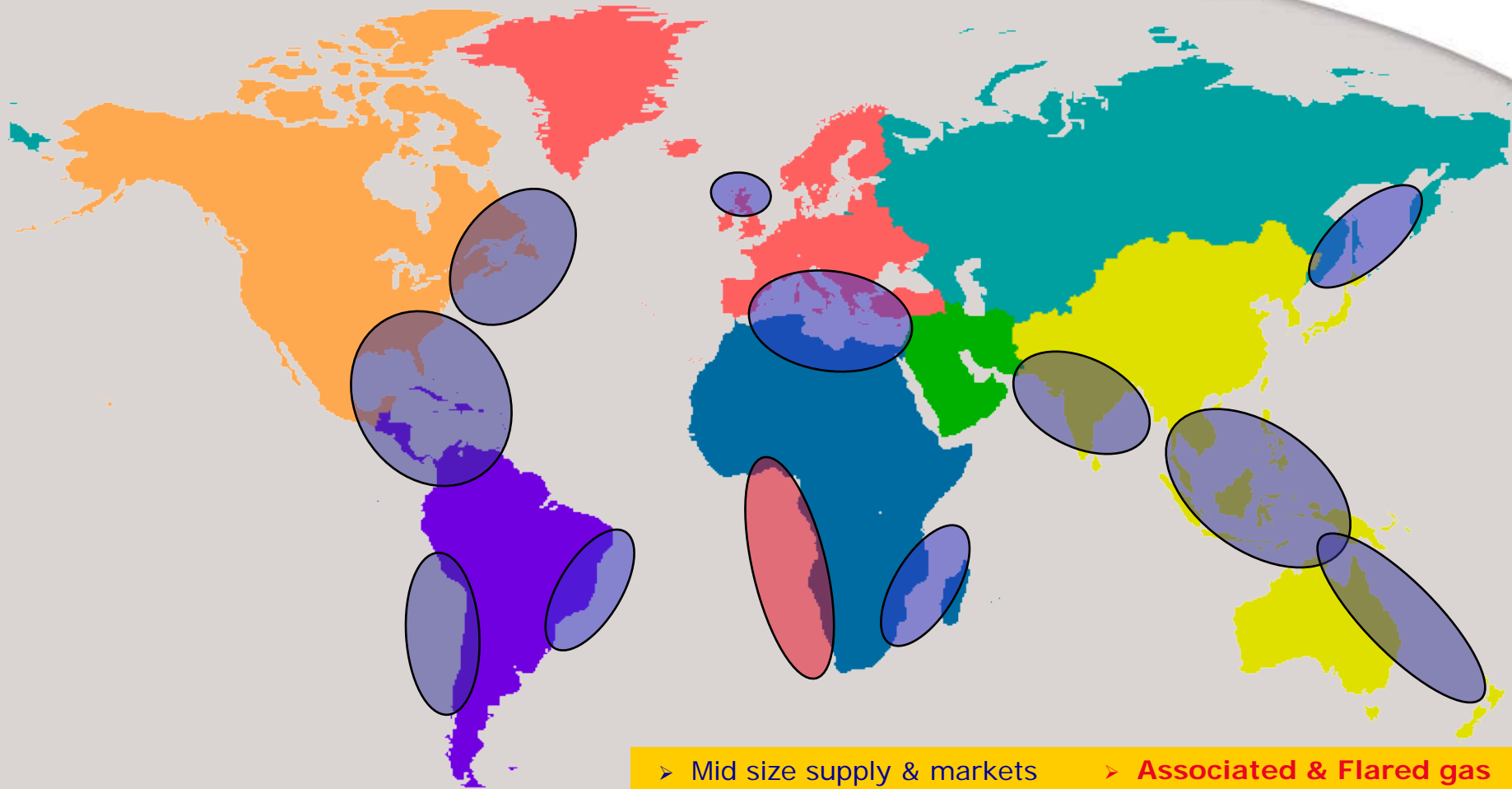
Horizontal Configuration

# Proven Terminal Equipment

- Traditional port or offshore terminal options
- Buoy systems well established in oil & gas operations
- Proven & reliable systems in North Sea adapted for CNG
- Dual buoys for uninterrupted production
- Verification through Logistics & Reliability analyses



# Regions Actively Investigating CNG Projects



- › Mid size supply & markets
- › Medium haul
- › Dynamic supply sources
- › Emerging gas economies
- › **Associated & Flared gas**
- › Deepwater
- › Risky areas
- › Fast track projects

# Flared Gas – CNG Case Study



- Associated gas production alternatives to flaring
  - Pipeline
  - CNG
  - Others - Floating LNG, GTL, Gas to Wire, Hydrates
  - Re-injection (dependent on reservoir)
- Commercial viability of CNG is defined by:
  - Cost to deliver gas from supply to market
  - Market price or value for delivered gas
  - Cost avoidance for re-injection
  - Benefits from credits for flaring reduction
  - Other - Environmental benefits and possible increased production

# Flared Gas – CNG Case Study

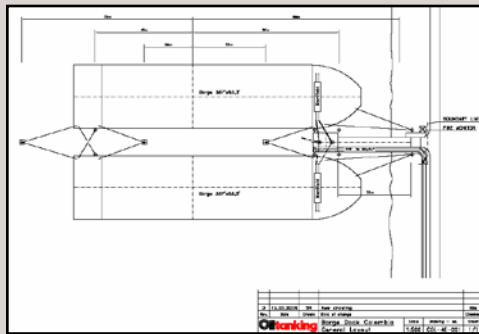
- Delivered Gas Rate: 80 MMscfd
- Gas Composition: 1265 btu/scf
- Water depth: 1,500 m
- Supply pressure: 120 bar
- Storage temperature: -15°C
- Transport distance: 200 – 600 km
- Buoy Loading
- **Continuous production**
- **Continuous offloading**
- **Feedstock for LNG Plant**



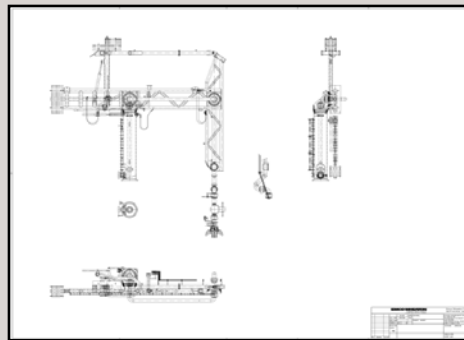
**EnerSea's CNG system can accommodate wide range of gas compositions and rates**

# Receiving Terminal Requirements

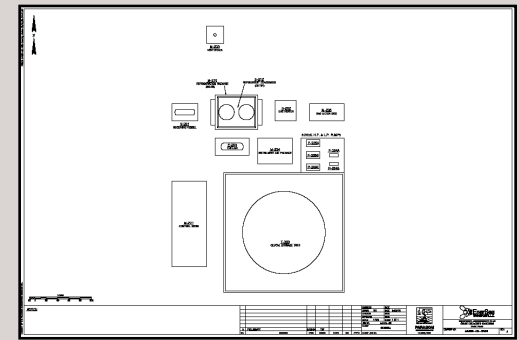
- Simple finger jetty required – minimal infrastructure
- Port draft of <math>< 6\text{m}</math>
- 24 Hour/day access
- Proven loading arms for gas transfer
- Terminal Facilities could be sited on a small-barge or onshore
- Gas Storage – can be provided, if needed



Jetty



Gas Transfer Arms



Offloading Facilities

# Project Components

- CNG Loading Equipment:
  - Gas compression (provided by field operator)
  - CNG transfer equipment
- Gas Transport Fleet of CNG Ships
- Gas Delivery Terminal:
  - Offloading lines and equipment at existing port facility
  - CNG transfer facilities
- Operations & Maintenance:
  - Marine Fleet, Dry-docking, annual service and inspections
  - Utilities (fuel gas and electrical power)
  - Gas delivery terminal and offloading facilities
- Service does not include:
  - Port development costs (quays, docking or mooring facilities, dredging, etc.)
  - Port facilities & entry fees, Land, Governmental Fees or Licenses
  - Fuel gas (cargo gas used)
  - Permits

Distance to Market (km)	Ship Size (MMscf)	CNG Fleet	Tariff (\$/MMBtu)
200	110	3	2.00
400	170	3	2.45
600	110	4	2.60

# Producer Economics: CNG vs. Re-injection



- Producer Costs: (Per MMBtu)
  - Gas Gathering: \$1.00
  - CNG Transport: \$2.60 (600 Km Case)
  - Liquefaction: \$1.00
  - LNG Shipping \$0.50 (Europe/US)
  - Regasification: \$0.50
- Producer Netback:
  - Gas sales price: \$7.00 (Europe/US)
  - Producer costs: (\$5.60)
  - Cost avoidance \$0.50 (Re-injection)
  - Emissions Credit \$0.50
  - **Producer Net Back \$2.40 per MMBtu**

**Total Volume Gas Saved: 580 BCF (20 years)**

**Net Commercial Value: \$1.8 Billion**

**Commercial Viability NPV<sub>10</sub>: \$0.8 Billion**

# CNG – Flaring Solution: Summary

- Commercially viable for flaring and many other applications
- Simple System with proven components & equipment
- Validated system technology
- Ready for project deployment

