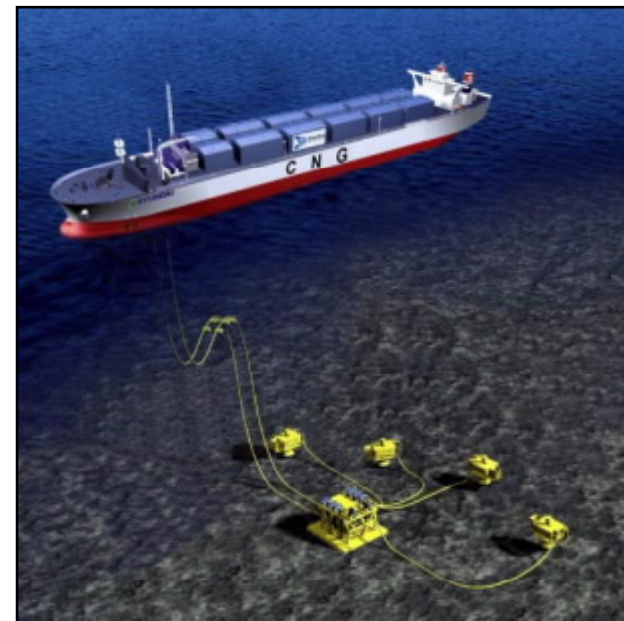# Natural Gas Production-Shuttling
Unique Applications of Low Pressure CNG
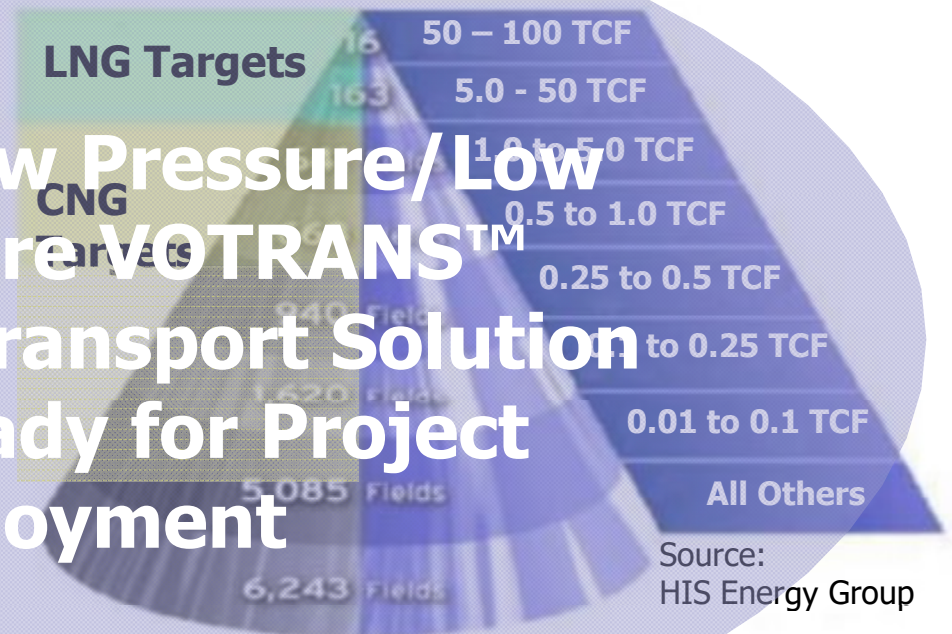

International Marine CNG Forum
Centre for Marine CNG
St. John's, Newfoundland
October 2007

What is the Resource Sector for Marine CNG?

- Enables development of smaller stranded fields
  - On shore or offshore reservoirs
- Highly Scalable solution to suit variable gas profiles
- Market solution for power generation
- Create value from flared gas
  - CO_2 reduction

EnerSea's Low Pressure/Low Temperature VOTRANS™ Marine CNG Transport Solution Proven Ready for Project Deployment

LNG Targets

CNG Targets

50 – 100 TCF
5.0 - 50 TCF
1.0 to 5.0 TCF
0.5 to 1.0 TCF
0.25 to 0.5 TCF
0.1 to 0.25 TCF
0.01 to 0.1 TCF
All Others

Source:
HIS Energy Group

Distribution of World's Gas Fields by Size

Gas Production & Storage Shuttle (GPSS)

- **Gas wellstream produced "Direct-to-Ship"**
- **Field operations & production support on ship**
- **Gas/Liquids separation & storage on board**
- **Twin buoys provide un-interrupted production**
- **Fleet (2-3) of GPS Shuttles provide high reliability**
- **Re-deployable assets**
- **Applicable in 100-3000 meters**

GPSS for shallow water
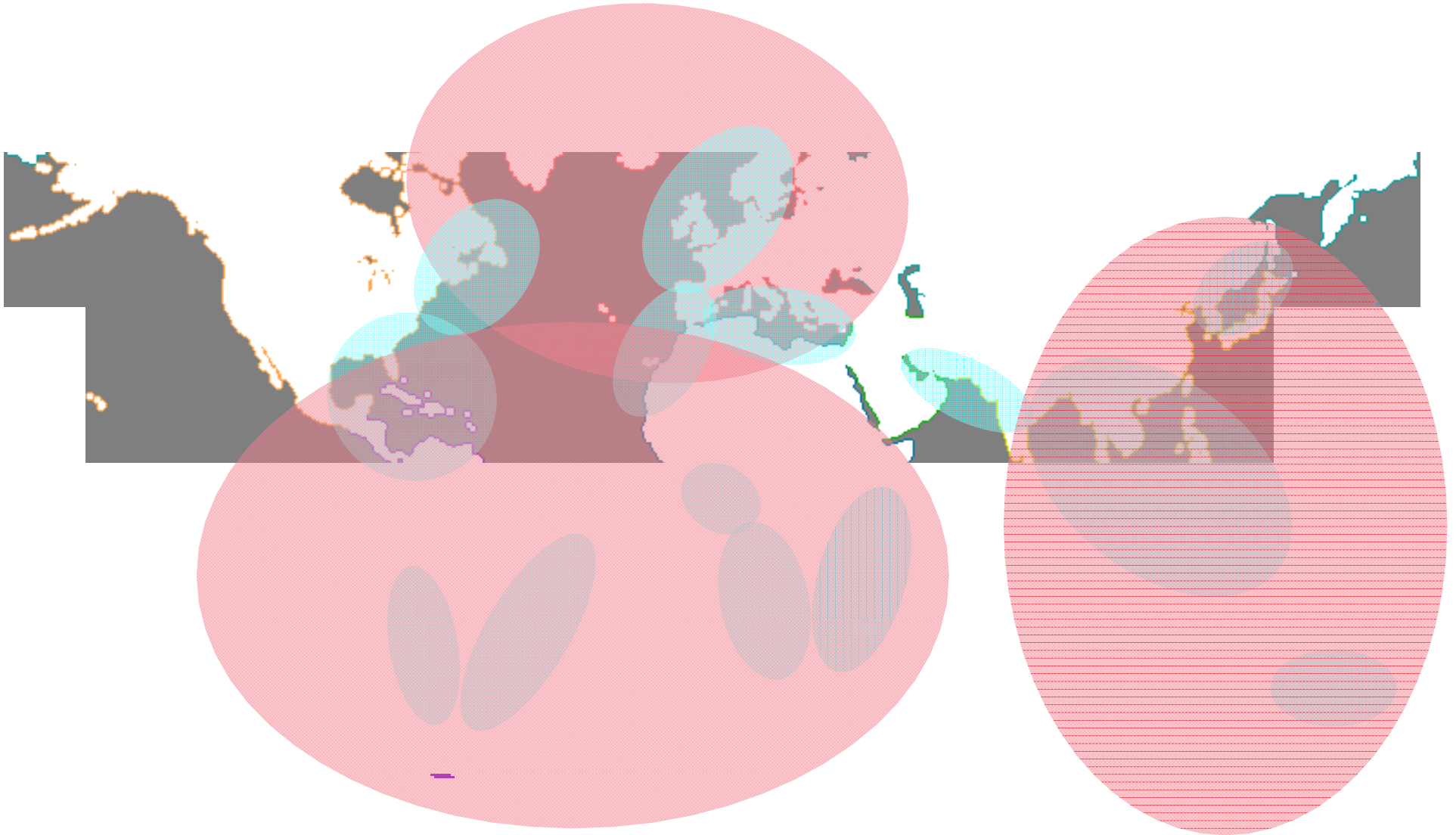

GPSS for ultra-deepwater
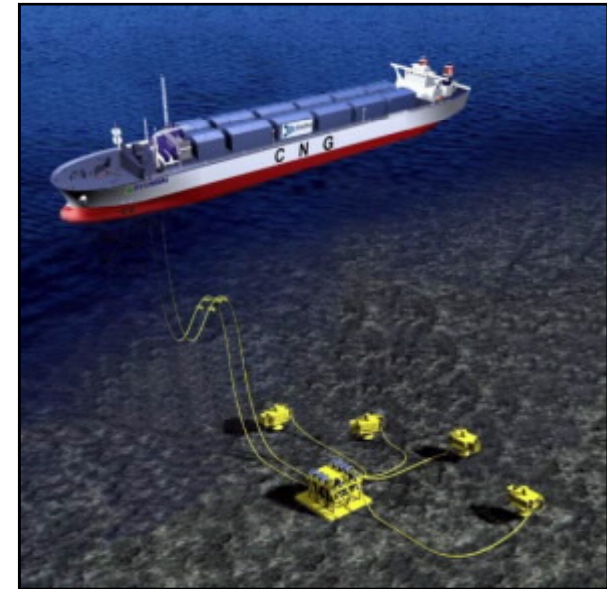
GPSS Solution Used For:
- **Ultra-deepwater field – no infrastructure**
- **Arctic and harsh environments – no infrastructure**
- **High productivity – short field life reservoirs**
- **Early Production System for tight gas reservoirs:**
  - **Value of information**
  - **Value on stand-alone basis**

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Gas Production/Shuttling Opportunity Areas

Shaded areas indicates regions opened by GPSS concept

Gas Production/Shuttling Technical Viability
Confirmedthrough Ultra-deepwater Study for Kerr McGee

- Gulf of Mexico deepwater frontier (~2500m WD)
- Remote Subsea Wells development
- Hybrid Riser Tower supporting Jumper Risers & Umbilicals
- Two Offset Submerged Turret Production (STP™) buoys
- Production Operations supported from vessel
- Continuous production with 2 GPS Shuttles
    - Driven simply by reservoir pressure
- Gas off-loading buoy (STL) at offshore discharge location
- Tie-in to existing pipeline system
- No storage required at discharge location
    - Each shuttle offloads in 24 hours

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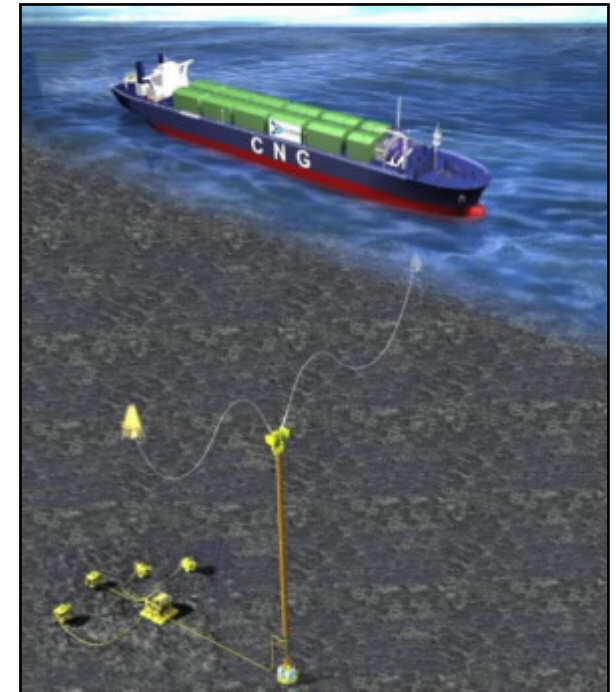
Technical Viability Confirmed
Ultra-deepwater GOM Study for Kerr McGee

Basic Design Parameters

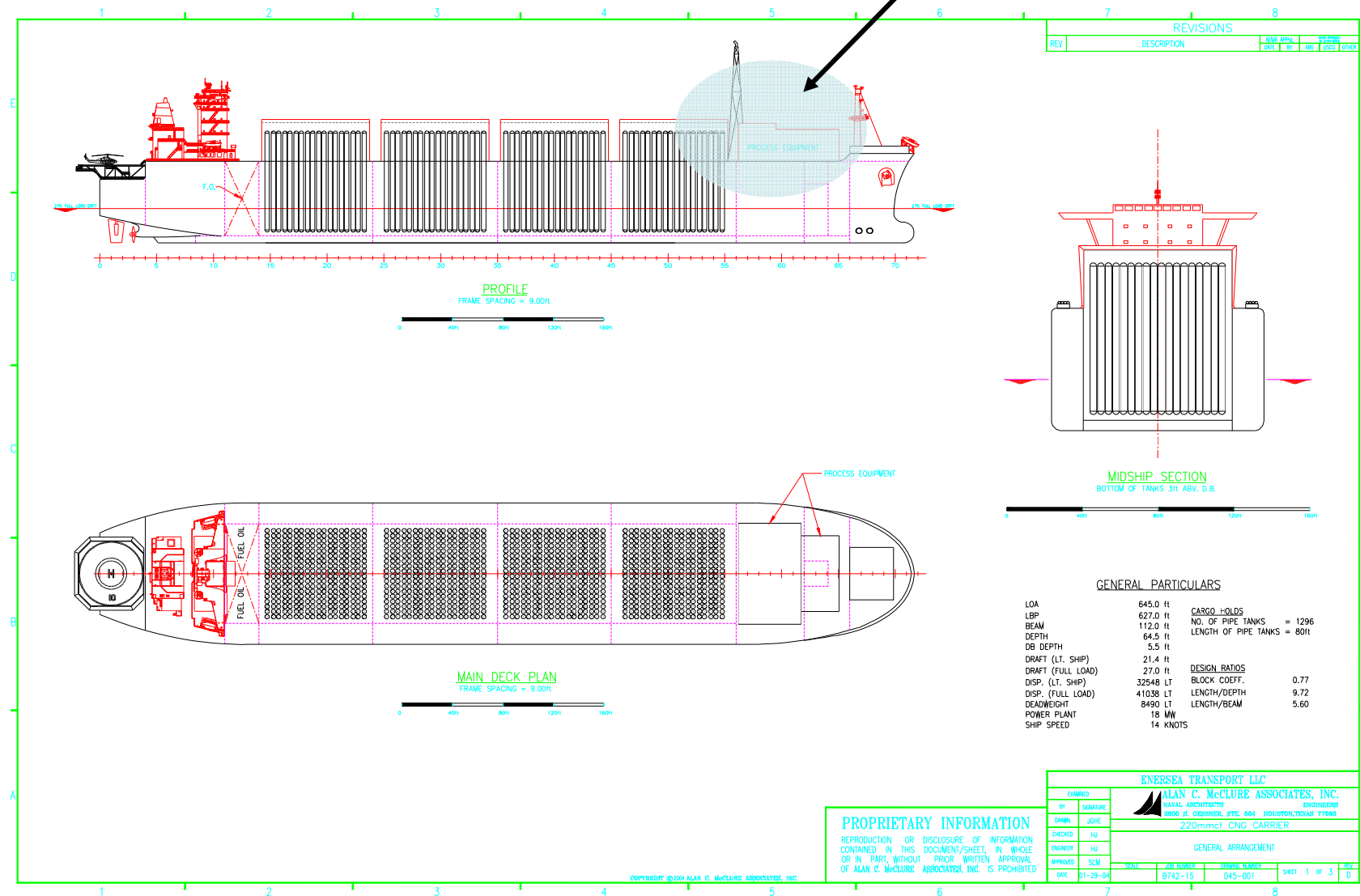|	
Water Depth:	8000ft
Distance to Market:	150 nm (260km)
Rate:	100 mmscfd (2.83Mscmd)
Life:	20 years *nominal*
Gas Type:	Lean (+5bbl/mmscf condensate)
CO2/H2S:	Insignificant
Storage Conditions:	**120 bar** **-30**^{0}C
Arrival Conditions:	180 bar 5^{0}C
Offloading Conditions:	80 bar 0°C
Operating Limits:	100yr Winter Storm &/or 8deg roll
Dynamic Positioning:	DP Class 1

HIPPS isolates swivel & GPSS from highest reservoir pressures

EnerSea Scope of Work
Ultra-deepwater GOM Study

③ GPSS Vessel design

③ Subsea System & controls

③ Flowlines

③ Flow assurance

③ Deepwater Riser system

③ Turret & Mooring systems

③ Subsea and GPSS interface

③ GPSS operations, logistics

③ Market delivery location

③ Offshore gas terminal/port

③ Fabrication & construction

③ GPSS installation

③ Safety and environmental

③ Cost estimate
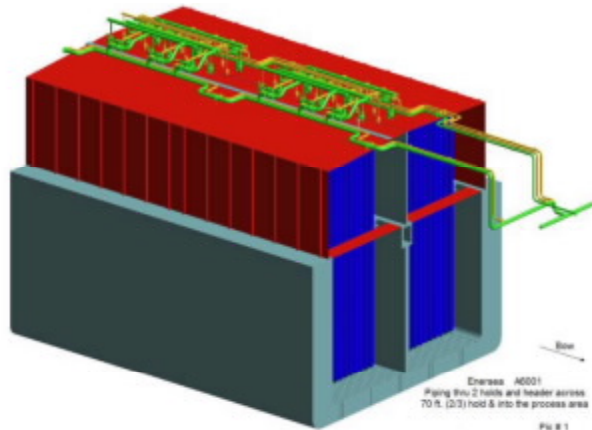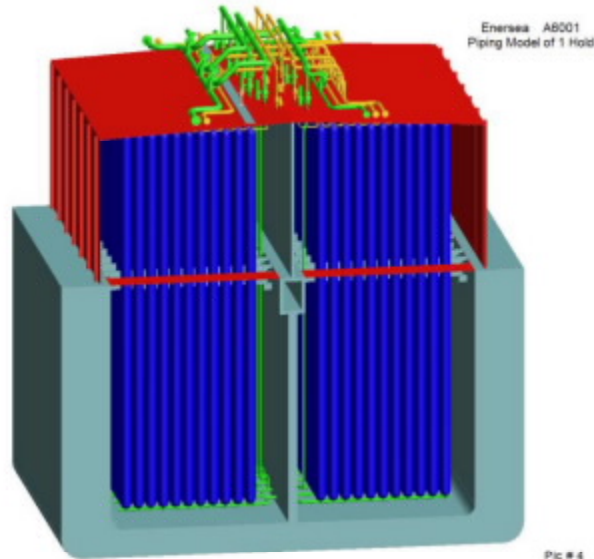
③ Project economics

③ Government approvals

③ Project schedule

# GPSS General Arrangement

Subsea Production Facilities on deck

# Ultra-deep GOM GPSS Gas Containment

Enersea A8001
Piping Model of 1 Hold

Pic # 4

Enersea A8001
Piping thru 2 holds and header across
70 ft. (2/3) hold & into the process area

Pic # 1

- Segregated containment
- 36-48 bottles per tank
- 3 tanks per hold
- 12 tanks per ship
- Four holds per ship
- 42"OD x 19 mm wall X80 pipe
  (cylinder body 80ft long)
- Follows ABS Guidelines aligned with ASME Section 8 Div 3
- Acoustic Emissions continuous integrity monitoring
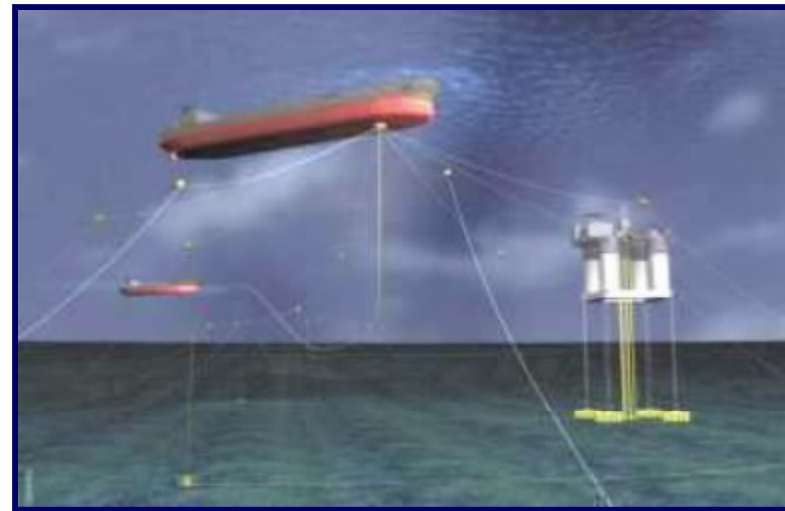
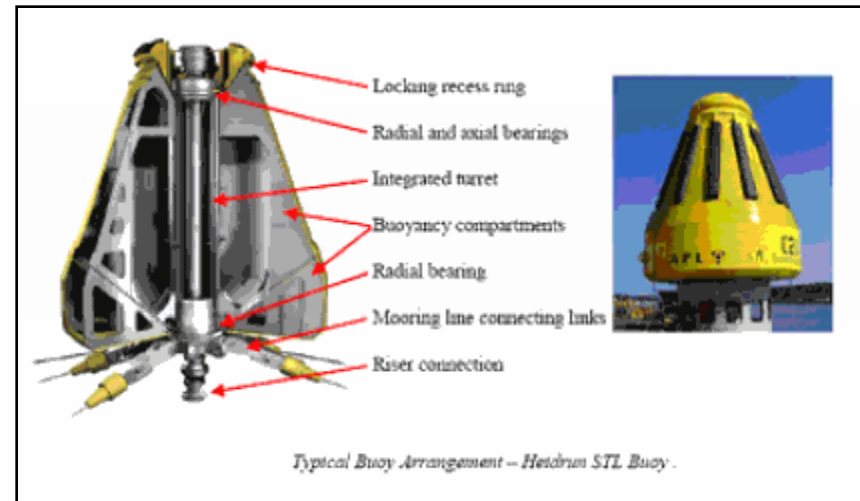# Hybrid riser Tower - Architecture
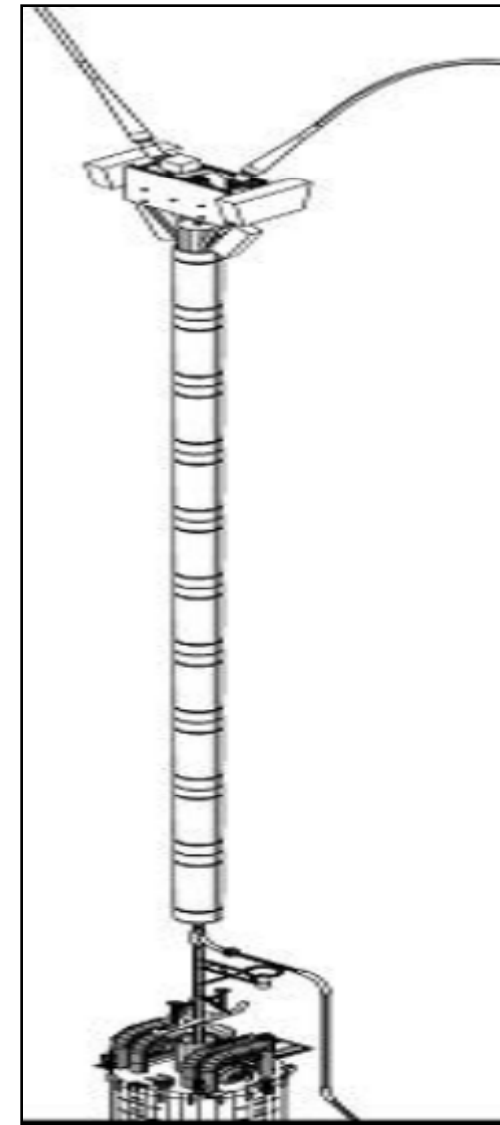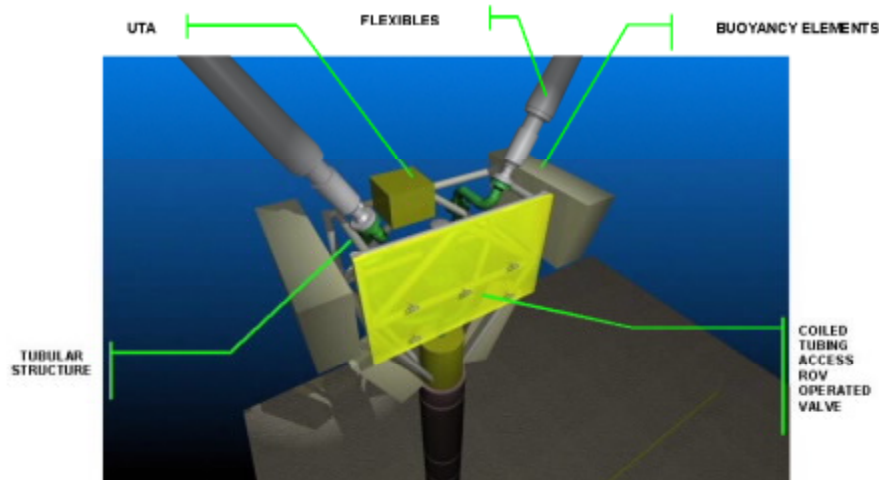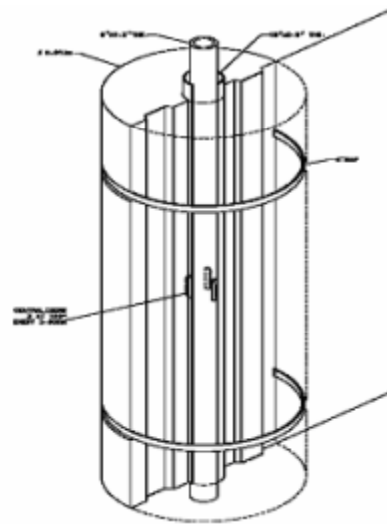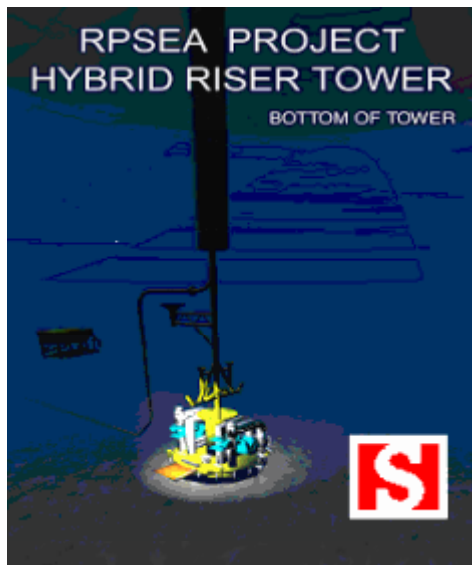
Offshore CNG Terminals
Proven Reliable Systems

- Proven production and loading systems
    - Statoil's Heidrun Field (STL™ Oil loading)
    - Pierce field North Sea (STP™ - Gas re-injection 370 bar)
    - Statoil's Lufeng Field in S. China Sea (STP)
- First gas loading system now operating in US GOM
- Dual buoys for uninterrupted production

1st Offshore CNG Ports by APL a/s
Qualified, Installed & Operational

Parameter	Gulf Gateway	VOTRANS
Pressure, Operating, Bar	100	100
Pressure, Max design, Bar	135	≤ 135
Temperature, Design, °C	−20	−20
Flow rate, Max design, MMCFD	680	≤ 680

Typical Buoy Arrangement – Heidrun STL Buoy.

- Locking recess ring
- Radial and axial bearings
- Integrated turret
- Buoyancy compartments
- Radial bearing
- Mooring line connecting links
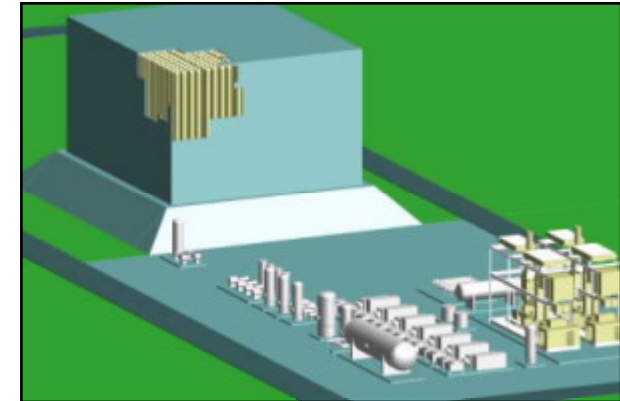- Riser connection

Current GPSS System Project Scope

- EnerSea has undertaken design studies and interacted with local regulatory authorities in preparation to deploy 1st GPSS system

- EnerSea's responsibilities to include:

  - Fleet of GPSS ships, inclusive operation on charter

  - Gas conditioning for storage

  - Gas production facilities (e.g. MeOH and condensate separation/storage)

  - Subsea Production Interface w/Riser

  - Offloading terminal and facilities

    - Including on shore storage (VOLANDS™)

  - Design & Engineering, Pre-delivery expenses

- Client's responsibilities:

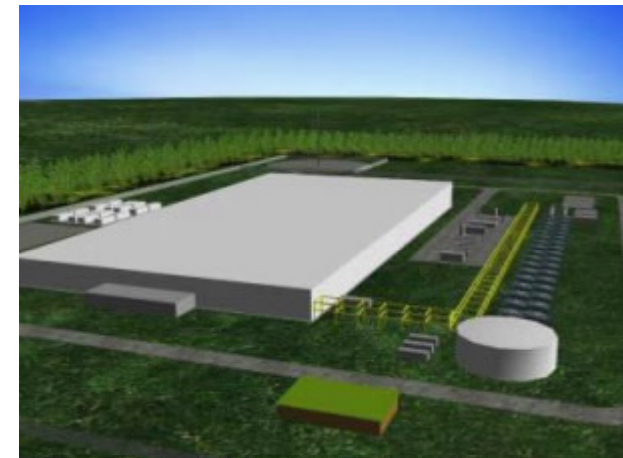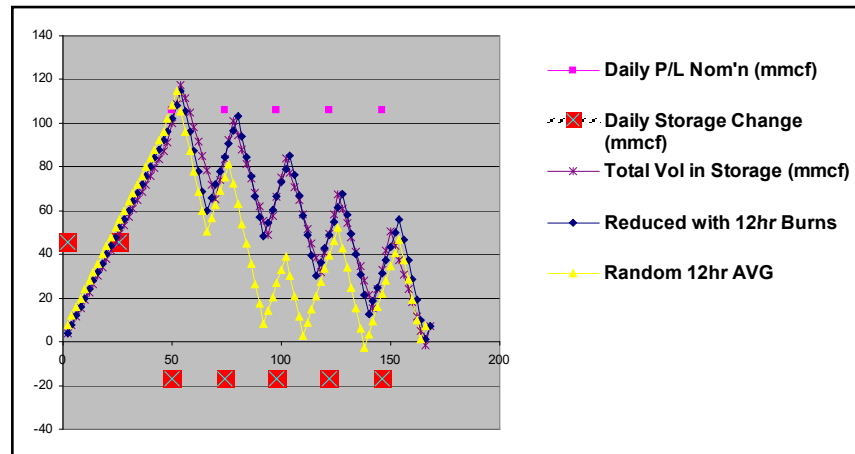 - Subsea wells and control system

  - Market interface and cargo sales

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VOLANDS™ CNG Storage

- ✆ Receipt of CNG cargo deliveries
- ✆ Ratable re-delivery to market
- ✆ High storage and delivery efficiencies
- ✆ Buffer to manage market demand fluctuations

Improved reliability of supply

Enhanced marine fleet capacity

Vertical Configuration

Legend:
- ■ Daily P/L Nom'n (mmcf)
- ⊠ Daily Storage Change (mmcf)
- ✳ Total Vol in Storage (mmcf)
- ◆ Reduced with 12hr Burns
- ▲ Random 12hr AVG

Horizontal Configuration

Summary

- Natural Gas production-shuttling provides a flexible, economic & fit-for-purpose gas development solution

- EnerSea's CNG systems are <u>ready for project deployment</u>
  - Material <u>and</u> functional testing – completed & approved
  - Regulatory approvals
  - Operational / reliability modeling

- EnerSea and its investors are prepared to deploy capital for project developments