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Supply of natural gas to island economies

CNG - A new alternative

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Agenda

- Island energy systems
- Energy supply goals
- Jamaica's energy situation
- Benefits of natural gas
- Alternatives for natural gas transportation
- Economics
- Markets
- Security of supply

Island energy systems

- Often isolated
- Limited demand
- Not connected to continental grid
- Limited space for infrastructure
- Environmental imperative (tourism)



Energy supply goals

- Economic
- Efficient
- Plentiful
- Reliable
- Clean



Energy requirements in Jamaica

- Jamaica requires energy for:
 - Generation of electricity
 - Industrial facilities
 - Commercial, residential and transportation use

Generation of electricity

- The Jamaica Public Service Company (JPS) is the main provider of power in Jamaica
- JPS has a total installed capacity of approximately 818 MW (including 197 MW of capacity from Independent Power Producers)
- Growth is strong and Jamaica is projected to need an additional
 - 80 MW of generation capacity in 2009
 - 150 MW in 2012
 - 150 MW in 2013
- 95% of electricity production is dependant upon diesel and heavy fuel oil
- Last year the cost of oil was over US\$1.5 billion
- Overall generation efficiency low due to aging equipment

Industrial facilities

- Alumina plants
 - Require large quantities of energy for production of alumina
- Cement plants
 - Require large amounts of energy to fuel high temperature cement kilns
- Sugar refineries
- Water distribution facilities
- Currently using fuel oils
- Bunker C transported from port to plant
- Need additional energy for expansion

- Hotels
 - Currently use electricity and LPG
 - Big cost of tourist business
- Residential
 - Uses electricity and LPG
 - Air conditioning, refrigeration, lighting, appliances
- Transportation
 - Gasoline
 - Diesel
 - Personal vehicles, freight, public

Challenges for Jamaica

- Add more capacity for
 - Power plants
 - Industrial facilities
- Upgrade old and inefficient power generation equipment
- Reduce “non-technical” losses
- Reduce import costs (balance of payments)
- Security of supply
- Reduce pollution
- Import an economic and secure fuel source

Natural gas can provide an attractive solution for Jamaica.

Advantages of natural gas

- Economic – competitive with fuel oils
- Efficient – most thermally efficient fuel for combined cycle gas turbine power plants
- Clean-burning
- Emits less greenhouse gas than other fossil fuels
- Easy fuel to handle once system established



Alternatives for natural gas transportation

Traditional methods of marine transportation are:

1. Sub-sea pipelines	Fixed line of pipe at 2500 psi
2. Liquefied (LNG)	<ul style="list-style-type: none">■ 600:1 gas/liquid volume reduction■ -161°C in liquid state■ Shipped and stored at atmospheric pressure
Now a third option...	
3. Compressed (CNG)	<ul style="list-style-type: none">■ Shipped in gaseous state at 3200 psi

Process: LNG vs. CNG

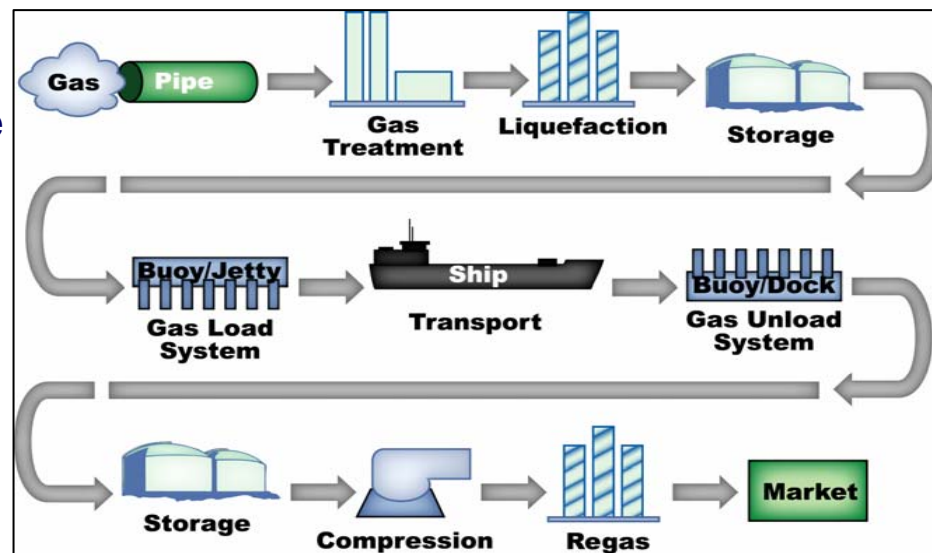
LNG: gas → liquid → gas

Loading: Gas treatment, liquefaction & storage

Terminals: Onshore in harbor

Ships: Sophisticated, efficient

Receiving: Storage, regasification



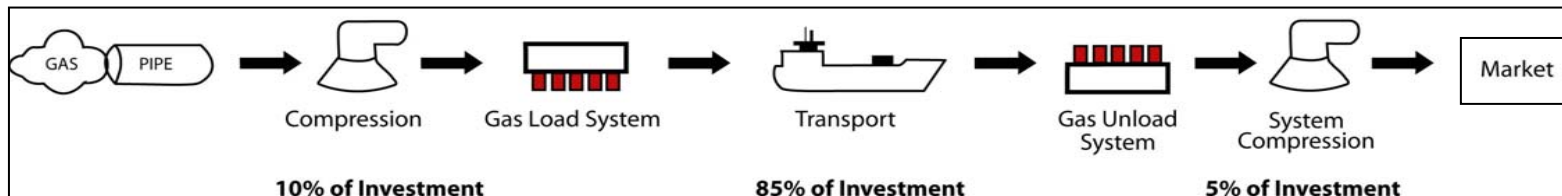
CNG: always a gas

Loading: Dehydration, compression

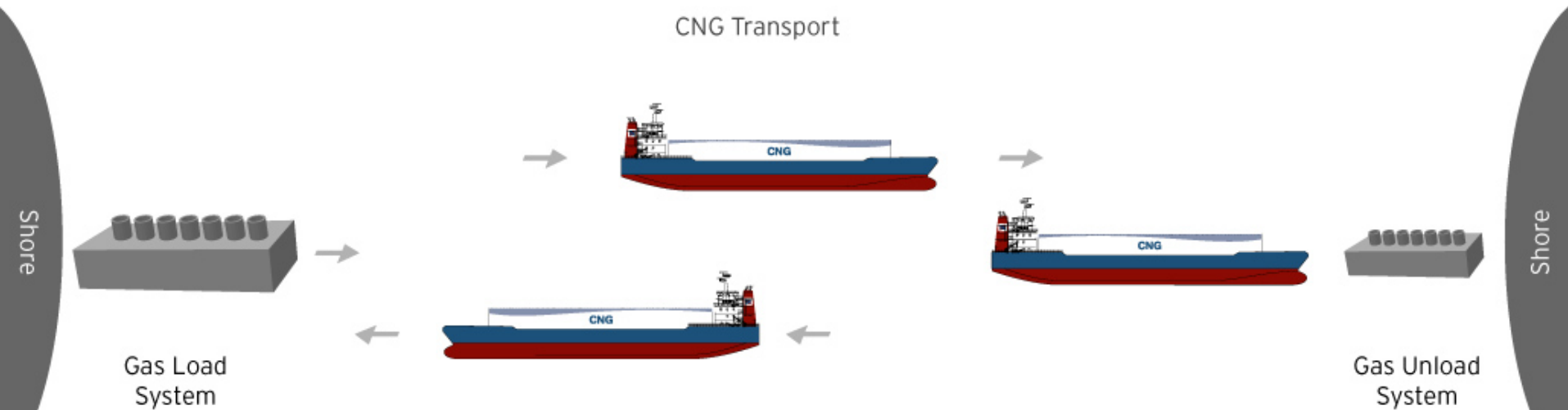
Terminals: Onshore or offshore (buoy)

Ships: Simple – like bulk-carrier

Receiving: Heating & scavenging compression



CNG shuttle system



Sub-sea pipeline

■ Pros

- Reliable
- Easy to operate

■ Cons

- Fixed point to point (not moveable)
- Construction can present topographical or environmental challenges
- Can be damaged by storms
- Marine pipelines more difficult to expand than terrestrial

■ Pros

- Transports large volume over long distance
- Established technology
- Many source options/countries
- Good safety record
- International “network commodity”

■ Cons

- High capital cost for on-shore facilities
- Large “footprint”
- Minimum threshold volume is large
- Long lead time to implement
- Subject to international market

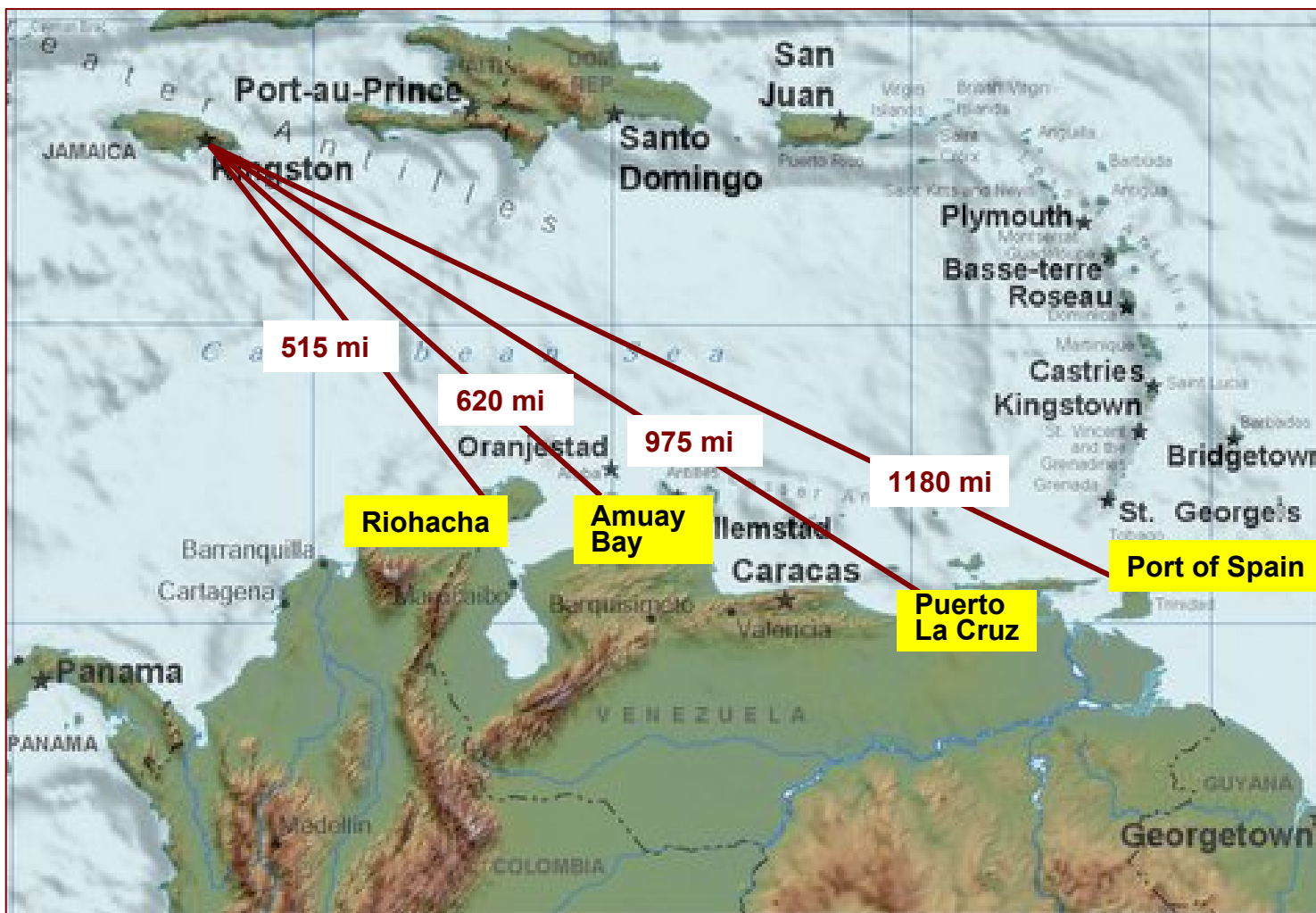
■ Pros

- Reduced capital cost
- Smaller project threshold, readily expandable
- Fast to implement
- Small “footprint”
- Can be more “financable”
- Regional supply

■ Cons

- More expensive to ship per additional km
- Diminishing effectiveness over 1500km
- New application (of proven technology)
- Smaller supply radius

CNG Supply alternatives to Jamaica



Project Costs – LNG and CNG

- Very difficult to estimate “generic” costs of projects
- Depends greatly on project specific factors
 - Availability, location and price of gas
 - Physical constraints at terminal areas
 - Consumption profile of customer(s)
 - Financial strength of parties
 - Deal structure
- Complicated by current commodity “boom”
 - Costs have recently soared (doubled in 3 yrs?)
 - Unavailability of components (engineering, equipment)

Capital costs – short range

Project of 105 mmscf/d over 312 mi (1,100 mmcm/y over 500 km)

Indicative capital costs

	LNG (1 and 2)*		CNG
Loading	US\$600 MM (€469 MM)	US\$0	US\$30 MM (€23 MM)
Shipping	US\$75 MM (€59 MM)	US\$30 MM (€23 MM)	US\$269 MM (€210 MM)
Unloading	US\$350 MM (€273 MM)	US\$488MM (€381 MM)	US\$16 MM (€13 MM)
Total	US\$1025 MM (€801 MM)	US\$518 MM (€404 MM)	US\$315 MM (€246 MM)
Time (after contracting)	5 years		3 years

*1. Costs estimated assuming a new 'greenfield' small-scale LNG plant.

*2. Costs estimated assuming spare capacity from an existing LNG liquefaction plant.

Indicative tariff – short range

Project of 105 mmscf/d over 312 mi (1,100 mmcm/y over 500 km)

Transportation tariff per mmbtu

	LNG (1 and 2)*		CNG
Loading	US\$3.64 (€2.84)	US\$0.25 (€0.19)	US\$0.38 (€0.29)
Shipping	US\$0.38 (€0.29)	US\$0.16 (€0.12)	US\$2.00 (€1.56)
Unloading	US\$2.12 (€1.65)	US\$3.00 (€2.34)	US\$0.08 (€0.06)
Total	US\$6.14 (€4.79)	US\$3.41 (€2.66)	US\$2.46 (€1.92)

*1. Tariffs estimated assuming a new 'grassroots' small-scale LNG plant.

*2. Tariffs estimated assuming spare capacity from an existing LNG liquefaction plant.

Indicative tariff – long range

Project of 105 mmscf/d over 1000 mi (1,100 mmcm/y over 1610 km)

Transportation tariff per mmbtu

	LNG (1 and 2)*		CNG
Loading	US\$3.64 (€2.84)	US\$0.25 (€0.19)	US\$0.38 (€0.29)
Shipping	US\$1.14 (€0.89)	US\$0.48 (€0.37)	US\$3.10 (€2.42)
Unloading	US\$2.12 (€ 1.65)	US\$3.00 (€2.34)	US\$0.08 (€0.06)
Total	US\$6.90 (€5.39)	US\$3.73 (€2.91)	US\$3.56 (€2.78)

*1. Tariffs estimated assuming a new 'grassroots' small-scale LNG plant.

*2. Tariffs estimated assuming spare capacity from an existing LNG plant.

Island markets for gas

- Gas displaces liquid fuels (HFO, LPG, LFO)
- Gas requires fixed local infrastructure
 - Pipelines, compression, storage
- System can be expensive to install
- Grid is slow to grow
- **But** ... once customers connected, a very effective fuel system

Island distribution system

- Best to expand distribution in stages
- First customers will be large and accessible
 - Coastal industries and power plants
 - Followed by large industries inland
 - Then retail customers in cities
 - Residential connections
 - CNG stations for vehicles
- In tropical countries, retail distribution grid not usually economic (no heating demand)

- Essential for island economies
- International gas trade has been very secure
 - Both terrestrial and marine
 - Occasional high profile disruptions should not obscure overall success
 - Safety record has been excellent
- Three types of risks to supply
 - Natural disasters
 - Geo-political
 - Project

- Geo-political risk
 - Unstable supplier country
 - Political disputes
- Project / commercial risk
 - Counterparty financial strength
 - Gas reserves not as predicted
 - Fundamental change in market
 - Technical break-down in delivery chain

Security of supply advantages

■ LNG

- Multiple potential sources
- Several LNG fleets
- Operators are substantial companies
- LNG processing becoming standardized

■ CNG

- Regional relationships
- Dedicated project
- Reserve requirements lower
- Gas need not compete with LNG chain
- Simple design and “off-the-shelf” materials
- Well compartmentalized cargo

Security of supply disadvantages

■ LNG

- Requires constant supply of large amount of gas over long period of time
- Supply shifts to highest priced markets
- Many moving parts in delivery chain
- High profile installation

■ CNG

- Fixed supply radius
- Tighter delivery schedule

- Storage is required as insurance against interruption
 - LNG
 - Built-in storage at regasification terminal
 - Easily stored as a liquid
 - CNG
 - Short-term storage on ship or shore
 - “Propane-air” system (produces synthetic natural gas) proven effective for back-up of interruptible natural gas supply
- Storage is not cheap in any form
- Power plant’s best option is dual-fuel capability using existing fuel oil storage tanks

Marine CNG now available for Jamaica



Sea NG ship - 16 Coselle

Length - **114 M / 472 ft**

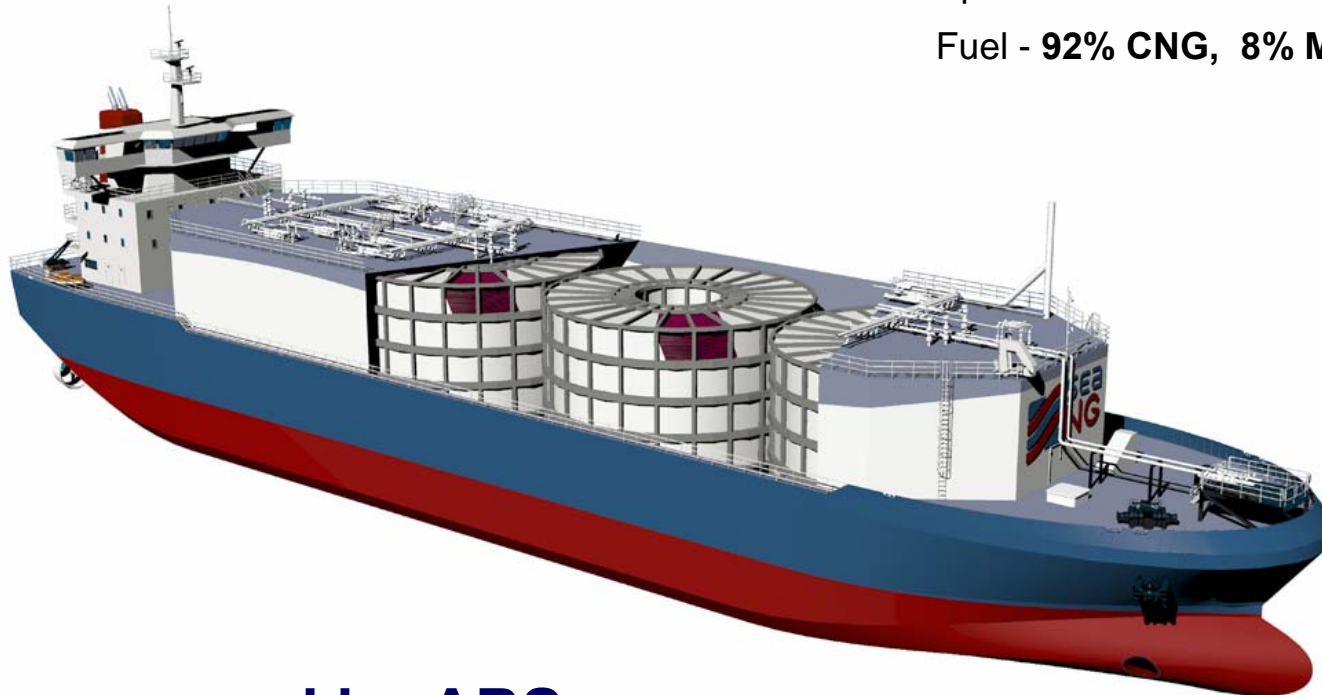
Beam (Width) - **24 M / 78 ft**

Depth - **7 M / 23 ft**

Gas Capacity – **1.4 MMCM / 50 MMSCF**

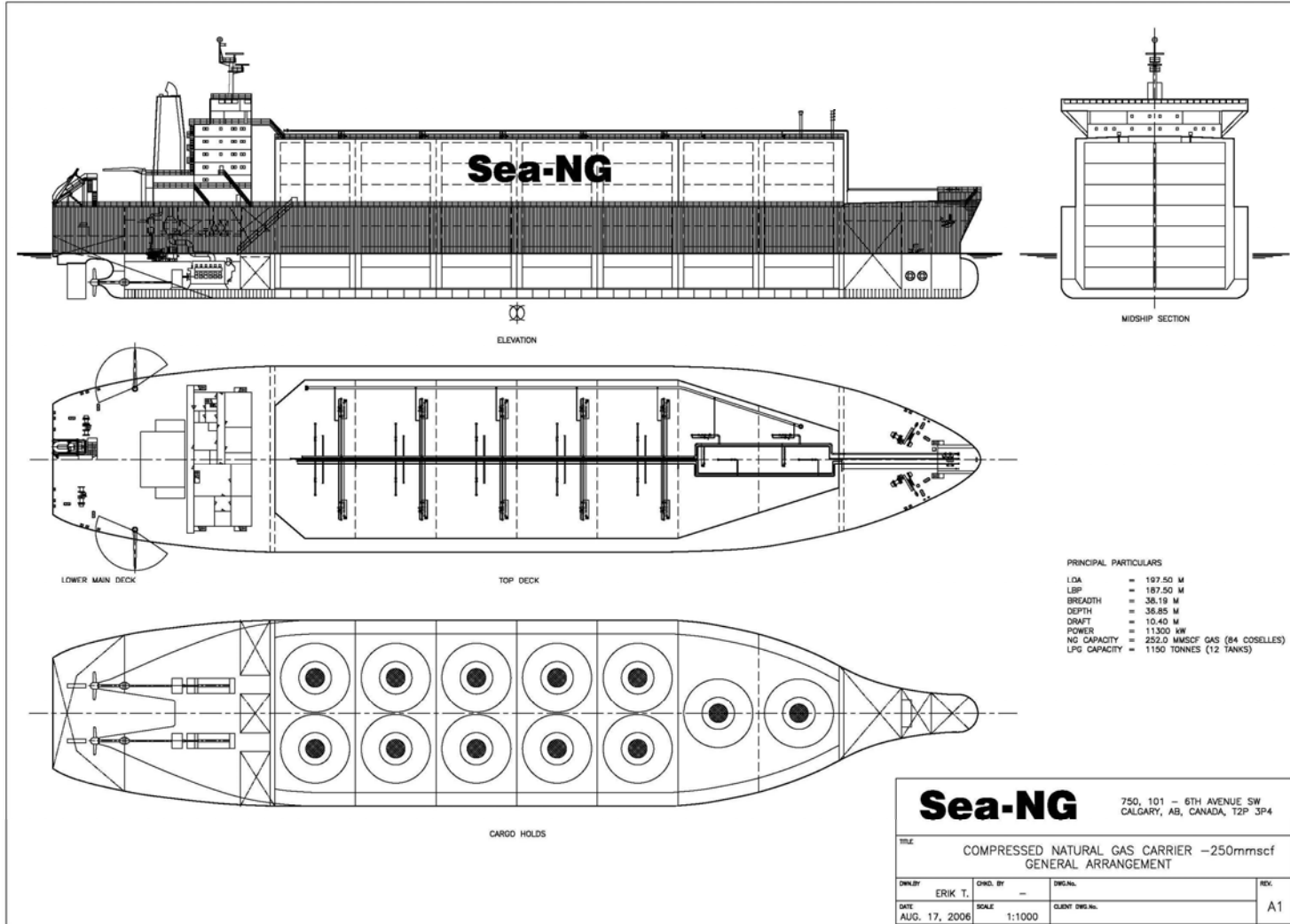
Speed - **13 Knots / 15 MPH**

Fuel - **92% CNG, 8% MDO**

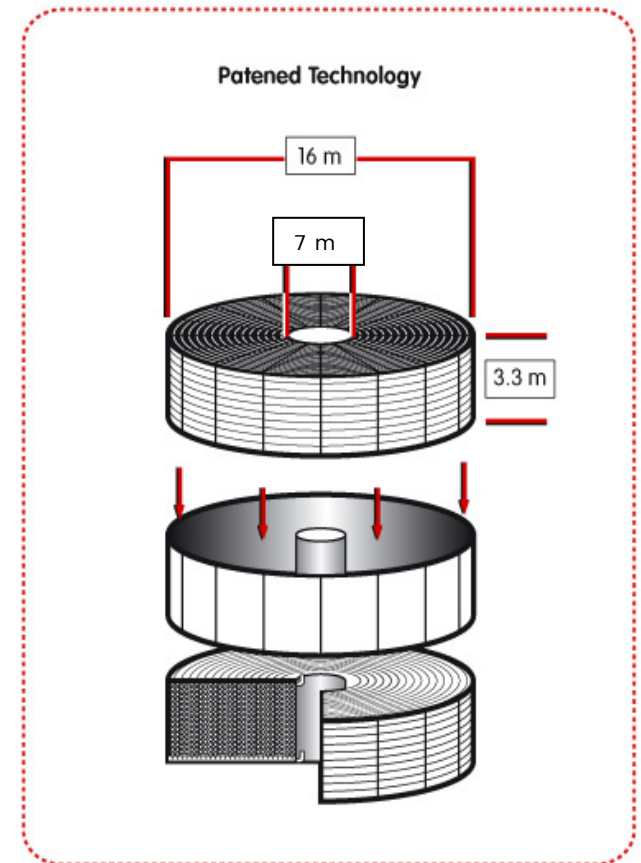


Fully approved by ABS

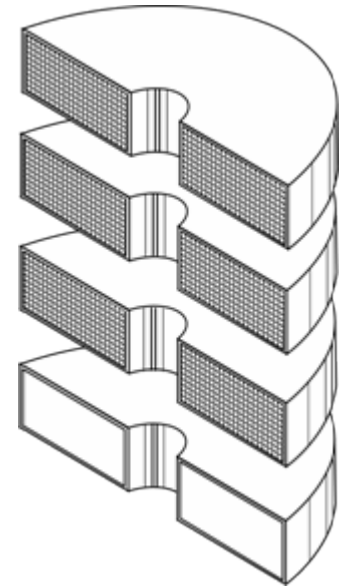
Sea NG ship – 84 Coselle



Coselle – coiled pipe in carousel



- Small diameter pipe
 - Low probability of pipe gas containment failure
 - Excellent ductility (due to modest wall thickness)
 - Fatigue tested to 15,000+ cycles (2006)
- Low consequence of failure
 - Even a full rupture can be safely vented
 - No chance of sequential rupture or explosions of adjacent Coselles (which is the greatest danger of “bottles”)
- Very large capacity in a single Coselle
 - 100 Coselles = 2000+ bottle-type pressure vessels
 - Fewer valves, simpler manifold – less chance of failure



Conclusion

- Jamaica has growing demand for energy
- Natural gas can provide an economic, clean solution
- Plentiful gas supplies exist in the Caribbean region
- There are three transport options
- CNG is the most-cost effective and fastest to implement
- Natural gas can be flowing to Jamaica by 2010

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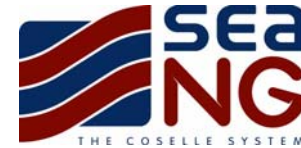
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