



MARINE TRANSPORTATION OF NATURAL GAS: LNG VERSUS CNG

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Case Study : AZ NG FLOATING DELIVERIES via GE - to BG & to RO

- ONE SUPPLIER – AZ: Max. 8 Bn CM/Y
- TWO MEMORANDUMS – ea. 8 Bn CM/Y
- 2 DIFFERENT SEA CARRYING METHODS
 - AGRI: L N G – Liquefied Natural Gas
 - AGBI: C N G – Compressed Natural Gas
- ⇒ ACTUAL STAGE: BOTH JV HAVE UNDER
PREPARATION THE FEASIBILITY STUDIES



THE TWO NEW PROJECTS SUPPLYING AZ NG TO RO AND BG





AZ – GE – BG PROJECT (I)

- ❑ NOV. 2009: AZ & BG JV FOR THE DELIVERY OF CNG TO BG BY TANKERS ACROSS THE BLACK SEA FROM GEORGIAN PORT KULEVI TO VARNA AND ONWARD TO EU
- ❑ **PROJECT COST (Est.) = USD 2 Bn**
- ❑ Q-TY WILL BE INCREASED FROM INITIAL 1 Bn C.M. UP TO 8M C.M., INCLUDING TRANSIT FOR 3rd PARTIES
- ❑ COOPERATION HYUNDAI - BULGARIAN SHIPBUILDERS FOR CNG TANKERS



AZ – GE – BG PROJECT (II)

□ CNG TANKERS:

- MORE EXPENSIVE THAN LNG TANKERS**
- DOES NOT REQUIRE LIQUEFACTION OF NG & ITS REGASIFICATION ELIMINATING THE NEED FOR THOSE EXPENSIVE INSTALLATIONS & PROCESSES**



AZ – GE – BG PROJECT (III)

- **THE DECOMPRESSED GAS CAN BE DELIVERED DIRECTLY INTO THE RECIPIENT COUNTRY'S PIPELINE NETWORK FOR NAT'L USE OR TRANSMISSION TO 3rd COUNTRIES**
- **THIS COST ADVANTAGE MAY WELL OFFSET THE INVESTMENT COSTS OF CNG TANKERS**



AZ - GE - RO PROJECT (I)

- THE AZERBAIJAN – GEORGIA – ROMANIA INTERCONNECTOR (AGRI) - A PROPOSED PROJECT TO TRANSPORT AZ NG TO RO
- NG WOULD BE TRANSPORTED:
 - BY THE PIPELINE FROM SANGACHAL TERMINAL IN AZ TO THE KULEVI TERMINAL ON THE BLACK SEA COAST OF GE
 - IN KULEVI, THE LNG EXPORT TERMINAL (LNG PLANT) WOULD BE BUILT
- COST OF THE PROJECT (Est.): **Euro 4 ... 6 Bn**



AZ - GE - RO PROJECT (II)

- LIQUEFIED NATURAL GAS WILL BE TRANSPORTED BY LNG TANKERS TO THE CONSTANȚA TERMINAL IN ROMANIA**
- AFTER REGASIFICATION, NG WILL BE DELIVERED THROUGH EXISTING GAS GRID TO RO AND TO OTHER EU MS**
- CAPACITY OF THE INTERCONNECTOR IS EXPECTED TO BE 8 BCM OF NG/YEAR, OF WHICH 2 BCM - FOR LOCAL NEEDS**



COMMON ASPECTS & TARGETS FOR BOTH PROJECTS (I)

- AFTER UNLOADING, NG CAN BE SHIPPED FROM CONSTANTA AND VARNA VIA EXISTING PL INTO ORIGINAL SYSTEM ENVISIONED FOR NABUCCO, AS WELL AS BE SHIPPED BY BARGES UP DANUBE AND INTO EUROPE'S CANALS & RIVERS SYSTEM
- A BARGE-BASED TRANSPORTATION SYSTEM CAN GO INTO OPERATION FAR FASTER THAN PIPELINE CONSTRUCTION, THUS ENHANCING EUROPE'S ENERGY SECURITY AND DIVERSIFYING SUPPLIERS MORE RAPIDLY THAN ORIGINALLY ANTICIPATED.



COMMON ASPECTS & TARGETS FOR BOTH PROJECTS (II)

- **BOTH INTERCONNECTORS SHOULD BE CONSIDERED VIABLE, FASTER & CHEAPER ALTERNATIVES TO NABUCCO**
- **EXPANSION OF BOTH NG TRANSPORTATION ROUTE MEETS THE PRIMARY PRECONDITION WHICH PROMPTED THE ORIGINAL EU & U.S. SUPPORT FOR, AND SPONSORSHIP OF, NABUCCO: NAMELY, NG TRANSPORTATION SYSTEM **FREE OF ANY GAZPROM CONTROL****



CAN WE JOIN THE TWO PROJECTS IN ONLY ONE ?

□ REASONS

- AZ OFFERED BOTH TO RO AND TO BG THE MAX. AVAILABLE QUANTITY IN ACCORDANCE WITH THE TOTAL PRODUCTION OF SHAH DENIZ I AND WITH ITS ACTUAL CONTRACTUAL OBLIGATIONS TO RU, TR AND GE
- DEVELOPING ONLY ONE COMMON PROJECT MEANS:
 - REDUCING THE INVESTMENT COSTS BY SELECTING THE PROPER ADAPTED TECHNOLOGY IN ACCORDANCE WITH THE LENGTH OF THE ROUTE AND THE ANNUAL QUANTITY TO BE DELIVERED AND TAKING INTO CONSIDERATION THE INTERNATIONAL EXPERIENCE FOR SIMILAR PROJECTS

□ WHICH TECHNOLOGY SHOULD WE ADOPT – LNG OR CNG ?



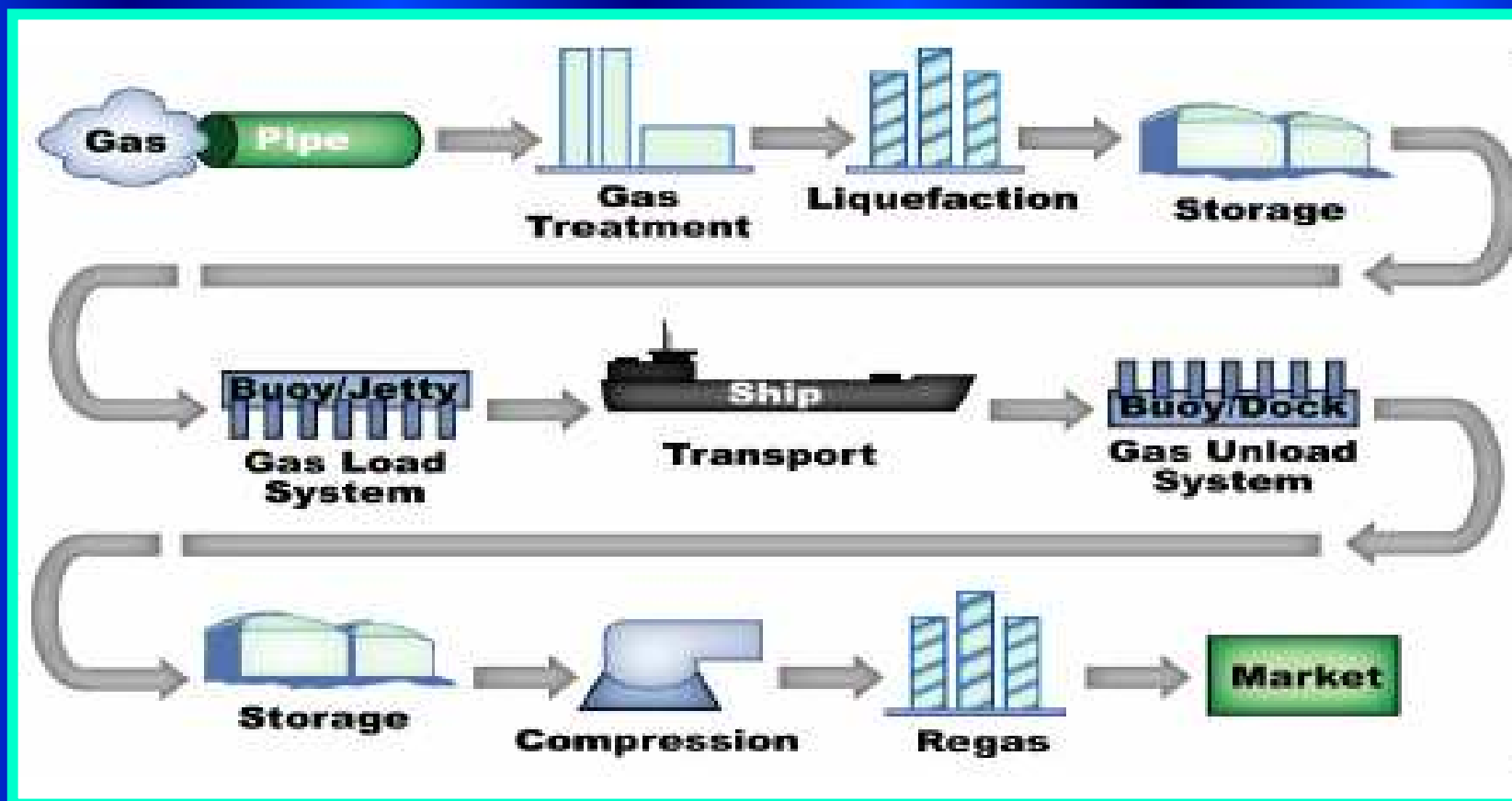
COMPARING THE TECHNOLOGIES FOR NAVAL TRANSPORT OF NATURAL GAS



I. LNG : LIQUEFIED NATURAL GAS(1)

MARITIME TRANSPORT CHAIN:

GAS → LIQUID → GAS





I. LNG : LIQUEFIED NATURAL GAS(2)

- TECHNOLOGIES FOR LNG LOADING IN CONTAINERS: PROCESSING, LIQUEFACTION, STOCKAGE
- TERMINALS : JETTY OR REGAS OFFSHORE TYPE
- TRANSPORT SHIPS: SOPHISTICATED – LNG TANKER TYPE
- UNLOADING: STOCKING, REGASEIFICATION





I. LNG: + / -

1. MOST ADVANTAGEOUS TECHNOLOGY FOR NG SEA TRANSPORTATION:

- ON LONG - DISTANCES (> 2.500 KM)**
- FOR LARGE QUANTITIES (> 10 BCM/Y)**

2. RATE OF ACCIDENTAL LOSSES HAZARD DURING TRANSPORT:

D/t ~ 1,000

3. COST OF LNG TANKERS: MEDIUM

1. HIGH COST OF ON-SHORE INFRASTRUCTURE DUE TO COMPLEX TECHNOLOGIES FOR LNG LOADING / UNLOADING:

PROCESSING, LIQUEFACTION, STOCKAGE, DELIQUEFACTION

2. AGGREGATION CARGO STATE AND TRANSPORT

TEMPERATURE: PERMANENTLY LIQUID – STATE AT -163 °C

3. PUBLIC ACCEPTANCE: LOW





II. **CNG** : **COMPRESSED NATURAL GAS**(1)

- **THE NEW CNG TECHNOLOGY : AN ALTERNATIVE THAT FILL THE GAP BETWEEN WELL ESTABLISHED TRANSPORTATION METHODS OF LNG & PL**
- **STRANDED GAS: AVAILABLE NG THAT CANNOT BE DEVELOPED ECONOMICALLY, BECAUSE:**
 - **THE VOLUMES ARE TOO SMALL TO JUSTIFY LNG PRODUCTION, OR:**
 - **IT IS TOO FAR FROM MARKET TO JUSTIFY PL**



II. CNG : COMPRESSED NATURAL GAS(2) = HIGH PRESSURE COMPRESSED METHANE GAS

**PERMANENT IN GASEOUS STATE,
ALSO DURING TRANSPORT**

- **LOADING TECHNOLOGIES :
DEHYDRATATION + COMPRESSION**
- **UNLOADING: HEATING +
DECOMPRESSION, WITH ENERGY
DISCHARGE BY DETENTION**



II. CNG : COMPRESSED NATURAL GAS(3)

- **THIS NEW CONCEPT IS HIGHLY COMPETITIVE COMPARED WITH PL & LNG TRANSPORT FOR DISTANCES OF UP TO 2,000 – 2,500 Km**
- **THE ADVANTAGE IS LESS INVESTMENT IN INFRASTRUCTURE AND GREATER FLEXIBILITY**



II. C N G : + / -

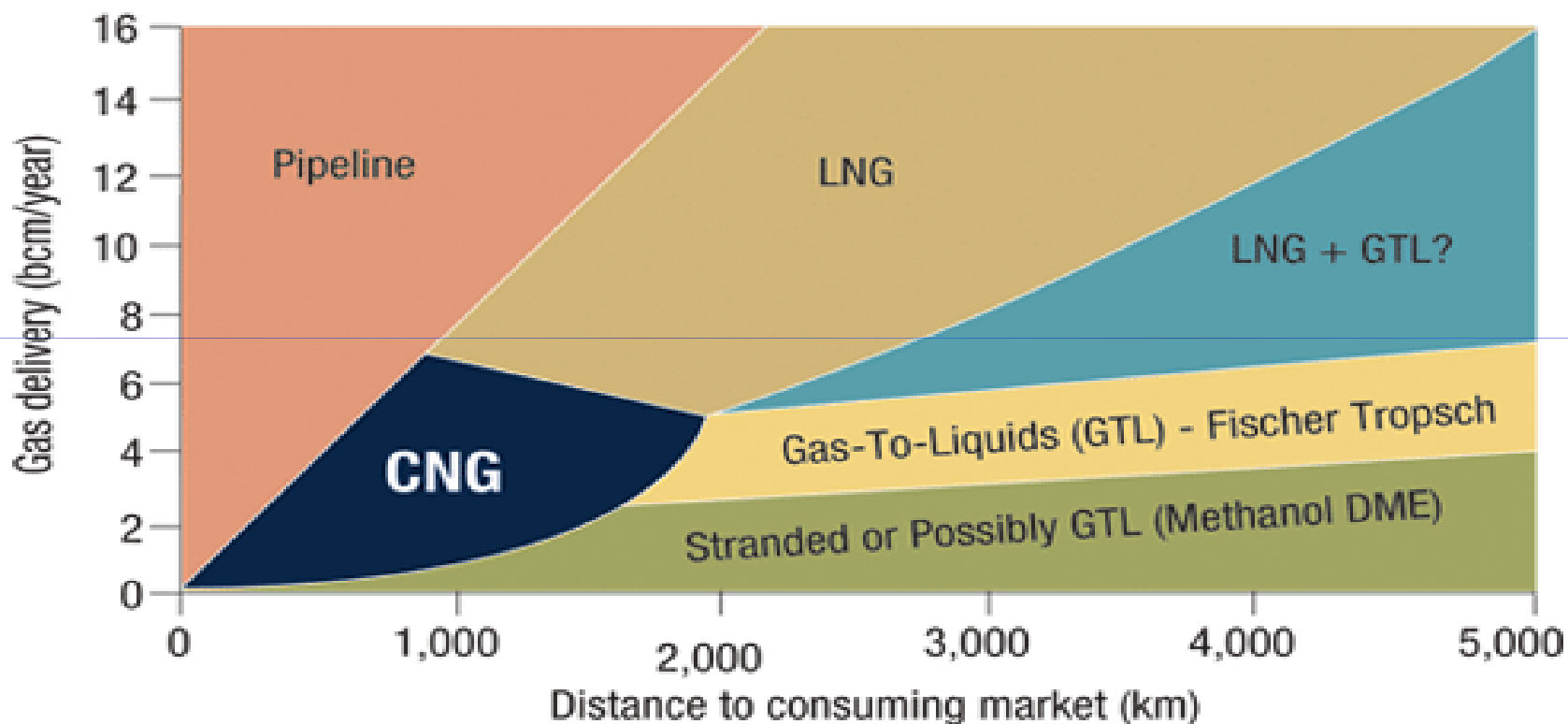
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- 1. MOST ADVANTAGEOUS TECHNOLOGY FOR NG SEA TRANSPORT:**
 - ON DISTANCES TO CONSUMING MARKETS < 2.500 KM
 - FOR MEDIUM QUANTITIES (< 10 BCM/Y)
 - 2. COST OF ON-SHORE INFRASTRUCTURE : LOW**
 - 3. AGGREGATION CARGO STATE AND TRANSPORT TEMPERATURE:
PERMANENTLY GASEOUS - T = -30...+40 °C**
 - 4. PUBLIC ACCEPTANCE: MEDIUM – TO - HIGH**

- 
- 1. COST OF CNG TANKERS: HIGH**
 - 2. RATE OF ACCIDENTAL LOSSES HAZARD DURING TRANSPORT:
D/t ~ 225...300**

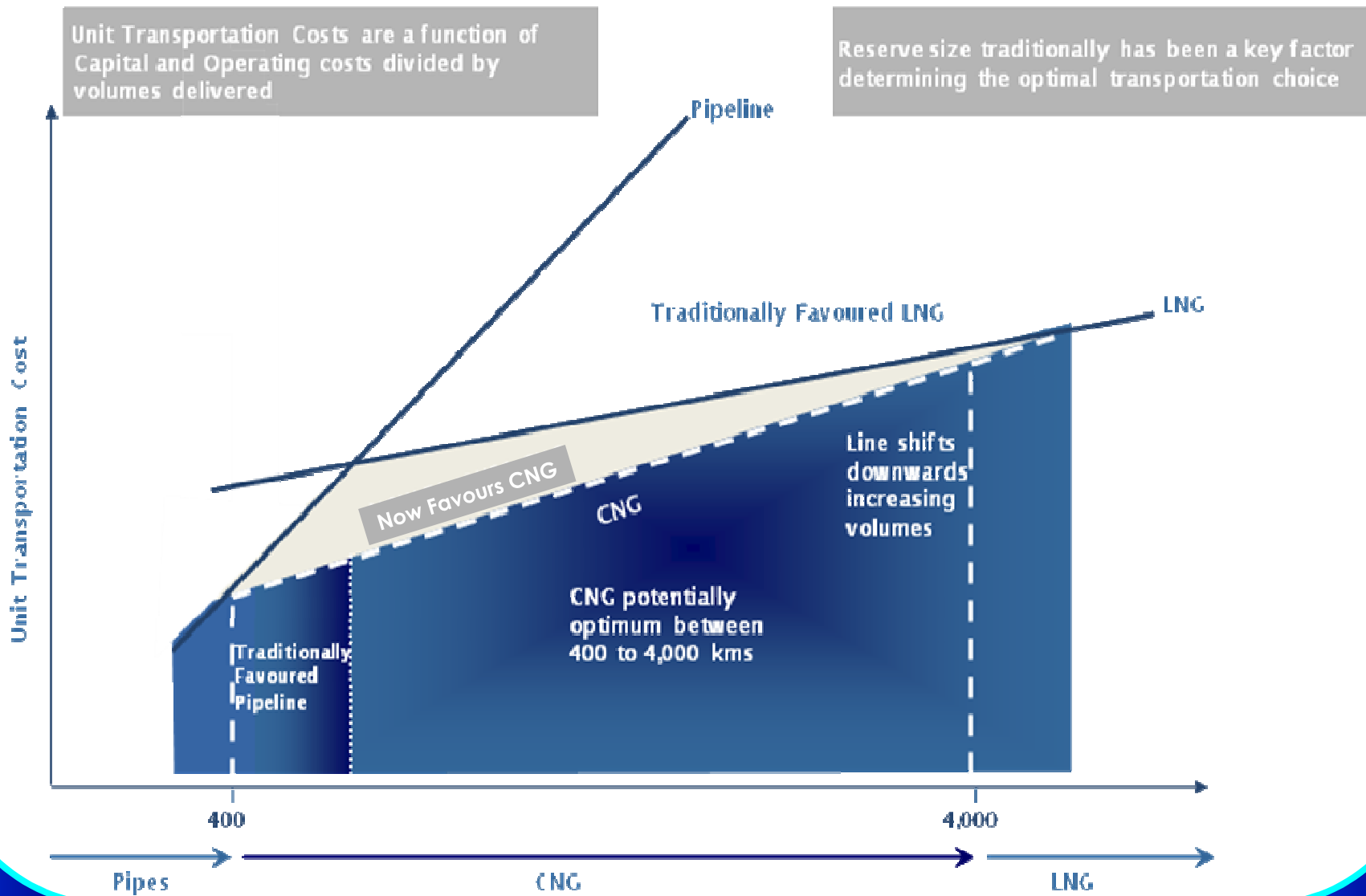


PUBLIC ACCEPTANCE: (1) L N G – LOW (2) C N G – MEDIUM/HIGH

Efficient Options for Monetizing Natural Gas

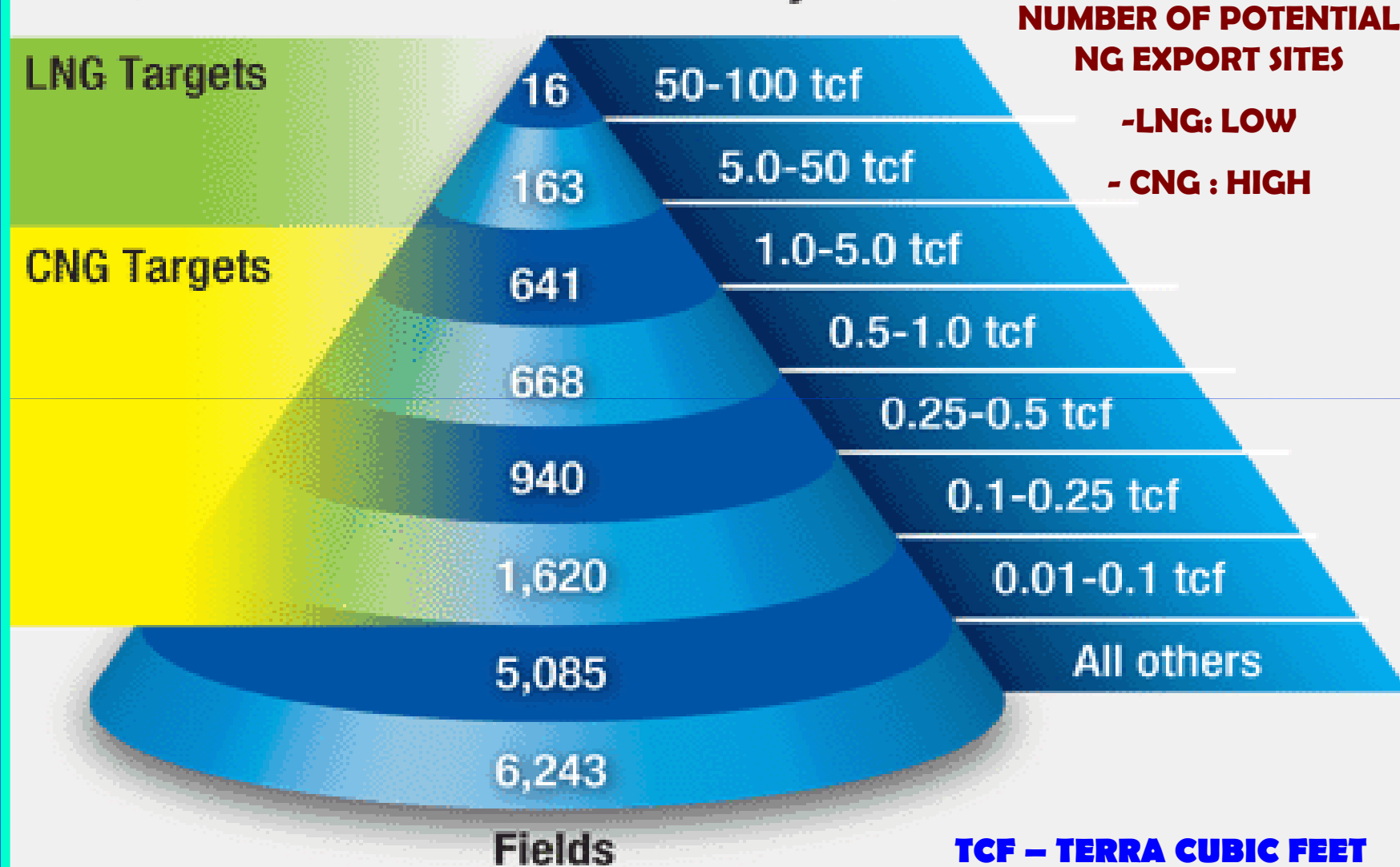


**THE UPSTREAM & DOWNSTREAM INFRASTRUCTURE COSTS :
(1) L N G – VERY LARGE / (2) C N G – LOW**



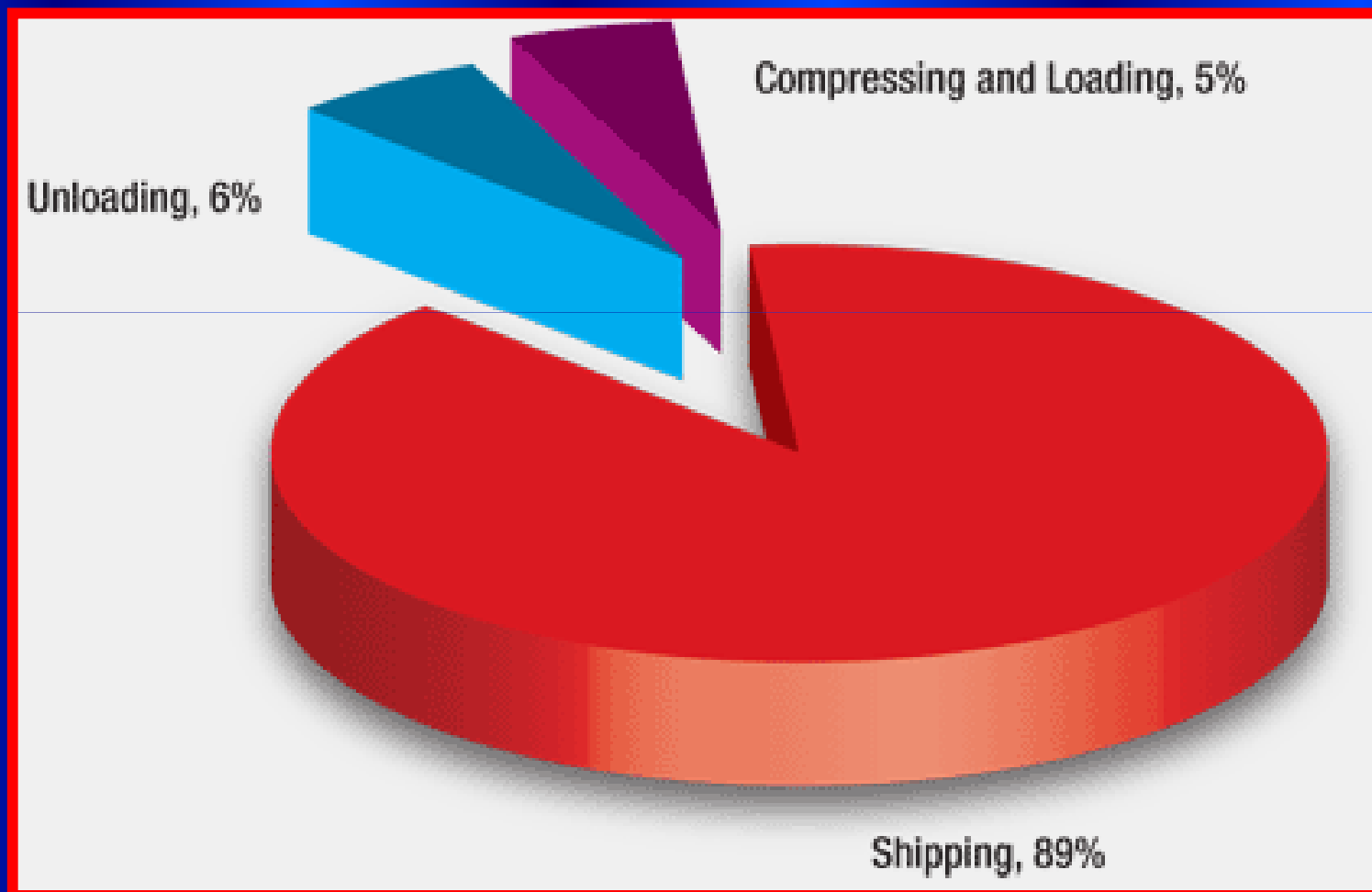


Distribution of World's Gas Fields by Size



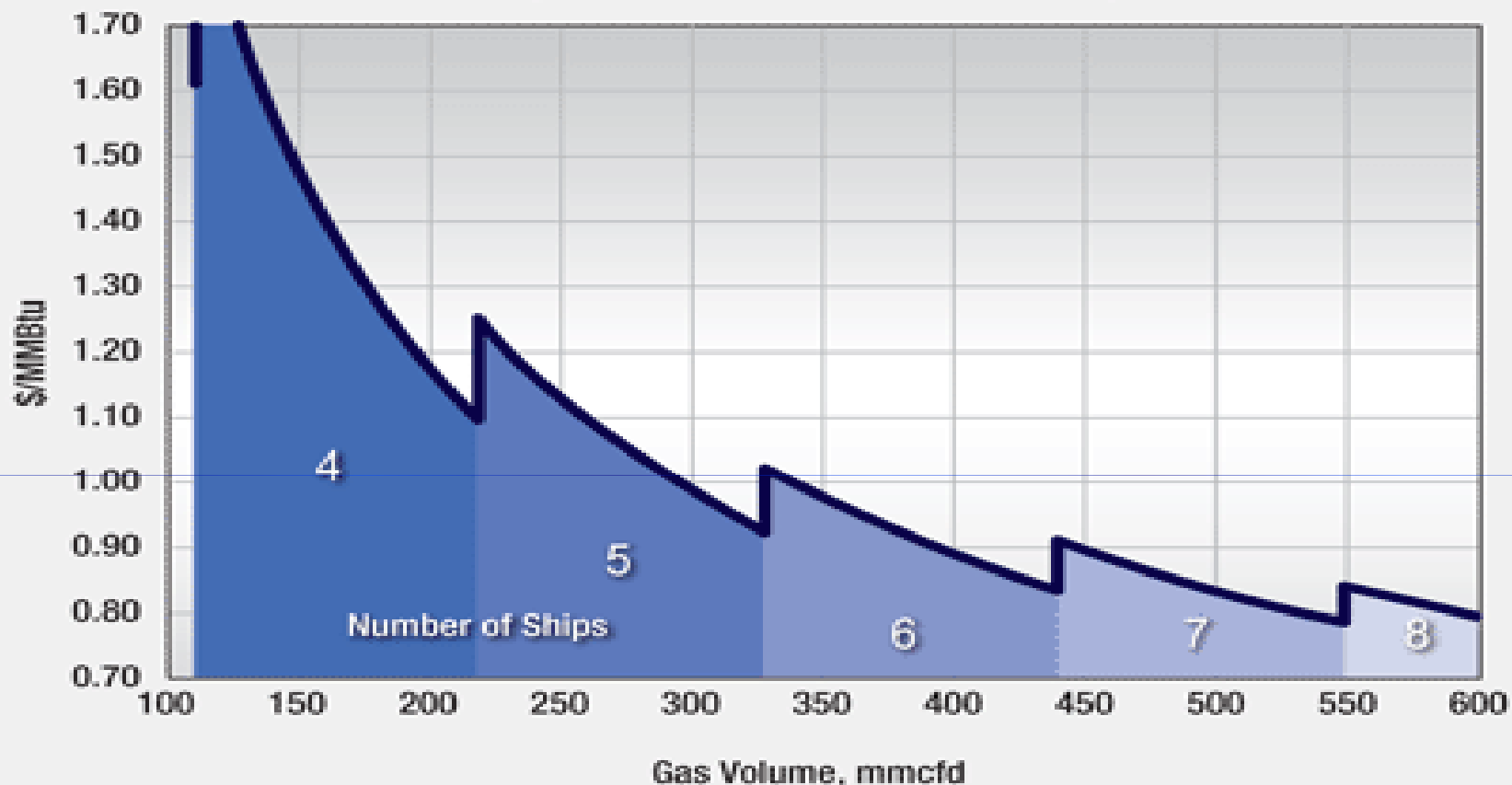


CNG SEA TRANSPORT - COST STRUCTURE -





Cost analysis for different CNG ship numbers

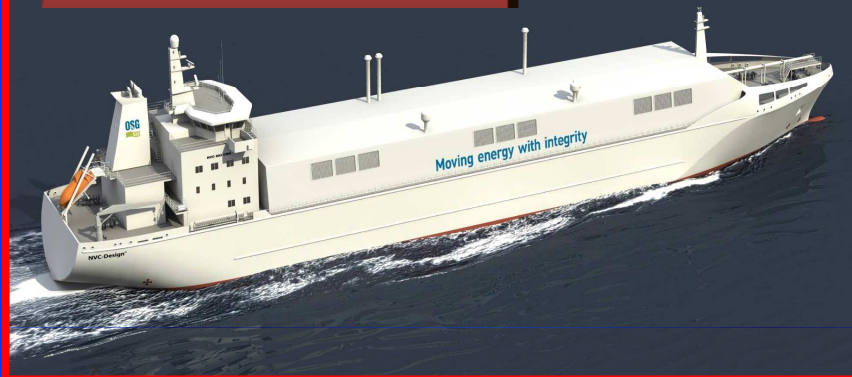


1 MBTU (ONE MILLION BTU) = STANDARD UNIT OF MEASUREMENT FOR NATURAL GAS AND PROVIDES A CONVENIENT BASIS FOR COMPARING THE ENERGY CONTENT OF VARIOUS GRADES OF NATURAL GAS AND OTHER FUELS. ONE CUBIC FOOT OF NATURAL GAS PRODUCES APPROXIMATELY 1,000 BTU, SO 1,000 CU.FT. OF GAS IS COMPARABLE TO 1 MBTU. MBTU IS OCCASIONALLY EXPRESSED AS MMBTU, WHICH IS INTENDED TO REPRESENT A THOUSAND THOUSAND BTU. (3412 BTU = 1 kWh & 1 BTU = 1,055.06 Joules). MMCFD: MILLIONS OF CUBIC FEET/DAY



II. **CNG** : COMPRESSED NATURAL GAS(4)

**TYPE NVC 602 CNG -
VESSEL TYPE A
LONDON – 23.04.2007**

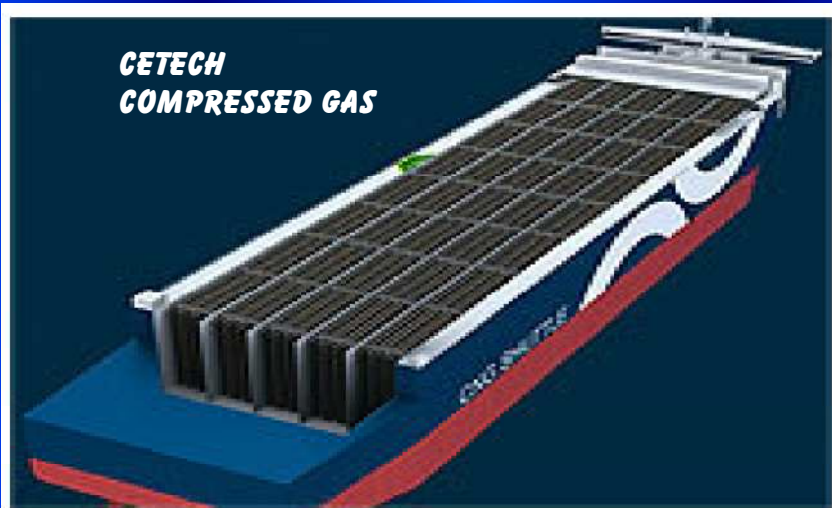


Length Over All:	149,90 m
Length between P.P.	142,00 m
Breadth m.l.	23,50 m
Depth to Double Bot	2,00 m
Depth m.l. to Main Deck	15,00 m
Hull / Steel Structure	5'300 t
Displacement (Cb = 0,73)	18'700 t
Deadweight at 7,50 m	2'000 t
Weight of compressed gas	1'430 t

- **TRANSPORT SHIPS: USUAL , SINGLE & TWIN DECK, BULK – CARRIER**
- **THE NEW SHIP TYPE COMBINES THE FEATURES OF A CRUDE OIL TANKER AND A CONTAINER SHIP. THE CONTAINMENT SYSTEM MAY COMPRISE A SET OF VERTICAL PIPES DESIGNED ACCORDING TO THE PRINCIPLES USED FOR PIPELINES. SHIPS HAVE SO FAR BEEN DESIGNED TO TRANSPORT UP TO 30 MSM³ GAS ON EACH VOYAGE.**



**CETECH
COMPRESSED GAS**



TRANSCANADA: 75 MMSCF CAPACITY



**GTM: 400 X 75' LG / STACKED 12
HIGH PRESSURE 3'150 PSI**

SEA NG 16 COSELLE



HARTH FAST CNG CONTAINER SHIP



**80 KNOTS THROUGH FORCE 7 BEAUFORT - 96 CONTAINERS
Panamex Friendly
Hydro Lance Engineering, Inc.**

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PARAMETERS	L N G	C N G
TRANSPORT CONDITIONS	ATMOSPHERIC PRESSURE (1 BAR)	HIGH PRESSURE (100 - 250 BAR)
TRANSPORT TEMPERATURE	CRIOGENYC (-163 °C)	-40 ... +30°C
AGGREGATION CARGO STATE	PERMANENT LIQUID-STATE	PERMANENT GASEOUS-STATE
IGNITION PROBABILITY DURING SEA TRANSPORT	LOW	HIGH
LOADING / UNLOADING - AGGREGATION STATE	LIQUID	COMPRESSED GAS
GAS COMPRESSION RATIO DURING TRANSPORTATION	~600 : 1	~250 ... 350 : 1 – SUBJECT TO GAS COMPOSITION & TO GAS STOCKAGE TEMPERATURE
RATE OF ACCIDENTAL LOSSES HAZARD DURING TRANSPORT	D / t ~1'000	D / t ~ 225 ... 300
MATERIALS USED FOR THE MANUFACTURING OF TRANSPORT CONTAINERS	ALUMINIUM, STEEL, HIGH – ALLOYS NICKEL - STEEL	HIGH ALLOYS STEEL – CARBON – MANGAN WITH FINE GRANULES





LNG VERSUS CNG VERSUS PIPELINE (PL) FOR THE FLOATING TRANSPORT OF DIFFERENT NG QUANTITIES BETWEEN BLACK SEA PORTS

	2 Bn C.M. / Year	5 Bn C.M. / Year	10 Bn C.M. / Year
2.000 Km	<p><u>CNG</u>: 5 Ships = \$ 1,84Bn Ops = \$ 85M/Year Total: \$ 1,925Bn</p> <p><u>LNG</u>: 5 Ships = \$ 490M Liq = \$ 2,25 Bn / Ops = \$ 194M Total = \$ 2,934Bn</p> <p><u>PL</u>: PL Inv = \$ 5,223Bn Ops = \$ 277M Total: \$ 5,5Bn</p>	<p><u>CNG</u>: 12 Ships = \$ 4,4Bn Ops = \$ 198M/Year Total: \$ 4,598Bn</p> <p><u>LNG</u>: 12 Ships = \$ 1,18Bn Liq = \$ 3,90 Bn / Ops = \$ 364M Total = \$ 5,113 Bn</p> <p><u>PL</u>: PL Inv = \$ 9,12Bn Ops = \$ 480M Total: \$ 9,6Bn</p>	<p><u>CNG</u>: 23 Ships = \$ 8,44Bn Ops = \$ 383M/Year Total: \$ 8,823Bn</p> <p><u>LNG</u>: 23 Ships = \$ 2,25Bn Liq = \$ 5,90 Bn / Ops = \$ 601M Total = \$ 8,751Bn</p> <p><u>PL</u>: PL Inv = \$ 14,065Bn Ops = \$ 535M Total: \$ 14,6Bn</p>
<p>1.200 Km (Kulevi – Varna & Kulevi - Constanta)</p> <p>2 Bn : LNG = 1,84 x CNG 5 Bn : LNG = 1,48 x CNG 10 Bn : LNG = 1,24 x CNG</p>	<p><u>CNG</u>: 4 Ships = \$ 1,47Bn Ops = \$ 70M/Year Total: \$ 1,54Bn</p> <p><u>LNG</u>: 4 Ships = \$ 392M Liq = \$ 2,25 Bn / Ops = \$ 183M Total = \$ 2,825Bn</p> <p><u>PL</u>: PL Inv = \$ 3,232Bn Ops = \$ 168M / Total: \$ 3,4Bn</p>	<p><u>CNG</u>: 9 Ships = \$ 3,3Bn Ops = \$ 159M/Year Total: \$ 3,459Bn</p> <p><u>LNG</u>: 9 Ships = \$ 882M Liq = \$ 3,9Bn / Ops = \$ 331M Total = \$ 5,113Bn</p> <p><u>PL</u>: PL Inv = \$ 5,509Bn Ops = \$ 291M / Total: \$ 5,8Bn</p>	<p><u>CNG</u>: 17 Ships = \$ 6,24Bn Ops = \$ 306M/Year Total: \$ 6,546Bn</p> <p><u>LNG</u>: 17 Ships = \$ 1,67 Bn Liq = \$ 5,9Bn / Ops = \$ 535M Total = \$ 8,105Bn</p> <p><u>PL</u>: PL Inv = \$ 8,358 Bn Ops = \$ 442M / Total: \$ 8,8Bn</p>
800 Km (Samsun – Constanta)	<p><u>CNG</u>: 3 Ships = \$ 1,18Bn Ops = \$ 60M/Year Total: \$ 1,24Bn</p> <p><u>LNG</u>: 3 Ships = \$ 294M Liq = \$ 2,25Bn / Ops = \$ 172M Total = \$ 2,716Bn</p> <p><u>PL</u>: PL Inv = \$ 1,994Bn Ops = \$ 106M / Total: \$ 2,1Bn</p>	<p><u>CNG</u>: 7 Ships = \$ 2,57Bn Ops = \$ 134M/Year Total: \$ 2,704Bn</p> <p><u>LNG</u>: 7 Ships = \$ 686M Liq = \$ 3,9Bn / Ops = \$ 309M Total = \$ 4,895Bn</p> <p><u>PL</u>: PL Inv = \$ 3,516Bn Ops = \$ 184M / Total: \$ 3,7Bn</p>	<p><u>CNG</u>: 14 Ships = \$ 5,14Bn Ops = \$ 224 M/Year Total: \$ 5,364Bn</p> <p><u>LNG</u>: 17 Ships = \$ 1,67Bn Liq = \$ 5,9Bn / Ops = \$ 502M Total = \$ 8,072Bn</p> <p><u>PL</u>: PL Inv = \$ 5,321Bn Ops = \$ 279M / Total: \$ 5,6Bn</p>



COST EVALUATION

PROJECT	MODE OF TRANSPORT	LENGTH (KM)	QUANTITY PER YEAR / TOTAL COST
 AGRI AZ - GE - RO	LNG	KULEVI – CONSTANTA 1.078 Km	2 Bn : USD 2,825 Bn 5 Bn : USD 5,113 Bn 10 Bn : USD 8,105 Bn
 AGBI AZ - GE - BG	CNG	KULEVI – VARNA 1.130 Km	2 Bn : USD 1,540 Bn 5 Bn : USD 3,459 Bn 10 Bn : USD 6,546 Bn



COMPARING THE INVESTMENT AND OPERATIONAL COSTS

		CNG / LNG			CNG / PL			PL / LNG		
DIS - TANCE In Km	QUANTITY In m ³ / Year	2 Bn	5 Bn	10 Bn	2 Bn	5 Bn	10 Bn	2 Bn	5 Bn	10 Bn
	800		1.240 / 2.716 = <u>46%</u>	2.704 / 4.895 = <u>55%</u>	5.364 / 8.072 = <u>66%</u>	1.240 / 2.100 = <u>59%</u>	2.704 / 3.700 = <u>73%</u>	5.364 / 5.600 = <u>96%</u>	2.100 / 2.716 = <u>77%</u>	3.700 / 4.895 = <u>75%</u>
1.200		1.540 / 2.825 = <u>55%</u>	3.459 / 5.113 = <u>68%</u>	6.546 / 8.105 = <u>81%</u>	1.540 / 3.400 = <u>45%</u>	3.459 / 5.800 = <u>60%</u>	6.546 / 8.800 = <u>74%</u>	3.400 / 2.825 = <u>120%</u>	5.800 / 5.113 = <u>113%</u>	8.800 / 8.105 = <u>109%</u>
2.000		1.925 / 2.934 = <u>66%</u>	4.598 / 5.444 = <u>84%</u>	8.823 / 8.751 = <u>101%</u>	1.925 / 5.500 = <u>35%</u>	4.598 / 9.600 = <u>48%</u>	8.823 / 14.600 = <u>60%</u>	5.500 / 2.934 = <u>187%</u>	9.600 / 5.444 = <u>176%</u>	14.600 / 8.751 = <u>167%</u>



**THANK YOU
FOR
YOUR KIND ATTENTION!**

