UN-ESCWA

UNITED NATIONS - Economic and Social Commission for Western Asia

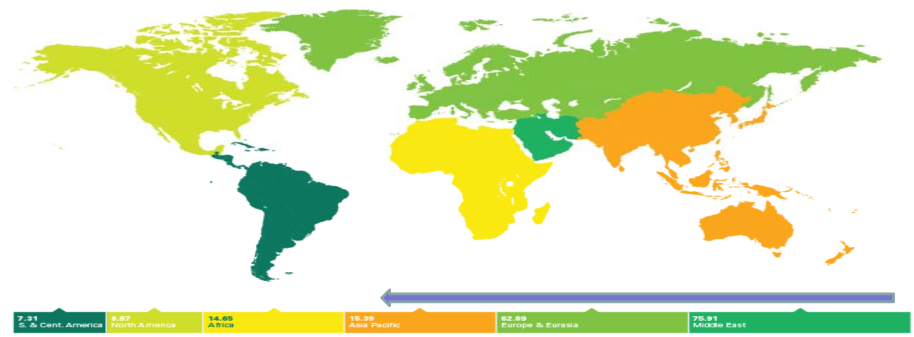
Natural Gas Transportation and Trading: Global and Regional Outlook

Dr. Salah Kandil
Energy Section
Sustainable Development and Productivity Division
UN-ESCWA

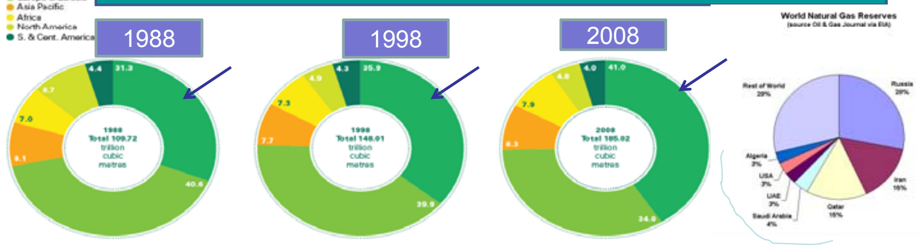
Expert Group Meeting on «The Role of Energy Networks in Regional Integration»,
22-2[illegible] December 2009, Beirut

Contents

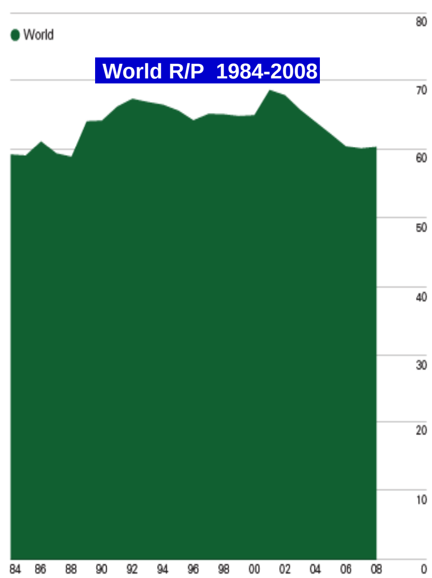
Distribution of proved natural gas reserve by region, 2008 "Trillion cubic metres"

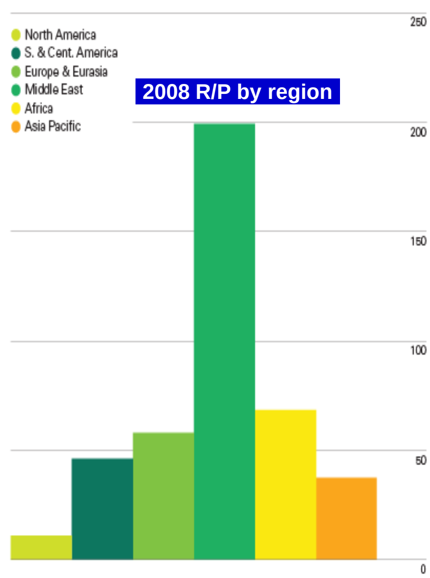


Development of proved NG reserves (1988-2008) "Trillion cubic metres"



Reserves-to-production (R/P) ratio "Years"

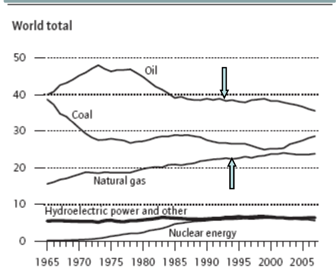




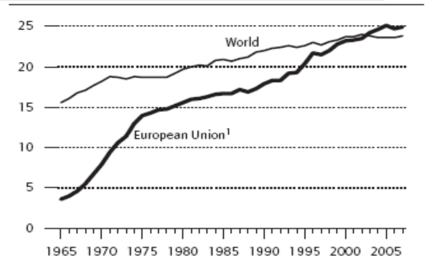
Global proved reserves of natural gas increased by 7.97tcm in 2008, and the R/P ratio increased to 60.4 years. Increases in Turkmenistan and Iran accounted for most of the growth.

Share of NG Consumption -%

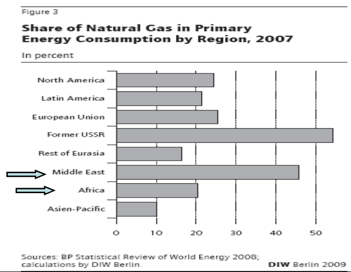
World NG Primary Energy Consumption-% (1965-2005)



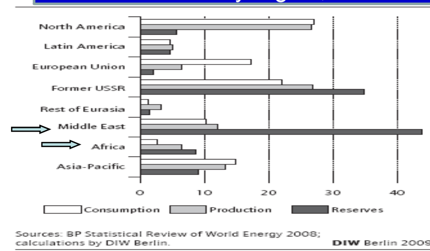
World NG consumption- % (1965-2005)



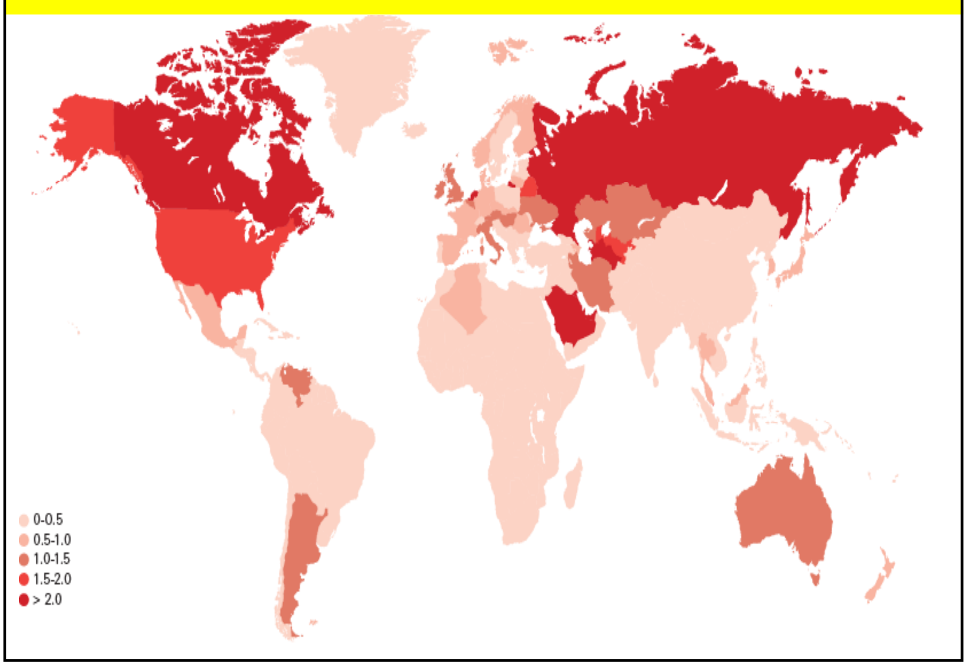
Share of NG gin primary energy consumption by region-% (2007)



NG consumption, production, and reserves by region, 2007



NG consumption per capita- 2008 “tonnes oil equivalent)

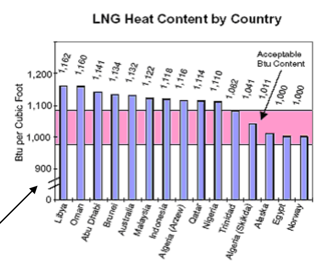


NG Transportation: Pipelines & LNG

Facts and considerations for NG transportation

NG Properties "depends on NG well)

- •Composition (CH_4, C_2H_6, C_3H_8 and others)
- •Density (less than air "0.6-0.8 kg/m3'
- •Flammability (5-15% by volume)
- •Self ignition temp. (600-700 deg. c)
- •Heating value (acceptable 990-1090 btu/ft3)
- •NG advantages "as a fuel" (technical, economic and environmental advantages)

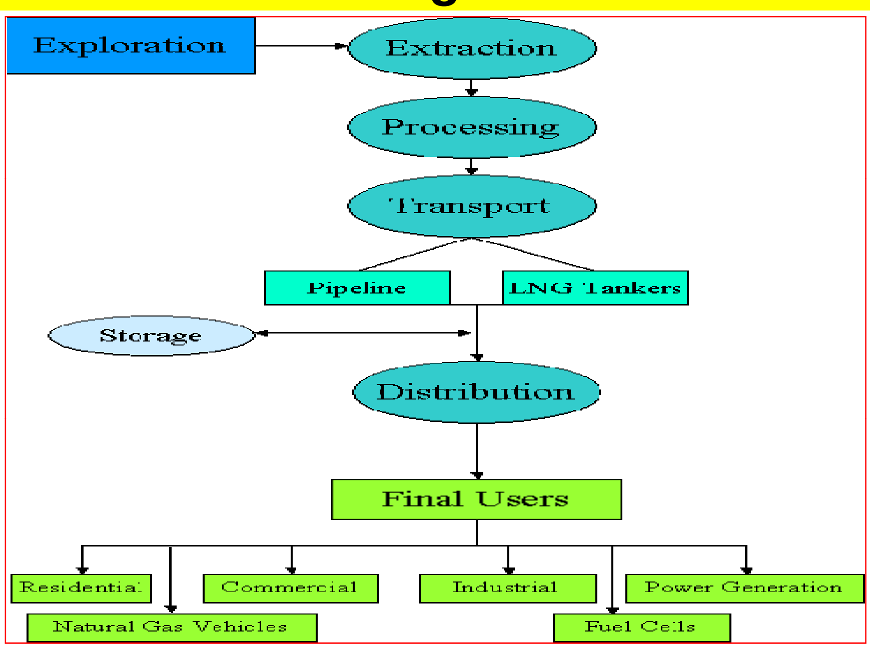


Sources: Libya: *World LNG Source Book 2001.* Other: Conversion Gas Imports, LLC and International LNG Alliance (ILNGA).

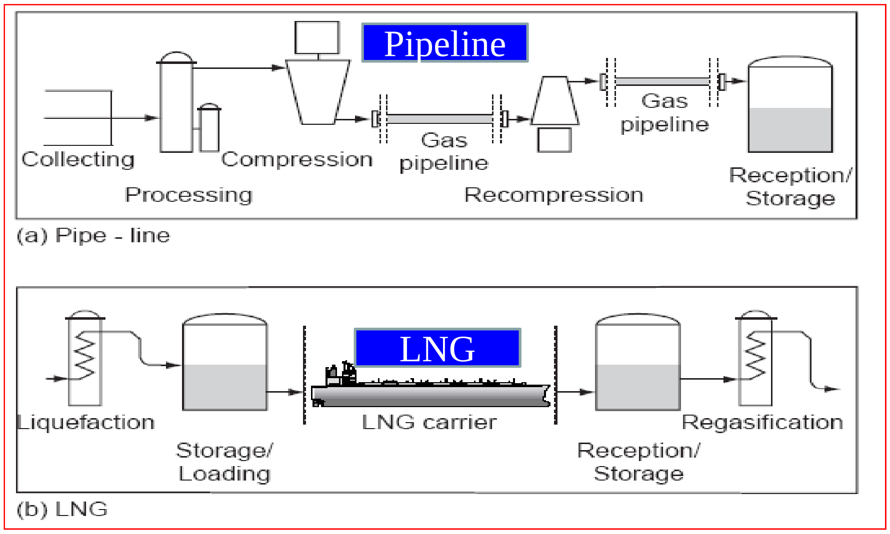
Facts and considerations for NG transportation

- 1 ton NG occupies a volume around 1350 m3, whereas 1 ton of oil occupies a volume slightly higher than 1 m3.
- Because of its physical nature, NG is more difficult and costly to transport/store than oil. It needs high pressures and/or low temperatures to increase the bulk density
- The cost of transporting NG per unit of energy is perhaps 10 times of oil.
- There are two methods to transport NG (PIPELINES and LNG)

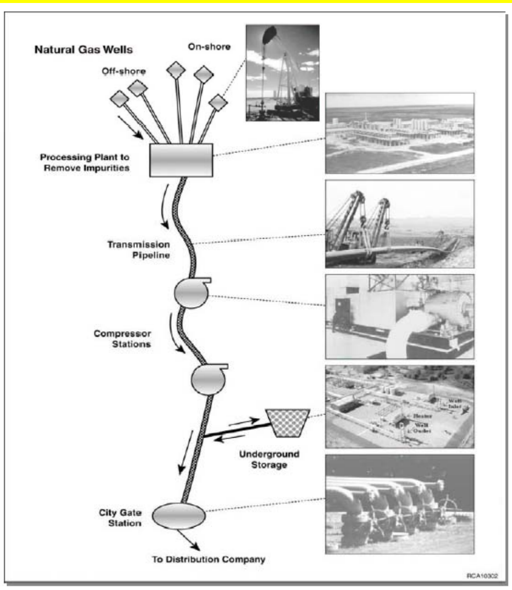
Natural gas chain

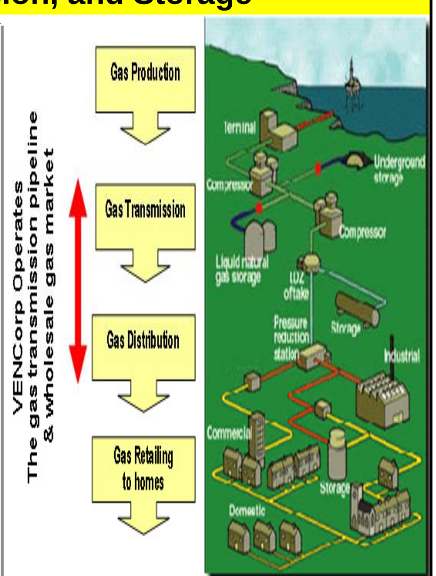


Gas chains



Transport by Pipelines: Production, Processing, Transmission, and Storage



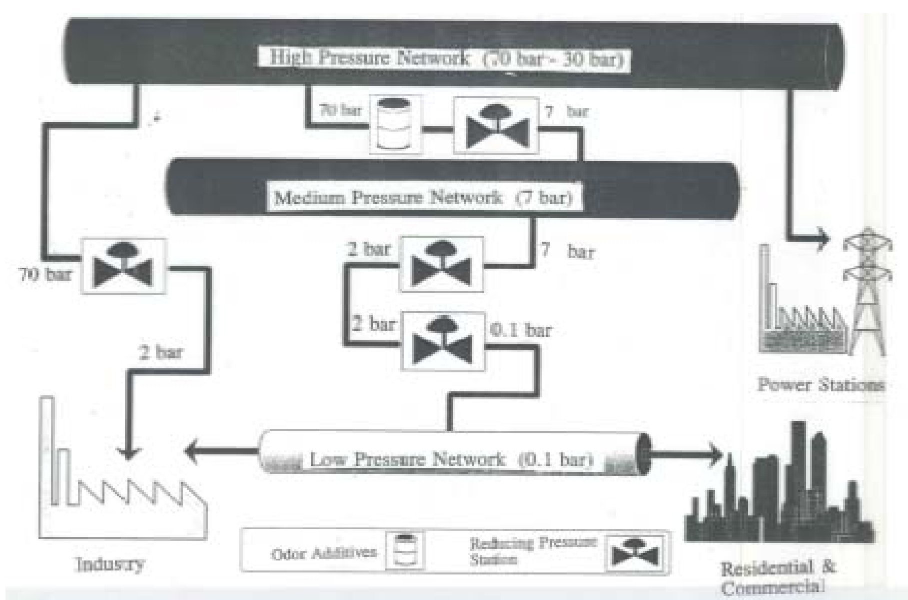


- The first pipelines were built in the late 1800s.
- Pipeline is a convenient method of transport but are not flexible as the gas will leave the source and arrive at its (one) destination

- The volume of transported gas depends on:
  - Pipeline operating pressure
  - Pipe diameter.

- Operating pressures:
  - About 70 bars/onshore
  - 100- 150 bars/off shore
  - Recompression station/100 -150 km.

NG network in Egypt



Capital costs allocation and pipeline construction workforce (%)

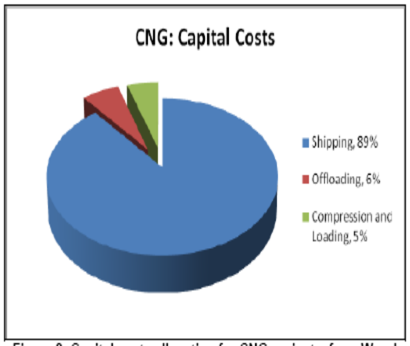
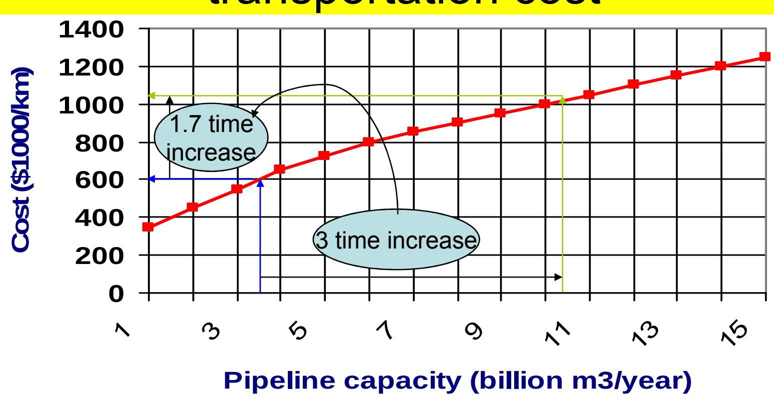


Figure 8: Capital costs allocation for CNG projects, from Wood *et al*, 2008 and Economides *et al*, 2005.

Labor Category	Percent of Total
Pipe fitters and welders	6
Equipment operators	27
Truck drivers	29
Laborers (including welder's helpers)	18
Supervisory	6
Others (construction inspectors, camp and catering, electricians, iron workers, etc.)	13

Relation between gas pipeline capacity and transportation cost



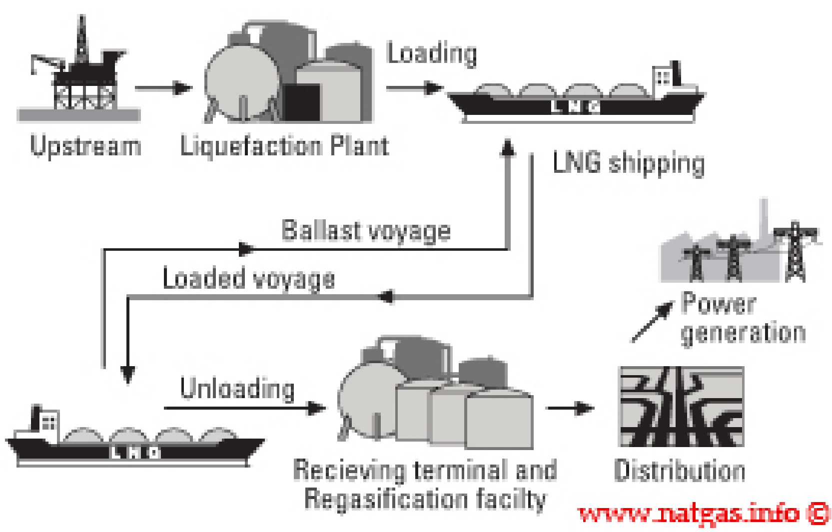
On average: Installation of *pipeline costs, 1–5 US$ million per mile*, sometimes even higher, *depending on* the land characteristics (such as for onshore, mountains or for offshore, seabed flatness and depth) plus compressor stations.

Liquefied Natural Gas Chain

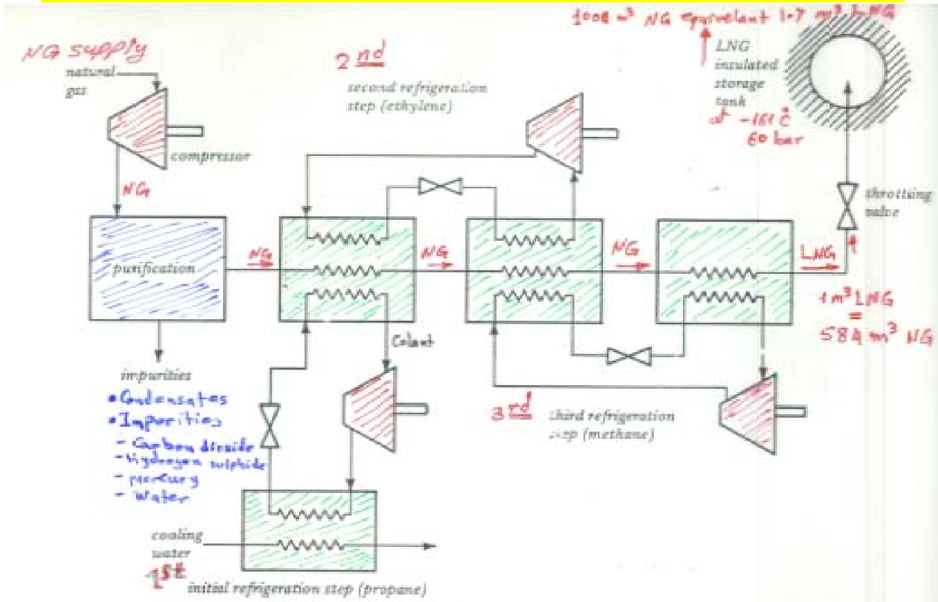
- The first commercial LNG facility was built in the U.S. in 1941, and the first large-scale LNG plant was built in Algeria.
- The LNG process is more complex than pipeline.
- Liquefaction plants are typically the most expensive element in an LNG project (8%–10% of gas delivered to the plant is used to fuel the refrigeration process.

↑

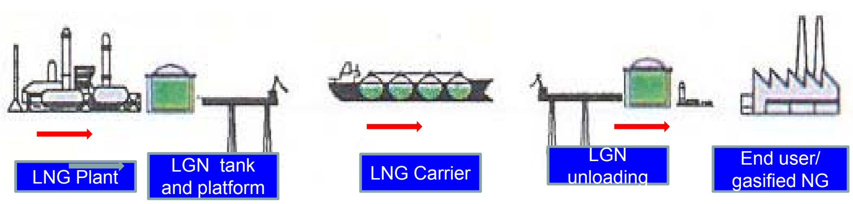
Liquefied Natural Gas Chain



Simplified NG Liquefaction



Cost of LNG Processes (from liquefaction to user)



Items	Cost
liquefaction plant	0.7 - 1 billion $
LNG reservoir + platform for filling LNG from reservoir to Carrier	1 - 1.5 billion $
A Carrier for LNG transportation	0.3-0.5 billion $
Platform for unload LNG and reservoirs to receive LNG	1 – 1.5 Billion $
Total Cost	**3 - 4.5 Billion $**

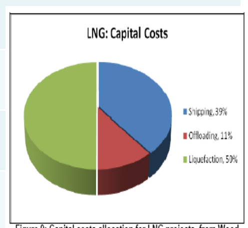
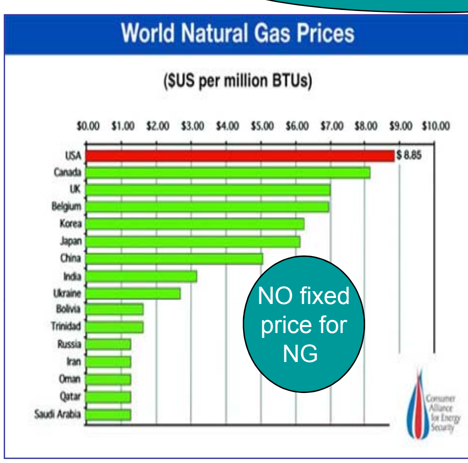


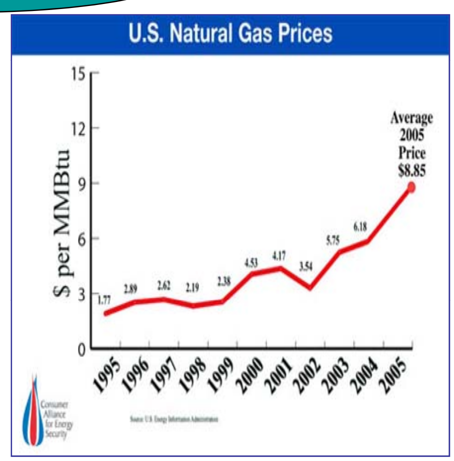
Figure 9: Capital costs allocation for LNG projects, from Wood *et al*, 2008 and Economides *et al*, 2005.

Natural Gas Prices and Cost of Transportation

World and U.S. natural gas price "2005" (US$/ Mbtu)

1 Cubic Meter NG = 35 Million btu





Prices of NG in different countries compared to Oil -US$/million btu "1985-2008"

Prices

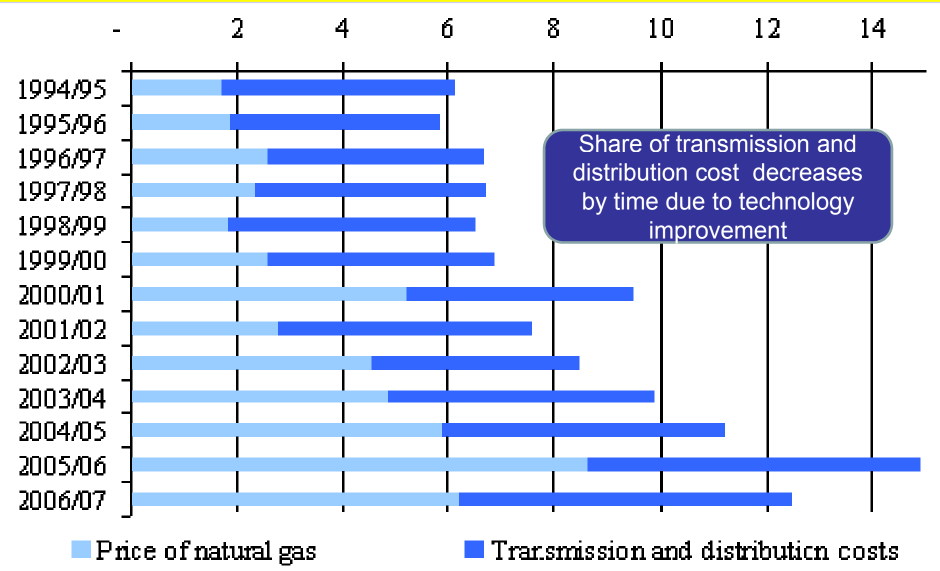
US dollars per million Btu	LNG Japan cif	Natural gas European Union cif	UK Heren NBP Index†	US Henry Hub‡	Canada Alberta‡	Crude oil OECD countries cif
1985	5.23	3.83	–	–	–	4.75
1986	4.10	3.65	[illegible]	–	–	2.57
1987	3.35	2.59	[illegible]	–	–	3.09
1988	3.34	2.36	[illegible]	–	–	2.56
1989	3.28	2.09	[illegible]	1.70	–	3.01
1990	3.64	2.82	[illegible]	1.64	1.05	3.82
1991	3.99	3.18	[illegible]	1.49	0.89	3.33
1992	3.62	2.76	–	1.77	0.98	3.19
1993	3.52	2.53	–	2.12	1.69	2.82
1994	3.18	2.24	–	1.92	1.45	2.70
1995	3.46	2.37	–	1.69	0.89	2.96
1996	3.66	2.43	1.87	2.76	1.12	3.54
1997	3.91	2.65	1.96	2.53	1.36	3.29
1998	3.05	2.26	1.86	2.08	1.42	2.16
1999	3.14	1.80	1.58	2.27	2.00	2.98
2000	4.72	3.25	2.71	4.23	3.75	4.83
2001	4.64	4.15	3.17	4.07	3.61	4.08
2002	4.27	3.46	2.37	3.33	2.57	4.17
2003	4.77	4.40	3.33	5.63	4.83	4.89
2004	5.18	4.56	4.46	5.85	5.03	6.27
2005	6.05	5.95	7.38	8.79	7.25	8.74
2006	7.14	8.69	7.87	6.76	5.83	10.66
2007	7.73	8.93	6.01	6.95	6.17	11.95
2008	12.55	12.61	10.79	8.85	7.99	16.76

NO international price for NG

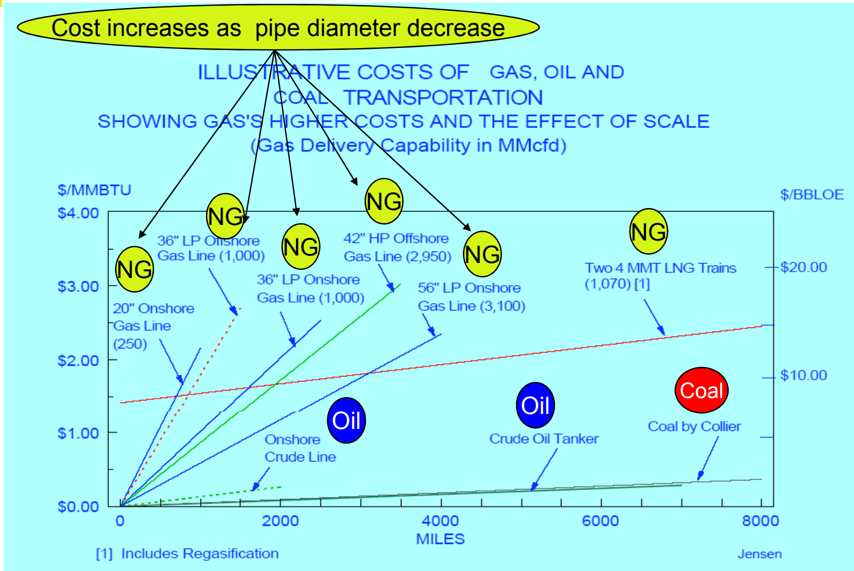
† Price is for NBP Day-Ahead Index. Source: ICIS Heren Energy Ltd.
‡ Source: *Natural Gas Week*.
Note: Btu = British thermal units; cif = cost+insurance+freight (average prices).

Average breakdown natural gas prices (US$ per million btu), 1995-2007

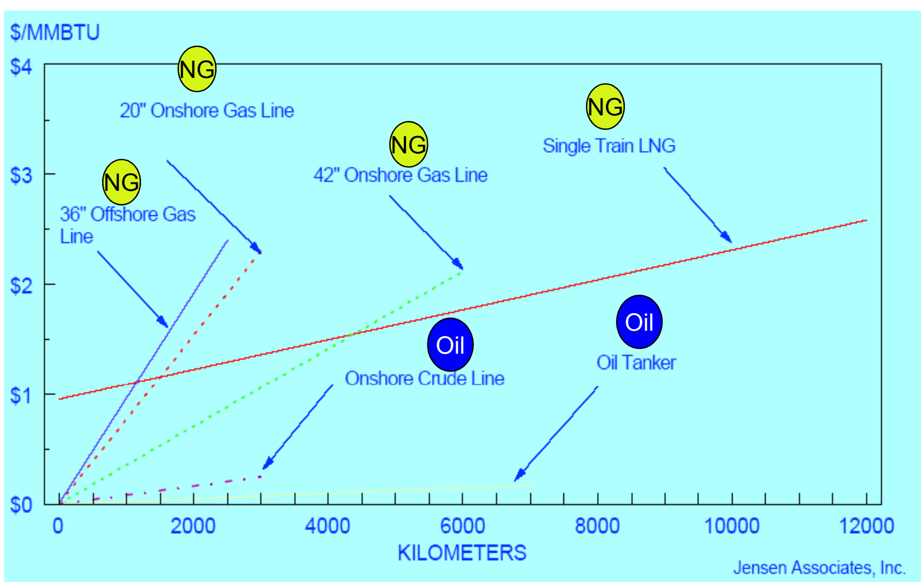
Source: UNCTAD based on data from Energy Information Administration, natural Gas Monthly



Costs Of NG Transportation Versus Oil and Coal



Costs Of NG Transportation Versus Oil



International NG Trading and Arab Share

NG **trade movements** "export & import" **by pipelines**, 2008 (billion cubic meter)

Trade movements 2008 by pipeline

Billion cubic metres — From

To	US	Canada	Mexico	Bolivia	Other S & Cent America	Belgium	Germany	Netherlands	Norway	United Kingdom	Russian Fed	Turkmenistan	Other Europe & Eurasia	Iran	Qatar	Algeria	Egypt	Libya	Mozambique	Indonesia	Malaysia	Myanmar	Total imports
North America																							
US	–	103.20	1.21	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**104.41**
Canada	15.90	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**15.90**
Mexico	10.28	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**10.28**
S. & Cent. America																							
Argentina	–	–	–	0.89	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**0.89**
Brazil	–	–	–	10.90	0.13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**11.03**
Chile	–	–	–	–	0.69	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**0.69**
Others	–	–	–	–	0.97	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**0.97**
Europe																							
Austria	–	–	–	–	–	–	1.20	–	1.10	–	5.80	–	–	–	–	–	–	–	–	–	–	–	**8.10**
Belgium	–	–	–	–	–	–	0.70	7.90	7.95	1.70	–	–	–	–	–	–	–	–	–	–	–	–	**18.25**
Bulgaria	–	–	–	–	–	–	–	–	–	–	3.10	–	–	–	–	–	–	–	–	–	–	–	**3.10**
Croatia	–	–	–	–	–	–	–	–	–	–	1.06	–	0.23	–	–	–	–	–	–	–	–	–	**1.29**
Czech Republic	–	–	–	–	–	–	–	–	2.01	–	6.60	–	–	–	–	–	–	–	–	–	–	–	**8.61**
Finland	–	–	–	–	–	–	–	–	–	–	4.50	–	–	–	–	–	–	–	–	–	–	–	**4.50**
France	–	–	–	–	–	0.80	2.40	8.00	15.90	0.60	8.80	–	0.16	–	–	–	–	–	–	–	–	–	**36.66**
Germany	–	–	–	–	–	–	–	20.50	26.40	1.60	36.20	–	2.40	–	–	–	–	–	–	–	–	–	**87.10**
Greece	–	–	–	–	–	–	–	–	–	–	2.80	–	0.40	–	–	–	–	–	–	–	–	–	**3.20**
Hungary	–	–	–	–	–	–	2.10	–	–	–	8.90	–	0.50	–	–	–	–	–	–	–	–	–	**11.50**
Ireland	–	–	–	–	–	–	–	–	–	5.00	–	–	–	–	–	–	–	–	–	–	–	–	**5.00**
Italy	–	–	–	–	–	–	1.10	8.70	6.00	0.70	24.50	–	–	–	–	24.44	–	9.87	–	–	–	–	**75.31**
Lithuania	–	–	–	–	–	–	–	–	–	–	3.09	–	–	–	–	–	–	–	–	–	–	–	**3.09**
Luxembourg	–	–	–	–	–	0.60	0.60	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	**1.20**
Netherlands	–	–	–	–	–	–	4.40	–	6.23	0.90	4.33	–	2.14	–	–	–	–	–	–	–	–	–	**18.00**
Poland	–	–	–	–	–	–	1.10	–	–	–	7.20	–	1.50	–	–	–	–	–	–	–	–	–	**9.80**
Portugal	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.93	–	–	–	–	–	–	**1.93**
Romania	–	–	–	–	–	–	–	–	–	–	3.50	–	1.00	–	–	–	–	–	–	–	–	–	**4.50**
Serbia	–	–	–	–	–	–	–	–	–	–	2.15	–	–	–	–	–	–	–	–	–	–	–	**2.15**
Slovakia	–	–	–	–	–	–	–	–	–	–	5.60	–	–	–	–	–	–	–	–	–	–	–	**5.60**
Spain	–	–	–	–	–	–	–	–	1.80	–	–	–	0.10	–	–	8.97	–	–	–	–	–	–	**10.87**
Switzerland	–	–	–	–	–	–	1.45	0.90	0.09	–	0.35	–	0.40	–	–	–	–	–	–	–	–	–	**3.19**
Turkey	–	–	–	–	–	–	–	–	–	–	23.55	–	2.95	5.80	–	–	–	–	–	–	–	–	**32.30**
United Kingdom	–	–	–	–	–	1.12	–	9.00	25.30	–	–	–	–	–	–	–	–	–	–	–	–	–	**35.42**
Others	–	–	–	–	–	–	0.09	–	–	–	2.38	–	0.91	–	–	0.41	–	–	–	–	–	–	**3.79**
Middle East																							
Iran	–	–	–	–	–	–	–	–	–	–	–	6.50	0.40	–	–	–	–	–	–	–	–	–	**6.90**
Jordan	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.72	–	–	–	–	–	**2.72**
United Arab Emirates	–	–	–	–	–	–	–	–	–	–	–	–	–	–	15.40	–	–	–	–	–	–	–	**15.40**
Others	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.70	–	0.14	–	–	–	–	–	**1.84**
Africa																							
Tunisia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.25	–	–	–	–	–	–	**1.25**
Other Africa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.50	–	–	3.20	–	–	–	**3.70**
Asia Pacific																							
Singapore	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6.65	1.62	–	**8.27**
Thailand	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8.55	**8.55**
Total exports	**26.18**	**103.20**	**1.21**	**11.79**	**1.79**	**2.52**	**15.14**	**55.00**	**92.78**	**10.50**	**154.41**	**6.50**	**13.09**	**5.80**	**17.10**	**37.50**	**2.86**	**9.87**	**3.20**	**6.65**	**1.62**	**8.55**	**587.26**

Notes: Flows are on a contractual basis and may not correspond to physical gas flows in all cases.
Data excludes trade within the Former Soviet Union, except the three Baltic States.

Source: Cedigaz (provisional).

NG **trade movements** by **LNG**, 2008 (billion cubic meter)

Trade movements 2008 – liquefied natural gas

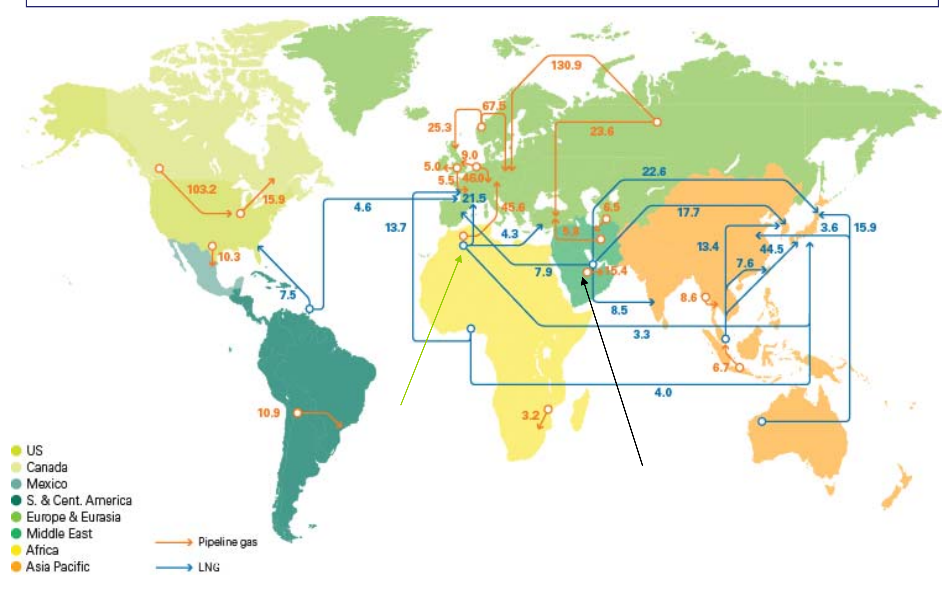
Billion cubic metres

To	From: US	Trinidad & Tobago	Belgium	Norway	Oman	Qatar	UAE	Algeria	Egypt	Equatorial Guinea	Libya	Nigeria	Australia	Brunei	Indonesia	Malaysia	Total imports
North America																	
US	–	7.47	–	0.48	–	0.09	–	–	1.56	–	–	0.34	–	–	–	–	9.94
Mexico	–	1.28	–	0.08	–	0.09	–	–	1.12	–	–	1.04	–	–	–	–	3.61
S. & Cent. America																	
Argentina	–	0.33	–	–	–	–	–	–	0.08	–	–	–	–	–	–	–	0.41
Dominican Republic	–	0.47	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.47
Puerto Rico	–	0.81	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.81
Europe																	
Belgium	–	0.08	–0.40	0.08	–	2.65	–		0.08	–	–	–	–	–	–	–	2.49
France	–	0.08	–	0.25	–	–	–	7.60	1.06	–	–	3.60	–	–	–	–	12.59
Greece	–	0.08	–	–	–	–	–	0.70	0.16	–	–	–	–	–	–	–	0.94
Italy	–	–	–	–	–	–	–	1.56	–	–	–	–	–	–	–	–	1.56
Portugal	–	–	0.05	–	–	–	–	–	–	–	–	2.58	–	–	–	–	2.63
Spain	–	4.32	0.18	1.05	0.17	5.12	–	4.90	4.91	0.08	0.53	7.47	–	–	–	–	28.73
Turkey	–	–	–	–	–	–	–	4.25	0.08	–	–	0.98	–	–	–	–	5.31
United Kingdom	–	0.47	–	–	–	0.12	–	0.37	0.08	–	–	–	–	–	–	–	1.04
Asia Pacific																	
China	–	–	–	–	–	–	–	0.17	0.25	0.16	–	0.24	3.61	–	–	0.01	4.44
India	–	0.24	0.09	0.08	0.35	7.98	0.13	0.65	0.26	0.44	–	0.41	0.16	–	–	–	10.79
Japan	0.97	0.67	–	0.17	4.25	10.91	7.41	1.12	2.21	1.64	–	2.36	15.94	8.22	18.79	17.47	92.13
South Korea	–	0.84	0.08	–	6.04	11.62	–	0.47	2.13	1.33	–	0.16	0.53	0.98	4.06	8.31	36.55
Taiwan	–	0.22	–	–	0.09	1.10	–	0.08	0.08	1.53	–	1.36	–	–	4.00	3.61	12.07
Total exports	0.97	17.36	0.00	2.19	10.90	39.68	7.54	21.87	14.06	5.18	0.53	20.54	20.24	9.20	26.85	29.40	226.51

Note: The negative entry for 'from Belgium to Belgium' represents the re-export of LNG which was delivered to Zeebrugge terminal and then reloaded and shipped to other destinations.

Source: Cedigaz (provisional).

Major NG trade movements worldwide –pipelines & LNG (billion cubic metres)



Total NG trade "pipeline & LNG" in the Arab region-2008 (billion cubic meter)

	LNG	Pipelines	Total
World	226.5	578.3	804.8
Arab countries/ total world	94.6 (41.7)%	67.4 (11.5%)	162 (20.1%)
Trade within Arab region/Total Arab trade	----	21.7 (32.2%)	
(LNG + Pipelines)	"13.5% within the region" "86.5% outside the region"		

Growth of NG trading

- The global gas trade is forecasted to increase by more than 2% per year for the next twenty years.
-
- LNG global trade has increased by 7.4 % per year (1995 to 2005)
- By the end of 2007
  - There were 15 LNG exporting countries and 17 LNG importing countries, with four more (Yemen, Angola, Peru, Russia) by 2012.
  - The three biggest LNG exporters were Qatar (28 MT), Malaysia (22 MT) and Indonesia (20 MT)
  - The three biggest LNG importers in 2007 were Japan (65 MT), South Korea (34 MT) and Spain (24 MT).
- More than $250 billion of new investment will be required to meet LNG demand until 2030.

Main Articles of NG Agreement/ Contract

A. Agreement for all participating countries "umbrella for all parties" to address fundamental issues that pertain to all parties.
B. Bilateral agreements between states and national law of each state can be considered as deemed necessary.
C. The more participating countries in Agreement the more difficulties

Main Articles

(1) Period

Internationally, especially where a gas development project will have a limited number of potential customers, the period could reach 20 or 30 years.

(2) Quantity.

Generally, there are two types of contracts:

1. *Depletion contracts*, the producing company dedicates the entire production from a particular field or reserve to a buyer.
2. *Supply contracts* the seller supplies a fixed volume of gas to the buyer for fixed term "20 -25 years". The seller is responsible for sourcing the gas, either from its own reserves or from third parties.

(3) Price

- Gas must be priced at a level competitive with alternate fuels in the marketplace and provide an adequate return for all parties in the chain.
- Pricing may be:
  - *Fixed* price over the period of the contract and is usually found in shorter-term contracts"
  - *Floating " fixed price with an escalator*" increases by certain percentage every year or other specified time frame.
  - *Floating price* "varies according to prices reported by neutral sources, such as newspapers and NYMEX "New York Mercantile Exchange" quotations. In this case, the contracts are revalued every month. or every week according to the reported prices
  - *Combinations of fixed and floating* prices.

(4) Delivery obligation

- *Rigid delivery* "obligates the producing company or seller to deliver the specified quantities over the period of the contract. If the delivery obligation is not fulfilled, the seller may be obliged to pay damages or cover the costs of alternate fuels used by the buyer".
- *Flexible delivery* "obligates the producing company to make attempts to fulfill the delivery obligation but does not require fulfillment of all the delivery obligations".

(5) Take-or-pay (TOP) obligations

- The buyer is obliged to pay for a percentage of the contracted quantity if the buyer is unable or fails to take the gas supplied by the seller, other than due to fault of the seller or force majeure incidents.
- The seller usually requires **TOP** obligation on the buyer to guarantee a predictable minimum cash flow
- Financial institutions involved in the gas field or pipeline development may require these obligations as a condition for financing.

(6) Delivery point / location where gas is delivered to the buyer

It could be at the gate of the power plant, the center of grid city,, the site of a compressor, international border, or the boundary of LNG plant.

(7) Gas quality

- Maximum and minimum *heating values* (Btu/MMcf);
- Maximum level of impurities like oxygen, CO_2, SO_x, and NO_x and Water vapor content.
- Delivery pressure;

Note: The LNG agreements requires numerous legal/articles than pipelines..

Findings and conclusions

- NG is more difficult and costly to transport than oil (transporting NG per unit of energy is about 10 times higher than oil) – Therefore, the countries which produce oil and gas should maximize their use of NG locally and export the oil.
- The global NG trade is expected to increase by about 2% per year for the next 20 years.
- LNG global trade has increased by 7.4 % per year (1995 to 2005) . The three biggest LNG exporters were Qatar (28 MT), Malaysia (22 MT) and Indonesia (20 MT
- More than $250 billion of new investment will be required to meet LNG demand until 2030.

- The Arab countries NG trade represents 21% of the total world (13.5% of this percent is carried out within the Arab region, while 86.5% outside the region). Therefore there is a need to find appropriate mechanisms to promote NG trading between Arab countries.
- The Arab region has a huge NG reserve (reserve/production in the middle east = 200 years), this gives a trust to establish long term NG transportation/trading projects in the region.
- Main obstacles against NG transportation and trading:
  - High investment
  - Crossing the borders between countries
  - Differences between interests of counties/parties
  - Differences in regulations/laws for each county/party
  - Political, financial and technical risks

Some common unit conversions

These conversions are based on: bbl oil = 5.8 MMBtu = 5,800 MBtu --1 ft^3 gas = 1,000 Btu = 1 MBtu Thus: 1 bbl oil ≈ 5,800 ft^3 gas = 5.8 Mcf gas--1 boe ≈ 5.8

1 cf (1 ft^3) is equal to	1 cm (1 m^3) is equal to
0.0283 m^3	35.31 ft^3
1,000 Btu	35,314.67 Btu
1 MBtu	35.31 MBtu
0.000172 boe	0.00609 boe
1,055 kJ	37,257 kJ

1 Mcf (1,000 ft^3 ; 1x10^3 ft^3) is equal to	1 Mcm (1,000m^3 ; 1x10^3 m^3) is equal to
28.32 m^3	35,314.67 ft^3
1,000,000 Btu	35,314,666 Btu
1,000 MBtu	35,314.67 MBtu
1 MMBtu	35.31 MMBtu
10 Therm	353.15 Therm
0.17241 boe	6.09 boe
1,055 MM J	37,256.97 MM J
0.0205 ton LNG	0.7251 ton LNG

1 MMcf (1 million ft^3 ; 1x10^6 ft^3) is equal to	1 MMcm (1 million m^3 ; 1x10^6 m^3) is equal to
28,320.6 m^3	35,314.67 Mcf
1,000,000 MBtu	35,314.67 MMBtu
1 billion Btu (1x10^9)	35.31billion Btu (1x10^9)
10,000 therm	353 M therm
172.41 boe	6,088.74 boe
1.06 TJ (1x10^{12})	37.26 TJ (1x10^{12})
20.53 ton LNG	725.15 ton LNG

1 Bcf (1 billion ft^3 ; 1x10^9 ft^3) is equal to	1 bcm (1 billion m^3 ; 1x10^9 m^3) is equal to
28,320.6 M m^3	35,314.67 MM ft^3
28.321 MM m^3	35.31 bcf
0.0283 bcm	0.0353 tcf
1 trillion Btu (1x10^{12})	35.315 trillion Btu (1x10^{12})
10,000 M therm	353,147 M therm
10 MM therm	353.15 MM therm
172.41 Mboe	6,088.74 Mboe
1.06 PJ (1 x 10^{15})	37.26 PJ (1 x 10^{15})
0.021 MM ton (MT; million) LNG	0.725 MM ton (MT; million) LNG

1 tcf (1trillion ft^3 ; 1x10^{12} ft^3) is equal to	1 tcm (1 trillion m^3 ; 1x$10^{12}$$m^3$) is equal to
28.32 bcm	35,314.67 bcf
1,000 trillion (1x10^{15}) Btu	35,314.67 trillion(1x10^{15}) Btu
1 Quad (1x10^{15} Btu)	35.31 Quad (1x10^{15} Btu)
172.41 MM boe	6,088.74 MM boe
1,055 PJ	37,257 PJ
20.53 MM ton(MT; million) LNG	725.15 MM ton(MT; million) LNG

1 ton LNG is equal to	1 m^3 LNG is equal to	Other energy equivalents
48,700 ft^3	20,631 ft^3	1 Btu = 0.252 kcal = 1.055 kJ
1,379.03 m^3	584.2 m^3	1 kWh = 860 kcal = 3,600 kJ = 3,412 Btu
8.40 boe	3.56 boe	1 kWh = 3.41 ft^3 = 0.0966 m^3 = 0.00059 boe
48.7MM Btu	20.63 MM Btu	1 bbl LPG = 4.01 MM Btu
		1 bbl crude oil = 5.8 MM Btu
1 million tons / year (1 MTA) requires input of 48.7 bcf (1.38 bcm) per year, equivalent to 133 MMcfd		1 bbl diesel = 5.825 MM Btu
		1 bbl gasoline = 5.25 MM Btu
		1 bbl fuel oil = 6.29 MM Btu

Conversions based on	
1,000 Btu energy equivalent to	1 boe energy equivalent to
1,000 ft^3	5,800 ft^3
35,314.67 m^3	164.24 m^3
0.174 boe	5.8 MM Btu
1,055 kJ	6,119 kJ

References for more information

1. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V2S-49CKW33-1&_user=1916176&_coverDate=11%2F30%2F2003&_rdoc=1&_fmt=full&_orig=search&_cdi=5710&_sort=d&_docanchor=&view=c&_searchStrId=1091604367&_rerunOrigin=google&_acct=C000055305&_version=1&_urlVersion=0&_userid=1916176&md5=0a27004b8b08dd6309fa387cd7bbb0d7#fig1
2. http://www.natgas.info/html/gastrade.html
3. Energy Information Administration: http://www.eia.doe.gov/
4. http://corridoreis.anl.gov/documents/docs/technical/APT_61034_EVS_TM_08_5.pdf
5. http://www.unctad.org/infocomm/anglais/gas/prices.htm
6. BP Statistical Review of World Energy: http://www.usaee.org/usaee2009/submissions/presentations/Finley.pdf
7. http://faculty.kfupm.edu.sa/SE/salamah/mis/natural%20gas%20saudi%20arabia.htm

Thank you for your attention