Pre-Feasibility Study of the Trans-Korean Peninsula Pipeline

Ken Asakura*
General Secretary, National Pipeline Research Society of Japan
Research Director, Mitsubishi Research Institute
Tokyo, Japan

INTRODUCTION

Economic growth in the Asia-Pacific region is expected to stimulate concomitant growth in energy demand. Between 1989 and 2000, aggregate energy consumption in this region is expected to increase by 70%. But no dramatic increase in petroleum supply can be anticipated. Moreover, petroleum and its products are now considered environmentally "unfriendly." Thus, developed NEA countries are hoping to utilize natural gas which has the added benefit of being much less harmful to the environment.

To increase the intra-regional use of environmentally-clean natural gas, the National Pipeline Research Society of Japan proposes the construction of international trunk pipelines, collectively called the "Trans-Asian Natural Gas Pipeline Network," linking the gas fields in developing NEA with major consumer markets. This Trans-Asian Pipeline will play a vital role in the international infrastructure of the 21st century and assist in finding a solution to problems involving global environmental issues and long-lasting security in Asia. This paper presents a preliminary analysis of some pipeline projects in NEA, as a part of the Trans-Asian Natural Gas Pipeline Network, focusing especially on the Trunk Pipeline Project from the West Baikal natural gas fields to Japan.

NATURAL GAS DEMANDS IN NORTHEAST ASIA

Total primary energy demand in Asia is expected to double from 1992 to 2010. Natural gas demand is also expected to increase by 2.8 times for

---

*The views described in this paper are those of the author and do not necessarily reflect the views of the National Pipeline Research Society of Japan.

Asia, and 2.5 times for NEA in the same period (Table 1). On March 3, 1995, the First International Conference on Northeast Asian Natural Gas Pipelines was organized by the National Pipeline Research Society of Japan in Tokyo. On this occasion, China, South Korea and Japan presented the projected natural gas demands for their countries. In 2010, natural gas demand for these countries and Taiwan is expected to be 2.6-2.9 times that of 1994 (Table 2), implying that 181 BCM of gas will be required in 2010. This gas will likely be imported as LNG through international pipelines.

INTERNATIONAL PIPELINE PROJECT FROM WEST BAIKAL

The most important project in the Northeast Asian Natural Gas Pipeline Network would be an international trunk pipeline from West Baikal (Figure 1). The international pipeline would be divided into two sections: the Kovyktsinskoye gas field to Beijing, and Beijing to Kita-Kyushu (Japan). The first section would run via Mongolia (B-Line) and the other via Manchuria (A-Line). There are three alternatives for the latter section: via the Korean Peninsula (C-Line), via the Yellow Sea and South Korea (D-Line) and via the East China Sea (E-Line) (Figure 1). The pipeline lengths are shown in Table 3.

GAS VOLUME TRANSPORTED

The volume of natural gas delivered to each country from Kovyktsinskoye field is assumed to be 10.0 BCM/Y for Irkutsk, 8.0 BCM/Y for China, 10.0 BCM/Y for South Korea and 10.0 BCM/Y for Japan (Table 4). This assumption is feasible based on our survey of Kovyktsinskoye gas field and the natural gas demand of each country.

COST ESTIMATES AND GAS TARIFF

Based on these assumptions of transported natural gas, we have simulated the dynamic gas flow and determined the required thickness and diameter of the pipe and the compressor specifications (Table 5). The operating ratio of the pipeline is assumed to be 80%. Material costs include pipes, compressors and valves. The construction costs consider the ground conditions, i.e., flat desert (0.008 M$/inch·km), rocky mountain (0.011 M$/inch·km), swamp (0.011 M$/inch·km) and seabed (0.05 M$/inch·km). Control, monitoring and design/engineering costs have also been calculated. The construction period is estimated at 5 years and the project period is 20 years. The interest on investment is taken as 8% and the secured profit as 5% for the gas price.

Table 1 Natural Gas Demand in Asia (MTOE)

	1992	2000	2010
Japan	47.6	62.4	67.9
China	13.6	23.0	50.8
South Korea	4.4	13.4	28.3
Taiwan and Hong Kong	3.0	11.4	24.0
Sub-total	68.6	110.2	171.0
	(16.4)	(25.0)	(36.0)
ASEAN (6 countries)	32.3	64.6	114.5
	(75.5)	(132.5)	(173.7)
Total	100.9	174.8	285.4
	(91.8)	(157.4)	(209.6)

Note: ( ) = Total domestic supply.
Source: MITI (Japan) (1995).

Table 2 Natural Gas Demand for Northeast Asia (BCM)

	1994	2000	2010	Sources
China	16.6	30.0-35.0	50.0-80.0	China National
	(16.6)	(20.0-25.0)	(30.0-60.0)	Petroleum Corporation[a]
South Korea	7.4	19.5	30.2	Korea Gas Union[b]
	(0)	(0)	(0)	
Japan	56.0	94.0	124.6	NPRS,[c] Japan
	(1.4)	(5.6)	(5.6)	
Taiwan	3.9	9.0	12.3	NPRS,[c] Japan; Taiwan
	(0.9)	(0.9)	(0.9)	organizations
Total Demand	83.9	152.5-157.5	217.1-247.1	
Total Domestic Supply	18.9	26.5-31.5	36.5-66.5	
Balance	⇩65.0	⇩126.0	⇩180.6	

Notes: ( ) = Domestic supply.

a. Shi Xunzhi. Present situation and forecast of natural gas exploitation and utilization in China. International Conference on Northeast Asian Natural Gas Pipeline, Tokyo, March 1995.
b. H.B. Sunwoo. Present and future trend of natural gas utilization in Korea. International Conference on Northeast Asian Natural Gas Pipeline, Tokyo, March 1995.
c. Masaru Hirata. A proposal on trans-Asian natural gas pipeline network. International Conference on Northeast Asian Natural Gas Pipeline, Tokyo, March 1995.

Figure 1

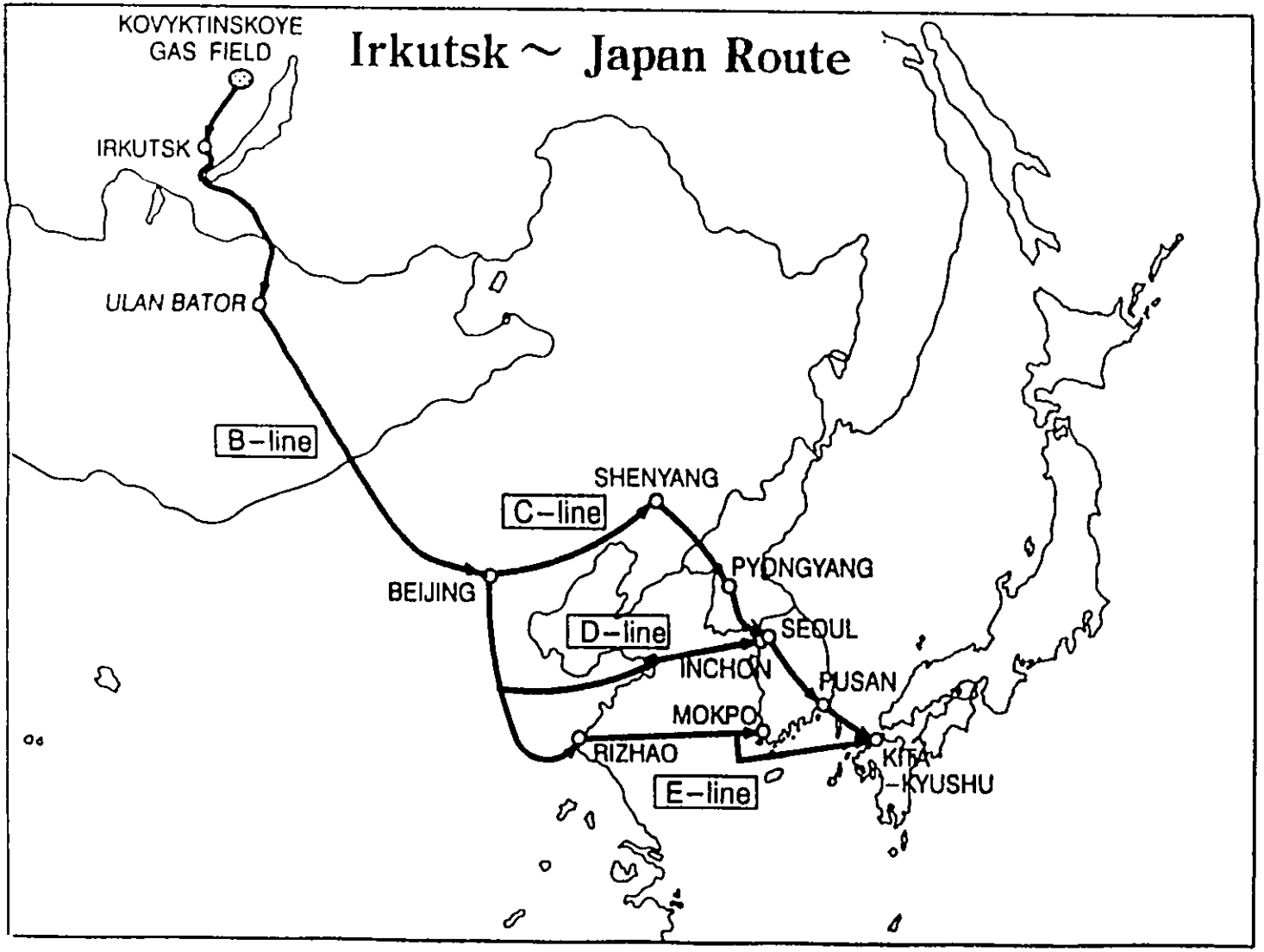

Irkutsk ~ Japan Route
KOVYKTINSKOYE
GAS FIELD
IRKUTSK
ULAN BATOR
B-line
SHENYANG
C-line
BEIJING
PYONGYANG
D-line
SEOUL
INCHON
PUSAN
MOKPO
RIZHAO
KITA-KYUSHU
E-line

Figure 1 (Continued)

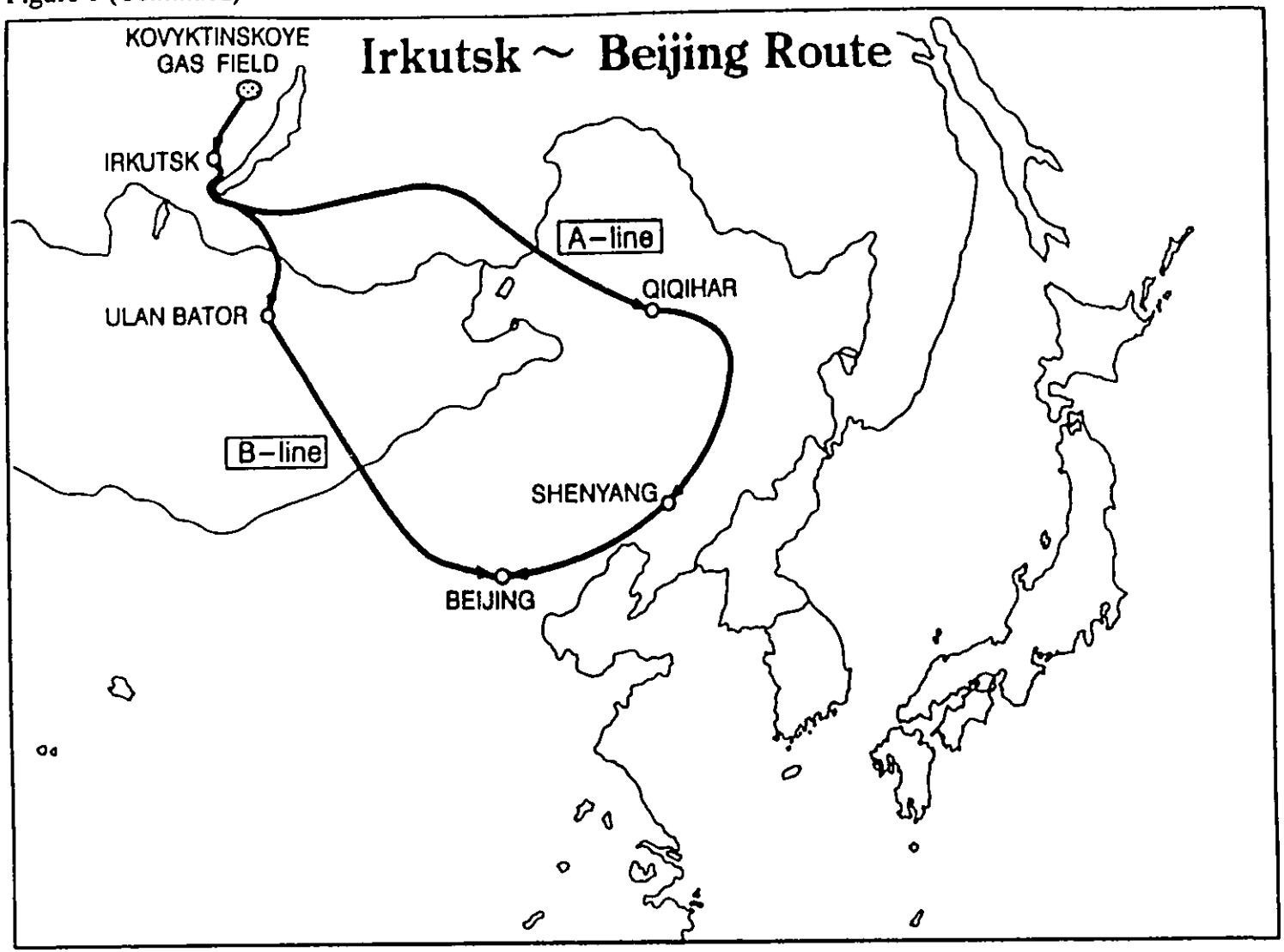


Table 3 Lengths of Pipeline Routes[a]

1. A-line (via Qiqihar and Shenyang)	
Desert	2,665 km
Rock	1,135 km
Swamp	150 km
Total distance	3,950 km
2. B-line (via Ulaan Baatar)	
Desert	1,450 km
Rock	1,350 km
Total distance	2,800 km
3. C-line (via Shenyang, Pyongyang, Seoul and Pusan)	
Desert	1,675 km
Rock	300 km
Ocean	210 km
Total distance	2,185 km
4. D-line (via Inchon and Pusan)	
Desert	1,275 km
Rock	200 km
Ocean	580 km
Total distance	2,055 km
5. E-line (via Rizhao and Mokpo)	
Desert	1,050 km
Ocean	1,370 km
Total distance	2,420 km

Note: a. The length of each section was measured on the Global Navigation and Planning Chart, Defence Mapping Agency, 12 March 1986 (Scale 1:5,000,000).

Table 4 Natural Gas Volume Delivered to Each Country

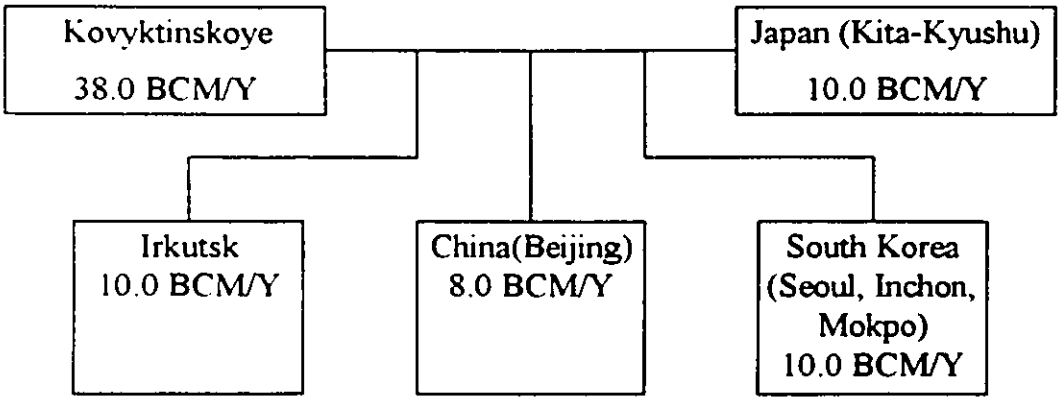


Table 5 Pipe Specifications

Route	Material	Diameter	Thickness
Kovyktinskoye-Beijing	API 5LX-65	56"	20.6 mm
Beijing-Seoul or Rizhao	API 5LX-65	48"	17.5 mm
Shangdong Peninsula-Inchon	API 5LX-65	52"	23.8 mm
Rizhao-Mokpo	API 5LX-65	56"	23.8 mm
Seoul-Kita/Kyushu	API 5LX-65	40"	15.9 mm
Mokpo-Kita/Kyushu	API 5LX-65	46"	20.6 mm

The grand total construction costs are: the A-Line—14,600 M$; the B-Line—10,666 M$; the C-Line—5,875 M$; the D-Line—6,792 M$; the E-Line—10,151 M$ (Appendices A-D). Thus, if the wellhead price of gas is 0.5$/MMBTU or 0.02 $/m^3, the gas tariff at Beijing would be 1.99$/MMBTU for the A-Line and 1.59$/MMBTU for the B-Line. The B-Line would thus be more economical than the A-Line. The gas tariff at Kita-Kyushu would be 2.90$/MMBTU for the C-Line, 3.18 $/MMBTU for the D-Line and 3.96$/MMBTU for the E-Line, using the B-Line for Irkutsk-Beijing (Figure 2). The C-Line would thus be the most economical from a technical perspective. However, the above calculation did not consider the transit royalty to be paid for third countries. Moreover, based on the recent contribution of the Europe-Magreb International Pipeline, the construction cost may be reduced by as much as 35% from the initial estimate because of the strong influence of recent price decreases in Europe (Appendix E).

Therefore another calculation should be executed to obtain a more precise assessment of the gas tariff. This calculation adds two conditions:

(1) a transit royalty of 0.03$/MMBTU for 100 km of the third country (Appendix 2); and

(2) a construction cost reduction of 35%.

The result is that the gas tariff at Kita-Kyushu would then be 3.21-4.02$/MMBTU for the C-Line, 3.28-4.18$/MMBTU for the D-Line and 3.68-4.85$/MMBTU for the E-Line (Figure 3). The C-Line would still be the most economical.

Figure 2

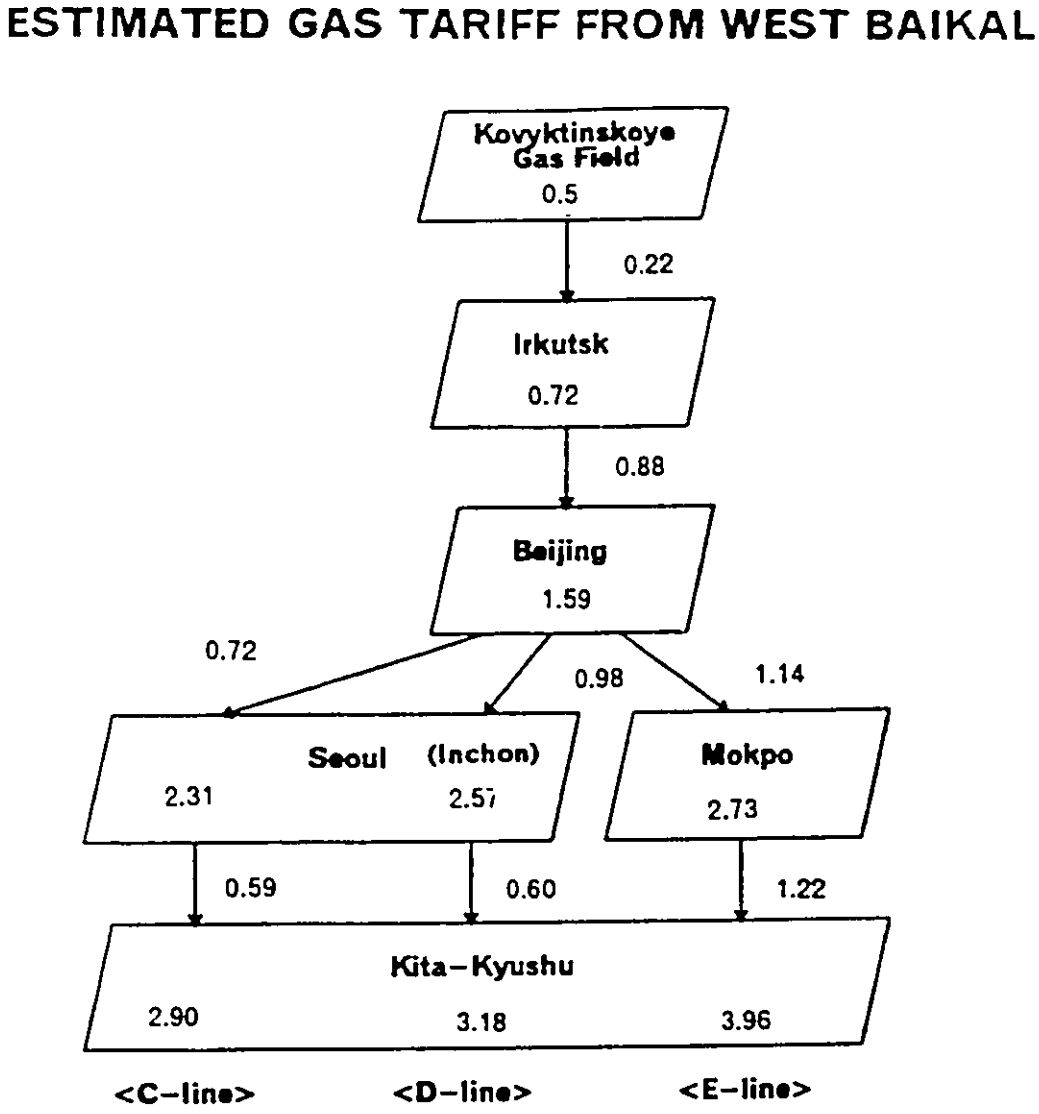
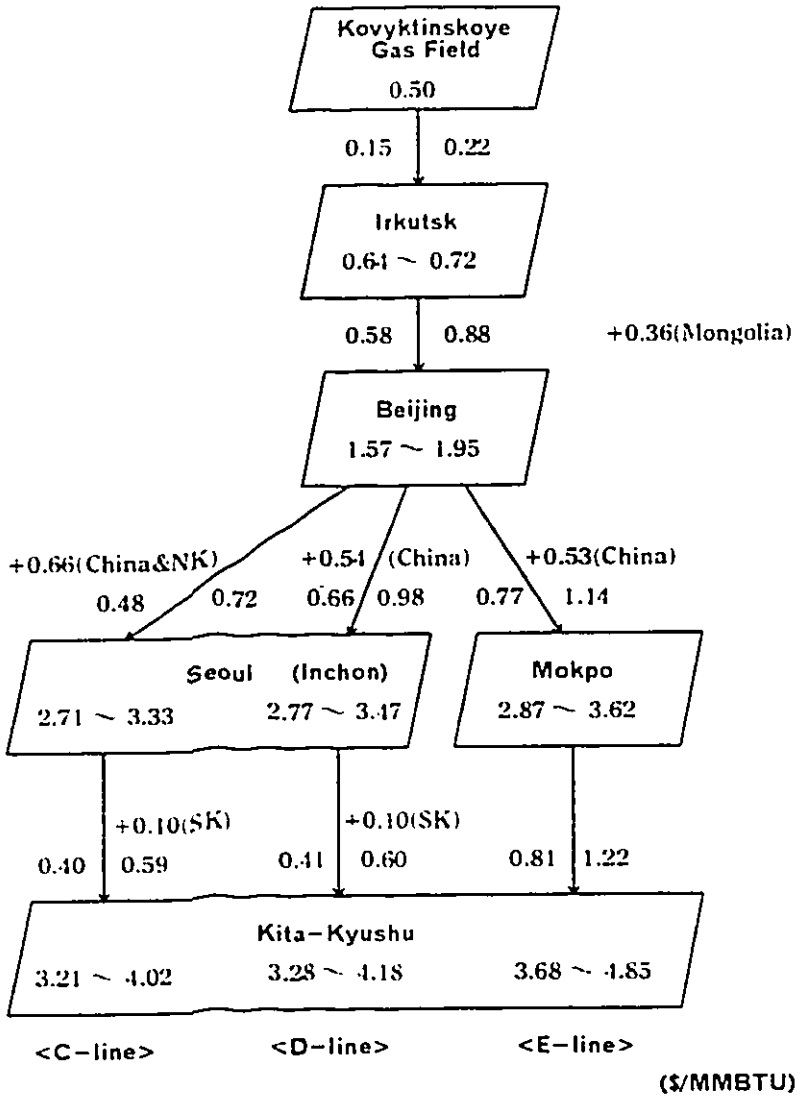

ESTIMATED GAS TARIFF FROM WEST BAIKAL
Kovyktinskoye Gas Field
0.5
0.22
Irkutsk
0.72
0.88
Beijing
1.59
0.72
0.98
1.14
Seoul (Inchon)
2.31
2.57
Mokpo
2.73
0.59
0.60
1.22
Kita-Kyushu
2.90
3.18
3.96
<C-line>
<D-line>
<E-line>

Figure 3

ESTIMATED GAS TARIFF FROM WEST BAIKAL (2)



Note: 1) Figures with "+" indicate "transit royality".
2) Left-side figures indicate those of the cases with reduction of construction cost by 35%.

Appendix A Estimated Tariff on a Natural Gas Pipeline in East Asia (A,B Line)

Fixed Cost (Total Capital Costs) (US$M)

Line	A,B	A	B	Note
Supply	Kovyktinskoye	Irkutsk	Irkutsk	
Consumer	Irkutsk	Beijing	Beijing	
Length (km)	400	3,550	2,400	
Volume of Gas (million m^3)	38,000	28,000	28,00	
Construction Cost	1,988	9,786	6,614	
Interest During Construction Period	477	2,349	1,587	
Total Fixed Costs	2,465	12,135	8,201	

Annual Cost (US$M)

Capital Cost	251	1,236	835	
Running Cost				
Natural Gas	760	800	800	
Maintenance	10	49	33	
Operating	3	11	8	
Fuel for Comp.	8	8	8	
Indirect Cost	54	111	89	
Total Annual Cost	1,085	2,214	1,772	

Cost and Tariff Cost (Gas Price)

(US$/$m^3$)	0.009 0.029	0.051 0.079	0.035 0.063	Tariff only
(US$/MMBTU)	0.22 0.72	1.27 1.99	0.88 1.59	Tariff only

Unit Cost of Pipeline Construction

(US$/m)	4,969.4	2,756.6	2,755.7	

Real Interest (%)

Line	A,B	B	B	Note
Interest During Construction Period	24.00	24.00	24.00	
Rate per Year of Construction Cost	10.19	10.19	10.19	

Appendix B Estimated Tariff on a Natural Gas Pipeline in East Asia (C Line)

Fixed Cost (Total Capital Costs) (US$M)

Line	C1	C2		Note
Supply	Beijing	Seoul		
Consumer	Seoul	Kita-Kyushu		
Length (km)	1,600	585		
Volume of Gas (million m^3)	20,000	10,000		
Construction Cost	3,487	1,252		
Interest During Construction Period	837	300		
Total Fixed Costs	4,323	1,552		

Annual Cost (US$M)

Capital Cost	440	158		
Running Cost				
Natural Gas	1,266	917		
Maintenance	17	6		
Operating	6	3		
Fuel for Comp.	13	9		
Indirect Cost	92	58		
Total Annual Cost	1,833	1,150		

Cost and Tariff Cost (Gas Price)

(US$/$m^3$)	0.028 0.092	0.023 0.115		Tariff only
(US$/MMBTU)	0.72 2.31	0.59 2.90		Tariff only

Unit Cost of Pipeline Construction

(US$/m)	2,179.1	2,139.6		

Real Interest (%)

Line	C1	C2		Note
Interest of Construction Period	24.00	24.00		
Rate per Year of Construction Cost	10.19	10.19		

Appendix C Estimated Tariff on a Natural Gas Pipeline in East Asia (D Line)

Fixed Cost (Total Capital Costs) (US$M)

Line	D1	D2	D3	Note
Supply	Beijing	???	Inchon	
Consumer	???	Inchon	Kita-Kyushu	
Length (km)	1,100	370	585	
Volume of Gas (million m^3)	20,000	20,000	10,000	
Construction Cost	2,371	1,855	1,252	
Interest During Construction Period	569	445	300	
Total Fixed Costs	2,940	2,300	1,552	

Annual Cost (US$M)

Capital Cost	299	234	158	
Running Cost				
Natural Gas	1,266	1,678	1,021	
Maintenance	12	9	6	
Operating	4	1	2	
Fuel for Comp.	13	17	10	
Indirect Cost	84	102	63	
Total Annual Cost	1,678	2,041	1,260	

Cost and Tariff Cost (Gas Price)

(US$/$m^3$)	0.021 0.084	0.018 0.102	0.024 0.126	Tariff only
(US$/MMBTU)	0.52 0.11	0.46 2.57	0.60 3.18	Tariff only

Unit Cost of Pipeline Construction

(US$/m)	2,155.4	5,013.2	2,139.6	

Real Interest (%)

Line	D1	D2	D3	Note
Interest During Construction Period	24.00	24.00	24.00	
Rate per Year of Construction Cost	10.19	10.19	10.19	

Appendix D Estimated Tariff on a Natural Gas Pipeline in East Asia (E Line)

Fixed Cost (Total Capital Costs) (US$M)

Line	E1	E2	E3	Note
Supply	Beijing	Rizhao	Mokpo	
Consumer	Rizhao	Mokpo	Kita-Kyushu	
Length (km)	1,050	620	750	
Volume of Gas (million m^3)	20,000	20,000	10,000	
Construction Cost	2,030	3,152	3,005	
Interest During Construction Period	487	756	721	
Total Fixed Costs	2,517	3,908	3,726	

Annual Cost (US$M)

Capital Cost	256	398	380	
Running Cost				
Natural Gas	1,266	1,631	1,085	
Maintenance	10	16	15	
Operating	4	1	1	
Fuel for Comp.	13	16	11	
Indirect Cost	82	109	79	
Total Annual Cost	1,631	2,170	1,570	

Cost and Tariff Cost (Gas Price)

(US$/$m^3$)	0.018 0.082	0.027 0.109	0.048 0.157	Tariff only
(US$/MMBTU)	0.46 2.05	0.68 2.73	1.22 3.96	Tariff only

Unit Cost of Pipeline Construction

(US$/m)	1,933.3	5,083.6	4,006.7	

Real Interest (%)

Line	E1	E2	E3	Note
Interest During Construction Period	24.00	24.00	24.00	
Rate per Year of Construction Cost	10.19	10.19	10.19	

Appendix E Long-distance Natural Gas Supply Cost Estimates for Western Europe

Departure	Via	Total Pipeline Length (km)	Length in Third Countries (km)	Minimum Number of Third Countries Crossed	LNG Distance (nautical miles)	Technical Cost (US$/MBtu)	Transit Fees (US$/MBtu)		Total Transport Cost (US$/MBtu)		Total Supply Cost (US$/MBtu)	
							A	B	A	B	A	B
Pipeline												
Russia (Yamal)	Belarus, Poland	6,000	1,600	2		1.8-2.0	0.30	0.50	2.20	2.40	3.20	3.40
	Ukraine	6,500	2,100	3		2.0-2.2	0.45	0.60	2.50	2.75	3.50	3.75
Iran	Turkey, Balkans	7,000-7,500	5,000	5		2.2-2.5	0.90	1.50	3.30	3.85	4.30	4.85
	Ukraine	6,500-6,800	4,600	5		2.0-2.3	0.90	1.40	3.00	3.55	4.00	4.55
Qatar	North Africa	6,000+160	5,000	4		2.1-2.4	0.40	1.50	2.70	3.75	3.70	4.75
	Turkey/Balkans	7,000	5,000-7,000	6		2.1-2.4	0.90	2.10	3.25	4.45	4.25	5.45
Turkmenistan	Iran, Turkey, Balkans	7,200	6,500	6		2.2-2.5	1.00	1.95	3.35	4.30	4.35	5.30
	Caspian Sea, Turkey, Balkans	6,400+400	5,700	7		2.3-2.6	1.20	1.70	3.65	4.15	4.65	5.15
Kazakhstan	Ukraine	6,000	4,500	4		1.8-2.1	0.50	1.35	2.50	3.30	3.50	4.30
	Turkey, Balkans	8,700	7,200	7		2.7-3.0	1.25	2.16	4.10	5.00	5.10	6.00
Iraq	Turkey	5,500	5,100	5		1.7-1.9	0.65	1.5	2.45	3.30	3.45	4.30
Pipeline+LNG												
Qatar	Egypt (Port Said)	2,000	1,900	2	1,600	2.55	0.15	0.50	2.70	3.05	3.70	4.05
Iraq	Syria	1,000	650	1	1,800	2.30	0.10	0.55	2.40	2.85	3.40	3.85
LNG												
Qatar/Iran	Suez Canal				3,600	2.7-2.8			2.70-2.80		3.70-3.80	
Nigeria					4,000	2.5			2.50		3.50	

Notes: A = Withdrawal of 5% of the gas transported through the third country.
B = Remuneration of 0.03 $/MBtu per 100 km of the third country.
Assumption of a production country departure gas price: 1 $/MBtu.
Delivery at Italian or German border.

Source: Observatoire Méditerranéen de l'Energie.