# VIABILITY OF NATURAL-GAS PROJECTS FOR NORTHEAST ASIA

## FUNDAMENTAL PRINCIPLES AND PRACTICAL CONSIDERATIONS

**Remarks of Arlon R. Tussing and Samuel A. Van Vactor**
**Alaska-Cambridge Programme on Northeast Asian Energy Development**

**PREPARED FOR THE**

**FOURTH INTERNATIONAL CONFERENCE ON NORTHEAST ASIAN NATURAL-GAS PIPELINES**

**ULAANBAATAR, MONGOLIA, 16-18 AUGUST, 1998**

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## Introduction.

The following is a summary of the broad views reached by our colleagues in the Alaska-Cambridge Programme on Northeast Asian Energy Development,[1] on

- the outlook over the next decade for expansion of natural-gas use in Northeast Asia, and particularly
- the use of natural gas from Eastern Russia.

In this summary, we shall allude briefly to

- The fundamental physical and economic principles at issue,
- salient lessons, both positive and negative, from the history of the natural-gas industry in North America and Europe,[2] and
- our views regarding the strategic tasks to be accomplished and the key obstacles to overcome over the next decade.

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1 Principal participants in this programme include Governor Steve Cowper (The Northern Forum), Victor Fischer (University of Alaska), Dr. Ronald D. Ripple (Edith Cowan University, Perth, Australia), Benjamin J. Seligman (Cambridge University), Emiko Takahashi (Economic Insight Inc.), Dr. John Tichotsky (Cambridge University and University of Alaska), Dr. Arlon R. Tussing (University of Alaska and ARTA Inc.), Samuel A. Van Vactor (Cambridge University and Economic Insight Inc.), and Dr. Piers Vitebsky (Cambridge University). The specific presentation in this paper was organized by Tussing.

2 For an elaboration of the historical background, see Chapters 1 and 2, Arlon R. Tussing and Bob Tippee, with Connie C. Barlow, Charles G. Stalon, Robert J. Michaels, et al., *The Natural Gas Industry: Structure, Evolution and Economics.* Second edition. Tulsa: PennWell Publishing Company, 1995.

1. **Economically, piped natural gas is potentially the most efficient energy source for most stationary applications in Northeast Asia. Environmentally, natural gas is potentially the most beneficial fuel for Northeast Asia.**

2. **However, natural gas has these advantages only to the extent that it can be delivered to its places of use at a competitive cost.**

3. **Everywhere, the key to competitive delivery costs for piped natural gas is economies of scale.** Low unit costs for delivered gas are available only to the extent that it can be transported in large volumes.

4. **Few cost or efficiency breakthroughs can be expected from additional commerce in LNG, because the economies of scale in LNG production and transport are very limited relative to those of gas delivered by pipeline.**

5. **Unless natural gas can take full advantage of the economies of scale associated with pipeline transport, it is not likely to gain a decisive cost advantage in Northeast Asia over less secure or environmentally less desirable fuels, including oil imports or coal.**[3]

6. **The economies of scale in pipeline transport result from fundamental physical principles.**[4] **Within very broad limits, minimizing pipeline**

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3 However, even without the cost advantages possible from piped gas, consumption of additional natural-gas volumes in the form of LNG may have technical or environmental benefits relative to coal, nuclear power, and imported oil.

4 The **volume** of gas that a pipe is able to move is proportional to the pipe's **cross-sectional area**. However, the **amount of steel** that a pipe of given capacity needs to contain depends upon its **circumference**, which is proportional to only the **square root of that cross-sectional area**. Likewise,

- the amount of **ground area** that the same pipe occupies,
- the **diameter of any tunnel** or hole that has to be bored for its passage, and
- the **dimensions of any trench** that has to be dug to bury it,

all depend on a pipe's **diameter**, which is also proportional to only the square root of its cross-sectional area.

Gas is compressible without practical limit. Compressed gas moves through a pipe by expansion. The rate at which it can be delivered out of a pipe of a given diameter depends upon the **operating pressure** at its outlet. Thus, within broad limits, the unit cost of natural gas can be reduced by transporting and delivering more of it in **larger-diameter pipelines**, and at **higher operating pressures**.

**transit costs per unit of gas per kilometer requires <u>maximizing throughput capacity</u> and throughput volumes.**

Maximizing throughput capacity thus requires:

- the biggest possible pipeline diameter, and
- the highest possible operating pressures,

. . . consistent with the quality of steel that gives a pipeline the necessary structural rigidity at that diameter, and the necessary tensile strength and toughness to contain those pressures safely.

7. **Maximizing pipeline throughput capacity, in turn, requires the largest possible supply concentrations in individual fields.[5]**

8. **It is desirable that these supply concentrations be achieved under unified operating management and unified political jurisdiction.[6]**

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[5] A valid rule of thumb is that a secure supply of N units per year for T years from a given natural-gas deposit requires that initial reserves be at least N*(T+R), if the deposit's reserves-to-production [R/P] ratio is to remain at least R. Accordingly, to fill a 56-inch pipeline such as proposed for the Irkutsk project with a level 2 bcf/day [=20.5 bcm/year] for 25 years, initial reserves would have to be equivalent to 40 years of production, or .82 tcm. This provision would leave a reserves-to-production ratio of 15 at the end of 25 years.

To put this criterion into historical perspective, consider the 1950s and 1960s, when the biggest surge of North American gas-pipeline construction was taking place. Financial underwriters and regulators both demanded that pipelines maintain reserves-to-sales ratios of at least 20. Under the much tighter and more efficient management conditions that prevailed during the 1980s and 1990s, average R/P ratios in North America and the United Kingdom have tended to be as low as 8 or 9. Nevertheless, for Northeast Asian conditions in the near future, it would surprising if lending agencies tolerated ratios much less than 20.

[6] In principle, very large concentrations might conceivably be achieved by gathering gas for a given transport system:

- from both gas wells and oil wells,
- in several or many reservoirs,
- of widely different sizes,
- with widely different technical characteristics,
- under different ownership and operating management, and
- under different political jurisdictions.

These features describe the diversity that exists in the gas-producing areas of North America and the North Sea. In a mature and competitive natural-gas industry, such diversity can foster efficiency and supply security. But note that it took about 70 years for the petroleum industry and State governments in the USA to perfect efficient rules and procedures for "unitizing" the production and conservation management of oil and gas reservoirs that have multiple owners.

The extreme diversity of producing conditions t**hat now exists in Sakhalin**, for example, can be a serious handicap to aggregating sufficient supplies simultaneously to create a viable natural-gas project for Northeast Asia. (See Arlon R. Tussing and Samuel A. Van

In the present embryonic state of the natural-gas industry of Northeast Asia, the Kovyktinskoye field 350 kilometres North of Irkutsk, seems to be the most attractive single supply source in Eastern Russia for a world-scale pipeline project. This is because, according to the field's operator, more than a trillion cubic meters of gas is accessible at Kovyktinskoye in a single hydrocarbons accumulation under undivided operating and political jurisdictions.

## 9. Maximizing pipeline throughput volumes requires the largest possible market aggregations.

For example, the biggest planning challenge for the proposed Irkutsk project may be to pool total demand of at least 20 billion cubic metres per year among three, four or five nations, whose domestic market development varies greatly. This size of market that will be needed to take full advantage of this pipeline proposal's economies of scale.

### 9.1 Planning for world-scale natural-gas projects in Northeast Asia requires a special effort to organize the Japanese market. [7]

Japan offers the highest-value and most assured potential market growth for natural gas in Northeast Asia. However, realizing this market depends on capturing economies of scale associated with pipelines, in order both to ---

- procure large volumes of natural gas from Eastern Russia, and to
- deliver and market large volumes of additional gas at low cost within Japan.

### 9.2 South Korea's domestic market may be the best organized in Northeast Asia to accept additional gas supplies. South Korea's own demand may be insufficient to support low-cost pipeline

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Vactor, "Russian Natural Gas for Northeast Asia: The Sakhalin Experience," *Financial Times Energy Economist*, July 1998.)

[7] Japan represents Northeast Asia's biggest, highest-value and geographically most concentrated market for fuels and energy, including natural gas in the form of LNG. However, Japan's present consumption of natural gas is extraordinarily low for ---

- space-heating and other residential uses,
- peak-load electrical generation, and
- industrial fuel (other than fuel for base-load electrical generation).

Use of gas in these categories of demand is low because Japan has the developed world's highest delivered gas prices. The high prices, in turn, result from a combination of Japan's reliance on LNG for gas supply and its lack of domestic gas transmission and distribution infrastructure. (See Hikaru Yamada and Arlon R. Tussing, "Japanese Gas Grid Mapped Out, Seeking U.S. Help," *Natural Gas Journal*, May 1998.)

**capacity from Russia, however, unless it is combined with added demand from China and/or Japan.**[8]

**9.3 China will ultimately be the biggest consumer of natural gas in Northeast Asia, and will receive the greatest total benefit from substituting gas for coal, imported oil, and nuclear power.**[9]

**9.4 Domestic markets in the Russian Far East and East Siberia have a great perceived "need" for large new fuel supplies, and for natural gas in particular.**

For the purpose of planning and funding gas-supply projects, however, requirements for new natural-gas projects to serve gas-users in Irkutsk or Vladivostok, for example, must be regarded as deadweight financial burdens rather than as components of firm demand. The chief reason is the inability of developers to identify a sufficient aggregation of domestic gas customers that are willing and able to guarantee payment for purchased gas.

**10. Japanese domestic transmission and marketing pipelines is probably the most urgent single component of natural-gas industry infrastructure in Northeast Asia.**

**10.1 Such a domestic gas-transmission network is a physical necessity if Japan is to benefit from economies of scale associated with piped gas imports from Asia.**

**10.2 In the absence of Japanese market participation in any large-scale Northeast Asian gas import pipeline (whether from Irkutsk, the Sakha Republic, or Sakhalin), the benefits of pipeline economies of scale may not be sufficient to justify South Korea's participation.**

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8 Unlike Japan or China, South Korea is already building an integrated nationwide gas-pipeline infrastructure. This new transmission/distribution grid is scheduled to be complete in 2000. This system will

- level and balance aggregate supply and demand, and thus
- minimize domestic transmission and distribution costs per unit. (See Arlon R. Tussing and Samuel A. Van Vactor, "South Korea's Thirst for Gas," *Financial Times Energy Economist*, March 1998)

However, South Korea's gas market is still walled off behind North Korea from potential pipeline supplies of Russian gas. Moreover, South Korea's own potential demand may be inadequate to support the necessary alternative --- a 350-kilometer underwater pipeline crossing of the Yellow Sea, unless it is combined with added demand from Japan,

9 China nevertheless may have the farthest to go to organize its domestic energy markets so as to take advantage of the opportunities offered by Russian gas. See Arlon R. Tussing and Ronald D. Ripple, "Northeast Asia, Outlook for Gas Sales and IPPs," *Natural Gas Journal*, June 1988; also Arlon R. Tussing, "The Coming Natural-Gas Boom in Northeast Asia," *Oil and Gas Journal*, 6 July 1998.

**Without Japan's markets, China's benefits from an Asian international pipeline are also likely to be smaller.**

**10.3 Establishment of a domestic pipeline infrastructure offers Japan huge benefits in ---**

- **greater reliability of supply, and**
- **natural-gas delivery-cost reductions of 50 percent or greater for residential and industrial consumers ---**

**by connecting the 20 existing LNG marine terminals with one another, with gas-storage facilities, and with major load centers throughout the four main islands.**

These benefits would not depend upon pipeline imports of Asian gas, but would result from enhanced efficiency and competition even within the existing system of LNG imports.

**11. All of the potential Northeast Asian gas-importing nations should expand and "firm up" their domestic natural-gas demand by adopting a self-administering two-part gas-market strategy.**

The essence of the two-tier strategy is division of the market into two classes of sales, "firm" (or high-priority) sales for higher-value energy uses at premium prices, and "interruptible" (or low-priority) sales for lower-value energy uses at low prices.[10]

**11.1 Premium fuel use.**

**In a two-tier market, seasonal, cyclical, and other "premium" users and uses of gas, such as ---**

- **Spaceheating and other household and institutional gas uses,**
- **electrical peaking service,**
- **high-value process-gas and chemical feedstock applications, and**
- **"select" gas use to control air pollution ---**

**receive first call on gas supplies, either without limit or to the extent of their respective maximum contract entitlements.**[11]

**11.2 Interruptible, bulk-fuel use.**

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[10] The natural-gas industry in North America has successfully implemented such a two-tier marketing strategy for more than sixty years. This overall strategy has been the key to efficient use of gas-producing and transport capacity through three distinct stages of market development: unregulated private monopoly before about 1940, tight government regulation to about 1985, and most recently competitive markets.

[11] Premium prices on high-value uses are set, either by regulation or by supply and demand, at levels high enough to cover most of the fixed costs of production and of transport and distribution infrastructure.

**Conventional fossil-fuel steam-electric plants, and other industrial users of B-fuels (coal and heavy fuel oil) are encouraged or required to install dual- or multi-fuel burners. These facilities receive gas when it is available after premium customers are satisfied.** [12]

[12] Prices for "interruptible" service to low-priority customers are typically less than the prevailing cost of B-fuels.