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Abstract
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The Emerging Trade in Gas Technologies

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1. The Potential for Natural Gas in the Global Energy Mix

Technology is the critical factor in determining the future of gas markets

There is a point of view held by some energy analysts, and becoming more common among policymakers, that natural gas will replace petroleum as the dominant fuel in the global energy mix within a few decades. There are economic and political factors apparent in the world today that support that viewpoint, but there also are practical constraints on the expansion of the role that gas can play in meeting requirements for a multiplicity of energy services. Technologies for the exploration, production, transportation, and particulary the conversion of gas to an ultimate service are the critical factors in determining the future of gas markets.

Long before the global trade in natural gas itself begins to rival the oil trade, an international market in gas technologies will be well established

There is a common global interest in the development of gas technologies. Long before the global trade in natural gas itself begins to rival the oil trade, an international market in gas technologies will be well established. The success of this technology trade will dictate the pace of the global gas trade.

The increasing interest in natural gas appears to be the result of a number of unrelated factors. In Western Europe, the delivery of significant quantities of gas from the Soviet Union, together with the discoveries of new resources in the North Sea, have led to brisk competition for potential gas markets. In North America, deregulation of US gas export policy, renewed interest in LNG, efforts to market Alaskan gas resources, and development of resources in Mexico and Venezuela have made the gas trade newsworthy. In the Pacific, gas discoveries in Australia, Indonesia and elsewhere have led to proposals for additional liquefied natural gas projects to expand the use of gas in Japan and to serve

other industrializing Pacific economies. In the developing economies, considerable attention by governments and by international financial institutions is being given to commercializing indigenous gas resources where they exist.

Overlying these regional opportunities, there has been a worldwide resurgence of concern over environmental matters. Chernobyl has had an impact on some European nuclear programs, and public opposition to the nuclear option is also becoming more general in Japan and Korea. Acid rain and metropolitan air quality issues are receiving national and international prominence in North America, Europe, Taiwan, Japan and elsewhere. Finally, the unusual weather conditions of last summer, although they are probably unrelated, have raised the consciousness of the public and many policymakers regarding the potential global climatic consequences of fossil fuel combustion. "Global warming" has become, and promises to remain, a favorite issue for international conferences.

Natural gas is an environmentally preferred energy source

Natural gas is an environmentally preferred energy source. Its production, transportation and use result in less troublesome emissions and residual wastes than those of the major competitive sources — coal, petroleum and nuclear energy. Even with regard to the "greenhouse" effect, gas is the lowest contributor of carbon dioxide among the fossil fuels.

Natural gas currently accounts for 20% of world primary energy demand. Worldwide gas production is increasing by about 5% each year. The displacement of gas as an electric generation fuel by new nuclear and coal-fired powerplants in Europe and North America has been compensated for by increased industrial, residential and commercial use in Western Europe and by growth in industrial and electric utility consumption in the Pacific. The volume of international trade in gas is still small, but it is growing both in pipeline deliveries, particularly from the Soviet Union, and in liquefied natural gas carried by tanker.

Gas is clearly capable of a much greater role in the global energy mix

Enthusiasm for expanded use of gas is supported by the availability of the resource. Gas is clearly capable of a much greater role in the global energy mix. Total discovered world reserves of gas are the equivalent of about 710 billion barrels of oil as compared to 900 billion barrels of petroleum reserves. Current consumption of gas, however, is only about half that of oil, so that proved gas reserves alone could easily support a substantial increase in consumption.

Total recoverable conventional gas resources have been estimated to be about 8,000 trillion cubic feet, more than 100 years of supply at current consumption rates. This resource capability could be greatly expanded through advanced technologies for the intensive recovery of conventional gas and for the development of less conventional types of resources. In the very long-run future, the infrastructure that is provided for the transportation

and use of natural gas could be utilized for synthetic gas and ultimately for hydrogen.

When the expanding global requirement for energy services is viewed in light of the worldwide capability to supply gas and especially when the inherent strategic and environmental problems confronting some of the other energy forms are considered, enthusiasm for gas as the "global fuel of the future" can be readily supported. But planners for the technology base that will support this role must couple enthusiasm with realism. For many years, the role that natural gas will play will be decided in isolated regional situations. The use of gas will be based upon the physical, technical and economic advantages and disadvantages it has in competition with alternative fuels in each geographic situation. There are few, if any, exclusive markets for gas in the way that transportation now is an exclusive market for petroleum. The use of gas will usually be a competitive choice, and in new markets the capital costs for new gas transportation systems will often be dominant considerations. The competitive advantages of gas will also vary greatly among geographic situations. A global trade in natural gas rivaling the oil trade is many years away.

Planners for the technology base that will support natural gas in its projected role as the "global fuel of the future" must couple enthusiasm with realism

In many applications, new technology can improve the economic advantages of gas. A worldwide common interest in methane R&D is here today and an international trade in gas technologies is already emerging.

2. The Prospects for Gas Use and the Significance of Technology

In considering the potential role for natural gas, we should avoid any notion that it is a premium fuel that enjoys an inherent advantage in interfuel competition. To expand its significance in the global energy mix, gas will have to gain in preference over the chief competitors, petroleum and coal.

Compared with oil, natural gas is plentiful, widely distributed, and can generally be found and developed at comparable prices. But gas is not as conveniently transported and stored as liquid petroleum and there is no international trade in gas that is remotely comparable to the world oil trade. Only about 13% of world gas production is traded internationally and two-thirds of that trade is tied to existing pipeline systems. Much of the world's natural gas resource is remote from the centres of energy demand and will require new transportation infrastructure to enter the market.

Although oil is an expensive fuel, thanks to an established global trade it usually imposes the least capital investment for supply infrastructure upon a new user. Coal suffers the disadvantage of requiring large capital investment in transportation, storage and handling facilities. But coal itself can be delivered to

most places in the world, certainly to all tidewater ports, at costs per unit of energy well below those of either gas or oil.

The nature of end-use energy services will also influence the relative competitive advantages of alternative energy sources.

Today's economics continue to favor petroleum for the large and rapidly growing transportation market and alternatives can only compete where government policies, in the nature of taxes or outright restrictions, favor the alternatives. But the pollution created by vehicle congestion in metropolitan areas has defied all efforts to control it. Public policies to diversify transportation fuels away from petroleum are gaining support. The competition for this policy-created market share will be among compressed natural gas, alcohol fuels (primarily methanol) and, in limited applications, electricity. Compressed natural gas can win this competition on the basis of long-term economics, but the advantages of compressed gas can be further enhanced by improved technology. Lightweight and lower cost vehicular storage tanks, low cost compression and storage facilities for refuelling, and better engine design for gas fuels are all possible through R&D. Natural gas vehicle technology has had relatively little attention because of its marginal competitive position compared to gasoline and diesel fuel. Now such R&D deserves more attention.

Public policies to diversify transportation fuels away from petroleum are gaining support

Industrial uses of energy represent complex and diverse applications. Currently, natural gas serves about 21% of delivered industrial energy requirements in the OECD, 17% of the growing industrial energy demand of developing countries and probably 33% of the industrial energy requirement of centrally planned economies.

The best opportunity for an expanded role for natural gas in industrial steam production will be through the advantages of cogeneration. Modern, gas-fired technologies such as combined cycle units, can achieve high efficiencies in these applications, which offset gas fuel costs. There are also opportunities to improve the competitive position of gas in other industrial applications. The targets of R&D must include not only fuel savings, but also improvements in the control and convenience of fuel use and in the quality and productivity of the industrial process itself through gas-based technology. Although the specific industrial uses are quite varied, advances in R&D can provide a portfolio of new generic technologies that will have broad applications. Examples are: concepts for improved heat transfer including metallic and ceramic recuperators; enhanced combustion technologies such as catalytic coatings for radiant tubes; low-cost controllers to govern combustion fuel mixes; and advanced materials capable of withstanding the high temperature and corrosive environments of industrial processes.

The best opportunity for an expanded role for natural gas in industrial steam production will be through the advantages of cogeneration

Advanced technologies will also greatly enhance the capability of gas to serve commercial energy service needs. The space-cool-

ing component often dominates commercial building requirements, and gas-cooling technologies, such as advanced engine-driven chillers and gas heat pumps, can make gas-cooling competitive in the larger commercial applications. Smaller, pre-engineered and packaged cogeneration units, and ultimately fuel cells, can extend gas use in large office buildings, hospitals, hotels, shopping centres, and district heating facilities.

Where gas distribution systems do not exist, the decision to introduce gas into end-use residential and commercial services will involve the costs of new delivery infrastructure. There are substantial opportunities through advanced technologies and innovative methods to reduce the costs of gas delivery systems. Plastic and flexible piping, pipe laying equipment, and advanced metering technologies are examples.

Most significantly, it is probable that the global demand for electricity will increase more rapidly than overall energy demand. The generation of electricity will consume increasing proportions of total primary energy. The trend is apparent in most of the world today. Lighting, television, computers and other communications and electronic uses, small appliances and electric motor drive, lasers and robotics are all rapidly increasing services that are inherently electric.

In developing economies the conversion of indigenous gas resources to electricity will often prove to be the efficient option

Furthermore, in the developing economies, electric service is an essential aspect of modernization. Lighting, communications, and refrigeration are critical services that cannot be provided directly by the traditional non-commercial fuels. As these countries industrialize and urbanize, the conversion of indigenous gas resources to electricity and distribution of domestic energy in that form will often prove to be the option that best meets the most critical needs of society and conserves scarce capital.

The best currently available gas-fired technologies for the generation of electricity are adequate to ensure broad applications for gas in new powerplants. Significant potential remains, however, to improve gas turbine design and materials through R&D specifically directed to electric generating service. Fuel cell technology also offers operating advantages in some situations if the costs can be reduced for utility-sized units.

Conventional natural gas resources are clearly adequate to meet the potential gas demand for many decades to come, even in the mature North American market. The development of gas resources, however, has not achieved its maximum economic efficiency. The cost of discovery is about half the total cost of supplying gas at the wellhead and the investment in gathering and transmission infrastructure is high. It is important, therefore, to expand the economically recoverable gas from discovered and developed resources to the greatest extent possible.

Recent advances have been made in the technologies of exploration and development, but much more can be done. The hostile

frontier environments of the Arctic and deep offshore still present a challenge. Technologies to achieve more intensive recovery of gas in discovered fields and to bring less conventional resources, such as the less permeable formations, into the economic resource base will help to extend the value of investments in exploration and development and deter excessive escalation in the cost of gas supplies.

3. The Global Trade in Technology

In the final analysis, the success of natural gas in a national, regional or global energy mix will turn on its ability to win the interfuel competition in a complex mix of energy applications. The fundamentals are the same everywhere. Gas must be produced and transported at prices that cover the costs involved and offer a rate of return adequate to attract new investment to the industry. The global strategy cannot be "to sell cheap gas where opportunities appear." It must be to "make gas competitive" in viable, long-term applications. The ultimate success of that strategy will turn on technology. Advances in technology can lower the costs and increase the reliability of finding, producing and transporting gas. New technologies will provide users with new options to choose gas as the fuel for a wide range of energy services. Technological advances will keep gas-using equipment equal in convenience and efficiency to the alternatives.

The global strategy must be to make gas competitive in viable, long-term applications

Even though gas markets in the Pacific Rim, Europe, North and South America, the Soviet Union and elsewhere may remain largely isolated from one another for decades, gas users throughout the world can share technologies for the exploration, production, transportation, and utilization of gas. International trade in the gas technology business is likely to involve trade in unconventional gas production techniques and equipment; advanced methods and materials for the construction, operation and maintenance of gas pipelines and distribution facilities; fuel cells, gas turbines; combined cycle powerplants and cogeneration equipment; gas heat pumps and cooling equipment; and the full range of gas-using residential appliances and commercial and industrial equipment. The trade is a near-term prospect and is significant to us all.

Even though gas markets may remain largely isolated from one another for decades, gas users throughout the world can share technologies

As brokers in R&D for the US natural gas industry, the Gas Research Institute (GRI) is already deeply involved in the exchange of technologies between nations. GRI's portfolio of applied research efforts includes not only those technologies that have been developed for the US domestic markets, but also technologies that have been adapted from outside the US.

GRI pioneered the development of practical commercial fuel cells in the 40kW range and proved the technology with a field test program involving forty-six units, two of which were outside

of the US. Easily installed, fuel cells can provide part or all of the electrical and heating requirements of a building at a net energy and cost saving. The technology promises to provide more flexibility in siting and to serve a wider range of applications than other types of cogeneration. Currently, as a direct outgrowth of the GRI program, a commercial venture including multinational participation is showing promise for near-term production of commercial fuel cells.

A brisk international trade in new technologies, technical experience and equipment has already begun

There are numerous examples of the opportunities for mutually beneficial exchanges of technology within GRI's experience. Testing of Japanese technologies for flexible interior gas piping and connectors in US applications may lead to the production of similar products in the US. GRI technologies nearing commercialization will have applications in foreign markets for each of the energy sectors. An example that will have industrial applications worldwide is an advanced oxygen/gas burner for electric arc furnaces. With much of the world's raw steel production moving to such furnaces, the application of this technology can expand the industrial use of gas.

GRI has recently consummated an innovative agreement with British Gas to facilitate the licensing and application of our respective proprietary technical developments to the mutual benefit of us both. For example, methodologies have been developed in Britain to inspect buried transmission pipelines. The basic technologies will require further development for the US situation, but the investment already made in the technologies, and the experience gained by the British, will speed introduction in the US.

As we await the development of a future global gas trade, we can prepare the way with the advanced technologies that will expand the role of gas in the energy mixes of each of our countries. Meanwhile, we will find that a brisk international trade in the new technologies, the technical experience, and the equipment as well, has already begun.