Natural Gas from Seaweed: Is Near-Term R&D Funding by the U.S. Gas Industry Warranted?†

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INTRODUCTION

This paper is the result of a study of critical factors the Gas Research Institute (GRI) needed to consider in deciding whether to continue R&D funding of a Marine Biomass Project (MBP). The mission of this project is to determine the commercial feasibility of large marine biomass farms for methane conversion and to develop such farms if they prove viable (Aquaculture Associates, 1982).

The paper develops a macroanalytic framework for R&D decisionmaking in an innovative but high-cost and high-risk method of natural gas production. It identifies and analyzes principal factors having significant bearing on the U.S. natural gas industry and against this background examines implications for R&D funding of the MBP. The study is based on an extensive review of secondary data sources on the economics and technology of natural gas production supplemented by personal discussions with a number of experts.

This paper suggests that decisions on near-term R&D funding of the MBP should be based on careful study of the current, continuing, and projected developments in the U.S. natural gas industry as a whole rather than on narrow and short-term considerations.

CRITICAL DECISION FACTORS

This section identifies and critically evaluates key decision factors in the context of R&D funding of the MBP.

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Demand-Supply and Price Outlook for Natural Gas

During the past few years several efforts have been made to estimate demand for natural gas in the United States through the year 2000 (Schurr, 1979). Some of the most reliable estimates are presented in Table 1. It is clear from this table that even the most optimistic projection of natural gas demand for the year 2000 falls somewhat below the GRI estimate of a continued demand of 20 quads. The low estimate by the Institute of Energy Analysis is approximately half the GRI estimate.

Table 1. Outlook for Natural Gas Demand, 2000 (Projected) (Quads)

Institute of Energy Analysis	10.8 (Low)		13.4 (High)
National Academy of Science	11.0 (Scenario B)		19.0 (Scenario A)
U.S. Department of Energy		16.57	
U.S. Department of Commerce (1983)		18.43	

Source: Adapted from Schurr (1979) and Gustaferro (1983).

Table 2 shows that actual consumption of natural gas in the United States declined steeply from 22.57 quads in 1973 to 17.46 quads in 1983 (the full year for which figures are available) (U.S. Department of Energy, 1984). Note that a consistent declining trend in gas consumption was evident during the 1978–1983 period, adding further credibility to the demand projections. The lack of a clear trend toward continued high demand for natural gas is a source of serious concern in light of future commitments of substantial R&D funds for new gas discoveries or production.

From an examination of the outlook for natural gas supply in the United States in the years ahead (Table 3), it appears that total U.S. gas supply from domestic and foreign conventional and nonconventional sources may be quite adequate to meet projected demand through the year 2000 (OECD, 1982; Oppenheimer, 1980).

Table 4 lists demand-supply projections for natural gas beyond the year 2000. These projections are based on information obtained from the Energy Information Administration of the Department of Energy on actual consumption and production of natural gas for the ten-year period, 1970–1980. Projections were obtained by linear extrapolation of the ten-year average annual change in natural gas consumption and production to forecast the change in demand and supply, respectively, for the 2000–2050 period. Unless there are dramatic changes in the pace and pattern of energy use in the United States in the next fifteen years or so, these projections should provide a

Table 2. Natural Gas Consumption in the United States, 1973–1983

Year	*Consumption (Quads Btu)*
1973	22.57
1974	21.73
1975	20.00
1976	20.42
1977	19.98
1978	20.09
1979	20.72
1980	20.35
1981	19.86
1982	18.43
1983	17.46

Source: Energy Information Administration, USDOE (1984).

Table 3. Total Gas Supply Projections for the United States: Conventional and Nonconventional Sources (tcu)

Source	*1980*	*1990*	*2000*
Domestic natural gas	19.5	18.5	19.1
New technologies	0.05	1.8	5.0
Alaskan gas	–	1.6	3.6
Coal gasification	–	0.6	3.3
LNG imports	0.4	2.0	3.0
Canadian imports	1.4	1.1	0.8
Mexican imports	0.2	1.0	1.0
SNG from light hydrocarbons	0.5	0.5	0.5
Total	22.0	27.1	36.3

Sources: OECD (1982) and Oppenheimer (1980). E. J. Oppenheimer, *Natural Gas: The New Energy Leader*, New York: Pen and Podium Productions, 1980.

reasonably accurate picture of the demand-supply situation for natural gas for the fifty-year period under consideration. Table 4 clearly shows a continuing trend of natural gas supply outstripping demand by a wide margin during 2000–2050. These projections, therefore, seem to lend substantial additional support to the conclusion that the case for funding the seaweed project is very weak.

What emerges is a scenario in which the supply of natural gas in the next several decades is adequate to meet the demand. Prospects, therefore, are bleak for sharp price increases that could legitimize the production of high-cost gas. From a R&D perspective, this presents a less-than-compelling case for funding projects with high degrees of risk and uncertainty. In light of this,

Table 4. Projected Demand for and Supply of Natural Gas, 2000–2050

Year	Demand (Quads)	Supply (Quads)
2000	14.72	17.59
2010	12.66	15.83
2020	10.88	14.25
2030	9.36	13.32
2040	8.05	11.99
2050	6.92	10.80

Source: Energy Information Administration, U.S. Department of Energy.

the Marine Biomass Project (especially if it is based on a capital-intensive, offshore farm concept) should be treated as a low-priority research effort.

Methane From Unconventional Natural Gas Resources

An aspect that merits careful consideration in any estimation of the outlook for natural gas is the U.S. gas industry's current efforts to produce methane from unconventional fossil resources or reserves. In the United States, substantial quantities of methane are known to exist in Devonian shales, in coal seams, in tight gas formations in different parts of the country (especially in the West), and in geopressured brines along the Gulf of Mexico. Information about these resources and their contributions to the U.S. natural gas supply is presented in Table 5. Quantities of methane in Devonian Shales are almost equal to the proved reserves of conventional natural gas. Quantities in tight sands are about twice those of conventional resources (USDOE, 1978). Currently some gas is commercially produced from both sources. Many coal seams contain large quantities of natural gas released during mining. Geopressured brines could also add significantly to future U.S. gas supplies. Estimates of the quantity of natural gas from this source range from 3000 to 49,000 trillion cubic feet (tcu). There is considerable uncertainty, however, both in estimates of the size of the resource base and in the size of the resource base that can be economically recovered.

A review of the literature reveals there is a good deal of uncertainty about both the size of the resource base and the supply price. Despite this, "it is now believed that considerable unconventional methane could be obtained at prices below that required to produce methane from coal or to import liquefied natural gas" (Landsberg, 1979). For instance, according to a Congressional study, Devonian shale deposits could be brought to the market for $2 to $3 per thousand cubic feet (Simon, 1981).

With all these factors in mind we can examine the case for a methane-from-marine biomass project. For example, the proposed 100-square mile marine

Table 5. U.S. Unconventional Gas Resources

		Recoverable Quantities		
Resource Type	*In-place Quantities (tcu)*	*Recovery Factor (Percent)*	*Quantity Recovered (tcu)*	*Quads of Btu Equivalent*
Tight Sands	793	25	198	203
Black Shales	284	25	71	73
Coal Seams	850	10	85	87
Geopressured Zones	7000	10	300	308
Total	4927		654	671

Source: Adapted from Schurr (1979).

biomass farm is estimated to produce only 0.03 quad, a mere 0.2 percent of the current natural gas consumption in the United States. This suggests that it would take 100 conceptual systems to produce an annual supply of 3 quads of methane from marine biomass. This is in sharp contrast to the considerable quantity of methane that has a reasonable chance of being recovered from unconventional fossil gas resources. A number of research efforts currently are under way to tap this vast energy reserve including some by the Gas Research Institute. Another critical consideration is the cost of producing methane from marine biomass. Both the projected average cost of energy at \$6.15 per thousand ft^3 and the first year average cost of \$4.53 appear to be appreciably underestimated. Even assuming that these are valid estimates, the cost of producing methane from unconventional fossil sources is substantially lower (\$2 to \$3). Methane from marine biomass, therefore, appears to be a much less appealing option in terms of both quantity and cost than methane from the fossil sources discussed above (Aquaculture Associates, 1982).

Supplemental Natural Gas from Abroad

Although self-sufficiency in natural gas is the long-term goal, short-run reliance on foreign sources to meet the country's demands is both efficient and economical. With proper monitoring, "it can in fact be considered an important but limited component of future energy supply for a long time to come." (Schurr, 1979).

According to projections in a recent study of U.S. natural gas imports (Kaufman and Bodily, 1981), prospects seem good for the next several years for an assured supply of natural gas from Canada and Mexico at reasonable prices (see Table 6). The National Energy Board of Canada late in 1979 set the price of export gas as \$3.45 per Mcf, and starting at this figure, price

Table 6. Present Value of Canadian and Mexican Gas Shipments to the United States, 1980–1990 (from New Sources)

Year	Gas Volume (Bcf/Year)	Price/Mcf (1979 $)	Gas Volume (Bcf/Year)	Price/Mcf (1979 $)
	Canada		Mexico	
1980	130	$4.00	60	$3.63
1981	447	4.63	100	4.38
1982	754	5.10	150	4.82
1983	741	5.35	100	5.06
1984	714	5.46	290	5.16
1985	740	5.57	400	5.26
1986	740	5.68	510	5.37
1987	740	5.79	690	5.48
1988	740	5.91	790	5.59
1990	740	6.02	690	5.70

Source: Kaufman and Bodily (1981).

increases are expected roughly to parallel those of world oil—rising to $5.57 by 1985 and to $6.02 in 1990. Incorporated into these projections were the Canadian gas reserve base and a 3-percent-per-year growth in Canadian demand for natural gas as postulated by the National Energy Board. The study concludes: "Given these two factors, there should be adequate Canadian gas available for exports to sustain our assumed level."

Late in 1984 the Canadian gas export price stood at U.S.$4.40/Mcf, significantly lower than earlier export price projections. This development further reinforces the importance of natural gas from Canada as a reliable source of supply (The Economist Intelligence Unit, 1984).

A steady and cheap supply of natural gas from Mexico (barring unforeseen political problems) for the next several years appears a virtual certainty, largely because of continuing dramatic increases in gas production in recent years. The natural gas output in Mexico at the end of 1983 stood at a record high of about 1624 billion ft^3 (The Economist Intelligence Unit, 1984).

Natural gas from other countries, notably Indonesia, also appears to be a distinct possibility. In light of these apparently assured sources of methane, the marine biomass project seems to lose a good measure of its urgency.

Financial Requirements and Capital Supply

This section reviews financial requirements of the energy sector (including natural gas) to carry out its various development projects through the 1980s. It also examines whether funds are available on a scale large enough to meet these requirements. An attempt is then made to determine the likely impact of strains in the capital supply on the funding of a project for the production of methane from marine biomass.

A comprehensive study of the capital requirements of energy companies for the 1975–1990 period expresses serious concern about the future availability of sufficient funds. (Subcommittee on Energy and Power, U.S. House of Representatives, 1977). The gap between funds available and funds needed is projected to be $10 million during this period. There has been a drastic increase in the cash flow shortfall of energy companies in recent years.

The outlook for continued availability of investment funds for energy companies in general and synthetic fuel production in particular appears rather bleak. Some of the reasons for this assessment are:

1. Inflationary pressures that developed during the 1970s have adversely affected the "funding procedures and liquidity of all business corporations," including energy companies.
2. The appeal of energy has decreased vis-a-vis other types of investment available in the United States.
3. Energy companies have been "losing their old flexibility in methods of financing" and are faced with the prospect of having to search for new sources of funds. However, such sources appear to be limited. This has been especially true of external financing, which was as high as 74 percent in 1974.
4. Prospects for increased availability of internal funds also appear remote. Retained earnings, after payment of dividends and allowance for funds tied up during construction, are likely to make little, if any, addition to the supply of internal funds.
5. Governmental funds for the development of commercial-scale synthetic fuel oil production are hard to come by. It is "also clear that the intrinsic economies do not favor the development of nonconventional fuel sources through private risk taking."
6. Natural gas, which in the past has sometimes been developed for as little as $100 per thousand cubic feet of daily production, now calls for up to 10 times that rate of investment.
7. The natural gas industry faces serious financing problems in the future. Critical among these is the fact that "investment projects now facing the transmission industry are so large as to dwarf any ventures thought feasible in the past."

The availability of capital sufficient to enable commercial production of methane from marine biomass thus would appear to be a remote possibility.

Deregulation of Natural Gas Prices

Another factor that merits careful consideration in the context of R&D commitments for the Marine Biomass Project is the likely impact of deregulation of natural gas prices that went into effect on January 1, 1985. Experience with oil price decontrol nearly four years ago has been most encouraging, "stimulating new investment, more exploration, and better conservation" (The Economist Intelligence Unit, 1981).

Although the problems involved in the decontrol of natural gas are much more complex, its ultimate impact on investment in research and development efforts to explore new unconventional sources generally is likely to be positive. However, the decision to spend additional R&D funds on research on methane from marine biomass must be based on its economic feasibility in relation to methane from other sources such as tar sands, Devonian shales, and so forth. On the basis of available information, these latter options appear to be more cost-effective. Thus, the decontrol of natural gas prices seems likely to have minimal impact on the marine biomass project.

Future of Federal Support for Energy R&D

The risk and uncertainty associated with the MBP coupled with the massive capital outlays involved normally would make this project an ideal candidate for major support under the R&D programs of the U.S. Department of Energy. A few years ago, its focus on a renewable energy source would have added further to its chances for funding; however, under the recent budget proposals for the Department of Energy (DOE) things look most unpromising.

The budget for research on fossil fuels stood at $203 million in FY 1985 and $217 million in FY 1984, substantially lower than $566 million in 1982 and $994 million in 1981. Further deep cuts in research and development funds for fossil fuels and solar and other renewable energy sources are anticipated in FY 1986 (Science, 1982, 1985; Department of the Interior, 1985). Thus it would appear that the likelihood of any governmental support in the near future for marine biomass energy research is very slim, indeed. In charting its future course of action with respect to this projection, the Gas Research Institute may want to give careful consideration to this dismal prospect.

CONCLUSION

Demand and supply projections for natural gas for the next several decades clearly point to a scenario of relatively stable natural gas prices, offering minimal incentive for the production of high-cost gas. The commercial production of fairly low-cost methane from unconventional, nonrenewable gas resources appears highly likely in the next five to ten years. Reasonably priced natural gas from abroad is expected to be available in the years ahead to supplement the domestic supply, considerably lessening the urgency to tap high-cost, high-risk options like methane from marine biomass. Capital for energy exploration (including natural gas) is becoming increasingly difficult to come by, rendering highly capital-intensive projects like marine biomass less appealing. Prospects for federal support to private research and development efforts in the case of synthetic fuels in general appear to be bleak in the forseeable future. Thus, the overall conclusion reached from a careful assessment of these critical factors is that the case for imminent research and development funding for the Marine Biomass Project is less than compelling.

REFERENCES

Aquaculture Associates, Inc. (1982). "Energy from Marine Biomass Program Review." Report prepared for the Gas Research Institute. Honolulu: Aquaculture Associates, Inc.

Economist Intelligence Unit (1981, 1984). *Quarterly Energy Review: North America* (3d Quarter). London: Economist Intelligence Unit.

Economist Intelligence Unit (1984). *Quarterly Energy Review: Latin America and the Caribbean* (3d Quarter). London: Economist Intelligence Unit.

Gustaferro, J. F. (1983). *U.S. Energy for the Rest of the Century*. Washington, D.C.: U.S. Department of Commerce.

Kaufman, A. and S. J. Bodily (1981). "Supplemental Sources of Natural Gas: An Economic Comparison." *The Energy Journal* 2 (4).

Landsberg, H. S. et al. (1979). *Energy: The Next Twenty Years*. Cambridge, Mass.: Ballinger Publishing Company.

Oppenheiner, E. J. (1980). *Natural Gas: The New Energy Leader*. New York: Pen and Podium Productions.

Organization for Economic Cooperation and Development (1982). "Natural Gas: Prospects to 2000" Unpublished report. Paris: Organization for Economic Cooperation and Development.

Science, February 19, 1982, p. 947.

Science, February 15, 1985, p. 726.

Schurr, S. et al. (1979). *Energy in America's Future*. Baltimore: Johns Hopkins Press, pp. 206–09, 231.

Simon, J. (1981). *The Ultimate Resource*. Princeton: Princeton University Press.

Subcommittee on Energy and Power, U.S. House of Representatives and Committee on Energy and Natural Resources, U.S. Senate (1977). *Project Interdependence*. Washington, D.C.: U.S. Government Publications Office.

U.S. Department of Energy (1978). *Non-Conventional Natural Gas Resources*. Washington, D.C.

U.S. Department of Energy (1984). *Monthly Energy Review*. Washington, D.C.: Energy Information Administration (August).

U.S. Department of Interior and Related Agencies Appropriation for 1985 Hearings (1985). Washington, D.C.