3.1.2.4 Coalmine Methane

Background

Methane emissions from coal mines are a significant source of greenhouse gases. The U.S. Environmental Protection Agency (EPA) estimates that in 1988 about 9.0 to 12.6 million metric tons of carbon equivalent (MMTce) was released from methane emissions of 60 mines classified as large and gassy (>0.5 million tons of coal per year and >500 cubic feet of methane per ton of coal). EPA further estimates that 19.2 to 30 MMTce will be released from coal mines in 2000.

Coalmine methane is distinguished from *coalbed* methane in that coalmine methane is an environmental issue which must be controlled, while coalbed methane is an abundant source of natural gas supply which must be enhanced.

Under current Fossil Energy programs, technologies have been and are currently being developed and demonstrated for recovery and utilization of energy gases. The private sector has identified many of these technologies for reducing methane emissions associated with coal mining. These technologies include the use of high-efficiency gas turbines, gas fuel cells, internal combustion engines, and up-grading processes for the methane gas to be used in gas pipelines.

Major Goals

The overall implementation strategy for the program is to conduct feasibility studies, field testing, demonstration, and eventual commercialization. The goal of the program is to expand existing research efforts to broaden the range of cost-effective technologies/methods for recovering methane associated with mining. It is expected that after the demonstration phase, coal mining companies or other industry firms will invest in equipment to utilize gas generated from mining operations.

Project Objectives

Both the Phase I feasibility study and the Phase II detailed conceptual design for a proposed technology demonstration at a mine site will be a collection, assessment, and planned use of existing field and technology data from coal mining activities, particularly data related to methane emissions from mining operations.

As part of the President's Climate Change Action Plan and its goal of reducing greenhouse gas emissions, DOE will support outreach, cost-shared demonstration, and market entry projects to investigate and apply new and existing technologies for capturing and using energy gases related to the coal mining process.

Current contractors and projects in this research area are:

- *Northwest Fuel Development, Inc.,* a service company to the coal, gas, and electric utility industry is working with Peabody Development Company at the Federal #2 Mine in northern West Virginia to capture mine ventilation air for gas turbine use in local power supply.
- *Jim Walters Resources Inc.,* a coal mining company in Alabama is focused on using gob gas for power generation with gas turbine technology.
- *Noumenon Corporation,* a natural gas producer in West Virginia is designing an upgrading demonstration for using gob gas from longwall mining operations.
- *West Virginia University Research Corporation,* a consortium of the mining industry, State agencies, and academia, is investigating use of gob gas from mining operations for power generation at a local mine site in southwestern Pennsylvania.

- *Energy Research Corporation,* a fuel cell manufacturer in Connecticut, is working with a coal mining company in eastern Ohio to use coalmine methane for generating power at the local mining operation.

Expected Benefits

Any and all technologies used in this DOE-industry effort will be value added to the goal of improving air quality and reducing greenhouse gases, such as methane. This effort is a design phase that focuses on the feasibility of using existing technologies and assessing the applicability by industry of a certain technology to a specific coal mining site.

Planned Products

This effort is a paper study on a conceptual design that will detail all aspects of a field demonstration of a particular technology, such as gas turbines or fuel cells, with coalmine methane as the fuel source.

Strategy

Funding of $1 million requested for this program in the FY 97 budget was not approved by Congress. The five ongoing projects are presently completing a design phase of the applied technology to be demonstrated at a mine site.

Time and investment for methane recovery and utilization technologies selected for mine demonstration will likely vary for each of the alternatives selected. For any given technology to be regularly used in mining operations, about 5 years is expected to be required. Individual mine demonstrations should be completed in three years. Adopting successful technology for use in a significant share of mining operations would require another two years. Total additional funds required, including the FY 98 request of $0.963 million, are estimated to be $4 million. For any given mine demonstration project, the industry cost-sharing contribution will be greater than the Federal funds required.

FY 98: Funding of $0.963 million has been appropriated this program in the FY 1998 budget. This amount will allow for completion of the design phase for the applied technologies and preliminary site preparation of those projects selected to the field demonstration phase.

FY 99: Funding of $2 million will be needed. The industrial partners in this joint effort will be expected to contribute 51 percent cost sharing in each of the projects selected to continue into the field demonstration phase. This amount of joint-funding will allow those projects selected for the field demonstration effort to proceed with the acquisition of those technologies to be demonstrated at the project mine site.

FY 2000: Funding of $1 million will be needed. This will allow the industry partners to prepare and install the equipment and technology(s) at the mine site for testing.

Recent Accomplishments

Completed Phase I feasibility study effort FY 95. Initiated five Phase II conceptual design studies FY 96.

Program Funding

DOE Historical Spending ($ in Millions)

Projects	FY 1996	FY 1997	FY 1998
Jim Walters Mine, AL (JW)	0.075	0	0.193
Harisson Mine, OH (ERC)	0.075	0	0.193
Emerald Mine, PA (WVURC)	0.075	0	0.193
Daybrook Mine, WV (Noumenon)	0.075	0	0.193
Federal # 2 Mine, WV (Northwest)	0.075	0	0.193
Total	**0.375**	**0**	**0.965**

Cost Sharing ($ in Millions)

Projects	FY 1996	FY 1997	FY 1998 Estimate
Jim Walters Mine, AL (JW)	0.013	0	0.033
Harisson Mine, OH (ERC)	0.013	0	0.034
Emerald Mine, PA (WVURC)	0.018	0	0.046
Daybrook Mine, WV (Noumenon)	0.006	0	0.013
Federal # 2 Mine, WV (Northwest)	0.075	0	0.037
Total	**0.125**	**0**	**0.163**

Schedule

Projects	1997	1998	1999	2000	2001	2002
Jim Walters Mine, AL (JW)						
Harisson Mine, OH (ERC)						
Emerald Mine, PA (WVURC)						
Daybrook Mine, WV (Noumenon)						
Federal # 2 Mine, WV (Northwest)						

JW: Jim Walters Resources, Inc.

ERC: Energy Research Corporation

WVUER: West Virginia University Research Corporation

3.1.2.5 Low-Quality Gas Upgrading

Background

Considerable quantities of low quality natural gas (LQNG) exist in the United States. In general, LQNG use will depend on effective and economical separation of hydrocarbon and non-hydrocarbon components, with degree of separation required depending on the particular use and transportation requirements. High inerts (i.e. nitrogen) are normally undesirable because of needless pipeline shipment costs. On the other hand, non-hydrocarbon component(s) may be marketable, such as nitrogen and/or carbon dioxide for enhanced oil recovery operations, and salable elemental sulfur is recoverable from hydrogen sulfide contaminants.

Important issues that need to be resolved for LQNG separation technologies are: (1) cost of fuel needed to drive the separation and the need to increase the energy efficiency of the process, and (2) high unit cost of gas conditioning if gas is processed in scaled-down quantities. Consequently, there is a need to develop new separation concepts that can yield significant efficiency improvements and cost reductions. Novel membrane applications, solvent absorption and adsorption fundamentals, and the thermodynamics and chemistry of natural gas mixtures are viable research areas.

LQNG upgrading research activities include: (1) parallel research on novel passive and facilitated-transport polymeric membrane concepts to increase the selectivity, permeability, and long-term stability under practical operating conditions; (2) developing novel adsorbents and absorbents and evaluating them in a pressure, temperature, and/or vacuum swing mode; (3) advancing novel hybrid LQNG separation technologies, and developing adaptive technology for field application; and (4) conducting process and economic evaluations of membranes, adsorbents, absorbents, and other single and hybrid technologies as they apply to upgrading LQNG to pipeline specifications.

Major Goals

The goals of the Natural Gas Upgrading (NGU) products team are: (1) to develop advanced cost-efficient methods of upgrading (to pipeline quality) contaminated natural gas; (2) to foster necessary field evaluation, and testing of advanced upgrading technologies and subsequent industry adoption of the improved technology, and (3) to increase utilization of higher hydrocarbons as fuels conversion products at a level which helps to displace imported oil.

About one-third of U.S. gas resources fall below pipeline quality in composition and normally require some upgrading, although some can be brought to specification with careful blending of non-contaminated gas. Applicability of alternative treatments varies with the mix of impurities and the gas flow volume to be treated.

Changes are needed in separation technologies to process selected new supply sources economically as well as to increase gas processing efficiency and reduce costs. Conventional gas separation technology is often exceedingly costly for processing very sour (hydrogen sulfide) and high nitrogen content natural gas. Advanced natural gas upgrading technologies will assist in increasing available U.S. natural gas reserves, in separating natural gas from inert cushion gas in gas storage operations, and in upgrading gas to meet specific quality requirements for end-use applications, including most chemical conversion processes. These require sulfur-free gas to avoid process catalyst poisoning.

Research efforts have been initiated to develop selected new or improved membrane separation processes that remove and recover sulfur compounds with less environmental impact than conventional approaches, and others that remove nitrogen from natural gas at lower costs.

Project Objectives

The objective of the NGU program is to develop and field validate within 10 years, polymeric membrane and novel hybrid gas separation technologies that will advance economical utilization of low-quality natural gas. Emphasis is on membrane products because of their lower cost, modularity and smaller size than traditional adsorption and absorption gas separation techniques.

Expected Benefits

Within 10 years, the NGU program expects commercialization of polymeric membranes for carbon dioxide and hydrogen sulfide (acid gas) removal from natural gas. Costs for nitrogen separation from natural gas should be improved by one-half over existing conventional cryogenic technology. Transfer of these technologies to 50 percent of gas treatment design engineers should be accomplished.

Planned Products

LQNG contains impurities such as carbon dioxide, hydrogen sulfide, and nitrogen that must not exceed adopted pipeline limits [maximum 4 percent CO_2 plus N_2, 4 parts per million (ppm) of S] for pipeline quality natural gas. Advanced technology efforts to separate impurities from natural gas more effectively are as follows:

- Develop and characterize thin, composite, enhanced, transportation-exchange membrane films for removal of carbon dioxide and hydrogen sulfide, and conduct field tests.
- Conduct laboratory-scale testing of advanced polyimide membranes for separating carbon dioxide, hydrogen sulfide, water vapor, and nitrogen from contaminated natural gas by selective permeation. Evaluate the economics of these processes.
- Develop inorganic sol-gel thin film membranes that combine small pore diameters, narrow pore size distributions, and tailored pore surface chemistries, which are useful for separating gases by such mechanisms as molecular sieving or prevaporation.
- Develop an advanced membrane gas separation technology for economical removal, recovery, or disposal of sulfur from sulfur-contaminated natural gas, i.e., economically upgrade sulfur contaminated gas to pipeline specifications, and recover or properly dispose of the sulfur or sulfur compounds in an environmentally acceptable manner.
- Develop an advanced absorption gas separation technology for economical removal, recovery, or disposal of sulfur from sulfur-contaminated natural gas; i.e., economically upgrade sulfur contaminated gas to pipeline specifications, and recover or properly dispose of the sulfur or sulfur compounds in an environmentally acceptable manner.
- Develop a high-efficiency absorption gas separation process for separating hydrogen sulfide and water vapor from contaminated natural gas.
- Utilize a membrane separation technology or a pressure swing adsorption/ absorption separation process for upgrading gob gas for on-site fueling purposes, such as coal drying and power generation, while meeting the new clean air standards of the Clean Air Act Amendments of 1990 (CAAA), and specifications for pipeline-quality natural gas, or both.
- Develop an economical, efficient, novel, liquid absorbent process to produce pipeline-specification natural gas from nitrogen-contaminated gas at the wellhead. This absorbent will be designed to have a high affinity for nitrogen and little or no affinity for methane or any other hydrocarbons present.

- Develop an economical, efficient, hollow-fiber, membrane natural gas dehydration process to produce pipeline-specification natural gas from raw wellhead natural gas. This membrane will be designed to be robust, economical, and reduce methane losses.
- Conduct process and economic evaluations of the above and other advanced competing gas separation processes that upgrade low quality gas to pipeline specifications.
- Provide a field demonstration of an advanced gas separation technology that economically removes and recovers or disposes of sulfur from sulfur-contaminated natural gas; i.e., economically upgrades the sulfur contaminated gas to pipeline specifications, and recovers or properly disposes of the sulfur or sulfur compounds in an environmentally acceptable manner.

Strategy (FY 97 Funding: $1.1 Million)

- Continue second phase, laboratory of two advanced nitrogen removal processes.
- Continue field validation of high efficiency acid gas solvent upgrading process utilizing structured packing.
- Expand database for biochemical regeneration of Redox solution in hydrogen sulfide removal.
- Continue coordination evaluation and research into advanced LQNG upgrading with the Gas Research Institute.

Recent Accomplishments

- Demonstration of natural gas denitrogenation using methane permeable membranes is technically and economically feasible.
- N-Formyl Morpholine has shown great potential for treating subquality natural gas.

Program Funding

DOE Historical Spending ($ in Millions)

Projects	FY 1996	FY 1997	FY 1998
Upgrading Natural Gas via Organic Membranes (Syracuse University)	0.020	0.000	0.000
Upgrading Natural Gas via Sol-Gel Membranes (SNL[1])	0.125	0.124	0.125
LQNG Sulfur Removal/Recovery No. 1 (MTR[2], Inc.)	0.050	0.000	0.000
Upgrading Natural Gas via High Efficiency Contactors (IGT[3], GRI[4])	0.150	0.100	0.000
Nitrogen Removal from Natural Gas (MTR)	0.678	0.050	0.085
Nitrogen Removal from Natural Gas (SRI)	0.000	0.540	0.300
Microbial Redox Reoxidation (Texas A&M, GRI)	0.050	0.050	0.100
Advanced Hybrid Gas Separation (TBD)	--	--	TBD
Bioprocessing for Sulfur Removal (Arctech)	0.050	0.050	0.050
Offshore Natural Gas Assessment	0.020	0.000	0.000
Gas Research Support (In-house)	0.200	0.055	0.055
Upgrading Support (TBD)	0.000	0.000	TBD
GSAM (ICF)	0.000	0.124	0.000
Total	**1.343**	**1.093**	**0.715**

[1] SNL: Sandia National Laboratories
[2] MTR: Membrane Technology Research, Inc.
[3] IGT: Institute of Gas Technology
[4] GRI: Gas Research Institute

Cost Sharing ($ in Millions)

Performer	Projects	FY 1996	FY 1997	FY 1998 Estimate
IGT & GRI	High Efficiency Contactors	0.000	0.200	0.000
Arctech	Bio Process for Sulfur Removal	0.050	0.050	0.050
MTR, SRI	Nitrogen Removal	0.000	0.500	0.300
SNL	Sol-Gel Membranes	0.000	0.250	0.250
Total		**0.050**	**0.950**	**0.600**

Schedule

Projects	1994	1995	1996	1997	1998	1999
Upgrading Gas via Polyimide Membranes	▬	▬	▬	▬		
Upgrading Gas via Sol-Gel Membranes	▬	▬	▬	▬	▬	
LONG Sulfur Removal/Recovery	▬	▬	▬	▬	▬	▬
Upgrading Gas via High Efficiency Contactors	▬	▬	▬	▬		
Microbial Redox Reoxidation	▬	▬	▬	▬	▬	▬
Nitrogen Removal		▬	▬	▬	▬	▬
Advanced Hybrid Gas Separation					▬	
Bioprocessing for Sulfur Removal			▬	▬	▬	▬

3.1.2.6 Gas-to-Liquids

Background

Supplies of natural gas, domestic and worldwide, are abundant. However, many of these natural gas reservoirs are located in relatively remote areas and high transportation costs tend to prohibit extensive use of this resource. In order to offset these costs, efficient and lower cost natural gas conversion processes must be identified and developed.

Gas-to-liquids conversion technologies use chemical or physical methods to convert natural gas to a liquid form suitable for ready transport or direct use. Conversion is accomplished in one of two ways: (1) compression and refrigeration, in which the gas is liquefied cryogenically and subsequently regasified for later use, and (2) chemical conversion, in which the gas molecules are chemically altered and combined to form a stable liquid that can be used directly as a transportation fuel or petrochemical feedstock or product.

Both methods of conversion are relatively costly and inefficient. Therefore, cost reduction of either of these conversion methods, by process or chemical improvements, would clearly have a significant favorable economic and energy efficiency impact on the natural gas, fuel and chemical markets.

Major Goals

The goal of this program is to economically convert natural gas, primarily methane, to readily transportable hydrocarbon liquids and/or higher value petrochemicals in a simplified one- or two-step process. This will be achieved by the following routes:

- Eliminate intermediate conversion steps during the conversion of natural gas to higher value petrochemicals and improve natural gas conversions and product selectivities for these processes.
- Develop conversion processes which operate at lower temperatures and pressures, thereby decreasing both capital and operating costs of the reactor systems.
- Introduce novel, cost-effective technologies to existing processes to lower capital and operating costs.

Project Objectives

In partnership with industry, develop and demonstrate advanced technologies and processes for economical conversion of methane to liquids that can be used as fuels or chemical feedstocks. This will increase available sources of supply for liquid transportation fuels and reduce demand for crude oil derived liquid transportation fuels.

Expected Benefits

Near-Term

Leads to discovery, development, and proof-of-concept of new chemistry for direct and indirect conversion of methane-rich gases to environmentally desirable liquid fuels and to new techniques to liquefy and transport gas from remote well locations without pipeline access.

Mid-Term

Encourages or promotes construction of commercial plants based on new direct and indirect conversion processes.

Planned Products

- Initiation of a major research effort to develop oxygen ion transport ceramic membranes for the conversion of natural gas to syngas.
- Scale-up of the Thermoacoustic Driver-Orifice Pulse Tube Refrigerator (TAD-OPTR) to produce 500 gallons per day of liquefied natural gas (LNG).
- Determine economics of conversion plant costs in Alaska.

Strategy (FY 97 Funding: $5.066 Million)

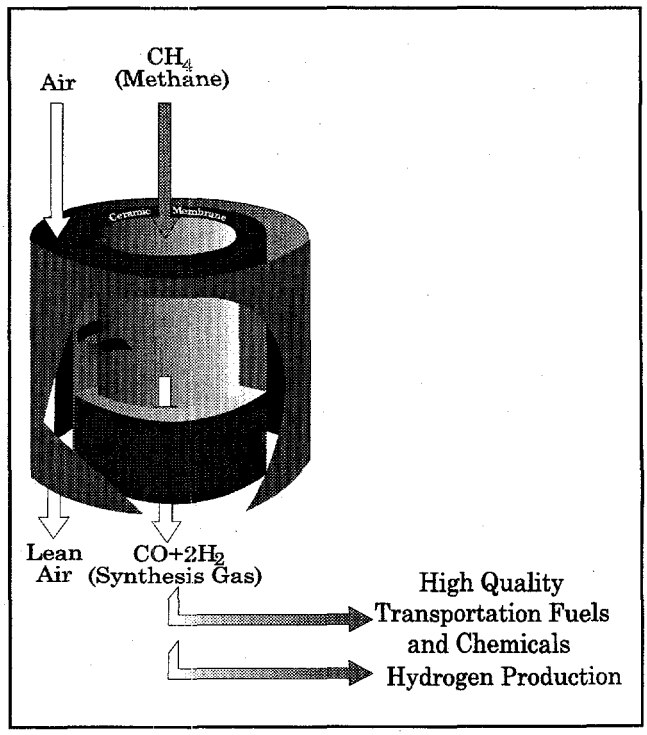
The research strategy is carried out through two coordinated activities, one focusing on the direct (one-step) conversion of natural gas to either a liquid "gas" or to a hydrocarbon liquid of different composition; the other concentrating on indirect (two-step) conversion methods, whereby natural gas is transformed to reactive intermediates such as syngas (CO and H_2), or acetylene, and subsequently converted to desired liquids.

- *One-Step Natural Gas-to-Liquids*: This is a multidisciplinary research effort focused on the development of economic, direct conversion processes to convert natural gas to higher value liquid fuels or to a dense liquid "gas" at low temperature and pressure. Activities include theoretical and experimental investigations of catalytic and non-catalytic conversion processes. Specific objectives of the research are to: (1) derive fundamental information and concepts about chemical reactions during conversion; (2) enhance conversion rates and selectivity; and (3) improve separation and recovery of the products. In addition, research is being conducted to advance the economics of physical conversion of natural gas, directed towards enhancing remote gas marketability.
- *Two-Step Natural Gas-to-Liquids*: This research is focused on developing a scientific and engineering knowledge base for industry use in manufacturing hydrocarbon fuels and chemicals from natural gas. Currently, the three most advanced two-step conversion technologies are: (1) partial oxidation; (2) oxyhydrochlorination; and (3) oxidative coupling. The program seeks to accomplish innovative improvements over the state-of-the-art conversion technologies through staged development from laboratory scale to bench scale and finally to proof-of-concept scale.

Recent Accomplishments

- Demonstrated production of 100 gallons per day of liquefied natural gas using the Thermoacoustic Driver-Orifice Pulse Tube Refrigerator.
- Completed preparation of a draft report comparing pipeline costs with liquefied natural gas production costs.
- Completed preliminary economic evaluation of the oxyhydrochlorination natural gas conversion process.
- Developed and tested a bench scale prototype plasma quench reactor for the conversion of natural gas to higher hydrocarbons. Significant improvements over prior tests were achieved.
- Completed economic and process evaluation of modular offshore natural gas conversion plants and gathering line prospects.

Ceramic Membrane Technology for the Conversion of Natural Gas to Synthesis Gas



Program Funding

DOE Historical Spending ($ in Millions)

Performer	Project	FY 1996	FY 1997	FY 1998
FETC	In-House Research	0.300	0.228	0.200
K&M	Offshore Natural Gas Assessment	0.080	0.000	0.100
Lawrence Berkeley National Laboratory (LBNL)	Catalytic Conversion by Coupling Chemical Reactions and Separations	0.000	0.113	0.150
Idaho National Engineering and Environmental Laboratory (INEEL)	Feasibility Study to Evaluate Plasma Quench Technology for Natural Gas Conversion Applications	0.277	0.297	0.350
University of Oklahoma	Enhancement of Methane Conversion Using Electric Fields	0.000	0.180	0.100
Los Alamos National Laboratory (LANL)	Thermoacoustic Natural Gas Liquefier	0.450	0.396	0.400
Idaho National Engineering and Environmental Laboratory (INEEL)	North Slope of Alaska Natural Gas Resource Development and Utilization Study	0.191	0.990	0.100
Energy International	Conversion of Associated Natural Gas to Liquid Hydrocarbons	0.130	0.000	0.000
Lawrence Berkeley National Laboratory (LBNL)	Oxidative Coupling Catalyst Development	0.100	0.000	0.000
Burns and Roe Site Contractor - PGH	Technical Support	0.000	0.085	0.000
Dow Corning Phase I	Methyl Chloride via Oxyhydrochlorination of Methane	0.068	0.000	0.000
Colorado School of Mines	Development of Vanadium-Phosphate Catalysts for Methanol Production by Selective Oxidation of Methane	0.060	0.000	0.000
Massachusetts Institute of Technology	Conversion of Light Hydrocarbon Gases to Metal Carbides for Production of Liquid Fuels and Chemicals	0.089	0.050	0.000
SRI International	Oxidative Coupling - Fullerene	0.045	0.000	0.000

Continued

Program Funding

DOE Historical Spending ($ in Millions) (continued)

Performer	Project	FY 1996	FY 1997	FY 1998
Worcester Polytechnic Institute	Methane Coupling by Catalytic Membrane Reactor	0.106	0.000	0.000
Institute of Gas Technology	Carbon Disulfide	0.225	0.000	0.000
University of California - Davis	Light Hydrocarbon Conversion - Superacid Catalysis	0.087	0.000	0.000
Argonne National Laboratory (ANL)/Amoco	Ceramic Membranes for Methane Conversion (CRADA)	0.325	0.000	0.000
CANMET	Consortium on the Conversion of Natural Gas (CCNG)	0.050	0.050	0.050
Dow Corning Phase 2	Methyl Chloride via Oxyhydrochlorination (OCH) of Methane: A Building Block for Chemicals and Fuels from Natural Gas	0.302	0.000	0.000
APCI, et al.	Engineering Development of Ceramic Membrane Reactor Systems for Converting Natural Gas to Hydrogen and Synthesis Gas for Liquid Transportation Fuels	0.000	2.677	0.800
Argonne National Laboratory (ANL)	ITM Support	0.000	0.000	0.700
Pacific Northwest Laboratory (PNL)	ITM Support	0.000	0.000	0.200
TBD	Exploratory Research	0.000	0.000	TBD
Total		**2.885**	**5.066**	**3.150**

Cost Sharing ($ in Millions)

Performer	Project	FY 1996	FY 1997	FY 1998 Estimate
FETC-Morgantown	Assessments and Economics	--	--	--
K&M	Offshore Natural Gas Assessment	--	--	--
Lawrence Berkeley National Laboratory (LBNL)	Catalytic Conversion by Coupling Chemical Reactions and Separations	--	--	--
Idaho National Engineering and Environmental Laboratory (INEEL)	Feasibility Study to Evaluate Plasma Quench Technology for Natural Gas Conversion Applications	--	--	--
University of Oklahoma	Enhancement of Methane Conversion Using Electric Fields	0.088	--	--
Los Alamos National Laboratory (LANL)	Thermoacoustic Natural Gas Liquefier	--	--	--
Idaho National Engineering and Environmental Laboratory (INEEL)	North Slope of Alaska Natural Gas Resource Development and Utilization Study	--	--	--
Energy International	Conversion of Associated Natural Gas to Liquid Hydrocarbons	--	--	--
Lawrence Berkeley National Laboratory (LBNL)	Oxidative Coupling Catalyst Development	--	--	--
Burns and Roe Site Contractor - PGH	Technical Support	--	--	--
Dow Corning Phase I	Methyl Chloride via Oxyhydrochlorination of Methane	0.100	--	--
Colorado School of Mines	Development of Vanadium-Phosphate Catalysts for Methanol Production by Selective Oxidation of Methane	--	--	--
Massachusetts Institute of Technology	Conversion of Light Hydrocarbon Gases to Metal Carbides for Production of Liquid Fuels and Chemicals	--	--	--
SRI International	Oxidative Coupling - Fullerene	0.008	--	--

Continued

Cost Sharing ($ in Millions) (continued)

Performer	Project	FY 1996	FY 1997	FY 1998 Estimate
Worcester Polytechnic Institute	Methane Coupling by Catalytic Membrane Reactor	0.063	--	--
Institute of Gas Technology	Carbon Disulfide	--	--	--
University of California - Davis	Light Hydrocarbon Conversion - Superacid Catalysis	--	--	--
Argonne National Laboratory (ANL)/Amoco	Ceramic Membranes for Methane Conversion (CRADA)	--	--	--
CANMET of Natural Gas (CCNG)	Consortium on the Conversion	0.500	0.500	0.500
Dow Corning	Methyl Chloride via Oxyhydrochlorination (OCH) of Methane: A Building Block for Chemicals and Fuels from Natural Gas	--	0.000	0.000
Program Opportunity Notice	Engineering Development of Ceramic Membrane Reactor Systems for Converting Natural Gas to Hydrogen and Synthesis Gas for Liquid Transportation Fuels	--	2.677	0.800
Argonne National Laboratory (ANL)	ITM Support	--	--	--
Pacific Northwest Laboratory (PNL)	ITM Support	--	--	--
TBD	Exploratory Research	--	--	TBD
Total		**0.759**	**3.177**	**1.300**

Schedule

Projects	1996	1997	1998	1999	2000	2001	2002	2003
Economic, Market, and System Evaluations								
LNG Process Development								
Ceramic Membrane Syngas Exploration and Process Development								
Testing of Novel Catalytic Concepts and Reactors								
Oxyhydrochlorination Process Exploration and Development								
Exploratory Gas Processing Research								
High Priority Concept Follow-up								

3.1.2.7 Natural Gas and Oil Technology Partnership

Background

New technologies are needed to produce more gas from domestic reservoirs while safeguarding the environment and working within today's economic constraints. The past decade has seen a dramatic shift in funding emphasis within the U.S. petroleum industry which has had to reevaluate all aspects of its business, including R&D and technology investments. Initiated in 1988 as the Oil Recovery Technology Partnership, the Natural Gas and Oil Technology Partnership has responded through a mechanism of collaborative projects to bring the capabilities of DOE's National Laboratories to the industry. This industry-driven program establishes active industry interfaces through review panels and forums that define industry needs, provide annual project reviews, and recommend priorities of new proposals and ongoing projects.

Major Goals

Transfer technologies derived from DOE-funded weapons and energy research and make the capabilities, expertise, equipment, and facilities of the national laboratories available to the petroleum industry.

Develop new, innovative mechanisms for interactions with industry to expedite this transfer.

Maintain close coordination with industry to ensure that industry needs are being addressed.

Project Objectives

Conduct a slate of joint industry-National Laboratory projects which address industry needs in four technology areas, each of which is critical to improved natural gas supply and which is aligned with a technical research area in DOE's Petroleum Technology Program:

- Diagnostic and imaging technology
- Drilling, completion, and stimulation technology
- Oil and gas recovery technology, and
- Environmental technology (exploration and production related)

Such projects include application of state-of-the-art computing and associated technologies to improve the acquisition, processing, and interpretation of geologic, geochemical, geophysical, and engineering data required to optimize exploration and development of natural gas and oil fields and reservoirs.

Expected Benefits (Near- and Long- Term)

Partnering among industry, national laboratories and the Federal government will result in accelerated market entry of new technologies, will reduce risks associated with technology development, and will enhance competitiveness of the U.S. industry. Specific benefits include: leveraged R&D funds; shared R&D risk; access to state-of-the-art exploration and production (E&P) knowledge, expertise, and facilities; interactions with the DOE national laboratories; and effective technology transfer.

Planned Products

Increased emphasis and support towards natural gas exploration and production in all four of the Partnership's technology areas outlined above. The kinds of future technical products resulting from multiple Partnership projects should reflect the range of accomplishments listed below.

In FY 97, the Partnership had three of its projects funded through the natural gas program at FETC. These projects are addressing improved well completion techniques in gas wells through a better understanding of perforation dynamics in geological media; improvements in coiled tubing drilling with small-diameter bottom hole assemblies capable of underbalanced directional drilling for minimal formation

damage in gas producing formations; and techniques for locating geopressured hydrocarbon reservoirs in soft clastic sediments through identifying associated pressure seals. In addition, most of the advanced seismic processing projects in the Partnership have direct applications for improving drilling success rates in complex geological structures such as the Gulf of Mexico.

Strategy (FY 97 Funding: $1.0 Million)

Aggressively support the Partnership's unique paradigm with an increasing shift in emphasis and support towards natural gas exploration and production.

Recent Accomplishments

Recent accomplishments from over 60 joint industry-national laboratory projects include the following: computational tools for advanced reservoir management; improved natural and hydraulic fracture mapping technology; technology improvements for independents (spanning such diverse areas as artificial lift hardware to data information systems); increasing the effectiveness of hydraulic fracturing; new codes which predict near-well effects controlling production (such as perforation damage and wellbore stability); advanced borehole seismic source and receiver systems; algorithms for processing very large complex seismic data sets in a massively parallel computing platform; methodologies and techniques for improved, efficient seismic imaging of complex, hard-to-resolve regions, such as reservoirs below salt sheets in the Gulf of Mexico; and ties with the Petroleum Technology Transfer Council (PTTC) for enhanced technology transfer.

Cost Sharing

Cost sharing is a requirement of the joint projects conducted under this program; it generally occurs in the form of in-kind cost sharing. While no minimum level is specified, industry's in-kind overall cost share has averaged more than fifty percent over the life of the program.

Schedule

Each project under the Partnership program has its own individual schedule and milestones.

The Partnership review cycle has been recently revised to occur in the first quarter of the fiscal year.

Program Funding

DOE Historical Spending ($ in Millions)

Source of Funds	FY 1996	FY 1997	FY 1998
Fossil Energy	1.0	1.0	1.0
Total	**1.0**	**1.0**	**1.0**

3.1.2.8 International Center for Gas Technology Information

Background

Today, a variety of organizations collect information about energy and technology, but none of these organizations exclusively focuses on natural gas technology. Furthermore, there is no international clearinghouse to facilitate exchange of such information among participants and potential users of technology. There are substantial efforts underway throughout the world to improve gas production technologies, transportation, and utilization. An inventory of new technological concepts awaits introduction into the marketplace, and experience is being gained with field testing and early introduction of new practices and equipment in a number of locations around the world. The body of information gained in these activities is being communicated, but usually only in bilateral exchanges among the most active participants.

International Energy Agency (IEA), founded in 1974, is the energy forum for 21 industrialized countries. Among its other activities, IEA helps member countries set up collaborative projects for RD&D of energy related technologies. In October 1990, IEA sponsored a conference in Lisbon, Portugal, on emerging natural gas technologies. The main conference recommendation was that an International Center for Gas Technology Information (ICGTI) be established. In response, DOE and the Danish Ministry of Energy agreed to present a joint proposal for formation of the Center. DOE asked GRI to be the focal point for forming the Center.

The international natural gas community recognizes the need for better access to information about gas technologies and for enhanced RD&D cooperation and technology transfer in gas supply, transportation, and utilization. Many interested participants need access to a comprehensive source of information in order to improve coordination of investments in RD&D, more rapidly and broadly disseminate both research results and early marketplace experience with new technologies, and facilitate adoption of proven technologies over wider geographic markets.

ICGTI represents an effort through the Department and the Gas Research Institute for the U.S. natural gas industry to exercise its appropriate leadership in the global gas industry.

Major Goals

ICGTI's primary mission is "to provide an international forum on gas technology information so that gas technologies are transferred and global gas market needs are met efficiently." In accomplishing this, the Center developed an Internet-based technology information exchange, GTI Online (*http://www.icgti.org*). In the first nine months of 1997, ICGTI built GTI Online into an important new source of gas technology and related information, including more than 10,000 technical entries. By the end of 1997, a complete record of the World Gas Conference (WGC) will be exclusively available on the GTI Online site and a technology directory of 6,000 companies serving the global gas industry will be available.

The Center does not contemplate funding or managing any RD&D projects. The Center is a nonprofit organization funded by those member countries desiring to participate. Policy guidance and strategic direction come from the International Executive Committee of sponsoring IEA members. Gas Technology Information, Inc., a joint cooperation between GRI and the Danish Technology Center, is the current legal entity acting as the Operating Agent for the Center.

Project Objectives

The objective of this project is to promote widespread commercialization of gas-related technologies by providing a continuing international forum for increased information dissemination and international cooperation and collaboration concerning gas technologies.

Expected Benefits

- Promotes technology information exchange geared toward accelerated technology transfer.
- Provides high-value information on gas technology development and market trends to companies searching for solutions to real-world industry problems.
- Helps technology and know-how suppliers identify relevant gas markets.
- Leverages U.S. R&D investments through connections to other technology developers around the world.
- Demonstrates U.S. leadership in the global gas industry.

Planned Products

GTI Online will expand the key components of this technology information exchange, adding 7,500 technical files to the system. Through an agreement with the International Gas Union, GTI Online will be the exclusive Internet location of the proceedings and related documents of WGC '97.

GTI Online is adding a Technology Directory that will provide ICGTI members with data on thousands of firms active in the global gas industry. Phase I, implemented in Fall 1997, provides basic data for approximately 6,000 companies. Phase II, in 1998, will involve adding basic data on additional companies and more in-depth information on the Phase I companies. The goal is to make this Technology Directory one of the major reference sources for the global gas industry.

Strategy (FY 97 Funding: $0.312 Million)

The key strategy of ICGTI is to combine advanced communication techniques, information technologies, and gas industry expertise in order to serve senior executive of gas companies and of companies supplied by the gas industry and, especially, professionals working in engineering and marketing positions for the global gas industry.

In the two years since the Center was formally established at a signing ceremony at OECD Headquarters in Paris, France, ICGTI has made important progress in gaining visibility for the U.S. natural gas industry in the international natural gas industry. The original six charter member nations (Denmark, Japan, Portugal, Russia, Spain and the United States) has expanded to an "electronic village" with more than 500 companies from 14 participating nations. Moreover, visitors from more than 50 nations have used the open sections of GTI Online that are made available to the global gas industry at no charge.

Recent Accomplishments

Headquarters operation of the Center has been successfully established in the United States, co-located with the Washington-area offices of the Gas Research Institute. The Center has added its first member from Latin America, Brazil. At a recent set of meetings at CENPES, the R&D center for Petrobras, many ideas and opportunities for the sharing of technology information were identified.

The ICGTI-Canadian Gas Association (CGA) Leak Detection Workshop was held in Toronto, Canada in November 1997, and follow-up activities will take place through electronic discussions within the GTI Online system. GTI Online has become an important new source of technical information for the global gas industry.

Since mid 1997, visits to GTI Online have exceeded 100,000 per month, clearly making this an important new focal point of the global gas industry.

Program Funding

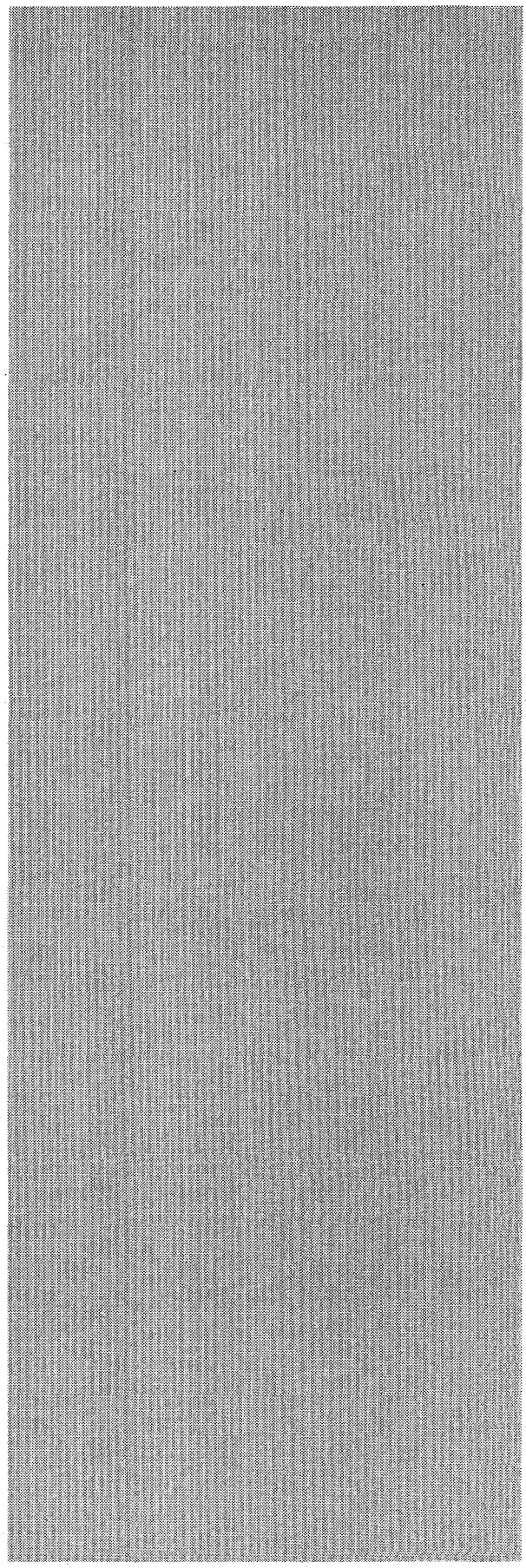
DOE Historical Spending ($ in Millions)

Projects	FY 1996	FY 1997	FY 1998
ICGTI	0.314	0.312	0.318
Totals	**0.314**	**0.312**	**0.318**

Cost Sharing

The Center is jointly funded by the Department of Energy and a variety of sources from the other 14 ICGTI nations and Columbia Gas Systems as a U.S. corporate sponsor. The DOE contribution is leveraged at more than a three-to-one factor. Additional companies and countries are exploring participation in the Center.

Current participants include Australia, Brazil, Canada, Denmark, Finland, Japan, the Netherlands, New Zealand, Portugal, Russia, Spain, Sweden, United Kingdom, and the United States.



3.1.2.9 Fundamental Geosciences Research

Background

This is one facet of a broad-based geoscience research program emphasizing fluid-flow (e.g., geothermal, hydrocarbon, groundwater) in porous and fractured geologic media. The issues requiring investigation include: (1) the rate and nature of natural gas and oil generation from organic-rich sediments; (2) stability of natural gas in the subsurface; (3) origin and development of secondary porosity; (4) evolution of fracture systems with particular emphasis on potential reservoir and seal rocks; and (5) geophysical imaging for characterization of reservoirs and related rocks.

Major Goals

- *Origin:* Obtain and interpret geochemical and isotopic data on the limits to oil and gas generation in deeply buried sediments during and subsequent to diagenesis.
- *Migration:* Develop basic understanding of fluid flow in porous and fractured rocks through laboratory, field, computational, and modeling studies.
- *Entrapment:* Provide the foundation for understanding of scale-dependent reservoir heterogeneity and anisotropy.
- *Exploration:* Develop new and improved high resolution geophysical techniques and approaches for imaging subsurface fluid-bearing reservoirs.
- *Production:* Provide new concepts and information on rock fracture and failure under in-situ conditions to improve drilling methods; develop sensor systems for geophysical imaging capability ahead of the bit as a basis for adaptive drilling.

The integrating theme is to reduce exploration and drilling costs and improve the environment through better understanding of the geologic host for the gas resource.

Project Objectives

The program conducts fundamental studies on the origin, migration, and entrapment of natural gas for improved understanding of geologic factors controlling and limiting availability of this resource.

Strategy (FY 97 Funding: $3.8 Million)

The program strategy is to support fundamental research activities at the Nation's academic institutions and DOE laboratories. Much of this research is broad and generic.

Expected Benefits

Limited near-term impacts are anticipated because of the basic nature of the research. However, new insights are rapidly applied by scientists and engineers in industry as a result of communication by publication in the open literature and presentations at regional, national, and international professional meetings.

Mid-term impact is well illustrated by contributions in previous years which have been transferred to industry, such as:

- Computational model for petroleum generation routinely used in industry;
- Downhole seismic sources and receivers undergoing commercialization; and
- Technique for nondestructive determination of in-situ stress commercially available.

Recent Accomplishments

- Determined experimentally the pressure-volume-temperature relationships in C-O-H-N mixtures at conditions comparable to those in reservoirs.
- Concluded that rare gas isotopic composition in some reservoirs strongly suggests importance of long-distance fluid transport.
- Demonstrated existence of an alternative, catalytic pathway to the origin of natural gas from carbonaceous sedimentary rocks rich in transition metals.
- Developed technique for determination of pore structure, and surface texture, at the 10 micrometer scale in sedimentary rocks using synchrotron computed X-ray microtomography in collaboration with Mobil.
- Development of a fast algorithm for estimating formation permeability from Stoneley wave logs.
- Demonstrated effect on seismic velocity of the quantity and location of solid phases in the pores of sedimentary rocks, such as gas hydrates, for increased understanding of marine seismic reflection data.
- Sponsored workshop on High-Performance Computing in Seismology under the auspices of the National Academy of Sciences/National Research Council Committee on Seismology.

Program Funding

DOE Historical Spending ($ in Millions)

Projects	FY 1996	FY 1997	FY 1998
Fundamental Geosciences Research	5.5	3.8	3.8
Total	**5.5**	**3.8**	**3.8**