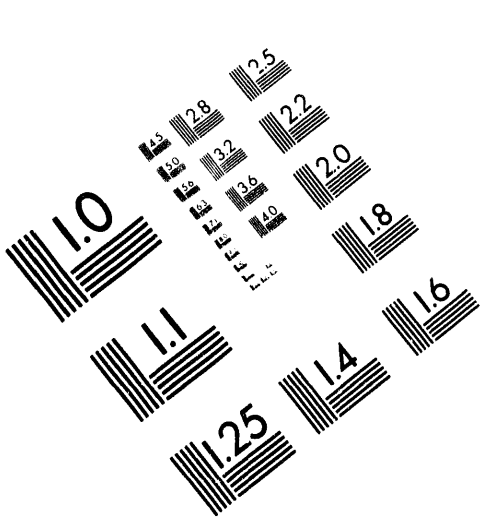

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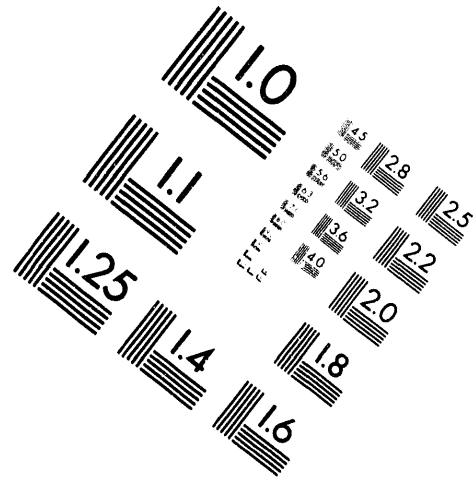

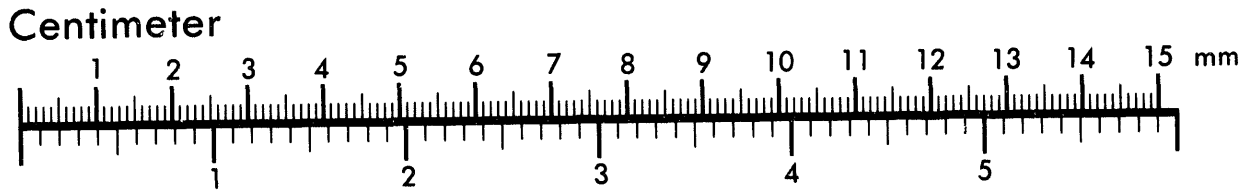

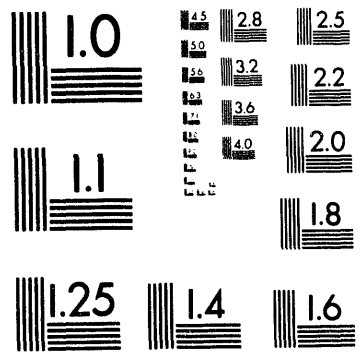

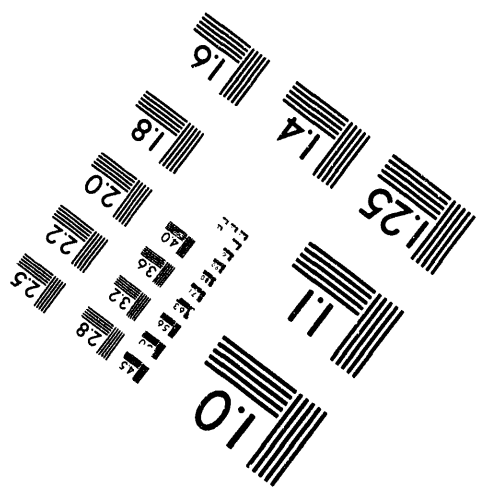

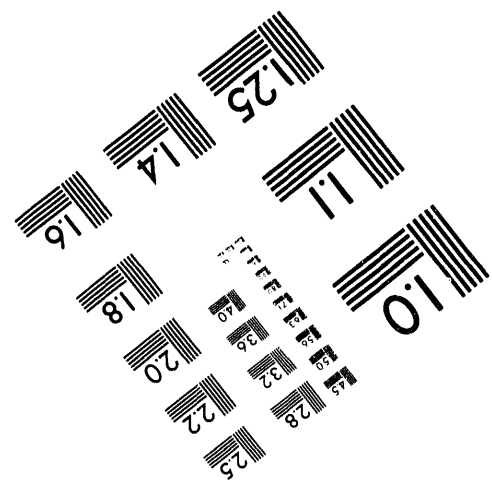

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READINESS THROUGH RESEARCH

GAS UTILIZATION TECHNOLOGIES

by

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GAS UTILIZATION TECHNOLOGIES

Introduction

The Institute of Gas Technology (IGT) was founded in 1941 with a charter to specialize in scientific instruction and research for the gas industry. Today, IGT employs over 200 scientists, educators, and support staff. Research and technology development efforts cover a broad spectrum, and emphasis is placed on applied research and technology transfer in the areas of environmental protection and remediation, supply, and energy utilization. This paper will focus on new developments and market drivers for natural gas utilization technology.

One of the constant challenges facing the research community is the identification of technology needs 5 to 15 years from now. A look back into history indicates that the forces driving natural gas research have changed from decade to decade. In the 1970s research was driven by concerns for adequate supply; in the 1980s research was aimed at creating new markets for natural gas. What then are the driving forces for the 1990s? Recent reports from the natural gas industry have helped define a new direction driven primarily by market demand for natural gas. A study prepared by the Interstate Natural Gas Association of America Foundation entitled "Survey of Natural Research, Development, and Demonstration RD&D Priorities"[1] indicated that in the 1990s the highest research priority should be for natural gas utilization and that technology development efforts should not only address efficiency and cost, but environmental and regulatory issues as well. This study and others, such as the report by the American Gas Association (A.G.A.) entitled "Strategic Vision for Natural Gas Through the Year 2000," clearly identify the market sectors driving today's technology development needs. The biggest driver is the power generation market followed by the industrial, transportation, appliance, and gas cooling markets. This is best illustrated by the GRI 1994 Baseline Projection[2] on market growth in various sectors between the year 1992 and 2010. (See Figure 1.) This paper highlights some of the recent technology developments in each one of these sectors.

Power Generation

The power generation market is driven by the Clean Air Act Amendments of 1990 and the Climate Change Action Plan announced by the Clinton Administration,[3] which aims to decrease the growth in the emissions of greenhouse gases and encourages utilities to use more natural gas. Research efforts are focused on three areas: 1) cofiring and reburn technologies using natural gas, 2) high-efficiency gas turbines, and 3) fuel cells.

Cofiring and reburning natural gas in coal-fired utility boilers and waste-to-energy plants reduces stack emissions, increases fuel flexibility, and solves a number of operational problems. Cofiring simply adds natural gas to the combustion chamber and essentially controls emissions by dilution and provides some improvement in boiler performance. Natural gas reburning is a more controlled addition of natural

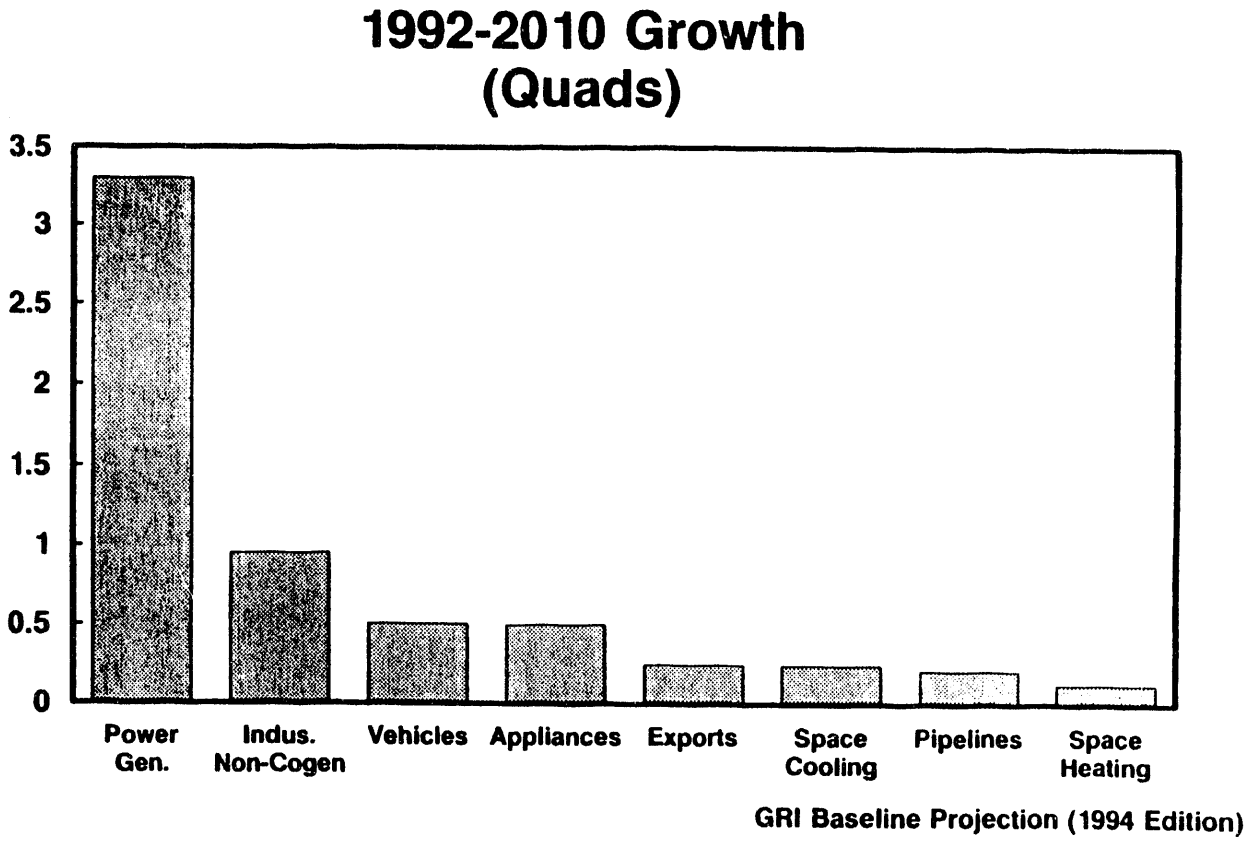

Figure 1. U.S. GAS MARKETS BY APPLICATION

gas and combustion air designed to create fuel-rich and burn-out zones in the combustion chamber. Thus, through the knowledge of combustion chemistry, the formation of nitrous oxides is greatly reduced, and when combined with the dilution of sulfur oxides, total emissions are substantially lowered. This has been demonstrated in a special program funded by the Gas Research Institute (GRI).[4]

IGT also recently completed a successful series of field tests on a municipal waste combustor at the Olmsted County waste-to-energy facility in Rochester, Minnesota. Using a natural gas reburn technique termed METHANE de-NOX^{SM}, nitrogen oxide emissions were reduced by 60%, and carbon monoxide by 50%. Since municipal solid waste contains very little sulfur, sulfur oxide emissions were negligible. These results, which are based on about 15% natural gas addition, are very significant because the plant employed a state-of-the-art combustor with fairly low baseline emissions levels. Technologies, such as reburn for coal-fired combustors and METHANE de-NOX for municipal solids combustors, offer a near-term, quick-fix solution to emissions for existing power plants.

The development of gas turbine and fuel cell systems, on the other hand, provide longer term solutions for highly efficient and cost-effective power generation. The U.S. Department of Energy (DOE), the Electric Power Research Institute (EPRI), GRI, and industry have joined in a major effort to

develop advanced, high-efficiency gas turbines. Gas turbine systems provide an economical solution to fluctuating power generation needs and ever more stringent environmental regulations. They are easier to deploy and can be installed in modular units. Advanced systems will operate at higher temperatures and will use innovative heat recovery systems, such as thermochemical recuperation (TCR), to produce power more efficiently. New combined-cycle plant installations are announcing efficiencies as high as 54% (LHV). IGT is presently on a development team headed by the Westinghouse Power Generation Business Unit to develop ultra-high-efficiency gas turbine systems that will provide system efficiencies exceeding 60% (LHV). Development efforts will consider higher temperature materials and coatings, improved cooling, low-emission combustors, and advanced heat recovery systems including TCR. IGT will assist in system studies and reformer designs for TCR that use exhaust heat to reform natural gas to hydrogen and carbon monoxide. The hydrogen and carbon monoxide are subsequently burned in the turbine combustor. This captures additional heat in chemical form and raises cycle efficiencies over 60%. The development program calls for an 8-year timetable, with production capability at the turn of the century.

In the long run, however, fuel cells have the potential to revolutionize the power production business. Because the electrochemical process does not depend on combustion to extract the fuel's chemical energy, fuel cell power plants can achieve electrical efficiencies in excess of 60% while producing virtually no emissions (sulfur oxides, nitrogen oxides, carbon monoxide, or hydrocarbons). Its modularity and factory construction provide unique customizing capabilities essential to distributed power generation systems.

Three different types of fuel cells are being developed for power generation. One is the phosphoric acid fuel cell being developed in the United States by International Fuel Cells, a subsidiary of United Technologies Corp. The second is the molten carbonate fuel cell being developed by the Energy Research Corp. and M-C Power. The third is the solid oxide fuel cell, the least developed of the three options. The largest of the solid oxide development efforts is being led by Westinghouse Electric Corp. At IGT, we are presently concentrating our efforts on the molten carbonate fuel cell, which appears to be best suited for power production in the range of 1 to 25 megawatts. IGT's subsidiary, M-C Power, was formed in 1987 for the sole purpose of commercializing our molten carbonate fuel cell (MCFC) technology. A fuel cell, such as the MCFC, resembles a battery in many ways. Natural gas is reformed to hydrogen and carbon monoxide, which is fed directly to an anode. Oxygen and carbon dioxide are fed to the cathode and together with available electrons react to form carbonate ions that are conducted through the electrolyte. At the anode-electrolyte interface, carbonate ions and hydrogen react, liberating electrons and forming a carbon dioxide and water discharge stream.

M-C Power is presently testing 20-kW systems at their Burr Ridge, Illinois, production facility and plan to have their first 250-kW demonstration operating at the San Diego Kaiser Permanente

Hospital in 1995. The fuel cell development program, like the turbine program, is obtaining significant funding from DOE, EPRI, GRI, and several utilities. It is expected that phosphoric acid fuel cells will be the first commercially available models; however, molten carbonate fuel cells, as reported recently in an EPRI publication, have unique advantages including higher efficiencies and thus have greater long-term potential.[5] It is expected that the molten carbonate fuel cell will begin competing in the power generation market after the year 2000 and that the solid oxide fuel cell will capture portions of the smaller commercial market.

Industrial/Large Commercial Sector

New gas technologies are being developed for this important market to meet our nation's energy policy. The Clinton Administration's Domestic Energy Initiative[6] is designed to lessen the country's dependence on foreign oil and aims to stimulate natural gas markets. Industrial and large commercial facilities represent an important and diverse market for the gas industry. Three technology areas are presented here: boilers, steel production, and glass melting.

Boilers have been used throughout industry and represent a significant load for the gas industry. IGT is concentrating its effort on the development of very low-emissions burners for retrofit installations on existing boilers and new package systems. Manufacturing partners are Burnham Co., owner of the Kewanee boiler line and Takuma Co., Ltd., for firetube boilers; and Tampella Power Corp., owner of the Keeler boiler line for watertube boilers. IGT is using premixed natural gas and air combustion techniques to lower boiler NO_x emissions below 15 ppmv without utilizing expensive options, such as flue gas recirculation or steam injection.

In the steel production area, GRI is funding a significant effort to demonstrate natural gas injection in blast furnaces, develop scrap preheaters, and deploy combustion technologies to reduce electric power consumption in electric arc melting and ladle refining. GRI has demonstrated the use of natural gas injection for blast furnaces at an Armco Steel Co. plant in Middletown, Ohio. Using 150 pounds of natural gas per ton of hot metal, coke consumption was reduced by 20%, and metal production rates were increased 8%.

Another area receiving considerable attention is the glass melting area. In the long term, natural gas/oxygen firing promises to greatly reduce NO_x emissions and increase the productivity of the glass industry. Deployment of this technology, however, requires a continued decrease in the price of oxygen. For the near term, IGT has developed a staged combustion technique that uses only small quantities of industrial oxygen to significantly lower NO_x emissions. In recent tests on a 165-ton/d container glass furnace at the Anchor Glass plant in Huntington Park, California, we reduced NO_x emissions by 50% to about 2.5 pounds of NO_x per ton of glass produced. This is well below the new regulations passed in Southern California and has sparked the interest of Anchor Glass for applying this technology in the

Houston area where emission trading allowances promise to provide a substantial return on their investment. Combustion Tec, Inc., and Air Products and Chemicals, Inc., our commercial partners, are also investigating the potential for applying this technology on other industrial high-temperature processes.

Natural Gas Vehicles

Driven by the Clean Air Act Amendments and U.S. energy policy, natural gas vehicles are ready for deployment today. The Federal government plans to invest $136 million by the end of 1997 to convert Federal fleet vehicles to clean-fuel vehicles. We believe that a significant fraction of these conversions will be to natural gas. Natural gas vehicles provide the lowest emissions when compared to reformulated gasoline or methanol and are much lower in cost when compared to the electric vehicle. GRI is working with the big three automakers to provide us with dedicative and cost-effective vehicle options that will operate on compressed natural gas. Efforts are also underway to deploy liquefied natural gas (LNG) for transportation. Three utilities, Consolidated Natural Gas, Columbia Gas, and Southern California Gas Co. are working with Roadway Express in Akron, Ohio, to evaluate the LNG option for use in truck transport. Several utilities and IGT are also investigating the use of carbon in on-board storage cylinders to adsorb natural gas and thus lower the required storage pressure to less than 500 psig. This would allow the development of low-cost refueling compressors and would enhance the deployment of the natural gas vehicle in the private passenger vehicle market. IGT is also working with GRI and several utilities to reduce the cost of fleet vehicle fueling stations and improve the reliability of components.

Appliances

The Gas Research Institute and the American Gas Association Laboratories are working together to provide modern high-efficiency appliances for both commercial and residential use. An important market sector for the gas industry is the commercial food service sector which is growing at 1.5% to 2% per year. The industry is striving to provide innovative equipment that features acceptable first costs and lower life-cycle costs, reduces fuel and labor costs, offers simplified operation, complies with or exceeds all relevant emission regulations, and accomplishes these goals while assuring acceptable food quality and productivity and portraying a modern, high-tech image.

One such development is the Clamshell® broiler/griddle, which caters to the needs of fine dining establishments. Since its market introduction in 19[illegible], Lang Manufacturing has installed hundreds of these units in restaurants and institutional settings.

Gas Cooling

Deployment of gas cooling provides an effective demand side management option for electric utilities and represents a large new market potential for the gas industry. The phase-out of chlorofluorocarbons (CFCs) also has sparked renewed interest in gas absorption cooling systems. In addition, the Federal government plans to spend $800 million by the end of 1997 to improve the energy efficiency in Federal facilities. Natural gas cooling technologies can meet these market needs and a number of systems are now entering crucial market evaluation periods. One of these is the deployment of the residential engine-driven gas heat pump. Key players in the development are York International Corp., Briggs & Stratton Corp., and Honeywell Inc. York has built 50 of these 3-ton units, which are being sold through its dealer network. Financial support is provided by more than 100 gas companies and pipelines. A 2000-unit market introduction is now planned for the York Triathlon Unit, with full support from the utility sector.

For the larger commercial market, York International Corp. has brought direct absorption technology back to the United States. York is offering a Para Flow™ product line of CFC-free, natural gas-fired chillers in capacities from 200 to 1500 tons. Commercial building operators in areas with high electric demand charges can reduce operating costs substantially by minimizing peak electricity use. In addition, an optional natural gas burner is available that reduces NO_x emissions to a level that can meet virtually any national, state, or local burner code.

Conclusions

In summary, the 1990s provide both a challenge and an opportunity for natural gas and the research organizations serving the gas industry. New regulations and competition from inside and outside the industry have focused RD&D efforts more than ever on industry needs and the markets that are served by natural gas. The Institute of Gas Technology, which serves as the only dedicated performing research entity for the gas industry, is presently focusing its RD&D efforts with the help of the Gas Research Institute and its utility membership on the efficient utilization of natural gas. New gas technologies for power generation, industrial and large commercial installations, transportation, appliances, and space conditioning are meeting the challenge of new environmental regulations and the need for productivity gains in a highly competitive marketplace.

References Cited

1. Flynn, C. S., "Survey of Natural Gas Research, Development, and Demonstration (RD&D) Priorities." Paper presented to the INGAA Foundation, April 9, 1993.

2. GRI Baseline Projection, 1994 Edition.

3. "Clinton's Climate Program Backs More Use of Natural Gas," Natural Gas Week 9, No. 43 (1993) October 25.

4. Gas Research Digest, Winter 1993/1994.

5. Fuel Cell Demonstration Planned, EPRI Journal, 35 (1993) September.

6. "Natural Gas Would Win in Plan for Less Oil Imports," Natural Gas Week 9, No. 43 (1993) October 25.

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