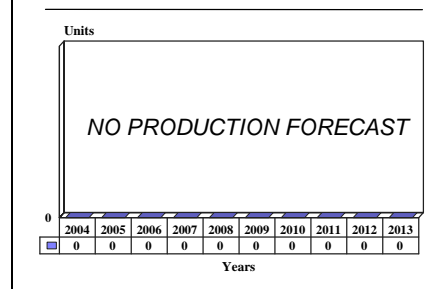


# GTI Power Generation/Gas Projects - Archived 3/2005

## Outlook

- Recent emphasis on fuel cells, distributed generation, industrial combustion, gas supply issues
- A single 2004 core program area consists of six projects
- Ongoing cooperation maintained with other organizations such as EPRI and AGA
- Despite 2005 withdrawal of FERC funds, GTI will remain a major technology and information provider

10 Year Unit Production Forecast  
2004 - 2013



## Orientation

**Description.** A widely encompassing series of projects and concepts aimed at the development and refinement of technology applicable to the natural gas industry, to gas-fired industrial gas turbine machines, and to reciprocating engines (diesel and/or gas-fired) and their utilization.

**Note:** *This report does not cover engines/machines that are in series production.*

**Sponsor.** While this overall effort is under the auspices of the Gas Technology Institute (GTI), Des Plaines, Illinois, USA, it continues to receive U.S. Federal Energy Regulation Commission (FERC) funding.

**Note:** *In April 2000, the Gas Research Institute (GRI) and the Institute of Gas Technology (IGT) combined to form the Gas Technology Institute (GTI).*

Additional funding and sponsorship have been provided by U.S. utilities, gas suppliers, and private corporations.

**Contractors.** Numerous engine manufacturers have been involved in work sponsored by GRI/GTI, including Tecogen, Caterpillar, Allison, Rolls-Royce (Allison), General Electric Company (USA), Cummins, Hercules, Navistar, and Detroit Diesel.

**Status.** The overall work of GTI is ongoing. The overall effort may be seriously affected by the end of funding provided by the U.S. FERC in 2004.

**Total Produced.** Owing to the R&D nature of the GTI effort, no production-viable machines or engines will emerge.

**Application.** Applications include industrial, commercial, and residential power sources. The technologies are applicable to gas turbines as well as to reciprocating/gas engines (diesel and/or gas fired) and to fuel cells.

**Price Range.** Owing to the nature of the overall efforts, a pricing structure or price range is inapplicable.

**Competition.** Numerous firms and institutions have been involved in GTI's projects from time to time, and in different projects.

GTI's efforts complement those of other organizations, including the Electric Power Research Institute (EPRI) and the American Gas Association (AGA). Because of the broad scope of projects conducted by GTI, no entity can be singled out as prime contractor or manufacturer.

## Technical Data

Owing to the nature of the GTI efforts, technical information and data that emerge from the various projects can be utilized by heat engine manufacturers for their products.

## Variants/Upgrades

Because of the evolving nature of the GTI efforts, no specific variants of any machinery are included in the 2004 to 2008 R&D plan. Work on any machine

variants is done internally by the various OEMs that have been part of GTI's programs and projects.

## Program Review

**Background.** The Gas Technology Institute (GTI), formed by the merger of the Gas Research Institute (GRI) and the Institute of Gas Technology (IGT), manages a cooperative R&D program for the mutual benefit of the gas industry and its customers. GTI works with research organizations, manufacturers, and its member companies to develop gas technologies and to transfer new products and information to the marketplace.

In April 1998, the U.S. Federal Energy Regulatory Commission (FERC) approved a settlement for (then) GRI that provided for a transition to a fully voluntary funding system for research, development, and demonstration (RD&D) programs after December 2004.

The settlement provided for continued funding of core and non-core RD&D projects for a three-year transition period, 1998 to 2000. Non-core RD&D was not provided for in the settlement beyond 2000. As such, only core projects are included in the GTI budget request to the FERC for the years 2003 to 2007. The zero budgets of the R&D program for 2005 to 2007 underscore GTI's acknowledgment that FERC R&D funding ends in 2004.

The 2003 core program, as filed, contained 19 projects in six program areas. For 2004, GTI proposed that the six program areas be consolidated into one program area, and that the 19 projects be consolidated into six projects. The consolidation was seen as facilitating a logical, orderly, and consumer-beneficial closeout of core program R&D funding by December 3, 2004, and a final accounting by July 1, 2005.

The six 2004 projects are aligned to directly address the major categories of consumer need that were specified in the 1998 Settlement Agreement's definition of core projects. The project names and objectives in the 2004 program match the names and objectives of the six program areas of the 2003 program.

In scope, the new 2004 program area and projects align with the six approved program areas and 19 projects covered in 2003. No new categories of consumer need were to be added subsequent to the filing of the 2004 program.

While the 2004 program structure consolidates and reduces the number of projects, the particulars of R&D

have been maintained. The year 2004 is the seventh year of the Settlement period that began in 1998.

Beginning with 2001, the Settlement provided funding for core programs only. The Settlement capped the core program funding at US\$60 million in 2004. Beginning in 2005, GTI funding will become fully voluntary.

A total of US\$41.6 million of the US\$60 million FERC-approved 2004 core program budget is for contract RD&D obligations. The remainder is devoted to operating expenses, including a charge for extraordinary expenses incurred from 1998 to 2001.

**2004 Programs.** The proposed 2004 FERC-approved RD&D contract obligations budget is US\$41.60 million for the single 2004 core program area.

No contract RD&D funding is requested for 2005-2008. The proposed program area budget is exclusive of operating expenses.

As discussed above, the single proposed 2004 core program area consists of six projects, whose bases are briefly summarized below. Each of those projects addresses one of the core program criteria, also previously referred to as categories of core program consumer need.

The planned scope of the 2004 program has been maintained without material changes since the filing of the 2003-2007 RD&D plan, and there have been no changes in the planned distribution of effort among the six core program criteria. The proposed 2004 project budgets are the same as the planned 2004 program area budgets previously submitted in the 2003-2007 RD&D plan.

In its budget development process, GTI strategically allocates proposed funding among the major parts of its program in order to respond to gas consumer and member company needs and to maximize programmatic benefit-to-cost ratios.

Five of the six projects receive 2004 budget shares in the range of 17-21 percent. At 21 percent, the Reliability and Integrity and the Increased End Use Efficiency projects receive the largest segments of the 2004 budget. Those two projects are targeted to help maintain and extend the lifetime of the gas transmission and distribution network and also provide substantial

opportunities for improved energy services to gas consumers.

The smallest share of the 2004 budget, 7 percent, is allocated to the Enhanced Health and Safety project. The 2004 share of the budget allocated to that core program criterion is the same or greater than in the approved 2002 and 2003 programs.

#### **Increased Gas Supply from Emerging Resources**

Yet to be exploited are emerging resources in carbonate formations, deeper and tighter geological formations, pressure compartments, thin formations and additional recovery from depleted reservoirs. RD&D to delineate these resources' reservoir geology and develop concepts for cost-effective gas recovery would provide substantial consumer benefits. Low-cost gas cleanup processes would enable the use of emerging resources whose low-quality natural gas is currently uneconomical to produce. New technologies for reaching gas-bearing formations and performing preproduction functions, such as well stimulation, could help gas producers drill and complete wells at a much lower cost than conventional drilling.

#### **Improved Gas System Reliability and Integrity**

Technologies are needed to ensure piping system integrity by mitigating or preventing corrosion and identifying and evaluating damaged pipe. Gas measurement research is needed to enable ultrasonic flow metering standards and to improve the orifice meter accuracy. Gas storage operators must improve storage well delivery capacity, which is critical to meeting peak gas demands. New options for large-volume gas storage, such as caverns in salt deposits, are needed. New retrofit technologies for pipeline compressor engines would enable cost-effective upgrades to improve compressor station reliability, deliverability, efficiency, and pollutant emissions.

Additional RD&D is needed to develop standards that support the current regulatory trend toward risk-based management of pipeline integrity, which is believed to offer improved reliability at lower cost.

#### **Lowered Operating and Maintenance Costs**

RD&D has developed no-dig technologies, keyhole excavation technologies, and other innovative construction methods and has significantly improved plastic pipe materials and installation practices. However, these technologies are far from being developed to the point of diminishing returns. Significant additional cost savings are still possible from improvement in the technologies, expansion of the conditions under which they can be used, and improvement in the way they are applied. Costs could be reduced, and customer service improved through integrated data collection and com-

munication protocols and robotic devices to automate distribution system operations. Technologies that detect or prevent third-party damage to buried piping could reduce repair costs and help ensure against unforeseen service interruptions.

#### **Increased Efficiency of Use**

Most industrial gas is used in energy-intensive industries, where efficiency gains would have the greatest overall impact. The energy efficiency of most energy-intensive processes is not high, and there is much room for improvement. To be accepted by industry, the improvement in energy efficiency must be accompanied by improvements in process productivity and product quality. The efficiency of residential and commercial applications is usually high, and large improvements are unlikely; but even small improvements will have a large effect because of the large number of appliances in service.

Distributed generation of electric power, based on engine, turbine, or fuel cell prime movers, offers a large potential for increasing gas use efficiency because it enables the useful recovery of byproduct heat from the prime movers. Central power plants usually waste this heat. To achieve those energy savings, distributed generation systems must penetrate markets, and this penetration requires advances in cost, reliability, and system design.

#### **Enhanced Environmental Quality**

Current environmental issues that are important to the gas industry and gas consumers and can be addressed by RD&D include:

- Fine particulate matter and partially oxidized organic compounds emitted by some combustion processes;
- Remediation of contaminated land use sites, such as former manufactured gas plants and E&P sites;
- Low-emission natural gas appliances; and
- The use of natural gas to reduce emissions from coal combustion.

#### **Enhanced Health and Safety**

Ongoing health and safety needs include adequate venting of appliances to maintain indoor air quality. The benefits of RD&D to deal with this issue are so broadly distributed among gas consumers (and gas companies) that the RD&D can only be implemented practically through a central shared program. Technologies to detect and warn of buried utilities during gas system construction and repair operations will help avoid accidents that raise gas distribution costs and interrupt the continuity of gas service.

GTI Basic Research. GTI maintains a continuing commitment to basic research as part of this proposed RD&D program. Basic research accounts for US\$4.8 million, 11.5 percent of the proposed 2004 core RD&D program.

Basic research topics addressed in the 2004 program include the feasibility of laser and microwave energy use for gas well drilling and completion, the use of fiber optics for transmitting data from down-hole in gas wells to the surface, basic exploratory in-line inspection research; microbially induced corrosion; and fuel cell materials and cell stack design.

#### **Increased Efficiency of Use – Project 2404**

The objective of this project is to improve current levels of energy use efficiency to decrease natural gas costs and conserve gas. Its focal points are fuel cells, distributed generation, industrial combustion, and gas appliances. The material that follows concentrates solely on distributed generation.

The distributed generation RD&D will:

- Specify the application characteristics and technical requirements for strategically using gas-fired distributed power generation equipment;
- Develop new high-performance technologies and systems for distributed power generation; and
- Disseminate accurate information on distributed generation applicability, reliability, performance, and cost to local distribution companies, distributed generation companies, and potential users.

Previous GRI RD&D (most of it in the Non-Core Program Area):

- Commercialized a low-NOx combustor and an ultra-low-NOx combustor for gas turbines;
- Commercialized an advanced gas engine control that enabled a gas engine to achieve 50 percent more power and 13 percent higher efficiency in a 1-MW system;
- Commercialized a 70-kW microturbine generation system;
- Developed user-friendly software to evaluate the applicability and economics of distributed energy systems;
- Defined the technology needs and market issues for natural gas in commercial applications of distributed energy systems; and
- Ensured gas industry viewpoint representation in the DOE Distributed Energy Resources Group RD&D roadmap.

In 2004, GTI will:

- Complete performance tests of two additional prototype integrated systems for building cooling, heating, and power;
- Report on the technology needs and market issues for natural gas in residential applications of distributed energy systems;
- Enhance previously developed software to evaluate the applicability and economics of distributed energy systems; and
- Update the above-mentioned DOE Distributed Energy Resources Group RD&D roadmap.

RD&D Issues and Pathways. Distributed generation and cogeneration based on natural gas can provide many advantages for gas consumers. However, for distributed generation to become widely used, potential users must have the facts regarding potential benefits, tools to determine where and how distributed generation should be applied, technologies and controls that provide appropriate interfaces with the electric power grid, and continuing improvements in performance and economics. Therefore, this RD&D focuses on opportunities for energy-efficient, next-generation power generation in homes and businesses through better integration of distributed generation equipment.

Activities. Activities will include:

- Development of technologies for advanced lower-cost distributed energy systems that maximize the use of waste heat to achieve high overall efficiencies;
- Economic assessment to quantify and validate the benefits of distributed generation in actual applications;
- RD&D to identify best practices for installation (reliable interconnection and integration with the gas and electric distribution systems) and operations (communications and controls strategies that allow optimal flexibility of the dispatch duty of distributed generation units);
- Modeling and technical support to develop packaged information and evaluation tools (reports, guidebooks, and software) to characterize situations where gas-fired distributed generation technology offers the best option for enhanced electric power reliability and improved energy service;
- Development, testing, and transfer of key system integration technologies;

- Technical analysis of new gas technologies that use innovative cycles, enhanced heat transfer, and advanced controls and sensors to provide combined cooling, heating, and electric power generation services; and
  - Development of energy-efficient low-emissions technologies.
  - Cofunding sources include California Energy Commission, U.S. Department of Energy, GTI's Sustaining Membership Program, local distribution companies, Illinois Department of Commerce and Economic Opportunity, City of Chicago.
  - Performance tests of several prototype integrated systems for building cooling, heating, and power (a 600-kW system and a 30-kW system are being developed and will be evaluated in 2003; two other systems will be evaluated in 2004);
  - User-friendly software to evaluate the applicability and economics of distributed energy systems;
  - Definition of the technology needs and the residential, and industrial market issues for natural gas in distributed energy (a report on industrial markets, 2003; a report on residential markets, 2004); and
  - Gas industry viewpoint represented in the DOE Distributed Energy Resources Group RD&D roadmap.
- Planned Results. Planned results include:
- Test procedures and protocols for validating the performance of distributed energy systems (2003);

## Funding

Totals in the funding chart that follows are dollar amounts only, since no units are being procured or funded. All amounts are in millions of 2004 U.S. dollars.

It should be noted here that, in the 2004-2008 RD&D Plan, the 2004 funding is US\$60 million. The proposed 2005-2008 funding is zero, consistent with the April 1998 FERC-approved Settlement Agreement.

Of the US\$41.60 million in 2004, the total for basic research is US\$4.8 million, while the total for applied research is US\$36.80 million.

RD&D funding for the year 2004 was not identified.

**GTI: 2004 Funding Program**  
(in millions of 2004 U.S. dollars)

| <b>GTI Projects</b>                           | <b>FERC<br/>2003</b> | <b>Cofund<br/>2003</b> | <b>RD&amp;D<br/>2003</b> | <b>FERC<br/>2004</b> | <b>Cofund<br/>2004</b> | <b>RD&amp;D<br/>2004</b> |
|---|----------------------|------------------------|--------------------------|----------------------|------------------------|--------------------------|
| Increased Gas Supply from Emerging Resources  | 7.81                 | 3.80                   | 0.80                     | 7.81                 | 1.20                   | –                        |
| Improved Gas System Reliability and Integrity | 8.60                 | 4.10                   | 1.10                     | 8.60                 | 1.30                   | –                        |
| Lowered Operating and Maintenance Costs       | 7.65                 | 3.70                   | –                        | 6.15                 | 0.90                   | –                        |
| Increased Efficiency of Use                   | 9.27                 | 4.50                   | 1.23                     | 8.77                 | 1.30                   | –                        |
| Enhanced Environmental Quality                | 7.27                 | 3.50                   | –                        | 7.27                 | 1.10                   | –                        |
| Enhanced Health and Safety                    | 3.00                 | 1.40                   | 0.20                     | 3.00                 | 0.50                   | –                        |
| <b>Total</b>                                  | <b>43.60</b>         | <b>21.00</b>           | <b>3.33</b>              | <b>41.60</b>         | <b>6.30</b>            | <b>–</b>                 |

## Recent Contracts

No major identifiable contracts have been issued by GTI during the recent past.

## Timetable

Each GTI project has its own timetable. As such, no traditional timetable is provided below. It should be noted here that in May 2003, the GTI Board of Directors approved the 2004 core budget of US\$60 million.

## Worldwide Distribution

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Owing to the nature of GTI efforts, the organization itself does not fabricate heat engines or machines. Technology generated from its work is available for adoption by engine manufacturers for their machines or processes, including high-performance component technologies such as turbine blades based on advanced materials.

## Forecast Rationale

The Gas Technology Institute (formerly the Gas Research Institute) works closely with the major engine manufacturers, manufacturers of other heat engines, component suppliers, and the overall gas/natural gas industry. It follows the pulse of the natural gas industry, and responds to industry shifts and changes in focus. Along with the American Gas Association (AGA), it contributes technology to benefit the gas consumer and the gas industry, and to increase efficiency among energy producers.

It should be remembered that the GTI's mission is to deliver high-value technology, information, and technical services to gas and related energy markets through cooperative research, development, and commercialization. It has been successful because it has been responsive to customer needs – building on established research programs, providing innovative

technical solutions, and obtaining competitive returns for investors.

Many hardware programs have been completed during the recent past – in particular, programs to develop gas turbine machines and combustors. Heavy emphasis is placed on increased gas supply from emerging resources, improved gas system reliability and integrity, increased efficiency of use, lowered operating and maintenance costs, and enhanced health and safety in the natural gas industry. Its overall work is still considered vitally important since natural gas is rapidly gaining ground as *the* fuel of choice for new electrical generation worldwide.

It should be noted that GTI has recently stressed fuel cells and distributed generation technology, products and concepts that are dramatically changing the worldwide landscape of electrical generation.

## Ten-Year Outlook

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The overall work undertaken by GTI will extend beyond 2005 despite the end of FERC funding. New efforts to benefit the gas consumer and the gas industry will be added or withdrawn as the Institute sees fit.

At this time, it is too early to envision what the GTI R&D Program in 2005 and beyond will look like. We expect to see continued emphasis on fuel cells and distributed generation.

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