



Carbon Management

Carbon management is a key environmental concern, with private industry and government agencies seeking common sense, cost-effective solutions that can reduce annual emissions of carbon dioxide and other potential greenhouse gas emissions to the atmosphere.

There is also growing focus on carbon management in the energy sector, as it affects all facets of the industry from supply to delivery to utilization. Environmental factors, including carbon emissions, are becoming part of the risk profile in financial evaluations of corporations. Private industry and government agencies are evaluating means to reduce carbon impacts, including development and application of cost-effective technology-based solutions. Research can identify and develop timely options to enhance the environmental performance of energy sector industries.

CARBON MANAGEMENT APPROACHES

There are three primary means to reduce carbon emission to the environment.

Increase Energy Efficiency

- > The development of energy-efficient technologies is one of the most important, cost-effective, and fastest ways that we can lower energy consumption, reduce energy costs, and control greenhouse gas emissions. GTI programs in end use are typically targeted at efficiency and emission drivers and include programs in power generation (including combined heat and power), transportation, industrial, residential, and commercial markets.

Use Less Carbon-Intensive Fuels

- > Natural gas can be a big part of the solution to climate change concerns, while serving as a bridge to a clean energy future. Natural gas is the cleanest-burning fossil fuel, producing lower levels of greenhouse gas emissions than coal and oil. The direct use of natural gas in high-efficiency equipment can significantly reduce carbon emissions, and technologies developed at GTI are exploiting this advantage.
- > Increased application of renewable fuels—including biomass-derived methane and liquid fuels—and hybrid solar thermal/natural gas systems offers platforms for reduced fossil fuel use and consequent environmental benefits.

Carbon Capture and Sequestration

- > A direct solution for controlling greenhouse gas emissions is to capture and store carbon in underground formations such as saline aquifers, depleted petroleum reservoirs, unmineable coal seams, or other locations.

GTI SOLUTIONS

GTI is at the forefront of carbon management initiatives. We have experience in all facets of carbon management across a broad array of technology areas—from assessment, through research, to implementation. GTI is leading programs that address carbon management issues through each of the three primary approaches.

CO₂ Reduction

> *Efficiency Driven Products*

A principle driver of GTI end use programs has been energy efficiency to improve the life-cycle economics of natural gas products. Efficiency gains also provide a direct reduction in greenhouse gas emissions per unit of energy produced. GTI has broad expertise on alternative combustion systems and approaches that lower the carbon intensity for products targeted to residential, commercial, industrial, transportation, and power generation markets. For residential furnaces, GTI was instrumental in the initial development of high-efficiency heating products that now represent over 40% of the market. Similar broad efficiency gains in industrial markets are anticipated through developments such as the Super Boiler, with fuel-to-steam efficiency exceeding 94%.

GTI is also actively developing solutions for high-efficiency combined heat and power systems for industrial and commercial buildings—and potentially for home use too.

GTI's energy efficiency efforts dovetail with an expanding effort by North American natural gas and electric utilities who are leading the way with over \$3 billion per year in incentives, rebates, and related program initiatives aimed at helping consumers save energy (while also reducing carbon emissions).

> *Renewable Energy Technologies*

Blending renewable fuels with fossil fuels or substituting altogether is a proven path for significantly reducing carbon emissions. GTI is active in a range of biomass conversion processes that can produce a variety of value-added outputs such as methane, liquid fuels, syngas, power, steam, or heat. These include biomass gasification (including blending with coal), biogas production and clean-up to renewable methane from digesters and landfills, and solar thermal/natural gas hybrid systems for use in residential, commercial, and industrial buildings.

> *Methane Leaks*

Methane (CH₄) as a greenhouse gas is approximately 20 times more effective at trapping heat in the atmosphere. While natural phenomena and agricultural operations are the primary source of methane release, the gas industry is active in identifying and reducing methane emissions from its operations. Related GTI programs include advanced leak detection products, distribution system repair, and improving methane emissions estimates from distribution systems.



GTI's Carbon Management Information Center (CMIC) is an industry resource for carbon management information, products and tools for investors and their customers.
www.gastechnology.org/CMIC



CO₂ Capture

GTI programs encompass a broad range of technologies for carbon capture and control, including development and application of physical



solvents, membranes, and clean combustion systems. One recently proven and commercialized approach is Morphysorb[®], a physical solvent process that removes acid gases including CO₂ from raw natural gas or from syngas.

GTI also has developed and applied gas/liquid membrane concepts for CO₂ separation from exhaust streams and for natural gas treatment. Working with an industrial partner, GTI has developed a gas/liquid membrane contactor process for removal of CO₂ as a replacement for conventional towers and columns for gas absorption and CO₂ separation.

CO₂ Sequestration

To address the technical, economic and environmental challenges associated with long-term CO₂ storage, GTI has conducted research on the sequestration of CO₂ from industrial and power generation applications. Specific areas of research include sequestration site selection, migration detection, and various technologies for measurement, monitoring and verification.

In one project, GTI applied its experience in seismic imaging for assessing and monitoring CO₂ sequestration in coal seams, which offers a practical and economic sequestration alternative because adsorption of CO₂ to the coal surface releases methane molecules, which can then be commercially produced. Based on application of advanced seismic technology, GTI has developed a site selection and monitoring technique for sequestration of CO₂ in unmineable coal seams in the Illinois Basin.

Environmental Monitoring

Characterization and tracking of atmospheric emissions can monitor changes in concentrations of greenhouse gases (such as CO₂ and CH₄) as well as provide insight regarding the sources of the emissions. GTI has expertise in state-of-the-art measurement and tracking approaches and environmental forensic investigation and analysis.

CAPABILITIES AND EXPERIENCE

GTI works with government and industry both individually or in collaboration with others to reduce the time and cost of getting new technology to market.

Partnering closely with natural gas and electric utilities, major industrial firms, equipment manufacturers, private investors, entrepreneurial start-up companies and government agencies, we're ramping up our efforts to develop energy technologies that contribute to a greener way of using energy. We act as product enablers, helping technologies reach the marketplace at every stage from lab testing through commercial demonstration.



EQUIPMENT AND FACILITIES

GTI has a broad array of modern laboratory facilities that apply to various facets of carbon management as outlined above. These include:

Catoosa Test Facility

GTI Catoosa is a facility near Tulsa, Oklahoma for the evaluation of advanced drilling, formation evaluation, and completion of wells.

Flex-Fuel Test Facility

The Henry R. Linden Flex-Fuel Test Facility evaluates innovative gasification processes and facilitates the commercialization of advanced gasification and downstream end-use technologies.



Advanced Gasification Test Facility

The Advanced Gasification Test Facility houses pilot-scale gasification and gas processing systems for integrated process development.

Gasification Laboratory

Within this laboratory, GTI evaluates a variety of feedstocks for gasification performance, including fossil and renewable fuels.

Hot Gas Cleanup Laboratory

This is GTI's primary laboratory for evaluating sorbents for potential use in cleaning up the hot gas produced by a gasifier.

Gas Processing Laboratory

This lab develops and assesses gas processing technologies (e.g., membranes and solvents) which can be applied to separate and capture carbon dioxide from exhaust streams.

Combustion Laboratory

Within this facility, researchers develop and evaluate advanced steam and power technologies, and combustion systems for use in commercial and industrial products and systems.



Residential/Commercial Appliance Laboratory

This facility is designed to foster the development and advancement of gas appliances in terms of efficiency, safety and performance.

Advanced Energy Systems Center

The center provides technology solutions to the hydrogen energy and alternatively-fueled transportation system sectors, with an emphasis in fuel cells, infrastructure, and safety.

Environmental Science & Technology Laboratories

GTI's Environmental Science & Forensic Chemistry Center provides innovative and affordable solutions for environmental problems affecting the energy industry.

Leverage GTI's facilities and expertise to reach your solution faster.

For More Information

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GTI—BRINGING SOLUTIONS TO MARKET

GTI takes on tough energy challenges, turning raw technology into practical solutions that create exceptional value for our customers in the global marketplace. GTI strives to enhance the effectiveness and implementation of these solutions through the integration of several principles and characteristics:

- > **Market-focused.** GTI programs are based on the direct needs of customers and constituents in the market—identifying and addressing both business and technical needs.
- > **Commercialization partner involvement.** Early partnering and deployment strategy development identifies and mitigates potential implementation issues.
- > **Beyond research to practical application.** GTI solutions build from proven science and fundamental research to deliver well-grounded and workable approaches.
- > **Integrated technology solutions.** GTI provides perspective and capabilities that encompass the full range of the fuel cycle from supply, through delivery, to utilization.