Gas Technology Institute
Daniel S. LeFevers
Executive Director, Washington Operations
655 15th Street N.W., Suite 420
Washington, DC 20005-5708
Daniel.lefevers@gastechnology.org
202-661-8645

Gas Technology Institute (GTI) is an independent not-for-profit organization serving research, development, and training needs of the natural gas industry, gas consumers, and energy markets. Most of the 250-person GTI staff is based at GTI's headquarters located on an 18-acre campus in Des Plaines, Illinois. Over 70% of our personnel are technically trained engineers and scientists. GTI has over 280,000 square feet of office, laboratory, shop, library, and training space with over 110,000 square feet devoted to laboratory, fabrication and testing facilities.

GTI provides programs and services (contract R&D, collaborative R&D, technical services, and education programs) to the natural gas industry, Federal and State governments and consortia that seek the development and implementation of technology. GTI programs help organizations outsource and leverage technology investments. GTI also operates offices and facilities in Washington, D.C., Catoosa, Oklahoma, Houston, Texas, and Birmingham, Alabama.

GTI currently manages approximately $60 million in research and development contracts per year (over 100 projects), and has been managing contracts of this type since the 1940's. GTI performs contract Research and Development for the United States Department of Energy and is very familiar with many of its programs.

GTI has almost 1200 patents and has entered into 750 licensing agreements by applying its research, development, and demonstration processes. The estimated commercial value generated by GTI developed technologies is more than $1 billion over the past 20 years. GTI has a long history of successful commercialization of new technologies. GTI has also taken technologies to market through newly formed ventures for that express purpose.

Testimony

GTI welcomes the opportunity to comment on USDOE's Quadrennial Technology Review of its energy technology policies and programs.

Because of the large number of issues and questions that the USDOE has presented in its request for comment, GTI has chosen to focus specifically on the first 3 goals that the administration has outlined, which are:

- Reduce energy-related greenhouse gas emissions by 17% by 2020 and 83% by 2050 from a 2005 baseline
- Supply 80% of America's electricity from clean energy sources by 2035 and
- Support deployment of 1 million electric vehicles (EVs) on the road by 2015

After commenting on these specific goals GTI will comment on sections A, B, D, E, & F.

While GTI does not take a position on global climate change, as we are a scientific based organization and have no climatologists on staff, we recognize that many climate scientists point to man-made carbon emissions as a contributor to global climate change and/or global warming.

So we will not comment specifically on this goal, simply to say that there are many potential technology plays that can contribute significantly to reducing US carbon emissions. One that is seldom highlighted by the USDOE, or the current administration, is the role natural gas can play in reducing carbon emissions.

It is likely that – in fact – expanding the use of natural gas in the power and residential sectors is one the fastest and least costly means to dramatic carbon emission reduction in a very short time frame. GTI developed an analysis which shows that expanding the role of natural gas along with renewable and energy efficiency can reduce US carbon emissions substantially. Please find Whitepaper starting on the following page.

The following Whitepaper and immediate comments following, address the **Administration's first goal to:**

- **Reduce energy-related greenhouse gas emissions by 17% by 2020 and 83% by 2050 from a 2005 baseline**

Response starting with Whitepaper on following page

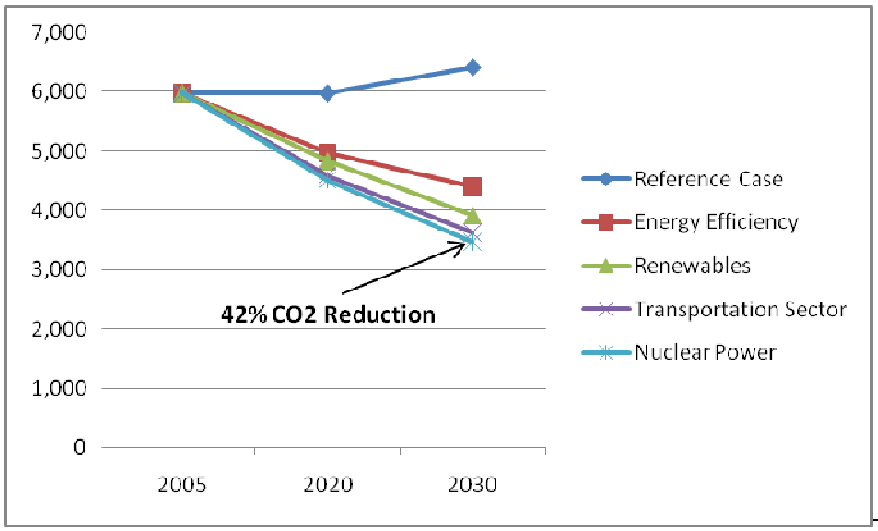
HOW ENERGY EFFICIENCY, NATURAL GAS AND RENEWABLES CAN SUBSTANTIALY REDUCE U.S. CARBON DIOXIDE EMISSIONS

Expanded use of Energy Efficiency, Natural Gas and Renewables can reduce U.S. carbon emissions (2005 levels) by 42% by 2030.

SUMMARY

Currently, U.S. policymakers, elected officials, scientists, organizations and businesses are grappling with the issue of how to reduce carbon emissions while analyzing the costs and market realities that will be part and parcel of any pathway to reach specific carbon emission reduction goals.

What seems to be missing in many of the scenarios/visions that are being discussed by policy makers and others is the role that natural gas can play in dramatically reducing CO_2 emissions. Natural gas is the clean efficient fossil fuel and the synergies between renewables, energy efficiency and natural gas are highlighted in this document.



Some climate scientists suggest a need to move quickly to ensure that reductions will have the desired effect on global warming and climate change, yet many of the scenarios put forth to reduce carbon emissions require billions of research dollars to be invested annually and the development of yet uncertain or untested technologies or processes. This is not necessarily a recipe for short and mid-term results.

> The scenario outlined is this document is one version of a potential future and is not suggested to be the only viable means to reaching a 42% reduction in CO_2 emissions by 2030. It is however, designed to illuminate various options and to spur policy makers to undertake additional analysis to better understand what options exist that may offer lower costs, less obstacles, more jobs and a practical path to a lower carbon future.

The U.S. House of Representatives has proposed[1] a reduction of U.S. energy related carbon emissions of 42% by 2030 and 83% by 2050.

The scenario outlined in this document relies mostly on already proven technology, is achievable by 2030, and takes a holistic approach to the goal. The energy units and emission reductions described are incremental to the EIA reference case for 2030

[1] http://www.govtrack.us/congress/bill.xpd?bill=h111-2454&tab=summary

published in 2007.[2] The CO_2 reference case shown in the figure is energy-related CO_2 emissions from the latest EIA Annual Energy Outlook.[3]

Following, are listed the means by which to reach a 42% reduction in CO_2 emissions by 2030. They are also depicted in the chart on the first page. The reduction totals listed are discussed throughout the document, yet parsed under various headings. Within the document, you will find in yellow the CO_2 reductions that added together equal the total reductions depicted in the chart.

1. Improved efficiency in homes, businesses, industry and electricity generation based on full fuel cycle analysis (2,004 million metric tons – MM tonnes CO_2 reduction)
2. Expanded renewable energy use in homes, businesses, industry and electricity generation (494 MM tonnes)
3. Tightened Corporate Average Fuel Economy (CAFE) regulations for light-duty vehicles and expanded use of alternative fuels (natural gas and bio-fuels) in the transportation sector (298 MM tonnes)
4. Incremental increase of nuclear power plants (154 MM tonnes)

This scenario relies substantially on existing technologies coupled with the expansion of the U.S. electric and natural gas infrastructure.

New, and to date, unproven technologies will need to be developed and deployed to reach the 2050 goal. This scenario provides the window of time to research, develop, refine and test these new technologies.

The U.S should continue to increase resources to support R&D to develop new advanced low-carbon technologies and systems of the future, but non R&D deployment efforts should mainly focus on proven or near commercial technologies to ensure the 2030 goal will be attained.

ENERGY EFFICIENCY

Currently, energy efficiency measures are often defined by the deployment of products and devices which are very energy efficient but are powered by primary energy sources which are produced and delivered through less efficient means. Programs designed solely based on end-use efficiency, which discount the efficiency of the power source and delivery system can actually increase CO_2 emissions nationally.

The scenario outlined in this document is based almost entirely on the deployment of technologies which are already utilized in various applications and does not assume comprehensive development and deployment of a CO_2 capture, delivery and sequestration infrastructure or extensive deployment of new breakthrough technologies. Breakthrough technologies and new CO_2 infrastructure for coal and natural gas power generation may take several decades to deploy comprehensively, yet even without this deployment, the 2030 goal is achievable.

The energy efficiency described in this document suggests that energy efficiency is defined from "source to site" and that the efficiency of the entire energy cycle can be improved. This includes electricity production, as well as the delivery of energy to the customer.

For example the production and delivery of natural gas to a customer is 91% efficient compared to an average efficiency for

[2] U.S. DOE Energy Information Administration (EIA), 2007 Annual Energy Outlook.

[3] U.S. DOE EIA 2009 Annual Energy Outlook, Table 14, p. 52.

electricity delivered to a customer at around 27% .[4]

Based on this approach we have defined the following means to increase energy efficiency and substantially lower CO_2 emissions.

1. Direct use of high-efficiency natural gas appliances and processes in homes, buildings, and factories to displace less-efficient natural gas, oil, and electricity-based technologies.[5] (432 MM tonnes)
2. Electric end-use energy efficiency improvements[6] (lighting, HVAC, electronics, appliances, insulation and building shell) (808 MM tonnes)
3. Improved efficiency of electricity production (from 32-35% for a coal-fired power plant[7] to 48-60% for a natural gas combined cycle plant[8]) through expanded use of natural gas (764 MM tonnes)
4. Improved efficiency of the transportation sector through increasing the miles per gallon (MPG) of vehicles (38 MPG for light-duty cars and 28 MPG for light-duty trucks) (165 MM tonnes)[9]. [This CO_2 reduction is summarized under transportation heading].

[4] American Gas Association, "Source Energy and Emission Factors for Residential Energy Consumption," August 2000

[5] GTI, "A Lower-Cost Option for Substantial Carbon Dioxide Emission Reductions in the U.S.," GTI -9/0002, July, 2009.

[6] McKinsey & Company, "Unlocking Energy Efficiency in the U.S. Economy," July, 2009, p. 29 (residential), p. 55 (commercial), p. 75 (industrial)

[7] Black & Veatch, Presentation to the Kansas Energy Council, http://home.eng.iastate.edu/~jdm/ee590/EnergyConvert-TransportTechnologies.pdf, 2006.

[8] GE, "Advanced Technology Combined Cycle," GER-3936A, May 2001.

[9] McKinsey & Company, "Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?" Executive Report, December 2007, p. 43

NATURAL GAS

Natural gas and the energy industry have a very large role to play in improving the efficiency of residential, commercial and industrial applications as well as electricity production; and to enhance the opportunity for renewable energy use throughout the nation. As described in the energy efficiency section of this document, natural gas can improve efficiency and lower carbon emissions in residential and commercial end-use and electric power applications. There are also efficiency gains to be made in industrial processes that currently use natural gas.

Another opportunity for natural gas that has been significantly deployed by several nations, yet somewhat less by the U.S., is the expanded role natural gas can play in powering medium- and heavy-duty and fleet vehicles. (Highlighted in Transportation section)

Expanded use of natural gas to improve energy efficiency and reduce carbon emissions in end-use and the electric power sectors (highlighted in the Energy Efficiency section) coupled with an increasing role for natural gas vehicles (NGVs) can provide 1,221 MM tonnes in CO_2 emission reduction.

The nation's desire to improve efficiency while simultaneously reducing carbon emissions is timely because of the new technologically available sources of domestically produced natural gas from shale formations throughout the U.S. These new sources of natural gas can build the foundation for new energy efficiency gains and dramatic CO_2 emission reductions.

These newly developed sources can easily provide the additional 3.3 quads[10] of natural gas needed in 2030 to support the increased role for natural gas to improve energy efficiency, lower CO_2 emissions and fuel more NGVs in the transportation sector.

[10] GTI calculations, August 2009

Additionally, the opportunity exists for renewable gases produced from livestock manure, landfills and renewable biomass to be transported through the natural gas delivery system. This new role for renewable bio-gas can revolutionize delivery of renewables to all energy sectors and displace 10%[11] of the natural gas needed in the U.S. by 2030. Renewable bio-gas can provide renewable low-carbon options for residential, commercial, and industrial customers as well as provide fuel for electricity production and transportation leading to 156 MM tonnes of CO_2 emission reductions in 2030.

RENEWABLES

Renewable energy can come from many sources including wind, solar, hydro and renewable biomass. Many think of renewables as only a means to create electricity but the opportunity exists to transform renewable resources into liquid transportation fuels as well as renewable bio-gas.

Below are outlined the means to reach substantial reductions in national CO_2 emissions through the expanded use of renewables.

1. Adding 206 GW of renewable electricity generation, including 116 GW of wind energy, 80 GW of solar[12], and 10 GW of hydropower[13], leading to 338 MM tonnes of CO_2 reduction in 2030
2. As discussed previously, adding[14] 2.9 trillion cubic feet (Tcf) of renewable bio-gas into the natural gas pipeline system from renewable biomass, landfills and animal waste (156 MM tonnes)
3. As discussed in the transportation section, adding 30 billion gallons per year of bio-fuels[15] for vehicles (109 MM tonnes)

NUCLEAR

Nuclear power plants produce no CO_2 during their operation. This scenario assumes that some new nuclear power plants will be built by 2030, that is:

1. Sixteen GW of new nuclear plants[16] over the EIA reference case, leading to CO_2 reductions of 154 MM tonnes in 2030

TRANSPORTATION

This scenario also postulates major reductions in emissions from the transportation sector. These were previously outlined individually in the Energy Efficiency, Renewable and Natural Gas sections.

1. Tightened CAFE standards for light-duty cars (up to 38 MPG) and trucks (up to 28 MPG), leading to CO_2 reduction of 165 MM tonnes in 2030
2. Production of 30 billion gallons per year of bio-fuels from starchy and cellulosic ethanol (109 MM tonnes)
3. Expanded use of natural gas to fuel medium- and heavy duty vehicles[17] and smaller fleet vehicles[18, 19] (25 MM tonnes)

---

[11] GTI-9/0002

[12] McKinsey, 2007, p. 19

[13] EPRI, "Assessment of Waterpower Potential and Development Needs," Final Report, March, 2007

[14] This is not an unrealistic projection. The Oak Ridge National Laboratory study, "Biomass as a Feedstock for a Bioenergy and Bioproducts Industry: the Technical Feasibility of a Billion-Ton Supply," (April 2005), projected that one-third of U.S. consumption of liquid fuels could be displaced by bioenergy, or over 13 quads per year.(ORNL/TM-2005/66).

[15] McKinsey, 2007, p. 19

[16] McKinsey, 2007, p. 19

[17] Natural Gas Vehicle Coalition, http://www.ngvc.org/pdfs/NGVAIssueBrief022309.pdf

[18] Transportation Energy Data Book: Edition 28-2009, Chapter 7, Fleet Vehicles and Characteristics, www-cta.ornl.gov/data/tedb28/Edition28_Foreword.pdf

[19] U.S. DOE Energy Information Administration, EIA AEO98 NEMS, Table 3, LD Vehicle MPG by Technology Type

As you can see from the whitepaper, an expanded role for natural gas coupled with efficiency and renewables can provide a dramatic reduction in carbon emissions.

The scenario outlined in the whitepaper above does not include any deployment of carbon capture and sequestration (CCS) technologies, meaning that if CCS deployment was added to the scenario, additional and substantial carbon emission reductions would be realized.

Looking out to 2050, there is the potential for extensive CCS deployment and for the deployment of small-scale residential CHP (fuel cell or other) systems providing hot water and electricity to homes. The expanded use of these technologies coupled with the likelihood that all renewable natural gas will be focused on residential use, because CCS will be available for natural gas power generation, will result in lower residential emissions. In addition, major EE improvements will occur in building envelopes along with the integration of residential solar; and when you add all these factors together, direct use of gaseous fuels can be part of a 2050 US energy scenario in which the 83% carbon emission reduction goals can be reached. This point is very critical when looking at the overall USDOE technology review and what research and development to support today and into the future.

Today – an expanded role for natural gas can bring about the largest reduction in carbon emissions meeting future goals faster and at the lowest cost.

Today - natural gas can deliver the most efficient and lowest cost energy to homes and business – heating our homes and water – lowering emissions and energy bills. Our national energy policies and R&D funding need to reflect this opportunity and reality.

Today – natural gas power generation is low cost and is a minimum 50% cleaner than other fossil fueled power generation. It is also much more efficient - with new combined cycle power plants being up to 60% efficient and the development of new technologies continue to improve that efficiency. USDOE's Fossil Energy Program should support development of more efficient natural gas power generation and CCS technology development for natural gas generators.

Today –natural gas power generation is best suited and lowest cost to partner with renewables because of its ability to ramp up and down to support intermittent generation sources. More natural gas power generation will assist with a robust expansion of centralized wind and solar facilities - but proper regulations are needed to ensure this opportunity. FERC should investigate how the natural gas system can support greater integration of intermittent generation resources into the electric grid.

Today – Renewable natural gas projects from livestock manure and landfills – even though they receive no federal incentives – are pumping carbon negative fuels into our nation's pipeline system delivering green gas to homeowners, vehicles and electric power facilities. These types of projects could be greatly expanded as many European countries have already discovered, delivering renewables throughout our energy sectors – if only Congress would pass laws providing similar incentives like those received currently by renewable electricity and renewable liquid transportation fuels. This is an inequity in our renewable energy tax code and should be rectified. USDOE should also focus a portion of their renewable fuels development on technology that produces renewable natural gas from woody-biomass and other renewable energy sources.

It is time for Congress and the President to ensure natural gas is not left out when developing energy R&D policy. Currently almost no federal funding is provided for natural gas R&D and technology demonstration. The proposed USDOE budget provides nothing for natural gas vehicles, efficiency improvements for natural gas power generation or home appliances, efficiency for natural gas commercial cooking, natural gas carbon capture, renewable natural gas technology or development of hybrid solar natural gas technologies for energy intensive businesses.

It is suggested, by some, that funding for natural gas technologies is somehow a subsidy for fossil fuels yet the proposed fossil energy budget of over $400M is all for carbon capture and sequestration from coal fired generation – not for gas generation - and the USDOE Buildings program focuses almost all of it non-renewable funding on electric appliance and building energy efficiency yet 67% of electricity is produced from fossil fuels, 43% of that being coal. It doesn't appear that development of more efficient electric appliances is considered a fossil fuel subsidy and natural gas efficiency improvements for technologies to be utilized in homes, buildings and businesses should not be either. It is time for Congress and the President to step up and support funding for natural gas research and development and if there is a clean energy standard passed - natural gas needs to be included.

Now let's talk about the future. As shown in the whitepaper highlighted in this testimony, an expanded use of natural gas coupled with renewables and energy efficiency could meet a 43% reduction in our nation's carbon emissions by 2030. This would be without any carbon capture technology deployment.

Many have suggested that natural gas is a bridge to a clean energy future – It may be a destination.

Many have suggested that a clean energy future is one of massive centralized power plants with carbon and capture and sequestration and everything including home heating and transportation powered by electricity.

There is a potentially a lower cost - higher efficiency vision of 2050, one that that should not be discounted and here is what it might look like.

In the future – lower carbon based natural gas, because of the addition of renewable gas and hydrogen, will be delivered to homes to power fuel cell systems that provide electricity and hot water for homes. These homes will have the option to include hybrid solar systems providing additional electricity and thermal energy to augment the homes' other energy sources. This type of system will ensure maximum efficiency of all energy resources.

Natural gas power generation with CCS will be the dominant source of electricity coupled with centralized wind and solar facilities. This will provide the lowest cost and most efficient production and delivery of renewable electricity. The gas and electric grids will be integrated into a smart energy grid that realizes the synergistic connections between our nation's natural gas pipeline and delivery system and electric transmission and distribution systems. Fast ramping gas-fired power generation will complement variable renewable resources to provide reliable and secure electricity.[20]

---

[20] GTI, Navigant, "Natural Gas in a Smart Energy Future," GTI-11/0001, January, 2011, p. 11.

Hybrid electric vehicles will dominate. The vehicles main energy source will be natural gas or bio-fuels. Light duty vehicles will have a plug in option designed to provide a portion their range. These vehicles may also have a fuel cell engines. The medium and heavy duty vehicle market will be dominated by compressed natural gas, bio-fuels or liquid fuels produced from natural gas. Many of these vehicles will have hydraulic hybrid systems.

Now this is only one vision – point being is that we can all propose or see a specific vision but it may be just as important to understand what clean energy options we have today and ensure that these options are improved - and not discounted - based on some potential, and yet uncertain, vision of our future.

Because of the stated carbon emission reduction goal of the current administration, and for reasons of national security, job creation and the opportunity to deliver low cost energy, the USDOE should focus more of its R&D budget on natural gas technology development throughout all sectors of the energy economy including, residential, commercial, industrial, power generation, transportation and exploration and production.

Below is background on recent funding support of natural gas technology development by the USDOE. Considering, the number one stated energy goal of the administration is the reduction of carbon emissions, it is unclear why there is so little focus on natural gas R&D.

For R&D related to natural gas, a review of the combined budgets of EERE and Fossil programs alone, show that in 2010, the U.S. Government provided a paltry estimated $80 million(3.5%), out of an almost $2.3 billion total. It is clear that if the U.S. wants to support an expanded role for clean burning natural gas, leading to improved energy independence, energy efficiency, job creation and reduced emissions, additional R&D dollars are needed. These new natural gas technologies could be utilized in all energy sectors including homes, businesses, manufacturing, power generation and transportation; as well as to enhance reliability and safety of the natural gas production and delivery system and to prepare the natural gas grid to transport other lower carbon gases including hydrogen and renewable natural gas.

USDOE natural gas R&D funding information and observations

1. *The $100M Industrial Technology Program (ITP) continues to be only program at USDOE that focuses a portion of their budget on developing new more efficient technologies for manufacturing. Many of these technologies will be powered by natural gas.*
2. *The approximately $200 million Buildings Program at EERE has no specific program to support natural gas technologies for homes and businesses even though approximately 70,000,000 US homes and businesses use natural gas.* [21]
3. *Approximately 60% of the $673 million 2010 Fossil Energy budget for research and development was appropriated for coal, while only 2.5% was directed to natural gas.*
4. *During 2010, coal accounted for 22% of the country's primary energy use while natural gas represented 25% of the county's primary energy use. It would be fair and prudent to spend comparable R&D funding for natural gas within the fossil energy program.*[22]

---

[21] A.G.A. "Gas Facts: with 2008 Data", Tables 8-2 and 8-3.

[22] http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2011&subject=0-AEO2011&table=2-AEO2011&region=1-0&cases=ref2011-d120810c

5. *The ARRA spending stimulus provided $3.4 billion to the Fossil Energy Program. All was spent on coal.*
6. *Currently natural gas vehicle (NGV) R&D at USDOE is $5 million dollars and electric vehicle R&D is approximately $128 million.*

To reiterate, while a portion of the funding proposed in the Industrial Technology Program at USDOE will likely be spent on natural gas technology, the current USDOE budget proposed by the Administration has ***no*** specific money outlined for natural gas technologies, even though these technologies strongly and directly support the number one stated energy policy objective of the Administration.

The second stated energy goal of the Administration is:

- **Supply 80% of America's electricity from clean energy sources by 2035**

Response:

This goal is unclear as it does not delineate a specific metric or definition to measure what is clean. The first goal, however, suggests a metric of carbon emission reductions; is one to infer this will be the metric here? What about criteria pollutants or mercury? Should they be considered as well?

Clean is a subjective term, however, recent information from the White House would suggest that many energy sources are on the table, including natural gas, nuclear and clean coal (undefined), and all renewable sources.

So if the goal includes most everything, and carbon *may be* the metric, then continuing research & development activities in the areas of wind, solar, natural gas, nuclear and hydro along with renewable bio-mass sources continue to be applicable.

An important point in looking at renewable power generation now and into the future, is that it is more energy efficient to convert carbonaceous materials like woody bio-mass directly into renewable natural gas and then deliver this product through our nation's pipeline system, to be used in the most efficient natural gas combined cycle turbines, than it is to burn wood in traditional boilers to make renewable electricity directly.

Wood resources are important to many industries, and using those resources most efficiently to meet any state or future Federal renewable electricity mandates is critical. The efficiencies of making renewable natural gas first, and then powering combined cycle natural gas facilities compared to co-firing coal with biomass or using biomass in traditional electricity producing boilers, can improve the overall conversion efficiency of feedstock to electricity by up to 65%.

Additionally, during the conversion of biomass to pipeline quality gas, when utilizing gasification technologies, all carbon dioxide produced, that does not go into the end product (pipeline quality gas) is captured and ready for sequestration or to be used in processes like enhanced oil recovery. This type of operation can be carbon negative and can lead to an opportunity for substantial carbon emission reductions.

In the areas of fossil fuel generation, we believe that carbon capture and sequestration R&D should include RD&D for natural gas power generation, particularly CCS for combined cycle natural gas turbines. The USDOE's own analysis suggests that natural gas plants with CCS will use less water, create less criteria pollutants and be less costly than coal fired plants with CCS.

While the cost for gas powered generation with CCS may be lower than coal with CCS, it would still be much higher than existing natural gas fired generation and it would be wise for the Fossil Energy program budget to include some funding for CCS for natural gas power generation. New carbon capture technologies are in the development stage. These technologies have the potential to reduce the cost of CCS for natural gas power generation by 35%. This type of technology development and demonstration should be supported by the USDOE.

Also, since immediate carbon emission gains can occur by switching from coal to gas powered generation, R&D funding within the Fossil Energy budget should, in part, be focused on improving the efficiency of natural gas turbines which could provide energy efficiency gains throughout the electric delivery system along with further CO2 emission reductions. Energy efficiency in this case, and all cases, should be considered from the beginning of the energy production cycle through final delivery and use of the energy product.

Currently, the USDOE has focused what it calls its "Smart Grid" Initiative through the office of Electricity and Energy Reliability. These efforts are touted as a means to make our "Energy Grid" smarter to improve efficiency, develop the opportunity for two way communication between the consumer and other technological advances to the electric grid.

This is important, but if the ultimate goal is to have a "Smart Energy Grid" then improving (making smarter) the interaction between our natural gas pipeline system, natural gas power generators and intermittent sources of electricity like wind and solar will be critical to meet the goal of an 80% clean energy grid by 2035.

As an example, electricity driven pipeline compressor stations, during an electric power outage can impact the natural gas pipeline system, which can further decrease the reliability of the electric grid, because of the potential for natural gas delivery disruptions to electric generating stations. With increased amounts of intermittent energy supplies like wind, natural gas deliveries may need to be increased, with short notice, to provide more power for natural gas electric generators. Is there a need to develop smarter communication to increase gas delivery to electric generators when the wind is not blowing? These are just two examples of the interdependence between the gas delivery system and the electric grid. In a recent study[23] it was similarly found that "tighter integration of natural gas with electricity could also have an important effect on the reliability of electricity service to consumers."

[23] GTI, Navigant, "Natural Gas in a Smart Energy Future," GTI-11/0001, January, 2011, p..21

As stated in "Natural Gas in a Smart Energy Future"[24] achieving a clean energy future, where natural gas is a key component, will require a number of near term actions related to policy, technology development, and implementation of capabilities in each of the energy sectors. Regarding R&D, the report recommends:

- Include natural gas in advanced metering infrastructure development to optimize common infrastructure, interoperability and cross-compensation among all utility infrastructures including electricity and water;
- Ensure that future federal funding programs including Smart Grid encourage and allow the use of funding for dedicated natural gas projects and combined electric/natural gas projects;
- Develop a technology roadmap for natural gas in a smart energy future, including critical input from a broad group of stakeholders and the energy technology R&D community;
- Increase federal/provincial funding for basic as well as applied research in natural gas safety and reliability and smart energy infrastructure technology; and
- Establish a federal/provincial public-private research, development and deployment program for natural gas similar in size to the electric Smart Grid programs that includes component and system suppliers.

USDOE is spending the entire budget of the Office of Electricity and Energy Reliability on electricity issues while overlooking the integration of our natural gas pipeline infrastructure with the electricity system. This issue is a key area of R&D for the second part of the office's title, "Energy Reliability".

Energy reliability is not just about the electric grid but about a host of other issues and factors which include the role of distributed generation, communication between pipelines and generators, smart natural gas meters, as well as a much deeper understanding of the role that natural gas and other fuels and technologies will play in providing firming and enhancing capacity factors for intermittent energy resources like wind and solar.

USDOE's office of Electricity and Energy Reliability should develop a program that will provide funding to support the modernization and technology development for the entire "energy grid" not just the electric energy grid. This effort will help accomplish the Administration's goal of reaching 80% of America's electricity coming from clean energy sources.

The Third Goal of the Administration is to

- **Support deployment of 1 million electric vehicles (EVs) on the road by 2015**

Response:
While the first two goals offered by the Administration, could be debated on an organization's or individuals point of view, they are strategic in nature. The third goal offered is very tactical and is

[24] GTI/Navigant, IBID, p. 23

about picking and supporting a specific winner in the market place. USDOE has specifically stated that it is not government's role to pick winners in advance, but to create technology options, allowing the private sector and the free market to determine which technologies will "win."

This goal appears out of place considering that it will do little to support the first or second strategic goal outlined by the Administration and it creates market distortions by supporting only one technology that may not be the most cost effective or even the cleanest.

One million EV's, considering the carbon footprint of the electric grid in 2015, and the relatively small amount of carbon produced by compact light duty vehicles annually, means this effort will produce little or no reduction in carbon emissions, depending on which life cycle analysis you consider; especially if the electricity is produced primarily from coal-fired power plants without CCS.

Additionally, deploying a product that may not be ready for the market place or have widespread acceptance by the consumers, can backfire. You only have to go back to the 1980's and 1990's to consider the debacle of methanol in California, and the unrealized promise the electric car. Electric vehicles in the 1990's were not accepted because of the issue of range and infrastructure. Methanol was found to leak into groundwater supplies so that eliminated the fuel from consideration in California.

Natural gas vehicles also had some difficulties in the 1990's and yet have gained world-wide acceptance. This is in part, because technical issues have been solved, and business leaders, who understand the connection between infrastructure development, fuel savings, and how to put the entire package together for medium and heavy-duty vehicles, have moved into the market place. This market continues to grow and is gaining consumer acceptance especially for high mileage, centrally fueled fleets.

Currently, electric vehicles still have very limited range as well as a major lack of infrastructure. It is still unclear, what type of impact electric vehicles may have on the electric grid regarding investments needed if major deployment was realized. Also considering the relatively inefficient delivery of electricity in this country for energy source conversion at the power plant to the plug, electric vehicle life-cycle efficiency is in question.

Considering all these issues, this goal is not strategic, will not assist in meeting the number one stated goal of the Administration to reduce carbon emissions, thus we recommend this goal be eliminated as a goal by the Administration, or broadened to include NGV's and other alternatively fueled vehicles, with the stated goal of reducing emissions and reducing our dependence on imported oil.

If the Administration believes that electric vehicles may play a major role in the future transportation needs of our country, then we recommend that they focus their efforts on R&D to improve batteries, vehicle platforms and charging technologies. This can lead to improvements in the technology which may eventually make EV's more acceptable to the marketplace leading to a much better opportunity for consumer acceptance.

Major deployment efforts of technologies not yet ready for the market place can lead to negative consumer attitudes which will make it more difficult for future acceptance once the technology is in a better position to be competitive. This can lead to exactly the opposite outcome for which the Administration is looking.

If the Administration is looking to support a major push of alternatively fueled vehicles that can lead to carbon emission reductions, high efficiency on a "well to wheels" basis, are powered by domestically produced fuel and are growing in acceptance especially among large fleets, it would be well served to support the deployment of natural gas vehicles.

Comments on Quadrennial Technology Review from GTI, A, B, D, E & F

A. ***DOE Energy Technology Mission: "To facilitate the invention, refinement, and early deployment of meaningful technologies that enable options for scaling by the private sector toward nation energy goals", appropriate for energy technology development and deployment programs by the Department.***

Response:
This statement is reasonable as a mission for technology development for the USDOE. One caution regarding the term "early deployment": The Federal Register information provided for these comments defines early deployment as "supporting some activities beyond first commercial demonstration. "

Later in the Federal Register Information it states that when USDOE works to "enable options" it specifically does not mean that it is picking winners and losers: the market makes those choices. If "early deployments" supports some activities beyond first commercial demonstration then these two statements appear to be mutually exclusive.

It would be best for USDOE to focus funding on activities through commercial demonstration and not beyond, thus not getting into the business of picking winners and losers. USDOE funding demonstrations of technologies should have the effect of attracting private capital to move forward with commercialization and marketing. While the USDOE should support some limited commercialization activities by potentially funding development of information and other means to publicize the development of new technologies, it should not directly provide funding for widespread deployment of technologies that it deems more important to our national energy goals.

These goals may not be viewed the same by members of Congress, other policy makers or the marketplace, and that is why it is best for USDOE to focus on research, development and demonstration with little activity reaching into the mass deployment phase.

B. ***U. S. Energy Framework: USDOE has identified six strategies to address our National energy goal. These strategies divide into two trios: One for transport, and one for stationary energy (heat and power). The transport strategies are (1) increase vehicle***

efficiency, (2) promote progressive electrification of the vehicle fleet and (3) develop alternative fuels. The stationary strategies are (4) Increase Building and industrial efficiency, (5) modernize the grid and (6) drive adoption and deployment of a clean electricity supply. Have we correctly structured these six strategies?

Response:

Strategies for Transport:

(1) Increase vehicle efficiency
Increasing the efficiency of vehicles is a reasonable and important goal in moving our nation to improved energy independence and lower emissions from vehicles. An important factor in achieving this goal is that the fuel source, and its life cycle efficiency of delivery to the point of being placed into the vehicle, should be part of the equation when looking at vehicle efficiency. A very efficient vehicle could operate on fuel that was produced very inefficiently. This does not accomplish the goal of overall energy efficiency and could increase overall energy consumption and emissions.

(2) Promote progressive electrification of the vehicle fleet
Comments provided earlier in this document address some of the pitfalls of striving to electrify the fleet. The word promoting seems out of place here. Is the goal to increase the energy capacity of batteries, improve the operation of charging stations or develop hybrid electric platforms for heavy duty-vehicles? We again warn against the impulse to pick a solution more suited for a potential future energy scenario which does not exist, may never exist and might not be the best energy future anyway. ***We suggest dropping this goal, as it is picking a specific selected winner and replace it with the goal "Develop and improve alternative fuel vehicle platforms and systems".***

(3) Develop alternative fuels
This goal should include specific fuels types when considering the development of bio-fuels. USDOE should concentrate its programs on developing drop-in renewable replacement fuels for gasoline, diesel, and natural gas. These are the dominant fuels in the United States and all can be created from renewable feedstocks. A program focused on producing renewable versions of these fuels would not only support the transportation sector but would include direct fuel use for homes and businesses and for the electric power sector.

It is already feasible to create these fuels from renewable feedstocks but more research and development needs to be done to lower the cost of making renewable versions of these fuels. The USDOE should focus on research and development to create renewable versions of these fuels so that existing infrastructure can be utilized to deliver renewables to the consumer much like renewable electrons have been successfully integrated into the electric delivery system.

Stationary strategies:

(4) Increase building and Industrial efficiency.
For this goal to be meaningful, life cycle energy analysis must be considered for the best understanding of specific technology solutions developed. In the residential and commercial sectors concentrating on building envelope issues will increase the efficiency of structures regardless of the energy fuel mix. When developing R&D programs for appliances with multiple fuel options a full fuel cycle analysis should be practiced to gain desired efficiency and emissions results.

Within the industrial efficiency program, industrial processes should be the focus, because they are where the greatest efficiency gains can be made. Developing the next generation technology to produce glass, aluminum, steel and to perform heat treating processes are critical. Both breakthrough and incremental improvements of processes should be supported. The industrial program should concentrate on the entirety of manufacturing businesses, not skewed towards one specific industry, though the energy intensity and impact on employment should be considered when directing resources.

(5) Modernize the Grid
The Grid should be defined as the entirety of the energy delivery systems in the US and specifically should include the delivery and distribution system for natural gas. To only focus on the electric grid could potentially create an imbalance where one system is modernized and the other is lagging. Since it is clear that there are many key synergistic connections between the two energy delivery systems, an approach which just modernizes the electric grid without looking at other energy delivery systems, could create catastrophic consequences including, blackouts, uneven power, inadequate ability to integrate intermittent renewable electricity sources into the grid and high energy prices for consumers. The USDOE should immediately develop a roadmap to focus some of its resources in the Office of Electricity and Energy Reliability to support a more holistic view and approach to energy reliability. A view that recognizes that energy reliability must address the entirety of our nation's energy delivery system.

(6) Drive adoption and deployment of a clean electricity supply
This goal is unclear, as noted earlier in this testimony. Without metrics included how can a goal be defined or reached? How can you say you have reached your goal? Putting this issue aside and looking at the number one goal brought forth in the Quadrennial plan, which is the reduction of carbon emissions, the Fossil Energy program at USDOE should not only focus on carbon capture and sequestration (CCS) for carbon emissions created from coal, but should also focus a portion their resources on:

a. Increasing the efficiency of power generation from natural gas and coal
b. Demonstration projects for natural gas power generation carbon capture technologies
c. Augment the existing Section 999 program with additional funding focused on developing new technologies and processes to ensure the safe, environmentally benign, and reliable of extraction of natural gas from shale formations

Environmental research to support continued development of natural gas from shale formations is critical to this country's ability to use this domestically available, clean energy resource. And yet DOE's natural gas R&D budget has been zeroed out.

(C) We are not responding to C

(D) What principles should the Department follow for allocating resources among technologies of disparate maturity and potential time to impact?

1. ***What should be the criteria for including a technology in the DOE portfolio? What should be the criteria for removing a technology from the DOE portfolio? How should programs be structured and managed to accommodate entry and exit of technologies within the DOE portfolio?***
2. ***How do we balance the diversity of technology options the Department could provide for the private sector against timeliness, scale, and cost-effectiveness?***
3. ***How can DOE be more effective at each stage of the innovation chain?***
4. ***What are useful metrics to guide DOE technology activities?***

Response:

GTI believes that a portfolio of technologies of different maturities, available in different time frames, and across market sectors should be supported by the Department.

In terms of technology goals, GTI endorses having both cost and performance (efficiency, reliability, durability) goals. "Stretch" goals that challenge the research labs and technology developers are preferred. "Easy" goals, while achievable, may divert the research efforts from needed technology development.

However, in terms of breakthrough research versus technology development, while it is important that ARPA-E and Basic Energy Sciences focuses on breakthrough research, it is important that critical technology gaps be addressed by EERE, Fossil, and the more applied RD&D programs. So the focus should be change in technology (efficiency, cost) and potential market impact rendered by the R&D, not whether or not it is "breakthrough."

For instance, many of the technologies that GTI and DOE developed for unconventional gas development, including hydraulic fracturing, 3-D seismic, and horizontal drilling, could be considered "incremental" rather than breakthrough. However, the synergistic effect of these technologies combined was to double the U.S. natural gas technically recoverable resource base in less than two decades.

Similarly, the GTI development of the first fully condensing furnace in the early 1980s'pushed home furnace efficiencies from 60% to over 90%. While the technology was not breakthrough, the market impact was. Over 25% of furnaces sold in this country today are fully condensing, as are 75% of the furnaces sold in cold weather climates like Wisconsin. In the 1990's, GTI and DOE development of the Vertex 90% efficient tank-based water heater, while not "breakthrough", created a huge shift in gas water heater efficiency moving it up from 55%.

When to declare victory? The technology needs to be carried through to commercialization, with assistance provided regarding regulatory and market barriers when appropriate, so that the private sector can then proceed with market deployment on its own. The previously mentioned Vertex water heater has not achieved full market penetration. Why not? Is it first cost? Venting issues or the need for larger gas pipe in the home or the lack of vendor knowledge of the technology? It is likely all of the above; and these issues can be address by demonstration and education funding.

Can hydraulic fracturing of the gas shales use Fossil R&D funding to address critical environmental concerns? Yes, it can. Will it benefit the nation? Yes, it will help provide a 100-year plus supply of domestically produced natural gas to U.S. consumers.

(1) Criteria should include energy savings, reduced environmental impacts (emissions, water, and land impacts), enhanced national security, and U.S. jobs creation potential. Air emissions should include criteria pollutants and greenhouse gases. Emissions calculations should include "full fuel cycle" analysis, from wellhead to burner tip, or coal mine to power production, including transmission and distribution losses, to end-user energy use. Advanced technologies should not be considered in a vacuum, but against their most likely competitor.

Enhanced national security means less dependence on foreign sources of fuel, particularly oil, and more use of domestic resources, like domestically produced natural gas.

Jobs creation potential should include manufacturing, energy production, transmission, and distribution, installation, and maintenance of end-use equipment. Direct and induced jobs should also be included.

(2) It is important that the Department be "fuel neutral" and continue to offer the residential, commercial, and industrial consumer the choice of technologies across fuel types. For instance, the focus on electric vehicles, without offering similar emphasis to natural gas vehicles (NGVs), is one-sided and ignores the potential for reduction in oil-use by utilizing a domestically produced resource.

Similarly, in the Buildings sector, the focus on electric heat pump water heaters ignores the potential for condensing tankless natural gas water heaters, with efficiencies of over 90%, or gas heat pump water heaters, with efficiency factors of 1.5 (150% efficiency equivalent).

While ground source electric heat pumps are being developed, minimal funding is being provided gas heat pumps (GHPs) for heating and cooling. Only one unit, funded by DOE, has reached the market in Arizona and Nevada, a "warm weather" version not hardened for our northern winters. Department funding of GHPs with heating efficiencies above 150% and cooling efficiencies of up to 120% can lead to major changes in home energy use, and reductions in peak electric loads.

(3) The Department needs to ensure that the "hand off" of technologies between basic and applied research, or between technology development and product development, is not a "toss over the fence" approach. Manufacturers, R&D organizations, utilities, and end users need to be brought into the previous RD&D stage efforts before that work is completed to ensure a smooth transition. For instance, 75% of the cost of a product is embedded in the conceptual design. If a potential manufacturer is not involved in applied research or technology development phase, then manufacturing and assembly costs can become "locked in" before the private sector has a chance to examine the technology for manufacturing, assembly, and installation.

(4) See "(1)" above for useful metrics.

In one of the referenced documents, the Department indicated that it would work on technologies that had a one quad impact or more. This is short sighted, as many important residential and commercial technologies can impact the way millions of customers use energy. For instance, a 90% efficient fully condensing (tank-based or tankless) gas water heater compared to today's 55% efficient tank-based water heaters can save almost 10 MMBtu per household, about 12% of natural gas use on average. Yet, even applied to 10 million homes, the total market impact is 0.1 quads per year. Yet it results in a 12% reduction of gas use per household! Is this not a worthwhile goal?

(E) What are the optimal roles for the private sector, government laboratories, citizens and academia in accelerating technology innovation?

1. ***How can DOE best coordinate activities between and among these types of organizations (including the wide variety of institutions within each class)? How should we gauge the effectiveness of this coordination? How can the basic-applied coupling be optimized? Are there examples in other sectors or other countries that can serve as models?***
2. ***What are the design principles for an effective 'technology user facility'?***
3. ***How can the Department best gather technology market information? How can information on private sector innovation be captured without compromising competitive advantage?***

Response:

(1) It is very important that the Department take advantage of working with membership-based non-profit RD&D organizations like GTI and EPRI that have been created by private industry segments. It is the surest way of developing the technology in partnership with the private sector, and in disseminating the results of the R&D out to the market place. These organizations also provide a link to other groups like the National Association of Regulatory Utility Commissioners (NARUC), which provides a tie to the utility regulatory segment.

(2), (3) - no response

(F) What are principles and best practices in performing large-scale demonstration projects?

1. ***How close to commercial viability does a demonstration have to be? What are the optimal cost sharing arrangements? How might demonstrations be coordinated with DOE financing activities?***
2. ***How can demonstration projects better benefit all stakeholders beyond the immediate participants? How are lessons-learned best captured and promoted, and how is intellectual property best handled?***
3. ***How should DOE determine whether demonstrations adequately address technical and operation risks?***
4. ***What defines failure or success in the demonstration phase?***

Response:

(1) Small scale demonstration, which should be measured by overall cost, can be further away from commercial viability and still receive USDOE funding. Large-scale demonstrations which can cost tens or hundreds of millions of dollars should be very close to commercial viability.

For large scale demonstration projects the current requirement of 50% cofunding is suitable. For smaller scale demonstration projects, for technologies not as close to commercialization, 20% cofunding should continue to be the rule.

Those large-scale demonstration projects, which receive USDOE grant funding, should also be eligible for USDOE low interest financing.

(2) Intellectual property should be stay in the hands of those performing the research and any agreement regarding intellectual property should be made between the participants.

(3) USDOE project managers should investigate the technical, operational and market issues before funding a specific demonstration project so as to have a complete understanding, after the demonstration is completed, as to whether or not the demonstration has moved the technology adequately towards commercialization.

(4) It is not a matter of success or failure but understanding whether or not additional RD&D activities are needed and knowing if this technology has an opportunity to be successful in the market.

As with other Department programs, it is important that the portfolio of demonstration projects be "fuel neutral." In the discussion of Carbon Capture and Sequestration (CCS), the referenced documents talked almost entirely about the need for coal-based CCS demonstrations. Yet, for the nation to achieve an 83% reduction in GHG's, it is critical that natural gas combined cycle turbine (NGCCT) plants, with over 50% efficiency, also be able to use CCS. Yet, no demonstrations are planned by DOE for NGCCT systems. With their smaller CO2 streams, these demonstrations are critical for commercialization of this technology.

(G) A number of non-technical barriers—including federal, state, and local regulations, market failures, and non-technical risks—impact the rate of deployment of energy technologies. What, if any, role should the Department have in addressing these barriers?

Response:

The demonstration and deployment phases of RD&D should be designed to address market failures (e.g., renter/landlord issues), regulatory barriers (environmental, other), and infrastructure issues that fall between market participants.

As mentioned above, the need to address environmental concerns related to development of the gas shale resource is critical to the full utilization of this domestic, clean energy resource.

For buildings, interior gas piping and venting issues inhibit deployment of some of the higher-efficiency condensing technologies, and need to be investigated. This is one of the infrastructure issues that is not within the purview of the utility or the equipment (appliance) manufacturer, but can result in a failure to fully commercialize the technology.

The role of the USDOE should be to investigate potential market barriers and develop educational materials and activities to draw attention to these obstacles, so that stakeholders and regulators can have an impact on their removal.