



**Emission Reductions Associated with U.S.
Oil and Gas Industry Investments in
Greenhouse Gas Mitigation Technologies**

**Thomas Tanton
President, T² and Associates**

March 2010

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Undertaken for API

Executive Summary

U.S. based oil and gas industry sources report reductions of greenhouse gas emissions totaling 48.3 million metric tons CO₂ equivalent for 2008 compared to 2007.¹ This is equivalent to taking 9.7 million cars off the road.²

Reported reductions in 2008 fall into three major categories:

- fuel substitution, such as increasing natural gas supply through capturing fugitive emissions, replacing more carbon intensive fuels,
- non-hydrocarbon, such as biofuels produced at biorefineries, and,
- end-use, including combined heat and power.

Forty-six percent of the U.S. based oil and gas industry emission reductions between 2007 and 2008 are estimated to have occurred in the fuel substitution category, largely due to enhanced management of methane in the natural gas supply and distribution network. Thirty-five percent of the reductions are estimated to have occurred in the end use category, largely from investment in combined heat and power (cogeneration) at refineries and other facilities. The remainder, 19 percent is in the non-hydrocarbon category.

Reported Emission Reductions 2008 v 2007 Oil and Gas Industry in North America

Category	Emission Reductions (MMTCO ₂ e)	Emission Reductions (percent)
Fuel Substitution	22.1	46%
Non Hydrocarbon	9.4	19%
End Use	16.8	35%
TOTAL	48.3	

¹ Estimates of emission reductions reported herein include both actual reductions and avoided emissions, e.g., a plant expansion with a CHP unit that increases facility emissions but by less than what would have otherwise occurred without the CHP unit.

² Passenger vehicles estimate derived from <http://www.epa.gov/otaq/climate/420f05004.htm>, by dividing total reductions by average passenger vehicle emissions

Introduction

This report provides a compilation of greenhouse gas (GHG) emission reduction estimates reported by the U.S. based oil and natural gas industry and follows the methodology used in summarizing investments made by the industry previously documented in *Key Investments in Greenhouse Gas Mitigation Technologies by Energy Firms, Other Industry and the Federal Government: An Update*, June 2009. The emission reduction estimates for 2007-2008 presented herein were compiled strictly from company reports including annual shareholder reports and various corporate responsibility reports. As discussed in the Methodology section of this report, there are indications this summary of reported reductions is an underestimate of actual reductions.

The more than \$58 billion in GHG mitigation technology investments made by the U.S. based oil and natural gas industry over 2000 to 2008 clearly impacted the 2007-2008 emission reductions given the types of emission reductions documented here. However, it needs to be recognized that other factors make specific linkage between aggregate emission reductions and individual past investments problematic. For example, while this report documents emission reductions between 2007 and 2008, Energy Information Administration data indicate that U.S. crude oil and natural gas drilling activity increased by 6.3% and natural gas production increased by 4.4% at the same time that crude oil production and refinery throughput declined by about 2.5%.³ Further, investments made can often take time to complete and result in emission reductions. Some of the reductions in 2007-2008 are likely due to investments in early to middle years of the 2000-2008 period.

The above cited June 2009 report compiled investments in GHG emission mitigation technologies in North America during the period 2000 through 2008, but made no estimates of the emission reductions that occurred from those investments. Investments were reported for the private sector and the Federal government and by technology/energy category. The data were compiled from a

³ EIA, http://tonto.eia.doe.gov/dnav/pet/pet_pnp_unc_dcu_nus_a.htm;
http://tonto.eia.doe.gov/dnav/pet/pet_crd_crpdn_adc_mbbldpd_a.htm;
http://tonto.eia.doe.gov/dnav/ng/ng_prod_sum_dcu_NUS_a.htm;

review of over 420 company annual reports, federal budget documents, and other public sources. The investments in GHG emission mitigation technologies also may yield other benefits including broadening a company's technological expertise as well as increasing and/or diversifying energy supplies, or improving efficiency.

The GHG mitigating technologies were placed into four categories: fuel substitution, nonhydrocarbon, end-use and enabling technologies, as laid out in the organizational chart on page 9.

The investments mitigate greenhouse gas emissions in a variety of ways.

- Improving efficiency lowers energy use thereby decreasing GHG emissions.
- CHP – also called cogeneration or combined heat and power – saves energy through the simultaneous production of both electricity and thermal energy (steam, hot water, or hot air). According to the *EPA*,⁴ CHP improves energy efficiency by as much as 55 percent.
- LNG (liquefied natural gas) and unconventional natural gas increase the availability of natural gas. The combustion of natural gas emits about 45 percent less carbon dioxide than coal.
- Many renewables, such as solar and wind, provide intermittent electricity with no or significantly less greenhouse gas emissions than through the combustion of hydrocarbon fuels.
- Reduced fugitive gas emissions covers mainly methane emissions from oil and gas production, and emissions associated with pipeline transmission and local distribution to customers. These reductions not only reduce methane emissions into the atmosphere but also increase the supply of lower-carbon natural gas.
- Another way to reduce atmospheric emissions would be to capture the CO₂ that is released from, fossil fuel-fired power plants and store it underground, referred to as carbon capture and storage (CCS). This is the focus of significant and increased attention, as power generation accounts for about one-third of CO₂ emissions from fossil fuel use. Progress in CCS technology

⁴ <http://www.epa.gov/CHP/basic/efficiency.html>

depends heavily on the oil and gas industry's multi-decade experience in using CO₂ to boost the nation's domestic oil production.

National Trends

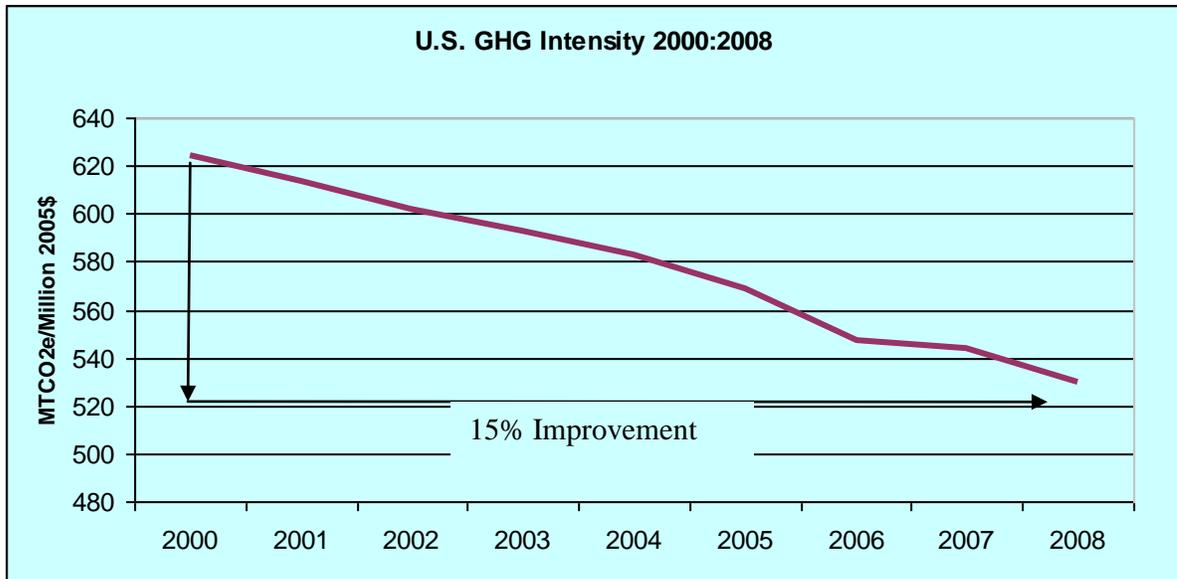
From 2000 to 2008, the carbon dioxide intensity of the U.S. economy—measured as metric tons carbon dioxide equivalent (MTCO₂e) emitted per million dollars of gross domestic product (GDP) — improved by over 15 percent or 1.7 percent per year, as shown in Figure 1.⁵ Oil and gas industry investments over the last decade in GHG mitigating technologies have contributed to this declining trend. For the latest pair of years, carbon dioxide intensity improved by roughly 2.7%, and actual GHG emissions fell by 2.8% over the same period.⁶

At the national level, the decrease in U.S. anthropogenic carbon dioxide emissions and intensity in 2008 resulted primarily from three factors: higher energy prices that led to a drop in petroleum consumption; economic contraction in three out of four quarters of the year resulting in lower energy demand for the year as a whole in all sectors except the commercial sector; and lower demand for electricity combined with lower carbon intensity of electricity supply. In addition, the GHG mitigation investments made by the oil and gas industry made significant contributions to improved carbon intensity and to the overall emission reductions as seen in the trend of improving intensity for the U.S. economy for the 2000-2008 period.

⁵ U.S. Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2008*, Dec 2009.

⁶ U.S. Energy Information Administration, *Ibid.*

Figure 1



Source: U.S. Energy Information Administration *Emissions of Greenhouse Gases in the United States 2008*, Dec 2009

Greenhouse Gas Mitigation Technology Investments

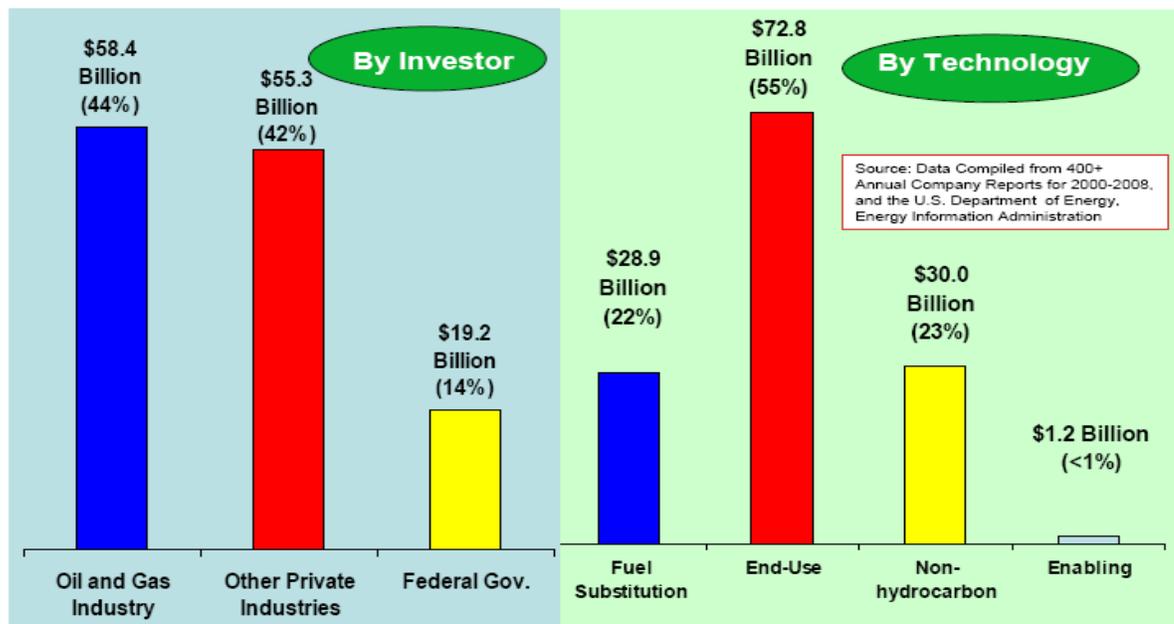
U.S. based companies⁷ and the Federal government invested approximately \$132.9 billion from 2000 to 2008 on greenhouse gas mitigating technologies in the North American market. The U.S. based oil and gas industry invested \$58.4 billion, 44 percent of the \$132.9 billion total, in end-use, fuel substitution, non-hydrocarbon technologies, and enabling technologies. Other private industries invested an estimated \$55.3 billion or 42 percent of the total, predominantly in end-use and non-hydrocarbon technologies. During the same eight-year period, the Federal government invested in a wide array of greenhouse gas mitigation technologies, with expenditures of approximately \$19.2 billion, or 14 percent of the total North American investment (**Figure 2**).⁸

⁷ U.S. based companies include both U.S. companies and foreign-owned companies operating in the U.S.

⁸ State and local alternative-energy investment would add approximately \$2 billion to this total on the public-sector side. <http://www.dsireusa.org/>

Figure 2

GHG Mitigation Investments in North America 2000-2008
(Total Investment=\$133 billion)



Source: *Key Investments in Greenhouse Gas Mitigation Technologies by Energy Firms, Other Industry and the Federal Government: An Update*, June 2009

Oil and Gas Industry Investments from 2000 to 2008

It is estimated that U.S. based oil and gas companies invested \$58.4 billion from 2000 through 2008 in GHG mitigating technologies in the North American market.⁹ (**Figure 2**) This expenditure represents 44 percent of the estimated total of \$132.9 billion spent by U.S. companies and the Federal government. The oil and gas industry invested \$30.6 billion (or 52 percent of its \$58.4 billion sector total) for advanced end-use technologies, mostly for efficiency improvements through combined heat and power (cogeneration), carbon capture and storage¹⁰ and for advanced technology for vehicles. Significantly, this \$30.6 billion investment in end-use technologies represents 42 percent of the estimated total amount (\$72.8 billion) spent by all U.S. companies and the Federal government in this technology category.

The second largest investment share made by the oil and gas industry, roughly 36 percent or \$21.1 billion, was to develop substitute (and less carbon intensive) fuels,

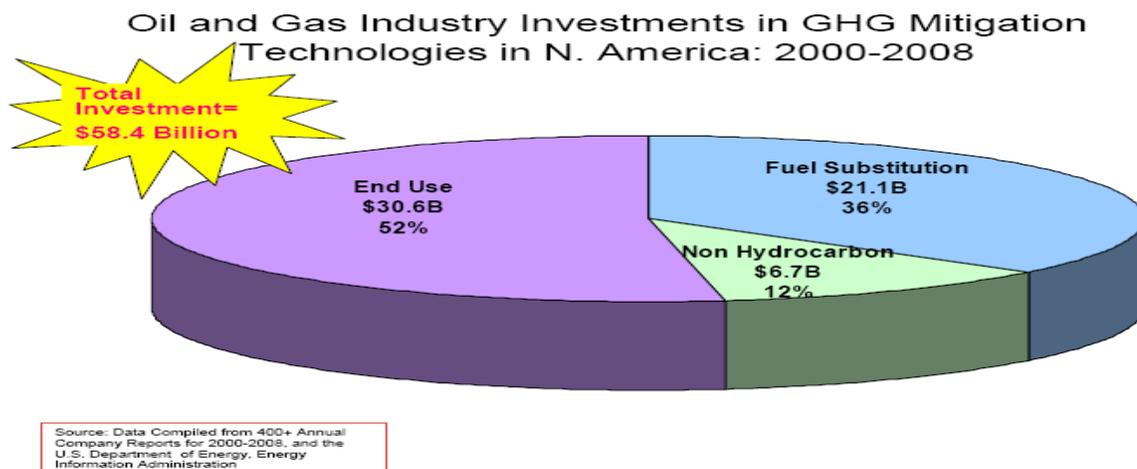
⁹ "North American market" is used herein to include Canada and the U.S.

¹⁰ Carbon Capture and Storage was moved from "enabling" in the May 2008 Report to "end-use" in the June 2009 Investment report.

e.g., LNG, and to reduce methane fugitive emissions. This \$21.1 billion investment in fuel substitution technologies represents 73 percent of the estimated \$28.9 billion invested in total in this technology class. Fuel substitution can have significant impacts on greenhouse gas emission levels. For example, substituting natural gas for coal can reduce carbon dioxide emissions 45 percent or more per unit of energy delivered (and the mitigation improves even further when methane is captured and used, rather than released to the atmosphere).¹¹

Publicly announced nonhydrocarbon investment by the U.S. based oil and gas industry in the North American market is estimated at just over \$6.7 billion for the 2000 – 2008 period, or about 12 percent of its industry total. Significantly, this represents 22 percent of the total industry and Federal government investments of approximately \$30 billion in this technology class. The oil and gas industry’s top investments are in wind and biofuels; expenditures were also made in solar, geothermal, and landfill digester gas.

Figure 3



Source: *Key Investments in Greenhouse Gas Mitigation Technologies by Energy Firms, Other Industry and the Federal Government: An Update*, June 2009

¹¹ This investment in natural gas arguably should have included investments in unconventional gas, such as tight sands, but did not do so. As such, it is an underestimate.

Reported Greenhouse Gas Emissions Reductions by Oil and Gas Industry

Reported emission reductions by the oil and gas industry in the North American market are shown in Table 2. These are reductions that occur from the various companies' operations, such as improved efficiency in energy use in their facilities and improved fugitive emission control.¹²

U.S. based oil and gas industry sources have reported direct emission reductions totaling 48.3 million metric tons CO₂ equivalent for 2008 compared to 2007. The reductions of 48.3 million metric tons is equivalent to taking 9.7 million cars and light trucks off the road.¹³ For comparison, there are 211 million cars and light trucks in the USA, according to the U.S. Department of Transportation¹⁴.

- Forty-six percent of the emission reductions occur in the fuel substitution category, largely due to efforts to enhance management of methane in the natural gas supply and distribution network. This includes projects such as the installation of improved plunger lift seals and lower emission well completion technology.
- Thirty-five percent of the reductions are in the end use category, largely from investments in combined heat and power (also known as cogeneration) at refineries and other facilities. Combined heat and power projects totaled 4670 MW of capacity during the 2000 to 2008 period.
- The remainder of the reductions, 19 percent is in the non-hydrocarbon category, including electrical generation facility construction using wind and solar, as well as biofuels production. Oil and gas industry participants installed over 250MW of wind generation during 2000-2008. **Table 2**

¹² Many reporting companies utilize the SANGEA™ model, which is maintained by API. In conjunction with API, the U.S. oil and natural gas industry has provided a suite of tools for consistently estimating emissions. It includes API's 2009 compendium of emissions estimation methodologies, the SANGEA software for emissions estimation and inventorying, and guidelines (created by the international petroleum organization IPIECA) to assist in the accounting and reporting of emissions. These tools are available at ghg.api.org

¹³ Passenger vehicles estimate derived from <http://www.epa.gov/otaq/climate/420f05004.htm>, by dividing total reductions by average passenger vehicle emissions

¹⁴ <http://www.fhwa.dot.gov/policyinformation/statistics/2008/>

Table 2
Reported Emission Reductions 2008 v 2007
Oil and Gas Industry in North America

Category	Emission Reductions (MMTCO ₂ e)	Emission Reductions (percent)
Fuel Substitution	22.1	46%
Non Hydrocarbon	9.4	19%
End Use	16.8	35%
TOTAL	48.3	

Methodology and Potential Underestimation of Reductions

This analysis reflects a straightforward compilation of reported emission reductions from company reports, including annual shareholder reports and “corporate responsibility reports.”¹⁵

While this methodology is straightforward, there are indications it results in an underestimation of emission reductions.

- First, not all companies reported emission reductions, so the reductions compiled here should be considered conservative.
- Second, methane emission reductions reported in EPA’s Natural Gas STAR program are substantially greater than that reported here. More specifically, the 22.1 million metric tons of CO₂e reductions reported for the Fuel Substitution category includes but is not limited to methane emission reductions from improved exploration and production equipment and practices. However, EPA’s Natural Gas STAR program¹⁶ reports 2008 methane reductions from the production sector of 89.3 billion cubic feet or roughly 24 million metric tons of CO₂e. This exceeds the total reductions reported here for the entire Fuel Substitution category.

Emission reductions reported were then categorized based on company descriptions of how the reductions were achieved. For example, reductions achieved through

¹⁵ Corporate responsibility reports go by a variety of names including “sustainability reports,” “citizenship” and other similar names. We use “Corporate Responsibility” here in the generic sense to include all such reports.

¹⁶ See <http://www.epa.gov/gasstar/accomplishments/index.html#three>

efficiency improvements were assigned to the end use category. Emission reductions that were reported by some companies on a global basis were prorated to the North American market using secondary sources. This was done only in the fuel substitution category, associated with emission reductions due to methane capture from fugitive emissions. In this case we used reported emission reductions from EPA's Natural Gas Star Program to prorate global emission reduction estimates to the North American market.

Some companies reported reductions (or intensity improvements) based upon their equity involvement in shared facilities (such as refinery complexes) while some reported the reductions for the entire facility, especially if they were/are the primary operator of that facility. We include reductions based on equity positions to avoid double counting.

Appendix A

Glossary of Terms

Fuel substitution technologies include liquefied natural gas (LNG), nuclear, and landfill gas.

End-use technologies include efficiency improvements, such as cogeneration (CHP), improved lighting, and carbon capture and storage (CCS).

Non-hydrocarbon technologies include any energy form that is not a hydrocarbon energy source, such as wind and solar.

Enabling technologies include various consortia that are researching and developing a wide variety of technologies, and include several university programs.

Alternative Fuel Vehicles and Advanced Technology Vehicles use both petroleum and nonpetroleum based fuels (or mixtures) or fuel-cell technologies.

Biomass uses plant materials, animal fats and wastes, or woody construction debris to produce energy.

Biorefineries produce a broad slate of products from plant materials and/or animal fats.

Biodiesel is an increasingly important sub-group of this technology. Biodiesel is produced by chemically altering plant oils (e.g., soybean oil) and/or animal fats into diesel fuel substitutes. The term generally refers ONLY to diesel substitutes produced from vegetable oils and/or animal fats. However, we do include other bio-derivatives including those produced as refinery products, such as certain higher alcohols and alkanes.

Carbon Capture and Storage (CCS) is the capture and long term storage of carbon dioxide emissions from combustion processes.

Cogeneration, or combined heat and power (CHP), is the simultaneous production of both electricity and thermal energy (steam, hot water, hot air).

Ethanol is currently produced by the fermentation of various sugars, primarily from corn and sugar cane. Sugar cane is not a significant source in the North American market. Technologies to produce ethanol from cellulose are in the development stage.

Gasification is a thermal process for converting solid materials (e.g. biomass, coal or petroleum coke) into a synthetic gas. The gas may be used directly, or converted to hydrogen or liquid fuels.

Gas Flaring occurs when crude oil is extracted from the earth and natural gas associated with the oil is produced to the surface as well. In areas of the world lacking infrastructure and markets, this associated gas is usually flared (burned) or sometimes vented (emitted as unburnt gas).

Liquefied natural gas (LNG) is natural gas that has been super-cooled to a liquid for transport. This dramatically reduces the volume for cost-effective transport over longer distances.

Landfill gas (LFG) is methane that is produced anaerobically in landfills from the decomposition of waste material.

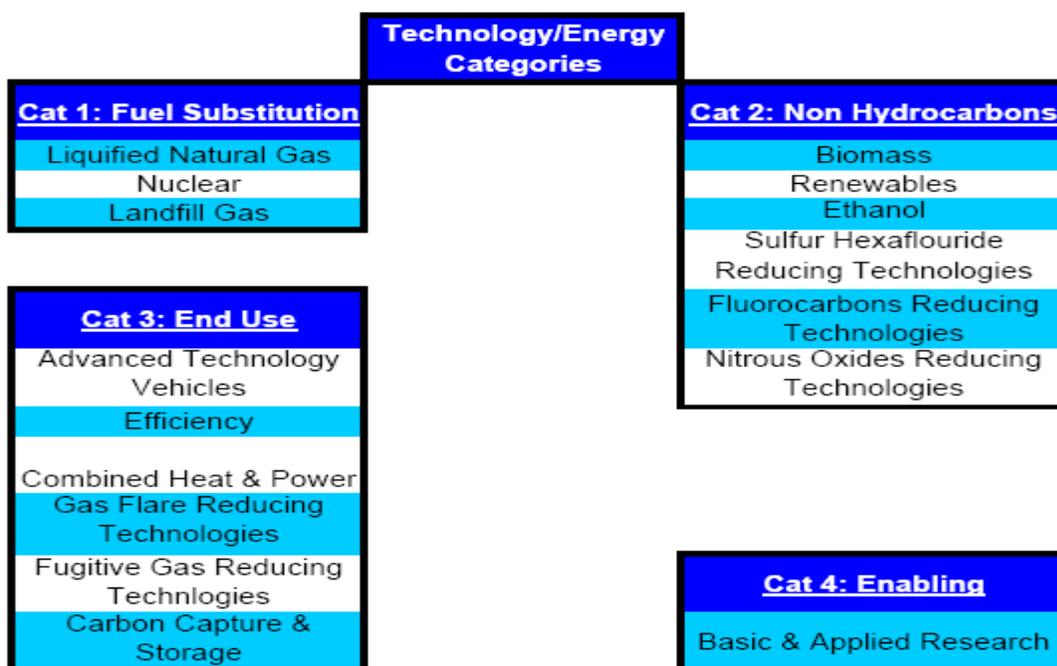
SF6 is sulfur hexafluoride. It is used in the electrical industry as a dielectric and within the magnesium production industry. It is a potent greenhouse gas.

Fluorocarbons are various chemicals used as either refrigerants or industrial cleaning agents. Several of them are potent greenhouse gasses, while others can deplete ozone. Industry continues to develop substitutes for those fluorocarbons.

Nitrous Oxides (N₂O) are produced by both biogenic and anthropogenic sources. Primary anthropogenic sources of N₂O are agricultural practices related to the use of fertilizer. Nitrous oxide is also produced naturally from a wide variety of biological sources in soil and water, particularly microbial action in wet tropical forests. In agriculture, it can be reduced through improved farming practices, such as low-tillage.

A *Disruptive Technology* is a new technological innovation, product, or service that overturns the existing dominant technology in the market, despite the fact that the disruptive technology is radically different from the leading technology and requires fundamental infrastructure and support changes.

Categorization of GHG Mitigating Technologies



Global Warming Potential of Greenhouse Gases

Each greenhouse gas has a different impact or “global warming potential” that is measured relative to carbon dioxide (CO₂). The gases that are included within this analysis have the following global warming potentials¹⁷:

*Actual value depends on specific chemical within a class

¹⁷ U.S. Environmental Protection Agency, Inventory Of U.S. Greenhouse Gas Emissions And Sinks: 1990-2007 (April 2009); <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

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