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EQUITY RESEARCH: GLOBAL

Thematic Investing

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Global

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Climatic Consequences

Investment Implications of a Changing Climate

- **Investment Issue — For *investors*, the issue is *not whether* climate change is occurring. Today a variety of entities (governments, regulators, corporations, and individuals) *are reacting* to the perceived climate change threat, creating a number of *near-term* opportunities.**
- **Physical Implications — While physical implications may become apparent over the long term, there may already be some repercussions today — warmer winters and hotter summers in the U.S., droughts in Spain and Australia, and an increased frequency of intense hurricanes in the Gulf of Mexico.**
- **Regulatory Implications — There has already been a move to regulate greenhouse gases, ranging from international conventions sponsored by the United Nations, to legislation at the state level in the U.S. Importantly, companies with international operations are increasingly subject to various emissions regulations and standards in key markets, most notably today in the EU.**
- **Behavioral Implications — Even when not facing imminent regulation, a growing number of corporations are pursuing various climate strategies.**
- **Who Will Benefit? — We identify 74 companies (across 21 industries and based in 18 countries) that seem well positioned to benefit from these trends.**

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Citigroup, Inc. is a financial supporter of the World Resources Institute, and Todd Thomson, Chairman and CEO, Citigroup Global Wealth Management, serves on WRI's board of directors.

Although climate change is a long-term issue, there are a number of near-term investment opportunities.

Multiple agendas.
Climate initiatives are, in many regions of the world, part of a much broader agenda that covers a range of issues — economic (energy efficiency), political (security of energy supply), and social ("fuel poverty").

A climate "tipping point."
A number of *countries* appear to be close to a tipping point that will result in greater regulatory involvement in climate issues. For example, in the U.S., leading candidates for both the Democratic and Republican presidential nominations support mandatory greenhouse gas (GHG) emission limits. Then, too, it seems that climate initiatives being undertaken by consumers, litigants, and investors will also lead to a tipping point in *corporate* behavior.

GHG abatement is not necessarily "green."
Nuclear power plants are completely carbon-free sources of electricity, but they produce radioactive waste that needs to be stored for thousands of years. Palm oil and sugarcane cultivation for the production of biofuels threaten the habitats of rare species in some parts of the world (e.g., orangutans in Malaysia).

Well positioned.
Among companies that are well positioned:

- *Physical Implications*: Select U.S. natural gas exploration and production companies, farm equipment suppliers, agricultural biotechnology companies, and select U.S. property insurers.
- *Regulatory Implications*: Select electric utilities, engineering and construction firms, capital goods companies, natural gas suppliers, select automobile companies, food processors, fertilizer suppliers, wind and solar power companies, and companies focused on building energy efficiency.
- *Behavioral Implications*: "Climate consultants" offering services that promote efficient energy usage, and companies that facilitate carbon trading.

Our thematic outlook is not without risk.
The key risk to our climatic consequences theme is that governments, regulatory organizations, and/or corporations no longer feel compelled to take *near-term* steps to respond to the perceived threat of global climate change. In addition, part of our analysis is based on the assumption that restrictions on the emissions of various greenhouse gases will be tightened within a number of countries in future years, which may not happen for a variety of reasons, including political and economic considerations at a national and local level.

We further note that our analysis does not consider stock-specific metrics such as valuation, EPS, and P/E ratios, or balance sheets, market capitalization, and liquidity. Accordingly, when making decisions, investors should view thematic analysis as only one input. Further, since this analysis employs a longer-term methodology, the conclusions of a fundamental analysis may be different.

Figure 1. Climatic Consequences Companies

See Appendix D for more information

Acciona	Gazprom
ACE Limited	General Electric
Aguas de Barcelona	GFI Group
Allegheny Technologies	Honda Motor
American Intl Group	Iberdrola
Arch Capital Group	IJM Plantations
Archer Daniels Midland	IOI Corp
Bajaj Hindusthan	Itron
Balrampur Chini	Johnson Controls
BG Group PLC	KL Kepong
BorgWarner	Magna International
Brasil Ecodiesel	Monsanto
Bunge Limited	Neste Oil Corporation
Centrica PLC	Noble Group
Chesapeake Energy Corp	Ormat Technologies
Chicago Mercantile Exchange	Peugeot SA
Compagnie de St Gobain	Philips Electronics
Conergy AG	Potash Corp of Saskatchewan
Constellation Energy	Q-Cells
Cosan SA	RPS Group PLC
CropEnergies AG	RWE AG
Deere	Schneider Electric
DSM NV	Sharp
DuPont	Shaw Group
Ebro Puleva	Siemens AG
Electricité de France	SIG PLC
Emerson	SolarWorld
ENCE	Southwestern Energy Co
Energy Developments	SunPower Corp
Entergy Corp	Suntech Power
ESCO Technologies	Swiss Reinsurance
Evergreen Solar	Syngenta AG
Exelon Corp	Terra Industries
Fortum Oyj	Toyota Motor
FPL Group	TXU Corp
Gamesa	Vestas Wind Systems
Gaz de France	XTO Energy Inc

Source: Citigroup Investment Research

Figure 2. Climatic Consequences: A Summary

Physical Implications: *Whatever the exact causes, in recent years there have been a number of unusual climatic trends affecting: (i) temperature — a slow and almost continual warming of the global climate; (ii) precipitation — an increased risk of drought duration, severity, and extent; and (iii) wind — an increase in the frequency of intense hurricanes.*

➤ **Warmer winters and hotter summers** would likely lead to a *net decline* in U.S. demand for natural gas. However, in the aggregate, climate change issues — most notably, an increased use of "clean" natural gas for electricity generation by utilities — would likely be *supportive* of U.S. natural gas prices. ***Chesapeake Energy, Southwestern Energy,*** and ***XTO Energy*** have relatively "efficient" operations and no exposure to the hurricane-prone Gulf of Mexico.

➤ **Drought conditions** are making water a scarce commodity in many areas. As many parts of Spain have been experiencing drought, Spanish per capita water consumption is at record highs. ***Aguas de Barcelona*** is the leader in water supply in Spain, with a 55% share of the privatized market. Reduced harvests of some drought-afflicted crops are pushing up the prices of those crops globally. High crop prices are having a positive impact on U.S. farmers' income, and on demand for ***Deere's*** farm equipment. ***Monsanto*** is working on the development of drought-tolerance traits in crops.

➤ **An increase in the frequency of intense hurricanes** has led many large insurers and reinsurers to reduce their exposure to hurricane-prone regions of the U.S. The absence of competition by "mega-carriers" in some populous states creates an opportunity for smaller companies, including those competing in the "excess and surplus" segment, e.g., ***ACE Ltd.*** and ***Arch Capital Group.***

Regulatory Implications: *Fully half of carbon dioxide emissions result from the burning of fossil fuels for electricity generation (32%) and transportation (18%), e.g., automobiles. The building sector accounts for a significant portion (20%) of carbon dioxide emissions, both directly (fossil fuel combustion) and indirectly (consumption of electricity). Not surprisingly, then, these three sectors are the focus of several regulatory initiatives, including mandated increases in the use of renewable energy sources and alternative fuels. Greater fuel efficiency is another strategy favored by regulators.*

➤ **Electricity generators** that have exposure to relatively "clean" nuclear and gas generation are well positioned *in the long run*, compared to operators of "dirty" coal-fired plants. However, the European Union Emissions Trading Scheme is resulting in *short-term* windfall profits, even for "dirty" utilities.

- *Electric Utilities.* ***Constellation Energy, Electricité de France, Entergy Corp, Exelon Corp, Fortum Oyj,*** and ***FPL Group*** are operators of nuclear power plants. ***RWE AG,*** which emits significant amounts of carbon dioxide, has been reaping windfall profits.
- *Engineering and Construction.* ***Allegheny Technologies, General Electric, Shaw Group,*** and ***Siemens*** benefit from increased spending on "cleaner" power generation.
- *Natural Gas.* ***BG Group*** and ***Centrica*** benefit from increased demand for natural gas in the U.K. ***Gaz de France*** is one of the largest gas utilities in Europe. ***Gazprom*** is the sole exporter of Russian natural gas to Europe.

➤ **Automobile emissions** can be reduced by drivetrain technologies that increase fuel efficiency, by vehicle load (weight) reduction, and by switching to less-carbon-intensive fuels; the companies listed below are poised to benefit. Original equipment manufacturers: ***Honda*** (advanced diesel), ***Peugeot SA*** (advanced diesel), and ***Toyota Motor*** (hybrid technology). Auto parts suppliers: ***BorgWarner*** (fuel efficiency and diesel) and ***Magna International*** (vehicle load reduction).

➤ **Alternative fuels and renewable energy sources** are increasingly feasible options in the automotive and power generation sectors, respectively.

- *Alternative fuels.* ***Archer Daniels Midland, Cosan SA, CropEnergies, Ebro Puleva,*** and ***Noble Group*** have direct exposure to global ethanol demand. ***DSM***, ***DuPont, Monsanto,*** and ***Syngenta*** are developing biotechnology products that offer the potential for greater ethanol yields. ***Deere*** benefits from rising farmer income driven by burgeoning ethanol demand. ***Potash Corp.*** and ***Terra Industries*** are fertilizer companies that supply important nutrients for grain cultivation. ***Bajaj Hindusthan*** and ***Balrampur Chini*** benefit from a higher trading price band for sugar, arising from diversion of sugarcane volumes to ethanol production. ***Brasil Ecodiesel*** is a leading biodiesel producer in Brazil. ***Bunge,*** the largest vegetable oil producer in the world, benefits from growing demand for biodiesel. ***Neste Oil*** is a Finnish independent refiner that focuses on high-value-added petroleum products, including biodiesel. ***IJM Plantations, IOI Corp,*** and ***KL Kepong*** own Malaysian palm oil plantations, which also benefit from global biodiesel trends.
- *Wind.* ***Gamesa, General Electric,*** and ***Vestas Wind Systems*** are turbine manufacturers. ***Acciona, FPL Group,*** and ***Iberdrola*** are wind power generators.
- *Landfill gas and geothermal.* ***Energy Developments*** has landfill gas generation facilities in Australia, the U.K., and the U.S. ***Ormat Technologies*** is a leading geothermal company worldwide.
- *Solar.* ***Conergy*** (a solar system integrator), ***Evergreen Solar*** (a manufacturer of solar wafers, cells and modules)***, Q-Cells*** (a solar cell manufacturer), ***Sharp*** (a solar cell manufacturer), ***SolarWorld*** (a manufacturer of everything from silicon wafers to solar panels), ***SunPower*** (specializing in silicon solar cells, solar panels, and inverters), and ***Suntech Power*** (a manufacturer of silicon crystal solar cells), compete in various parts of the solar equipment value chain.

➤ **Building and housing efficiency standards** are being tightened in order to promote reduced consumption of energy, both directly (fossil fuel combustion) and indirectly (consumption of electricity).

- *Thermal efficiency*: ***Compagnie de Saint Gobain***, ***Emerson, Johnson Controls,*** and ***SIG PLC*** offer products and services that improve the thermal efficiency of buildings.
- *Electricity efficiency*: ***ESCO Technologies*** and ***Itron*** manufacture "smart meters." ***Philips Electronics*** and ***Schneider Electric*** manufacture *products* that promote efficient use of electricity.

Behavioral Implications: *Even when not facing imminent regulation, a growing number of corporations are pursuing various climate strategies.*

➤ **"Climate consultants"** — including ***Emerson, Johnson Controls,*** and ***Siemens*** — are facilitating the reduction of GHG emissions by offering *services* that promote efficient energy usage.

➤ **GHG emissions offsets** are being traded by a growing number of companies, including those facing emissions restrictions, and those that voluntarily desire to be "carbon neutral." ***Balrampur Chini, ENCE,*** and ***Energy Developments*** generate emission reduction credits. ***American International Group, Chicago Mercantile Exchange, GFI Group, Noble Group, RPS Group PLC,*** and ***Swiss Reinsurance*** are well positioned to develop products and services that facilitate the burgeoning market in carbon trading.

➤ **Being "grandfathered"** might be the goal of ***TXU Corp.,*** which is planning on rapidly building a large number of coal-fired power plants in the U.S., where there are currently no federal restrictions on carbon dioxide emissions.

Source: Citigroup Investment Research

420,000 Years of Climate Change

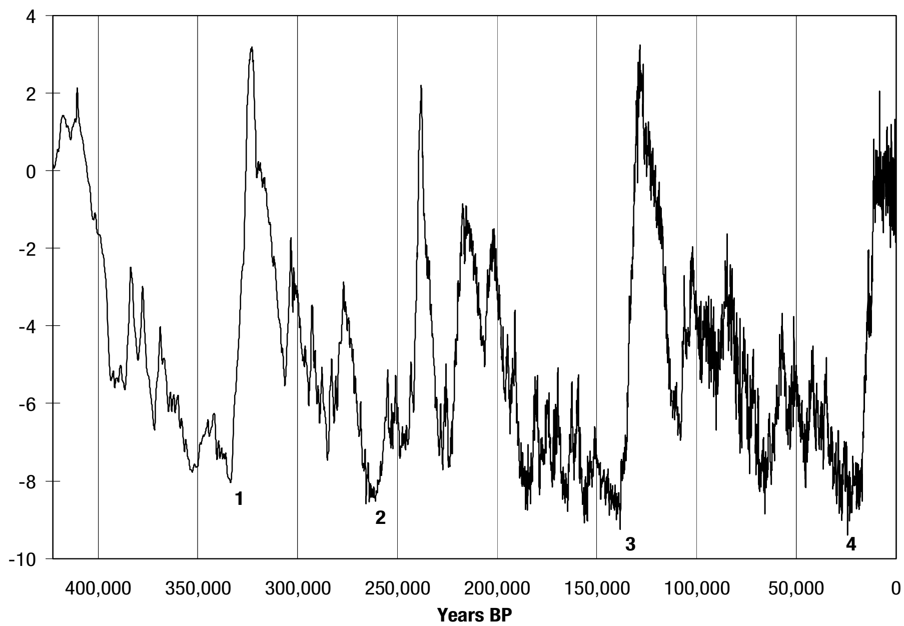
In 1998, an international team of scientists finished drilling the deepest ice core ever (up to that time), to a depth of 3,623 meters (over two miles) through the Antarctic ice sheet at Russia's Vostok Station. Ice cores appeal to scientists because their entrapped air inclusions provide records of past changes in atmospheric composition.[1]

In the past 420,000 years, there have been four transitions from glacial to warm periods.

The Vostok ice core captured about 420,000 years of climate[2], through four transitions from glacial to warm periods: the first about 335,000 years before the present ("BP"), then at 265,000, 135,000, and 25,000 years ago — see "1," "2," "3," and "4," respectively, in Figure 3.

Figure 3. Variation with Time of the Vostok Temperature Record from the Modern Surface Temperature

Variation in degrees Celsius between present (= 0) and years before present ("BP")



Source: J.R. Petit et al., *Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica*, Nature 399 (1999)

As Figure 4 illustrates, the glacial periods have typically lasted *much longer* than the warmer intervals. In summary, Figure 3 and Figure 4 illustrate that previous transitions were characterized by a steady warming over the course of 16,000 years, on average, climaxing in a peak in temperature, which was then followed by a steady cooling over the next 87,000 years, on average.

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[1] Note that, because air bubbles do not close at the surface of the ice sheet but, instead, well below the surface, the air extracted from the ice is younger than the surrounding ice — some scientists have reported that the age difference between air and ice may be about 6,000 years during the coldest period.

[2] Subsequent studies have captured more climate data. For example, in 2002, the European Project for Ice Coring in Antarctica (EPICA) extended the record back to 650,000 years before the present.

Figure 4. Transitions from Glacial to Warm Periods

Length of warming and cooling

	Years BP	Variation in Degrees C	Years BP	Variation in Degrees C	Length of Warming	Length of Cooling
Transition 1	333,602	-8.0	322,638	3.2	10,964	
	322,638	3.2	265,595	-8.6		57,043
Transition 2	265,595	-8.6	237,975	2.2	27,620	
	237,975	2.2	138,193	-9.2		99,782
Transition 3	138,193	-9.2	128,357	3.2	9,836	
	128,357	3.2	24,363	-9.4		103,994
Transition 4	24,363	-9.4			?	
				Average	**16,140**	**86,940**

Source: J.R. Petit et al., op cit, Citigroup Investment Research

Previous transitions were characterized by a steady warming, which was then followed by a steady cooling.

What has been "abnormal" thus far is the absence of a cyclical cooling.

It seems, however, that this pattern is *not* being followed in the current cycle. After a rebound from the frigid late Ice Age (during which the inhabitants of caves located in southern France drew images on the walls of the wooly mammoths and other animals they hunted in the glacial climate — see Figure 5), temperatures have remained relatively stable over the course of the past 11,000 years. *So, what has been "abnormal" thus far is the absence of a cyclical cooling.*

Wooly mammoths roamed southern France approximately 15,000 years ago, in a glacial climate.

Figure 5. "Mammoth with the Eye"

18,000 – 13,500 B.C.

Source: Grotte de Rouffignac, France

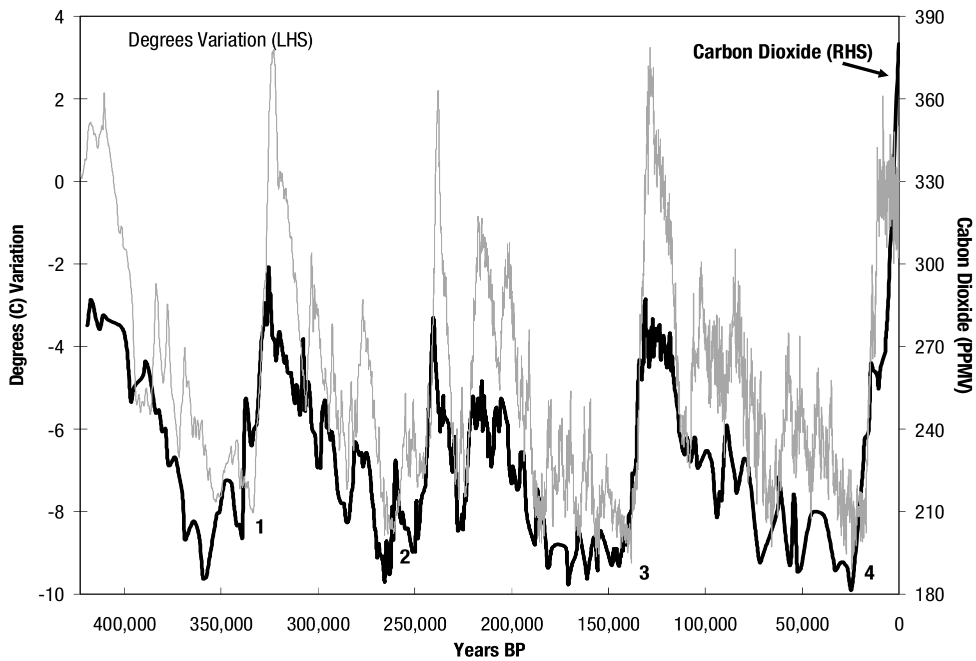
Transitions from glacial to warmer periods were accompanied by increases in atmospheric carbon dioxide.

Importantly, in addition to providing information about temperatures, the Vostok ice core also documents changes in atmospheric concentrations of important greenhouse gases (GHGs), including carbon dioxide. As Figure 6 illustrates, *all* of the four Vostok transitions from glacial to warmer periods were accompanied by increases in atmospheric carbon dioxide, from 200 parts per million by volume (PPMV) to 290 PPMV, on average. However, Figure 6 also illustrates that, at about 380 PPMV, *carbon dioxide levels today are 25% above prior peak levels.*

Carbon dioxide levels today are 25% above prior peak levels.

Figure 6. Variation with Time of Temperature and Carbon Dioxide Levels

Variation between present (= 0) and years before present ("BP")



Source: J. R. Petit et al., op cit,

At the risk of stating the obvious, the activities of mankind were hardly a factor causing GHGs 100,000-plus years ago. But, regardless of the exact pattern of cause and effect between climate change and GHGs in previous transitions (we discuss some theories in Appendix B), *the presence of GHGs in the environment is conducive to temperature increases*, given that such gases warm the earth's surface by trapping solar energy.

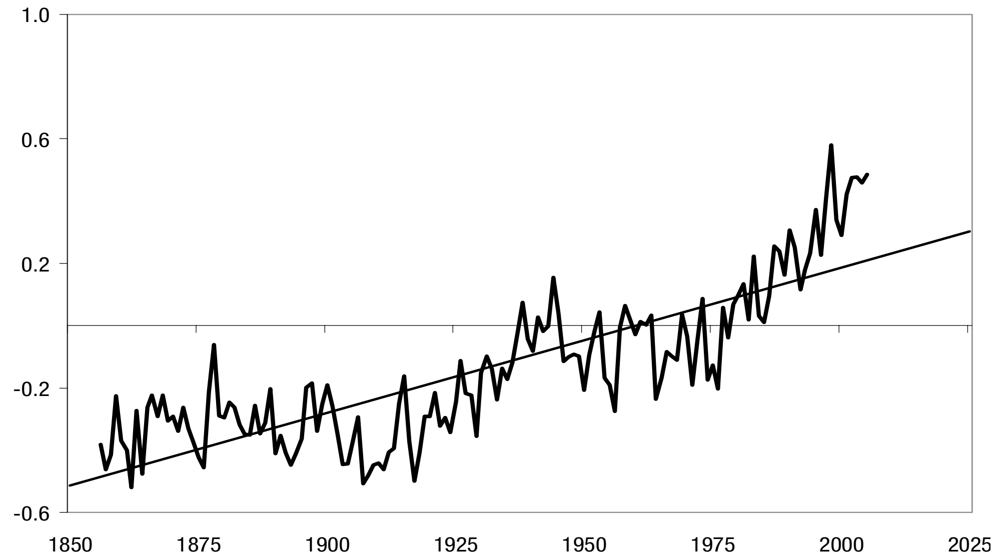
Civilization and Climate

Examining a shorter time period, over the past 100 years, the global climate has warmed slowly and almost continually (see Figure 7). As outlined in Appendix B, climate change can occur as a result of *internal variability* within the climate system (e.g., changes in the orbital parameters of the earth that likely trigger the end of a glacial period). Then, too, climatic changes can be the result of *external factors*, both natural (e.g., volcanic activity) and man made ("anthropogenic").

Over the past 100 years, the global climate has warmed slowly and almost continually.

Figure 7. Global Annual Temperature Anomalies (Degrees Celsius), 1856–2005

Relative to the 1961-1990 mean, with trend line added



Source*:* University of East Anglia, Norwich, United Kingdom

A body of the scientific research exploring the causes of *recent* climate change has pointed to anthropogenic factors as the likely cause of the observed variability in the climate system. For example, in computer climate simulations,[3] the surface temperature warming that resulted from known fluctuations in solar radiation (discussed in Appendix B) between 1650 and the present amounts to only 0.45° C. Less than 0.25° C of warming from solar radiation can be attributed to the period 1900–90, when surface temperatures rose 0.6° C. So, changes in solar radiation appear to account for *less than half* of 20th century warming.

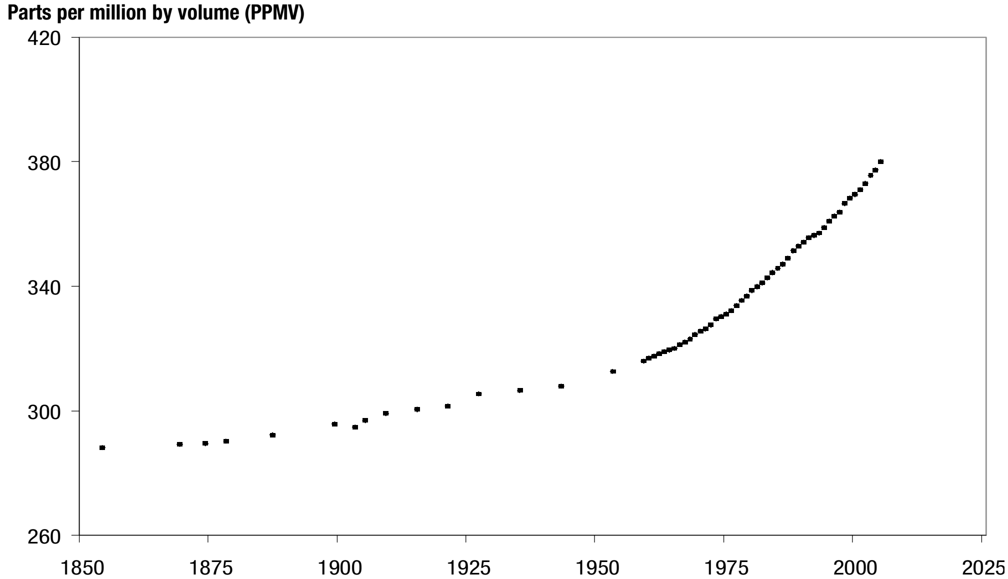
Atmospheric Greenhouse Gas Emissions

With regard to other possible causes of surface temperature warming, carbon dioxide concentrations *rose dramatically* at the very end of the time series illustrated in Figure 6, corresponding to the past 150 years and the emergence of the modern industrial age — see Figure 8.

[3] *What's Driving Climate Change in the 20th Century — Changes in Solar Radiation or the Buildup of Greenhouse Gases?*, U.S. Global Change Research Program Seminar, November 23, 1999

Figure 8. Atmospheric Carbon Dioxide Concentrations Since the Industrial Age

Carbon dioxide concentrations rose dramatically during the past 150 years.



Source: Carbon Dioxide Information Analysis Center

According to the Intergovernmental Panel on Climate Change (IPCC), about three-quarters of the anthropogenic emissions of carbon dioxide into the atmosphere during the past 20 years have been due to fossil fuel burning (i.e., coal, oil, and natural gas). The rest was predominantly due to land-use change, especially deforestation (in the course of photosynthesis, plants and trees capture carbon dioxide).

Significantly, carbon dioxide is not the only potential cause of global warming — other GHGs, such as methane and nitrous oxide, *have a much greater impact per unit.* So, for example, as Figure 9 illustrates, methane has 23 times the heat-trapping impact of carbon dioxide.

Figure 9. Global Warming Potential Relative to Carbon Dioxide

Methane and nitrous oxide have a much greater global warming potential than carbon dioxide.

Source	Gas	Carbon Dioxide Equivalent	Share of Global GHGs
	Carbon Dioxide (base)	1	77%
Natural and Manmade	Methane (CH4)	23	14
	Nitrous Oxide (N2O)	296	8
	Hydrofluorocarbons	12 - 12,000	<1
Manmade	Perfluorocarbons	1 – 14,900	<1
	Sulfur Hexafluoride	22,200	<1

Source: Intergovernmental Panel on Climate Change and World Resources Institute

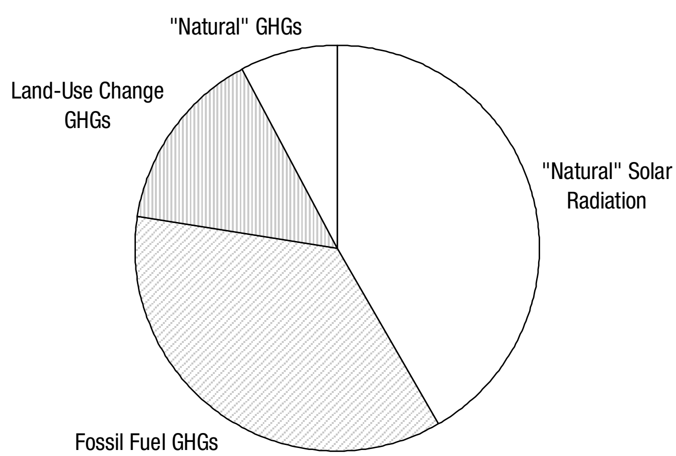
Similar to the pattern for carbon dioxide, the concentration of other GHGs in the atmosphere has risen significantly too:

- *Methane*. According to the IPCC, the present atmospheric methane concentration has not been exceeded during the past 420,000 years. Slightly more than half of current methane emissions are anthropogenic; e.g., use of fossil fuels, cattle, wetlands rice cultivation, and landfills. (Note that methane also has natural sources, e.g., bogs, swamps, and wetlands.)
- *Nitrous Oxide*. The IPCC has concluded that the present atmospheric nitrous oxide concentration has not been exceeded during at least the past 1,000 years. About one-third of current nitrous oxide emissions are anthropogenic, e.g., due to agricultural practices (such as fertilizer application) and the chemicals industry. With regard to other emissions, the gas also has natural sources, e.g., soils.

So, with "natural" factors accounting for only about one-half of 20th century surface temperature warming, it would seem that anthropogenic activities that create GHGs are a key cause of variability in the climate system — see Figure 10.

Human activities that create GHGs — land-use change and fossil fuel combustion — are likely a key cause of surface temperature warming.

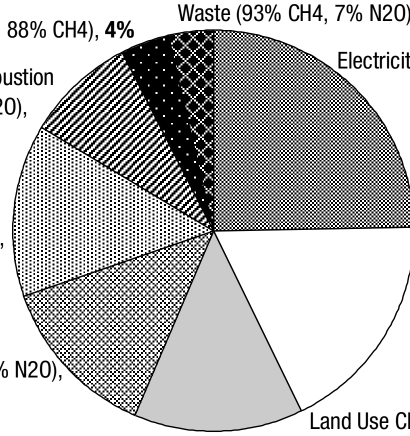
Figure 10. Likely Causes of 20th Century Surface Temperature Warming



Source: Citigroup Investment Research estimates

Figure 11 and Figure 12 summarize the key economic sectors responsible for global anthropogenic GHG emissions — see Appendix A for more details.

Figure 11. Share of Global GHG Emissions by Sector



Source: Citigroup Investment Research and World Resources Institute

Figure 12. Global GHG Emissions by Industry

Million tons of carbon dioxide

	Carbon Dioxide *(Combustion)*	**Carbon Dioxide** *(Electricity)*	**Methane** *(CH4)*	**Nitrous Oxide** *(N2O)*	**Other**	**Total**
Buildings: Residential	1880	2267				**4147**
Transport: Road	4123					**4123**
Oil/Gas Extraction & Refining	189	1412	1016			**2617**
Agriculture: Soils				2509		**2509**
Buildings: Commercial	703	1569				**2271**
Livestock & Manure			1931	191		**2122**
Industry: Other	1057	979	6		51	**2093**
Chemicals	1036	589		161	226	**2013**
Cement	1512	76				**1588**
Unallocated Fuel Combustion	254	664	273	260		**1451**
Iron & Steel	917	402				**1319**
Transport: Rail, Ship, Other	841	111				**952**
Waste: Landfills			822			**822**
Electricity T&D Losses		765			24	**789**
Transport: Air	668					**668**
Waste: Wastewater, Other			564	97		**661**
Rice Cultivation			609			**609**
Non-Ferrous Metals	160	349			74	**583**
Coal Mining, Processing		139	436			**575**
Agricultural Energy Use	374	200				**573**
Machinery	120	307				**427**
Food & Tobacco	219	201				**420**
Pulp, Paper, Printing	172	240				**412**
Agriculture: Other			238	153		**392**
Total*	**21843**	**10269**	**5896**	**3372**	**374**	**41755**

*Includes 7,619 million tons of carbon dioxide from Land Use Change & Forestry

Source: World Resources Institute

Climatic Consequences

What will be the extent of the climate change that appears to be under way today? Professor Wallace Broecker, an authority on climate, has written[4] that, were the Atlantic's conveyor circulation (that results in an enormous northward transport of heat) to stop (because of, say, melting glaciers), then

> winter temperatures in the North Atlantic and its surrounding lands would abruptly fall by five or more degrees. Dublin would acquire the climate of Spitsbergen, almost 1,000 kilometers north of the Arctic Circle.

Similarly, according to Professor Broecker, London would experience the winter cold that now grips Irkutsk in Siberia. Nevertheless, he is cautiously optimistic:

> A conveyor shutdown or comparable drastic change is unlikely, but were it to occur, the impact would be catastrophic. The likelihood of such an event will be highest between 50 and 150 years from now, at a time when the world will be bulging with people threatened by hunger and disease and struggling to maintain wildlife under escalating environmental pressure. *It behooves us to take this possibility seriously* [italics added].

Just as Professor Broecker implores, today a variety of entities — ranging from governments to regulatory organizations to corporations — *are reacting* to the issues surrounding global climate change. It's the opportunities that will arise over the next three to five years due to the reactions to the perceived threat of global climate change that are the focus of this report.

To be sure, an event such as the shutdown of the Atlantic's conveyor circulation, as outlined by Professor Broecker, would have catastrophic implications, but with the likelihood of such an event "highest between 50 and 150 years from now" such a scenario is outside the time horizon of investors today. That said, as we discuss in detail below, in recent years there have been some natural occurrences that *may* be connected to climate change, e.g., an increase in the frequency of intense hurricanes.

In summary, global climate change issues have three distinct implications for investors:

- *Physical* implications — these may, or may not, be material in the next three to five years.
- *Regulatory* implications — governments are already imposing regulations, e.g., pertaining to GHG emissions.
- *Behavioral* implications — even when not facing imminent regulation, a growing number of corporations are pursuing various climate strategies, perhaps in anticipation of potential litigation and reputation risks.

[4] Wallace S. Broecker, *Chaotic Climate,* Scientific American, November 1995

Key Climatic Variables

The Intergovernmental Panel on Climate Change (IPCC) glossary definition of "climate" is as follows:

> Climate in a narrow sense is usually defined as the "average weather" or, more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time, ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as *temperature, precipitation, and wind* [italics added].

In that context, we discuss below some of the apparent physical manifestations of climate change.

Rising Sea Levels

The global temperature levels illustrated in Figure 7 are derived by combining surface air temperatures over land *and* sea surface temperatures. With regard to sea surface temperature, as ocean water warms, it expands, occupying more space. Sea level also changes when the mass of water in the ocean increases or decreases, which occurs when ocean water is exchanged with the water stored on land.

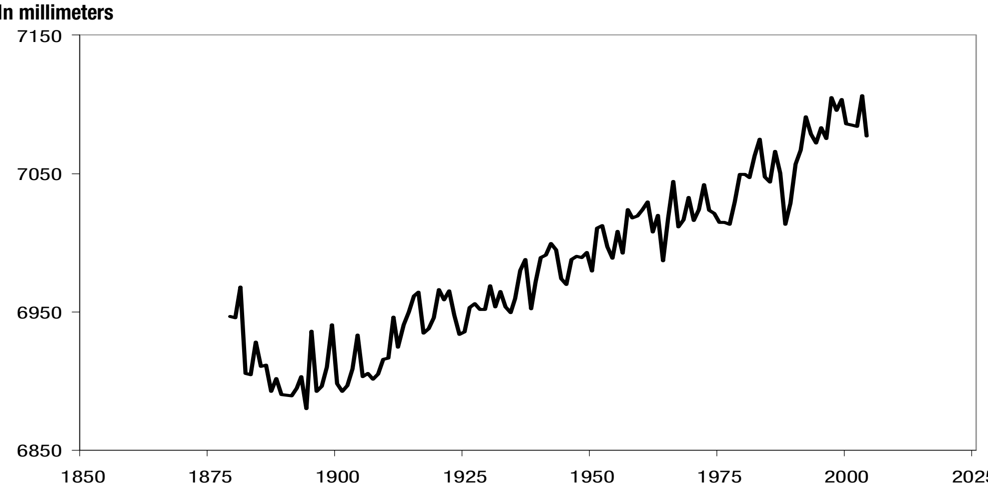
The major store of water on land is the water frozen in glaciers and ice sheets. While glaciers and mountain ice caps make up only a few percentage points of the world's land-ice area, they are *more sensitive* to climate change than the larger ice sheets in Greenland and Antarctica, because those ice sheets are in colder climates with low melting rates.

As Figure 13 illustrates, global sea levels have been rising. Although some scientists believe part of this increase is due to natural variations, other scientists believe global warming has played a large part, in the form of both ocean thermal expansion and melting glaciers and ice caps.

Global sea levels have been rising.

Figure 13. Average Sea Level in 23 Global Locations*

In millimeters



*Locations based on those in *Global Sea Rise: A Redetermination*, Bruce C. Douglas, Surveys in Geophysics, 1997

Source: Permanent Service for Mean Sea Level

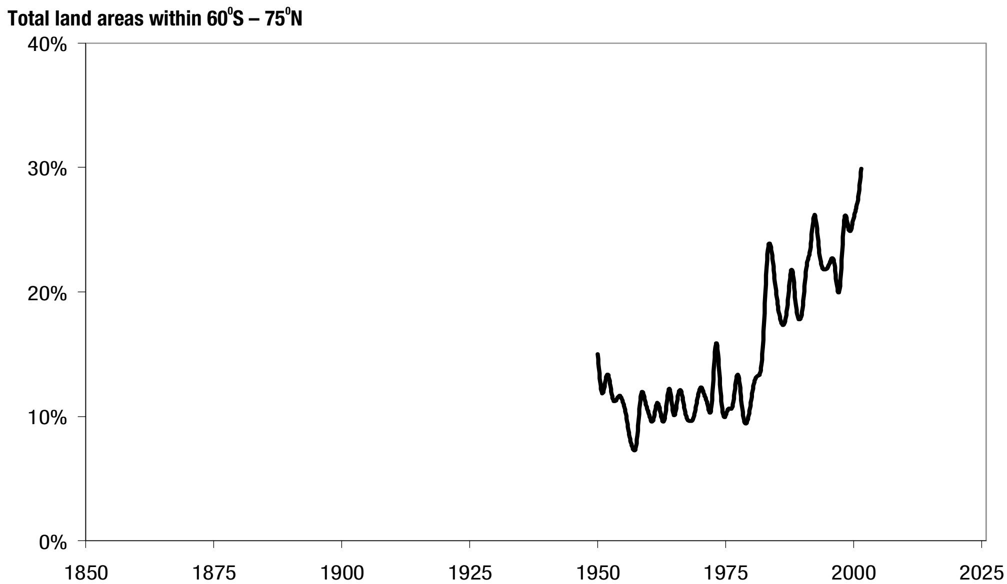
Droughts

In Appendix B, we discuss how, during the Younger Dryas period (11,500–10,600 B.C.), *natural* global warming caused a huge amount of fresh water to flow into the Labrador Sea, cutting off the northward flows that had kept Europe several degrees warmer than equivalent latitudes elsewhere. Subsequently, temperatures fell rapidly in Europe, while, in many eastern Mediterranean lands, the Younger Dryas ushered in a thousand year drought, as cold, dry winds from the northeast (e.g., modern Siberia) replaced moist westerly winds from the Atlantic and Mediterranean.

Academic studies suggest global warming has increased the risk of droughts.

Recent academic studies provide evidence that *anthropogenic* global warming has increased the risk of drought. A 2004 analysis[5] by scientists at the National Center for Atmospheric Research found that "the global very dry areas...have more than doubled since the 1970s, with a large jump in the early 1980s" (see Figure 14). In particular, "most parts of Eurasia, Africa, Canada, Alaska, and eastern Australia became drier from 1950 to 2002."

Figure 14. Percentage of Total Global Land Area in Very Dry Conditions



Source: National Center for Atmospheric Research

The study concluded that the results were:

> …consistent with increased evaporation under greenhouse gas-induced warming, as predicted by comprehensive coupled climate models. Global temperature increases have become pronounced after the 1970s and have been attributed to human-induced climate changes arising primarily from greenhouse gases. Higher temperatures increase the water-holding capacity of the atmosphere and thus increase potential evapo-transpiration. Hence global warming not only raises temperatures, but also enhances drying near the surface...The increased risk of drought duration, severity, and extent is a direct consequence…

[5] *A Global Dataset of Palmer Drought Severity Index for 1870-2002: Relationship with Soil Moisture and Effects of Surface Warming*, Aiguo Dai et al., Journal of Hydrometeorology, December 2004

A Hurricane Effect?

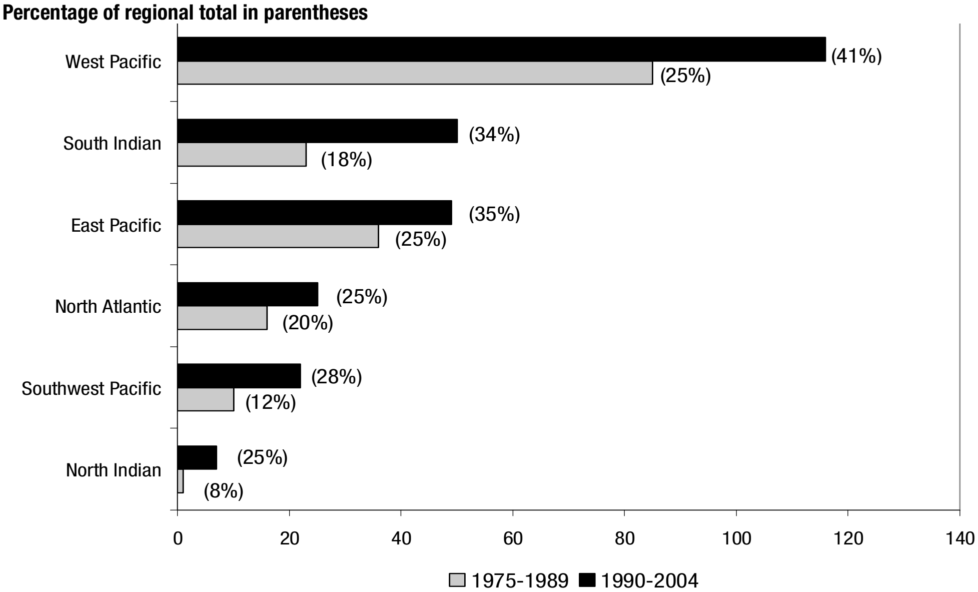
Have climate change factors also led to an increase in the frequency of intense hurricanes? (In simple terms, hurricanes are "heat engines" that extract energy from warm, moist air over oceans and then release that energy in the form of storm winds.) Some studies suggest that the answer is "yes."

For example, in a recent article[6] published in the magazine *Science*, a team at the Georgia Institute of Technology analyzed data on all hurricanes recorded from 1970 to 2004 in the Atlantic, Pacific, and Indian oceans. During this period, a large increase was seen in the number and proportion of hurricanes reaching categories 4 and 5 (see Figure 15), and the team concluded that "the trend of increasing numbers of category 4 and 5 hurricanes for the period 1970–2004 is directly linked to the trend in sea-surface temperature..."

It appears that, in recent decades, there has been a large increase in the number and proportion of hurricanes reaching categories 4 and 5.

Figure 15. Number of Category 4 and 5 Hurricanes in Various Regions in Two Periods

Percentage of regional total in parentheses



Source: *Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment*, P.J. Webster, et. al, Science, September 2005

The first hurricane ever reported in the South Atlantic hit southern Brazil in March 2004.

In addition, the first hurricane ever reported in the South Atlantic (named "Catarina") hit southern Brazil in March 2004. A 2005 study[7] concluded that "global warming scenarios could favor similar conditions [to those responsible for Catarina], increasing the probability of more Tropical Cyclones in the South Atlantic." And the first tropical cyclone on record to strike the Iberian Peninsula since 1851 (named "Vince") dissipated over Spain in 2005.

Other scientists, however, do not agree with the conclusion that there has been an unusual increase in the number of intense hurricanes in recent years. For example, Dr. Chris Landsea of the U.S. National Oceanic and Atmospheric Administration's National Hurricane Center examined major hurricanes in the North Atlantic back to

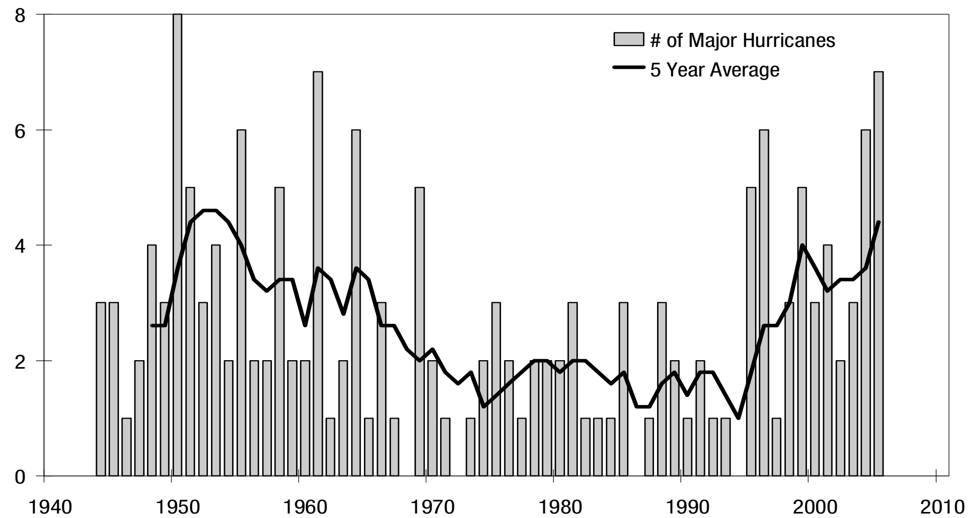
[6] *Deconvolution of the Factors Contributing to the Increase in Global Hurricane Intensity*, Carlos D. Hoyos, et al., Science, March 16, 2006

[7] *The first South Atlantic hurricane: Unprecedented blocking, low shear and climate change*, Alexandre Bernardes Pezza and Ian Simmonds, Geophysical Research Letters, August 2005

the 1940s and found a "kind of swinging back and forth or, you could say, a cycle of activity where it goes busy and quiet, alternating [over a] period [of] about 25–40 years"[8] — see Figure 16.

Figure 16. North Atlantic Major Hurricanes (Categories 3, 4, or 5)

A long time series does not appear to show an unusual increase in the number of intense hurricanes in recent years.



Source: Dr. Chris Landsea, U.S. National Oceanic and Atmospheric Administration National Hurricane Center

Regardless of which scientific camp is correct, key parts of the world — perhaps, most notably, the U.S. — appear *more vulnerable to the effects of major hurricanes today than they were in the past* due to the following:

- Greater population concentrations in coastal areas (according to the U.S. Census Bureau, the 1950 coastal population of the states stretching from North Carolina to Texas was 10.2 million; by 2005, that population had reached 34.6 million);
- More industrial activity that is vulnerable to storms (there are 82 oil rigs in the Gulf of Mexico today, versus 49 in 1959); and
- Increased ocean tourism (more than 5 million passengers cruised the Caribbean in 2005).

Reflecting these factors, while the debate continues about possible *physical* implications of climate change (e.g., an increase in the frequency of intense hurricanes), there have already been some *behavioral* ramifications. For example, as we discuss in detail below, the property insurance industry has changed its models to account for multiple severe hurricanes in the midst of an active multiyear hurricane cycle.

[8] Citigroup conference call, May 15, 2006

Adaptation vs. Mitigation

Climate change factors, including those outlined above, raise important questions for public policy, which is an important point to bear in mind when considering the investment implications of the various issues. Stripped down to the basics, makers of public policy face a choice when it comes to climate change issues — adaptation versus mitigation. That is:

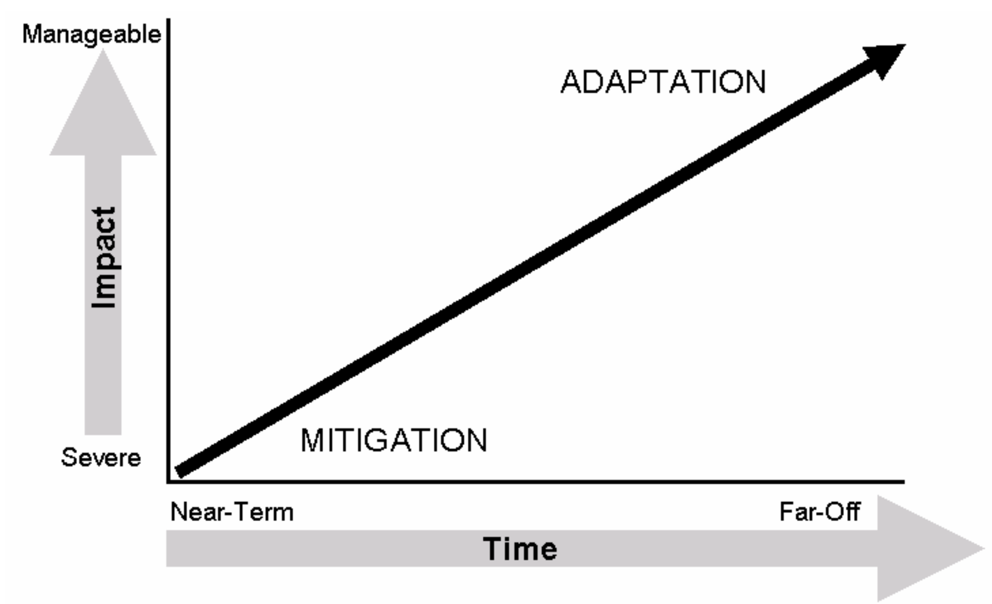
- Public policy could hold that economies and ecosystems should gradually *adapt* to changes in temperature, sea level, storm patterns, etc.; or
- Policy makers could take the position that climate change risks should be aggressively *mitigated* through, e.g., the reduction of GHG emissions.

These approaches are not mutually exclusive and, indeed, some level of adaptation is almost certainly required, given that a certain amount of climate change is likely to occur *even if GHG emissions stopped immediately*.

That said, there is *a clear tradeoff* between reactive versus proactive measures, and the context for policy decisions is shaped by an analysis of risks and expected costs, as well as public perception. So, for example, if it is perceived that the impacts of climate change are small, far off, and manageable, then adaptation is likely to rise on the public policy agenda. Conversely, if it is perceived that the impacts are likely to be near-term and severe, then mitigation of GHG emissions would likely take higher priority (see Figure 17).

Makers of public policy face a choice when it comes to climate change issues — adaptation versus mitigation.

Figure 17. Adaptation vs. Mitigation



Source: Citigroup Investment Research

To date, most policy development has centered on mitigation of GHGs rather than adaptation.

To date, most policy development has centered on some form of *mitigation* of GHGs (rather than adaptation). To this end, four primary policy tools have been utilized:

- market-based emissions trading systems (we discuss the European Union Emissions Trading Scheme below);
- fiscal incentives, such as carbon taxes (which are not yet in widespread use);
- government-funded technology research, development, and deployment (as we discuss below, the U.S. "Energy Policy Act of 2005" provided $200 million annually for clean coal research, and also authorized a prototype Next Generation Nuclear Plant project); and
- other regulatory measures and standards, such as product efficiency standards (the goal of the European "Directive on the Energy Performance of Buildings" is to improve the energy efficiency of public, commercial, and private buildings, which currently account for 40% of the European Union's energy requirements).

Here, too, these policy tools are not mutually exclusive and, indeed, they may work best when used in a complementary fashion.

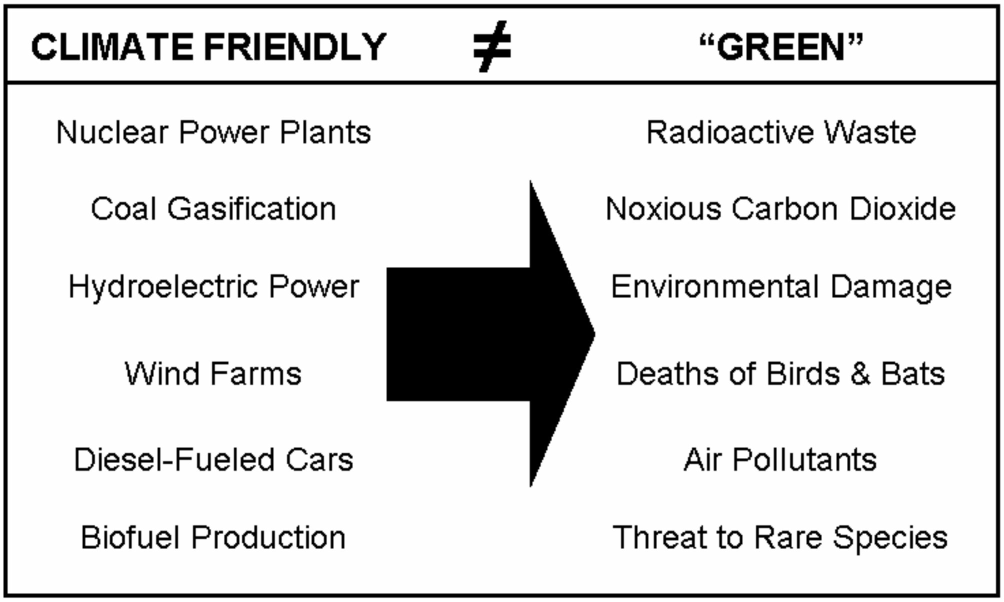
GHG Abatement Is Not Necessarily "Green"

As noted, GHG abatement is a key focus of climate change initiatives. However, it's important to point out that some of the options for reducing GHGs are *not necessarily environmentally friendly*:

- In contrast to coal-fired plants, nuclear power plants are completely carbon-free sources of electricity, but they produce radioactive waste that needs to be stored for thousands of years.
- Similarly, while coal gasification technologies offer the promise of carbon capture, that carbon dioxide will need to be stored someplace. (In 1986, 1,700 people died after a natural release of 1.2 million tons of carbon dioxide from the depths of Lake Nyos in Cameroon.)
- Hydroelectric power is another carbon-free source of electricity. However, the flooding caused by the construction of hydroelectric dams typically results in catastrophic damage to the surrounding environment.
- Wind farms that generate renewable electricity have been blamed for causing the deaths of birds and bats that fly into the turbines. In addition to the threat to flying creatures, there has been a backlash against wind power in many parts of the world, including Australia, because of the noise that turbines create, as well as their unsightly appearance, particularly in windy coastal areas (where a large portion of Australia's population lives).
- Diesel-fueled cars can be used with efficient compression-ignition engines so that carbon dioxide emissions are reduced by way of the greater fuel efficiency. However, diesel engines emit relatively large quantities of air pollutants, such as nitrogen oxide.
- Palm oil and sugarcane cultivation for the production of biofuels threaten the habitats of rare species in some parts of the world e.g., orangutans in Malaysia.

Some of the options for reducing GHGs are not necessarily environmentally friendly.

Figure 18. Climate Friendly ≠ Green



Source: Citigroup Investment Research

Conversely, some environmentally friendly initiatives do *nothing* to reduce GHG emissions — strategies that reduce power plants’ emissions of nitrogen oxides and sulfur dioxide (which are *not* GHGs) don’t reduce emissions of carbon dioxide, the leading GHG. Note that nitrogen oxides (NOx) should *not* be confused with nitrous oxide (N_2O), which is a GHG.

The Regulatory Response

Faced with these climatic impacts — both actual and anticipated — there has been a move to regulate the emission of GHGs. As we discuss below, these initiatives range from international conventions sponsored by the United Nations to emissions control legislation at the state level in the U.S.

The United Nations Framework Convention on Climate Change and the Kyoto Protocol

In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) began to negotiate a global treaty to reduce the emissions of six GHGs contributing to climate change (Figure 9). This process resulted in the Kyoto Protocol, which was adopted at the Convention's third meeting in 1997 in Kyoto, Japan, and which assumed full legality in February 2005.

Under the Kyoto Protocol, industrialized and transition economies assumed binding emission caps to be achieved during the five-year period from 2008 to 2012. As Figure 19 illustrates, targets ranged from a decrease of 8% relative to a 1990 baseline (major European Union countries), to an increase of 10% (Iceland), with an overall goal of reducing total GHG emissions by an average of 5% during the five-year period. (Note that even for those countries with a target *increase* relative to the 1990 baseline, meeting that target would typically still represent a significant *reduction* from "business as usual" emission levels.)

The Kyoto Protocol has an overall goal of reducing total GHG emissions by an average of 5%.

Figure 19. Kyoto's Greenhouse Gas Emissions Reduction Targets

Select countries. Relative to a 1990 baseline

EU-15	-8%
Bulgaria, Czech Rep., Romania, Switzerland	-8
U.S.	-7
Canada, Hungary, Japan, Poland	-6
Croatia	-5
New Zealand, Russia, Ukraine	0
Norway	+1
Australia	+8
Iceland	+10

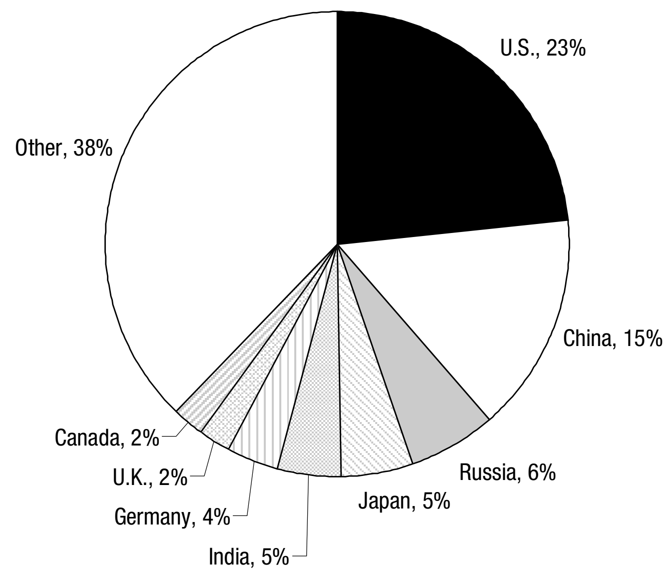
Source: United Nations Framework Convention on Climate Change

Significantly, developing countries, including major emitters such as China (see Figure 20), have *no emissions limits* under the current Kyoto agreement. On that point, on June 11, 2006, *the New York Times* reported that "the increase in global-warming gases from China's coal use will probably exceed that of all industrialized countries combined over the next 25 years, surpassing by five times the reduction in such emissions that the Kyoto Protocol seeks." Similarly, the World Resources Institute has pointed out[9] that "China is projected to surpass the United States as the world's largest emitter [by 2025]."

[9] *Navigating the Numbers*, World Resources Institute, 2005

Figure 20. GHG Emissions by Country

2002



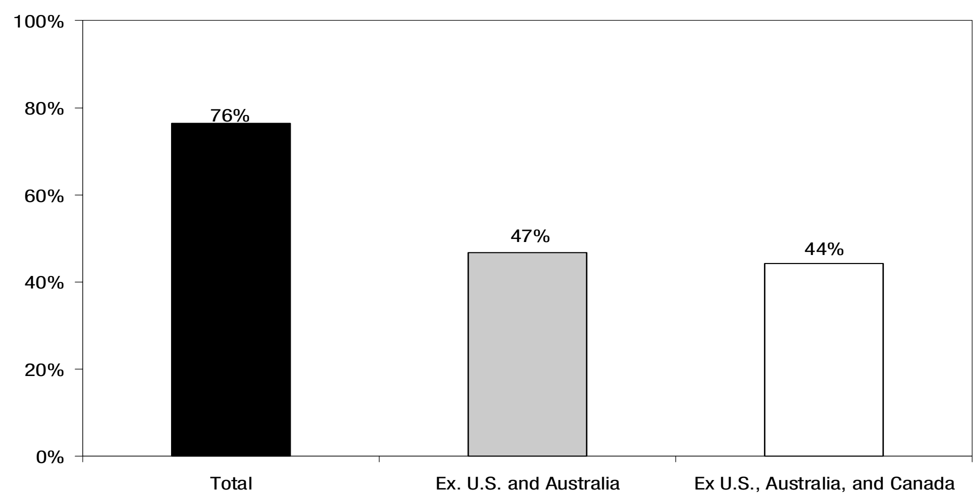
Source: World Resources Institute

Developing countries, including major emitters such as China, have no emissions limits under Kyoto.

Unhappy about this lack of emission limits for developing countries, the United States has not acceded to the Kyoto Protocol and is, therefore, not bound by its emission controls. Australia, the world's largest coal exporter, is another industrialized country that has not acceded to the Protocol. And while Canada has committed to the Kyoto Protocol and is, in principle, obligated to reduce its GHG emissions as prescribed by the treaty, the Conservative government, which took office in 2006, has been vacillating about those commitments.

As Figure 21 illustrates, the Kyoto "Annex 1" countries (including those listed in Figure 19) account for 76% of global GDP. Excluding the U.S. and Australia, that falls to 47%. And if Canada is also excluded, *a still significant 44% of global GDP* is committed to GHG emissions reductions under the Kyoto Protocol.

Figure 21. Percentage of Global GDP Accounted for by Kyoto "Annex 1" Countries



Source: United Nations Framework Convention on Climate Change and Citigroup Investment Research

Depending on compliance, 44%–76% of global GDP is committed to GHG emissions reductions under Kyoto.

The Kyoto Protocol offers countries flexibility in how they meet their targets. For example, a country may partially compensate for its emissions by increasing "sinks" — e.g., forests (within its own territory or in other countries) that remove carbon dioxide from the atmosphere. In addition, there are three other "flexibility mechanisms":

- *Joint Implementation* — creating emission reduction credits though project-based investment *among industrialized countries*. In practice, this will likely mean facilities built in the countries of Eastern Europe and the former Soviet Union — the "transition economies" — paid for by Western countries. The investor can then count the resulting emission reduction units (ERUs) against its own target; ERUs will be issued for crediting beginning in 2008. Note that, in addition to project-based investment, transition economies can also sell excess Kyoto permits — often referred to as "hot air."
- *Clean Development Mechanism* — creating emission reduction credits *in developing countries* utilizing investments from industrialized countries. (Industrialized countries making emission reduction investments in developing nations can use the resulting certified emission reductions (CERs) to help meet their own targets. The first CERs were issued in October 2005.)
- *Emissions Trading* — allowing the international transfer of national allotments of emission allowances, but only among "Annex 1" countries. (The Protocol allows countries with emissions units to spare to sell this excess capacity to countries that are over their targets. ERUs and CERs can also be traded.) We discuss emissions trading below. Note that while the Kyoto Protocol enables the trading of permits between *countries*, a system such as the European Union Emissions Trading Scheme results in trading between *companies* (although Kyoto's ERUs and CERs can, in effect, also be traded by companies).

The U.S. Regulatory Response

In the U.S., there is increasing talk about climate change at the national level, and increasing action about these issues at the regional and state levels.

There may be a perception among some investors that there is little activity related to climate policy and regulation of GHGs in the U.S. While this may have been true some years ago, today there is increasing *talk* about climate change at the *national* level, and increasing *action* about climate change issues at the *regional and state* levels.

The National Level: No Binding Commitment to Reduce Emissions

As noted, the U.S. has not acceded to the Kyoto Protocol, and it has made no binding national commitments to reduce GHG emissions. Even so, in July 2005, the U.S. joined five Asia-Pacific nations — Australia, China, India, Japan, and Korea — in launching the Asia-Pacific Partnership on Clean Development and Climate ("AP6"). According to President Bush[10], the goal of the partnership is to "develop and accelerate deployment of cleaner, more efficient energy technologies to meet national pollution reduction, energy security, and climate change concerns in ways that reduce poverty and promote economic development."

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[10] President's Statement on U.S. Joining New Asia-Pacific Partnership, July 27, 2005

While the U.S. government has stated[11] that the partnership "will complement, but not replace, the Kyoto Protocol," it remains to be seen what exactly this agreement will achieve, given that it involves no binding reduction targets or timetables.

With regard to actual legislation, in August 2005 the "Energy Policy Act of 2005" was signed into law. Per President Bush,[12] this legislation "promotes dependable, affordable, and environmentally sound production and distribution of energy for America's future." Portions of the Act are relevant to climate change issues:

- *Clean Coal*. The Act authorized appropriations for a Clean Coal Power Initiative, providing $200 million annually (through 2014) for clean coal research in coal-based gasification and combustion technologies. (We discuss coal gasification below.)
- *Nuclear*. The Act authorized a prototype next-generation nuclear plant project at the Idaho National Laboratory to produce electricity and hydrogen. It also established a tax credit of 1.8 cents per kWh for the first eight years of production from new nuclear power facilities.
- *Energy Efficiency*. The Act extended investment tax credits for improvements to building efficiency. It also allowed a tax deduction of $1.80 per square foot for investment in equipment in commercial buildings to reduce annual energy and power consumption by 50%.
- *Renewable Energy*. Among other things, the Act extended the "placed-in-service" date by two years (through year-end 2007) for renewable energy facilities (including wind and landfill gas) to qualify for credits for electricity production.
- *Alternative Fuels*. The Act established a standard that requires refiners to ensure that gasoline sold in the U.S. contains a specified volume of biofuels, increasing the level from 4.0 billion gallons in 2006 to 7.5 billion gallons in 2012.

  Biofuels are liquid fuels derived from biomass (e.g., vegetable matter) that can be used to power various transport modes, including cars. Biofuels can be divided into two types — bioethanol and biodiesel — with each type of biofuel being derived from different crop types. Bioethanol is produced from the fermentation of starch or sugar crops, such as corn and sugar cane; biodiesel is produced from vegetable oils, such as soy oil or palm oil.

  The attraction of biofuels is that they are, in theory, "carbon neutral" — because they come from recently grown plants, they do not increase the overall percentage of carbon dioxide in the atmosphere in the same way that the burning of fossil fuels does. (In other words, on their death, by rotting or burning, the carbon dioxide that plants captured via photosynthesis is then released "naturally" back into the atmosphere, as compared to the "unnatural" release of carbon dioxide produced by burning fossil fuels.)

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[11] U.S. Department of State, July 28, 2005

[12] President's Statement on Energy Policy Act of 2005, August 8, 2005

The Regional and State Levels: Mandatory Emissions Controls

Arguably, from a business standpoint, a comprehensive federal response to climate change is preferable to the patchwork of state and local climate policies that we discuss below. However, although the U.S. seems to be slowly moving toward a federal policy, precisely when it will reach this tipping point is unclear.

The general thrust of most of the initiatives being undertaken at the state and regional levels in the U.S is the gradual establishment of systems to curb GHG emissions. Among the most far-reaching initiatives in that regard is the "Regional Greenhouse Gas Initiative" (RGGI, pronounced "reggie"). This will be the first *mandatory* system for curbing carbon dioxide emissions from power plants in the U.S. The process started in 2003 and a Memorandum of Understanding (MOU) was signed on December 20, 2005. RGGI's jurisdiction includes Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York, and Vermont.

Under the RGGI, carbon dioxide emissions from electric generation units having a related capacity equal to or greater than 25 megawatts are capped at 1990 levels starting in 2009. (Note that, as we discuss below, other initiatives target a broader range of emitters, not just electric utilities.) Beginning in 2015, the cap will be reduced 2.5% annually, resulting in a required 10% cut in emissions by 2018. A key part of the system is emissions trading (we discuss trading systems below) — the agreement stipulates that each state determines how its allotments of tradable allowances are to be allocated.

Subsequent to the creation of RGGI, the Maryland legislature approved a bill to accede to the agreement. In the opinion of the World Resources Institute, other states, such as Massachusetts, are likely to follow suit.

In another sweeping initiative, the California Global Warming Solutions Act of 2006 mandates that a multi-industry, market-driven regime be implemented by 2012, which ultimately would reduce California's GHG emissions to 1990 levels by 2020. The state's Air Resources Board will be the agency that monitors and regulates greenhouse gases. Beginning January 1, 2008, the Board will be responsible for the reporting and verification of GHG emissions from significant sources on an annual basis.

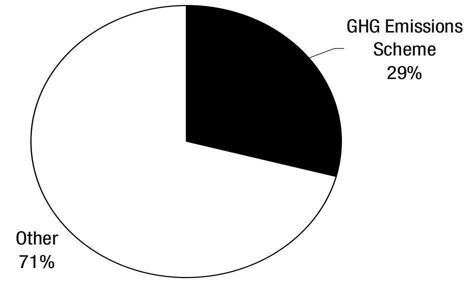
As for the mechanics of the scheme, in October 2006, Governor Arnold Schwarzenegger said that he was in favor of California developing a market-based program that would permit emissions trading with the European Union, the RGGI and other jurisdictions. (However, State Treasurer Phil Angelides, a political rival, said that only federal laws would allow the U.S. states to form an emissions exchange.)

So, as Figure 22 illustrates, it seems likely that, by 2012, nine states, which currently account for 29% of U.S. Gross State Product, will have implemented a scheme of one variety or another to curb GHG emissions.

By 2012, nine states, which currently account for 29% of U.S. Gross State Product, will likely have implemented schemes to curb GHG emissions.

Figure 22. Percentage of U.S. Gross State Product Likely Covered By GHG Emissions Schemes by 2012

California, Connecticut, Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, and Vermont.



Source: Citigroup Investment Research

In addition, we note that, while the California initiatives outlined above may sound negative for that state's economy, that may not actually turn out to be the case. In a September 7, 2006 article[13] in the *Economist,* the following were reported:

> Allan Zaremberg, president of California's Chamber of Commerce, says these [emissions] targets will impose huge new costs on local businesses. They will also cause CO_2-heavy factories to migrate to developing countries where they will be subject to less stringent restrictions and will therefore produce more CO_2.
>
> Similar complaints were heard in the 1970s, when California imposed unusually tough emissions standards for other pollutants. Yet Mr. Zaremberg concedes that business has *benefited* [italics added] from tough clean-air regulations. They have made California's environment more attractive, and the state has developed technologies for things like energy-efficient buildings that have subsequently been sold elsewhere. California's economic performance (despite power prices which, partly because of regulation, are 40% above the American average) makes it hard to argue that business in the state is groaning under its heavy regulatory burden.

In addition to mandatory systems centered on large emitters of GHGs, some states have also implemented some other programs:

- *Automobile emissions*. In 2004, the California Air Resources Board (CARB) approved a rule to reduce GHG emissions from passenger vehicles in California by about 30%. However, this law has been challenged in federal court by the Alliance of Automobile Manufacturers, along with some California auto dealers. A trial date early in 2007 is expected.[14] Depending on the legal outcome, Connecticut, Maine, Massachusetts, New York, New Jersey, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington have all indicated that they will follow the CARB's rule if it stands. Combined, these 11 states comprise approximately one-third of the auto market in the U.S.
- *Renewable portfolio standards*. Twenty-one states and the District of Columbia require power companies to use increasing percentages of electricity produced from renewable sources, such as wind and solar.

[13] *Doing It Their Way*, The Economist, September 7, 2006

[14] In the case of Central Valley Chrysler-Jeep, Inc., et al v. Catherine E. Witherspoon

The European Regulatory Response

As noted above, the European Union (EU) countries have committed to the Kyoto Protocol. Below, we briefly review some of the steps the EU member states are taking to restrict the emission of GHGs. These fall under three broad headings:

- emissions trading (to curb emissions from stationary sources);
- agreements with the auto sector; and
- renewable energy and alternative fuels programs.

Reductions from Stationary Sources via Emissions Trading

In January 2005, the European Commission launched the European Union Emissions Trading Scheme (EU-ETS) to help achieve its Kyoto Protocol commitments. The EU-ETS currently covers carbon dioxide emissions from 12,000 installations across major industrial sectors in the member countries. (We discuss the mechanics of carbon trading systems below.) Regulated installations include:

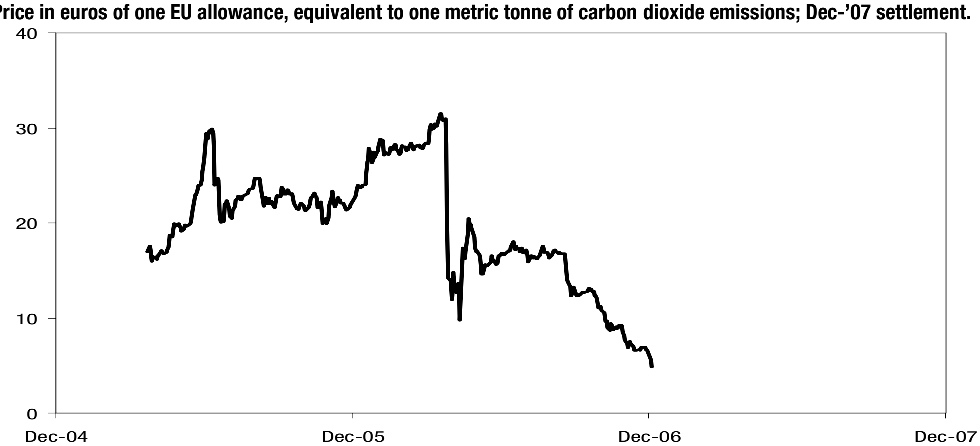
- energy facilities (e.g., power and heat generation; oil refineries);
- ferrous metal (i.e., iron and steel) producers;
- mineral processors (glass, cement and brick manufacture); and
- producers of pulp, paper, and board.

The EU-ETS consists of a first phase from 2005–07, and a second five-year phase coinciding with the Kyoto compliance period in 2008–12. Realistically, in the first "learning" phase, the emissions restrictions have not been too onerous. Indeed, in early 2006, Citigroup Investment Research analysts noted that the "EU allocation of [carbon dioxide emissions] allowances [exceeded] carbon dioxide emissions in 2005," so that the surplus of permits in the market meant that the carbon price should fall to "single digits."[15] Carbon prices remain in the single digits today (see Figure 23).

A surplus of permits in the emissions market has pressured carbon prices.

Figure 23. European Climate Exchange Emissions Index

Price in euros of one EU allowance, equivalent to one metric tonne of carbon dioxide emissions; Dec-'07 settlement.



Source: European Climate Exchange

[15] See Meg Brown and Mike Tyrrell's May 15, 2006, call note, "Permit Poker: Game Over."

Reductions from Mobile Sources

The European Commission has negotiated a voluntary GHG reduction agreement with European, Japanese, and Korean automobile manufactures. All three commitments contain the same quantified carbon dioxide emission objective for new passenger cars sold in the European Union, with reductions in carbon dioxide emissions of 15% from 2002 levels to be achieved by 2008 by the European manufacturers, and reductions of 20% and 23% to be achieved by 2009 by the Japanese and Korean manufacturers, respectively. Note, however, that it appears increasingly likely that these voluntary targets will be missed, raising the risk of mandated emissions reductions.

Renewable Energy and Alternative Fuels

The EU has set a target to double the share of *renewable energy* (e.g., from wind and solar power) in its energy consumption from 6% in 1997 to 12% by 2010. To promote renewable energy, the EU has adopted a number of initiatives including:

- tax incentives to encourage renewable energy consumption;
- grants for renewable project investment;
- feed-in tariffs (i.e., a minimum guaranteed price per unit of energy produced) targeted toward renewable energy producers; and
- legislation mandating that utilities provide a certain percentage of their power from renewable energy sources.

With regard to the development of *alternative fuels*, the EU has set a goal to achieve a 5.75% market share for biofuels in the overall EU transport fuel supply by 2010. In 2005, the portion of biofuels in the EU transport fuel supply was about 1%.

Multiple Agendas

To be sure, climate change initiatives are, in many regions of the world, *part of a much broader agenda that covers a range of economic, political, and social issues*:

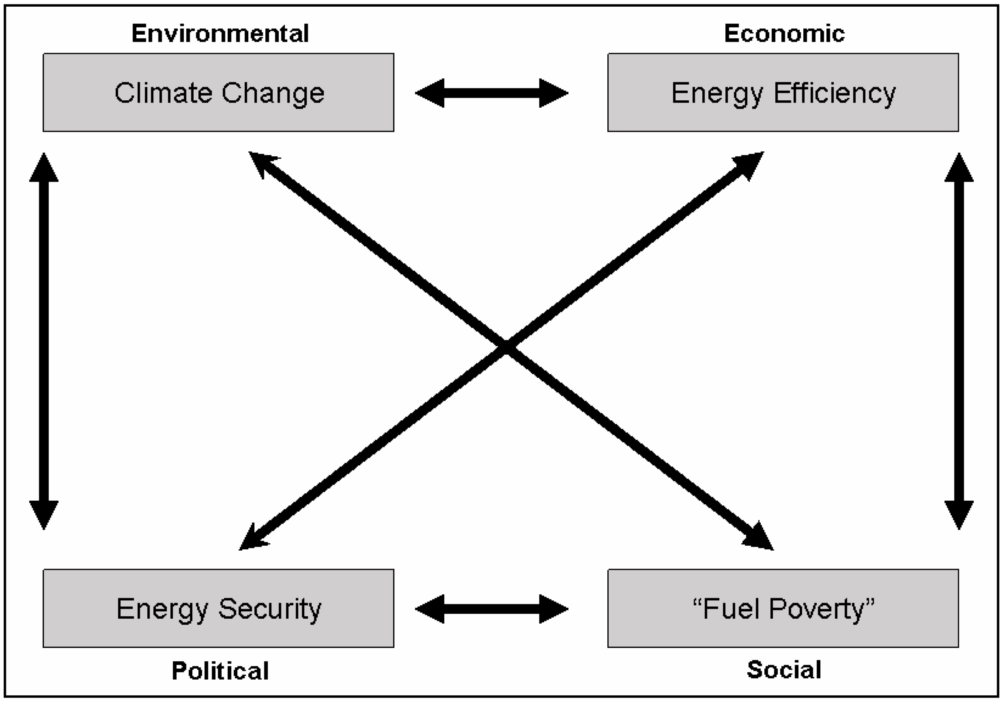
- *Energy Efficiency*. The recent spike in the price of oil to almost $80 per barrel has focused attention on the efficient consumption of energy.
- *Security of Energy Supply*. The heavy reliance on imports of natural gas from Russia is one of the reasons Finland is building a nuclear power plant and the U.K. is reviewing its moratorium on nuclear construction.
- *"Fuel Poverty."* High energy prices accentuate the gaps between the "haves" and "have-nots" and stimulate government programs that encourage the development of affordable energy sources.

So, for example, as we noted, the stated goal of the Asia-Pacific Partnership on Climate (AP6) is to "develop and accelerate deployment of cleaner, more *efficient energy* technologies to meet national pollution reduction, *energy security*, and *climate change* concerns in ways that *reduce poverty* [italics added]."

In addition, as we discuss below, some technologies address a number of these issues — so, for example, hybrid automobiles and nuclear power are "plays" on energy efficiency, security of energy supply, and climate change concerns.

Climate change initiatives are, in many regions of the world, part of a much broader agenda.

Figure 24. Multiple Agendas



Source: Citigroup Investment Research

Figure 25. A Climate Timeline

Select events

Some forthcoming events could have "climatic consequences."

2007

Trial of Alliance of Automobile Manufacturers v. California Air Resources Board

Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report

Atlantic hurricane season: June 1 - Nov 30. Pacific hurricane season: May 15 - Nov 30

U.S. Supreme Court ruling on Massachusetts et al. v. EPA

California Air Resources Board to establish GHG emissions reduction framework

U.S. wind power production tax credit set to expire

2008 Start of Kyoto 2008 – 2012 compliance period

Second phase of European Union Emissions Trading Scheme 2008 -2012

Voluntary carbon dioxide emissions reductions from European auto makers by 2008

U.S. Regional Greenhouse Gas Initiative (RGGI) allocation parameters outlined (e.g., auctioning)

U.S. Presidential elections

2009 Regional Greenhouse Gas Initiative (RGGI) emissions caps begin

Source: Citigroup Investment Research

Exhibit 1: Emissions Trading — the Concept

As outlined above, the Kyoto Protocol, the U.S. Regional Greenhouse Gas Initiative, and the European Commission have each proposed emissions trading systems as a way to reduce GHGs. "Carbon trading" is the popular expression for GHG emissions trading because

1. carbon dioxide is the most widely produced greenhouse gas, and
2. emissions of other greenhouse gases can be standardized and expressed in terms of carbon dioxide equivalent.

Such standardization is based on their relative global warming potential (GWP) relative to carbon dioxide — see Figure 9 above. In the various schemes, emission units are typically denominated in terms of *tons* of carbon dioxide equivalent.

A typical emissions trading system requires facilities to own permits for emitting GHGs. A government entity sets a "cap" on aggregate emissions, distributes an initial allocation of permits to regulated facilities, and allows those facilities to trade with others in the marketplace and buy allowances should their emissions exceed the number of permits held (hence the name "cap-and-trade" program). Conversely, if an entity possesses more permits than its emissions allowance, it can sell those permits in the market. (So, note that what is actually being traded is *not* a physical commodity but, rather, the certified *absence* of carbon emissions.) In most systems, fines exist for not owning sufficient permits, with those fines acting as a ceiling to carbon prices.

Emission permits (or *allowances*) can be distributed for free through a government allocation formula — for example, based on historical emissions — or auctioned for a fee. Such allowances are referred to as *Assigned Amount Units* (AAUs) in the Kyoto markets, or *European Union Allowances* (EUAs) in the EU ETS. Within the EU ETS, allowance allocation is dictated by each country's National Allocation Plan (NAP), which stipulates how each country's allotment of allowances is distributed throughout the economy.

Emission reduction credits arise from GHG offset projects. We discussed above two of the "flexibility mechanisms" of the Kyoto Protocol — Joint Implementation (which results in the creation of Emission Reduction Units, or "ERUs,"), and the Clean Development Mechanism (which results in the creation of Certified Emission Reductions, or "CERs"). These offset credits represent tradable carbon assets and are fully fungible with allowances. Figure 26 below provides a summary of the various concepts.

Conceptually, trading schemes can be regarded as a risk or an opportunity to companies involved because the very nature of a trading system implies that there will be winners and losers. In the case of carbon trading, larger companies are more likely than their smaller competitors to be able to balance out their carbon allowances across their operations. In addition, those companies with inefficient assets who have not previously attempted to reduce emissions will have significant scope for improvement.

That said, continuous improvement will become progressively harder as the "easy" emission reductions are achieved. So, as emissions regulations become progressively tighter (e.g., a "tougher" Phase 2 of the EU ETS beginning in 2008), that will likely involve a greater cost burden for the companies involved.

Figure 26. Emissions Trading: Key Concepts

Permits and credits

Concept	How Obtained	Kyoto Terminology	EU-ETS Terminology
Emissions allowances	Kyoto Protocol (for countries)	*Assigned Amount Units* (AAUs)	
Emissions permits	National governments (for companies)		*European Union Allowances* (EUAs)
Emission reduction credits	GHG offset projects	*Joint Implementation* (by industrialized countries) results in creation of *Emission Reduction Units* (ERUs)	
		Clean Development Mechanism (investments by industrialized countries in developing economies) results in creation of *Certified Emission Reductions* (CERs)	

Source: Citigroup Investment Research

The Physical Implications

As outlined above, whatever the exact causes, in recent years there have been a number of unusual climatic trends affecting:

- Temperature — a warming of the global climate.
- Precipitation — an increased risk of drought duration, severity, and extent.
- Wind — an increase in the frequency of intense hurricanes.

It's important to note, however, that *these trends have not continued in every year:*

- As Figure 7 illustrated, the global temperature rose sharply in 1998, and then fell just as sharply in 1999.
- As Figure 14 illustrated, the percentage of total global land area in very dry conditions reached a new peak in 1992, and then experienced a decline in 1993.
- And as Figure 15 and Figure 16 illustrated, there is a debate in the scientific community about the trend in major hurricanes in the North Atlantic.

Moreover, it is also the case that not *every region is impacted in the same way by these climatic trends.*

- The World Meteorological Organization (WMO) noted[16] that, in 2005, "areas of significant warmth were widespread, with large areas of Africa, Australia, Brazil, the Russian Federation, Scandinavia, Canada, China and the south-west United States showing significantly above-average temperatures. Much of the North Atlantic and south-west Pacific Oceans were also significantly warm, as was the Gulf of Alaska."

  But the WMO also noted that "extremely cold temperatures affected much of the Balkan region during the first half of February [2005]. In Morocco, a cold wave in January dropped temperatures to as low as -14° C. In Sevlievo, Bulgaria, a 50-year temperature record was broken with temperatures reaching as low as -34° C. During December, much of Japan, the Korean peninsula, China, Mongolia, and parts of the eastern Russian Federation experienced significantly colder-than-average temperatures. A series of winter storms brought below-normal temperatures over parts of Central Europe in December."
- The WMO observed that "prolonged drought conditions continued to affect parts of Africa, Australia, and the western United States. In 2005, western parts of Europe were also under the grip of a severe drought." At the same time, the WMO pointed out that "wetter-than-average conditions prevailed over Central America, eastern parts of Europe, India, China, and Canada."
- In terms of overall hurricane activity (number and intensity of storms), the WMO wrote that the "2005 Atlantic hurricane season has been clearly the most active season on record" while "conversely, in the eastern North Pacific, activity was below average."

[16] *WMO Statement on the Status of the Global Climate in 2005*

Relying, in part, on the opinions of a number of respected independent organizations, we shall assume that the *long-term* climatic trends affecting temperature, precipitation, and wind continue for the foreseeable future:

- The Intergovernmental Panel on Climate Change notes that the "globally averaged surface temperature is projected to increase by 1.4 to 5.8 degrees Celsius over the period 1990 to 2100."[17]
- According to a report by the Heinz Center for Science, Economics and the Environment, by 2060 "approximately 25% of [U.S.] homes located within 500 feet of the coast...will fall victim to the effects of erosion."[18]
- Following the intense 2005 season, ratings agencies prompted the U.S. property insurance industry to assume the occurrence of "multiple severe hurricanes in the midst of an active hurricane multiyear cycle."[19]

Below we discuss some of the investment implications of these trends.

Heating, Cooling, and "Global Warming"

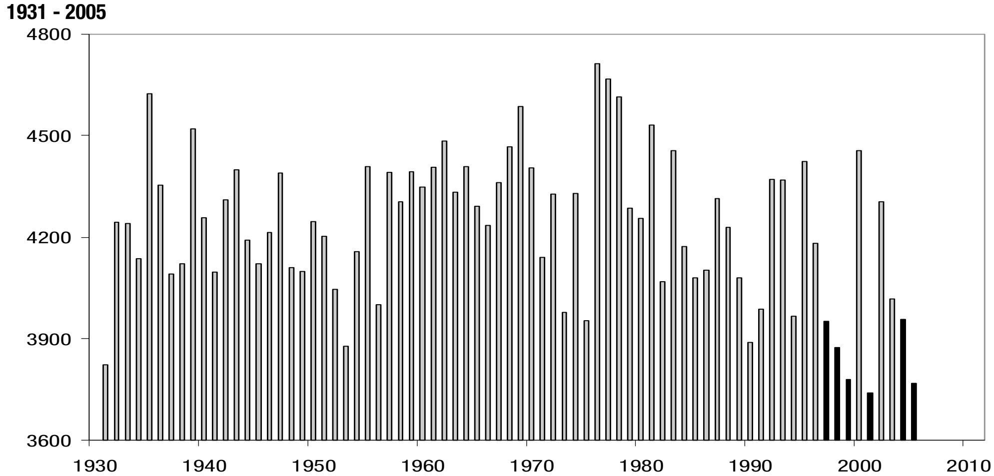
Counterintuitively, climate change issues will likely be supportive of U.S. natural gas prices, even though *warmer* weather would lead to a *reduced* demand for gas during the key winter heating season.

During the "winter" of October 2005 – April 2006, the U.S. experienced the second fewest number of heating degree days (HDDs) in the past 75 years. ("Heating degree days" are calculated based on how much below 65°F the mean temperature is on a given day. For example, if the mean temperature in the U.S. is 55°F on a certain day, there were 10 HDDs that day because 65 – 55 = 10). Indeed, six of the ten warmest HDD periods on record in the U.S. have occurred during the past ten years — see Figure 27 (note: a *low* level indicating *warm* weather).

Warmer winters in the U.S. in recent years.

Figure 27. Cumulative U.S. Heating Degree Days, October–April Period

1931 - 2005



Source: National Oceanic and Atmospheric Administration and Citigroup Investment Research

[17] Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report

[18] *Evaluation of Erosion Hazards*, The Heinz Center, April 2000

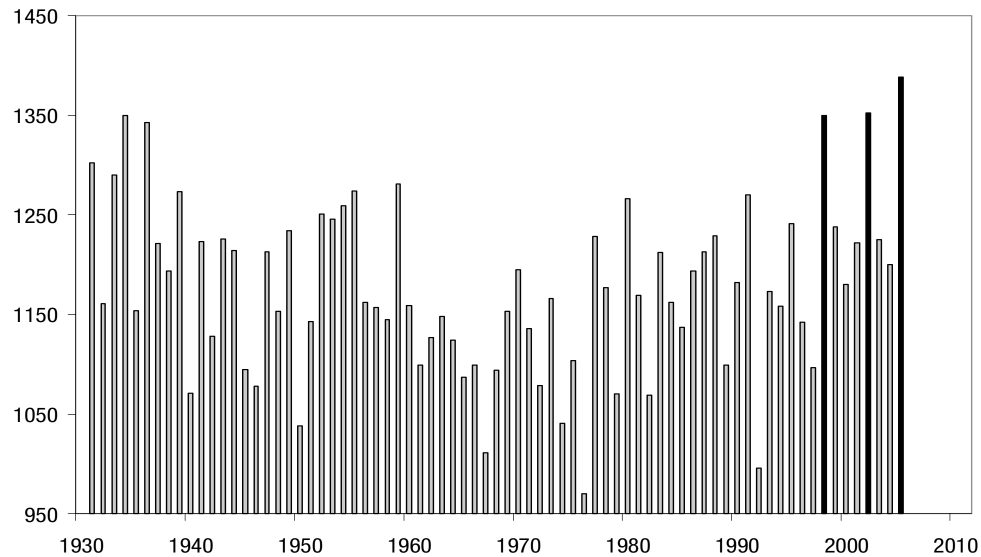
[19] See Josh Shanker's June 16, 2006, report, "Eye on the Storms," order no. GL06R072.

Conversely, during the "summer" of April – October 2006, the U.S. experienced the greatest number of cooling degree days (CDDs) in the past 50 years. ("Cooling degree days" are calculated based on how much above 65°F the mean temperature is on a given day. For example, if the U.S. has a mean temperature of 75°F on a certain day, there were 10 CDDs that day because 75 – 65 = 10.) Indeed, three of the four warmest April–October periods on record in the U.S. have occurred during the past ten years — see Figure 28 (note: a *high* level indicating *warm* weather).

Hotter summers in the U.S. in recent years.

Figure 28. Cumulative U.S. Cooling Degree Days, April–October Period

1931 - 2006



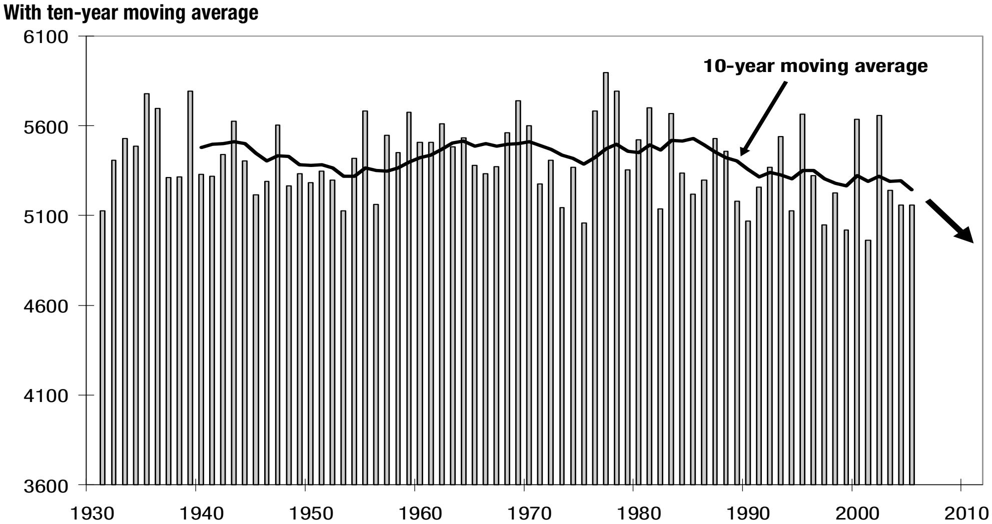
Source: National Oceanic and Atmospheric Administration and Citigroup Investment Research

So, in terms of U.S. demand for natural gas, "global warming" would seem to suggest *fewer* heating degree days (less gas for heating) and *more* cooling degree days (more gas burned to generate electricity for air conditioning), likely leading to a net *decline* in demand for natural gas — see Figure 29.

Warmer winters and hotter summers would likely lead to a net decline in U.S. demand for natural gas.

Figure 29. Cumulative U.S. Heating Degree and Cooling Degree Days

With ten-year moving average



Source: National Oceanic and Atmospheric Administration and Citigroup Investment Research

That said, declining consumption of natural gas per customer has been occurring for decades in the U.S., reflecting, in part, that:

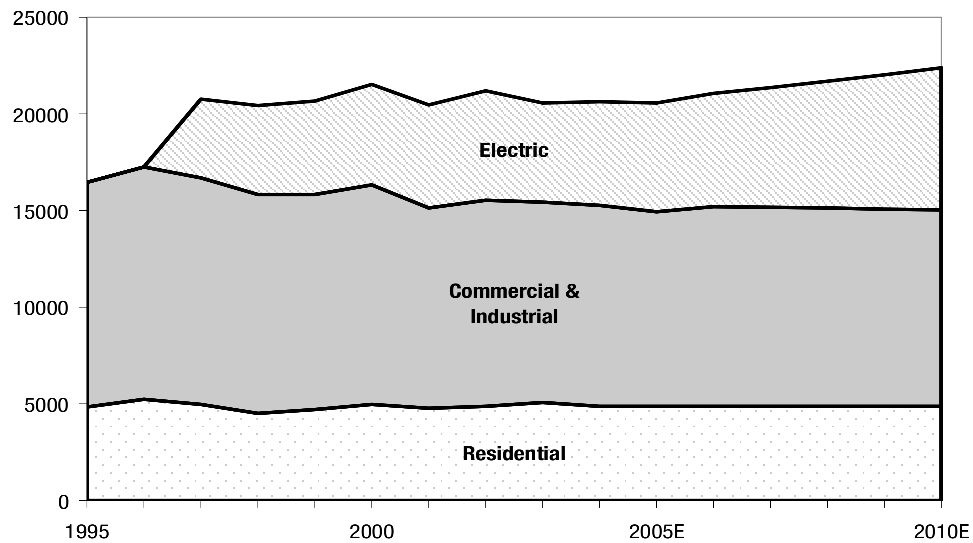
- *Residential customers* have improved the heating efficiency of their homes; and
- Many *industrial customers* have moved their operations to overseas locations that offer relatively inexpensive supplies of gas.

The picture is not entirely bleak, however, as demand from utilities for natural gas used in *electricity generation* has grown. In contrast to natural gas, which has experienced declining usage per customer, electricity has seen *rising usage per customer*, reflecting the proliferation of electronic products in the office and home. Consequently, as Figure 30 illustrates, while demand for natural gas by the residential and commercial/industrial segments is forecast to remain flat, demand by power generators is *forecast to rise by almost one-third* between 2005 and 2010.

Demand for natural gas by U.S. power generators is forecast to rise by almost one-third between 2005 and 2010, reflecting increased use for electricity generation.

Figure 30. U.S. Natural Gas Demand by Segment

Billions of cubic feet



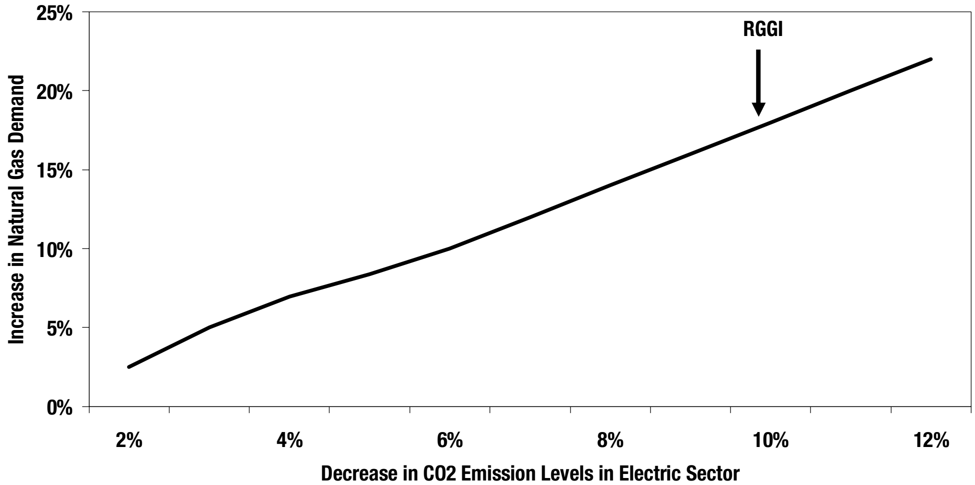
Source: Citigroup Investment Research and Energy Information Administration

In addition, recall that, as part of the effort to offset climate change trends, the U.S. Regional Greenhouse Gas Initiative (RGGI) requires that carbon dioxide emissions from large electric utilities be capped at 1990 levels starting in 2009, with the cap being reduced 2.5% annually beginning in 2015, resulting in a 10% cut in emissions by 2018. Figure 31 illustrates that NRG Energy, an electric utility, forecasts that the push toward usage of "clean" gas by utilities under RGGI schemes in *all 50* states *could lead to an almost 20% increase in natural gas demand.*

The push toward usage of "clean" gas by utilities could lead to almost a 20% increase in natural gas demand.

Figure 31. Estimated Increase in U.S. Natural Gas Demand Assuming Various Decreases in Carbon Dioxide Emission Levels in U.S. Electric Sector

Based on 2005 consumption of 22 trillion cubic feet of natural gas



Source: NRG Energy Inc.

On top of these demand-side factors, the supply picture is also quite favorable. Specifically, due to a more challenging production outlook (reflecting that gas is increasingly difficult to find), U.S. gas production has been trending downward for several years, while, at the same time, imports of Canadian gas have also been in decline. Although imports of liquefied natural gas (LNG) have been rising, they are still relatively small (3% of U.S. consumption) reflecting, in part, an infrastructure that is incapable of handling significant imports of LNG.

In terms of domestic production, Figure 32 ranks select North American exploration and production companies in terms of the "efficiency" of their operations — it shows cash from operations *less* the cost to replace reserves.

Figure 32. "Efficiency" of Select Exploration and Production Companies

$ per barrel of oil equivalent. Last 12 months cash from operations. 2005 finding and discovery costs.

	A Cash from Operations	B Cost to Replace Reserves	A-B "Efficiency"
Southwestern Energy Co	$36.63	$10.22	$26.41
Chesapeake Energy Corp	38.51	14.39	24.12
EnCana Corp	29.50	5.76	23.74
XTO Energy Inc	29.85	8.80	21.05
Devon Energy Corp	30.07	9.38	20.70
Apache Corp	30.35	9.67	20.69
EOG Resources Inc	30.86	10.33	20.53
Anadarko Petroleum Corp	29.66	11.39	18.27
Noble Energy Inc	27.23	13.98	13.25
Canadian Natural Resources Ltd	24.79	12.06	12.73
Pioneer Natural Resources Co	24.59	15.73	8.87
Forest Oil Corp	24.49	16.35	8.14
Talisman Energy Inc	30.09	23.01	7.08

Source: Citigroup Investment Research

U.S. Natural Gas Production and Hurricanes

As we noted above, there is a debate in the scientific community about the trend in major hurricanes in the North Atlantic. An increase in the frequency of intense hurricanes — particularly those impacting the Gulf of Mexico — would have implications for U.S. natural gas producers with exposure to that region.

While the Gulf of Mexico typically produces about *the same* amount of oil and natural gas (roughly 1.5 million barrels and 10 billion cubic feet per day, respectively), the Gulf actually accounts for a greater *percentage* of U.S. oil production (35%) than natural gas production (20%). However, it is important to remember that natural gas remains a regional commodity (with few imports), while oil is global in nature.

Until liquefied natural gas becomes a more significant part of U.S. natural gas supply, imports of natural gas (primarily from Canada) will remain relatively constrained. Thus, a major disruption to Gulf of Mexico supply would create *greater* chaos in the domestic U.S. natural gas market than in the oil market, which can more easily increase its level of imports. Domestic oil production accounts for only 35% of domestic consumption, while for natural gas, this figure is close to 85%.

So, even though the Gulf of Mexico typically produces about *the same* amount of oil and natural gas, hurricanes represent a bigger threat to the natural gas industry. Figure 33 ranks North American exploration and production companies in terms of their exposure to "safe" onshore production versus the "risky" Gulf.

Figure 33. Gulf of Mexico Exposure

Of select Exploration and Production companies

Canadian Natural Resources Ltd	0%
Chesapeake Energy Corp	0
EnCana Corp	0
EOG Resources Inc	0
Forest Oil Corp	0
Pioneer Natural Resources Co	0
Southwestern Energy Co	0
Talisman Energy Inc	0
XTO Energy Inc	0
Devon Energy Corp	10
Noble Energy Inc	16-18
Anadarko Petroleum Corp	25-30
Apache Corp	26-27

Source: Citigroup Investment Research

As can be seen from Figure 32 and Figure 33, ***Chesapeake Energy Corp, Southwestern Energy Co,*** and ***XTO Energy Inc***. are relatively "efficient" E&P companies with no exposure to the hurricane-prone Gulf of Mexico that seem well positioned to benefit from the trends outlined above.

Drought and Water Shortages

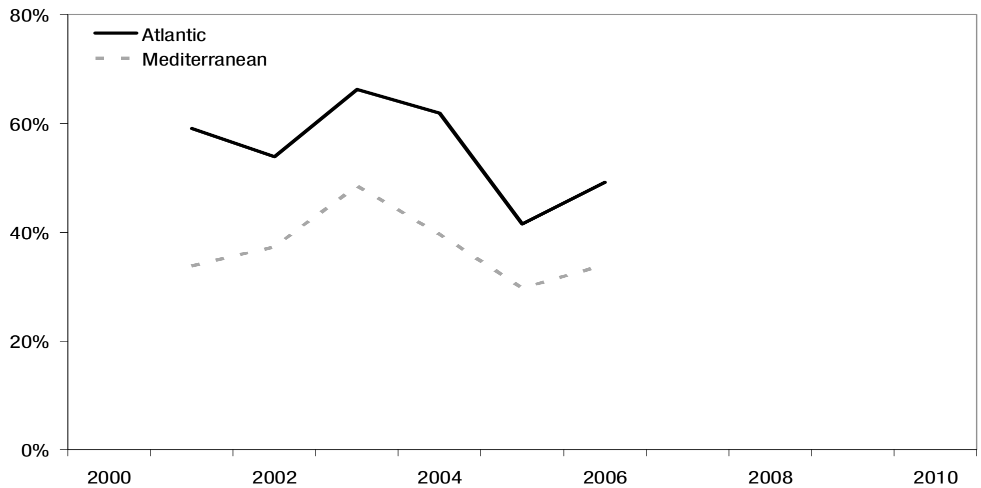
As we noted above, the World Meteorological Organization (WMO) observed that "in 2005, western parts of Europe were...under the grip of a severe drought." Specifically, the WMO noted that "during the period October 2004 to June 2005, rainfall was less than half the normal" in areas of Spain.

Indeed, a *Reuters* news story[20] pointed out that Spain's Meteorological Institute observed that, through September, 2006 was "the second consecutive dry year and follows 2004–05 in which [Spain] accumulated a national shortfall of 250 millimeters." (Heavy rainfall in October and November helped ameliorate the situation somewhat). Spain is influenced by the Mediterranean and by its proximity to Africa, and appears to be warming slightly faster than much of the rest of Europe. Not surprisingly then, water levels in reservoirs in Spain's Mediterranean region are significantly below the levels in reservoirs in the Atlantic region — see Figure 34.

Water levels in reservoirs in Spain's Mediterranean region are significantly below the levels in reservoirs in the Atlantic region.

Figure 34. Water Levels of Spanish Reservoirs by Region

Levels as a percentage of capacity



Source: Ministerio de Medio Ambiente

At the same time that much of Spain experienced drought conditions, Spanish water consumption per capita remained at record-high levels (and the highest in Europe), while water tariffs remained 50% *below* the European Union average. Note that, in Spain, there is no central governmental regulatory body that sets water tariffs; prices are fixed through negotiations between a municipality and the local operator, so that the price paid by customers is based on market forces. The fundamentals of the Spanish market suggest, therefore, that the future direction of water tariffs is upward.

Aguas de Barcelona ("Agbar") is the absolute leader in water supply in Spain, with a 55% share of the privatized market. Municipalities control 50% of the water market, but, with significant investments in water infrastructure required in coming years, privatizations are likely to accelerate. Agbar's strategy is to capture the investment opportunities that arise from such privatizations.

[20] *Spain Logs Second Year of Drought,* October 10, 2006

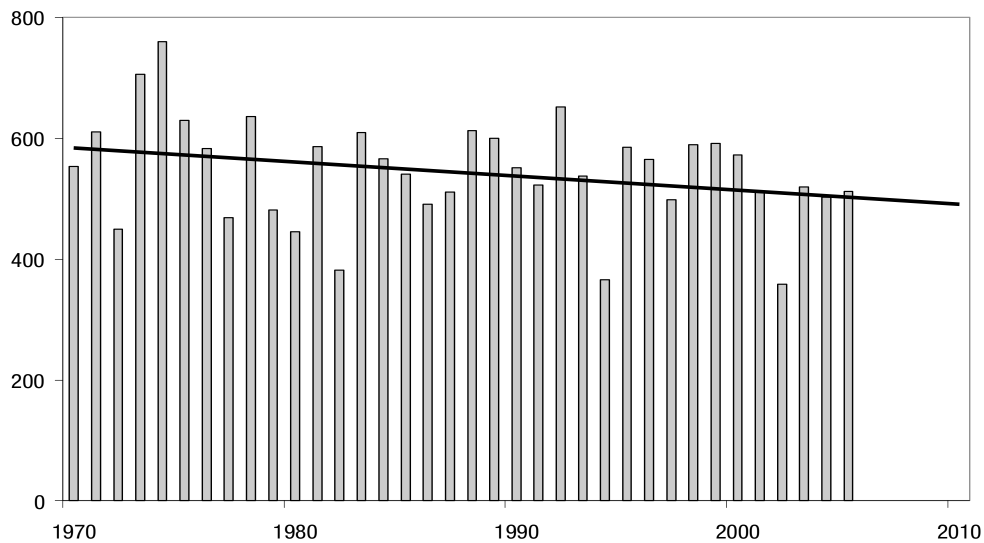
In a subsequent section we discuss the positive impact that ethanol is having on corn prices, and, hence, on farmers' incomes and on demand for ***Deere's*** farm equipment. In another positive for Deere, Citigroup Investment Research analyst David Raso has also cited[21] "wheat price rallies due to foreign competitors' drought," i.e., the drought that has been impacting wheat production in Australia, the world's third-largest exporter of the grain.

In that regard, the WMO noted that "the period January to May [2005] was exceptionally dry for much of Australia...During this period, Australia received an average of only 168 millimeters of rainfall, the second lowest January–May total since records commenced in 1900." With the drought still continuing, Australian rainfall levels have been trending downward (see Figure 35).

Australian rainfall levels have been trending downward.

Figure 35. Australian Average Total Rain on Wet Days

In millimeters, with trendline



Source: Australian Government Bureau of Meteorology

In the section on bioethanol below, we discuss ***Monsanto***, which has been at the forefront of the development of agricultural crops with biotechnology "traits," e.g., resistance to the bollworm, a common pest. The company is also at the forefront of the latest development in agricultural biotechnology: marker-assisted breeding. This process involves the mapping of particular genes that control certain desirable properties such as yield, moisture retention, and plant height.

In that regard, Monsanto is working on the development of drought-tolerance traits. The benefit of a drought-tolerance gene would be a reduced reliance on water, which, as noted, is becoming scarcer in many areas of the world. In addition, water costs also increase with escalating energy prices (i.e., higher pumping and spraying costs), thereby further raising the value of a drought-tolerant trait.

[21] See David Raso's September 13, 2006, industry note, "Nebraska farm show highlights patience needed."

Climate Change and Property Insurance

As discussed above, there are schools of thought within the scientific community that climate change factors have led to an increase in the frequency and/or severity of intense hurricanes. A hurricane is a severe tropical *windstorm,* rotating counterclockwise around a central core called an "eye." (These storms are also known as "typhoons" in the northwest Pacific Ocean, "severe tropical cyclones" in the southwest Pacific Ocean and southeast Indian Ocean, "severe cyclonic storms" in the north Indian Ocean, and "tropical cyclones" in the southwest Indian Ocean.)

In 2005, fully 96% of the $94 billion in global insured catastrophe losses was as a result of windstorms, up from 78% in 2004.

Citigroup Investment Research analysts estimate that, in 2005, fully 96% of the $94 billion in global insured catastrophe losses was as a result of windstorms, up from 78% in 2004. Recall that, in 2005, the U.S. observed three Category 5 hurricanes (Katrina, Rita, and Wilma) for the first time since these events have been accurately recorded. As we pointed out above, the growth in coastal populations in recent years (along with the steady increase in property values) has been a key factor in rising insurance losses.

The impact of the 2005 losses on the U.S. *primary* property insurance industry was, however, mitigated by two factors:

1. The relative prosperity of the industry at the time the storms struck — absent the storms, the *primary* industry was headed toward record underwriting profitability. This suggests that insurance terms and rates have, for the most part, kept pace with increased vulnerability to hurricanes.
2. The global *reinsurance* industry is estimated to have borne 60%–65% of the loss, reflecting that most losses were in commercial lines, which are generally more heavily reinsured than personal lines.

In the wake of the 2005 hurricane season, rating agencies downgraded a number of reinsurers and/or pressured reinsurers to raise capital or face downgrade. The rating agencies have since been aggressive in instituting stricter capital adequacy requirements and new measurement standards for catastrophe risk. Consequently reinsurers have been forced to explore ways to avoid downgrades and maximize capital efficiency through:

- raising additional capital;
- reducing exposure from catastrophe risk on balance sheets; and
- raising prices.

As a result, the *primary* insurers that rely on *reinsurers* to mitigate the risks on their books have been forced to either adjust their reinsurance purchasing habits (e.g., by paying a lot more or reinsuring less) or scale back their gross exposures. Either way, primary insurers are now bearing more of the risk associated with future losses from hurricanes.

By contrast, reinsurers are now likely *less exposed* to risk. Indeed, Citigroup Investment Research analyst Josh Shanker believes reinsurers could produce reasonably high profits even if a 2004-like hurricane season repeated itself. But too much good news could turn out to be *bad news* for reinsurers — a benign year for catastrophe losses (e.g., 2006) would likely lead to the reinsurers delivering a very solid set of results which, in turn, could raise concerns about an influx of capital into the sector and, consequently, lead to a faster reduction in insurance pricing than would otherwise have been the case.

So, for both the primary insurers and the reinsurers, an increase in the frequency of intense hurricanes is likely bad news over the long term (in contrast to near-term opportunities created by knee-jerk rate increases):

- The *primary insurers* are now bearing more of the risk associated with future losses from hurricanes.
- The *reinsurers* are vulnerable to insuring catastrophic losses in an environment of excess capital and weak pricing.

Many large insurers and reinsurers have reduced their exposures in the hurricane-prone regions of the U.S.

Not surprisingly, then, many large insurers and reinsurers have reduced their exposures in the hurricane-prone regions of the U.S. For example, both Allstate and Safeco did not renew a large number of policies in Florida in 2006, while St. Paul Travelers sold its personal catastrophe risk business in fourth quarter 2005. This reduction in exposure by some of the large insurers has created opportunities for smaller, regional companies.

In that regard, select companies that compete in two segments in certain regions seem well positioned:

- *Auto and Home Insurance*. We noted that Allstate and Safeco did not renew a large number of policies in Florida. Indeed, a general trend among "mega-carriers" is to reduce their exposure to hurricane-vulnerable states, which also happen to be the most populous, e.g., Florida, Texas, and New York. The more favorable pricing environment created by the departure of mega-carriers from these markets creates opportunities for a number of regional insurers, including Bristol West Holdings, Cincinnati Financial Corp., and Direct General Corp.
- *Excess and Surplus (E&S) Lines Insurance*. This segment of the insurance market facilitates the sale of property and casualty insurance through the "non-admitted market." A non-admitted carrier's pricing is not approved by a state, but it is allowed to do business in that state in lines that do not have enough penetration from standard ("admitted") carriers. The growth of the E&S segment reflects that the admitted carriers have elected not to insure certain risks, e.g., an older building in an undesirable neighborhood.

  The departure of mega-carriers from hurricane-prone Florida is creating opportunities for companies that compete in the E&S segment there.

  The departure of mega-carriers from hurricane-prone Florida for the reasons outlined above is creating opportunities for companies that compete in the E&S segment there, including ***ACE Limited*** (a diversified global insurance and reinsurance operation, with about $12 billion of net premiums written in 2006) and ***Arch Capital Group*** (an even smaller company, with about $3 billion of net premiums written in 2006).

The Regulatory Implications

As Figure 9 illustrated, while carbon dioxide is not the most potent greenhouse gas with respect to trapping heat in the atmosphere, it does have the largest absolute impact. Figure 12 illustrated that *fully half of global carbon dioxide emissions result from the burning of fossil fuels for electricity generation (32%) and transportation (18%),* e.g., automobiles. In addition, the building sector also accounts for a significant portion (20%) of carbon dioxide emissions, both directly (fossil fuel combustion) and indirectly (consumption of electricity). Not surprisingly then, these three sectors are the focus of multiple regulatory initiatives.

Importantly, *regardless of their nation of incorporation*, companies with international operations are increasingly subject to various emissions regulations and standards in key markets, perhaps most notably today in the European Union. Similarly, companies that operate in U.S. states with climate-related regulations will be subject to the varying requirements of those states.

Clinton, Gore, and McCain all support mandatory GHG emission limits.

Moreover, in the opinion of the World Resources Institute, it's likely that there will be a more aggressive and coordinated federal policy about GHG emissions in the U.S. in the next two to three years. Presumed candidates for both the Democratic and Republican presidential nominations — e.g., Clinton, Gore, and McCain — support mandatory GHG emission limits. (Senator McCain, with Senator Lieberman, recently reintroduced a version of the previously unsuccessful Climate Stewardship and Innovation Act, which proposes capping emissions from electricity generation, transportation, industrial, and commercial sectors.)

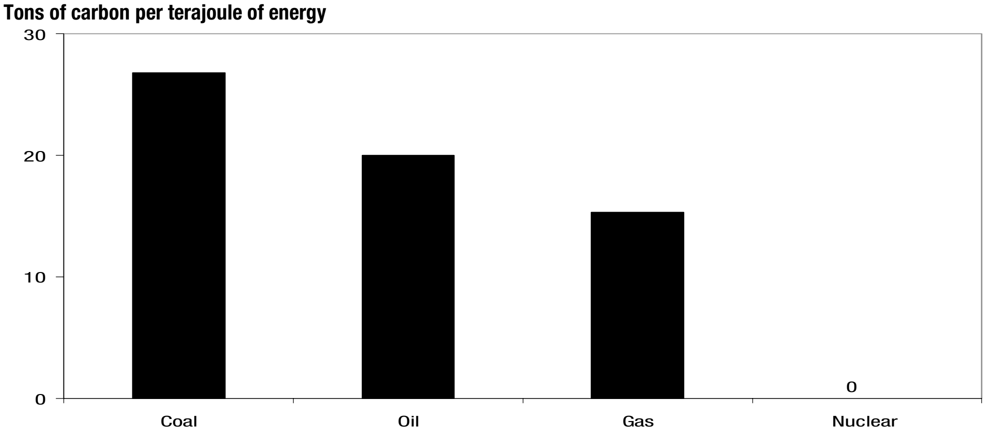
Power Generation in a Carbon-Regulated World

Those power companies that are heavily invested in producing power from carbon-intensive coal are particularly vulnerable to emissions regulations, compared to other companies that have investments in cleaner production using fuels such as natural gas. Carbon emissions per unit of electricity are about half as large from natural gas power plants as from coal plants, while nuclear plants are completely carbon-free sources of electricity — see Figure 36.

Nuclear plants are completely carbon-free sources of electricity.

Figure 36. Carbon Content of Fuels

Tons of carbon per terajoule of energy



Source: World Resources Institute

Therefore, in theory, *strict* restrictions on GHG emissions would:

- Significantly increase the operating costs of coal-fired power plants;
- Increase the operating costs of gas-fired plants by about only half as much; and
- Have no impact on the operating costs of nuclear plants.

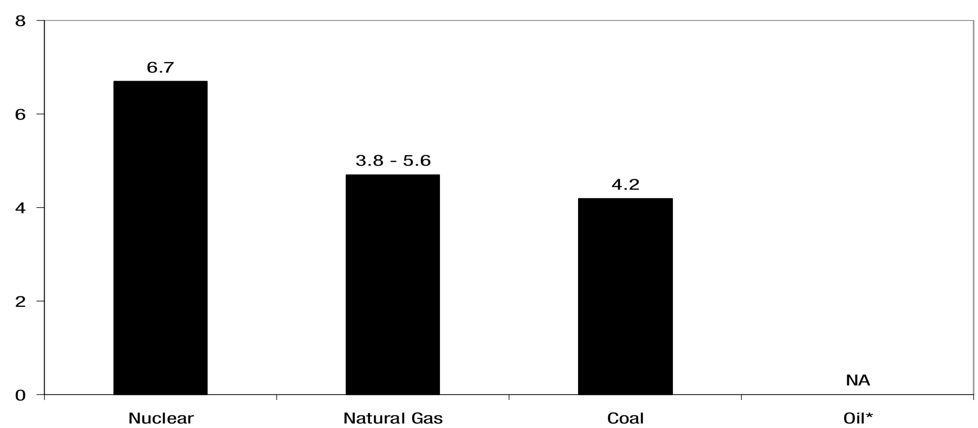
Nuclear: The Scarcity Factor

Despite its attractiveness from a GHG perspective, there are serious obstacles to *materially* increasing the contribution of nuclear power to the global energy supply:

- *Aging Plants.* 440 reactors now produce 16% of the world's electricity. Many of those reactors were built in the 1960s and 1970s, but the 30- to 40-year planned life span of many of those plants is now being reached. So, the average age of the 103 U.S. nuclear plants is roughly 23 years, with some facilities in operation since the 1950s. And, reflecting a design that is unique to the U.K., half of Britain's nuclear plants will close by 2010; the other half will close by 2023. If older power stations are taken off-line, nuclear's share of global electricity production will fall unless there is extensive building of new reactors.
- *High Construction Costs.* While the recent rise in the price of fossil fuels has made nuclear energy more competitive with plants fired by coal, oil, or natural gas, in many unregulated markets electricity generated by a nuclear power plant still costs more than electricity generated by fossil fuels, *largely because of very high capital costs*. So, for example, a Massachusetts Institute of Technology study[22] estimated that, in the U.S., electricity generated by a nuclear plant costs about 6.7 cents per kilowatt hour [kwh], compared to 4.2 cents per kwh for coal and 3.8–5.6 cents per kwh for natural gas (see Figure 37). The authors noted that "similar analysis for Europe and especially Japan and Korea would be somewhat more favorable to nuclear, since gas and coal costs are typically higher than in the United States." Note that building a nuclear power plant also takes a considerable amount of time.

Electricity generated by a nuclear power plant costs more than electricity generated by fossil fuels.

Figure 37. U.S. Electricity Generation Costs in Cents per Kilowatt Hour



*Oil is not a primary fuel source for electricity generation in the U.S.
Source: Massachusetts Institute of Technology

[22] *The Future of Nuclear Power*, Massachusetts Institute of Technology, 2003

- *Waste Storage and Terrorism*. Large-scale deployment of reactors would multiply the problem of waste storage, as well as the threat of terrorism. Moreover, any country that could enrich natural uranium to the concentration needed to fuel a power plant could easily use those same machines to enrich uranium to the concentration needed for a nuclear bomb.

- *Public Opinion*. There is still little evidence that climate change issues have reduced "NIMBY" (not-in-my-backyard) sentiments in many of the world's democracies, and made the global public generally more receptive to nuclear energy. Indeed, the recent move by Germany to phase out nuclear power by 2020 was made largely in reaction to public opinion (although the German government may be reassessing the prudence of that strategy).

Moreover, even if the share of the world's electricity produced by nuclear reactors doubled in coming decades, nuclear would still only supply *about one-third* of the world's electricity consumption. And with coal supplies still plentiful (particularly in the U.S., Germany, and Australia) there is no compelling economic (as opposed to environmental) need to seriously consider alternatives to fossil fuels for power generation. So, with the cost of fossil-fuel-generated electricity likely to rise in a carbon-regulated world, the factors outlined above would suggest that the current owners of "scarce" existing nuclear plants are relatively well positioned.

Windfall Profits in Europe; Potentially Well-Positioned in the U.S.

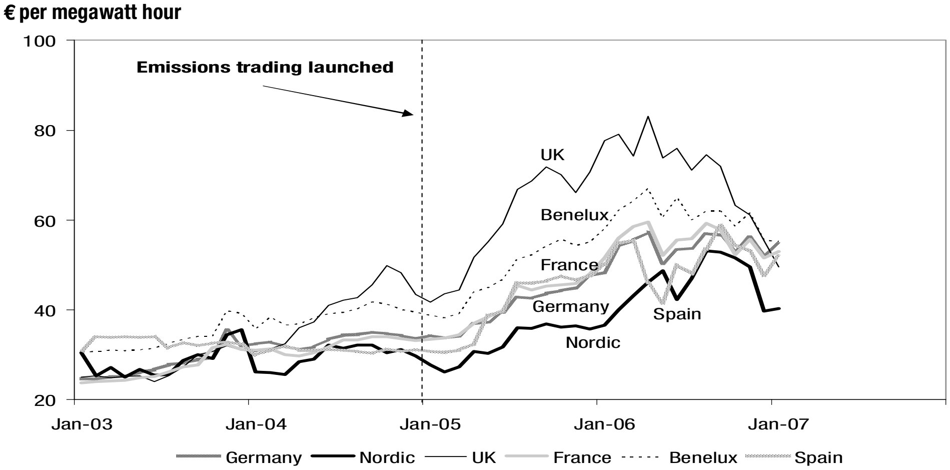
Of course, in addition to the *cost* of electricity production, one must also consider the *price received* by electricity producers in a carbon-regulated world. If the price received for electricity in such an environment is significantly greater than the cost of carbon, then that will lead to windfall profits, which is exactly what has happened in the first phase of the European Union Emissions Trading Scheme (EU-ETS).

We discussed above the mechanics of the EU-ETS, which was launched in January 2005, with Phase 1 scheduled to run through 2007. As Figure 38 illustrates, the introduction of the scheme was unquestionably a factor contributing to a *rise* in European power prices that began in 2005 (with other factors including the rise in the price of oil and a tightening of generating capacity).

The introduction of the EU-ETS was unquestionably a factor contributing to a rise in European power prices.

Figure 38. Time Series of Year Ahead Power Price in Select European Countries

€ per megawatt hour



Source: Platts European Power Daily

Even though the vast majority of permits (95%) were given away for free in Phase 1 of the EU-ETS, the introduction of carbon pricing drove an increase in European power prices, in part because *it is the marginal unit of electricity that sets the price*. So, in a very simplified example, if "DirtyEuroUtility" is permitted to emit 900 tons of carbon dioxide, but actually emits 1,000 tons in its generation of 800,000 kilowatt hours of electricity, it will need to go to the carbon market to buy permits for the excess 100 tons. The price of *those* permits is then a key factor in determining the price of *the full* 800,000 kilowatt hours "DirtyEuroUtility" supplies to the market.

In the second, "stricter" phase of the EU-ETS, which runs from 2008 through 2012, carbon emissions restrictions will be tightened, and "just" 90% of permits will be given away for free. Nevertheless, it would appear that that the generally favorable environment for European electricity generators will continue in Phase 2.

So, thanks to the windfall profits that have resulted from the EU-ETS, even "dirty" utilities, such as ***RWE AG,*** Germany's largest utility, have been faring well. In 2005, RWE's plants burned about 90 million tons of lignite, which is among the most-carbon-intensive types of coal. Consequently, in addition to generating 13% of all the electricity produced in Germany, RWE also emitted about 90 million tons of carbon dioxide, or about 10% of Germany's total. Nevertheless, thanks, in part, to windfall profits from the EU-ETS, RWE's EPS rose 16% in 2006.

In addition to reaping these windfall profits, owners of European nuclear plants are also well positioned for a *longer-term* tightening of carbon emissions restrictions. Then, too, nuclear operators have experience in building such plants, an important consideration given that "NIMBY" concerns will likely mean that a lot of new nuclear construction will be "brownfield" (i.e., located close to existing facilities) rather than "greenfield" (i.e., located at a completely new site).

- ***Electricité de France*** is the largest operator of nuclear assets in the world. Its nuclear plants are relatively "young," with an average age of just 19 years.
- ***Fortum Oyj,*** a utility serving Nordic countries including Finland and Sweden, has around 50% of its power generation capacity in nuclear.

With regard to the U.S., as we noted above, the World Resources Institute believes it is likely there will be a more aggressive and coordinated federal policy about GHG emissions within the next two to three years. For the reasons outlined above, it would seem that nuclear plants would be relatively well positioned in such an environment.[23]

- ***Exelon Corp*** operates the largest unregulated nuclear fleet in the U.S.
- ***Entergy Corp*** is the second-largest nuclear plant operator in the U.S.
- ***FPL Group*** is a nuclear operator, and is also the leader in U.S. wind power generation.
- ***Constellation Energy*** owns three merchant nuclear plants in the U.S.

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[23] Note that many owners of U.S. nuclear plants also have exposure to fossil fuels, so that it's necessary to calculate a company's net exposure to carbon limits — see, for example, Greg Gordon's September 11, 2006, call note, "Carbon Limits Are Coming."

Exhibit 2: Carbon Emissions Reduction Technologies

For fossil-fuel-based power plants, there are essentially three ways in which carbon emissions can be reduced:

- Fuel switching (e.g., from coal to gas);
- Improved efficiency, and/or
- Sequestration (i.e., carbon capture and storage, or "CCS").

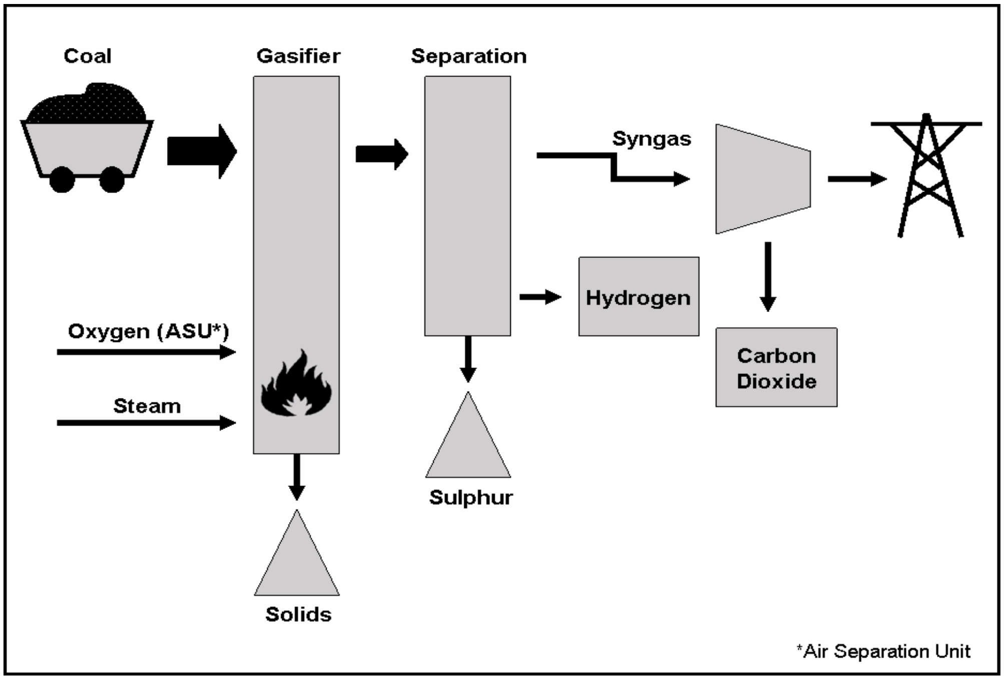
With regard to *improved efficiency,* in the section on automobiles below, we note that, while diesel is *more*-carbon-intensive than gasoline on a per unit basis, the fuel can be used with efficient compression-ignition engines, so that carbon dioxide emissions are *reduced* by way of the greater fuel efficiency. At the same time, however, diesel engines emit relatively large quantities of air pollutants, such as nitrogen oxide, which need to be filtered.

Similarly, while pollutants such as nitrogen oxide can be filtered (or "scrubbed") from the emissions of pulverized coal-fired power plants, carbon dioxide emissions are a function of the fuel efficiency of a plant. However, it can be a very expensive proposition to retrofit a power plant to reduce carbon dioxide emissions by boosting fuel efficiency. Therefore, major carbon emissions reductions achieved through efficiency improvements will likely *require new plant construction*.

From a technological perspective, there are several options for improving power plant fuel efficiency, including coal gasification. (We noted above that the U.S. Energy Policy Act of 2005 authorized appropriations for clean coal research in coal-based gasification and combustion technologies.) Whereas a conventional coal-fired plant operates at about 33%–38% efficiency, a gasification plant has the potential to operate at close to 60% efficiency. (By "efficiency," we are referring to the amount of heat released by a specific quantity of a fuel once it is combusted for electricity generation. Since there is no simple way for the heat generated to be used, it is simply vented into the atmosphere.)

- Gasification differs from combustion in that, instead of burning, most of the coal is chemically broken apart by the gasifier, setting in motion chemical reactions that produce "syngas," which is primarily carbon *monoxide* and hydrogen (see Figure 39).
- Carbon *dioxide* is the by-product of carbon inside coal reacting with oxygen. The carbon dioxide that is produced in the gasification process is in a concentrated gas stream — reflecting that a partial mixture of oxygen is used in the gasifier — making it relatively easy to separate and capture the carbon dioxide. So, a key attraction of gasification (compared to standard pulverized coal plants) is that it *facilitates carbon sequestration*.
- Syngas can be burned as a fuel in a gas turbine that drives an electric generator. Residual heat in the exhaust gas from the gas turbine is recovered in a heat recovery boiler as steam, which can then be used to produce additional electricity in a steam turbine generator, thereby producing significant efficiency improvements; as noted, efficiency could eventually approach 60%.
- Clean syngas can also be used as a source of hydrogen, which can be separated from the gas stream and used as a transport fuel.

Figure 39. Coal Gasification: An Overview



Source: World Business Council for Sustainable Development

Gasification differs from combustion in that, instead of burning, most of the coal is chemically broken apart by a gasifier, resulting in "syngas," which is primarily carbon monoxide and hydrogen.

Two gasification power plants — built with big government subsidies — have been operating in the U.S. for more than a decade (one near Tampa, Florida, owned by TECO Energy, and the other in Wabash, Indiana, owned by Duke Energy). A new generation of gasification plants is on the horizon: a recent *Wall Street Journal* article[24] reported that "there are proposals to build about two dozen such plants in the U.S. in coming years, perhaps amounting to one-quarter of the planned new coal-fired plants."

In that regard, ***General Electric,*** with its 50/50 partner Bechtel, now has three commercial Integrated Gasification Combined Cycle (IGCC) plants moving through design studies, two with American Electric Power and a third with Duke Energy (although GE is in talks with about a dozen utilities that are considering IGCC plants). Reflecting that, in the past, IGCC applications have all been "one-offs," the GE/Bechtel strategy is to standardize the plant design in order to benefit from a learning curve and drive down costs. Importantly, GE's technology is *already validated;* what it now needs to show is the integrated operation and reliability of a plant of this size.

IGCC is strategically important to GE because *it essentially converts a coal plant from a steam turbine play into a gas turbine play*. Recall, as we pointed out above, that as part of the coal gasification process, the syngas can be burned as a fuel in a gas turbine that drives an electric generator. Gas turbines are the heart of GE's energy franchise, and the key to the $8 billion-plus aftermarket business. So, while, in a traditional coal power plant, GE could compete for about 5% of the value of the plant (the steam turbine and generators), in an IGCC plant GE can capture about 40% of the value of the plant by selling the gasifiers and related systems, the gas turbines, the heat recovery system, the steam turbines and the generators.

[24] *Burning Debate: As Emission Restrictions Loom, Texas Utility Bets Big on Coal*, The Wall Street Journal, July 21, 2006

GE's gas turbine market share is about 46% compared to No. 2 ***Siemens,*** at about 28%. Siemens also recently signaled its intention to develop IGCC technology with the acquisition of Sustec, a Swiss group with expertise in IGCC. (Note that Siemens also has significant exposure to nuclear power plant construction.)

A key issue surrounding gasification is cost. In contrast to a "standard" pulverized coal plant, costing $1,200–$1,500 per kilowatt, a first-generation IGCC plant might cost $1,800–$1,900 per kilowatt, *excluding* carbon storage (discussed below). So, IGCC could materially increase the cost of electricity (currently averaging $65 per megawatt hour), but a carbon tax in the range of $30–$70 per ton of carbon dioxide would increase the attractiveness of coal gasification, because carbon capture and storage would become economically viable.

As noted, coal gasification involves the capture of carbon dioxide *before combustion*. Two other possible technologies for carbon dioxide capture from coal-fired power plants can be categorized as:

➤ Carbon Capture *After Combustion*. This involves capturing carbon dioxide post-combustion in power plant flue gas. This approach is expensive and also involves significant efficiency losses (reflecting that energy must be used to generate heat for the chemicals used in post-combustion capture).

➤ *Oxy-Combustion*. In this process, *pure* oxygen, rather than air is used to combust the fuel, producing a carbon-dioxide-rich flue gas that can subsequently be captured at relatively low cost and sequestered. One of the key barriers to implementation of oxy-combustion is, however, the cost of producing the oxygen. Note that, in contrast to gasification in which a *partial* mixture of oxygen (10%–70%) is required, oxy-combustion requires combustion in *pure* (i.e., 100%) oxygen. Vattenfall, a Swedish utility, recently began construction in Germany of a low-carbon, coal-fired power plant incorporating the oxy-combustion process; this demonstration plant could become operational in 2008.

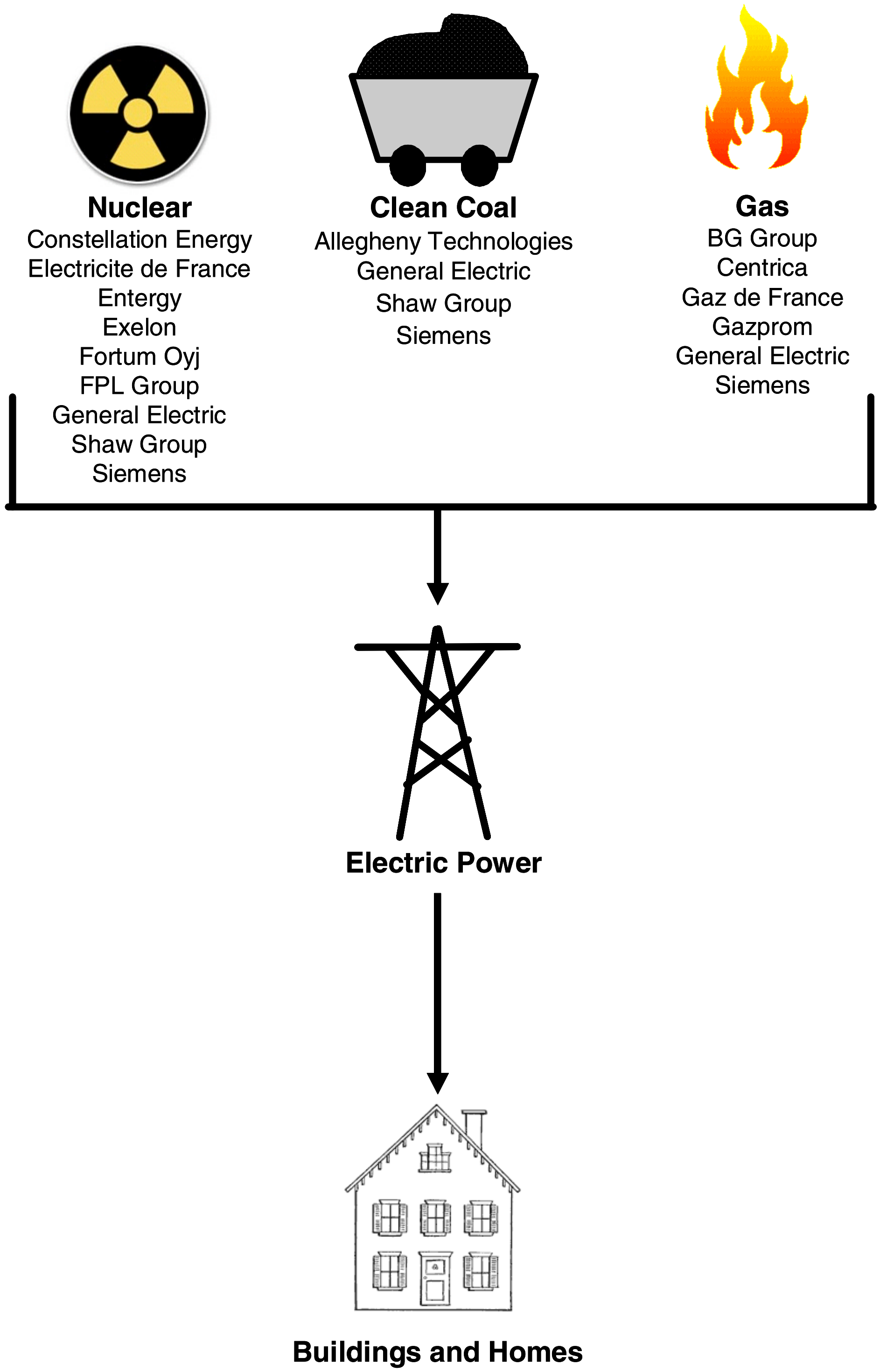
However carbon dioxide is captured, a separate key issue is storage. In that regard, the use of geologic formations for carbon dioxide sequestration is being investigated in many countries. Depleted gas fields, non-minable coal seams, and saline aquifers all offer carbon dioxide sequestration options. But the main challenge associated with geological storage of large amounts of carbon dioxide is the prevention of leakage, which could lead to the contamination of groundwater. Furthermore, measurement systems that monitor and verify carbon dioxide storage must also be developed.

Finally, we note that whatever the carbon emissions reduction technology of the future, it is reasonable to expect: 1) more pretreatment, such as coal gasification; 2) more demanding/precise operating conditions, such as high temperatures for super-critical coal combustion; and 3) more post-treatment, such as stack-gas scrubbing. These trends suggest strong demand for stainless steel, high-nickel alloys, and titanium.

A likely beneficiary in this regard would be ***Allegheny Technologies***, which makes the specialty alloys used in generating stations, as well as in nuclear reactors, LNG plants, pipelines, and ethanol plants.

Investment in nuclear power, "clean coal," and gas-fired power plants would lead to reduced emissions of carbon dioxide.

Figure 40. Power Generation in a Carbon-Regulated World



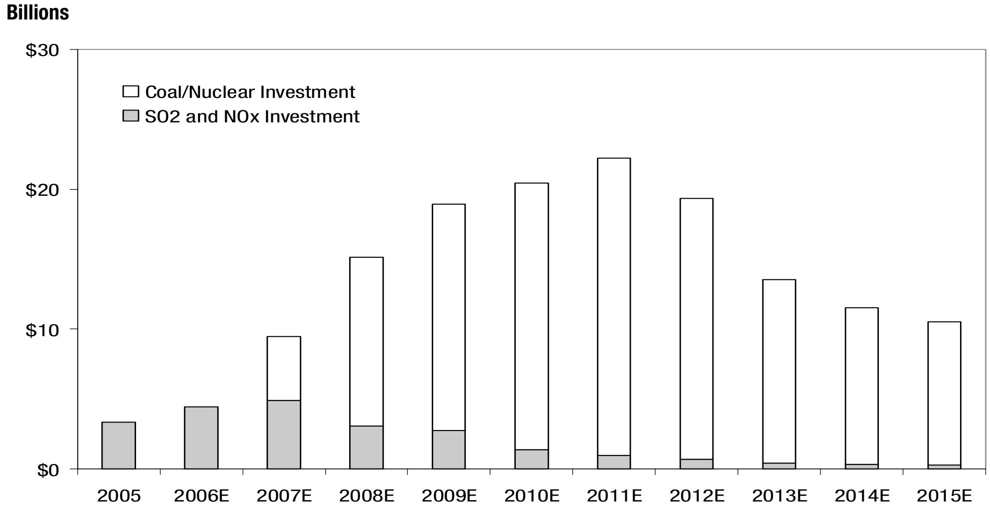
Source: Citigroup Investment Research

Engineering and Construction Companies and Power Generation

As we noted above, nuclear power plants are both expensive and time-consuming to build. But that's not to say that nuclear construction will not occur in the near future, especially as restrictions on the emissions of carbon dioxide are tightened globally. So, for example, Citigroup Investment Research analysts estimate[25] $125 billion in U.S. capital expenditures on new power generation facilities, including nuclear and "cleaner" coal, through 2015 — see Figure 41. (Note that these estimates assume that coal is "cleaned" of carbon, through either the retrofitting of power plants or coal gasification.)

$125 billion in U.S. capital expenditures on new power generation facilities, including nuclear and "cleaner" coal, through 2015.

Figure 41. U.S. Generation and Environmental Expansionary Capital Spending Outlook



Source: Citigroup Investment Research, Energy Information Administration, industry reports

It is important here to distinguish between two forms of power generation:

- A *base load* power plant is one that provides a steady flow of power regardless of total power demand by the grid. These plants run at all times through the year, except in the case of repairs or scheduled maintenance. Since nuclear and coal power plants require a long period of time to heat up to operating temperature, these plants typically handle large amounts of the base load demand.
- *Peaking power* plants generally run only when there is a high (or "peak") demand for electricity. In the U.S., this typically occurs in the afternoon, especially during the summer months when the air conditioning load is high. Natural gas power plants are typically scheduled to handle peak power demands since they can be ready to supply power in about 30 minutes or less.

In that regard, we pointed out in the discussion of the U.S. natural gas outlook that most of the *peaking* capacity is currently gas fired. However, Figure 41 illustrates expected capital spending on *base load* coal and nuclear plants, which typically take seven to 12 years to build. Relatively high natural gas prices currently favor building coal and nuclear plants in the U.S.

[25] *Launching on the E&Cs: Building for the Future*, Brian Chin, July 27, 2006

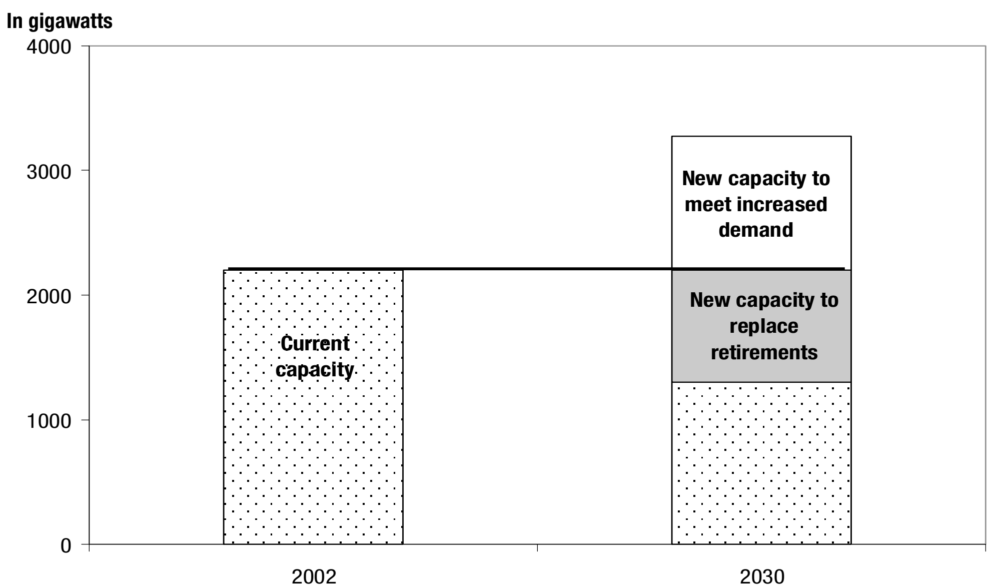
Figure 41 also shows that Citigroup analysts estimate $20 billion will be required to be spent in the U.S. on air emissions equipment for *preexisting* facilities (i.e., to curb sulfur dioxide and nitrogen oxides). These estimates of environmental spending do *not* include any spending by U.S. power generators on carbon dioxide sequestration equipment, which would likely occur if 1) a cap-and-trade system were adopted by the U.S., *and* 2) cost-effective carbon sequestration technologies are developed in the next few years.

Shaw Group, a leading engineering and construction company, is a key beneficiary of power generation and environmental spending in the U.S. With power generation accounting for 40% of total backlog — and nuclear construction half of that — Shaw Group is highly leveraged to spending by utilities. In addition, Shaw leads the U.S. market for environment control equipment.

As Figure 42 illustrates, global power generation trends are forecast to be similar to those in the U.S. in coming decades, with an increase in capital expenditures reflecting, in part, replacement of "dirty," older power plants with "cleaner," more modern technologies. The portion of the world's existing power generating fleet that is more than 40 years old will rise 75% in the current five-year period (2005–10) from the previous five-year period (2000–05.)

Global power generation trends reflect, in part, replacement of "dirty," older power plants with "cleaner," more modern technologies.

Figure 42. Power Generation Capacity in OECD Markets



Source: International Energy Agency, World Energy Outlook

In particular, spending on nuclear power generation looks set to pick up globally reflecting, in large part, the higher cost of fossil fuels, carbon emissions restrictions, and security of fuel supply concerns in many countries. New power plants are being built in France and Finland, while the U.K. (which, as discussed, is facing the closure of many of its plants) appears to be moving closer to restarting its nuclear building program. As we discuss elsewhere in this report, both ***Siemens*** and ***General Electric*** have significant exposure to nuclear power plant construction.

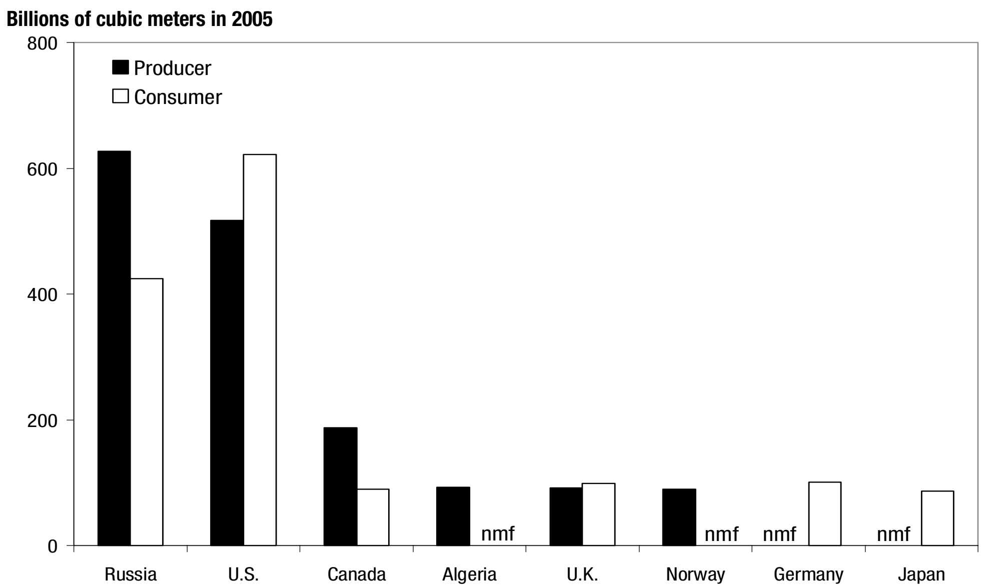
Natural Gas

As we noted, carbon emissions per unit of electricity are about half as large from natural-gas-power plants as from coal plants, suggesting that the attractiveness of natural gas as a fuel source should increase as restrictions on GHG emissions are tightened. In the section on physical implications of climate change — and, specifically, the impact of hurricanes in the Gulf of Mexico — we discussed U.S. companies with exposure to natural gas production. Outside the U.S., some other companies seem well positioned to benefit from the relatively low carbon emissions that result from burning natural gas, including:

- ***Gazprom***, which controls the Russian gas transportation system and is the sole exporter of Russian natural gas to Europe and the countries of the former Soviet Union. As Figure 43 illustrates, Russia is the world's biggest producer of natural gas, and exports a significant portion of its production to consumers in large European markets, such as Germany.

Russia is the world's biggest producer of natural gas, and exports a significant portion of its production.

Figure 43. Top Six Global Gas Producers and Consumers



Source: International Energy Agency, Natural Gas Information 2006

- ***BG Group***, which traces its roots back to British Gas. Although the company remains heavily weighted toward its fast-growth exploration and production platform, BG's goal is to build gas markets through investments in 1) power generation, 2) transmission and distribution assets, and, increasingly, 3) liquefied natural gas.

- ***Gaz de France,*** one of the largest gas utilities in Europe. While the bulk of its activities are regulated by the French government, the company also has a substantial exploration and production arm.

Exhibit 3: Micro-Generation

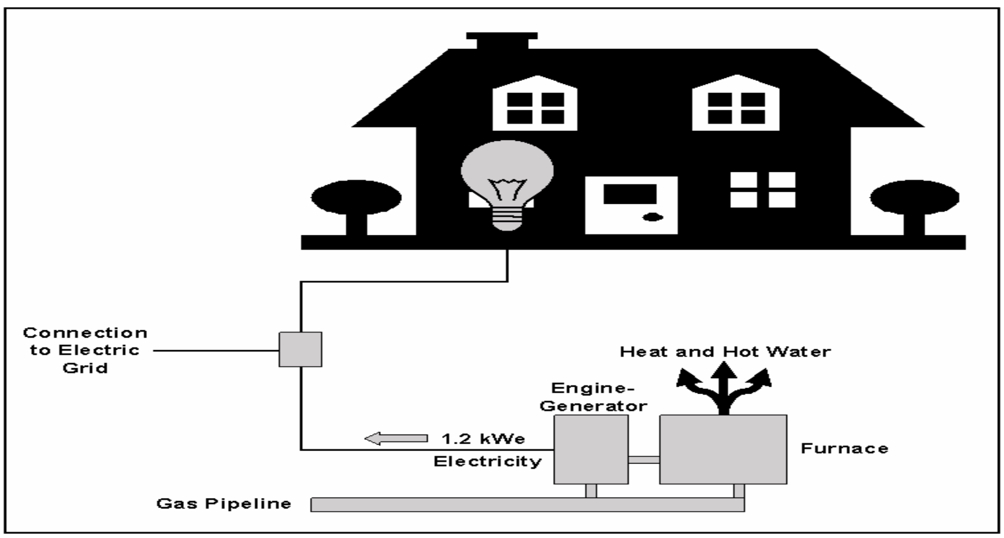
"Micro-generation" would change the electric utility landscape *by putting power generation back into the home*. Indeed, a recent Citigroup Investment Research report pointed to estimates that, in the U.K., one form of micro-generation, "combined heat and power" (CHP), has the long-run potential to "generate 12.5 gigawatts per annum (about 15% of the U.K.'s existing capacity)," which would call into question "the necessity of a full revamp of nuclear generation" in that country.[26] As the name suggests, CHP is a system that produces both heat and electricity.

CHP micro-generation would be particularly attractive in the U.K. market, given that most British homes are heated for a good part of the year, reflecting that country's relatively cool and damp climate. In that regard, Ceres Power Holdings has been developing a CHP unit with ***Centrica*** (known as "British Gas" to residential customers in the U.K.). Centrica has 11.5 million gas customers, as well as 6 million electricity customers, and the company operates the U.K.'s largest fleet of gas-fired power stations.

Under a U.K. CHP system, residences would be primarily dependent on a gas pipeline (see Figure 44), in contrast to the current system whereby hot water and central heating are typically provided by gas power, and electricity is provided via a wire into the home.

A CHP system produces both heat and electricity.

Figure 44. A Micro-Generation CHP System



Source: Citigroup Investment Research

A typical CHP unit — designated by the electrical output — would be about one kilowatt, which is the average hourly electricity consumption of a typical U.K. residence. Power from the grid would provide additional electricity to cover spikes in usage in a home.

A CHP system would mean that heat is constantly produced, but this would *not* be inefficient compared with a standard boiler, as the latter is typically much more powerful and its use for one hour a day to heat water would be equivalent to the one kilowatt CHP system *running for 24 hours*.

[26] See Nick Williamson's June 16, 2006, report, "Fuel Cells."

We discussed in Exhibit 2 that average fossil-fuel-driven electricity generation efficiency is less than 50% (especially when transmission losses are factored in). In other words, since the heat generated from burning fossil fuels to create electricity is distanced from the homes the electricity is serving, there is no simple way for that heat to be used, so it is simply vented into the atmosphere.

In a CHP system, by contrast, electricity is produced *at its point-of-use*. Not only does this save on transmission losses, but the system is also *highly efficient*:

➤ So, for example, the Ceres CHP system will convert about 45% of the energy value of the gas into electricity (i.e., about the same as a power plant).

➤ Since the Ceres unit is sited in the home, the heat generated from electricity production can *also* be used for hot water and central heating, a process that will capture the 45% of the fuel's energy value that is typically vented into the atmosphere by a utility.

So, overall CHP efficiency of the Ceres unit is predicted to be about 90%, comparable to that of a condensing boiler. (Modern condensing boilers have been a requirement in the U.K. since 2005.)

Note here that it may seem strange that Centrica is involved in producing a CHP unit that may decrease its own revenues by effectively providing a significant proportion of its customers' electricity for free. There are, however, several reasons for this:

➤ Centrica is obliged to meet certain government targets under energy efficiency commitments. (Energy efficiency obligations were first introduced in the U.K. in 1994 for electricity suppliers, and extended to gas suppliers in 2000 to provide a framework to help lower carbon emissions.)

➤ The company is keen to tap into new revenue streams, such as selling CHP units, maintaining them, and providing services contracts.

➤ Centrica sees CHP as inevitable, and it wants to be a leader in the technology.

Obviously, accurate pricing of a CHP product would be key to ensuring a successful launch. Initial research undertaken by Ceres and Centrica suggests that, if the CHP price premium to a condensing boiler (including installation) was the equivalent of one year's electricity saving, then most customers would accept CHP.

Finally, the U.K. government views CHP as one way to increase energy efficiency to combat climate change and meet greenhouse gas reduction targets; in 2006 it reduced Value Added Tax (VAT) on CHP units from 17.5% to 5%.

Automobiles and Emissions Regulations

As noted above, climate policies that impact the auto sector include initiatives by some U.S. states to reduce GHG emissions from passenger vehicles, as well as the voluntary GHG reduction agreement that the European Commission has negotiated with European, Japanese, and Korean automobile manufactures.

The technologies that currently seem best-positioned to reduce GHG emissions in the auto sector can be split into three categories:

1. Drivetrain technologies that increase fuel efficiency of the standard internal combustion engine (as discussed below).
2. Vehicle load (weight) reduction, thus requiring less fuel to move the vehicle. For example, ***Magna International***, one of the world's largest auto parts suppliers, is developing specialty, lightweight products and components for automotive use, including ultra high-strength steel, hybrid (aluminum/steel) structures, and lightweight composites and drivetrain components.
3. Switching to less-carbon-intensive fuels (such as bioethanol or biodiesel, which are discussed in the next section).

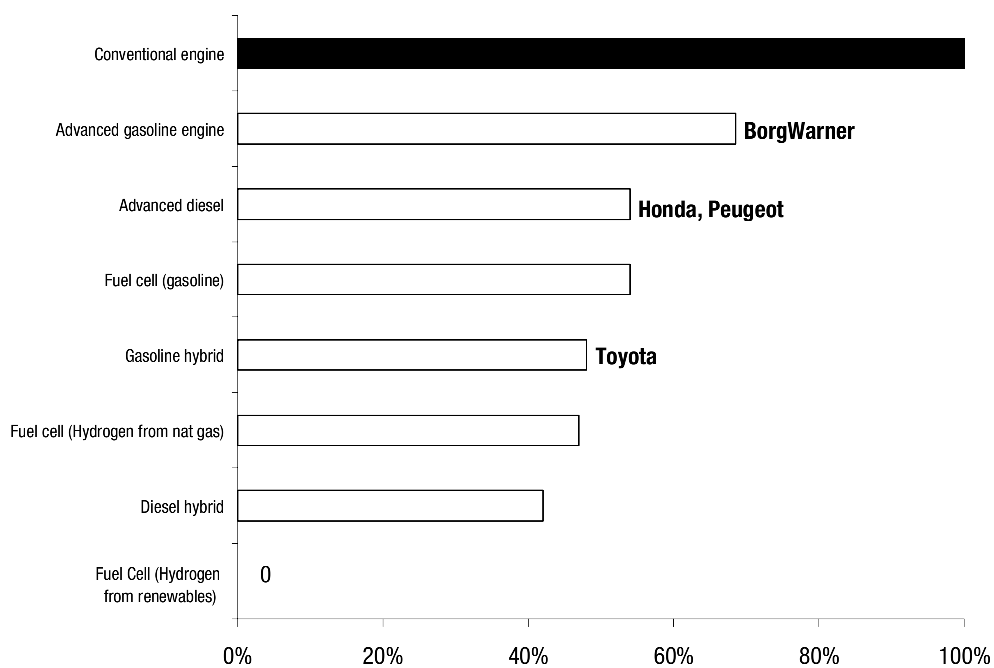
Increased Fuel Efficiency

Technologies that improve automobile fuel economy include those that increase engine efficiency *as well as* the efficiency of accessories that draw down energy from the vehicle, such as air conditioning and heating. In that regard, Figure 45 illustrates various options for reducing the relatively high carbon dioxide emissions of conventional gasoline-powered combustion engines.

There are various options for reducing the relatively high carbon dioxide emissions of conventional gasoline-powered combustion engines.

Figure 45. Carbon Dioxide Emissions Relative to a Conventional Combustion Engine

"Well-to-wheel" carbon emissions

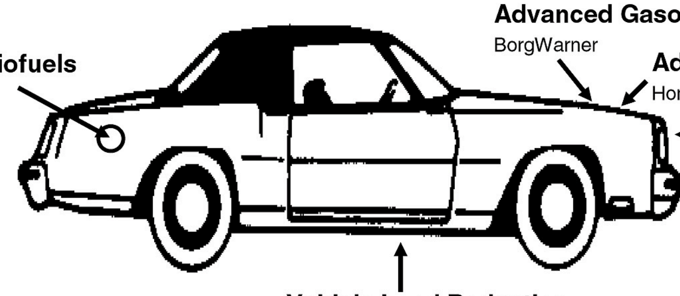


Source: World Resources Institute and Citigroup Investment Research

Technologies that seem best-positioned to reduce GHG include drivetrain technologies that increase fuel efficiency, vehicle load reduction, and less-carbon-intensive fuels.

Figure 46. Select Automobile GHG Emission Reduction Technologies

Reducing "well-to-wheel" carbon emissions



Source: Citigroup Investment Research

- *Advanced Gasoline Engine*. Studies have shown that adding incremental technologies to the standard gasoline internal combustion engine platform — including direct fuel injection — could achieve carbon savings of more than 30%, compared to a 1996 reference vehicle.[27]

  With regard to auto suppliers, almost all of ***BorgWarner's*** key products offer the benefits of higher fuel efficiency and/or lower emissions from a gasoline internal combustion engine. We discuss *diesel* technology below — in addition to BorgWarner's diesel timing chains and turbochargers, BorgWarner's significant ownership stake in Beru AG gives it material exposure to the diesel engine market given, for example, Beru's diesel ignition products.

- *Advanced diesel*. As a fuel, diesel is *more*-carbon-intensive than gasoline on a per unit basis. However, diesel can be used with compression-ignition (CI) engines, which are 20%–40% more efficient than the spark-ignition (SI) engines required to combust gasoline. As a result, a diesel vehicle emits 10%–30% fewer carbon dioxide emissions per kilometer traveled than a comparable gasoline-fueled vehicle. At the same time, however, diesel engines emit *greater* quantities of air pollutants, such as nitrogen oxides, than gasoline engines.

  Among ***Honda's*** product strategies is a new "super-clean" diesel engine, which emits significantly reduced levels of nitrogen oxides. This new diesel drivetrain features a unique method that generates and stores ammonia within a two-layer catalytic converter to turn nitrogen oxide into harmless nitrogen. Recall that, in 1973, Honda introduced the first gasoline engine to meet U.S. clean air guidelines without a catalytic converter.

  In Europe, ***Peugeot*** has a wide offering of diesel-fueled cars. In addition, reflecting 1) that the company offers consumers the widest range of small cars available in Europe, and 2) other initiatives, including its early adoption of mild-hybrid systems, Peugeot is one of the most fuel-efficient automobile manufacturers on the continent. Note that Peugeot also owns 71% of Faurecia, one of Europe's main suppliers of diesel particulate filters.

[27] See Malcolm Weiss et al, *Comparative Assessment of Fuel Cell Cars* (Cambridge, MA: MIT, 2003).

➤ *Hybrid Technology*. Hybrid electric vehicles (HEVs) have drivetrains that combine an electric drive (consisting of an electric motor and some form of electricity storage, typically a battery) with a fuel-based engine (e.g., an internal combustion engine). HEVs take advantage of the fact that most driving conditions only require a fraction of the power available from a car's engine — at steady highway speeds, as opposed to starting or passing, the average car needs about only 20 horsepower. HEVs may use onboard electrical power to varying degrees — "full hybrids" permit some actual propulsion using electric power, whereas "mild hybrids" may limit use of the electric motor, e.g., to vehicle idling. HEVs have the potential to reduce carbon dioxide emissions by 50% compared to today's diesel and gasoline engines.

Toyota Motor is the global leader in hybrid vehicles. At a broad level, the company is focused on the development of environmental technologies on three fronts:

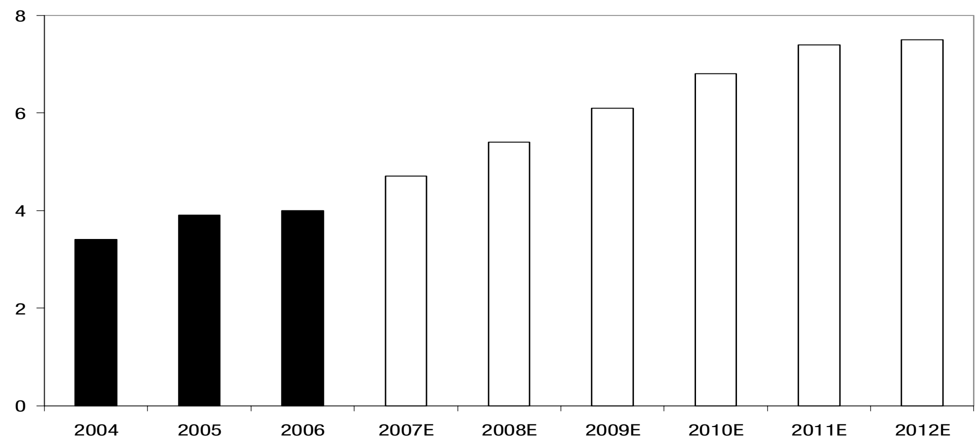
1. cutting carbon dioxide emissions through improved fuel economy (e.g., its new four-cylinder engines);
2. preventing atmospheric pollution by promoting use of hybrids; and
3. diversifying energy sources used as fuel for its vehicles (e.g., bioethanol).

Alternative Fuels and Renewable Energy

As noted above, the U.S. Energy Act of 2005 was the first official U.S. commitment to expand the usage of alternative fuels, such as bioethanol (produced from sugar crops such as corn and sugarcane). The Act requires refiners to ensure that gasoline sold in the U.S. contains a specified volume of biofuels, with a minimum of 4.0 billion gallons in 2006, increasing to 7.5 billion gallons by 2012 — see Figure 47.

Refiners are required to ensure that gasoline sold in the U.S. contains an increasing volume of biofuels.

Figure 47. Billions Gallons of Biofuel Required by U.S. Energy Act of 2005



Source: Renewable Fuels Association and Citigroup Investment Research

Similarly, the EU has set a goal to achieve a 5.75% market share for biofuels, such as biodiesel (produced from vegetable oils) in the overall EU transport fuel supply by 2010. Brazil also requires that ethanol blends be used (see Figure 48). Note that Brazil is the world's leading sugar exporter, and the country's car fleet is heavily dependent on ethanol — currently, 77% of the new light vehicles produced in Brazil are "flex-fuel," i.e., automobiles that can alternate between two sources of fuel, such as gasoline and bioethanol.

A growing number of countries are mandating a greater use of biofuels.

Figure 48. Select Biofuel Policies

Argentina	Requires use of 5% ethanol blends until 2010
Australia	Voluntary ethanol blending of up to 10%
Brazil	Requires 25% ethanol blends. 2% biodiesel blend in 2008, increasing to 5% by 2013
Canada	Requires 5% average renewable content in gasoline and diesel fuel by 2010
China	Five provinces require ethanol blends of 10% in all gasoline
Colombia	Requires 10% ethanol blending in gasoline, gradually increasing to 25% by 2025
European Union	Requires 5.75% biofuels target in 2010
India	Requires 5% ethanol blend in all gasoline
Japan	Requires 3% ethanol blends, increasing to 10% in 2010
Thailand	All gasoline sold in Bangkok must have a 10% ethanol blend
United States	Requires a minimum usage of renewable fuels through 2012

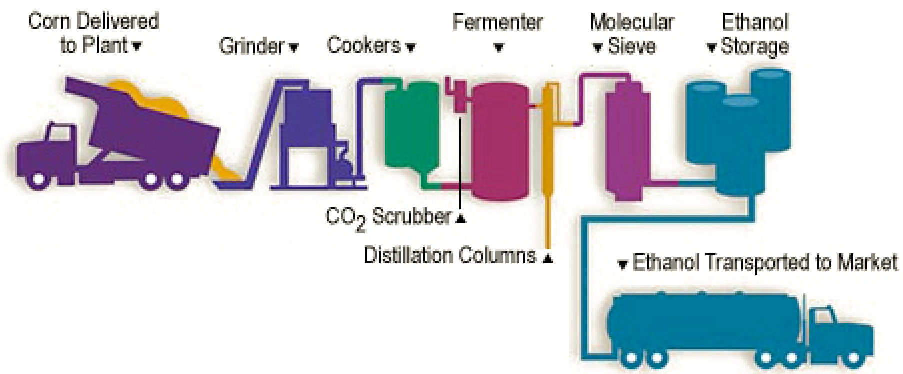
Source: Citigroup Investment Research

Exhibit 4: An Ethanol Production Process

At its most basic, ethanol is grain alcohol, produced from crops such as corn and sugarcane. Ethanol is a clean-burning, high-octane fuel that is typically blended into unleaded gasoline in an E10 formulation, which consists of 10% ethanol volume and 90% gasoline volume. Ethanol can be used to replace the blending agent MBTE, which makes gasoline burn more cleanly, but which can contaminate groundwater. (Note that ethanol contains approximately 34% *less energy* than gasoline, indicating that a vehicle containing ethanol will receive *less* mileage per gallon of fuel versus a vehicle running on pure gasoline.)

Ethanol can be produced by two corn-processing methods: *wet* corn milling and *dry* corn milling. Wet corn mills are more expensive to construct, with the result being that dry corn mills currently represent about 75% of U.S. ethanol production.

Figure 49. Ethanol Dry Corn Milling Process



Source: Renewable Fuels Association

Figure 49 illustrates the dry corn milling process. Among the key steps:

- *Grinder*: The *entire* corn kernel is first ground into flour, referred to as "meal." The meal is slurried with water to form a mash. Enzymes are added to the mash to convert the starch to dextrose, a simple sugar.
- *Cookers*: The mash is processed in a high-temperature cooker to reduce bacteria levels ahead of fermentation.
- *Fermenter*: The mash is then cooled and transferred to fermenters, where yeast is added, and the conversion of sugar to ethanol and carbon dioxide begins. (The carbon dioxide released during fermentation is captured and sold, e.g., for carbonating soft drinks.) The fermentation process generally takes about 40–50 hours.
- *Distillation Columns*: After fermentation, the resulting "beer" is transferred to distillation columns, where the ethanol is separated from the remaining "stillage" (i.e., non-solubles). The ethanol is concentrated to 190 proof using conventional distillation.
- *Molecular Sieve*: The ethanol is then dehydrated to approximately 200 proof in a molecular sieve system. The dehydrated ethanol is blended with about 5% denaturant (such as natural gasoline) to render it undrinkable and, thus, not subject to alcoholic beverage tax. It is then ready for shipment to gasoline terminals or retailers.

Bioethanol

A number of companies have *direct* exposure to global ethanol demand:

- ***Archer Daniels Midland*** procures, transports, stores, processes, and markets a wide range of agricultural products, and it is one of the world's largest processors of oilseeds and corn. The company has about a 20% market share (by production) in the U.S. ethanol market, and ethanol accounted for an estimated 30% of ADM's segment operating profits in fiscal 2006 (ended June).
- ***Cosan SA*** is Brazil's largest sugar and ethanol company, and the second-largest ethanol producer globally (after Archer Daniels). As Brazilian demand for ethanol continues to rise, the company will gradually switch from being one of the world's largest sugar exporters to focusing on solidifying its leadership position in Brazil's domestic ethanol market, currently the largest in the world.
- ***CropEnergies*** operates Europe's largest bioethanol plant; its parent, Südzucker, is the leading European sugar manufacturer. CropEnergies' main feedstock materials are wheat and thick juice (from sugar beet); the company usually builds its plants next to existing Südzucker installations, which provides inexpensive access to thick juice supply as well as substantial cost-sharing potential. At the moment, CropEnergies' central functions (administration, IT, etc.) are largely outsourced to Südzucker and paid for on a per use basis, which minimizes costs. Importantly, CropEnergies can make full use of Südzucker's extensive R&D department (some 250 people work there), which could lead to significant production cost reductions in the future should, for example, a breakthrough on high-yielding yeast be achieved.
- ***Ebro Puleva*** is Spain's largest food manufacturer, with interests in sugar, rice, pasta, and milk. The company, which is the biggest sugar refiner in Spain, is gradually abandoning sugar production, and it is investing about €200 million to expand production of more lucrative biofuels, including ethanol and biodiesel.
- ***Noble Group,*** an Asian competitor of Archer Daniels, operates a global supply chain supporting agricultural commodities (including corn, soybeans, and other grains), and energy products (including ethanol). So, for example, Noble is a major grain trader with a global network of sourcing agents, processing facilities and warehouses. With regard to ethanol, thanks to partnerships with producers (i.e., farmers), and various stakes in "greenfield" ethanol projects, Noble is aiming to control up to 1 billion gallons of ethanol for U.S./global distribution by 2008 (or approximately 14% U.S. market share).

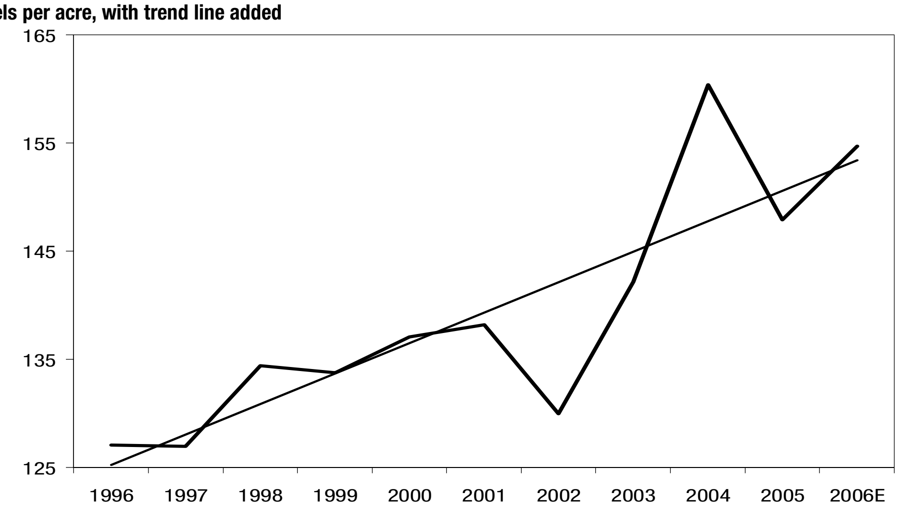
For other companies, burgeoning demand for ethanol has positive repercussions too. In particular, agricultural biotechnology companies are benefiting in two ways:

- First, they benefit from the *increased acreage* being planted globally for crops, such as corn, that can be used in biofuel production.
- Second, they benefit from a desire to *boost the yields* of those acres in order to produce the greatest possible amount of ethanol. As Figure 50 illustrates, thanks to the use of traits (e.g., resistance to common pests) that enhance crop yields, there has been a 20% increase in U.S. corn yields over the past decade.

Thanks to the use of traits that enhance crop yields, there has been a 20% increase in U.S. corn yields over the last decade.

Figure 50. U.S. Corn Yields

Bushels per acre, with trend line added



Source: U.S. Department of Agriculture and Citigroup Investment Research

➤ ***Monsanto*** produces seed with traits that enhance crop yields. With regard to ethanol, the company has developed conventionally bred hybrid corn seed (i.e., no biotech traits) designed to boost the starch content and improve the "fermentability" of corn, thus raising its value in the ethanol-production process.

➤ ***DuPont*** too should benefit from ethanol trends, given that, along with Monsanto, it is one of the two-largest U.S. corn seed producers. DuPont is also developing several yield-enhancing biotechnology traits. Agriculture represents about 25% of DuPont's business, in contrast to fully 100% for Monsanto.

➤ ***Syngenta*** was one of the original creators of agricultural biotechnology products, but it has lagged in this area. Beginning in 2007, however, the company will roll out new products with a particular focus on the biofuel market, e.g., a trait specifically designed to lower the costs of converting corn to bioethanol. Although the key markets for agricultural biotechnology products will be the U.S., Brazil, and the Americas, growing demand for biofuels in Europe should also boost demand in that region for Syngenta's "traditional" agricultural products, e.g., herbicides.

We also note that rising ethanol demand is also a positive for ***Deere***, the farm equipment supplier. In a recent report,[28] Citigroup Investment Research analyst David Raso observed that "the very significant number of ethanol plants coming on-line in the next 12–24 months has many farmers being approached directly by ethanol plant owners to sign corn production contracts for even beyond one year, at corn prices at a premium to current prices." As a result, he writes:

> the initial feeding of these [ethanol] plants [that are set to be built] will...set the stage for healthier farm income in 2007–08, stimulating a farm equipment recovery.

[28] See David Raso's September 13, 2006, "Nebraska Farm Show Highlights Patience Needed" industry note.

Demand for ethanol also has implications for fertilizer:

- ***Terra Industries*** is well positioned to benefit from corn ethanol because corn is a nitrogen-intensive crop, and Terra produces nitrogen products exclusively.
- ***Potash Corp.*** is also well positioned, as it produces three nutrients (potash, nitrogen, and phosphate), all of which are important in grain cultivation.

Corn ethanol can only ever be a fuel additive; there's just not enough corn to replace motor fuels. Cellulosic technology offers a way for ethanol to become a major source of motor fuel.

In our description of an ethanol production process, we noted that, in dry corn milling, the entire corn *kernel* is first ground into flour. Obviously, there is a lot more to a corn plant than just the kernel, including leaves and stems. In that regard, in contrast to "normal" ethanol, whose original raw materials are starches, the starting raw material of "cellulosic" ethanol is cellulose, which forms the primary structural component of green plants. The key challenge in making cellulosic ethanol, however, is *the identification of enzymes that facilitate the efficient transformation of cellulose into ethanol*. (Note that corn ethanol can only ever be a fuel *additive*; there's just not enough corn to replace motor fuels. Cellulosic technology offers a way for ethanol to become a major source of motor fuel.)

A number of companies are pursuing "white" biotechnology, which involves applying biotechnology to industrial processes, e.g., creating industrial enzymes to improve the efficiency of production. (By contrast, "green" biotech is applied to agricultural processes, while "red" biotech is applied to medical processes.) ***DSM NV*** is a specialty chemical company, and it is one of the few companies globally to have identified white biotechnology as a key future growth driver of the chemicals industry. (In 2001, DSM filed the most biotech patents of any company in Europe.)

With its history of fermentation-based technologies and investment in biotechnology, DSM is well positioned to be a leading force in the advancement of white biotechnology — it already uses microorganisms and enzymes to generate €1.5 billion of its revenues. It's likely that, going forward, advances in white biotechnology will improve production process yields in a number of areas, including those pertaining to renewable resources.

The move to alternative fuels such as ethanol will also likely result in global sugarcane volumes being increasingly diverted away from sugar to ethanol production. Citigroup Investment Research analysts[29] believe that, in addition to other factors — including rising imports of sugar into China and India, reflecting, in large part, rising standards of living in those countries — diversion of cane volumes to ethanol production will likely result in a higher trading price band for sugar.

Potential beneficiaries of a higher trading price band for sugar include two Indian companies:

- ***Bajaj Hindusthan,*** the largest sugar manufacturer in India, and among the ten largest globally. The company also manufacturers ethanol, and recently announced plans to increase its ethanol capacity by 150% in 2007.
- ***Balrampur Chini,*** one of the top-tier sugar manufacturers in India.

[29] See Princy Singh's October 6, 2005 "Global Sugar" report.

Biodiesel

A number of companies are well-positioned to benefit from growing global demand for biodiesel:

- ***Brasil Ecodiesel*** is a leading biodiesel producer in Brazil. A mandatory 2% blend of biodiesel into diesel will be implemented in Brazil in 2008, creating a $700 million industry. When the mandatory blend rises to 5% in 2013, the biodiesel market should be $2 billion.

- ***Bunge Ltd.*** is the largest vegetable oil producer in the world, with an estimated global production capacity of approximately 16.6 billion pounds. The company's strategy in North America is to enter into partnerships with biodiesel producers, in which Bunge provides the biorefineries with their raw materials (soy oil) as well as access to Bunge's logistics capabilities (e.g., transportation to move the biofuel to end users). In Europe, Bunge has a 40% stake in a biodiesel joint venture, Diester Industries, which produces an estimated 160 million gallons of the fuel annually.

- Archer Daniels Midland is also a significant producer of vegetable oil, with 15 billion pounds of production capacity. In addition to its U.S. operations, ADM is also a producer of biodiesel in Europe, with production capacity of approximately 265 million gallons.

- ***Neste Oil*** is a Finnish independent refiner that focuses on high-value-added petroleum products, including biodiesel. The company has a proprietary third-generation biodiesel technology (NExBTL), which can use any vegetable oil or animal fat as feedstock. In addition, this biodiesel has the potential to be used exclusively as an end-product, rather than as a blend. The company will complete a biodiesel plant at its Porvoo refinery in Finland in 2007, which will be followed by three other plants — another in Finland, and one each in Austria and France.

Malaysia and Indonesia combined control 85% of global output of palm oil.

- Malaysian plantations that produce palm oil are also benefiting from biodiesel trends. Palm oil is Malaysia's third-biggest export, and while Malaysia is currently the world's largest palm oil producer, it may soon be overtaken by Indonesia, which has more land available for new cultivation. The two nations combined control 85% of global output of palm oil.

  Global demand for palm oil remains strong. So, for example, it has been forecast[30] that, driven in large part by biodiesel initiatives, China's imports of palm oil will rise 9% in 2007, with similar robust growth in palm oil imports into the E.U.

  - ***IJM Plantations*** has an attractive oil palm age profile, averaging less than seven years. As more oil palm trees hit the peak maturity age, IJM's production should enjoy strong organic growth.

  - ***IOI Corp.*** is one of the largest integrated palm oil producers in the world. IOI is a good proxy for palm oil demand in the European Union on account

[30] Oil World, November 10, 2006

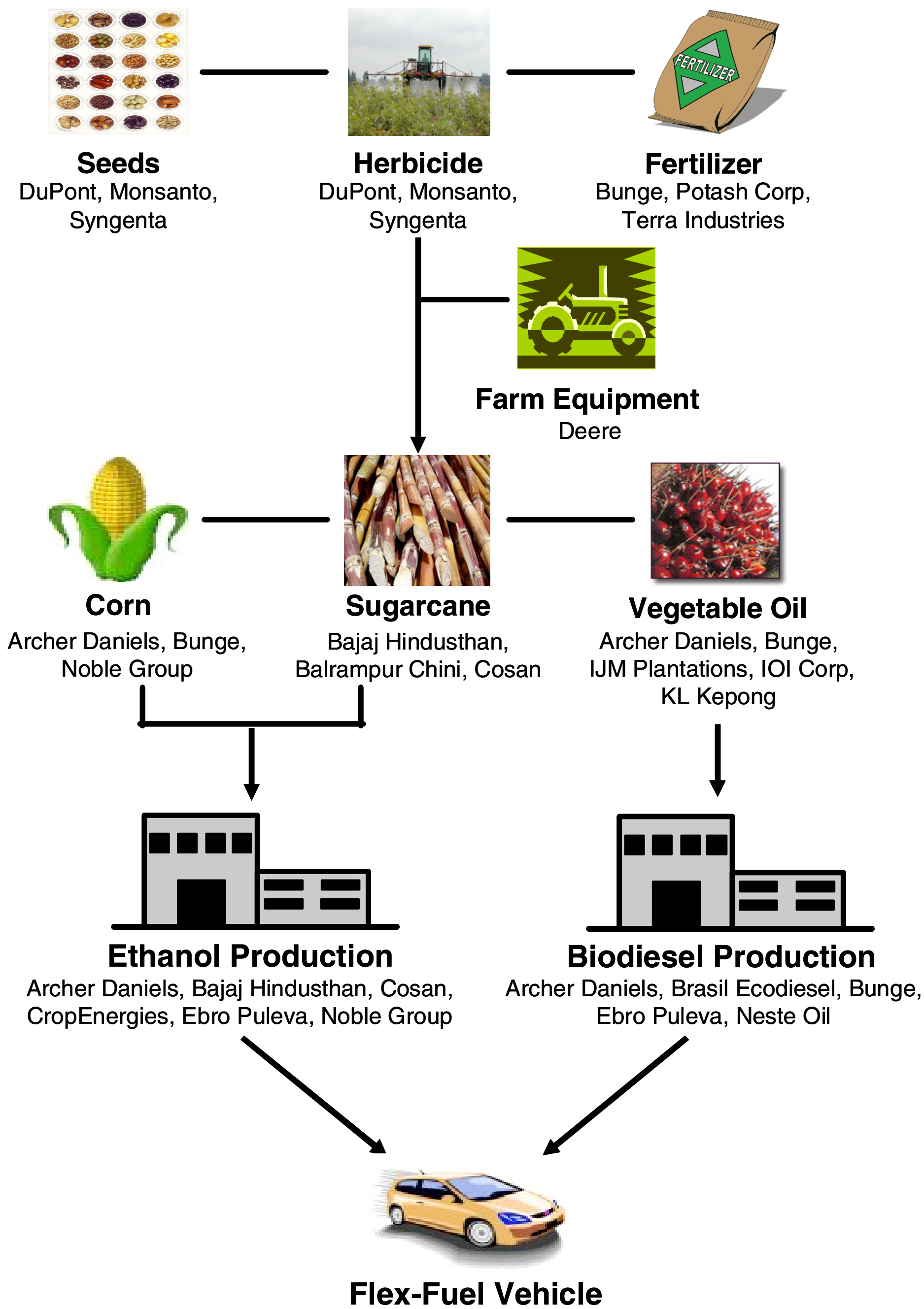
of its strong direct presence in that market (thanks to a 2002 acquisition of Loders Croklaan, a company with roots in Europe).

- ***KL Kepong*** is primarily a plantation company (75% of assets), with some exposure to property and downstream manufacturing. In addition to palm oil plantations located in peninsular Malaysia and Indonesia, KLK also has vegetable oil operations in China.

The biofuel value chain — from seeds to crops to fuels to vehicles.

Figure 51. The Biofuel Value Chain

Select companies



Source: Citigroup Investment Research

Renewable Energy

With regard to renewable energy, we noted above that there are a number of initiatives in place. For example, the E.U. has set a target to double the share of renewable energy in its energy consumption from 6% in 1997 to 12% by 2010, while 21 U.S. states and the District of Columbia have adopted renewable portfolio standards that require power companies to use increasing percentages of electricity produced from renewable sources. In addition, Figure 52 lists renewable energy targets in some other countries.

A growing number of countries are mandating increased usage of renewable energy sources.

Figure 52. Select Renewable Energy Targets

Country	Target(s)
Australia	9.5 Terawatt-hours of electricity annually by 2010.
Brazil	3.3 Gigawatts added by 2016 from wind, biomass, small hydro.
Canada	3.5% to 15% of electricity in 4 provinces; other types of targets in 6 provinces.
China	10% of primary energy by 2010, 15% by 2020.
Germany	12.5% of electricity output by 2010.
India	10% of added electric power capacity during 2003–2012 (expected 10 Gigawatts).
Israel	2% of electricity by 2007; 5% of electricity by 2016.
Japan	1.35% of electricity by 2010, excluding geothermal and large hydro.
Korea (South)	5% of electricity by 2010.
Mali	15% of energy by 2020.
New Zealand	30 Petajoules of added capacity by 2012.
Norway	7 Terawatt-hours by 2010.
Philippines	An increase in renewables of 4.7 Gigawatts by 2013.
Singapore	Approximately 35 Megawatt-hours of solar thermal systems by 2012.
South Africa	10 Terawatt-hours added by 2013.
Switzerland	3.5 Terawatt-hours by 2010.
Thailand	8% of total primary energy by 2011 (excluding traditional rural biomass).
U.K.	10% of electricity output by 2010.

Source: Renewable Energy Policy Network for the 21st Century and International Energy Agency

Broadly speaking, renewable energy technologies can be grouped into four categories:

1. *mature technologies,* e.g., onshore wind, hydroelectric, landfill gas, and geothermal;
2. *maturing technologies,* e.g., offshore wind;
3. *viable technologies* with low penetration rates, e.g., photovoltaic solar; and
4. *technologies under development,* e.g., wave energy.

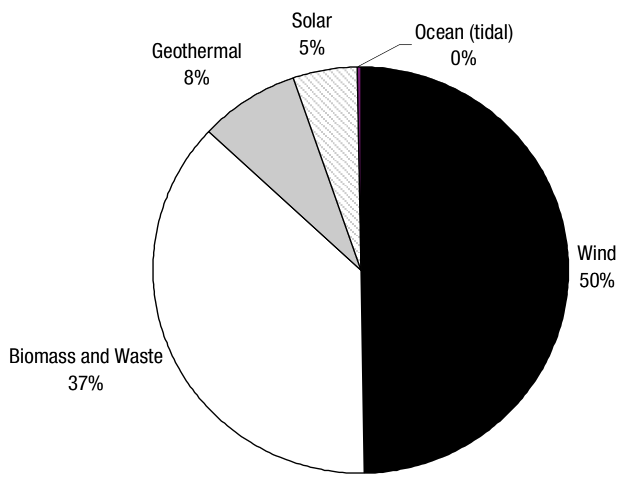
Of course, at the risk of stating the obvious, some forms of renewable energy are only feasible in certain locations, and then under certain conditions. For example, solar power is likely not much of an option in Finland, which typically experiences just 1,900 hours of sunlight, on average, each year. Moreover, in those sunny and windy locations where various alternative power sources are feasible, the supply of energy will likely vary, depending on day-to-day conditions.

At the moment, wind power represents a significant portion of global renewable energy, followed by biomass — see Figure 53. With regard to biomass, note that a significant amount of renewable energy is consumed in developing countries, principally in the form of traditional biomass, e.g., firewood and charcoal.

Wind power represents half of global renewable energy.

Figure 53. Global Renewable Energy Existing Capacity (Excluding Hydro)

As of year-end 2005



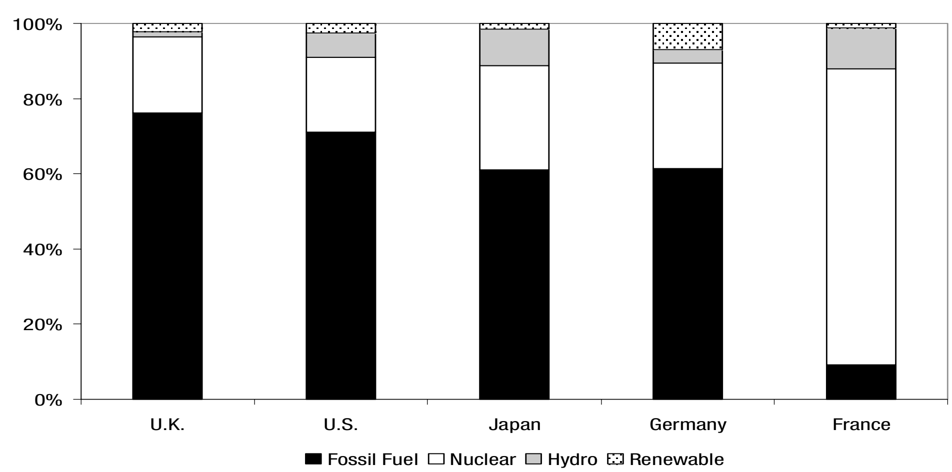
Source: Renewable Energy Policy Network for the 21st Century

We also note that, despite considerable growth in certain sources of renewable energy — particularly wind and solar (discussed below) — nontraditional power sources *still account for a relatively small percentage of most developed countries' electricity production* (see Figure 54).

Nontraditional power sources still account for a relatively small percentage of most developed countries' electricity production.

Figure 54. Electricity Generation by Type

2004



Source: Energy Information Administration

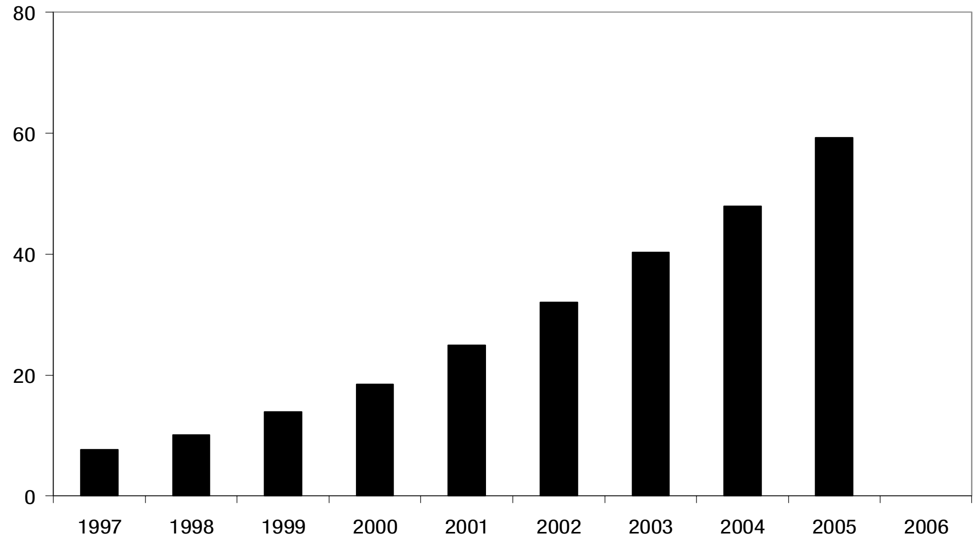
Wind

In the eight-year period between 1997 and 2005, the global wind energy industry experienced a compound annual growth rate of 29% in terms of installed capacity (see Figure 55). Nevertheless, wind-generated electricity still accounts for less than 1% of global electricity production.

Despite rapid growth, wind generated electricity still accounts for less than 1% of global electricity production.

Figure 55. Cumulative Installed Wind Turbine Capacity

In gigawatts



Source: BTM Consult

Onshore wind accounts for virtually all (99%) of the wind energy market today. Although *offshore* sites have a number of appeals (including the fact that noisy wind turbines are, for the most part, out of the public's view), offshore locations present a number of challenges, including weather and corrosion proofing, greater installation challenges, and more complex grid connections.

The majority of installed generating capacity is in Europe, which accounted for 69% of the global market in 2005. In recent years, the U.S. market has experienced strong growth (and accounted for 15% of installed global generating capacity in 2005), and that is likely to continue to be driven, in part, by a production tax credit at the federal level (which is typically extended every two years), and a renewable portfolio standard initiative organized by a number of states (which requires that a percentage of electricity produced comes from renewable sources).

The key to wind's success in becoming commercially viable has been technologies that have allowed turbine size to grow from an average of 10 meters in diameter in the mid-1970s to over 80 meters today. To build and run such huge turbines, companies have made a number of advances, including new composites for the blades, variable-pitch blades that catch the slightest of breezes, and variable-speed drive motors.

Just five turbine manufacturers accounted for nearly 80% of wind energy capacity installed globally in 2005:

1. ***Vestas Wind Systems*** (with a 29% share), a Danish company, and the market leader in the production of turbines.
2. GE Wind (18%), a subsidiary of ***General Electric***.
3. Enercon (13%), a privately owned German company.
4. ***Gamesa Corporacion Tecnologica*** (13%), a Spanish company. Reflecting generous government subsidies, Spain has been one of the world's fastest-growing producers of wind-generated electricity.
5. Suzlon Energy (6%), an Indian company, and the largest wind turbine manufacturer in Asia.

With regard to the users of this equipment, ***Iberdrola*** is the largest wind power generator in the Spanish market, and one of the leaders worldwide, with 4,000 megawatts (MW) of installed capacity. Today about 90% of this capacity is in Spain, but the company has an ambitious international expansion plan, with a target of 10,000 MW of total wind power capacity by 2011, of which 2,500 MW will be outside of Spain (mainly in the U.S. and Southern Europe). This international strategy is one of the reasons behind Iberdrola's bid for Scottish Power, which owns about 2,000 MW of wind power, mainly in the U.S. market.

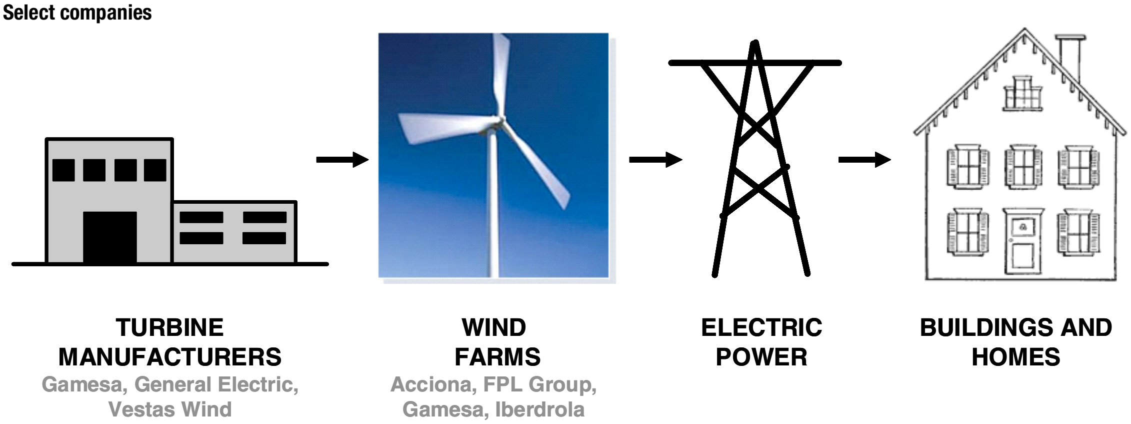
In addition to its 15% of capacity in wind power, Iberdrola's hydro assets represent 33% of its portfolio, and combined cycle gas turbine (CCGT) — a highly efficient form of electricity generation — represents 25%. The company also has exposure to nuclear power, representing 12% of its installed capacity.

Acciona, another Spanish company, has, in the last few years, acquired several companies with initiatives in the renewable energy sector, mainly wind power. Currently, Acciona is the second-largest wind power generator in the Spanish market (after Iberdrola), and it ranks third in the world in terms of installed wind capacity (after Iberdrola and FPL Energy, a unit of ***FPL Group***). The company is also very active in solar power and biofuels.

In 1997–2005, the global wind energy industry experienced an installed capacity CAGR of 29%.

Figure 56. The Wind Power Value Chain

Select companies



Source: Citigroup Investment Research

We referenced above the GE Wind division of ***General Electric***. This sprawling conglomerate supplies a range of products and services that enable climate change mitigation, including:

- *Wind Turbines*. This business generates around $3 billion in annual revenues.
- *Gas Turbines*. Reflecting GE's 46% global market share in gas turbines, this business generates about $2.5 billion in annual revenues.
- *Nuclear Reactors/Fuel Assemblies*. This business generates around $1 billion in annual revenues.
- *Services*. This business, which generates $9.5 billion in annual revenues, services and maintains the various GE products that have been sold into its customer base.

While putting an exact number on its "climate revenues" is tricky, as we discuss below, GE estimates that it generated about $10 billion in revenues in 2005 from products and services that provided environmental advantages to customers (out of a total of $98 billion).

Reflecting its commitment to tackling climate issues on a number of fronts, in May 2005, GE launched "Ecomagination," which consists of several distinct commitments related to GHG emissions and climate change:

- *Investment in R&D*. GE will invest $1.5 billion annually into cleaner technologies by 2010, up from $700 million in 2005.
- *More Ecomagination Products*. GE will double the revenue goal for products and services that provide significant and measurable environmental performance advantages to customers — from $10 billion in 2005 to at least $20 billion in 2010.
- *Reducing GHG Emissions and Improving Efficiency*. GE has committed to reduce its GHG emissions 1% in absolute terms by 2012, and to reduce the intensity of its GHG emissions 30% by 2008. ("Intensity" refers to the amount of GHG emissions that result from a particular economic activity.)

Landfill Gas

Landfills emit methane, a GHG, and the primary component of natural gas. As Figure 9 above illustrates, methane has 23x the global warming potential of carbon dioxide.

- ***Energy Developments*** has landfill gas generation facilities in Australia, the U.K., and the U.S. The company generates revenues from a number of sources, including 1) sale of electricity to direct customers, such as large energy retailers and consumers; 2) generation and sale of environmental credits, such as GHG abatement certificates, to third parties; and 3) management of landfill gas fields on behalf of landfill owners.
- Waste Management's Wheelabrator division (6% of revenues) generates energy from landfill gases, which results in a double benefit — by recycling methane, Wheelabrator not only captures the embedded energy in the gas that would otherwise go to waste, but also removes the potent GHG.

Geothermal

Ormat Technologies is the second-largest geothermal energy provider in the U.S. (after Calpine) and is a leading geothermal company worldwide, with operations in the Asia, Central America, and Africa.

Like nuclear power, the production of geothermal energy does not result in the emission of carbon dioxide; traditional geothermal power involves directing water heated naturally by the earth through turbines. However, the hot water that comes out of the ground typically contains chemicals that are highly corrosive; Ormat specializes in the design of geothermal plants that overcome this issue.

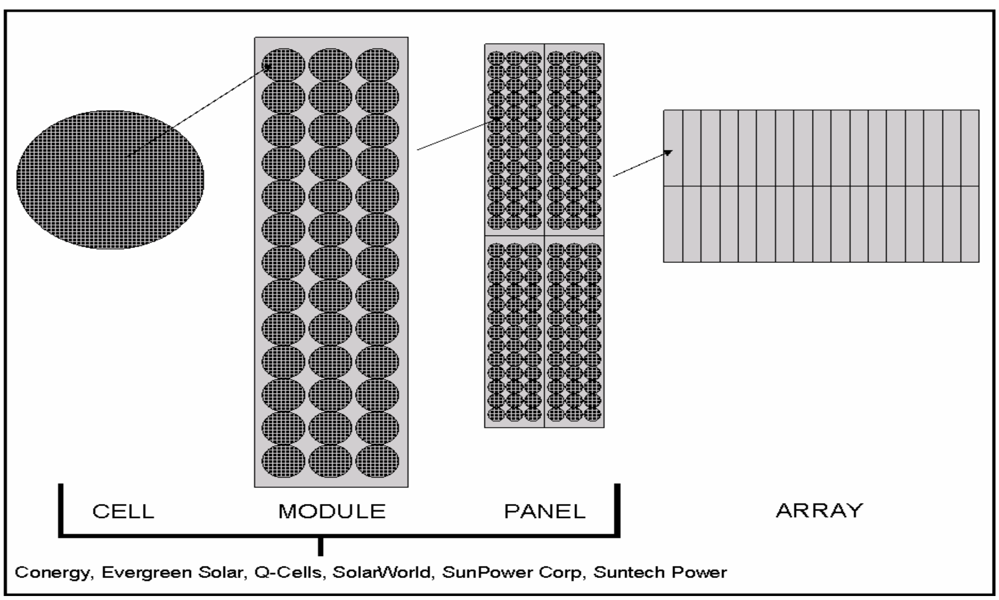
Solar

A photovoltaic (PV) cell is a device that generates electricity when exposed to light, such as solar radiation. (The word "photovoltaic" refers to something that is capable of producing a voltage when exposed to radiant energy, especially light.) Over 95% of all the solar cells produced worldwide are composed of silicon.

The PV *cell* is the basic building block of a PV system (see Figure 57). Individual cells vary in size from 1 centimeter to about 10 centimeters in diameter. Since one cell produces just a small amount of power (e.g., 1 or 2 watts), numerous cells are connected together to increase overall output. Individual cells are combined to form *modules*, which are then joined together to form *panels.* Panels are often combined to form solar *arrays,* which can contain thousands of individual PV cells, and so can produce large amounts of electricity.

The photovoltaic cell is the basic building block of a solar system.

Figure 57. The Solar Building Blocks



Source: Citigroup Investment Research

The following players comprise the solar equipment value chain:

➤ A *silicon manufacturer* refines silicon to various quality grades. (Solar grade silicon is less refined than semiconductor grade, reflecting that semiconductors used in information technology cannot tolerate any impurities in the silicon.)

- The silicon manufacturer supplies ingots or wafers to the *solar cell manufacturer*.
- The cell manufacturer can take the cells and assemble panels, or it can sell cells to *systems integrators*.
- Integrators typically have their own *distribution channels* (e.g., retailers), or they can sell panels directly to customers, who might use them to form giant arrays.

Reflecting, in part, that it is a somewhat complex technology (requiring professional installation), PV solar still has low penetration rates (less than 0.1% of annual global electricity production). The big issue, however, is that, relative to other energy sources, PV electricity prices are still not competitive in most parts of the world given the *high cost of manufacturing systems*. An important factor in this regard is that silicon costs have tripled in the past three years. As a result of these issues, the global PV industry depends almost entirely on government subsidies, either in the form of direct investment subsidies, or favorable "feed-in" tariffs.

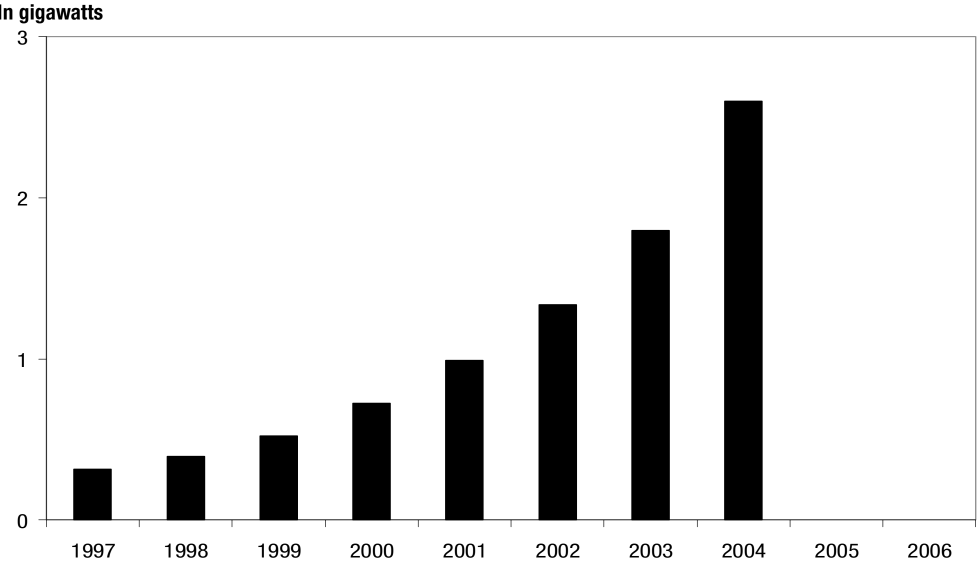
"Feed-in" tariffs result in a minimum guaranteed price per unit of energy produced. These subsidies are intended to stimulate investment in PV power, thereby allowing the industry to reap economies of scale, which will ultimately bring down the price of PV electricity. (In contrast, wind energy is now a commercially viable business, without subsidies, in a number of countries around the world.)

Driven by a number of factors, including favorable government policies (as well as increased conventional energy/oil prices), global PV installed capacity, although still low — particularly in comparison to wind energy — has been rising steadily (see Figure 58). Reflecting a growing commitment to renewable energy sources, the use of PV power will likely continue to increase in coming years, especially in southern European countries with a "sunny" climate, as well as in sunny U.S. states e.g., California and Nevada.

Global photovoltaic installed capacity, although still low, particularly in comparison to wind energy, has been rising steadily.

Figure 58. Cumulative Installed Solar PV Capacity

In gigawatts



Source: IEA Photovoltaic Power Systems Programme

Japan's ***Sharp Corp.*** is the world's biggest maker of solar cells, reflecting high electricity prices and political support for the industry in that country. Note that Japan has essentially no natural resources, a key factor behind the country's decision to adopt a tax credit program for solar (although that program recently ended, in part reflecting its success). Sharp expects that significant technical progress will be made in future years with regard to the critical issue of the cost of solar power — *Reuters* recently reported that Sharp's president forecast that the cost of generating solar power would be cut in half by 2010, and that it would be comparable to that of nuclear power by 2030.

While Japan remains a significant PV market, Germany is fast growing, with the key driver behind this growth being a change in 2004 in the laws governing renewable energy. Very generous feed-in tariffs for PV power were established and guaranteed for 20 years.

Reflecting this favorable environment, there are a number of solar-energy-related stocks listed in Germany. Of those, ***Q-Cells*** is the world's second-largest solar cell manufacturer (after Sharp); ***SolarWorld*** is a fully integrated solar energy company, covering virtually all steps in the PV value chain, from wafer production to system distribution; and ***Conergy*** is the world's largest PV system integrator. Note that Conergy recently made the decision to move into the PV production business by building a state-of-the-art wafer/cell/module production facility.

Other companies with exposure to the global PV solar opportunity include:

- ***Evergreen Solar***, an integrated U.S. manufacturer of solar wafers, cells and modules. (Note that Evergreen recently augmented its manufacturing capability by way of a joint venture with Q-Cells.)
- ***SunPower Corp***, another U.S. company, specializing in silicon solar cells, solar panels, and inverters, which convert the direct current generated by solar panels into grid-compatible alternating current. (Following a 2005 spin-off of the solar company, Cypress Semiconductor still has a 75% stake in SunPower.)
- ***Suntech Power***, a leading Chinese manufacturer of silicon crystal solar cells, with a roughly 80% share of China's solar cell market.

Pricing schemes that favor renewable energy— such as solar power — are being made possible by new technologies such as "smart" meters, which allow for hour-by-hour variation in power prices. These make it possible for utilities to charge, for example, much more for power during the midday peak than early in the morning or late at night. Of course, solar panels produce their greatest power output in the middle of the day, just when prices would be at their peak under a variable-pricing regime, making solar an attractive alternative.

The U.S. Energy Policy Act of 2005 requires states to investigate the use of advanced utility metering. At the local level, California and Texas, in the U.S., as well as the province of Ontario, in Canada, are pioneering programs to promote use of automated meter reading (AMR):

- Where the business case supports it, California's utility commission will permit recovery of the cost of implementing AMR through higher utility rates.
- The province of Ontario has a project under way to install smart meters in every home and business by 2010.

In addition, Enel, Italy's national energy company, is rolling out smart meters to 30 million customers across the country.

AMR products have only been around since the 1990s, and demand for these products has grown at a 25%–35% annual rate since. ***ESCO Technologies*** and ***Itron*** are leading U.S. manufacturers of AMR products for the electric utility industry:

- ESCO's AMR systems send two-way signals over low frequencies across powerlines.
- Itron's AMR systems are radio frequency based, collecting data either with handheld, mobile, or fixed base station systems that communicate over wireless channels.

Citigroup Investment Research analysts estimate the U.S. AMR electric market is only roughly 25% penetrated. Outside of North America, there are roughly 1.2 billion meters in use globally, with an estimated 3% AMR penetration rate.

Building, Housing, and Efficiency Standards

We noted above that producers of building materials — manufacturers of glass, cement, and brick — are among the industries included in the EU's Emissions Trading Scheme. (The manufacture of one ton of glass results in the emission of approximately one ton of carbon dioxide; the manufacture of one ton of cement results in the emission of about a half ton of carbon dioxide). In addition, in December 2002, the European Parliament adopted the "Directive on the Energy Performance of Buildings." The goal of the Buildings Directive is to improve the energy efficiency of public, commercial, and private buildings, which currently account for 40% of the European Union's energy requirements.

Some of the measures covered by the Directive include:

- A methodology for calculating the energy performance of buildings.
- Application of performance standards on new and existing buildings. (For example, the Directive requires homebuilders to meet certain standards of thermal efficiency.)
- Certification schemes for all buildings. (All homes and other buildings must undergo Energy Performance Certification before they are sold or rented.)
- Regular inspection and assessment of boilers/heating and cooling installations.

The 2002 Directive required that the initiatives be transposed into the national laws of the member countries by early 2006. However, the Directive allowed for an additional three-year period to allow member states to apply certain provisions, with the result being that the full implementation of the Directive across the European Union countries will be a gradual process.

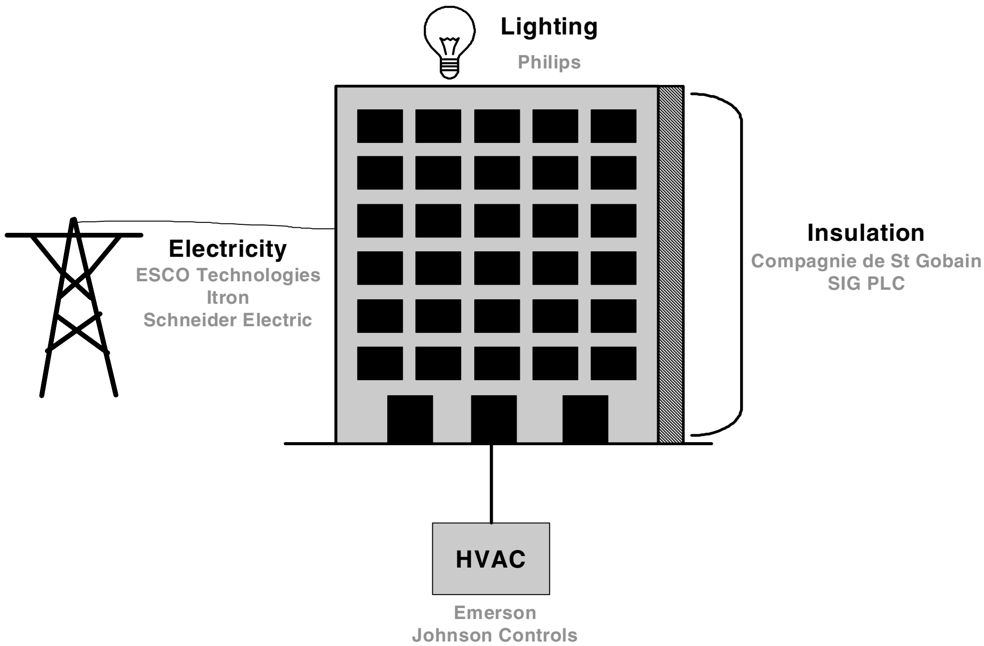
Even so, we noted above that climate change initiatives are, in many regions of the world, part of a much broader agenda that covers a range of economic, political, and social issues, *including energy efficiency*. The recent spike in the price of oil to almost $80 per barrel was a key factor in focusing policy makers' attention on the efficient consumption of energy. So, for example, the U.S. "Energy Policy Act of 2005" extended investment tax credits for improvements to building efficiency, and allowed a tax deduction of $1.80 per square foot for investment in equipment in commercial buildings to reduce annual energy and power consumption by 50%.

Building and housing energy efficiency initiatives can be classified under two broad headings:

1. *Thermal efficiency* (i.e., pertaining to heating and air conditioning); and
2. *Electricity efficiency* (i.e., pertaining to lighting, and consumption of electricity for other purposes).

Building and housing energy initiatives focus on thermal efficiency and electricity efficiency.

Figure 59. Building and Housing Energy Efficiency Initiatives



Source: Citigroup Investment Research

Thermal Efficiency

Increasing regulatory requirements to improve the thermal efficiency of buildings will likely lead to greater demand for insulation products (for both new construction and retrofitting), and building HVAC (heating, ventilation, and air conditioning) management systems.

- ***Compagnie de St Gobain*** is a French building materials company that supplies a diverse range of products; one of its nine operating divisions is focused on insulation products. The company is geographically diverse too, with large exposure to France and other European countries, as well as North America.
- ***SIG PLC*** is a British company that operates throughout Europe, specializing in the distribution of insulation (46% of its business), as well as roofing and commercial interior products.
- ***Johnson Controls*** operates in two broad segments, namely automotive and building efficiency. In terms of its building efficiency services (which represent about 50% of operating income), Johnson offers facilities management (i.e., systems that control a building's HVAC, as well as its lighting), and building retrofitting (to lower energy usage). Johnson Controls is the largest provider of facilities management services to the Fortune 500 companies.
- Two of ***Emerson's*** businesses have exposure to energy efficiency initiatives. Leveraging Emerson's leadership position in compressors for air conditioners, the *Climate Technologies* business offers sophisticated climate control technologies. Within its *Process Management* division, Emerson's *Performance Monitoring and Optimization* business helps industrial customers optimize their energy usage.

Electricity Efficiency

A number of companies seem well positioned to benefit from a desire for greater electricity efficiency in homes and other buildings:

- With regard to homes and other residences, we discussed "smart meter" companies, such as ***ESCO Technologies*** and ***Itron***, in the context of renewable energy.
- ***Philips Electronics*** is the world's largest lighting manufacturer. The recent spike in oil prices has enhanced the attraction of energy-efficient lighting sources. Consequently, Philips has been lobbying the European Commission and other state governments to highlight the advantages of a switchover from incandescent bulbs to energy-saving bulbs. (Incandescent light bulbs are very energy inefficient, because 95% of the energy consumed is wasted as heat.) Citigroup Investment Research analysts[31] have pointed to estimates that "converting to the most efficient forms of lighting in Europe could save €14 billion of electricity costs per year, 59 million tonnes of CO_2 emissions, and the equivalent of 67 medium-sized power plants."
- ***Schneider Electric's*** Energy Management division is comprised of three units: *MGE* (a manufacturer of uninterruptible power supply systems), *Power Logic* (a solution for management of energy consumption using meters, networked monitoring and Web-enabled browsers), and *Power Measurement* (a hardware and software energy-management system that allows energy suppliers and large energy customers to view energy use in real time). In addition, the company also manufactures customized sensors that promote energy efficiency.

[31] See Simon Smith's December 7, 2006, report, "Philips Electronics: Enlightened Self Interest"

Some Obvious Omissions

Our discussion of various initiatives to curb GHG emissions includes some, what may seem to be, "obvious omissions." Among the most notable:

- *Hydrogen*. As we illustrated in Figure 45, a car powered by a fuel cell containing hydrogen made from a renewable source produces *no* emissions of carbon dioxide, while a fuel cell that contains hydrogen made from natural gas produces only about *half as much* carbon dioxide as a conventional engine. However, while there are a large number of diesel-engine vehicles on the roads (particularly in Europe), and a growing number of hybrid electric vehicles and flex-fuel cars (running on bioethanol or biodiesel), there are only about 500 hydrogen vehicles worldwide, *in large part reflecting the absence of a network of roadside hydrogen fuel stations*.

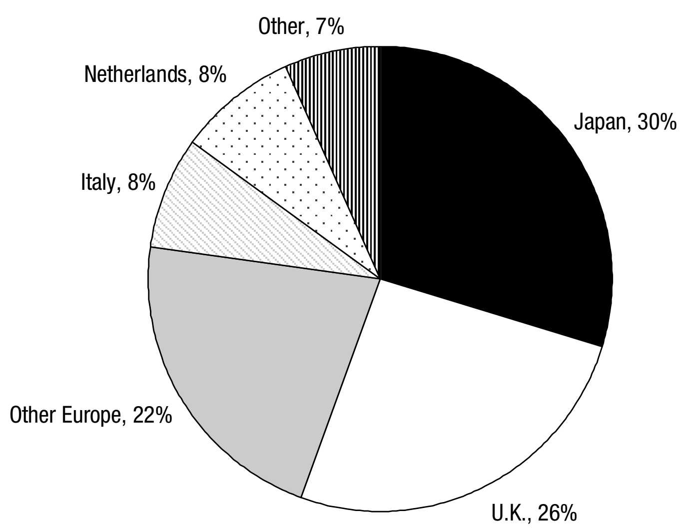
- *Japan*. The country that is home to Kyoto is, obviously, a major OECD "Annex 1" country. Yet, with the exception of PV solar (which, it could be argued, is more of an economic issue than a climate issue in Japan), there has been relatively little mention of the country in the sections above. The reason for this is that, although Japan has a number of policies in place that will likely reduce its aggregate emissions of GHGs, in the opinion of the World Resources Institute, the country will likely rely heavily on Kyoto's flexible mechanisms.

  Accordingly, Japanese companies have been at the forefront of developing and promoting Clean Development Mechanism projects, and the Japanese government is expected to resort to international emissions trading to help meet the country's Kyoto requirements. Not surprisingly then, Japan has been at the forefront in the purchase of credits generated from emission-reducing projects (see Figure 60), with the vast majority of those projects pertaining to the Clean Development Mechanism.

Japan has been at the forefront in the purchase of credits generated from emission-reducing projects.

Figure 60. Buyers of Emissions Reductions from Project-Based Transactions

By volume; January 2005 through September 2006



Source: International Emissions Trading Association and World Bank

The Behavioral Implications

In contrast to our discussion of the physical and regulatory implications of climate change, an analysis of the behavioral implications is somewhat more speculative. In other words, while it is possible to draw some plausible conclusions about the likely implications of, say, an increase in the number of intense hurricanes, or tightened restrictions on carbon dioxide emissions, it is more difficult to predict how climate change issues will impact behavior. That said, below we speculate about the impact of climate change issues on the behavior of four distinct groups:

1. consumers;
2. litigants;
3. investors; and
4. corporations.

As we discuss here, at the moment there are some relatively small initiatives being undertaken by consumers, investors, and litigants. We believe, however, that, over the course of the next few years, these initiatives will multiply, leading to a "tipping point" in *corporate behavior,* which will have material investment implications.

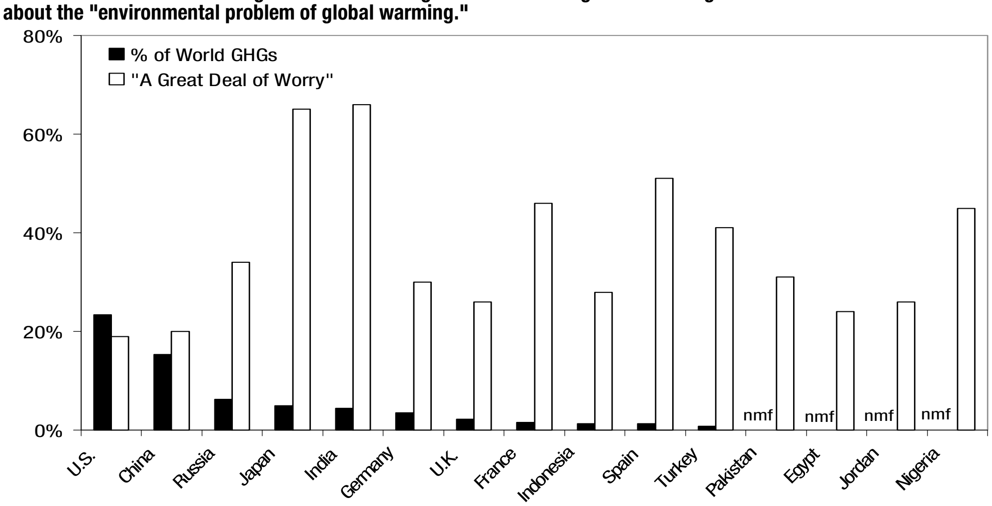
Consumer Behavior

A 2006 survey[32] by The Pew Global Attitudes Project revealed that while "there is nearly universal awareness of global warming in major industrialized countries," there is "no evidence of alarm over global warming in either the United States or China — the two largest producers of greenhouse gases" (see Figure 61). In other words, *consumers in the two countries responsible for the most emissions of GHGs care least about the issue.*

Consumers in the U.S. and China, the two countries responsible for the most emissions of GHGs, care least about the issue.

Figure 61. GHG Emissions and Global Warming Concerns

Emissions in 2002. Percentage that worries "a great deal" about global warming based on those who have heard about the "environmental problem of global warming."



Source: World Resources Institute and The Pew Global Attitudes Project

[32] *No Global Warming Alarm in the U.S., China*, June 13, 2006

There is still little evidence that climate change factors are a significant issue yet when it comes to global consumers' purchasing decisions.

Moreover, even though many people worldwide profess "a great deal" of concern about global warming, there is still little evidence that climate change factors are a significant issue *yet* when it comes to global consumers' purchasing decisions:

- A 2006 European Commission report[33] revealed that 59% of European consumers would *not* "be prepared to pay more for energy produced from renewable sources than for energy produced from other sources," and another 24% would only pay up to 5% more for energy from renewable sources.
- Some consumers do have the option of "voting with their wallets"— today, utilities in 34 U.S. states offer customers "green pricing" programs in which customers can opt to pay a premium on their electric bills to have a percentage of their power provided from renewable sources. However, a 2006 government report[34] revealed that, at the end of 2005, "the average rate of participation in utility green pricing programs among eligible utility customers was 1.5%." In a similar scheme in Australia ("Green Power"), household participation rates are also only in the low single digits.
- While sales of hybrid automobiles have grown strongly in recent years, they are still relatively small, representing, for example, only about 1% of auto sales in the U.S., the world's largest market for hybrids. Moreover a 2006 Consumer Reports survey[35] revealed that, of those U.S. consumers considering a hybrid for their next purchase, their list of "very important factors" was dominated by "better fuel economy" (98%). Of the five other factors cited, "minimized environmental impact" ranked second to last (64%), ahead of "tax incentives" (46%).

But an analysis of previous environmental concerns (including chlorofluorocarbons and dolphin-friendly tuna) by the U.K.'s Carbon Trust[36] suggests that "this [consumer sentiment] can change quite rapidly," so that "*what consumers 'do' may be soon linked to climate change*" [italics added].

Consumer Backlash against CFCs

Chlorofluorocarbons (CFCs), which are nontoxic, nonflammable chemicals, were long used in the manufacture of aerosol sprays and, also, as refrigerants. However, in the 1970s it was discovered that, while CFCs are safe to use in most applications and are inert in the lower atmosphere, they undergo significant reaction in the upper atmosphere, with the result that they destroy ozone. (Ozone absorbs harmful ultraviolet radiation, which can cause biological damage in plants and animals.) The ozone-damaging properties of CFCs received widespread press coverage, and many consumers boycotted products containing CFCs (e.g., by switching from aerosol deodorants to stick deodorants).

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[33] *Energy Issues*, European Commission Special Eurobarometer, November 2006

[34] *Trends in Utility Green Pricing Programs*, National Renewable Energy Laboratory, October 2006

[35] *Drivers feel pressure at the pumps*, ConsumerReports.org, May 2006

[36] *Brand value at risk from climate change*, Carbon Trust, February, 2005

Largely as a result of this public outcry, in 1987, 27 nations signed a global environmental treaty that addressed the issue of compounds that depleted the ozone layer. (Then, too, the development of other gases that could be used as refrigerants instead of ozone-depleting CFCs facilitated a switch away from those compounds.) The manufacture of those chemicals ended, for the most part, on January 1, 1996, two decades after the initial consumer backlash against CFCs.

Consumer Boycott of Tuna

Reflecting the propensity of some species of dolphin to associate with yellowfin tuna, particularly in the eastern Pacific, thousands of dolphins were caught in tuna fishing nets annually, resulting in a sharp decline in some dolphin populations. This issue received widespread press coverage in the 1980s and, in 1986, the International Marine Mammal Project organized a consumer boycott of tuna.

As a result of this boycott, in 1990, the three-largest tuna companies in the world agreed to stop purchasing, processing, and selling tuna caught by intentional chasing and netting of dolphins. In this example, the period between initial consumer reaction and product modification was *about a decade*.

Consumers and Climate Today

Today, reflecting a growing preference for environmentally friendly products, many companies label their products in a variety of ways, e.g., "packaged in recycled material," "made with no animal testing," or "this product is biodegradable."

Moreover, some companies have also started to offer their customers the option of purchasing offsets to the GHG emissions that result from use of certain products. So, for example, in Australia, BP's "global choice" program offers business customers more expensive "offset" gasoline, with the premium paid used to invest in Australian projects that offset GHG emissions. In the U.K., Climate Care (an offset firm founded in 1998) is partnered with British Gas, which is offering its residential customers the chance to purchase offsets to their gas and electricity emissions.

Similarly, British Airways' passengers can offset the emissions created during their flight by using an "emissions calculator" to gauge the offset cost of a particular flight; the money raised is used by the U.K.'s Climate Care to fund sustainable energy projects around the world. And travel reservation site Expedia is partnered with TerraPass (founded in 2004), so that air passengers can "undo" the damage of aircraft emissions. (TerraPass also has a partnership with Ford Motor to encourage drivers to buy carbon offsets.) With regard to organized vacations, *the New York Times* recently[37] noted that "increasingly, tour operators are buying carbon offsets to compensate for the amount of carbon dioxide produced on trips."

To be sure, the participation rates in offset projects are still relatively low, but the participation of large corporations (BP, British Gas, British Airways, Ford Motor), in such schemes clearly reflects growing consumer interest in climate issues. Then, too, the growing number of climate-related regulations — ranging from usage of biofuels to building efficiency standards — means that consumers worldwide are increasingly aware of climate issues in their daily lives.

[37] *Raising the Ante on Eco-Tourism*, The New York Times, December 10, 2006

In the media world, a number of high-profile movies aimed at the mass market are focused on climate issues, including Al Gore's "An Inconvenient Truth" (Figure 62) and "The Great Warming" (Figure 63), which is narrated by Alanis Morissette and Keanu Reeves.

A number of high-profile movies aimed at the mass market are focused on climate issues.

Figure 62. "An Inconvenient Truth"

Source: Paramount Pictures

Figure 63. "The Great Warming"

Source: Stonehaven Productions

Litigant Behavior

In the CFC and tuna examples above, a variety of corporations ultimately modified their behavior in response to pressure from *consumers*. Then, too, there are examples of corporations modifying their behavior as a direct result of actions taken by *litigants*.

A 2002 report[38] by the American Enterprise Institute-Brookings Joint Center examined the issue of "regulation through litigation," in part by studying examples of litigation that "allowed litigants to use their financial leverage to force changes of a policy nature, including regulatory policies and excise taxes." Among the examples studied:

- *Tobacco*. The most salient example of regulation through litigation consists of the suits by the state governments that sought to recover from the tobacco industry Medicaid expenses that they attributed to cigarettes. As part of the settlement of the litigation launched by the states, the cigarette industry agreed to extensive regulation of cigarettes from a product safety and marketing standpoint, as well as a settlement formula that was tantamount to an excise tax.
- *Asbestos*. Historically, asbestos risks had not been strongly regulated, but the emergence of a wave of asbestos litigation by sufferers of asbestosis induced the Occupational Safety and Health Administration and the Environmental Protection Agency to set stringent regulations.
- *Silicone Breast Implants*. Although the breast implant litigation that had been initiated by attorneys on behalf of women did not lead to negotiated settlements that imposed regulation, it did stimulate regulatory action by the U.S. Food and Drug Administration (FDA). Specifically, the litigation led to the production of company documents that alerted the FDA to problems with the product, including leakage of the silicone gel from the implants, as well as concealment of these problems by the manufacturers. The FDA imposed a ban on silicone breast implants in 1992.

Litigants and Climate

We noted above that the U.S. currently accounts for the greatest portion of GHG emissions (see Figure 20), so it is important to point out that, amid a number of climate-related legal initiatives (see Figure 64), *the U.S. Supreme Court is set to rule on the federal regulation of GHG emissions*.

(Recall also that we noted that a trial date early in 2007 is expected for a lawsuit filed by the Alliance of Automobile Manufacturers against the California Air Resources Board and its efforts to reduce GHG emissions from passenger vehicles in California.)

[38] Accessible at *http://www.aei.brookings.org/publications/abstract.php?pid=253*

Figure 64. Select U.S. Climate-Related Lawsuits

A summary

Case	Issue	Status
Alliance of Automobile Manufacturers v. CARB	GHG emissions from passenger vehicles	Early 2007 trial date
Massachusetts et al. v. the Environmental Protection Agency	EPA's regulation of GHGs	Supreme Court to rule in 2007
Eight States & NYC v. "Top Five U.S. Global Warming Polluters"	Carbon dioxide emissions by electric utilities	Dismissed in September 2005
Ten States v. the Environmental Protection Agency	Carbon dioxide emissions from new power plants	Awaiting trial
State of California v. World's Six-Largest Automakers	Carbon dioxide emissions from automobiles	Awaiting trial

Source: Citigroup Investment Research

Massachusetts et al. v. the Environmental Protection Agency

In June 2003, the states of Massachusetts, Connecticut, and Maine filed a lawsuit that argued that, by failing to regulate carbon dioxide, the Environmental Protection Agency (EPA) was violating its mandatory duty under the Clean Air Act. In August 2003, shortly after the lawsuit was filed, the EPA 1) withdrew its earlier position that carbon dioxide is an air pollutant subject to regulation under the Clean Air Act, and 2) concluded that it lacked legal authority to regulate GHGs.

On the same day, the EPA also denied a petition that environmental groups filed in 1999, which requested that it regulate carbon dioxide and other GHGs emitted from new motor vehicles. The EPA based its denial of that petition primarily on its newly issued position that it lacked legal authority to regulate GHGs.

In October 2003, a coalition of 12 states, led by Massachusetts, filed appeals challenging *both* of the EPA's August 2003 rulings — whether the EPA has authority to regulate GHGs associated with climate change, and whether the EPA may decline to issue GHG emission standards for motor vehicles. Those appeals were ultimately consolidated into one case, Commonwealth of Massachusetts, et al. v. the EPA. In June 2006, the U.S. Supreme Court agreed to hear arguments in the case, and it is expected to rule on the issues later in 2007.

Eight States & NYC v. "Top Five U.S. Global Warming Polluters"

In a second case, in 2004, eight U.S. states and New York City joined together to sue what they described as "the five-largest global warming polluters in the U.S." — American Electric Power, Southern Company, Tennessee Valley Authority, Xcel Energy, and Cinergy. The lawsuit claimed that, together, these companies owned or operated "174 fossil-fuel-burning power plants in 20 states that emit some 650 million tons of carbon dioxide each year — almost a quarter of the U.S. utility industry's annual carbon dioxide emissions and about 10% of the nation's total."

No monetary damages were sought in the lawsuit; instead, the action called on the companies to reduce their pollution. The complaint was dismissed in September 2005 on the basis that the suit involved "non-judiciable political questions."

Ten States v. the Environmental Protection Agency

In a third case, in April 2006 ten Attorney Generals sued the EPA for "failing to adopt strong emission standards to reduce air pollution *from new power plants* across the nation" [italics added]. According to that complaint:

> The Clean Air Act requires that the EPA review and revise emission standards for new pollution sources every eight years to ensure that they protect public health and the environment. On February 27, 2006, the EPA issued revised regulations in accordance with a court order. However, the revised standards completely fail to regulate power plant emissions of carbon dioxide, the major contributor to global warming.

State of California v. World's Six-Largest Automakers

And in a fourth case, in September 2006 the State of California sued the world's six-largest automakers demanding that they pay for environmental damage caused by their vehicles' emissions. California's Attorney General Bill Lockyer stated that:

> Global warming is causing significant harm to California's environment, economy, agriculture, and public health. Vehicle emissions are the single-most rapidly growing source of the carbon emissions contributing to global warming, yet the federal government and automakers have refused to act.

The suit accused General Motors, Toyota, Ford, Honda, Chrysler, and Nissan of creating a public nuisance by building millions of vehicles that collectively discharge 289 million metric tons of carbon dioxide into the atmosphere annually.

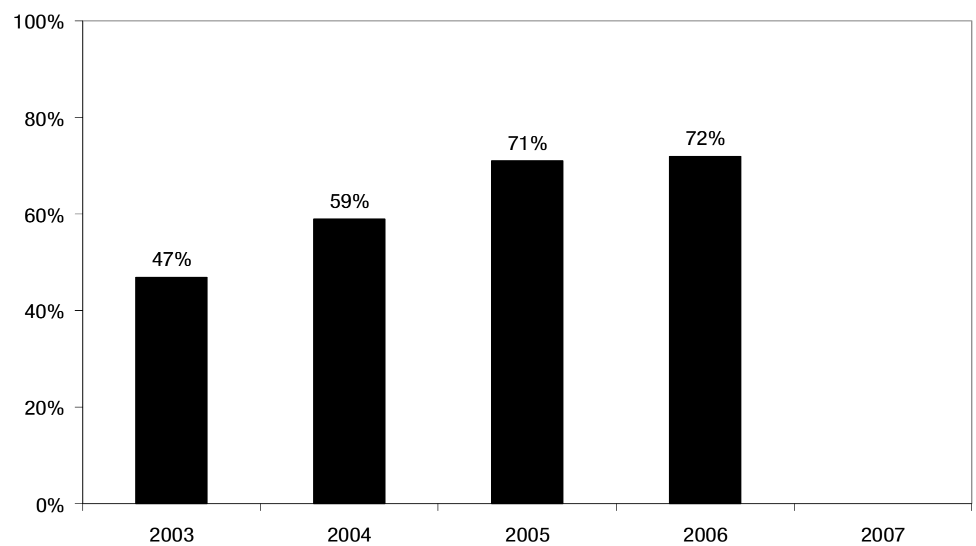
Investor Behavior

Investor reaction to climate change issues has taken a number of forms, which might be classified as either relatively "passive" (e.g., requests for corporate GHG disclosures, shareholder resolutions) or, alternatively, more "active" (e.g., socially responsible investment, or flows into "clean technology" venture capital funds).

➤ *Requests for Corporate Disclosures*. In response to requests by investors, a growing number of corporations are making disclosures about the risks and opportunities they face from climate change issues. For example, the Carbon Disclosure Project, a coalition of institutional investors representing more than $31 trillion in assets, has, for the past several years, been requesting information pertaining to GHG emissions from large multinational companies. 72% of the Financial Times Global 500 companies responded to the request in 2006, up from 47% in 2003 (see Figure 65).

72% of the FT Global 500 companies participated in the Carbon Disclosure Project in 2006, up from 47% in 2003.

Figure 65. Percentage of *Financial Times Global 500 Companies* Responding to the Carbon Disclosure Project

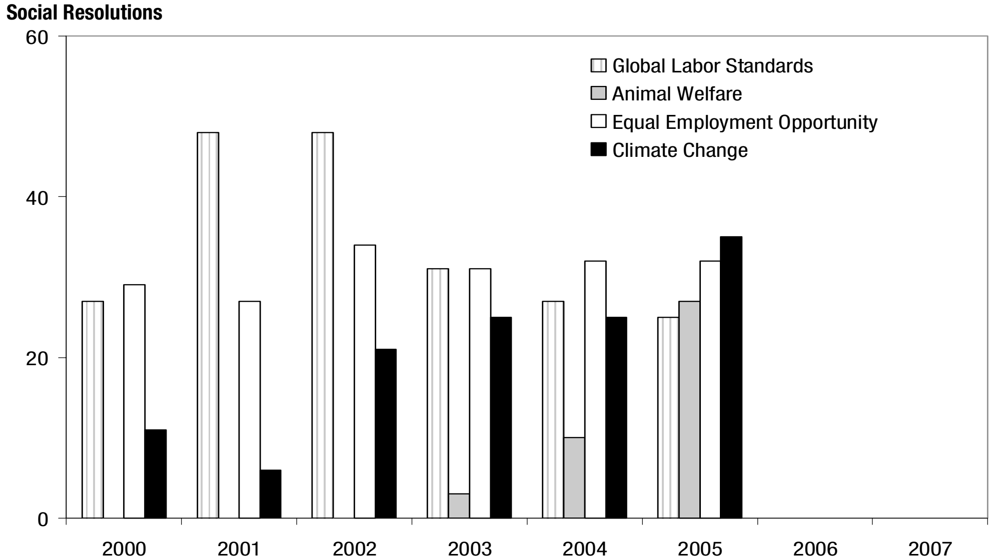


Source: Carbon Disclosure Project

➤ *Shareholder Resolutions*. In addition to requests from organizations such as the Carbon Disclosure Project, some investor coalitions have also filed shareholder resolutions requesting more disclosure from companies related to climate risk. Indeed, more than two dozen climate-related resolutions were filed with U.S. companies in 2004 and 2005, triple the number in 2000 and 2001. Moreover, as Figure 66 illustrates, in terms of various social resolutions proposed by shareholders in the U.S., resolutions pertaining to climate change issues were most numerous in 2005.

More than two dozen climate-related resolutions were filed with U.S. companies in 2004 and 2005, triple the number in 2000 and 2001.

Figure 66. Shareholder Resolutions Proposed in the U.S.

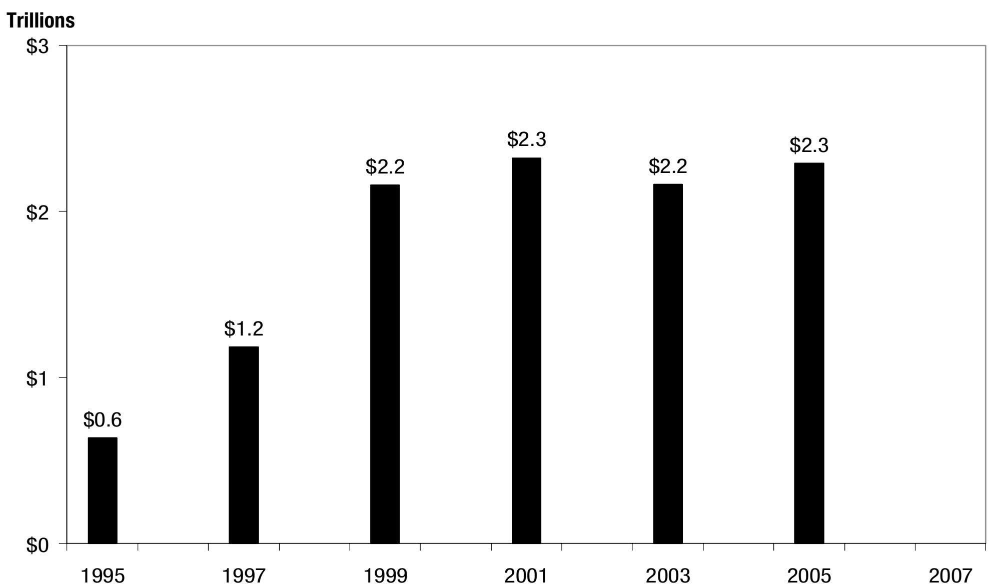


Source: Social Investment Forum

➤ *SRI Funds*. According to a biannual report by the Social Investment Forum (SIF), socially responsible investing (SRI) assets in the U.S. rose from $639 billion in 1995 to $2.29 trillion in 2005 (see Figure 67), so that nearly one out of every ten dollars under professional management in the U.S. was involved in socially responsible investing.[39]

Nearly one out of every ten dollars under professional management in the U.S. is involved in socially responsible investing.

Figure 67. Socially Responsible Investing Assets in the U.S.



Source: Social Investment Forum Foundation

[39] See Social Investment Forum's January 24, 2006, "2005 Report on Socially Responsible Investing Trends in the United States."

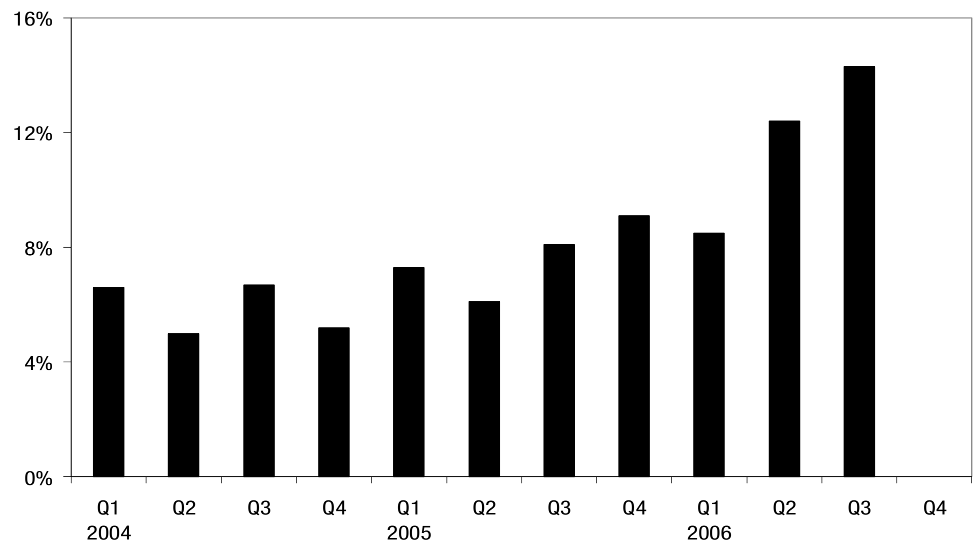
The SIF defines "socially responsible investing" as "an investment process that considers the social and environmental consequences of investments, both positive and negative, within the context of rigorous financial analysis."

With regard to investments likely to pertain specifically to climate change issues, the SIF noted that, in 2005, "the environment" was a "factor for 95 [mutual] funds with more than $31 billion in total net assets." Note that SRI is by no means exclusive to the U.S. — the SIF noted that "the European Sustainable and Responsible Investment Forum (EuroSIF) has identified €336 billion in assets that are involved in various forms of social investing."

- *Venture Capital Flows.* According to Cleantech Venture Network, a group that tracks capital flows into clean technology companies, North American investment in this space is increasing and, in third quarter 2006, ranked third in size as an industry segment (behind software and biotech) — see Figure 68.

Venture capital investment in clean technology companies has grown steadily, ranking third in size behind software and biotech.

Figure 68. North American Venture Capital in Clean Technology as a Percentage of Total Capital Invested



Source: Cleantech Venture Monitor

Corporate Behavior

In summary, we believe that, as a direct result of pressure from consumers, litigants, and investors, there will, in the next few years, be a "tipping point" in corporate behavior with regard to climate change issues:

- Consumers are expressing growing interest in climate change, while the burgeoning number of climate-related regulations — ranging from usage of biofuels to building efficiency standards — means that individuals worldwide are increasingly aware of climate issues in their daily lives.
- Litigants are forcing courts to rule on climate-related issues.
- Investors are concerned that corporations acknowledge the risks associated with climate issues.

From a corporate perspective, climate-friendly policies have five distinct advantages:

- They may lower costs, particularly if the company embraces energy efficient strategies in order to curb GHG emissions.
- They enhance the reputation of the corporate brand in the minds of consumers and corporate customers that care about climate issues.
- They may yield a "first-mover" advantage to a company that voluntarily adopts climate-friendly policies ahead of competitors that are forced to do so by regulators. In that regard, it was recently noted in *BusinessWeek*[40] that "as political pressure mounts to make reduction of greenhouse gases mandatory, companies with a head start on eco-friendly technology will have the credibility to participate in, or even shape, the debate over how to further reduce emissions." (So, for example, one could argue that British Petroleum, which has been focusing on climate issues for many years, and which regularly shows up at the top of surveys[41] of "climate-friendly" companies, is relatively well positioned, compared to ExxonMobil, which has funded pro-carbon advertisements.)
- They may lead to expanded market potential for new products and services.
- They institutionalize a climate-friendly mentality and keep management alert to climate opportunities and threats that may have a material impact on the company's future operations (e.g., lawsuits and investor initiatives).

Not surprisingly, then, climate change issues are increasingly catching the attention of corporate executives — in a recent McKinsey survey,[42] 28% of executives in 116 countries cited environmental issues, including climate change, as one of the issues likely to have the most impact on shareholder value over the next five years (see Figure 69).

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[40] *Green Is Good for Business*, by Todd Thomson, Chairman and CEO, Citigroup Global Wealth Management, BusinessWeek, May 8, 2006

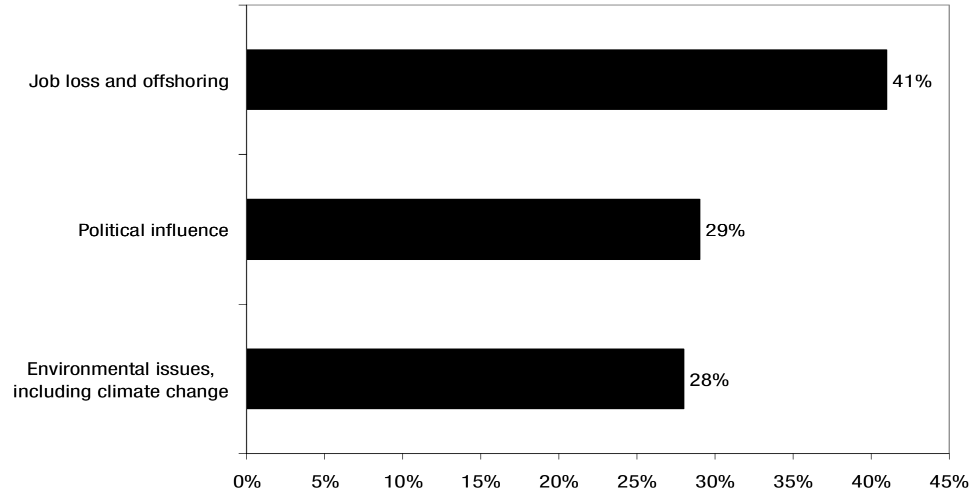
[41] See, for example, Ceres' March 2006 report, *Corporate Governance and Climate Change: Making the Connection*

[42] *Global Survey of Business Executives*, The McKinsey Quarterly 2006 Number 2

Climate change issues are increasingly catching the attention of corporate executives.

Figure 69. "What Issues Will Affect Shareholder Value over the Next Five Years?"

Percentage of respondents selecting given issue as one of top 3



Source: The McKinsey Quarterly 2006 Number 2

Similarly, 87% of the global companies responding to the 2006 Carbon Disclosure Project indicated that climate change represented "commercial risks and/or opportunities," although less than half (48%) of those companies said they have implemented a GHG reduction program.

One factor driving heightened executive awareness of climate change issues might be potential legal and regulatory implications. In a 2006 report,[43] U.S. risk and insurance company Marsh (a unit of Marsh & McLennan) noted that:

> the increased oversight of climate risks from regulators, investors...and other public-interest groups has implications for directors and officers (D&O) liability insurance...Recognizing climate risk as an issue and addressing it in some fashion is becoming an important consideration for company managers and boards of directors. The most significant concerns center on how a company recognizes, analyzes, and discloses environmental and/or climate risk. *Disclosure — or the failure to disclose — is central to much D&O litigation* [italics added].

The Marsh report continued:

> The Securities and Exchange Commission (SEC) has not finalized rules regarding disclosure specifically on climate change-related risks. However, the SEC does require — under Item 101 of Regulation S-K — a disclosure with respect to the effects of complying with federal and/or state provisions on the discharge of materials into the environment. Item 303 of Regulation S-K calls for additional disclosure around future trends likely to affect profitability. And it's interesting to note that the U.S. Government Accountability Office has issued a report calling for the SEC to improve and track the transparency of environmental disclosures.

[43] *Climate Change: Business Risks and Solutions*, Marsh, April 2006

"Voluntary" Regulation

Perhaps in anticipation of these litigation and reputation risks, some corporations in sectors that are currently "carbon unregulated" have started to set targets in order to voluntarily regulate their emissions of GHGs. Figure 71 provides some examples of corporate GHG reduction targets. Most of these initiatives simply involve reduced energy usage but, as we discuss below, some other forms of GHG emissions reductions can be more complex.

In addition to "voluntary regulation," other types of "positive" corporate behavior in response to climate change issues include:

- Engaging "climate consultants" (who facilitate the reduction of GHG emissions by, for example, offering services that promote efficient energy usage); and
- Purchasing offsets to GHG emissions (e.g., to become "carbon neutral").

"Climate Consultants"

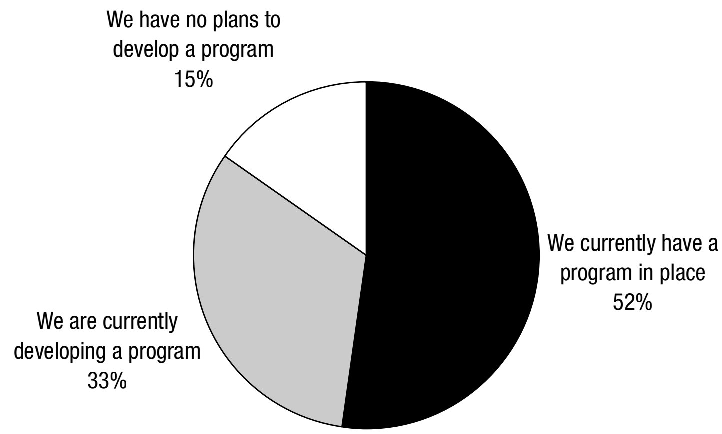
A recent study[44] by the U.S. *Conference Board* revealed that about 75% of respondents in a survey of 92 international companies are actively measuring their "carbon footprint" — the range of emissions of carbon equivalents (i.e., GHGs) from their operations, both direct and indirect. Of the companies that are measuring their carbon footprint, respondents said they were measuring the footprint "directly through an emissions inventory" and/or "indirectly, through calculating [the] company's use of purchased power, travel, etc."

Given these carbon footprint measurement initiatives, it's not surprising then that just over 50% of respondents indicated they have a program in place to "actively reduce or offset GHG emissions," while an additional 33% are developing such a program (see Figure 70).

85% of companies surveyed are focused on reducing or offsetting GHG emissions.

Figure 70. Does your company currently have a program in place to actively reduce or offset GHG emissions?

92 international companies



Source: Conference Board

[44] *"Carbon Footprint" a Growing Management Concern*, The Conference Board, October 2006

Figure 71. Corporate Greenhouse Gas Reduction Targets — Some Examples

"Intensity" refers to the amount of GHG emissions that result from a particular economic activity

	Absolute targets
3M	Reduce GHG emissions by 30% from 2002 levels by 2007
AEP	Reduce total U.S. GHG emissions by 6% below an average 1998-2001 base by 2010
Alcoa	Reduce GHG emissions by 25% from 1990 levels by 2010
Allianz	Reduce GHG emissions by 20% from 2000 levels by 2012
Bank of America	Reduce total U.S. GHG emissions by 9% 2004-2009
British Telecom	Reduce total GHG emissions by 25% below 1996 levels by 2010
Cinergy	Reduce total U.S. GHG emissions by 5% from 2000 to 2010
DuPont	Reduce GHG emissions by at least 15% from base year of 2004 by 2015
Eastman Kodak	Reduce total global GHG emissions by 10% from 2002 to 2008
Entergy	Reduce total U.S. GHG emissions by 20% from 2000 to 2010
Exelon	Reduce total U.S. GHG emissions by 8% from 2001 to 2008
Goldman Sachs	Reduce GHG emissions by 7% by 2012 from 2005 levels
International Paper	Reduce total U.S. GHG emissions by 15% from 2000 to 2010
JP Morgan Chase	Reduce GHG emissions by 5-7% by 2012 from 2005 levels
Johnson & Johnson	Reduce GHG emission by 14% from 2001 to 2010
Polaroid	Reduce Global GHG emissions by 25% from 1994 levels by 2010
Sony	Reduce absolute GHG emissions by 7% from 2000 levels by 2010
Staples	Reduce U.S. GHG emissions by 7% from 2001 to 2010
Sun Microsystems	Reduce total U.S. GHG emissions by 20% from 2002 to 2012
Swisscom	Reduce C02 emissions by 17% between 2002 and 2010
Swiss Re	Reduce GHGs by 15% below 2002 levels by 2013
Wal-Mart	Reduce global GHG emissions by 20% from 2006 to 2013
Weyerhaeuser	Reduce GHG emissions by 40% from 2000 levels by 2020
Xerox	Reduce total global GHG emissions by 10% from 2002 to 2012
	Intensity targets
Ball Corp.	Reduce U.S. GHG emissions by 16% per production index from 2002 levels by 2012
Baxter Int'l	Reduce GHG emissions by 20% indexed to revenue from 2005 levels by 2010
Bristol-Myers Squibb	Reduce C02 emissions by 10% per dollar of sales between 2001 and 2010
Canon	Reduce C02 emissions per unit of production by 25% by 2010 compared to 2000
Caterpillar	Reduce C02 emissions per million dollars of revenue by 20% between 2002 and 2010
EMC Corp	Reduce U.S. GHG emissions by 8% per square foot from 2005 to 2012
FPL	Reduce U.S. GHG emissions by 18% per kWh from 2001 to 2008
Gap Inc	Reduce U.S. GHG emissions by 11% per square foot from 2003 to 2008
Intel Corp	Reduce global GHG emissions by 30% per production unit from 2004 to 2010
Interface	Reduce U.S. GHG emissions by 15% per production unit from 2004 to 2010
Lockheed Martin	Reduce U.S. GHG emissions by 30% per dollar revenue from 2001 to 2010
Marriot Int'l	Reduce U.S. GHG emissions by 6% per available room from 2004 to 2010
Oracle	Reduce U.S. GHG emissions by 6% per sq ft from 2003 to 2010 non-data center space
PSEG	Reduce U.S. GHG emissions by 18% per kWh from 2000 to 2008
Raytheon	Reduce U.S. GHG emissions by 33% per dollar revenue from 2002 to 2009
STMicroelectronics	Reduce U.S. GHG emissions by 50% per manufacturing unit from 2000 to 2010
Toyota	Reduce C02 emissions volume per sales unit by 20% from 2001 levels by 2010
	Combined target
General Electric	Reduce absolute emissions 1% by 2012, and the intensity of GHG emissions 30% by 2008 compared to 2004

Source: Citigroup Investment Research

However, as the *Conference Board* report pointed out, GHG emissions inventories can be both demanding and complex to conduct. The complexity derives from:

- Measuring the range of GHG emissions (there are six major gases that emanate from varied sources).
- Defining the gases over which a company has control or influence.
- Calculating varied types of emissions from diverse sources.
- Verifying both the appropriateness of the selected sources and the accuracy of the calculations.

In response to this growing demand by businesses and organizations for reporting and managing their GHG emissions, ***Johnson Controls*** developed a software system that integrates utility bill processing and other information to help inventory, track and report GHG emissions. In addition, Johnson Controls also enters into performance contracts with clients, under which Johnson commits to reducing emissions of GHGs (direct or indirect) at facilities owned by the client.

Siemens' Building Technologies division offers similar guaranteed energy saving performance contracts, which result in a reduction of GHG emissions. And, as we noted in the section on thermal efficiency above, ***Emerson's*** *Performance Monitoring and Optimization* business helps industrial customers optimize their energy usage, which ultimately leads to a reduction in GHG emissions.

GHG Emissions Offsets

Some companies are also *voluntarily* buying offsets to their GHG emissions. As we discussed in the section on emissions trading (Exhibit 1), these offsets can be in the form of a surplus permit/allowance from an emissions trading scheme, or a credit arising from a GHG offset project. (Note that *voluntary* purchases are in contrast to purchases by other companies that are effectively *required* to buy offsets on account of their inclusion in an emissions trading scheme).

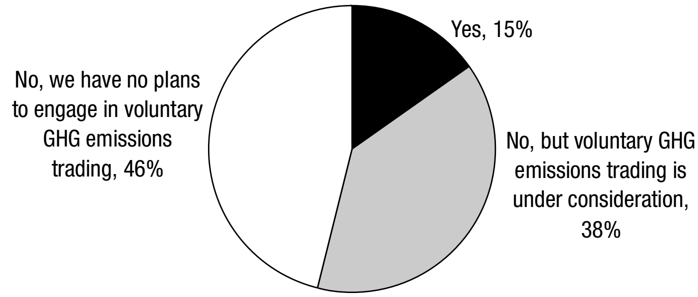
Of course, for every buyer of a GHG offset there must be a seller. As we discuss below, some companies are using the growing demand for emissions offsets to generate incremental revenues, while other companies are facilitating carbon abatement initiatives.

With regard to the voluntary purchase of GHG emissions offsets, in the aforementioned U.S. *Conference Board* study, 15% of respondents said that their company is "currently engaged in voluntary GHG emissions trading," while nearly 40% said that "voluntary GHG emissions trading is under consideration" — see Figure 72.

53% of companies surveyed are focused on voluntary GHG emissions trading.

Figure 72. Is your company currently engaged in voluntary GHG emissions trading?

91 international companies



Source: Conference Board

The *Conference Board* noted that, among those companies engaging in voluntary trading, motivations include (among others):

- Anticipation of potential regulation.
- To develop a track record for possible credit for prior emissions reductions.
- For reputation benefits, e.g., to be "carbon neutral."
- To learn the process.

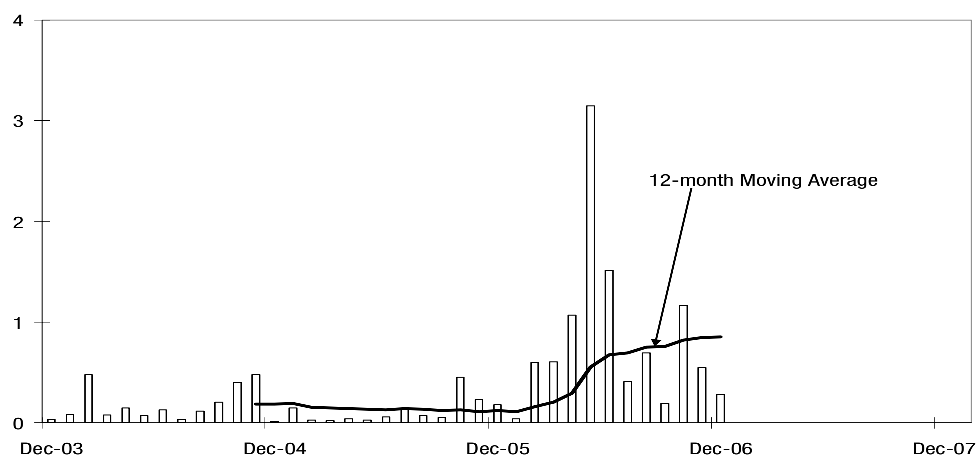
Similarly, in the emissions-unregulated U.S., membership of the Chicago Climate Exchange (CCX) rose from 23 firms at the end of 2003 to 220 in late 2006. CCX members voluntarily commit to cutting their GHG emissions 6% below a baseline by 2010 (based on each member's 1998–2001 average emissions). Richard Sandor, chairman and CEO of the CCX, was quoted in the *Economist*[45] as saying:

> members join for a variety of reasons: to improve their image, to gain insight into a nascent industry, to prepare for future regulation, or to appease green shareholders, customers or staff.

As Figure 73 illustrates, carbon trading on the CCX has grown rapidly of late.

Carbon trading on the CCX has grown rapidly.

Figure 73. CCX Carbon Financial Instrument Contracts (Millions)



Source: Chicago Climate Exchange

[45] The Economist, August 3, 2006

"Carbon Sellers"

Some companies are using growing demand for emissions offsets to generate incremental revenues:

- ***Balrampur Chini*** was discussed in the section on bioethanol, given that it is one of the top-tier sugar manufacturers in India. The company's plants are fueled by a sugarcane residue, and units of surplus electric power that the company sells are eligible for carbon credits — i.e., carbon emission reductions (CERs) — under the Kyoto Protocol.
- ***ENCE***, a Spanish company, is the largest producer of eucalyptus pulp (used to make high-quality papers) in Europe. As part of its pulp production process, the company generates electricity from biomass, a significant portion of which it sells into the Spanish electricity market at a very profitable tariff. And, as a direct result of the biomass power plants, ENCE has become a significant owner of carbon dioxide emission rights (685,000 tons per year).
- ***Energy Developments*** was discussed in the section on landfill gas, given that it has landfill gas generation facilities in Australia, the U.K., and the U.S. We also noted that the company generates revenues from the sale of GHG abatement certificates to third parties.

"Carbon Facilitators"

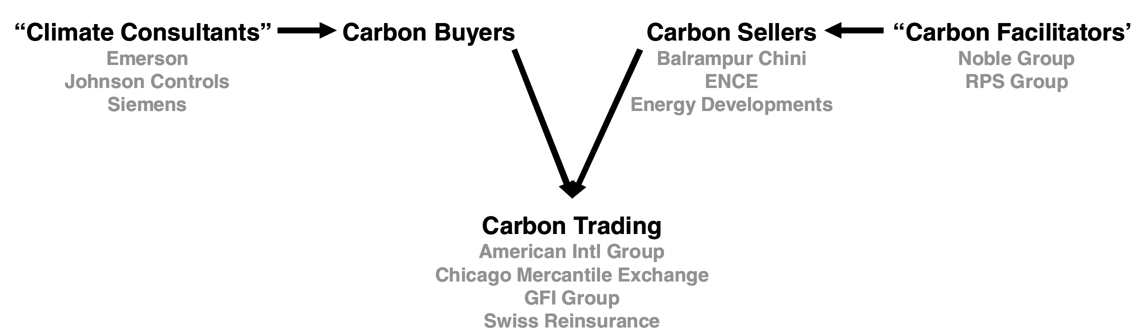
Some other companies are growing their business by facilitating carbon abatement initiatives:

- ***Noble Group,*** which we discussed above in the context of bioethanol, has a division called *Noble Carbon Credits*. This unit focuses on 1) sourcing carbon credits from overseas emissions reduction projects, 2) transacting Certified Emission Rights (CERs), and 3) sourcing EU allowances. The various clients of this unit include coal and steel companies.
- ***RPS Group,*** a British environmental consulting firm, offers a range of services, including the preparation of "environmental statements" that support carbon abatement projects, e.g., wind farms.

A wide range of companies are involved with the burgeoning carbon trading market.

Figure 74. Carbon Trading

Select companies



Source: Citigroup Investment Research

Carbon Trading

A number of companies seem well positioned to benefit from growth in carbon trading. Amerex, an over-the-counter (OTC) energy broker, and one of the initial members of the Chicago Climate Exchange, was recently acquired by ***GFI Group***, an inter-dealer broker focusing on the OTC derivative markets.

GFI is already active in emissions trading, most notably in Europe, where it used coal derivatives as a segue into emissions brokering. So, for example, if a client wanted to construct a trade that would profit from a cold winter in Europe, it might purchase derivatives on both coal (more fuel burned in a cold winter) and on carbon (more emissions from the coal). As the emissions markets grow in the U.S, there will likely be a role for OTC inter-dealer brokers, such as GFI Group, in carbon trading; it's possible that GFI could make further acquisitions to develop its U.S. emissions brokering capability.

In addition, both ***Chicago Mercantile Exchange*** (CME) and Chicago Board of Trade (BOT) currently offer futures contracts for ethanol. (Note that these two companies are merging.) These contracts act as a means of price discovery in a highly volatile, rapidly growing market. Going forward, there could be additional opportunities for a futures exchange such as the CME to develop innovative products and risk management tools for companies impacted by climate-motivated regulations; the cost of adding such products would be minimal to the exchanges.

"Carbon Insurance"

As we discussed above, the Carbon Disclosure Project (CDP) is a coalition of institutional investors. For the past several years, the CDP has been requesting information pertaining to GHG emissions from large multinational companies. As Figure 65 illustrates, fully 72% of the *Financial Times* Global 500 companies responded to the request in 2006 (virtually unchanged from 2005), up sharply from 47% in 2003. However, a recent report[46] commissioned by Ceres (a national coalition focused on sustainability challenges, including climate change) that studied insurers and climate change issues noted that:

> few U.S.-based insurance companies provided sophisticated responses [to the 2005 CDP questionnaire]. This is particularly striking when compared to European and Japanese insurers. Only 50% of the U.S. insurance companies that were contacted responded to the questionnaire compared to the 100% response rate of those insurance companies domiciled outside of the U.S. Of the U.S. insurers that did respond, *AIG is the clear thought-leader on the issue* [italics added].

Ranking ***American International Group*** as a leader in terms of climate issues was supported by an analysis conducted by the authors of the Ceres report. Specifically, they examined whether 93 international insurance companies were involved with 11 distinct climate initiatives. Of those 93 companies, American International and ***Swiss Reinsurance*** ranked the highest, with each company involved with seven of 11 climate initiatives (see Figure 75).

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[46] *From Risk to Opportunity: How Insurers Can Proactively and Profitably Manage Climate Change*, Ceres, August 2006

Figure 75. Involvement with Climate Initiatives of American International Group and Swiss Reinsurance

AIG and Swiss Re are each involved with seven of 11 climate initiatives.

	AIG	Swiss Re
Informs and educates customers about climate issues	X	X
Financial incentives to customers to take climate-friendly actions	X	
Develops specialized policies and products	X	
Direct investment in climate change solutions	X	X
Customer risk- and energy-management inspections		
Engaged in policy discussions about appropriate codes and standards		X
R&D spending on clean energy and energy efficiency		
Climate modeling and research		X
In-house energy management	X	X
Disclosure of exposure to carbon risk	X	X
Carbon markets involvement	X	X

Source: Ceres

Some specific examples of climate initiatives by AIG and Swiss Re include:

- *Direct investment in climate change solutions*. In its "Policy and Programs on Environment and Climate Change" released in May 2006, AIG stated that, over the next 18–24 months, it will "allocate additional private equity investments to projects, technologies, or other assets that contribute to greenhouse gas (GHG) emission mitigation." Swiss Re has invested directly in a number of climate-friendly companies, including Evergreen Solar (prior to its initial public offering).
- *In-house energy management*. Swiss Re has pledged to become entirely greenhouse gas neutral across its operations by 2013 through a combination of in-house efforts to reduce energy use, and investments in the World Bank Community Development Carbon Fund that offset the company's lowered emissions. AIG is monitoring its "internal GHG and environmental footprint," in part by compiling data on the amount of electricity purchased in owned and leased buildings that AIG companies use for business activities.
- *Disclosure of exposure to carbon risk*. Both AIG and Swiss Re participated in the 2005 and 2006 Carbon Disclosure Project.

Perhaps most significant, however, is *the involvement of both Swiss Re and AIG in the carbon markets.*

- In January 2006, Swiss Re announced[47] that it jointly implemented "the carbon markets' first insurance product for managing Kyoto Protocol–related risk in carbon credit transactions." The policy provides coverage for the risks related to Clean Development Mechanism (CDM) project registration and the issuance of Certified Emission Reductions (CERs). These risks include the failure or delay in the approval, certification, and/or issuance of CERs from CDM projects.
- Similarly, AIG is developing new products that, among other things, insure against the failure of a project to generate tradable carbon reductions.

[47] RNK Capital and Swiss Re Structure First Insurance Product for CDM Carbon Credit Transactions, June 13, 2006

"Grandfathering"

We discussed various types of corporate behavior above that are positive for the climate. Then, too, there are other strategies in response to climate issues that are not at all "climate friendly."

A July 21, 2006 *Wall Street Journal* article, "Burning Debate: As Emission Restrictions Loom, Texas Utility Bets Big on Coal," discussed how ***TXU Corp.*** is "racing to build 11 big power plants [over the next four years] in Texas that will burn pulverized coal." A possible reason, according to the *Journal*, is:

> The federal government may slap limits on carbon-dioxide emissions. If it does, plants completed sooner may have a distinct advantage. That's because the government may dole out "allowances" to release carbon dioxide, and plants up and running when regulations go into effect may qualify for more of them than those built at a later date.

There is a precedent for a "grandfathering" strategy — a 1990 federal program to reduce emissions of sulfur dioxide, a contributor to acid rain, employed a "cap-and-trade" system. Existing polluters were given allowances that they could use themselves or sell to others; over time, the number of annual allowances handed out was reduced.

Gambling on a grandfathering strategy could, however, be a risky move given that, if regulators believe that a utility has attempted to abuse the spirit of the process, they could easily decide to set, say, 2005 (or some other year before emissions restrictions were enacted) as the baseline year for measuring carbon emissions.

On the other hand, a grandfathering strategy could pay off for TXU under two scenarios:

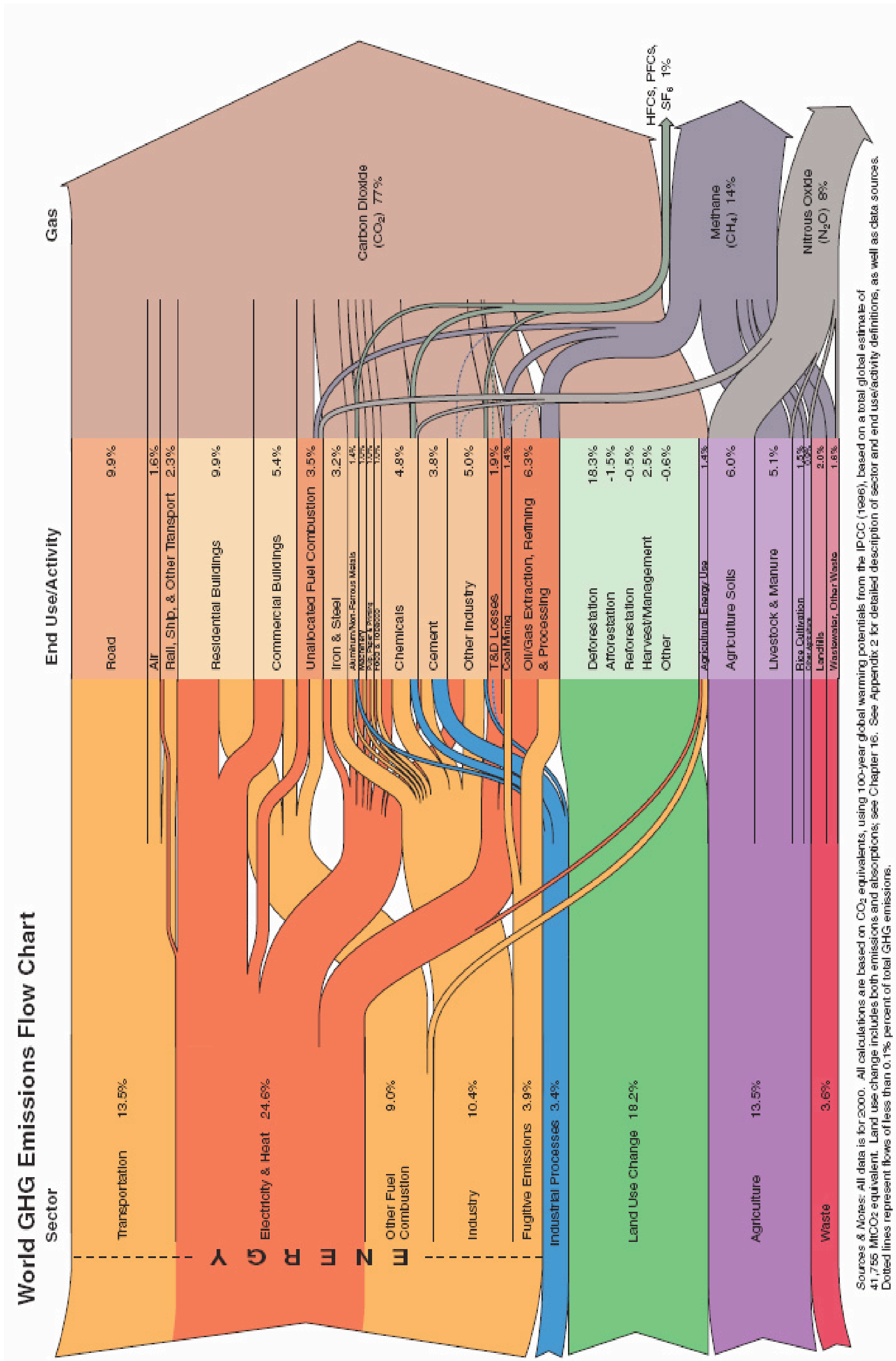
- If it results in the issuance of carbon dioxide emission allowances for the new plants; or
- If a viable sequestration technology is developed by the time carbon emissions restrictions are introduced. TXU has announced that it is investing $1 billion in sequestration research and development.

Two other factors in TXU's favor with regard to this strategy are:

- On the demand side, Texas needs more generating capacity; and
- On the supply side, TXU has plentiful access to coal, which still provides more than 50% of the energy needs of the U.S. The company has its own lignite mines in Texas, and it also has easy access to Powder River Basin coal.

So, it seems that TXU's grandfathering strategy could be a smart move — in a best-case scenario, its coal-fired power plants might be either "grandfathered" or "cleaned" by new sequestering technology, while, in a worst-case scenario, its "dirty" plants might face the same carbon emissions regulations that apply to all electric utilities across the U.S.

Appendix A:
World GHG Emissions Flow Chart



Source: World Resources Institute

Appendix B: Some Theories About Climate Change

According to a variety of theories, it is likely that a sequence of events — involving astronomical factors, ocean circulation, and GHGs — explain previous transitions from glacial to warmer periods.

Astronomical Factors

It is believed that changes in the orbital parameters of the earth — including the tilt of the earth's spin axis and in the eccentricity of its orbit — have, over the course of thousands of years, caused variations in the distribution of solar radiation.

- *Tilt.* Currently about 23.5 degrees from the vertical, the earth's spin axis fluctuates from about 22.1 degrees to 24.5 degrees and back roughly every 40,000 years, as a result of external gravitational influences, e.g., the moon and the sun. The greater the tilt, the more intense seasons in *both* hemispheres become — summers get hotter (strong tilt *toward* the sun) and winters colder (strong tilt *away from* the sun).
- *Eccentricity.* With regard to the shape of the earth's orbit, over a period of about 100,000 years, the orbit stretches into a more eccentric (oval-shaped) ellipse and then grows nearly circular again. (The variance of the earth's eccentricity is primarily due to interactions with the gravitational fields of Jupiter and Saturn.) As the orbital eccentricity increases, the difference in the earth's distance from the sun at the orbit's nearest and farthest points grows, intensifying the seasons in *one* hemisphere and moderating them in *the other*. In other words, the hemisphere which is in summer at the closest approach to the sun will receive an increase in solar radiation, but that same hemisphere will be in winter at the furthest distance and so will have a colder winter. By contrast, the other hemisphere will have a relatively warm winter (during the closest approach) and cool summer (at the farthest distance).

By using astronomical factors such as these, in the 1920s a Yugoslav astronomer, Milutin Milankovitch, was able to formulate a comprehensive mathematical model that calculated surface temperature for 600,000 years prior to 1800. He then attempted to correlate these changes with the growth and retreat of the Ice Ages. Milankovitch calculated that astronomical factors varied the amount of sunshine reaching the high northern latitudes in summer over a range of about 20% — enough, he argued, to allow the growth of the great ice sheets that periodically advanced across the northern continents.

Supporting evidence for "Milankovitch cycles" came in the postwar years. So, for example, by examining deep-sea sediment, the authors of a study[48] published in *Science* in 1976 were able to extract the record of temperature change going back 450,000 years and found that major variations in climate were, indeed, closely associated with changes in the geometry of the earth's orbit.

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[48] J.D Hays, John Imbrie, and N.J. Shackleton, *Variations in the Earth's Orbit: Pacemaker of the Ice Ages*, Science, 1976.

Ocean Circulation

As outlined above, some scientists (e.g., Milutin Milankovitch) have speculated that the seasonality changes brought about by astronomical factors acted *directly* on the ice sheets of the Northern Hemisphere: A reduction in summer sunshine allowed ice to build up, and an increase in sunshine melted it away. The ice, in turn, altered the earth's climate.

Other scientists[49] believe instead that, by altering patterns of evaporation and rainfall, the changes in seasonal intensity associated with Milankovitch cycles have affected the ocean and atmosphere (a single, coupled system). According to this theory, when ocean circulation changed, heat was carried around the globe differently, the properties of the atmosphere were altered, climate changed, and the ice sheets grew or shrank.

To appreciate this theory, consider this possible pattern of ocean circulation:

- Prevailing winds transfer water evaporated from one part of the ocean (e.g., the North Atlantic) to other regions, where it falls as precipitation. This transport of vapor intensifies the salinity of the North Atlantic.
- The tendency of surface water to sink depends on its density, which reflects both temperature and salinity, with salinity being the decisive factor. Cold, salty water descends in the North Atlantic and begins a global circulation pattern.
- As warm water flows northward to replace the descending cold, salty water, the resulting transfer of heat has strong climate effects, with Northern Europe owing its current mild temperatures to the heat that surface water delivers to Arctic air currents. (This conveyor system is known as "the thermohaline circulation," which is based on the Greek words *thermo* for heat and *haline* for salt).

Some scientists speculate that a gradual shift in patterns of evaporation and rainfall caused by astronomical factors could have changed salinity in regions such as the North Atlantic, and thereby dramatically altered the global circulation pattern of the oceans, with significant implications for climate change.

Greenhouse Gases

A major shift in the operation of the oceans would also explain why carbon dioxide levels during glaciations have been much lower than during interglacial periods (see Figure 6). After all, th*e oceans hold 50 times as much carbon dioxide as the atmosphere*, and the gas readily diffuses between the ocean surface and the atmosphere.

The surface water concentration of carbon dioxide is controlled, in part, by living things, which act as a biological pump that transfers the gas from the surface to the ocean depths. In the course of photosynthesis, the tiny green plants of the ocean's sunlit upper layers capture dissolved carbon dioxide. Some of the plant matter, as well as animal tissue nourished by the plants, eventually sinks into the deep sea, where bacteria oxidize it back to carbon dioxide.

[49] See, for example, Wallace S. Broecker and George H. Denton, *What Drives Glacial Cycles?,* Scientific American, January 1990

The efficiency of this pump depends not only on the surface plant life but also on vertical mixing patterns of the ocean's layers. So, for example, if the mixing of deep waters with the surface is slowed, surface plant life will have more time to deplete the surface water of carbon dioxide before more of the gas is stirred up from the depths. Scientists speculate that, during glacial times, some combination of altered mixing and changes in ecology must have made the biological pump more efficient, thereby transferring more carbon dioxide from the surface to the ocean depths.

In this way, carbon dioxide levels were lowered significantly during glaciations, adding to the cooling by reducing the level of the GHG. Scientists also speculate that other GHGs — such as methane — were impacted during glaciations too. Methane is produced mostly in swamps and bogs; in northern regions, bogs were frozen underneath ice during glacial periods while, in the tropics, swamps dried out. The combined effect was a sharp drop in the atmosphere's methane content.

An Example of a Climatic Event: The Younger Dryas

A climatic event called the Younger Dryas[50] illustrates the possible link between the transport of fresh water (albeit liquid water, not vapor), ocean circulation, and climate change. About 12,000 years ago, temperatures had risen to typical interglacial levels; suddenly, however, in as few as 100 years, temperatures plunged rapidly (albeit not to late Ice Age levels). About 1,000 years later, this cold spell ended abruptly.

The origins of the Younger Dryas stretch back 14,000 years ago, when two enormous ice sheets mantled all of Canada and the northern reaches of the U.S.: the Cordilleran glacier in the far west, and the Laurentide ice sheet, which lay over eastern and central Canada. These ice sheets were never still, with the Laurentide advancing and retreating, depending on the climatic mix in the northern Atlantic.

Around 11,500 B.C. the retreating Laurentide ice sheet had created an enormous lake — Lake Agassiz —which, at its maximum extent, covered parts of Manitoba, Ontario, and Saskatchewan in Canada, and Minnesota and North Dakota in the U.S. The eastern margin of Lake Agassiz was formed by a bulge of the Laurentide ice sheet, which blocked the lake from draining into the Saint Lawrence River valley.

Natural global warming meant, however, that the Laurentide ice sheet retreated inexorably. Swollen by glacial meltwater, Lake Agassiz continued to grow, and eventually burst into the Saint Lawrence River so that, as one writer observed "within months, perhaps weeks, Lake Agassiz ceased to exist."[51] The huge outburst of freshwater flowed into the Labrador Sea, cutting off the northward flows that had kept Europe several degrees warmer than equivalent latitudes elsewhere. (Recall that the south of France is on the same latitude as South Dakota.) Within a few generations, temperatures fell rapidly, especially in northern Europe, while, in many east Mediterranean lands, the Younger Dryas ushered in a thousand year drought, as cold, dry winds from the northeast (e.g., modern Siberia) replaced moist westerly winds from the Atlantic and Mediterranean.

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[50] Climatologists named this event after a small polar flower that was commonplace during this thousand-year period. The pollen of this flower abounds in waterlogged deposits of the time.

[51] Brian Fagan, *The Long Summer* (New York: Basic Books, 2004).

Appendix C: Climate Change and Civilization

Various scientific studies have suggested that changes in climate have, over the millennia, had profound implications for mankind. In that regard, three distinct episodes of climate change are particularly noteworthy:

- The end of the late Ice Age.
- The thousand-year drought of 11,500–10,600 B.C. (a.k.a., the Younger Dryas, which was discussed above).
- The warmer temperatures and increased rainfall that followed the Younger Dryas period.

The End of the Late Ice Age: From Marooned Cave Dwellers to Roaming Hunter-Gatherers

As we noted above, in the late Ice Age — the frigid but gradually warming period from 18,000 to 13,500 B.C. — the inhabitants of caves in southern France drew images on the walls of the wooly mammoths and other animals they hunted. Reflecting an environment where temperatures hovered near freezing, or below, for much of the year, these Cro-Magnons lived in large groups in caves and rock shelters, with hide curtains likely covering the openings to retain the warmth from the large hearths within. During the nine-month winters, the Cro-Magnons hunted together to prey on the large animals that foraged near their caves; during the short summers, they also ate nuts, berries, and other edible plants.

About 18,000 years ago (i.e., just after the transition labeled "4" in Figure 3), the climate began to warm, with that warming accelerating dramatically around 15,000 years ago. As a result, many of the animals that the Cro-Magnons had preyed on — including mammoth, bison and reindeer — migrated northward with the retreating tundra. At the same time that the tundra retreated northward, birch and deciduous forests spread rapidly into southern Europe.

This climate change, and the accompanying change in the natural environment, enabled the Cro-Magnons to abandon their rock shelters, and disperse into much smaller bands that lived on forest animals (such as deer), and increasingly, on plant food. Out of the caves, most hunter-gatherer groups in Europe lived in forest clearings, near lakes and river banks, or by seacoasts. By 14,000 B.C., the last late Ice Age Cro-Magnon hunting societies had vanished in the face of natural global warming.

The Younger Dryas: From Hunter-Gatherers to Farmers

Around 11,000 B.C., a prolonged drought in many regions was triggered by a dramatic geological event in North America. As we discussed above, climatologists call this thousand-year event the Younger Dryas, which covered the period 11,500–10,600 B.C.

As the impact of the Younger Dryas took effect, landscapes in many parts of the world became drier and traditional foods sources for humans and the animals they hunted (e.g., nuts, berries, and other edible plants) became scarcer. It's likely that some people adjusted to the drier conditions by turning to standby foods, such as wild grasses, before taking the next logical step (in about 10,000 B.C.) — attempting to grow specific grasses in order to expand the harvest.

Agriculture first began in the "Fertile Crescent" of southwestern Asia, a broad swath covering the Nile valley at one end and southern Iraq at the other, with Israel, Jordan, southwestern Turkey, Iran, and northern Iraq in between. Wild plant species that were the basis of some of the world's most useful crops flourished within the Fertile Crescent, including wild einkorn, the ancestor of modern domesticated wheat.

Within a few generations, the habit of repeated planting and harvesting changed the genetic makeup of wild grasses. Einkorn was domesticated very rapidly in eastern Turkey, as were chickpeas. Barley, emmer wheat, peas, lentils, and flax were domesticated within a very short time elsewhere in the Fertile Crescent. Another wild grass, *Aegilops squarrosa*, grew on the shores of the Caspian Sea. When this grass hybridized with domesticated emmer wheat spreading east from the Fertile Crescent, the result was bread wheat, the most important of all ancient crops.

So, it was likely as a result of the droughts of the Younger Dryas that farming began, with a key result being that the former hunter-gatherers were now anchored by permanent villages to their fields.

After the Younger Dryas: From Farmers to City Dwellers

In about 9000 B.C., when warming resumed after the end of the Younger Dryas, animal domestication occurred simultaneously at several locations. Archaeologists can only speculate how domestication took place. The arid conditions during the Younger Dryas concentrated human settlements around permanent water sources, such as lakes, rivers, and springs. Here the most diverse wild plant foods were to be found, and here, too, game congregated, both for water and to graze on the lush vegetation. Inevitably, animals and humans were thrown together.

Agriculture and animal husbandry are not necessarily compatible activities, nor did cultivation lead to domesticated animals. But both plant cultivation and animal domestication resulted from the need to ensure reliable food supplies. And once domesticated, the remarkable diversity of useful plants and animals (such as goats and sheep) provided hunter-gatherers-turned-farmers with a balanced source of raw materials, such as vegetables, meat, and milk.

As the centuries passed, the small villages became clusters of rural communities located around a single larger settlement. Many of these were located in southern Mesopotamia — "the land between the rivers" — now southern Iraq. It was there that two great rivers, the Tigris and the Euphrates, entered a floodplain of channels and streams. Water was abundant, and was easily diverted onto fields. All the farmers needed to do was to build simple levees and canals.

By 5200 B.C., the largest of these towns covered about 24 acres and housed between 2,500 and 4,000 people. Subsequently, some of the earliest cities on earth (such as Ur) arose in this part of southern Mesopotamia. (Over 80% of all southern Mesopotamians lived in towns or cities by 2800 B.C.) These cities were different entities from the villages that they grew from, not just larger in size, but requiring both economic specialization and a more centralized social organization, with the end result being that many of the inhabitants of the cities lived on food produced by others.

Appendix D: Climatic Consequences Companies

Acciona ANA.MC 2M – M. Pinkney	The Spanish construction company ranks third in the world in terms of installed wind power generation capacity, and is also very active in solar power and biofuels.
ACE Limited ACE.N 1H – J. Shanker	The reduced exposure of "mega-carriers" to hurricane-prone regions of the U.S. creates an opportunity for this "small" insurer ($12 billion of net premiums written in 2006).
Aguas de Barcelona AGS.MC 2M – D. Vila	At the same time that Spain is experiencing drought conditions, Spanish water consumption per capita is at record high levels. "Agbar" has a 55% share of the privatized water market in Spain.
Allegheny Technologies ATI.N 1H – J. Hill	A U.S. manufacturer of specialty alloys used in power generating stations, as well as in nuclear reactors, liquefied natural gas plants, pipelines, and ethanol plants.
American Intl Group AIG.N 2H – J. Shanker	Ranked by Ceres as a thought-leader on climate change issues. Involved with a variety of climate initiatives, including the development of insurance products that facilitate carbon trading.
Arch Capital Group ACGL.Q 1H – J. Shanker	The reduced exposure of "mega-carriers" to hurricane-prone regions of the U.S. creates an opportunity for this "small" insurer ($3 billion of net premiums written in 2006).
Archer Daniels Midland ADM.N 1H – D. Driscoll	One of the world's largest processors of corn holds a 20% market share in the U.S. ethanol market, with ethanol accounting for an estimated 30% of segment operating profits in fiscal 2006.
Bajaj Hindusthan BJHN.BO 1M – P. Singh	The largest sugar manufacturer in India also manufactures ethanol. The diversion of global sugarcane to ethanol production, will likely lead to a higher trading price band for sugar.
Balrampur Chini Mills BACH.BO 1M – P. Singh	One of the leading sugar manufacturers in India also sells carbon credits. The diversion of global sugarcane to ethanol production, will likely lead to a higher trading price band for sugar.
BG Group PLC BG.L 2M – D. Thomas	The exploration and production company, which traces its roots back to British Gas, would benefit from increased demand for "clean" natural gas in the U.K. market.
BorgWarner BWA.N 1M – J. Rogers	Almost all of this U.S. auto parts supplier's key products offer the benefits of higher fuel efficiency and/or lower emissions. The company also has material exposure to the diesel engine market.

Brasil Ecodiesel ECOD3.SA 1S – T. Mello	A leading biodiesel producer in Brazil. A mandatory 2% blend of biodiesel into diesel will be implemented in Brazil in 2008, creating a $700 million industry.
Bunge Limited BG.N 1M – D. Driscoll	The largest vegetable oil producer in the world is a direct beneficiary of burgeoning demand for biodiesel. The company has exposure to both the North American and European markets.
Centrica PLC CNA.L 1H – P. Atherton	The company known as "British Gas" to 11.5 million residential customers operates the U.K.'s largest fleet of gas-fired power stations.
Chesapeake Energy Corp CHK.N 1H – G. Yang	Concentrating on the mid-Continent region of the U.S., this exploration and production company has relatively "efficient" operations, and no exposure to the hurricane-prone Gulf of Mexico.
Chicago Mercantile Exchange CME.N 2H – D. Fandetti	The world's largest futures exchange currently offers U.S. futures contracts for ethanol. There could be additional opportunities for futures exchanges to develop "climate" products.
Compagnie de St Gobain SGOB.PA 1M – C. Lewis	A French building materials company. European requirements to improve the thermal efficiency of buildings will likely lead to greater demand for insulation products.
Conergy AG CGYG.DE 1H – B. Kluftinger	Germany's largest solar photovoltaic system wholesaler. Driven by a number of factors, including government policies, global installed solar capacity has been growing rapidly.
Constellation Energy CEG.N 1M – G. Gordon	Owns three merchant nuclear plants in the Mid-Atlantic and New York state. Utilities with exposure to "clean" nuclear power would be well positioned in a carbon-constrained environment.
Cosan SA CSAN3.SA 1S – T. Mello	As Brazilian demand for ethanol continues to rise, the company is gradually shifting its focus from sugar exports to solidifying its leadership position in Brazil's domestic ethanol market.
CropEnergies AG CE2G.DE 2H – B. Kluftinger	The operator of Europe's largest bioethanol plant. Its parent is the leading European sugar manufacturer, which creates a number of benefits, including inexpensive access to feedstock materials.
Deere DE.N 1M – D. Raso	U.S. farmers' incomes are being boosted by burgeoning demand for ethanol, as well as by drought-conditions in some parts of the world, both of which are pushing up the prices of certain crops.
DSM NV DSMN.AS 1M – S. Jourdier	A Dutch specialty chemicals and biotechnology company with exposure to alternative fuels, including ethanol. Various biotech products offer the potential for higher ethanol yields.

DuPont DD.N 1M – P. Juvekar	Amid a booming market for alternative fuels, including ethanol, various biotechnology products offer the potential for higher ethanol yields.
Ebro Puleva EVA.MC 1M – D. Vila	Spain's largest food manufacturer. The company is gradually abandoning sugar production, and is investing about €200 million to expand production of more lucrative biofuels.
Electricité de France EDF.PA 1M – D. Martin	The largest operator of nuclear assets in the world. Importantly, its nuclear plants are relatively "young," with an average age of just 19 years.
Emerson EMR.N 1M – J. Sprague	Its Climate Technologies business offers sophisticated energy efficiency technologies; the Performance Monitoring and Optimization business helps optimize energy usage.
ENCE ENC.MC 2M – D. Vila	As part of its pulp production process, this Spanish company generates electricity from biomass, with the result that it has become a significant owner of carbon dioxide emission rights.
Energy Developments ENE.AX 2H – P. Graham	By utilizing its landfill gas generation facilities, this Australian company generates revenues from sale of GHG abatement certificates to third parties.
Entergy Corp. ETR.N 1M – G. Gordon	The second largest nuclear plant operator in the U.S. Utilities with exposure to "clean" nuclear power would be well-positioned in a carbon constrained environment.
ESCO Technologies ESE.N 1H – D. Smith	A U.S. manufacturer of powerline-based "smart" meters, which facilitate hour-by-hour pricing schemes that encourage renewable energy use.
Evergreen Solar ESLR.Q 1S – D. Smith	An integrated U.S. manufacturer of solar wafers, cells and modules. Driven by a number of factors, including government policies, global installed solar capacity has been growing rapidly.
Exelon Corp EXC.N 2M – G. Gordon	The operator of the largest unregulated nuclear fleet in the U.S. Utilities with exposure to "clean" nuclear power would be well-positioned in a carbon constrained environment.
Fortum Oyj FUM1V.HE 1M – D. Martin	This electric utility, which serves Nordic countries including Finland and Sweden, has around 50% of its power generation capacity in nuclear power.
FPL Group FPL.N 2M – G. Gordon	A nuclear operator and, also, the leader in U.S. wind power generation. Utilities with exposure to "clean" nuclear power would be well positioned in a carbon constrained environment.

Gamesa GAM.MC 2M – J. Gortazar	This Spanish company operates mainly within the wind power industry, where it acts as wind-turbine manufacturer and wind farm developer.
Gaz de France GAZ.PA 1M – E. Verdoja	One of the largest gas utilities in Europe. While the bulk of its activities are based on French regulated infrastructure, the company also has a substantial exploration and production arm.
Gazprom GAZP.RTS 1L – A. Korneev	The sole exporter of Russian natural gas to Europe would benefit from increased demand for “clean” natural gas in European markets.
General Electric GE.N 1L – J. Sprague	This sprawling conglomerate supplies a range of products and services that facilitate climate change mitigation, including wind turbines, gas turbines and nuclear reactors/fuel assemblies.
GFI Group Inc. GFIG.Q 1H – D. Fandetti	This inter-dealer broker focused on the OTC derivative markets is already active in emissions trading in Europe, and also has exposure to the growing emissions market in the U.S.
Honda Motor 7267.T 1M – N. Matsushima	While diesel engines are more fuel-efficient than gasoline engines, they emit more air pollutants. Among Honda’s product strategies is a new “super-clean” diesel engine.
Iberdrola SA IBE.MC 2M – A. Vigil	In addition to 15% of capacity in wind power, 33% of this Spanish utility’s portfolio is represented by hydro assets, 25% is in combined cycle gas turbine (CCGT), and 12% in nuclear.
IJM Plantations IJMP.KL 1L – A. Chow	The company has an attractive oil palm age profile, averaging less than seven years. As more oil palm trees hit the peak maturity age, IJM’s production should enjoy strong organic growth.
IOI Corp. IOIB.KL 1L – A. Chow	One of the largest integrated palm-oil producers in the world, the company is a good proxy for biodiesel-driven palm oil demand in the EU on account of its strong direct presence in that market.
Itron ITRI.Q 1H – D. Smith	A U.S. manufacturer of radio frequency-based “smart” meters, which facilitate hour-by-hour pricing schemes that encourage renewable energy use.
Johnson Controls JCI.N 1M – J. Rogers	Building efficiency services represent 50% of this U.S. company’s operating income. One service offered is a performance contract that commits to a fixed reduction of GHG emissions.
KL Kepong KLKK.KL 1L – A. Chow	In addition to palm oil plantations located in peninsular Malaysia and Indonesia that benefit from growing global biodiesel demand, the company also has vegetable oil operations in China.

Magna International MGA.N 1M – J. Rogers	A Canadian auto parts supplier that facilitates automobile GHG emissions reductions, given that vehicle load (weight) reduction means that less fuel is required to move the vehicle.
Monsanto MON.N 2M – P. Juvekar	Amid a booming market for alternative fuels, including ethanol, various biotechnology products offer the potential for higher ethanol yields.
Neste Oil Corp NES1V.HE 1M – J. Neale	A Finnish independent refiner, which focuses on high-value-added petroleum products, including biodiesel. A new biodiesel plant, which will use proprietary technology, will be completed in 2007.
Noble Group NOBG.SI 1H – P. Williamson	This Hong Kong–based company is aiming to control up to 1 billion gallons of ethanol for U.S./global distribution by 2008. In addition, Noble Carbon Credits facilitates carbon trading.
Ormat Technologies ORA.N 2S – B. Chin	A leading geothermal company worldwide. Ormat specializes in the design of geothermal plants that generate power despite the presence of highly corrosive chemicals in the hot water.
Peugeot SA PEUP.PA 1H – S. Pearson	One of the most fuel efficient automobile manufacturers in Europe reflecting 1) a wide offering of diesel-fueled cars; 2) the widest range of small cars; 3) early adoption of mild-hybrid systems.
Philips Electronics PHG.AS 1M – S. Smith	This Dutch company is the number one global lighting manufacturer. If all European lighting was upgraded to the latest technology, CO2 emissions would be reduced by 59 million tons.
Potash Corp of Saskatchewan POT.N 1M – B. Yu	This Canadian company produces three nutrients (potash, nitrogen, and phosphate), all of which are important in grain cultivation.
Q-Cells QCEG.DE 1M – B. Kluftinger	This German company's core business is the development, production, and sale of silicon-based solar cells. It is the world's second largest solar cell manufacturer.
RPS Group PLC RPS.L 2L – J. Brent	This U.K. environmental consulting firm offers a range of services, including the preparation of "environmental statements" that support carbon abatement projects, e.g., wind farms.
RWE AG RWEG.DE 1M – D. Martin	Despite emitting about 90 million tons of carbon dioxide, or about 10% of Germany's total, this "dirty" utility has been enjoying windfall profits in the EU Emissions Trading Scheme.
Schneider Electric SCHN.PA 2M – S. Smith	This French company's Energy Management business facilitates efficient electricity use by providing systems that allow energy suppliers and large customers to view energy use in real time.

Sharp 6753.T 2H – Y. Kanazawa	The world's largest solar cell manufacturer, reflecting Japan's high electricity prices, as well as political support for the industry in that country.
Shaw Group SGR.N 2S – B. Chin	With power generation accounting for 40% of this U.S. company's total backlog — and nuclear construction half of that — Shaw is highly leveraged to spending by utilities.
Siemens AG SIEGn.DE 1M – T. Adams	This German company recently signaled its intention to develop coal gasification technology. It also has significant exposure to nuclear power plant construction.
SIG PLC SHI.L 2M – A. Lammin	A British company specializing in the distribution of insulation. European requirements to improve the thermal efficiency of buildings will likely lead to greater demand for insulation products
SolarWorld SWVG.DE 1M – B. Kluftinger	A fully integrated solar energy company, covering virtually all steps in the solar PV value chain, from silicon wafer production to system distribution.
Southwestern Energy Co SWN.N 1H – G. Yang	This Texas-based exploration and production company has relatively "efficient" operations, and no exposure to the hurricane-prone Gulf of Mexico.
Sunpower Corp. SPWR.Q 1S – D. Smith	This U.S. company specializes in silicon solar cells, solar panels, and inverters, which convert the direct current generated by solar panels into grid-compatible alternating current.
Suntech Power STP.N 1S – D. Smith	A leading Chinese manufacturer of silicon crystal solar cells. The company has a roughly 80% share of China's rapidly growing solar cell market.
Swiss Reinsurance RUKN.VX 2M – J. Quin	A diversified reinsurer involved with a variety of climate initiatives, including the development of insurance products that facilitate carbon trading.
Syngenta AG SYNN.VX 2L – A. Benson	This Swiss company was one of the original creators of ag biotechnology products. Beginning in 2007, the company will roll out new products with a particular focus on the biofuel market.
Terra Industries TRA.N 1S – B. Yu	This U.S. company is well positioned to benefit from corn ethanol because, when it comes to fertilizers, corn is a nitrogen-intensive crop, and Terra produces nitrogen products exclusively.
Toyota Motor 7203.T 1M – N. Matsushima	The global leader in hybrid electric vehicles, which have the potential to reduce carbon dioxide emissions by 50% compared to today's diesel and gasoline engines.

TXU Corp TXU.N 2H – G. Gordon	Being "grandfathered" might be TXU's goal, as it is planning on rapidly building a large number of coal-fired power plants in the U.S., which currently has no carbon emissions restrictions.
Vestas Wind Systems VWS.CO 2H – M. Fielding	This Danish company is the market leader in the production of turbines. Driven by a number of factors, including government policies, global installed turbine capacity has been growing rapidly.
XTO Energy, Inc. XTO.N 1H – G. Yang	This U.S. exploration and production company has relatively "efficient" operations, and no exposure to the hurricane-prone Gulf of Mexico.

Note: Analyst Ratings as of January 18, 2007
Source: Citigroup Investment Research

Appendix E:
Companies by Sector

Sector	Company
Consumer Discretionary	BorgWarner
	Honda Motor
	Johnson Controls
	Magna International
	Peugeot SA
	Toyota Motor
Consumer Staples	Archer Daniels Midland
	Bajaj Hindusthan
	Balrampur Chini
	Bunge Limited
	Cosan SA
	Ebro Puleva
	IJM Plantations
	IOI Corp
	KL Kepong
	Noble Group
Energy	BG Group PLC
	Brasil Ecodiesel
	Chesapeake Energy Corp
	CropEnergies AG
	Energy Developments
	Gazprom
	Neste Oil Corporation
	Ormat Technologies
	Southwestern Energy Co
	XTO Energy Inc
Financials	Ace Limited
	American Intl Group
	Arch Capital Group
	Chicago Mercantile Exchange
	GFI Group
	Swiss Reinsurance
Industrials	Acciona
	Compagnie de St Gobain
	Conergy AG
	Deere
	Emerson
	ESCO Technologies
	Evergreen Solar

Sector	Company
Industrials (cont'd)	Gamesa
	General Electric
	Itron
	Philips Electronics
	Q-Cells
	RPS Group PLC
	Schneider Electric
	Sharp
	Shaw Group
	Siemens AG
	SIG PLC
	SolarWorld
	SunPower Corp
	Suntech Power
	Vestas Wind Systems
Materials	Allegheny Technologies
	DSM NV
	DuPont
	ENCE
	Monsanto
	Potash Corp of Sask
	Syngenta AG
	Terra Industries
Utilities	Aguas de Barcelona
	Centrica PLC
	Constellation Energy
	Electricité de France
	Entergy Corp
	Exelon Corp
	Fortum Oyj
	FPL Group
	Gaz de France
	Iberdrola
	RWE AG
	TXU Corp

Source: FactSet and Standard & Poor's

Appendix F: Companies by Country

Country	Company
Australia	Energy Developments
Brazil	Brasil Ecodiesel
	Cosan SA
Canada	Magna International
	Potash Corp of Sask
China	Suntech Power
Denmark	Vestas Wind Systems
Finland	Fortum Oyj
	Neste Oil Corporation
France	Compagnie de St Gobain
	Electricité de France
	Gaz de France
	Peugeot SA
	Schneider Electric
Germany	CropEnergies AG
	Conergy AG
	Q-Cells
	RWE AG
	Siemens AG
	SolarWorld
Hong Kong	Noble Group
India	Bajaj Hindusthan
	Balrampur Chini
Japan	Honda Motor
	Sharp
	Toyota Motor
Malaysia	IJM Plantations
	IOI Corp
	KL Kepong
Netherlands	DSM NV
	Philips Electronics
Russia	Gazprom
Spain	Acciona
	Aguas de Barcelona
	Ebro Puleva
	ENCE
	Gamesa
	Iberdrola
Switzerland	Swiss Reinsurance
	Syngenta AG
United Kingdom	BG Group PLC
	Centrica PLC
	RPS Group PLC
	SIG PLC
United States	ACE Limited
	Allegheny Technologies
	American Intl Group
	Arch Capital Group
	Archer Daniels Midland
	BorgWarner
	Bunge Limited
	Chesapeake Energy Corp
	Chicago Mercantile Exchange
	Constellation Energy
	Deere
	DuPont
	Emerson
	Entergy Corp
	ESCO Technologies
	Evergreen Solar
	Exelon Corp
	FPL Group
	General Electric
	GFI Group
	Itron
	Johnson Controls
	Monsanto
	Ormat Technologies
	Shaw Group
	Southwestern Energy Co
	SunPower Corp
	Terra Industries
	TXU Corp
	XTO Energy Inc

Source: FactSet

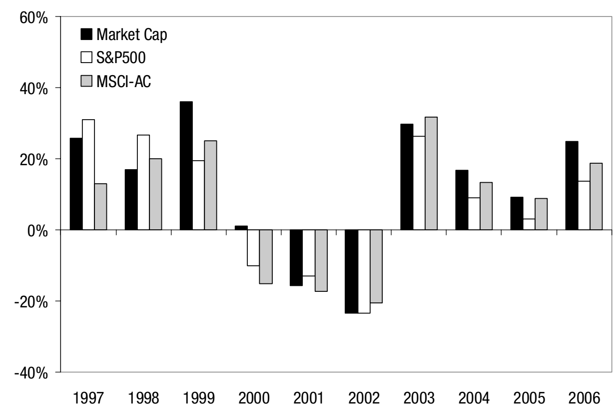
Appendix G: Performance

Figure 1 lists 74 companies (across 21 industries and based in 18 countries) that seem well positioned to benefit from these trends.

As Figure 76 and Figure 77 illustrate, a market cap weighted index of these stocks has outperformed both the S&P 500 and the MSCI AC (All Countries) World Index in each of the past three years.

Figure 76. Market-Cap Weighted Index

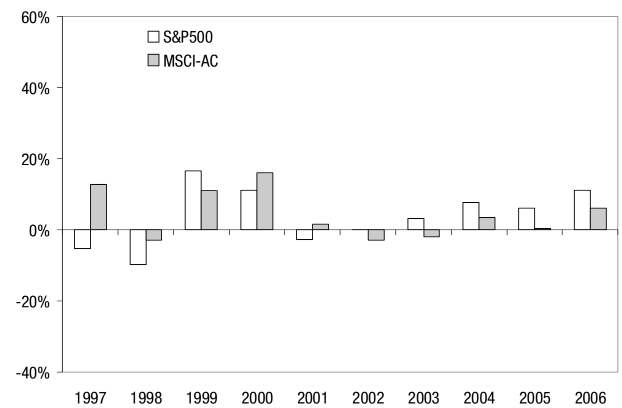
Absolute performance through 12/31/06



Source: FactSet and Citigroup Investment Research

Figure 77. Market-Cap Weighted Index

Relative performance through 12/31/06

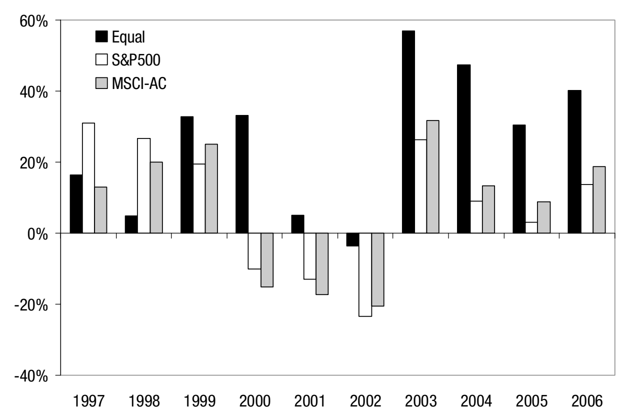


Source: FactSet and Citigroup Investment Research

Figure 78 and Figure 79 illustrate that an equally weighted index has had even stronger performance, but that likely largely reflects the robust performance of small-cap stocks relative to large-caps in recent years.

Figure 78. Equally Weighted Index

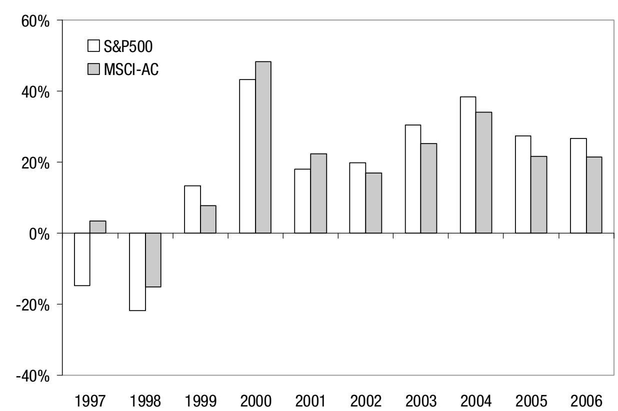
Absolute performance through 12/31/06



Source: FactSet and Citigroup Investment Research

Figure 79. Equally Weighted Index

Relative performance through 12/31/06



Source: FactSet and Citigroup Investment Research

ANALYST CERTIFICATION

Appendix A-1

We, Edward Kerschner and Michael Geraghty, research analysts and the authors of this report, hereby certify that all of the views expressed in this research report accurately reflect our personal views about any and all of the subject issuer(s) or securities. We also certify that no part of our compensation was, is, or will be directly or indirectly related to the specific recommendation(s) or view(s) in this report.

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Data current as of 31 December 2006	**Buy**	**Hold**	**Sell**
Citigroup Investment Research Global Fundamental Coverage (3106)	43%	41%	15%
% of companies in each rating category that are investment banking clients	45%	41%	34%
Alternative Energy -- North America (8)	63%	25%	13%
% of companies in each rating category that are investment banking clients	20%	0%	0%
Auto Manufacturers -- Europe (10)	10%	70%	20%
% of companies in each rating category that are investment banking clients	100%	86%	50%
Auto Manufacturers -- North America (10)	40%	30%	30%
% of companies in each rating category that are investment banking clients	50%	67%	33%
Building Products -- Europe (13)	54%	46%	0%
% of companies in each rating category that are investment banking clients	71%	0%	0%
Chemicals -- Europe (21)	19%	43%	38%
% of companies in each rating category that are investment banking clients	25%	56%	63%
Chemicals: Major -- North America (13)	15%	77%	8%
% of companies in each rating category that are investment banking clients	100%	70%	0%
China -- Asia Pacific (76)	54%	14%	32%
% of companies in each rating category that are investment banking clients	34%	55%	50%
Commodity Agriculture -- North America (5)	100%	0%	0%
% of companies in each rating category that are investment banking clients	0%	0%	0%
Construction -- Europe (13)	62%	31%	8%
% of companies in each rating category that are investment banking clients	38%	25%	100%
Diversified Commercial Services -- Europe (10)	30%	40%	30%
% of companies in each rating category that are investment banking clients	0%	0%	0%
Electric Utilities -- North America (30)	23%	70%	7%
% of companies in each rating category that are investment banking clients	86%	90%	100%
Emerging Europe/Middle East/Africa (114)	47%	34%	18%
% of companies in each rating category that are investment banking clients	37%	38%	19%
Emerging Growth -- Australia/New Zealand (29)	31%	59%	10%
% of companies in each rating category that are investment banking clients	11%	6%	0%
Energy Merchants -- North America (7)	29%	71%	0%
% of companies in each rating category that are investment banking clients	50%	60%	0%
Engineering -- Europe (31)	39%	58%	3%
% of companies in each rating category that are investment banking clients	33%	28%	100%
Engineering/Construction -- North America (4)	25%	75%	0%
% of companies in each rating category that are investment banking clients	0%	0%	0%
Exploration & Production -- North America (16)	44%	50%	6%

% of companies in each rating category that are investment banking clients	71%	38%	0%
Food Manufacturers -- Europe (13)	38%	46%	15%
% of companies in each rating category that are investment banking clients	60%	67%	0%
Food Manufacturers -- North America (11)	64%	36%	0%
% of companies in each rating category that are investment banking clients	71%	75%	0%
Hong Kong -- Asia Pacific (91)	53%	14%	33%
% of companies in each rating category that are investment banking clients	44%	62%	33%
India -- Asia Pacific (118)	58%	14%	28%
% of companies in each rating category that are investment banking clients	48%	50%	39%
Insurance--Property & Casualty -- North America (25)	28%	52%	20%
% of companies in each rating category that are investment banking clients	86%	85%	80%
Insurance--Reinsurers -- Europe (4)	0%	100%	0%
% of companies in each rating category that are investment banking clients	0%	25%	0%
Latin America (109)	47%	36%	17%
% of companies in each rating category that are investment banking clients	61%	51%	32%
Machinery -- North America (10)	60%	10%	30%
% of companies in each rating category that are investment banking clients	83%	100%	33%
Malaysia -- Asia Pacific (39)	56%	10%	33%
% of companies in each rating category that are investment banking clients	18%	25%	8%
Metals & Mining -- North America (7)	43%	57%	0%
% of companies in each rating category that are investment banking clients	100%	50%	0%
Multi-industry -- Europe (1)	0%	100%	0%
% of companies in each rating category that are investment banking clients	0%	100%	0%
Multi-industry -- North America (14)	29%	64%	7%
% of companies in each rating category that are investment banking clients	100%	56%	100%
Oil Companies--International -- Europe (11)	36%	55%	9%
% of companies in each rating category that are investment banking clients	75%	67%	100%
Paper & Forest Products -- Europe (8)	25%	50%	25%
% of companies in each rating category that are investment banking clients	50%	25%	0%
Refiners -- Europe (4)	50%	50%	0%
% of companies in each rating category that are investment banking clients	100%	50%	0%
Renewable Energies -- Europe (8)	88%	13%	0%
% of companies in each rating category that are investment banking clients	14%	100%	0%
Small/Mid-Cap--Industrials -- North America (10)	50%	50%	0%
% of companies in each rating category that are investment banking clients	20%	20%	0%
Specialty Finance -- North America (18)	39%	61%	0%
% of companies in each rating category that are investment banking clients	86%	55%	0%
Utilities -- Europe (31)	32%	52%	16%
% of companies in each rating category that are investment banking clients	90%	44%	60%
Utilities--Gas Distribution -- Europe (1)	100%	0%	0%
% of companies in each rating category that are investment banking clients	100%	0%	0%

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