

THE INVESTMENT IMPLICATIONS OF CLIMATE CHANGE

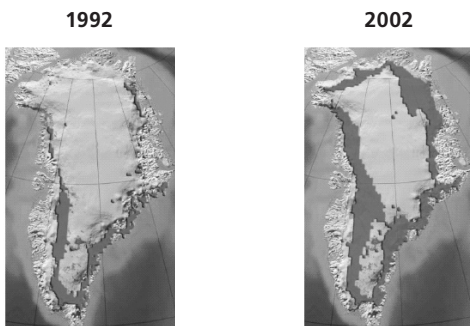
by Amy Raskin, Director—Research on Strategic Change

Regulations aimed at reducing the greenhouse gas emissions associated with climate change are likely to vastly increase spending on low-carbon electric power systems and energy efficiency, creating strong growth opportunities in a wide array of industries.

THE FABLED SNOWS OF KILIMANJARO ARE disappearing—along with snowcaps on mountains from Peru to Tibet. Greenland’s summer Ice Sheet has narrowed visibly since 1992 (*Display 1*). And atmospheric carbon dioxide, or CO₂, levels have jumped from 284 parts per million (the high end of its normal range) prior to the Industrial Revolution to an unprecedented 380 today. Most scientists believe that the jump in atmospheric CO₂ is a result of the increased burning of fossil fuels that began with the Industrial Revolution some 200 years ago and intensified as fossil-fuel-fired electric plants have proliferated over the last 100 years.

Display 1

The Greenland Ice Sheet is shrinking

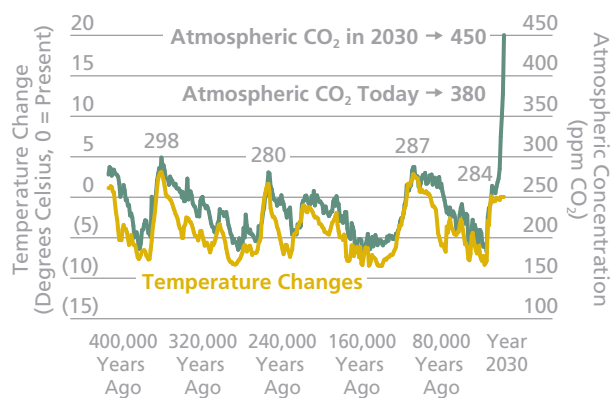


Arctic Climate Impact Assessment 2004
Source: Arctic Council and International Arctic Science Committee

Given the close correlation between global temperatures and the atmospheric concentration of carbon dioxide over the last 400,000 years (*Display 2*), most scientists agree that the shrinking mountain snowcaps and Greenland

Display 2

Temperature fluctuations have correlated with atmospheric CO₂



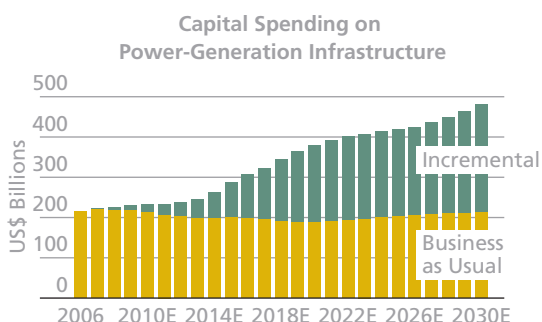
Source: Arctic and Antarctic Research Institute, Laboratoire de Glaciologie et Géophysique de l’Environnement, and Laboratoire des Sciences du Climat et de l’Environnement

Ice Sheet are signs of man-made global warming. They also predict that if atmospheric CO₂ continues its recent rise, in just two or three decades it could enter the 450–550-parts-per-million range, which could prove catastrophic in time. In just a few hundred years, dangerously higher temperatures could melt the polar ice caps, submerging coastal areas where hundreds of millions of people now live. Mountain snowcaps that supply river water to vast inland agricultural areas could disappear, resulting in famine. Warmer sea temperatures could foster more destructive hurricanes and other storms.

Our research suggests that these horrific potential consequences of climate change can be avoided. Regulations aimed at reducing the greenhouse gas emissions associated with

Display 3

Climate change concerns will result in a doubling of capital spending on power



Source: Energy Information Administration (EIA) and AllianceBernstein

climate change are being adopted in much of the world, and we expect these regulations to become stricter and more widespread. Existing and developing technologies will make a wide array of strategies possible.

The effort will be expensive: We expect annual capital spending in the power-generation sector alone to more than double to US\$480 billion a year by 2030 (*Display 3*). Relative to total global capital spending of more than \$10 trillion per year, however, the spending required to forestall climate change is manageable.

More directly relevant to us as investors, we see sweeping implications from this effort for a wide array of industries. Remarkably, we

Display 4

Many industries will benefit from initiatives to reduce carbon emissions

	Near Term	Mid-Term	Long Term
Generating Equipment	++	+++	+++
Transmission Equipment	+	+++	++
Electric Utilities	+ / -	++ / --	+++ / --
Oil Field Services	+ / -	++ / --	+++ / --
Pipeline Operators	+	++	+++
Engineering and Construction Firms	+	+++	+++
Power Electronics	+++	+++	+++

Near term is defined as less than five years, mid-term as from five to eight years, and long term as more than eight years.

Source: AllianceBernstein

expect there will be many winners (*Display 4*) but very few big losers, although households and industry will face higher electric bills. In our view, the macroeconomic impact of the effort to reduce carbon emissions is, on balance, likely to be positive.

The Key Issues

To estimate the magnitude of the investment required to mitigate climate change, we focused on two central and related problems: CO₂ and electric power generation. We focused on CO₂ because it's the largest contributor to the problem, accounting for more than 70% of man-made greenhouse gas emissions; it also stays in the atmosphere longest. And we focused on electric power generation because this segment produces 36% of total CO₂ emissions, and many of the solutions applicable for electric power can also be used for industrial processes, which represent another 30% of emissions.

To conduct our analysis, we examined all the possible ways mankind could reduce CO₂ emissions. The first way is to do less in order to use less energy: Drive cars less, air-condition and light fewer and smaller buildings, and pull the plug on flat-screen televisions, refrigerators, and other energy-intensive consumer devices. Although this would be a fairly cheap solution, most likely no one would agree to it, so we crossed it off our list.

The second way is to increase the Earth's natural absorption of CO₂. People would not have to reduce their standard of living, but our research suggests it would be technologically very difficult (if not impossible) and exorbitantly expensive. We crossed off that option, too.

Three options remain that are feasible:

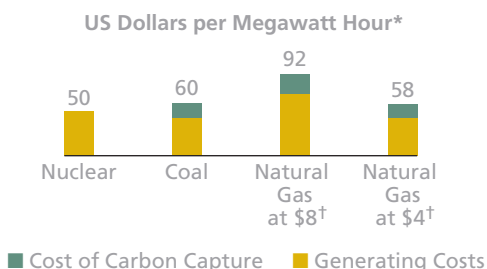
- > **Generate electricity from sources that don't create carbon dioxide.** Nuclear power and renewable resources, such as wind and solar, are costly, but not prohibitively so, and the technologies are proven. There are political obstacles to nuclear energy, but opposition is waning in many regions.
- > **Capture and sequester the CO₂ emissions produced by burning fossil fuels.** This, too, would have relatively little negative impact on users and would not be prohibitively expensive. The technology exists or is in development.
- > **Use more energy-efficient technologies.** Requiring use of such technologies or encouraging their use by raising electricity prices (or both) allows people to do as much with less energy. It wouldn't cost much and there are few implementation obstacles, but the potential reduction in total carbon emissions is limited.

Electricity from Nonfossil Fuels

Over 400 nuclear reactors in operation around the world today have the capacity to generate about 367 gigawatts of electricity. We forecast that by 2030 there will be over 900 gigawatts of nuclear-generating capacity, based on our

Display 5

Nuclear power is cheapest if the cost of capturing CO₂ is factored in



*Excludes financing cost

†US dollars per million BTU

Source: Intergovernmental Panel on Climate Change and AllianceBernstein

estimates of the economics of nuclear power: When the cost of curbing carbon emissions is taken into account, it is the cheapest way to generate electricity (*Display 5*).

If we are right, by 2030 the world will be spending more than \$90 billion per year on nuclear equipment, versus less than \$10 billion today; this figure does not include service-related spending. This would create a much bigger market opportunity for companies in the nuclear power industry such as Areva, Alstom, Cameco, GE, and Toshiba/Westinghouse.

Aside from hydroelectric power, renewable energy sources today generate a very small part of the global supply of electricity. Due to strong political support for renewable energy in many parts of the world, we expect much more renewable energy capacity to be added. We estimate that more than 2,200 gigawatts of generating capacity based on renewable sources will be in place by 2030, up from just over 1,000 today. Wind and solar power will account for most of the gains, but hydro will grow as well. In total, we forecast that spending on renewable resources will increase from about \$60 billion per year today to \$140 billion per year by 2030.

Our research shows, however, that increasing the use of nonfossil fuel energy sources won't be sufficient to meet growing global power requirements, in part due to low capacity utilization for renewables. While a nuclear reactor can operate virtually around the clock, a wind turbine generates electricity only when the wind is blowing, and solar power works only when the sun is shining.

To maintain global economic growth without curbing our lifestyles, CO₂ emissions from burning fossil fuels will have to be reduced.

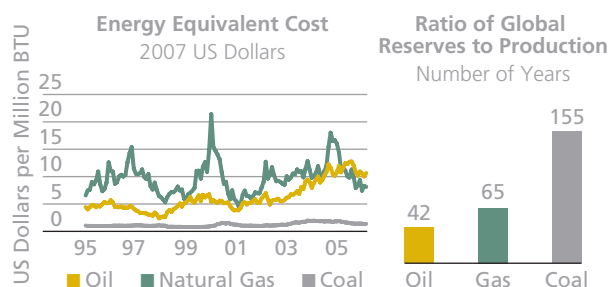
Fossil Fuel Choices

Three fossil fuels are now used for generating electricity: oil, coal, and natural gas. Oil is no longer a real option, given its scarcity and rising cost over the long term. There are almost no oil-burning electric plants being built today.

Coal has been much cheaper than either oil or natural gas for the last 10 years and is far more abundant (*Display 6*). Furthermore, coal reserves are located in key regions, such as rapidly growing China and India, as well as in many European countries and the US. But coal-burning plants emit far more CO₂ per unit of electricity generated than other types of electric plants (*Display 7*).

Display 6

Widely available, coal is consistently the cheapest fossil fuel



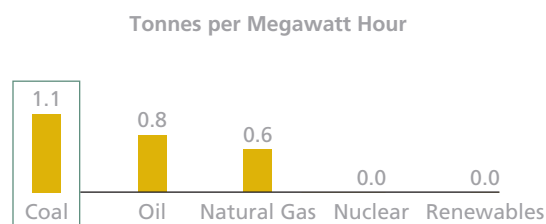
Source: Bloomberg L.P., BP Statistical Review of World Energy 2006, and AllianceBernstein

Today, much of the power-generation capacity being built in the US and Europe is based on natural gas, because natural gas plants emit fewer pollutants and are cheaper and quicker to build. If natural gas prices retreat from recent highs, the cost per megawatt hour of electricity generated could be lower for natural gas than for coal, if carbon emissions aren't subject to regulation.

But once CO₂ emissions are regulated, utilities will likely have to capture CO₂ from both natural gas and coal plants. With the cost of

Display 7

The problem with coal is high CO₂ emissions



Source: EIA and AllianceBernstein

capturing CO₂ factored in, it costs about as much to generate electricity from natural gas as from coal, even when gas prices are low, as the display on the preceding page indicates.

We predict that future decisions on whether to build coal- or gas-fired electric plants will largely be a function of each company's cost of buying the commodities. Coal will likely be more cost-effective in many locales.

Cleaning Fossil Fuels

Existing coal-generating plants can be retrofitted to reduce emissions. A chemical process or a filter in the plant's chimney (or flue) can be used to separate the carbon dioxide from the rest of the gas discharged. This is difficult because CO₂ represents less than 15% of flue gas, and the technologies haven't been tested for scale operations. It is also expensive: Adding a chilled ammonia CO₂ scrubber (a promising option) would increase the cost of producing a kilowatt hour of electricity by about 4.5 cents (US). In the US, where the average retail electric price is 7.3 cents per kilowatt hour, this would likely increase electricity prices by more than half. Other chemical and filtration methodologies are even more expensive, although companies such as Alstom, American Electric Power, and McDermott are seeking to improve them and lower their costs.

A second retrofit option is to replace the air that goes into a traditional coal plant with pure oxygen, so the plant produces a more concentrated stream of CO₂ that is easier to capture. This process adds an estimated 3.5 cents to the cost per kilowatt hour of generating electricity.

Unless there's significant progress in the retrofit options, utilities building new plants will likely choose yet another alternative: integrated gasification combined cycle (IGCC) technology. Already deployed in chemical manufacturing but new to power generation, IGCC transforms coal into a synthetic gas and captures the CO₂ before combustion. While it is more expensive to build and operate an IGCC plant than a traditional coal-burning plant, it is cheaper than building and operating a new coal plant and retrofitting it to capture CO₂.

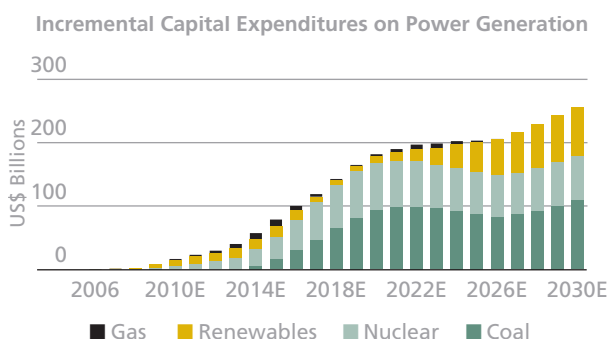
GE and Siemens, among other firms, are seeking to bring IGCC technology to the power-generation sector. Today, more than 30 coal gasification projects are under way in the chemical industry, and many more are on the drawing board, including a handful designed specifically for power generation.

Our research suggests that utilities will retrofit their largest and most efficient plants but replace smaller, inefficient facilities that do not justify the incremental expenditure.

With these costs in mind, we estimate that annual capital spending on coal power will increase from about \$60 billion in 2006 to more than \$210 billion in 2030. This would add meaningfully to the revenue and earnings growth of the industrial giants that produce this equipment.

Display 8

Coal, nuclear, and renewable energy will gain



Source: EIA and AllianceBernstein

Power Spending Overall

We forecast that incremental spending on power that is related to reducing CO₂ emissions will be greatest for coal. Uncertainty about the regulatory outlook and the long lead times required to build coal plants, however, means there will be little incremental spending growth until 2015 (*Display 8*). Growth in spending on nuclear energy will also be delayed for similar reasons. Increased spending on renewables will begin sooner; incremental spending for natural gas will be limited throughout our forecast period.

After all these new or improved plants are built, natural gas plants' share of total electricity generated globally will shrink from 20% to 13%, but nuclear energy's share will grow from 15% to 24%. Renewable energy sources will grow from 19% to only 21% of the total, despite significant growth in capacity, because of their much lower utilization rates.

Coal will retain its position as the world's largest fuel for power generation, with a 39% share of a total electricity market that will nearly double in annual output, from 18 trillion to 35 trillion kilowatt hours. As a result of clean-coal technology, however, total carbon emissions from coal-burning plants will be less than half the level today.

Carbon Transport and Storage

We also expect an entirely new market to emerge around transporting and sequestering the CO₂ captured. Most of the storage sites are likely to be oil fields, mines, saline aquifers, and other underground openings.

By 2030, mankind may be transporting more than 500 billion cubic feet of CO₂ per day, almost double the amount of natural gas transported today. Although CO₂ is likely to be transported over much shorter distances than natural gas, this massive new volume will likely require at least a doubling of the current global pipeline infrastructure.

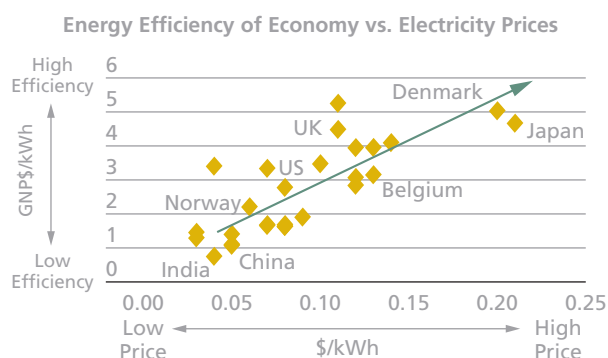
Once the CO₂ reaches the appropriate sites, it will have to be injected safely underground or deep in seabeds, thereby creating a new business for oil field service firms. The latter already inject CO₂ into the ground to raise the pressure in oil wells but have not yet used the process solely to sequester CO₂.

Enhancing Efficiency

The money to pay for new and retrofitted power plants, pipelines, and storage will most likely come from consumers, through higher electricity prices. This won't be popular, but there's no real alternative: Utilities can't pay for these massive investments without rate hikes or subsidies—and subsidies tend to encourage waste. Indeed, in countries where electricity is relatively cheap due to subsidies (China and India) or cheap hydropower (Norway), economic output per unit of electricity used is low (*Display 9*). In countries where electricity is expensive, usually due to steep taxation (Japan and Denmark), economic output per unit of electricity used is high. Thus, we expect efficiency improvements to be both the direct result of regulatory requirements and the indirect result of higher electricity prices.

Display 9

Price of electricity tends to drive efficiency



Data from 2000

Source: EIA, World Bank, and AllianceBernstein

Regulatory requirements are also effective at increasing energy efficiency. Since California adopted stringent energy efficiency standards two decades ago, its per-capita energy consumption has remained flat, while electricity consumption soared in the rest of the US—yet Californians have not curtailed their lifestyles. Many regions around the world are now considering much stricter energy standards than California's.

The two main ways to improve energy efficiency are to switch from mechanical to electrical systems and to improve the efficiency of electrical systems already in place.

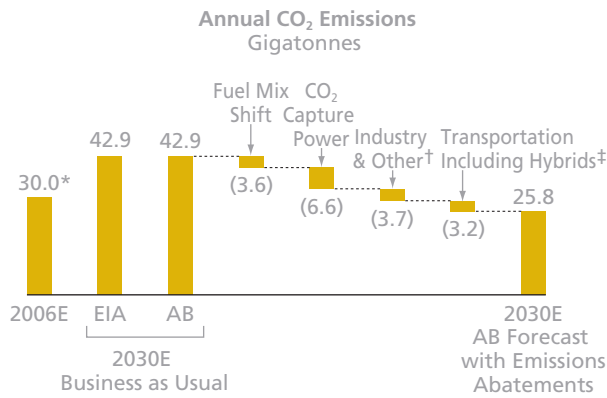
Although the switch to electrical systems is already well under way in most developed markets, most transportation is driven by mechanical systems. We expect the conversion of the global car fleet to hybrid vehicles to reduce energy consumption and CO₂ emissions, even with plug-in vehicles that draw power from the electric grid.

Enhancing the efficiency of the large motors that run industrial machinery, home appliances, and heat and air-conditioning systems can also improve overall energy efficiency

dramatically. Most motors produce the same amount of power without regard to power needed at a given time. Thus, we predict rapid sales growth for variable-speed motors that use sophisticated semiconductors to adjust the power generated to the power required.

Display 10

Emissions control efforts are likely to make a big difference



* Estimated from 2003 data

† Includes some CO₂ capture

‡ Reflects decline in emissions from increased fuel economy only

Source: EIA, Oak Ridge National Laboratory, World Resources Institute, and AllianceBernstein

How Big Is the Benefit?

Our research shows that the vast sums spent on reducing carbon emissions from power generation and on improving energy efficiency will indeed help reduce CO₂ emissions. We project that by 2030, less than 26 gigatonnes of man-made CO₂ will be emitted worldwide, less than the 30 gigatonnes emitted last year and far less than the 43 gigatonnes that will be emitted if nothing is done to address the problem (*Display 10*).

Reducing CO₂ emissions to 26 gigatonnes per year by 2030 is unlikely to be sufficient to reverse the warming trend. It would, however, probably be enough to delay reaching the critical 450–550-parts-per-million range of atmospheric CO₂ that scientists say could be catastrophic. As these strategies achieve mass scale and demonstrate success, improvements and new technologies will emerge that will likely make it feasible for governments to tighten regulations even further over time. ■