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CLIMATE POLICY AND ENERGY SECURITY: TWO SIDES OF THE SAME COIN?

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Climate Policy and Energy Security: Two Sides of the Same Coin?

Abstract

A policy of restricting CO₂ emissions might appear to address both climate change and energy security. We argue, however, that such restrictions may not be the most efficient way of responding to concerns about the potentially harmful consequences of climate change. They are also likely to severely compromise energy security, especially in the United States.

I. Introduction

At the height of the controversy over former British Prime Minister Tony Blair's support for the Bush administration's policy on Iraq, Blair said his "special relationship" with the United States would enable him to influence other policies important to European leaders. Foremost among those was the U.S. refusal to ratify the Kyoto Protocol. Blair declared in a speech in the United States on October 20, 2006 that "we must treat energy security and climate security as two sides of the same coin" — a refrain that other leaders in the European Union and United States have frequently repeated.

The claim that policies may be able to address climate change and energy security at the same time is plausible. On one side of the coin, climate policy is aimed at limiting or reducing human impacts on climate. Research based on global climate models (GCM) has suggested that the observed increases in average global temperatures in the final quarter of the twentieth century were caused by anthropogenic CO₂ emissions arising predominantly from burning fossil fuels. Furthermore, these same models, applied to scenarios about likely future fossil fuel use in the absence of policy adjustments, predict that future increases in atmospheric concentrations of CO₂ could produce detrimental climate changes. Avoiding this threat is what Prime Minister Blair equated to "climate security."

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On the other side of the coin, energy security is often identified with the goal of reducing macroeconomic vulnerability to disruptions in energy supplies and accompanying price increases. Since Hamilton (1983) pointed out that every U.S. recession except one since the end of World War II has been preceded by an increase in the oil price, many economists have presented evidence that oil price shocks reduce economic growth and appear to be a catalyst for recessions.

Oil importing countries also face energy security concerns centering on international relations or national security. For example, the Organization of the Petroleum Exporting Countries (OPEC) oil embargo of 1973 demonstrated that global dependence on Middle East oil could be used to influence foreign policy. Some countries took aggressive steps to limit this threat. For example, Japan diversified away from oil toward nuclear and natural gas, while France has pursued nuclear power to limit its dependence on imported energy.

Energy security concerns extend beyond oil markets. For example, recent disputes between Russian natural gas monopoly Gazprom and Former Soviet Union (FSU) transit countries, particularly Ukraine, over gas pricing and debt payments highlighted the risks of the E.U.'s heavy reliance on Russian natural gas supplies. It can be argued that Gazprom's disputes with these countries result from a desire to move toward market-based pricing.¹ However, Gazprom cut supplies when the effects would be most severe and for reasons that appeared political. Regardless of Gazprom's motives, using supply restrictions as a negotiating tool during winter peak demand months substantially increased E.U. energy security concerns.

In general, reducing dependence on imported fuels can enhance energy security. Greater use of alternative, or renewable, energy sources is one way to achieve this. If reduced fossil fuel use lowers CO₂ emissions then "climate security" would also benefit. In that sense, policies that could achieve both goals are "two sides of the same coin."

¹ The most pressing need for reform is within Russia itself, but there is little chance that the Russian public could be convinced of the need for higher natural gas prices while people in neighboring countries are supplied at subsidized prices.

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However, as we shall argue, restricting use of some fossil fuels, particularly in the U.S., could compromise energy security, especially in the short run. Furthermore, restricting use of these fossil fuels may not be an efficient response to the threat of climate change even if it had no negative consequences for energy security.

II. Policies to Promote Energy Security

Before we ask whether climate policy and energy security policy are complementary, we need to examine the basis for such policies. We begin with policies aimed at enhancing energy security. The fact that U.S. energy supply, the Middle East, and the U.S. military are often intertwined in foreign policy discussions makes energy security a part of the U.S. national security debate. For example, Kalicki and Goldwyn (2005) define energy security for the United States as “assurance of the ability to access the energy resources required for the continued development of national power.” Related to this is the notion that dependence on foreign energy supplies could compromise the ability of the U.S. armed forces to maintain operations during a sustained conflict. This is especially pertinent given that the Defense Energy Support Center reports that the U.S. military is the largest single consumer of oil products in the world.²

Other commentators, such as former CIA director Woolsey (2002) and Wirth, Gray and Podesta (2003), have argued that Middle East oil revenues have directly or indirectly financed groups hostile to U.S. interests and that U.S. dependence on Middle East oil has limited criticism of some of the region’s regimes. A recent task force report by the Council on Foreign Relations (Deutch et al., 2006) noted that oil revenues allowed governments to pursue strategic and political objectives that conflicted with the interests of the United States or its allies. For example, although animosity between the United States and Iran has deeper roots, Iran’s importance as an oil exporter and its location near the nexus of much of the world’s oil supply complicate negotiations regarding its nuclear ambitions. In the Western Hemisphere, Venezuelan leader Hugo Chavez has also used oil revenues to finance activities detrimental to U.S. interests.

² They report annual sales of between 130 and 144 million barrels of oil products to the U.S. armed services for fiscal years 2002 through 2006. The United States established the Strategic Petroleum Reserve (SPR) partly to insure against short-term disruptions of fuel supply to the armed services. As of June 2, 2008 the inventory was slightly above 704 million barrels.

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In the economic dimension, energy security concerns focus on macroeconomic vitality. Bohi and Toman (1996) define energy security as “the concept of maintaining stable supply of energy at a reasonable price in order to avoid the macroeconomic dislocations associated with unexpected disruptions in supply or increases in price.” By contributing to higher inflation and lower economic growth for at least a decade, OPEC’s oil embargo of 1973 highlighted concerns about economic, as well as national, security.

Historically, there is a very strong negative correlation between oil price movements and macroeconomic output in oil-importing countries (see Hamilton (1983), Mork et al. (1994) and Federer (1996), to name a few). Figure 1 illustrates the correlation for the United States from 1949 through 2007. It shows that when oil price increases, actual GDP tends to fall below potential GDP (where potential GDP is the U.S. Federal Reserve’s estimate of output if all factors of production were fully employed). The negative relationship has also been found in Japan and energy importing countries in the E.U. following price increases caused by events such as the OPEC oil embargo (1973-1974), the Iran-Iraq War (1980), and the Iraqi invasion of Kuwait (1990). Importantly, the negative relationship extends beyond just oil prices since market forces tend to link energy prices in the long term (see, for example, Hartley, Medlock and Rosthal (2008)).

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Figure 1 – U.S. GDP, Oil Prices, and Catalyst Events (1949-2007)

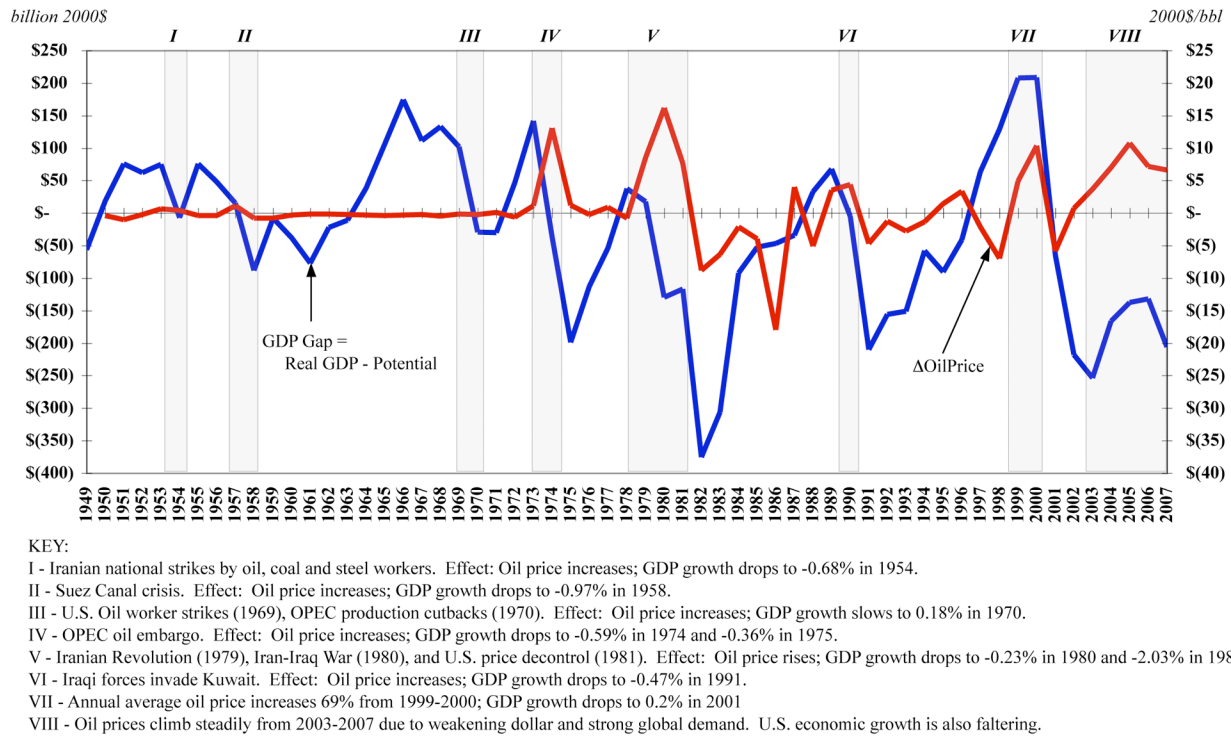


Figure Data from the U.S. Federal Reserve Database and the U.S. Energy Information Administration.

Since correlation does not imply causation, the existence of a *causal* relationship between oil prices and GDP is an open debate in the economic literature. At issue is the mechanism through which energy prices affect GDP. While some maintain that the negative macroeconomic consequences follow just from energy price increases, others have claimed that the response of monetary policy or other investment-related and sector-specific effects cause the negative consequences.³ In general, rising energy prices induce consumers to reduce discretionary spending and firms to curtail the operation of energy-using capital. This rational cost-minimizing behavior by households and firms has negative consequences for the economy as a whole, and is often referred to as an aggregate demand externality.

It might be thought that a nation can reduce its vulnerability to energy market shocks by diversifying its supply sources of a given energy commodity. However, this is likely to have only limited effectiveness in a global market for fungible commodities such as oil and, increasingly,

³ The appendix outlines various proposed mechanisms linking energy prices to macroeconomic performance.

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natural gas. A change in trading partners by any one country will mainly re-shuffle trades between other countries with little effect on overall demand or supply and, hence, prices.

An *increase* in the *elasticity* of demand for oil, however, could reduce oil prices. For instance, there is strong evidence that Saudi Arabia, and OPEC more generally, operates as a monopolist equating marginal revenue to the marginal cost of production.⁴ Therefore, an increase in the elasticity of demand for oil supplied by OPEC would lower the profit-maximizing price by reducing the difference between the demand and marginal revenue curves. The elasticity of demand for oil can be raised through an increase in the ability to substitute to alternative energy sources. Notably, increasing the elasticity of the supply of oil produced outside of OPEC would have a similar effect.

Since energy commodity prices are not *perfectly* correlated, a portfolio of energy inputs can have a more stable composite price. Thus, the ability to substitute to alternative energy sources limits to some extent the negative macroeconomic effects of higher prices for any one energy commodity. In particular, the negative macroeconomic impacts of unexpected oil price increases will be larger as the share of oil in total primary energy increases (see Medlock and Hartley (2003)). As a result, some governments have encouraged diversity of primary energy supply.

There is also evidence that declining energy intensity has reduced the negative effects of rising energy prices by lowering the share of energy in industry costs or household expenditures. Reductions in energy intensity have resulted from a shift in the composition of output toward less energy intensive services and improvements in energy efficiency in many industries.

III. Climate Policy and Fossil Fuels

Taking as given that continued anthropogenic CO₂ emissions will change climates in ways that have significant detrimental impacts, it does not necessarily follow that limiting CO₂ emissions is the best policy. To explore this idea, we shall classify climate change policy action into the following four categories:

⁴ See for example, Gately (2004) or Gao, Hartley and Sickles (2008). Soligo and Jaffe (2000) point out that, consistent with a profit maximization motive, Saudi Arabia has been practicing price discrimination against customers in the Far East in favor of customers in the United States and Europe.

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1. Reducing the emissions of greenhouse gases, particularly CO₂
2. Increasing sequestration of greenhouse gases, particularly CO₂
3. Limiting the potential harmful consequences of climate change
4. Improving remediation of damage resulting from climate change

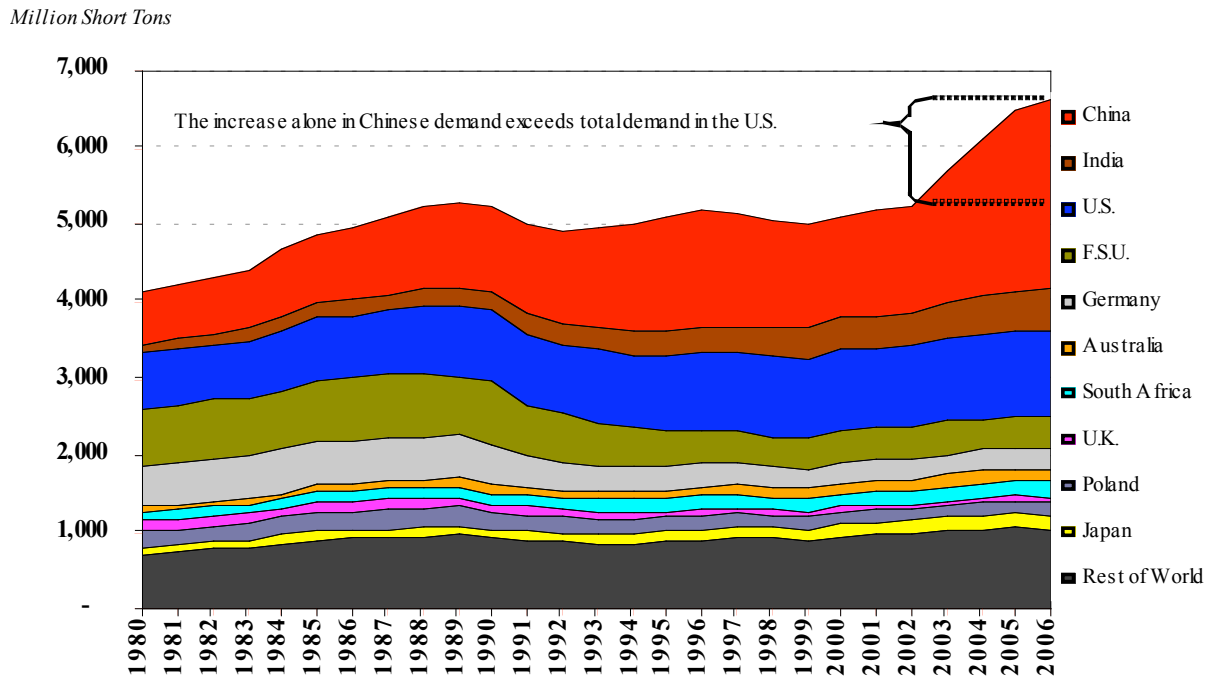
In the next four sub-sections, we shall consider some of the issues pertaining to policies in each of these categories. We then discuss some relevant considerations for choosing between policies from the different categories.

Reducing Emissions of CO₂

Figure 2, illustrating global coal use from 1980 through 2006, highlights the tendency of countries to use the lowest-cost energy resources first. In 2006, the United States, China, and India accounted for 16.7%, 37.3%, and 8.1% of coal use, respectively, and of the remaining 37.9%, Japan, Germany and Russia accounted for one-third, or about 12% of the world total. The United States, Russia, China and India have the first, second, third and fourth highest coal reserves in the world, respectively. Australia ranks just behind these countries in total coal reserves, and exports large amounts of coal to Japan, and increasingly China. The most striking feature of Figure 2 is the increase in Chinese coal use from 2001 to 2006, which tops 1.1 billion short tons and exceeds total U.S. consumption in 2006. This trend is indicative of a preference ordering that places economic development higher than concern about CO₂ emissions or even local pollutants such as particulates or oxides of sulfur and nitrogen.

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Figure 2 – Global Coal Use (1980-2006)



Source: Energy Information Administration

In particular, rapidly developing countries such as China and India, where low-cost energy is critical to sustained economic growth, are unlikely to adopt CO₂ emission controls. However, imposing controls in developed countries alone will encourage fossil fuel intensive industries to move to developing countries where such policies are not in force. This phenomenon, known as “carbon leakage,” may actually increase global CO₂ emissions. This follows because less efficient production methods may be used in the otherwise less-favored location and/or bulk products rather than intermediate energy inputs must be transported globally.

Even if coal-intensive developing countries such as China and India could be encouraged to reduce CO₂ emissions, it is unlikely that the major oil and gas producing countries of the Middle East would follow suit. In fact, this region already is attracting new oil refining, petrochemicals and aluminum facilities, and controls on CO₂ emissions in the rest of the world would likely accelerate the trend.

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Another issue is whether the maximum politically acceptable level of emission controls would be large enough to have a significant effect on future climate change. Proposals embodied in the Kyoto Protocol would at most marginally reduce growth in the consumption of fossil fuels. In fact, these policies appear to have had minimal impact on CO₂ emissions in many of the ratifying countries in Western Europe. From 2000–2004, annual CO₂ emissions in the United States increased 1.4% compared to 2.3% in the 15 core E.U. economies even though the United States experienced higher economic and population growth over that period and had *not* adopted any mechanisms aimed at reducing emissions.

More importantly, the constraints embodied in the Kyoto Protocol are miniscule compared to what would be needed to halt the accumulation of CO₂ in the atmosphere. The only currently feasible way to stop CO₂ accumulation would be to raise the cost of energy high enough to stifle economic growth. However, it is not realistic to expect democracies to countenance long periods of reduced economic growth, as economic prosperity is critical to political support in most democracies.

The development of new energy technologies capable of displacing fossil fuels on a massive scale is a feasible long-term solution to limiting the accumulation of CO₂ in the atmosphere.⁵

Non-depletable energy sources will eventually displace fossil fuels as depletion raises the prices of the latter and technological progress reduces the prices of the former. However, depletion-driven substitution, on a large scale, away from fossil fuels is likely decades away.⁶ In addition, some currently viable alternative energy sources have other costs that limit their suitability for widespread adoption. In particular, while nuclear fission could replace a substantial amount of fossil fuel in the generation of electricity, its restriction to base load generation and problems of waste disposal and nuclear proliferation limit its value.

⁵ Since the oceans and the biosphere sequester an amount of CO₂ that increases somewhat as its concentration in the atmosphere rises, a ceiling on the concentration in the atmosphere above pre-industrial levels is compatible with a continuing limited use of some fossil fuel primary energy sources.

⁶ As we discuss in further detail below, there are substantial remaining deposits of unconventional oil and coal, while methane hydrates are a promising alternative source of natural gas. According to an article in *The Canadian Press* on April 16, 2008, Canadian and Japanese researchers working in the Mackenzie Delta achieved a sustained flow of methane from hydrates “for six days at a rate lower than conventional gas but about equivalent to a coal-bed methane well” using modified conventional technologies, according to Scott Dallimore, the Geological Survey of Canada researcher in charge of the drilling program.

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Solar energy has few major environmental externalities and likely could displace all fossil fuels at some future date. Given the large solar resources in the southwestern United States and Mexico, solar energy would also have few, if any, adverse energy security implications for North America. However, substantial capital investment is required to harvest solar energy. Furthermore, to make solar a competitive energy source, further improvements are needed in the efficiency of solar plants, electricity storage, HVDC transmission and electric automotive technologies (see, for example, Zweibel et al. (2007)).

Increasing Sequestration of CO₂

Developing low-cost sequestration would support use of fossil fuels while limiting atmospheric CO₂ accumulation. CO₂ is already used for enhanced recovery of up to 4% of total U.S. oil production, and it can also be used to aid in the recovery of natural gas.⁷ Since oil, natural gas, coal and salt formations have retained methane and other hydrocarbons for eons, these same formations should be able to sequester CO₂. The U.S. Department of Energy and the U.S. Geological Survey are currently assessing the opportunities and costs of CO₂ sequestration in various geologic formations.

The National Energy Technology Laboratory (NETL) recently released an atlas of potential CO₂ sequestration sites in the United States and Canada. In 2004, 4365 assessed stationary sources most suitable for sequestration initiatives (more than 85% of which are power plants and another 4% of which are refineries or chemical plants) produced around 3.8 billion metric tons of CO₂, or almost 54% of U.S. CO₂ emissions. NETL determined that oil and gas reservoirs in the United States and Canada could sequester around 82 billion metric tons of CO₂. The estimates for potential sequestration in coal seams that are not suitable for mining range from 156 to 183 billion metric tons of CO₂. In deep salt formations the estimate ranges from 919 to 3378 billion metric tons of CO₂. Many of these formations are situated near industrial areas of the Midwest, New Jersey, Delaware, Florida, Central and Southern California and along the Gulf Coast.

⁷ ConocoPhillips has patented a process to sequester CO₂ while extracting methane from methane hydrates. It remains to be seen, however, whether it can be developed commercially.

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It is possible that the costs of reducing emissions from burning fossil fuels could exceed the marginal costs of sequestration. In addition, sequestration may be consistent with enhanced recovery of oil and natural gas. In either of these cases, U.S. domestic energy security could be compatible with a climate change policy that encourages sequestration.

Limiting Potential Harmful Consequences of Climate Change

Reducing emissions and increasing sequestration each attempt to reduce the anthropogenic element of climate change by controlling atmospheric CO₂ accumulation. A different approach involves accepting that climate will continue to change while taking steps to limit any resulting damages. Many measures can be taken to reduce the likelihood of large damages from climate change, including:

- building dykes to protect vulnerable coastlines
- burying power lines and enacting stricter building codes to limit damage from high winds, especially in coastal regions
- implementing improved evacuation procedures to move people from harm
- developing new, more resilient agricultural crops or techniques
- ceasing activities, such as subsidizing development in areas vulnerable to climate change, that increase the harm from climate change
- compensating people to move from areas susceptible to flooding

These types of measures could be cheaper than limiting or sequestering CO₂ emissions.

Improving Remediation of Damage

Another policy response that involves accepting climate change focuses on recovery efforts after a damaging event. Examples could include:

- developing improved procedures to position resources so they can be more effectively deployed after a disaster
- improving cooperation in planning and sharing resources between disaster relief teams from different areas
- developing better civil reconstruction capabilities

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An important feature of these types of measures is that they yield benefits in response to damaging events not related to climate change, such as earthquakes, tsunamis, fires, industrial and transportation accidents, and terrorist attacks.

Other Considerations Relevant to Designing an Optimal Climate Change Policy

Many anthropogenic and natural factors affect climate. This bears critically on the expected benefits of measures aimed at dealing with climate change. In addition to the emission of greenhouse gases, other significant anthropogenic influences on climate include land-use changes, large-scale irrigation, and the enhancement of urban heat islands. There is also evidence that climate continually changes on decadal, centennial, millennial and longer time scales as a result of natural forces.⁸ For example, the naturally occurring El Niño-La Niña Southern Oscillation, the Pacific Decadal Oscillation and the Atlantic Multi-decadal Oscillation affect the frequency and severity of droughts, floods and violent storms at the decadal scale. The periods known as the Little Ice Age, Medieval Warm Period and Roman Warm Period are well documented and indicate longer cycles of natural origin. A period of substantially warmer-than-current temperatures, known as the Holocene Optimum, occurred around 7,000 years before the present, while the most recent Ice Age ended only about 11,000 years ago.

The larger the proportion of climate change due to factors other than the accumulation of CO₂, the stronger the argument for using policies that limit damages or assist with disaster recovery. Such measures will help protect against climate change regardless of its source, while limiting CO₂ emissions or increasing CO₂ sequestration addresses only one source of climate change.

It also is possible that some effects of greater CO₂ accumulations and climate change, such as fertilizer effects⁹ and longer growing seasons or changes in rainfall, could provide net benefits

⁸ Two reports by the National Research Council (1995, 2005) document a diverse set of natural and non-CO₂ human sources of climate change. Roger Pielke Sr. has been at the forefront of climate scientists urging a broader view of the role of humans in the climate system (see, for example, Pielke (2002)).

⁹ This effect is exploited to raise yields in commercial greenhouses. It also has been documented in thousands of laboratory and so-called Free-Air CO₂ Enrichment (FACE) experiments (where CO₂ is released to maintain higher than normal concentrations in the air over an open plot of land). Finally, it has also been observed at numerous locations where CO₂ naturally escapes to the atmosphere leading to higher than normal local concentrations (see, for example, Raschi et al., 1997).

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for some regions.¹⁰ Thus, policies that limit the damage from climate change or assist with disaster recovery would preserve any net positive regional benefits. Policies that limit CO₂ emissions or increase CO₂ sequestration, however, would both carry the direct cost associated with imposing the restriction and forego any net positive benefits.

Another factor that differentiates CO₂ from conventional air pollutants (such as particulates or oxides of sulfur and nitrogen) is that the potential harm from CO₂ is associated with its accumulation in the atmosphere.¹¹ By contrast, conventional pollutants, such as SO_x and NO_x and particulate matter, are directly hazardous to human health or assist in the formation of ozone, which also is hazardous to health. Such pollutants need to be controlled locally and immediately in order to limit damages.

Since the potential harm from CO₂ arises from a gradual accumulation, the long-term effects will be similar under many different accumulation paths. For example, assume that very harmful consequences are projected to occur only when CO₂ concentrations in the atmosphere exceed 500 parts per million (ppm) by volume. In this case, it makes little difference to the discounted costs if the build-up occurs at the rate of 2 ppm per year for 50 years followed by 1 ppm for 15 years, or evenly at around 1.77 ppm per year over the same 65-year period. This observation is particularly salient when the costs of reducing emissions are considered. One very large cost of substantial near-term CO₂ emission reductions is that a substantial amount of fossil fuel-based electricity generating capacity would need to be replaced. A much less costly path could involve committing to emission controls on future plants, so new capacity produces less CO₂, but existing plants continue to generate electricity until they have reached their useful economic life.

10 Deschênes and Greenstone (2007) claim that U.S. agriculture is likely to be a net beneficiary in aggregate. They use deviations from average precipitation and temperatures at the county level to estimate how agricultural profits respond in unusually warmer, cooler, wetter or drier years in one county relative to other counties in the same state and year. They also allow the effect of weather variation to depend on the availability of irrigation in the county. Applying their estimates to long-run changes in U.S. climates predicted by GCM, they find annual aggregate U.S. agricultural sector profits will likely increase by 4%. They also find regional variations, however, predicting some states to be net losers. Furthermore, they only measure the effects of predicted changes in average growing season degree-days and precipitation and do not account for the effects of any possible changes in extreme weather events. On the other hand, they note that their estimates likely overstate the damages associated with average climate change because farmers have far fewer options for adapting to annual variations in weather than would be available for responding to long-term gradual changes in climates. Furthermore, they note that increased levels of CO₂ in the atmosphere will increase yield per planted acre for many plants independently of any effect on temperature and precipitation.

11 The negative externality is associated with the *stock* of CO₂ whereas in the case of particulates or oxides of sulfur and nitrogen, the negative externality is associated with the *flow* of emissions.

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The fact that future control is a substitute for near-term control may have another significant consequence. As long as the costs or benefits of control are uncertain, there is an option value to delaying taking action. For example, devoting resources to resolving the uncertainties in climate science may be more cost-effective than spending those same resources on controlling emissions today. If new information reveals the problem to be less serious than originally thought, the costs of control need not be incurred. On the other hand, if new information reveals the problem is more serious, stronger controls can be imposed to achieve the same long term accumulation of CO₂.

There may be another benefit to waiting if future cost reductions for alternative energy technologies are uncertain. On the one hand, acting immediately runs the risk of devoting resources to the adoption of an inferior technology, while if non-fossil fuel energy sources become competitive in a short amount of time CO₂ emissions will decline regardless. On the other hand, learning-by-doing favors immediately promoting investment in alternative technologies. For example, commercial application of alternative power generation technologies may provide valuable experience and lead to significant cost reductions. A simple cost-benefit analysis of acting immediately, therefore, suggests both potential positive and negative components, which at the very least suggests a prudent approach.

IV. Are Climate Change and Energy Security Policies Complementary?

Policies that increase the use of non-fossil sources of energy (such as nuclear, wind, solar, hydroelectric, geothermal, biofuels, and hydrogen) can serve both climate change and energy security goals. Some of these options, however, are expensive, have undesirable externalities and/or compromise other policy goals. As one example, the use of corn for ethanol production has affected the cost not only of corn, but also of beef, milk and other products. Moreover, by more closely linking food and oil prices, the ethanol policy provides an additional channel through which high energy prices affect the economy. As another example, very large hydroelectric projects such as the Three Gorges Dam in China can have negative effects on communities and river-based ecosystems. As a final example, wind farms are often opposed for spoiling attractive landscapes or interfering with the flight patterns of birds or bats.

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Increased energy efficiency also could both enhance energy security and lower CO₂ emissions. Energy is a *derived* demand, meaning it is demanded for the service it facilitates, such as transportation or space heating/cooling. Accordingly, consumers will seek cost-effective means to achieve a given amount of energy service, using less primary energy input. In this way, energy efficiency acts as a virtual source of supply that reduces the vulnerability of the economy to energy market shocks. To the extent that the reduced energy demand results in lower use of fossil fuels, it also helps reduce CO₂ emissions.

Generally, energy efficiency improves gradually as firms and consumers seek to reduce the operating cost of energy-using capital equipment. For example, if maintenance costs for old equipment are low, or replacement costs are high, consumers may continue to use the older, less energy-efficient, capital despite the potential energy cost savings from replacing it. Therefore, current and expected future energy prices are critical. If the price of energy is high and is expected to remain so, investments in energy efficiency are more likely to be cost-effective and energy efficiency will increase more rapidly.

Efficiency improvements are also relevant for commercial and residential structures, and tend to be adopted gradually in response to energy price changes. New construction and insulation codes, and newer materials that are more energy-efficient than older ones, raise energy efficiency over time. In addition, old buildings can be retrofitted with newer insulation, double-paned windows, and other items that raise energy efficiency.¹²

Policy also can foster increased energy efficiency by imposing taxes to raise the price of energy or through direct quantitative controls, such as mandating equipment specifications. Taxing energy is generally the most effective way to encourage efficiency improvements. Firms and consumers can increase energy efficiency in many ways apart from installing new equipment, such as altering procedures and processes or changing fuels. A tax allows consumers and firms to choose the best way to respond. Direct quantitative controls typically achieve lower gains for the same cost. This is a general conclusion that has long been demonstrated in the environmental

¹² As an example, Wal-Mart has a very aggressive energy efficiency program, which they report has reduced electricity consumption in their California stores alone by about 4.5 million kWh per month. Their program includes new equipment (such as daylight/dimming systems and high-efficiency heating/cooling units) as well as new procedures (such as centralized heating/cooling system control from Bentonville, Ark.).

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economics literature (see, for example, Atkinson and Lewis (1974), Seskin et al. (1983), Kolstad (1986), Magat et al. (1986), Oates et al. (1989), Jaffe and Stavins (1995), and Viscusi (1996)).

While some policies can enhance energy security while reducing CO₂ emissions, and thus appear as “two sides of the same coin,” other policies are in conflict. For instance, limiting the use of some fossil fuels will compromise energy security. This is particularly true of limits on the use of coal and unconventional oil, where such limits would make global markets more dependent in the long term on energy supplies from the Middle East and Russia.

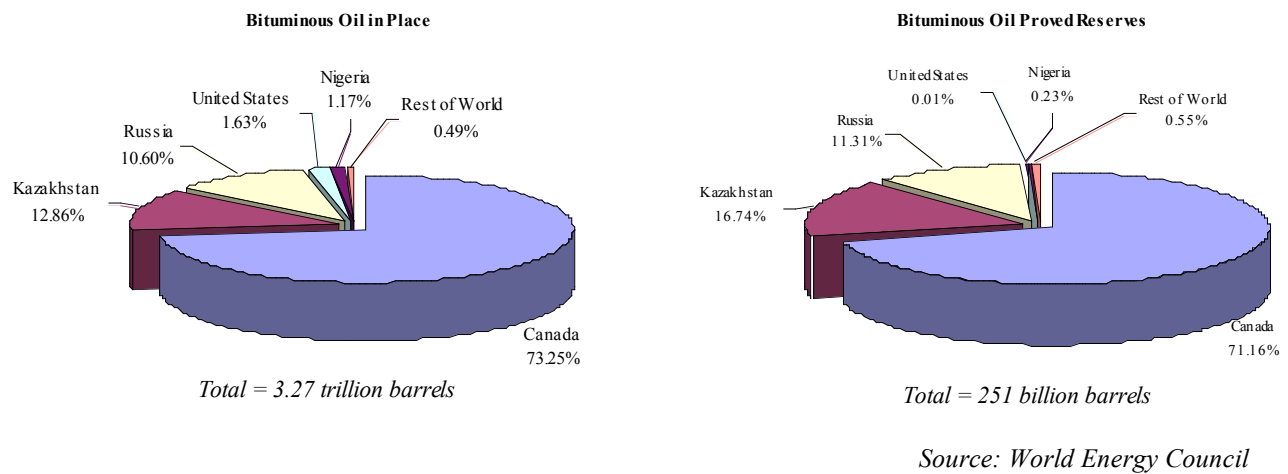
Bituminous sands in the Athabasca region of the Canadian province of Alberta (popularly called the Athabasca tar sands) have recently become a major source of unconventional oil. Heat and water are needed to upgrade the bitumen in these sands to synthetic crude suitable for transport and refining. In addition, since the bitumen contains hydrocarbons with a higher ratio of carbon to hydrogen than conventional crude oil, using it to produce gasoline and other oil products releases larger amounts of CO₂. Hence, exploitation of this resource is not consistent with the goals of climate change policy.¹³ However, this resource holds considerable value for energy security since it is a large supply of oil in a country with a stable political and economic system. Moreover, development of the Athabasca tar sands, as well as other unconventional oil resources, could aid in stabilizing world oil prices. When it comes to the Athabasca tar sands, climate change policy and energy security are definitely *not* “two sides of the same coin.”

13 The conflict between these objectives has become evident in a proposal to repeal Section 526 of the *Energy Independence and Security Act of 2007*. This provision prevents U.S. federal agencies from procuring “alternative or synthetic fuel, including a fuel produced from unconventional petroleum sources, for any mobility-related use ... unless the contract specifies that the life cycle greenhouse gas emissions associated with the production and combustion of the fuel ... [are]... less than or equal to such emissions from the equivalent conventional fuel produced from conventional petroleum sources.” Since the section does not define “conventional” sources or “life cycle greenhouse gas emissions” it is unclear how it might be interpreted or implemented in regulations. House Oversight Committee Chairman Waxman and ranking member Davis recently asked the Department of Defense how it intends to comply with Section 526 with regard to coal-to-liquid fuel or fuels from tar sands. In their letter, Waxman and Davis noted the complications arising from the fact that refiners use inputs from a variety of sources. Questions have also been raised about whether Section 526 violates the World Trade Organization (WTO) government procurement agreement or other WTO rules, while the Canadian government has already warned that it may challenge the provision if it discriminates against fuels derived from Canadian tar sands. On April 29, 2008, Senator Pete Domenici, ranking member of the Senate Energy and Natural Resources Committee, asked leaders of the Senate Armed Services Committee to repeal Section 526 on the grounds that it “will make it more difficult and expensive for the U.S. military to obtain fuel.”

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Figure 3 provides 2005 estimates of bituminous oil resources from various countries and regions, as reported by the World Energy Council (WEC). Note that these figures do not include resources categorized as “extra heavy oil” in Venezuela. The WEC also reports that the total world resources of bituminous oil in place amounts to 3.27 trillion barrels, which is considerably larger than the 1.22 trillion barrels of proved recoverable reserves of conventional crude oil and natural gas liquids (NGL) reported by WEC member countries.¹⁴

Figure 3 – Distribution of Estimated Bituminous Oil Resources and Reserves (2005)

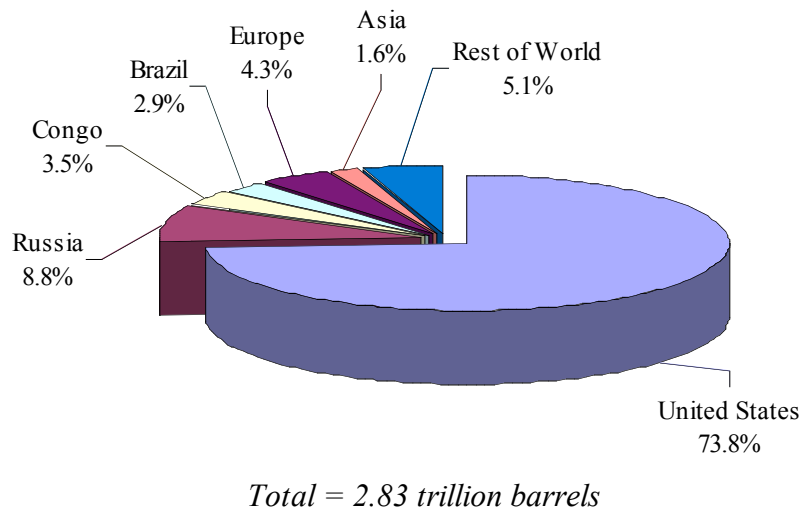


The potential conflict between climate change and North American energy security policy extends to shale oil resources, which are summarized for WEC member countries in Figure 4. As with bituminous oil, the estimated shale oil resources are very large relative to the estimated recoverable reserves of conventional crude oil and NGL. Furthermore, almost 75% of the estimated global shale oil resource is found in the United States alone. Therefore, shale oil could substantially enhance energy security in the United States and the Western world more generally.

¹⁴ The WEC warns that the reported reserves represent only a sample of all potential reserves in the world. They also compile data on crude oil and natural gas liquids resources in place, but far fewer member countries report these so we have used the reserves figures.

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Figure 4 – Distribution of Estimated Resources of Shale Oil (2005)



Source: World Energy Council

If more oil were produced from U.S. oil shale and Canadian bitumen resources, North American demand for conventional oil resources would decrease substantially. Since the United States alone consumes almost 25% of the world's petroleum, a reduced level of U.S. imports would leave more conventional resources to be consumed by the rest of the world. In addition, OPEC countries would likely face a higher elasticity of demand for their exports, thus reducing their monopoly power. Finally, since a greater proportion of the world oil market would be supplied by stable regions, energy market stability would likely increase.

Exploiting shale oil would, however, increase CO₂ emissions. Although this could be avoided if sequestration technology were employed, requiring CO₂ sequestration would likely make exploiting shale oil uneconomic, even at oil prices of \$100 per barrel. As with the Athabasca tar sands in Canada, when it comes to shale oil in the United States, energy security and climate change policy are not "two sides of the same coin".

The International Energy Agency (World Energy Outlook, 2006) projects that unconventional oil could represent as much as 9 million barrels per day (b/d) of the incremental 30-40 million b/d of

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new oil supply that will be needed to meet global demand by 2030. Production from the Athabasca tar sands could reach as high as 4.8 million b/d, upgraded heavy oil could represent an additional 2 million b/d, and coal-to-liquids and oil shale could provide an additional 1-2 million b/d. If this supply were curbed to meet CO₂ emission goals, dependence on Middle East oil in the coming decades, as well as price, would likely be substantially higher.

Policies affecting the use of coal are another area where energy security and climate policy conflict, especially for the United States. Coal is used to generate about 50% of total U.S. electricity, with natural gas and nuclear each providing about 20%. Hydroelectricity supplies another 7%, oil products just under 2% and other sources, including renewables, provide slightly over 2%.

Despite North America's historical reliance on coal, many commentators project that it will become a large importer of natural gas in coming decades. Natural gas combined-cycle plants have made natural gas a much more competitive fuel for generating electricity. When coupled with the environmental advantages of burning natural gas rather than coal and oil, this has stimulated demand for gas around the world. As demand has grown, conventional deposits in the United States and Canada are in or nearing decline, implying that production may be stressed to meet expanding demand. Recent announcements indicate that natural gas in shale deposits in North America could be quite substantial,¹⁵ but there nevertheless has been considerable investment in developing LNG import capacity into North America.

Any policy that limits CO₂ emissions will tend to increase reliance on natural gas relative to the carbon-intensive coal in the power generation sector.¹⁶ Efforts to diversify the transportation sector towards natural gas (by increasing the use of electric, electric hybrid or compressed natural gas vehicles) would place additional demands on domestic resources. The likely result would be substantial increases in natural gas imports. This could have negative consequences for energy security, particularly if they originate from countries in the Middle East and Africa.

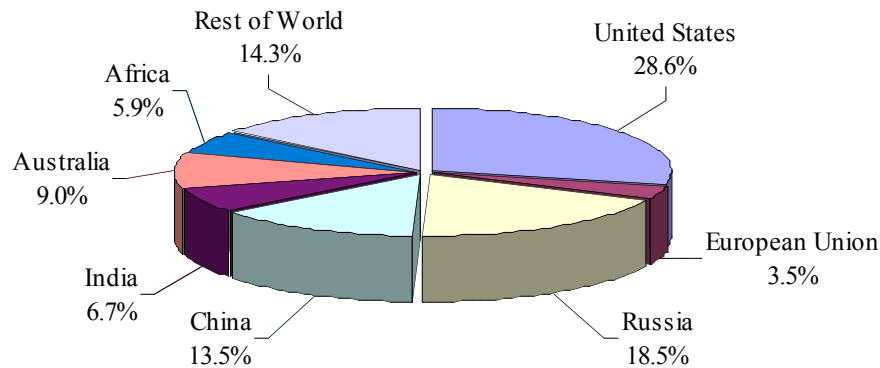
¹⁵ A recent study by Navigant Consulting, Inc. (2008) indicates there could be over 800 trillion cubic feet of technically recoverable natural gas in shale, an almost seven-fold increase over what was previously thought.

¹⁶ Natural gas is the likely primary alternative, with wind and other renewables filling a niche, because gas facilities are relatively easy to site and construct, can be operational rather quickly (24-30 months in most cases), are very reliable and highly efficient.

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More specifically, if LNG imports into North America increase substantially, natural gas may begin to raise energy security issues similar to those currently related to crude oil. Most of remaining conventional proved and potential reserves of natural gas are estimated to be in the Middle East and Russia. Thus, importing countries will become increasingly reliant upon the suppliers from the same regions of the world for both natural gas and oil.

Figure 5 – Distribution of Estimated Proved Recoverable Reserves of Coal (2005)



Total = 847.5 billion tons

Source: World Energy Council

Figure 5 reports WEC estimates of proved recoverable reserves of coal in selected countries or regions in 2005. Where coal is abundant and cheap, it can be used to produce not only electricity but also competitive substitutes for natural gas and, via the Fischer-Tropsch process, liquid transportation fuels. Indeed, before the widespread use of natural gas, many cities relied on coal gasification to provide gas supply.

For the United States in particular, limiting the use of coal substantially diminishes energy security. However, coal produces more CO₂ per unit of energy than any other fossil fuel, so barring its use is consistent with the goals of climate policy. In this case, therefore, energy security and climate policy are once again *not* “two sides of the same coin.”

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V. Instruments and Targets

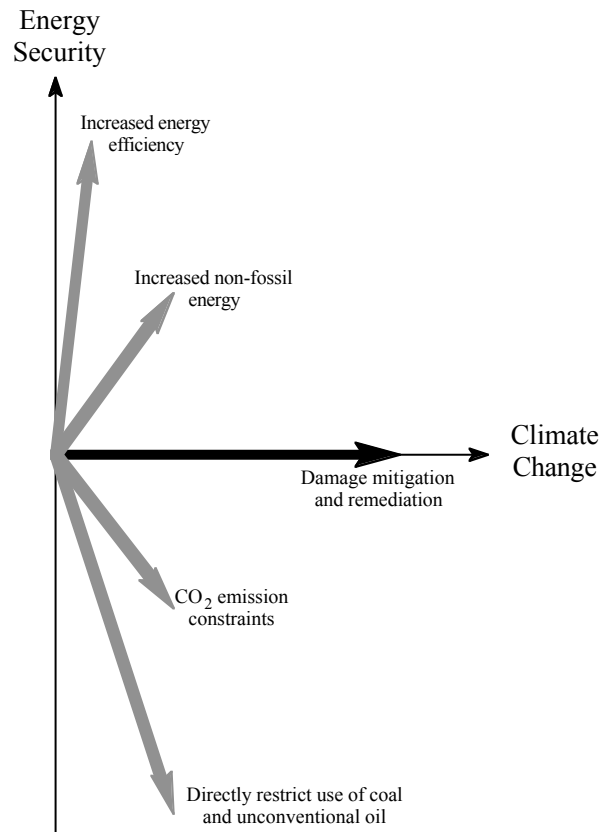
We can summarize the preceding discussion with the vector diagram in Figure 6. The goal of reducing harmful effects of climate change is on the horizontal axis, while enhancing energy security is on the vertical axis. Various policy instruments are graphed to demonstrate how they will likely affect both goals.

The gray policy vectors have an uncertain effect on the negative consequences of climate change for several reasons. To begin, they all address climate change only by affecting CO₂ accumulation, but many factors can alter climate. In addition, the effect of U.S. policies to reduce emissions will depend greatly on whether other countries adopt similar policies. If they do not, there is likely to be substantial “carbon leakage,” which could actually be counterproductive for controlling global emissions of CO₂.

Improved energy efficiency and increased use of non-fossil energy each contribute to both policy goals. Longer term, finding cost-effective, environmentally benign and secure alternatives to fossil fuels is the only way to limit CO₂ accumulation while maintaining economic growth. While we will eventually proceed down this path as fossil fuel supplies dwindle, encouraging faster development of alternative technologies could both increase energy security and reduce the risk of serious climate change. It may, however, also be very costly and may result in unnecessary expenditures on technologies that turn out to be inferior in the long run.

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Figure 6 - Policy Instruments and Targets



The currently favored climate policy instrument is a “cap and trade” scheme that places a quantitative limit on emissions but allows permits to be traded. There is a large literature on the relative merits of taxing CO₂ emissions versus directly limiting them via emission permits. If marginal abatement costs and the marginal damage from emissions were known, an emission tax or marketable permit system could achieve identical outcomes. In a more realistic setting, however, the efficiency of the two instruments is likely to differ. The classic article in this literature, Weitzman (1974), argues that, as the level of emissions changes, if the marginal costs of abatement rise faster than the marginal damages of emissions then emission fees are likely to be more efficient than permits, and vice versa. This result has remained largely intact in the subsequent decades of research with more complicated models.¹⁷ For example, Newell and Pizer

¹⁷ The main modification has been research showing that under various circumstances hybrid price and quantity regulations are likely to be more efficient than the “pure” version of either type of control (see, for example, Roberts and Spence (1976), Kwerel (1977), Dasgupta et al. (1980), Spulber (1988) and Bulckaen (1997)).

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(2003) find that “a price-based instrument generates several times the expected net benefits of a quantity instrument” when applied to the problem of controlling greenhouse gases. As in Weitzman (1974), the relative slopes of the marginal benefits and marginal costs of controlling emissions are crucial to their results, with a relatively flat marginal benefit curve favoring a tax.

Nordhaus (2005) also observes that the application of Weitzman’s result to the control of CO₂ emissions gives a strong presumption in favor of emission taxes rather than permits. The reason is that, as noted above, future controls are a close substitute for current controls. Hence, marginal damages from emissions in any single year will not vary much with the level of control. On the other hand, the marginal costs of emission controls are likely to increase more rapidly since further reductions in emissions in any one year will be much more expensive to obtain.¹⁸

Hassett and Metcalf (2007) also observe that although a permit system could raise revenue through permit auctions, in practice permits are often issued without charge. The forgone revenue from such a practice is likely to exacerbate efficiency costs since it will require other taxes to be higher. Issuing permits without charge also encourages firms to waste resources by lobbying to obtain permits. Finally, permit systems for CO₂ emissions are likely to have high administrative costs as detailed studies are undertaken to assess the “lifecycle emissions” of different processes before permits are issued or emissions are checked against permit levels.

An alternative policy, which is superior to either taxes or tradable permits for CO₂ emissions, would be to raise the tax on energy consumption, *no matter what the fuel source*, and then target the revenue toward a range of policies that address climate and/or energy security concerns. Such a policy would foster increased energy efficiency through higher prices without quantitatively penalizing energy sources critical for energy security.

¹⁸ This result perhaps is a major part of the explanation for the very strong preference among economists for CO₂ emission taxes rather than permits, while at the same time environmental economists on the whole have a very favorable view of the SO₂ emissions trading scheme in the United States.

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A tax on CO₂ emissions, or alternatively a tradable permit scheme,¹⁹ is equivalent to a tax on *energy* combined with a *rebate* for energy sources that are less CO₂-intensive, where the rebate increases with decreasing CO₂ intensity. Thus, for example, natural gas would get a larger implicit rebate than coal, and wind or solar power a larger rebate than natural gas. A tax on CO₂ emissions would tend to reduce CO₂ output both by encouraging increased energy efficiency and by altering the energy mix away from CO₂-intensive fossil fuels. However, the implicit rebates to lower CO₂-intensive energy sources imply that the CO₂ tax would raise less revenue than an energy tax at the same rate. An energy consumption tax also could finance explicit rebates, but the additional revenue could instead be used more purposefully.

In general, a CO₂ tax differs from an energy tax imposed on all fuel sources in three important respects. First, an energy tax would not be biased against more CO₂-intensive fossil fuels and therefore would be less adverse to energy security. For example, an energy tax would not encourage imported LNG at the expense of domestically produced coal, or imported oil at the expense of domestically produced oil from bituminous sands or shale. It would, however, result in greater CO₂ emissions in the short run than policies that specifically target CO₂-intensive fossil fuels. If the “short run” is not very long, perhaps because the energy tax revenues are used for research subsidies that result in rapid development of alternative energy sources, the difference in CO₂ emissions in the long run along the two policy paths will not be great.²⁰

Another major difference between the two policies is that they could favor different non-fossil energy sources. The implicit rebates under the CO₂ tax would encourage low CO₂ emitting energy sources that are close to commercial viability today. By contrast, a tax on energy consumption could be used to subsidize basic research into technologies that are not as close to commercial viability today but hold greater long-term promise for displacing massive amounts of fossil fuel. For example, tradable permits or a CO₂ tax, if instituted today, would tend to favor

19 For the sake of exposition, we focus on CO₂ taxes, although similar arguments pertain to a tradable permit scheme.

20 In addition, if continuing climate research suggests that more urgent control of CO₂ emissions is warranted, the revenue from an energy tax could be used to subsidize the same technologies that would be favored under the CO₂ emissions tax, making the two policies more similar.

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energy sources such as ethanol for liquid fuels and wind power. Neither of these technologies, however, is likely to provide enough primary energy to meet growing demand while displacing enough fossil fuels to stabilize CO₂ concentrations in the atmosphere. By contrast, research subsidies financed by an energy tax could target basic research into large-scale solar electricity generation, long distance high-efficiency electricity transmission, improved electricity storage and other technologies that have a greater chance of permanently displacing large amounts of fossil fuels.

The third difference is that the policies implemented to date that directly target CO₂ do not actually impose a tax. Rather, they have allocated marketable CO₂ emission permits to be used in a cap-and-trade program.²¹ Since the permits typically have not been auctioned, the policies have not raised substantial revenue. Even if permits in future schemes were auctioned or a CO₂ tax were directly levied, less revenue would be raised than under the equivalent energy tax. The substantial revenue raised by an energy tax could finance a range of programs aimed at addressing both climate change and energy security. For example, in addition to funding fundamental research into alternative energy technologies, the revenue could be used to assist with mitigation and recovery from unusual weather events. Such policies would have the advantage of protecting against the adverse effects of climate change regardless its source, along with other natural and man-made disasters.

Other counterproductive results could emerge from a CO₂ tax or tradable permit scheme, depending on the system design. For example, many such schemes do not provide full credits for sequestration activities. Nor do they impose taxes or require permits for land clearing. Thus, for example, if incentives for increased biofuels production are strong relative to penalties for deforestation, forests could be cleared to grow biofuels. Since energy taxes would not especially favor biofuels, they would not produce the same incentives for deforestation.

²¹ Some other policies, such as the proposed penalty on oil derived from Canadian tar sands, are effectively a variant on a CO₂ emission permit scheme. They are actually inferior to a tradable permit scheme, however, in that they mandate a particular mix of crude oil input into the refining process regardless of whether that is the least costly way of reducing CO₂ emissions.

VI. Concluding Remarks

Restrictions on CO₂ emissions are unlikely to be the most efficient response to concerns about the potentially detrimental impact of climate change. There are many reasons why this is so.

To begin, climate also changes for reasons that are unrelated to the accumulation of CO₂ in the atmosphere. Focusing only on CO₂ does nothing to alleviate the potential costs of climate change from other sources. Policy could instead aim to reduce the likelihood of large damages from climate change regardless of the source. The resources devoted to reducing CO₂ emissions might also be more effectively spent on improving recovery response after climate disasters, such as hurricanes and earthquakes. Such policies would have the added benefit of aiding recovery from *non-climate* disasters.

Second, CO₂ emission constraints will not likely be imposed throughout the world, leading to strong incentives to locate energy-intensive activities in countries where the constraints are not operative. The resulting “carbon leakage” will substantially lessen the impact of any emission controls that are put in place, possibly even making them counterproductive.

Third, CO₂ emission constraints will be expensive because they immediately make substantial amounts of otherwise useful capital obsolete. Furthermore, the largest marginal benefits from reduced CO₂ emissions today will be experienced far into the future. New information or technologies could make reductions today irrelevant in terms of materially affecting the future damage from climate change.

Last, but not least, we have argued that CO₂ emission constraints are likely to involve a considerable reduction in energy security for the developed world. Far from being “two sides of the same coin,” climate and energy security are likely to conflict in many respects. The huge deposits of unconventional oil in North America could substantially reduce dependence on imported crude, but exploiting unconventional oil is likely to increase CO₂ emissions. Similarly, the developed world has substantial deposits of coal that could be used to generate electricity

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and/or be converted to liquid and gaseous fuels. Finally, restricting CO₂ emissions will inevitably increase dependence upon natural gas for generating electricity. This will increase dependence in the developed world on the Middle East and Russia not only for liquid hydrocarbons, but also for natural gas as a fuel for electricity. Queuing at gas stations during the 1970s OPEC oil embargo is a memory not many hold in high regard. Imagine the outcry if that were coupled with rolling blackouts.

Policies aimed at encouraging energy efficiency and/or developing non-fossil energy sources can address potential damages associated with climate change, as well as energy security. An energy tax would be more effective than CO₂ emission constraints at accomplishing both goals. The energy tax would encourage energy efficiency, and the revenue could be used to enhance mitigation and recovery from harmful effects of climate change, and to subsidize basic research into alternative energy and sequestration technologies. Such a tax would also enhance energy security by allowing domestic production from large U.S. and Canadian endowments of coal and unconventional oil before large scale adoption of non-fossil energy sources becomes cost-effective on a large scale

VII. Appendix

Investigations of the negative correlation between energy prices and macroeconomic performance have proposed many “channels” through which energy prices could influence an economy, summarized as follows:

1. **Real Balances Channel:** Energy price increases lower the real value of nominal wealth (money and bonds) thereby reducing consumption of all goods and services.
2. **Monetary Policy Channel:** Counter-inflationary monetary policy responses to the inflationary pressures from energy price increases reduce investment and net exports, and consumption to a lesser extent.
3. **International Transfers Channel:** Energy price increases transfer income from energy importing to energy exporting countries, reducing consumption and depressing output in the energy importing countries.
4. **International Financial Instability:** Large monetary flows between energy importing and exporting nations can produce large changes in exchange rates, interest rates and the pattern of investment flows that produce correlated negative shocks to financial markets (see, for example, El Gamal (2008)).
5. **Complements Channel:** If energy and capital are complements in production, energy price increases will reduce capital utilization and suppress output.
6. **Sectoral Shocks Channel:** Energy price increases can decrease employment if training costs are high, there are other costs of shifting labor between sectors, and the shock is expected to be temporary, so specialized labor will wait until conditions improve rather than seek alternative employment.
7. **Uncertainty Channel:** Firms postpone irreversible firm-specific or industry-specific investment expenditures, like advertising and marketing expenditures or capital expenditures with low re-sale value, when prices are highly uncertain.

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