



Employment Impacts of Climate Change

by James Barrett



Growing the Economy Through Global Warming Solutions



Global warming is one of the most urgent problems of our time.

The good news is that many of the solutions to this extraordinary problem are within reach. Many of the solutions to global warming are not only feasible, they are economically and socially beneficial. While some claim that addressing global warming will have a negative impact on the economy, the most recent report by the Intergovernmental Panel on Climate Change (“IPCC”) asserts that there is substantial economic potential for the mitigation of greenhouse gas emissions over the coming decade. In fact, there is a growing global market to address global warming, and the United States must act now or risk being left behind.

Growing the Economy through Global Warming Solutions sets forth the steps we can take to curtail global warming, the governance models needed to encourage such a transition, and the economic benefits of doing so. By taking these steps as soon as possible, we not only will minimize the grave risks of global warming, we will position the United States as the leader in the clean industries and technologies that are emerging as the key growth engine of the Twenty-First Century.

It is now a given that global warming is happening. It is caused by the emissions of greenhouse gases – primarily carbon dioxide released during the combustion of fossil fuels -- and already has begun to inflict harms on climate, ecology and people. The most recent IPCC report confirms that global warming is here and will accelerate in the future with serious harms and risks if greenhouse gas emissions are not promptly limited. Dr. James Hansen, of NASA’s Goddard Institute for Space Studies, warns that a global average warming of 3.5 degrees Fahrenheit will produce a “different planet” by taking us over dangerous climate thresholds that greatly magnify the risks of disintegrating the great ice sheets on Greenland and West Antarctica, an event that would cause massive and rapid sea level rise. Dr. Hansen emphasizes that we can keep the planet within the known boundary conditions by limiting the future global temperature increase to no more than 3.5 degrees Fahrenheit.

To do so, we must stop the business as usual approach in which carbon dioxide and other greenhouse gas emissions increase every year. One of the primary obstacles to moving from this business as usual approach to a problem solving approach is the argument that mandates to limit emissions will cripple the U.S. economy and that the market will produce all necessary solutions on its own. But this argument focuses too narrowly on the economic impact to “big energy”, which for too long has dominated the political discussions in Washington. Growing the Economy through Global Warming Solutions asserts that we cannot afford to wait for voluntary market solutions. We must either invest now to implement solutions, or we will pay much more later as we have to adapt to the growing impacts of global warming. Many mitigation strategies, those that will help reduce emissions now, will not only be cheaper to implement, they will stimulate the economy.

Government has an essential role to play in developing a strong governance model – those procedures, rules and regulations that can work to bring greenhouse gas emissions under control. In fact, with the right set of government incentives to help focus their attention, the business community, which is already beginning to recognize challenges and opportunities - and looking to both adapt and innovate - will see even more possibilities for capitalizing on economic opportunities while achieving environmental gains. The good news is that, if we get started right away, we can rapidly move to this solutions-oriented approach in which emissions are limited and reduced in time to avert the worst risks of global warming.

Growing the Economy through Global Warming Solutions is a series of papers written by experts in the fields of economics, public policy, energy policy, architecture, insurance, investment, transportation, and agriculture. It details the solutions that can be taken off the shelf today. While there is no single silver bullet for addressing global warming, there are a wide variety of solutions that, taken together, will lead to a reduction of carbon dioxide emissions, the key to stopping global warming. These promising solutions must be phased in as we phase out our outmoded reliance on foreign oil and coal. Along with its companion reports, *Employment Impacts of Climate Change*, by James Barrett, sets out important next steps that can and should be taken in the near and medium term to ensure that we do everything possible to address the challenges of global warming.

We have the know-how and it is the American Way to innovate and problem solve. We have time.

We have to get started now.

“We have at most ten years—not ten years to decide upon action, but ten years to alter fundamentally the trajectory of global greenhouse emissions.” – Jim Hansen, Director of the NASA Goddard Institute for Space Studies, and Adjunct Professor of Earth and Environmental Sciences, Columbia University's Earth Institute.

Executive Summary

In order to avoid dramatic climate change, many are calling for reductions in CO₂ emissions by 70% or more by mid-century. Because emissions of carbon dioxide, the principal greenhouse gas, are closely tied to energy consumption, and energy consumption is in turn tied to economic activity, attempts to control emissions will require a complete overhaul of the energy system with potentially large employment and economic implications.

Predictions about the economic impact of transforming the energy system vary widely, but the key to ensuring a positive transition depends almost entirely on the policy choices that govern the transition. Climate policy that takes a comprehensive approach to dealing not only with carbon pricing, but also with the many and varied other failures of energy markets as well as pre-existing economic distortions in other parts of the economy can produce positive environmental and economic results at the same time. Predictions that ignore these options inevitably claim that climate policy will be extremely costly.


The most direct impact of a new energy policy will be price increases, which can produce some drag on the macroeconomy. Choices about how aggressive the emissions reduction goals are and how high carbon prices have to rise to achieve them will be the most important variables in this domain. However, there is a second set of variables that include the role of non-market policies, such as efficiency investments and regulatory standards; the interaction between domestic policies and those put in place by our trading partners; and the role of tax policy as it interacts with the domestic carbon policy. It is this second set of options, which generally receives far less attention than the first, that will determine whether climate policy helps or hinders the economy overall. For any given reduction target, a well-designed policy approach that puts a price on carbon emissions, uses the resulting revenues for targeted investments in renewables and efficiency, as well as reducing pre-existing taxes that hinder economic growth, and devotes revenues to protecting low-income households from the impacts of rising energy prices will generate lower economic costs and may even yield an economic benefit.



Introduction

Climate change is an environmental problem that has an important economic dimension. Because emissions of carbon dioxide, the principal greenhouse gas, are closely tied to energy consumption, and energy consumption is in turn tied to economic activity, attempts to control emissions will necessarily have fundamental impacts on our energy system and our economy. The relationship between energy and the economy is not nearly as strong as it used to be. The amount of energy consumed per dollar of Gross Domestic Product has fallen steadily since the late 1940's, so that the U.S. now uses less than half the energy per dollar of GDP than we did nearly 50 years ago. Though the data does not go back as far, emissions of carbon dioxide per dollar of GDP show a similar trend, falling over 40% in 25 years.¹ These trends are due to a combination of increased energy efficiency, greater deployment of low-carbon energy sources and the shift of the economy away from energy-intensive manufacturing industries and toward the less energy-intensive service sector.

Intensity measures do not tell the whole story, however. Both energy consumption and carbon dioxide emissions have increased substantially over the same time periods. In the face of these trends, it is clear that, though the US economy is slowly decarbonizing, some type of policy response will be necessary to achieve any substantial level of overall emission reduction. This paper addresses the options for policy response and how those options will impact employment and the economy. Despite the fact that energy is playing a reduced role in the economy, it still accounts for almost 9% of our annual expenditures economy wide, more than twice what we spend on national defense² and more than half what we spend on healthcare.³ In order to avoid dramatic climate change, many are calling for reductions in CO₂ emissions by 70% or more by mid-century. This would require a complete overhaul of the energy system with potentially large employment and economic implications.



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The Economics of Climate Policy

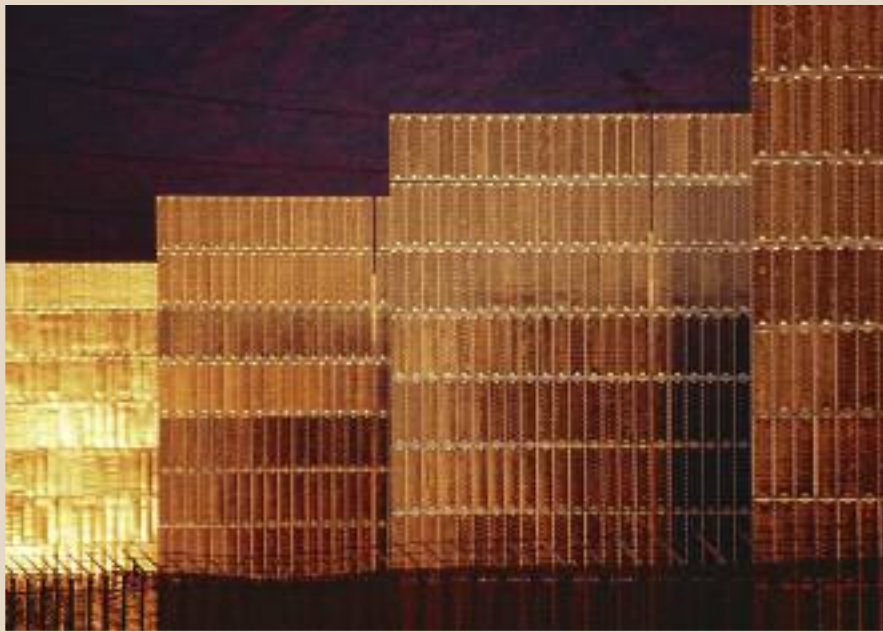
Before considering the economic impacts of climate policy, it is convenient to make several distinctions. The first is to distinguish between those policies that will affect energy producers and those that will affect energy consumers. Energy producers fall into the broadly defined energy sectors of coal, oil, and natural gas. While all industries and households consume energy, these sectors are the suppliers of most of the primary energy in the economy. Their energy production vastly outweighs their consumption. The electric power industry, however, is a special case in that it is both a major consumer and producer of energy, transforming a variety of energy forms into electricity, a more convenient form of energy for a number of purposes. The electric power industry depends largely on coal (53%) and natural gas (15%) for its energy input, but also uses significant amounts of nuclear power (21%) and hydropower (9%), which emit no carbon dioxide during operation.⁴ A small number of other industries are also energy suppliers, in that they produce some of the energy they consume. This is true for industries like paper that uses byproducts to generate energy that it then consumes. The majority of the energy produced at such facilities is consumed on-site, having little impact on the market at large.

The second important distinction lies in the mechanism by which climate policies affect various sectors of the economy. The direct impact will be through increased energy prices. This will have important impacts on energy products and energy-intensive industries as climate policies directly and fundamentally alter the nature of their business and the production processes they use. Rising energy prices will also have important, though less profound, impacts on households that will see increased energy bills. They will also see impacts in increased prices for other goods and services, as about half of household carbon emissions do not come from direct energy consumption, but rather as a result of the energy embodied in other

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products. These secondary price increases may go largely unnoticed by the average household, however, because they will be spread thinly and broadly over a wide range of goods and services.

For many households and businesses, however, the direct impact of higher energy and other prices may be less significant than the indirect impact that climate policies could have on the economy as a whole. Depending on the stringency of the carbon targets and the cost of reaching those targets, average household energy costs could increase by anywhere between



a few hundred and a few thousand dollars annually.⁵ Significant as this is, particularly for low to moderate income households (mean household income in 2005 was just over \$63,000⁶), the indirect impact of climate policies could be much higher. Following the signing of the Kyoto Protocol, for example, a number of studies attempted to assess the impacts of climate policy on the economy. Projections at the high end of this range found carbon abatement costs in the range of \$90 to \$115 per ton of CO₂. According to these studies, within about a decade, this would have produced GDP losses of between 2.1 and 4.2% and increases in unemployment rates of 1.5 to 2 percentage points. That is to say,

after about ten years of carbon policies, these studies predicted that GDP would be \$280 to \$540 billion lower than it otherwise would have been, and the economy would have created between 1.6 and 3 million fewer jobs. Thus, though the direct costs of climate policies as represented by increased energy bills could be significant, the impact on the health of the overall economy could be much greater.

While the ultimate macroeconomic impacts of climate policy will depend on a number of variables, including the response of monetary and fiscal policy, if these studies are to be believed, increased energy costs could reduce GDP, cause a significant rise in unemployment and inflation, and possibly induce an economic recession.⁷

At the same time, there are other studies that show that climate policy can actually be good for the economy. Again looking at assessments of policies designed to bring the U.S. into compliance with the Kyoto Protocol, or to achieve emissions reductions of a similar magnitude, economic assessments have found that these targets are achievable with smaller impacts on energy prices and positive impacts on the economy as a whole. These studies found that, over ten years, meeting or nearly meeting the Kyoto target could have been done with carbon abatement costs of between \$14 and \$40 per ton of CO₂, increases in GDP of between 0.4 and 0.6%, while creating between 240,000 and 660,000 more jobs than would have otherwise been created.⁸ Studies have found similar results in other policy contexts as well, with carbon reduction policies generating relatively small but positive impacts on economic and job growth while making substantial reductions in emissions.⁹

Predictably, this diversity among policy assessments produces significant confusion over which ones are accurate. Unfortunately for anyone in search of simplicity, the answer appears to be “all of the above.” All of the studies cited here, as well as numerous others on both sides of the debate, rely on fairly standard economic models that produce, with some limitations, reasonable and reliable assessments of policy options. Each approach has its strengths and weaknesses, but, despite the seemingly contradictory conclusions, none of the assessments cited here can be dismissed out of hand as being incapable of producing reputable results.

How, then, to reconcile the body of literature, and to believe simultaneously multiple conclusions that appear to be mutually exclusive? The answer lies in a closer look not only at how these studies are conducted but also at what they actually study. The differing results are only contradictory if they come from assessments of similar policy options with similar tools. They all do consider substantial reductions in carbon emissions over comparable time periods, and they use as their principle policy option some type of market mechanism that puts a price on carbon emissions. The similarities typically end there, however. Even though these studies are similar in the tools they use, the goals on which they focus, and in their use of market mechanisms to price carbon emissions, their conclusions as to economic impact vary widely because the policy options these studies assess are radically different.

Those looking for a quick answer to the question of whether or not climate policy will be expensive are bound to be disappointed. The fact is that climate policy can be either harmful or beneficial for the economy, depending on how it is implemented. A policy approach that merely puts a punitive cost on carbon emissions and raises it high enough to slow the economy sufficiently to meet a reduction target can not be economically beneficial. Studies that confirm this intuition are not surprising, nor particularly insightful. Alternately, climate policy that takes a comprehensive approach to dealing not only with carbon pricing, but also with the many and varied other failures of energy markets as well as pre-existing economic distortions in other parts of the economy can produce positive environmental and economic results at the same time.

Far from being contradictory, these policy assessments tell a compelling and consistent story: The economic stakes around climate policy are very high, and whether or not the economic impacts are beneficial or not will depend on a relatively small number of decisions, some of which may not be obvious at first blush.

Macroeconomic Issues

Policies that use market mechanisms to reduce carbon emissions work by creating scarcity where none previously existed, i.e. the right to emit carbon. Cap and trade systems put a limit on the amount of carbon that can be emitted, with the limit set lower than what would have otherwise occurred. (See Dallas Burtraw's paper in this series, "Cap and Trade Policy to Achieve Greenhouse Gas Emission Targets"). Emitters must hold a permit for each ton of carbon they emit. They are free to buy and sell permits from one another so long as the aggregate cap is not violated. Emitters will reduce their emission levels when the cost of doing so is less than the price of an emission permit. On the other hand, carbon taxes work by putting a direct cost on emissions, causing emitters to reduce their emissions when the cost of doing so is less than the tax rate, and to pay the tax if it is not. Under both systems, the mechanism works by putting a dollar cost on emissions, thus forcing emitters to consider their emissions rates in their bottom lines. These costs will be passed at least in part onto consumers in the form of higher prices for energy and, to a lesser extent, other goods and services produced using energy.



The direct impact of climate policy on the macroeconomy comes through these price increases. To provide some context, a carbon tax of \$30 per ton of CO₂, or an equivalent cap and trade system with a permit price of \$30 per ton would translate into about 29 cents per gallon of gasoline, 19 cents per therm of natural gas, and anywhere between one-half to 3 cents per kilowatt-hour of electricity, depending on what fuels are used to generate it. For the economy as a whole, aggregate price increase associated with a carbon charge of this level is impossible to know with certainty, as it depends on how much of the charge gets passed on to consumers, and how much emissions this level of charge would eliminate. However, with approximately 6 billion metric tons of CO₂ emitted in 2005, the total value of the carbon tax revenues or permit values resulting from a \$30 per ton carbon charge could easily exceed \$100 billion annually, and could be as high as \$180 billion.

There is little question that increased energy prices by themselves can produce some drag on the macroeconomy. What the ultimate economic impacts will be depends on a number of variables. How aggressive the emissions reduction goals are and how high carbon prices have to rise to achieve them are principal among them. Other variables include the role of non-market policies, such as efficiency investments and regulatory standards; the interaction between

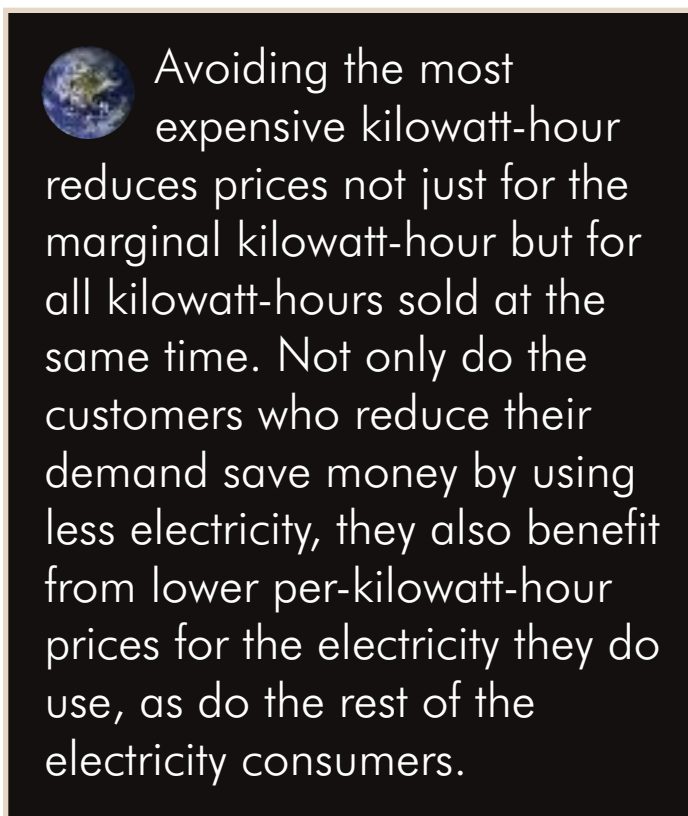
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domestic policies and those put in place by our trading partners; and the role of tax policy as it interacts with the domestic carbon policy. Interestingly, it is this second set of options, which generally receives far less attention than the first, that will determine whether climate policy helps or hinders the economy overall.

Many policy debates begin and end with discussion of the issue of how climate policy will impact energy prices. However, this is one part of the overall story. Two other classes of policy options play a critical role in determining the overall economic impact of climate policy, and can potentially dominate the price impact. The first includes both energy efficiency and renewable energy policy. (Two papers in this series, John Laitner’s “Wasted Days and Wasted Nights” and Robert Pratt’s “The Promise of Renewable Energy”, address the issues of energy efficiency and renewable energy respectively in some detail.) Investments in improving energy efficiency reduce the amount of energy and therefore fossil fuels needed to provide the services we derive from energy consumption. Investment in shifting energy use toward renewables further reduces the need for high carbon emitting fuels, such as oil and coal.

Like all investments, these entail some initial costs, which are recouped over time in the form of reduced energy costs and reduced expenditures on other forms emission abatement. The degree to which low-cost and even negative cost investments in energy efficiency are available is beyond the scope of this chapter. However, as Laitner and Pratt discuss, there are many opportunities for cost-effective renewable and energy efficiency investments that will reduce the overall costs of meeting any given emissions reduction target. These include carbon abatement options that have a negative net cost. It is important also to notice that while energy efficiency investments and other related policy options are often considered supplemental to the market mechanism, the fact, reflected in many climate policy studies, is that these supplemental policies are likely to produce as much if not more emissions reductions than the market mechanisms.¹⁰

It is further important to note the impact that energy efficiency can have on the electricity market. The marginal cost of generating electricity is relatively low and stable at low levels of generation, often referred to as “baseload” generation. In summer months and in late afternoon and early evening hours, however, electricity demand rises well above baseload levels. The generating capacity held offline during periods of baseload demand, so called “peak” generation, is more expensive than baseload, sometimes much more expensive. Generation costs, and therefore electricity prices, can rise steeply with peak demand. At any given time, wholesale electricity prices must be high enough to cover the cost of the most expensive kilowatt-hour sold.¹¹ As electricity prices rise to cover the higher costs of peak generation, all electricity produced at the same time is sold for the same higher price, even baseload generation which often costs one-fifth or less that of peak generation. The steepness of generating costs means that reducing electricity demand in peak hours can have a disproportionately large impact on electricity prices and costs. For even relatively small increases in demand, differences in generating costs for the most expensive kilowatt-hour can be quite large. Avoiding the most expensive kilowatt-hour reduces prices not just for the marginal kilowatt-hour but for all kilowatt-hours sold at the same time. Not only do the customers who reduce their demand save money by using less electricity, they also benefit from lower per-kilowatt-hour prices for the electricity they do use, as do the rest of the electricity consumers.



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The other broad class of policy options that play a critical role in the overall economic impacts of climate policy are economic in nature, and revolve around how the market mechanism is implemented and how the carbon tax or permit payments are treated. Under a carbon tax, it is clear that carbon emitters will pay for their emissions at the rate set by the government. As mentioned above, emitters will pass these costs, in whole or in part, onto their consumers, depending on market characteristics. The government will collect the full value of the tax, and will have to decide how to use the revenues. How these revenues are used are the key to fair and efficient climate policy. Having collected the revenues, the government must invest them in a wise manner: wasteful spending initiatives will not alleviate the economic costs of a carbon charge. Under a cap and trade system, there are, generally speaking, two options for distributing permits to emitters. One is to charge them for the permits, through an auction or some other mechanism. The other is to distribute the permits free of charge, based on historic emission levels, output levels or some other metric. Free distribution based on historic emission levels, often called “grandfathering,” is the most commonly discussed free distribution option, and the one used in the cap and trade systems to implement the carbon reductions in the European Trading System (ETS) and the SO₂ reductions in the northeastern U.S. under the Clean Air Act amendments of 1990.

While it seems obvious that auctioned permits will result in higher prices much the same way that an equivalent carbon tax would, it is often erroneously assumed that free permit allocations will not, i.e. that if emitters receive carbon permits for free, that there will be no costs to pass on to their consumers. Though intuitive, this reasoning is incorrect. Cap and trade systems increase energy and product prices because of the scarcity they introduce. That scarcity is what drives the price increases, not the method of permit distribution. Consider the emitter that does not receive enough permits to accommodate all of the carbon she would emit in the absence of a binding cap. If she is going to maintain production levels, she will need either to undertake some costly abatement or buy a permit from another emitter. In either case, her costs go up, and she will pass some or all of her costs onto her customers, just as if she bought the permit from the government. If she cannot raise her prices enough to maintain profitability, then she will have to reduce emissions by cutting back on her output. This reduction in supply would also push prices upward.¹² Emissions reductions are likely to be achieved by a combination of abatement where it is economical and output reductions where abatement costs are higher than the market will bear. The end result is that, whether permits are sold or given away for free, output prices will rise to reflect the scarcity imposed by the cap.¹³

It is also important to note that, while they appear quite distinct, carbon taxes and cap and trade systems are quite similar. Cap and trade systems put a clear limit on emissions and let the market determine how high the price of emissions will be,



while carbon taxes set the price of emissions and let the market determine how high emissions will be. Because of the uncertainty surrounding abatement costs, cap and trade systems have the advantage of being able to set a specific environmental goal. The disadvantage is that the costs of meeting that goal are uncertain and may turn out to be higher than is politically acceptable. On the other hand because carbon taxes put a specific limit on the price of emissions, they effectively limit aggregate abatement costs, but it is then uncertain what level of emissions reductions a given tax rate will achieve.

These differences aside, carbon taxes and cap and trade systems are, from an economic standpoint, quite similar. Both put a price on emissions, both allow individual emitters to choose whether or not to emit depending on their economic environment, and both systems will result in output price increases. A carbon tax set at \$30 per ton will have the same environmental outcome as a cap and trade system in which the permit price equalizes at \$30 per ton. In either situation, emitters who can reduce their pollution for less than \$30 will do so and avoid paying for

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the right to emit, while those who can not will pay the price to continue to emit. In either case the decision process is the same, resulting in the same levels of emissions by the same emitters, the same level of aggregate pollution, the same amount of aggregate abatement costs, and the same increase in output prices.

However there is a critical economic difference between the two types of systems: who actually bears the cost of reducing pollution. Under a carbon tax or an auctioned cap and trade system, emitters reduce their pollution levels and pass some or all of the costs of abatement onto their consumers in the form of higher prices. For every ton of carbon that is still emitted, polluters must pay a fee (either the carbon tax or permit price) to the government. Under an equivalent grandfathered cap and trade system, emitters also reduce their pollution, output prices rise by the same amount, but in this case, emitters do not pay for their emission permits yet still enjoy the benefits of higher prices for their products. The end result is equivalent to a government imposed tax that companies levy on their customers but then keep for themselves.



The resulting windfall benefit to emitters from a cap and trade system with free initial distribution of permits can be quite large, and depends on a number of factors including the stringency of the emissions reduction target. It is possible to identify a simplified upper-bound estimate of the windfall gain. For a 10% reduction in emissions, the annual economic value of the permits under a cap and trade system would be at least 18 times the annual aggregate costs of abatement. For a 50% reduction, the value would be at least twice aggregate costs.¹⁴ More sophisticated attempts to quantify the windfall value in work by Bovenberg and Goulder (2000) estimate that holding the entire coal, oil, and natural gas industries economically harmless would require less than 20% of the revenues from a carbon tax or permit auction.¹⁵ Full grandfathering to these industries would thus overcompensate them by a factor of more than 5.¹⁶

From a macroeconomic standpoint, this transfer of wealth is neither good nor bad when taken in isolation.¹⁷ The true cost of this transfer is the lost opportunity it represents. By increasing the cost of producing goods and services with fossil-based energy, a carbon tax or cap and trade system creates a disincentive to produce them.

As a consequence, output and employment will fall; the carbon policy acts like sand in the gears of the economy. Under a carbon tax or a cap and trade system with auctions, however, the policy that causes the problem simultaneously provides a mechanism that can be used to ameliorate the economic problem it creates. If the government collects revenues from a tax or a permit auction, it can put those revenues to economically productive uses. Existing taxes on labor and capital gains reduce the incentive to work and invest and thus slow economic growth. Using carbon revenues to reduce such taxes will reduce this disincentive effect and partially or fully offset the macroeconomic costs of the carbon policy. This combination of policies would create some drag in one part of the economy and reduce it in another. Similarly, if the government, for example, invests some or all of the revenues in technology promotion policies that reduce the costs of carbon abatement, the cost to the economy will fall, compensating for the push toward higher prices that results from the carbon tax or the cost of cap and trade permits.¹⁸

Because lump-sum wealth distributions do not create any incentives (or disincentives) for economic behavior, any such distribution will not reduce the macroeconomic costs of climate policy. Proposals to auction carbon permits and then rebate the revenues to individuals on a per-capita basis do not create any new incentives for job or capital creation, and thus do not eliminate any pre-existing sand in the economic gears. While such a policy has clear distributional benefits, it does not offset the economic disincentive created by the carbon cap in the way that funding greenhouse gas-reducing technological development or cutting other existing taxes would. There is thus a tradeoff between offsetting distributional inequities, which could best be achieved through some type of direct reimbursement, and maximizing aggregate economic benefit, which would best be achieved through financing appropriate research, development, and deployment or by offsetting other existing taxes.

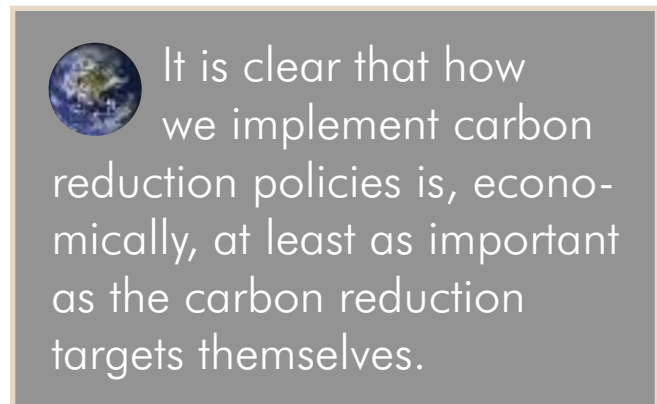
There is no reason why all of these options could not be used in concert to generate a specific policy outcome. For example, Elliot et. al. (2004) found that the bottom 20% of households are responsible for about 15% of carbon emissions in the U.S.¹⁹



Under the assumption that 100% of carbon abatement costs are passed forward onto consumers, it would be possible to fully compensate the bottom 20% of households for rising energy and product prices by using 15% of the revenues from a carbon tax or fully auctioned cap and trade system for a lump-sum transfer to those households. At the same time, research has shown that for any broad based energy tax, carbon tax, or cap and trade system, investing 15% of the tax or auction revenues in existing energy efficiency technologies and policy options could reduce household energy demand enough to offset higher energy prices enough to keep household energy bills constant.²⁰ This would

leave a large majority of the tax or auction revenues to devote to economically productive uses, such as tax cuts, industrial programs, renewable and energy efficiency research, development and deployment, transition assistance for adversely impacted workers and communities, or other uses.

A final issue that is often raised with carbon policy is the impact that it will have on international trade. Specifically, if the U.S. adopts a climate policy that raises the price of energy and other commodities, trading partners who do not adopt a similar policy will have a price advantage in both domestic and international markets. Manufacturing industries in particular already face significant competition from developing countries whose production costs are currently lower and are unlikely to adopt climate change mitigation policies. This would increase the price advantage they currently enjoy, and could lead to further erosion of domestic and international market share, particularly by energy intensive industries. One way to avoid this is through the use of border tax adjustments. Border tax adjustments would require that products imported to the U.S. pay a tax equivalent to what domestic producers face as the result of climate policy. At the same time, U.S. exporters would receive a rebate equal to the carbon charge embodied in their products. Such a policy would eliminate the price advantage that climate policy would otherwise confer on our trading partners both in domestic markets and internationally.²¹



It is clear from this discussion that how we implement carbon reduction policies is, economically, at least as important as the carbon reduction targets themselves. Specifically, relying on carbon pricing alone, particularly a grandfathered cap and trade system would produce needlessly high and regressively distributed economic costs. For any given reduction target, a well-designed mix of carbon policy, tax policy, and targeted investments will generate lower economic costs and may even yield an economic benefit.

Typically, those climate change mitigation assessments predicting very high economic costs rely almost exclusively on cap and trade systems with freely distributed permits. They set an environmental goal and rely solely on the effects of rising prices to lower emissions. Giving permits away for free forecloses the opportunity to invest in renewables or efficiency, to offset distributional burdens to households or reduce existing taxes. In essence, they ask the question: How high does the price of carbon have to be to beat the economy into submission? Under this formulation, it is not surprising that the economic projections show an economy beaten into submission. Alternately, those studies that assess a more comprehensive, and more realistic, package of policies that rely on the elements identified above tend to find that climate policy does not need to be economically expensive and can even be beneficial.

Industry-level Impacts

While it appears possible to design climate policy that makes steep reductions in carbon emissions while generating macroeconomic benefits, it is relevant to ask whether there are particular sectors that might face economic pressure and

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job losses even if the net overall impact is positive. In isolation, a carbon charge of about \$13.50 per ton of CO₂, either a through a carbon tax or a cap and trade system, would increase production costs by more than 2% for industries producing goods and services that make up about 13% of GDP. The other 87% of GDP is produced by industries that would see cost increases of less than 2%. About 8% of workers are employed making the 13% of output that would face cost increases of more than 2%.

Climate policy that combines a carbon charge with other policies eliminates much or all of the burden for the majority of industries: Using the revenues from the carbon charge to offset existing taxes on labor, for example, would reduce the impact on industry so that industries producing about 80% of national output and employing 90% of workers would see net reductions in production costs as a result. Production costs would increase by 2% or more for industries producing about 5% of output and employing 3% of workers. Similar results are found when investments in energy efficiency and renewables are included in the policy package.²²



For most industries and products, the production cost impacts under either scenario are thus fairly mild in either direction. For a relative few, however, even a well-designed comprehensive policy package that produces net economic benefits may result in substantial economic costs. This includes two classes of industries, energy producing (coal, natural gas, petroleum refining, and electricity generation) and energy-intensive industries, such as aluminum and other metals, cement, chemicals, and fertilizers. The impact is highest for energy producers, where a carbon charge of \$15 per ton could more than double the cost of coal and increase other energy costs by as much as 25%. In contrast, service sector industries that use little energy in relation to labor stand to benefit the most from this type of “tax shift.”²³ Additionally, industries that supply raw materials to the renewable energy sector as well as the renewable energy sector itself could see a significant increase in demand for their output, with an associated increase in employment and profits.

Because the impacts on coal, as the most carbon intensive fuel, are so much higher than the rest, it deserves individual attention. Coal is used predominantly in electricity generation. Nearly one-third of all U.S. CO₂ emissions come from coal-fired electricity generation. In a policy context where the goal is to reduce domestic carbon emissions by 60%-80% over the next several decades, this goal is possible only with widespread or complete conversion of the domestic generating fleet from traditional coal either to other energy sources or to coal-fired facilities with effective technologies built-in that can separate CO₂ from power plant emissions, capture it, and pump it into geologic formations capable of holding the carbon indefinitely.²⁴ Carbon capture and sequestration (CCS) technologies have yet to be proven either technically or economically viable at a sufficiently large scale.²⁵ If, after including all of the considerable environmental and health impacts of coal mining, using coal in tandem with CCS does not prove to be economically and environmentally superior to alternative emission reduction strategies, then coal production in the U.S. would have to all but cease by 2050. In 2006, the coal industry directly employed just under 79,000 people.²⁶ Employment predictions for the coal industry point to substantial decline in the near term even in the absence of climate policy.²⁷ Much of the employment reduction could potentially be met through natural attrition rather than actual layoffs. The fact that coal mining often takes place in geographically remote areas where coal mining dominates local economies means that entire communities may be at risk as a result of climate policy. This puts a premium on developing alternative economic activities with the strong potential of generating jobs and income to which these workers and communities can shift.

Similarly, reduced energy demand may generate reduced employment in the other energy supplying industries, though to a lower degree. Although both petroleum and natural gas are less carbon intensive than coal, emission reduction goals of 60%-80% leave little room for job or output growth and will almost certainly lead to declines in both in the long run. The electric power industry may be less impacted than others. In its final form, electricity is a carbon-free energy source. It is associated with emissions primarily through its source fuels. If carbon-free sources (such as wind and solar power) replace

existing fuels, then electricity generation and distribution will likely continue, and may even grow, though likely at lower levels than are currently projected. The electricity generation profile will be much different than is currently envisioned. So while the outlook for electricity is unclear, the output and employment patterns will be significantly different than they are today. While some jobs may be created in the electric power industry as a result of climate policy, they are likely to be different in nature and location than current projections.

The oil, gas, and electricity industries together accounted for over 650,000 jobs in 2004, with electricity accounting for about two-thirds of them. To the extent that they deal with the direct production and distribution of fossil fuels, there is little in the way of efficiency investments that can blunt the impact of climate policy: the purpose of climate policy is to reduce demand for these industries' products. As with coal, the timeframe for climate policy implementation is such that the magnitude of lost jobs could be accommodated through natural attrition (predominantly retirements and turnover). However, it is likely that job destruction will come in lumps as production facilities close rather than in a smooth downward path as might be easily absorbed via attrition.



A comprehensive transition assistance package could be provided to all impacted workers in these sectors and their communities for a small fraction of the revenues from a carbon tax or permit auction, between 2% and 10% of the revenues depending on how strict the eligibility guidelines are set. Barrett (2001) attempts to construct a "make whole" transition package for impacted workers that could leave them at least economically as well off as they would have been in the absence of climate policy. Based on a combination of income support, retraining, and retirement support, a transition package for the average coal miner would cost in excess of \$200,000.²⁸

Non-energy producing sectors fall into two broadly defined categories, energy intensive and non-energy intensive. The obvious challenge for energy-intensive industries will be rising energy prices, which will reduce profit margins and may threaten the viability of individual manufacturing facilities or even entire sectors. To the extent that higher production costs are passed on in the form of higher product prices, this will likely lead to reduction in product demand and lower output and employment levels. But it is important to note that even among energy intensive industries, energy costs are typically a small fraction of production costs or shipment values. The table below shows energy and labor intensity for selected industries:

Manufacturing Sector	Employees	Energy Expenditures Per \$ Shipped	Employee Compensation Per \$ Shipped
Nitrogenous Fertilizer	3,173	12.9%	6.4%
Primary Aluminum	8,482	19.2%	11.7%
Synthetic Rubber	8,570	5.6%	10.6%
Cement	17,149	14.9%	12.1%
Plastics	54,042	4.4%	6.3%
Iron & Steel Mills	101,606	6.6%	10.0%
Semiconductors	131,136	1.3%	16.5%
Cement & Concrete Products	231,100	3.8%	19.3%
Paper	414,049	5.3%	15.9%
Chemicals	747,134	3.3%	9.1%
Computer & Electronic Products	1,001,265	0.7%	19.8%
Transportation Equipment	1,525,067	0.7%	16.1%

Source: U.S. Census Bureau. Annual Survey of Manufactures, 2006

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For many industries typically regarded as being energy intensive, such as steel, paper, and semiconductors, energy costs represent a significant, but relatively low share of product shipments. For those sectors, rising energy costs may be offset by investments in energy efficiency. The Department of Energy and Environmental Protection Agency have numerous sector-specific programs aimed at increasing carbon and energy efficiency. Increased investment in basic research as well as technology deployment programs may, in some cases, completely offset increased energy costs.²⁹ Employee compensation is typically higher for these industries and will likely dominate output, shutdown and location decisions for many facilities.

For these industries, as well as those sectors that use relatively little energy, one key to economic health and long-term employment is long term health of the domestic economy as a whole. The U.S. steel industry, for example exports less than 10% of its product, and supplies over 75% of domestic consumption. As a key input to construction, durable goods, and transportation equipment, robust demand for these final products can help ensure stable demand for steel and continued economic viability of the industry. Climate policies that can maintain or enhance overall economic growth are critical for industries of this type and the millions that work in them.

There is a relatively small number of sectors and sub-sectors that are very highly energy intensive, for which energy efficiency investments may not be sufficient to offset higher energy costs. As measured by employment, they tend to be smaller, and are also typically geographically concentrated. In many ways, cement is a good example of such an industry. Like aluminum and similar sectors, it employs relatively few people, though as a critical intermediate input to for other products, changes to the cement industry can have impacts felt throughout the economy. Imports account for over 20% of U.S. cement consumption, and exports are economically negligible. A healthy domestic economy is critical for the health of the cement industry, although because the sector faces significant import competition, this is not sufficient to guarantee a healthy cement sector. The cement industry is also a rare example in that measuring its energy expenditures dramatically understates the impacts of climate policy on the industry. Less than half of the carbon dioxide emissions from the cement sector come from energy consumption, while the majority comes from process emissions. Additionally, though less significant, is the fact that coal historically has been the dominant fuel source for cement manufacturers.

Sectors like cement represent a pernicious problem for climate policy. Modest efficiency investments are unlikely to yield savings sufficient to offset the increased production costs either from energy consumption or from process related emissions. While massive retooling of the industry might conceivably reduce emissions or allow for sequestration, it may not be





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economically viable for plant owners. In the face of high capital costs of retrofitting, replacement, or upgrades, it may be more profitable to relocate cement plants to developing countries with lower labor costs, environmental standards, and less stringent or no climate policies in place. But this, of course, would achieve little environmental progress—possibly even increasing emissions—while simultaneously imposing significant economic harm on a concentrated and relatively disadvantaged population.

Therefore, industries such as these may only remain economically viable under very low carbon prices or with large amounts of public investment. To prevent mass layoffs and other economic harm, and to avoid simply

relocating emissions to other countries, it may be in the public interest to devote public resources to maintain these industries in the U.S. Such investments can range from public financing of capital upgrades to employment or output subsidies for producers who maintain a domestic presence.

The vast majority of workers are employed by industries that use relatively little energy and would see relatively little impact from a carbon charge. A policy that imposed a carbon charge, used the revenues for a combination of energy efficiency investments and lowering other taxes could reduce production costs in sectors like the service industry, which employs over 100 million workers. Because labor costs dominate energy costs in the sector, using carbon charge revenues to reduce taxes or other disincentives to labor can have yield a shallow but broad increase in employment in the sector.³⁰ As mentioned above, however, this outcome is not guaranteed, but rather can only be brought about as the result of well-designed and implemented climate policy

At the same time, of course, there are a number of sectors that would stand to benefit from large increases in renewables and energy efficiency that would be a part of comprehensive climate policy. The renewable energy industry benefit from increased demand as would the industries that supply it. The construction industry is likely to benefit as well, as many buildings would be retrofitted for higher energy efficiency. Bezdek (2007) attempts to quantify these impacts.³¹

Conclusion

Climate change is the single most important environmental challenge of this generation. Failure of the U.S. to reduce its emissions of CO₂ and other greenhouse gases may put the world on an irreversible path toward environmental and economic harm never before seen. Against this threat, the prospect of sacrificing a small share of national income and employment may seem trivial. However, the key to successful climate policy lies in developing successful economic policy. Because the costs of policy will begin to be borne well before the environmental benefits, and because the benefits will come in the form of avoided costs and thus not easily identified, it is unlikely that a politically sustainable solution to the climate problem can be an economically expensive one. Despite the uncertainties, enough research and observation has been done to warrant action on climate policy sooner rather than later. Similarly, despite uncertainties, enough economic research and observation has been done to point policy in the right direction.

This paper attempts to identify the critical issues in climate policy as they relate to employment and the economy as a whole. Climate policy will transform our energy and economic systems at a fundamental level, and if not done with care, climate policy can generate high, regressive and unnecessary costs on the economy as a whole and individual sectors. Alternately, comprehensive policy, based on the principle that polluters should pay for the environmental risks they impose on others, tax reform, targeted investment and redistribution can yield an economy that thrives under climate policy, that protects the most vulnerable among us, and ensures that the costs of mitigating climate change for the benefit of all do not fall on the relative few.

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ENDNOTES

¹ U.S. Department of Energy (2007). *Annual Energy Review, 2006*. Energy Information Administration (DOE/EIA-0384) DOE: Washington, DC.

² Congressional Budget Office (2007). *Long-Term Implications of Current Defense Plans: Detailed Update for FY 2007*. CBO: Washington, DC.

³ World Health Organization (2006). *Working Together for Health: The World Health Report 2006*. WHO: Geneva, Switzerland.

⁴ U.S. Department of Energy (2007). *Annual Energy Outlook, 2007*. Energy Information Administration (DOE/EIA-0383) DOE: Washington, DC.

⁵ For example, policies that create carbon abatement costs of \$10 per ton of CO₂, would increase average annual household energy bills by about \$210. Abatement costs of \$200 per ton would increase bills by about \$4200 annually. Though the costs of climate policy proposals is uncertain, this range represents a likely high and low range of policy proposals being considered today. Source: Author's calculations.

⁶ U.S. Census Bureau (2006) *Current Population Survey, Annual Social and Economic Supplements*. Median, rather than mean, household income is a more appropriate measure of typical or representative households because very high income households tend to skew mean statistics upward. Median household income in 2005 was just over \$46,000. I use average households income here, because data availability restricts the measure of impact on household energy costs to average rather than median basis.

⁷ See, for example, Energy Information Administration (1998). *Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity*. U.S. Department of Energy: Washington, DC. WEFA, Inc., (1998). *Global Warming: The High Cost of the Kyoto Protocol*. WEFA, Inc: Eddystone, PA. Charles River Associates (1999). *Report to the Energy Information Administration*. CRA, Inc.: Boston, MA.

⁸ Krause, Florenin, et. al. (2002) "Cutting Carbon Emissions at a Profit (Part I): Opportunities for the United States." *Contemporary Economic Policy* Vol 20, No. 4 pp 339-365. Krause, Florenin, et. al. (2003) "Cutting Carbon Emissions at a Profit (Part II): Impacts on U.S. Competitiveness and Jobs." *Contemporary Economic Policy* Vol 21, No. 4 pp 90-105. Barrett, James and Andrew Hoerner (2002) *Clean Energy and Jobs: A Comprehensive Approach to Climate Change and Energy Policy*. Economic Policy Institute: Washington, DC. Note: in Barrett and Hoerner, the carbon reductions would not have met the Kyoto Protocol, and U.S. emissions would have been about 6% higher than the Kyoto target in 2010.

⁹ See, for example, Repetto, Robert, and Duncan Austin (1997) *The Costs of Climate Protection: A Guide for the Perplexed*. World Resources Institute: Washington, DC. and Barrett, James and Andrew Hoerner (2005). *Jobs and the Climate Stewardship Act: How Curbing Global Warming can Increase Employment*. NRDC: Washington, DC.

¹⁰ In Barrett and Hoerner (2002), for example, the carbon pricing mechanism accounts for less than half of the carbon reductions generated by the policy package modeled.

¹¹ Electricity markets are typically segmented in hours, with all electricity sold in a market within the same hour selling for the same price. In this context "at the same time" actually means within the same market hour.

¹² In either case, the price increase will be equal to the marginal cost of abating the associated carbon.

¹³ The preceding argument is true for competitive markets where prices are set at the margin. The electricity market is one important, if partial, exception. Almost all electricity sold at the wholesale level is unregulated, and many states have initiated processes to deregulate retail electricity prices to various degrees, roughly half of the electricity sold in retail markets is at least partly price regulated. Under regulated electricity pricing, it is unclear how much emitters would be able to increase their prices if they receive freely allocated permits. Regulated retail electricity accounts for about 20% of all carbon emitted annually. For additional discussion of the cap and trade approach, see the paper in this series by Dallas Burtraw, "Cap and Trade Policy to Achieve Greenhouse Gas Emission Targets".

¹⁴ Assuming that marginal abatement costs start at zero and increase linearly, and that the goal of policy is to reduce emissions from 1000 tons to 900 tons (a 10% reduction). A cap and trade system will result in some price for emissions permits, P. The value of the permit pool created will be 900P. The total cost of abatement, with linearly increasing marginal abatement costs, will be $100P \div 2$, or 50P. The ratio of permit values to total abatement costs is 900P:50P or 18:1. For a 50% reduction the permit price would be higher, indicated by subscript 2. The value of the permit pool would be 500P₂ and the total abatement costs would be $500P_2 \div 2$, and the ratio of permit values to aggregate costs would be 500P₂:250P or 2:1. This result is invariant to both the actual price of permits and absolute level of emissions. These calculations produce an upper-bound estimate by assuming that the marginal costs of carbon abatement increase linearly. In reality, abatement costs increase at an increasing rate, so that aggregate abatement costs would be lower than the linear example above, and the ratio of permit value to abatement costs would be significantly higher.

¹⁵ Bovenberg and Goulder calculate that that share of the revenues would cover not only the cost of abatement but also the estimated reduced asset valuations of polluting capital as a result of permanent carbon limitations. Both of these types of costs must be covered to truly hold those industries economically harmless.

¹⁶ See Bovenberg and Goulder (2000). “Neutralizing the Adverse Industry Impacts of CO₂ Abatement Policies: What does it Cost?” in *Behavioral and Distributional Impacts of Environmental Policies*, edited by C. Carraro and G. Metcalf. Chicago, IL: University of Chicago Press.

¹⁷ Gross Domestic Product is indifferent to lump-sum transfers of this nature, it is merely a shift of wealth from one pocket of the economy to another and does not affect aggregate wealth or income levels.

¹⁸ Because technology promotion policies can only reduce the cost of meeting a target, it is unlikely that such an investment strategy alone could completely offset the macroeconomic cost of meeting a carbon reduction target. If there are existing taxes that are more economically costly than a carbon tax per dollar of revenue generated, using a carbon tax to reduce them could result in economic growth rates that are higher than would have occurred in the absence of the carbon policy.

¹⁹ Elliot, Matthew et. al. (2004) *African Americans and Climate Change: An Unequal Burden*. Redefining Progress: Oakland, CA.

²⁰ See: Geller, et. al. (1993). *Structuring an Energy Tax so that Energy Bills Do Not Increase*. American Council for and Energy Efficient Economy: Washington, DC. Barrett and Hoerner (2002) *Clean Energy and Jobs: A Comprehensive Approach to Climate and Energy Policy*. Economic Policy Institute: Washington, DC. Hanson, Donald and John A. Laitner (2004) “An Integrated Analysis of Policies that Increase Investments in Advanced Energy-efficient/Low-carbon Technologies.” *Energy Economics*, vol. 26 pp 739-755. Maryland Department of the Environment. (2007). *Economic and Energy Impacts from Maryland’s Potential Participation in the Regional Greenhouse Gas Initiative*. MD Department of the Environment: Annapolis.

²¹ See Hoerner (1998). *The Role of Border Tax Adjustments in Environmental Taxation: Theory and U.S. Experience*. Center for a Sustainable Economy: Washington, DC. Border adjustments can alleviate some or all of the potential for price predation. By rebating carbon charges on exports of energy intensive goods, they enter international markets as if there were no domestic carbon policy in effect. At the same time, importers will have to pay a fee equivalent to what is paid by domestic producers. Note that to the extent that imported products are more carbon intensive than their domestic counterparts, imported products will be under priced, as less efficient products should pay a higher rate than more efficient ones. So while a uniform international carbon charge would give efficient domestic producers a price advantage over less efficient imports, a border adjustment can only eliminate the disadvantage that a unilateral carbon policy could create.

²² Hoerner, Andrew (2000), *Burdens and Benefits of Environmental Tax Reform: An Analysis of Distribution by Industry*, Redefining Progress: Oakland, CA, and Barrett, James and Andrew Hoerner (2000) “Making Green Policies Pay Off” Economic Policy Institute Issue Brief #143, EPI :Washington, DC.

²³ See Hammond, Jeff et. al. (1997) *Tax Waste Not Work*. Redefining Progress: Oakland, California.

²⁴ See, for example, Barrett and Hoerner (2002) and Environmental Protection Agency (2007) *EPA Analysis of the Climate Stewardship and Innovation Act of 2007*, available at www.epa.gov/climatechange/economicanalyses.html, downloaded on October 9, 2007.

²⁵ There is some research indicating that carbon capture and sequestration could be possible at a cost of approximately \$30 per ton of CO₂ Massachusetts Institute of Technology. (2007). *The Future of Coal: Options for a Carbon-Constrained World*. MIT: Cambridge, MA.

²⁶ U.S. Department of Labor, Bureau of Labor Statistics, Current Employment Statistics Survey.

²⁷ The Department of Labor projects coal employment to fall to 55,000 workers by 2014. See Berman, Jay (2005), “Industry Output and Employment: Projections to 2014,” *Monthly Labor Review*, Nov., 2005.

²⁸ See Barrett, James (2001) *Worker Transition and Global Climate Change*, Pew Center on Climate Change: Arlington, VA. See also Barrett and Hoerner (2002).

²⁹ See, for example, Interlaboratory Working Group. 2000. *Scenarios for a Clean Energy Future* (Oak Ridge, TN; Oak Ridge National Laboratory and Berkeley, CA; Lawrence Berkeley National Laboratory), ORNL/CON-476 and LBNL-44029, November.

³⁰ See, for example, Barrett and Hoerner, 2002.

³¹ Bezdek, Roger (2007). *Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century*. American Solar Energy Society: Washington, DC.

Author Biography

James Barrett is an Economist and Executive Director of Redefining Progress, a public policy think tank devoted to a healthy environment, a strong economy, and social justice. He has worked on a variety of issues concerning energy and environmental economics, including the impacts of carbon reduction programs on the U.S. economy, the economic implications of opening the Arctic National Wildlife Refuge to oil exploration, and the technical and economic feasibility of hydrogen production.

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