Cap and Trade Policy to Achieve Greenhouse Gas Emission Targets

by Dallas Burtraw

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 Farhenheit 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, *Cape and Trade Policy to Achieve Greenhouse Gas Emission Targets, by Dallas Burtraw*, 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

A carbon cap and trade system is currently the frontrunner in public policy strategies for limiting emissions. Some form of a cap and trade program is embedded in the initiatives underway in the European Union, the Northeast Regional Greenhouse Gas Initiative, and the Kyoto Protocol. Similarly, cap and trade is the approach that today dominates federal legislative proposals to address climate change. Cap and trade is attractive to policymakers because it is flexible, adaptive and it is a strategy that many believe can spur additional innovations in the shorter term allowing time for more long term strategies and investments to take effect. A cap and trade system has already been successful in reducing sulfur dioxide.

As the name suggests, a cap and trade system has two key components. The *cap* provides an absolute limit on emissions for the regulated group of entities. The opportunity to *trade* emission allowances among entities allows emission reductions to be achieved where they will be least expensive. To emit under such a regulation, a source would be required to surrender an allowance for each measured unit of emission. By capping the number of allowances initially distributed, the regulator caps total emissions. The system creates a direct financial incentive to reduce or avoid emissions: a source that can reduce emissions cost-effectively can sell its extra allowances into the market; if it cannot find a way to reduce emissions, it must buy allowances from those sources that have already managed to reduce their emissions.

In developing a cap and trade system, policymakers must decide whether to target a particular sector, such as the electricity sector, or whether to make the system economy wide. Regardless of the chosen target, any good cap and trade system must contain several critical design components including simple open architecture that is easy to monitor and expand, rigorous monitoring and enforcement, strong and certain penalties for noncompliance, an adequate time horizon to spur innovation, and appropriate initial allocations.

Of all the design elements, allocation is the most important. Because a cap and trade system will create immensely valuable intangible property rights, getting the allocation right from the start is critical to both the actual and perceived fairness of the system. In the first few decades of a carbon cap and trade system, it is expected that the cost of compliance throughout the economy will lag behind the allowance value. Thus, depending on how emission allowances are distributed and on the ability of various industries to pass through their compliance cost to their customers, the program can creat an opportunity for certain sectors or industries to gain a windfall from the system. An auctioning of initial allowances will help to address this concern.

As with all strategies to address climate change, the effectiveness of cap and trade depends on technical capabilities for monitoring, as well as legal and institutional regulatory capabilities that may not yet exist in many industrial sectors, states, and nations. With adequate governance mechanisms, cap and trade will be an important tool in the national and international effort to reduce greenhouse gases. Despite its many virtues, however, it will be unable to accomplish all of the goals that most researchers feel are necessary to mitigate climate change. Cap and trade is naturally complementary with other types of regulation meant to promote the development of specific technologies or to overcome specific market failures that might otherwise persist under a cap and trade approach.

Introduction

The cap and trade approach to environmental regulation provides a new degree of certainty in attainment of environmental goals while giving firms a new degree of flexibility for compliance with these goals. As the name implies, this approach has two parts. The cap provides an absolute limit on emissions for the regulated group of entities. The opportunity to trade emission allowances among entities allows emission reductions to be achieved where they will be least expensive.

The number of emission allowances (i.e., permits) created corresponds to the stringency of the cap. To emit under such a regulation, a source would be required to surrender an allowance for each measured unit of emission. By capping the number of allowances initially distributed, the regulator caps total emissions. Certainty in attaining environmental goals is achieved because the regulated entities do not have recourse to seek exemptions, delays, or variances in their obligations as they do under traditional regulation. Instead, if an entity does not achieve the necessary emission reductions onsite, it must surrender emission allowances. Moreover, traditional regulation that specifies a performance standard will allow emissions to grow along with the economy, but a cap constrains emissions to a specific level.

Flexibility is derived from the ability of regulated entities to trade responsibility for compliance. That creates a direct financial incentive to reduce or avoid emissions: a source that can reduce emissions cost-effectively can sell its extra allowances into the market; if it cannot find a way to reduce emissions, it must buy allowances from those sources that have reduced emissions. Entities with low-cost opportunities are expected to be the first to achieve compliance, and all entities have an incentive to search for low-cost opportunities. If a cap and trade program is implemented well, meaning that there is accurate monitoring of emissions and meaningful enforcement of the regulation, then both potential buyers and sellers have a continuous incentive to find efficient ways to reduce emissions.

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In the last decade, the idea of cap and trade policies moved from the politically incorrect to the presumptive approach for many types of environmental policies. The reasons for this transition include, first, a broader understanding of the theoretical justification for a cap and trade approach and, second, the evident success of the sulfur dioxide cap and trade program and other subsequent programs, such as nitrogen oxide emission allowances trading. The EU Emission Trading System has brought almost 50% of the carbon dioxide emissions in 27 nations under an emission cap. The Regional Greenhouse Gas Initiative will implement such a system for all electricity generators in a 10-state region of the northeastern United States in 2009. Trading is embodied in the Kyoto Protocol, and cap and trade is the approach that today dominates federal legislative proposals to address climate change.

In concept, the cap and trade approach could be applied to nearly all emissions from all sources. However, several political and administrative barriers remain to be overcome before an economy-wide policy could be implemented. Many environmental advocates mistrust cap and trade based on the experience of some previous poorly designed markets for emissions and other commodities. As with any regulation, a cap and trade policy can be poorly designed or poorly implemented or both. Indeed, it can be deliberately engineered to enrich some segments of industry or society at the expense of others. The effectiveness of cap and trade depends on technical capabilities for monitoring and legal and institutional capabilities that may not yet exist in many industrial sectors, states, and nations (see chapter by Bell). However, where the pieces are in place, cap and trade can offer important cost savings.

Experience With Cap and Trade

Emission trading was slow to come to fruition in public policy. Having first been developed as an idea in the economics literature, cap and trade had its genesis in policy in the form of offset programs developed in the late 1970s. Some areas of the country that were in nonattainment of the National Ambient Air Quality Standards could not site new power plants or other new sources of emissions, which literally put the environment in direct conflict with economic growth, a situation everyone wanted to avoid. To solve this problem, the U.S. Environmental Protection Agency's (EPA) Regulatory Reform group in 1975–76 designed a system of emission offsets whereby new emitting sources could pay existing sources to reduce their emissions sufficiently to "offset" any increase in emissions. The offset policy sought a way to enable localities violating the air quality health standards to support economic development without further increasing emissions. Variations on this theme included the "bubble" policy, whereby one could imagine placing a bubble over the multiple smokestacks of a plant and permitting emissions to be "traded" (more precisely, allocated) among smokestacks. In the 1977 Clean Air Act Amendments, Congress recognized the offset policy in law and also made it possible to "bank" emission reductions for later use.

The 1990 Clean Air Act Amendments formalized the use of cap and trade by applying it to emissions of sulfur dioxide and establishing an aggregate emission cap over all except very small sources. Industry is allocated a fixed number of total allowances, and firms are required to surrender one allowance for each ton of sulfur dioxide emitted by their plants. Firms may transfer allowances among facilities. The program also accommodates an allowance bank such that, in any year, aggregate industry emissions must be equal to or less than the number of allowances allocated for that year, in addition to the surplus accrued from previous years. Under Title IV of the Clean Air Act, average annual sulfur dioxide allowance allocations are capped at 8.95 million tons; this is approximately 10 million tons less than the amount emitted by utility facilities in 1980, which is also equivalent to emission levels expected by 2010.

The effectiveness of the sulfur dioxide trading program can be measured in a number of ways, but environmental effectiveness is the most important measure. Title IV has produced substantial declines in power plant sulfur dioxide emissions over the past 10 years. During the first phase of the program, sulfur dioxide emissions fell dramatically relative to previous levels: total emissions in 1995, the first year of the program, were 11.87 million tons—25% below 1990 levels (see Figure 1).[1] The second phase of the program began in 2000, when the remaining emission sources were included. A substantial bank of emission allowances accumulated because of reductions in the first phase, as firms took early action to smooth the transition to a more stringent cap. The bank has been drawn down gradually over this decade and was on course to achieve a stabilized level to accommodate inter-annual changes in weather, etc., by around 2010, at which time the annual long-run average emission goal would have been obtained. But in 2005 the Bush administration promulgated the Clean Air Interstate Rule, which tightens the regulation of sulfur dioxide even further for sources operating in the eastern United States. The increasing stringency of the program imparts increased value to banked allowances and strengthens the incentive for early emission reductions in order to bank allowances for future use.

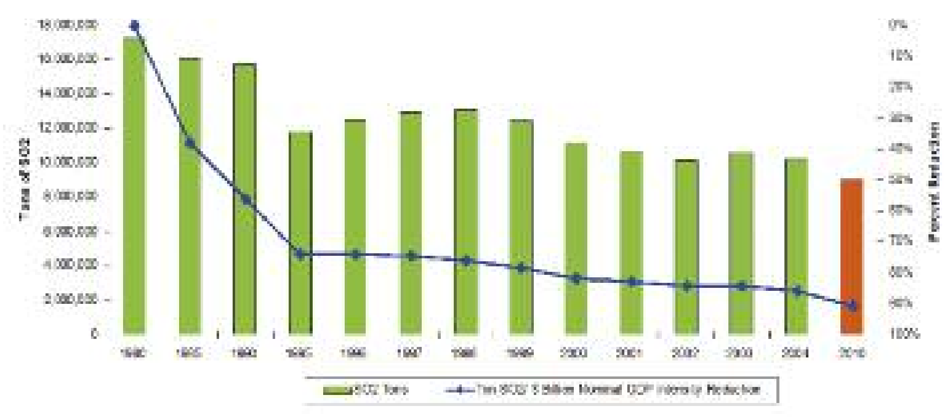


Figure 1. Sulfur dioxide emissions versus emission/GDP intensity (Source EPA)

The reduction in sulfur dioxide emissions under the cap and trade program is all the more remarkable given the large increase in electricity consumption during this period and the expanded use of coal for electricity generation. Figure 1 illustrates the dramatic change in the emission intensity of generation, measured as emissions per unit of gross domestic product. Even more striking, the anticipated cost of achieving emission reductions has fallen significantly. By these measures, the program is widely perceived as successful.

Allowance prices reflect the cost of emission reductions for the marginal facility, that is, one for which a strategy of further onsite emission reductions is essentially equivalent to the use of allowances for compliance. The costs of the emission reductions are 50–75% lower than EPA and others predicted when the program was adopted. The difference between projected and actual allowance prices is not a very good measure of the actual cost savings because changes in fuel markets—including the decline in the delivered cost of low-sulfur coal and in the price of natural gas and oil in the 1990s—contributed to a decline in emissions that likely would have occurred even in the absence of Title IV. However, after accounting for these changes, the total cost still fell 30–40% below costs forecast according to various studies (Carlson et al. 2000; Ellerman et al. 2000). This is significant because the cap and trade program provided firms with the flexibility to take advantage of these changes. In contrast to prescriptive regulation, the program enabled firms to develop individual strategies for achieving emission reduction goals.

Two subsequent experiments have reinforced the success of cap and trade in the sulfur dioxide program. One program of comparable magnitude was started by several northeastern U.S. states to regulate nitrogen oxide emissions from electricity generation facilities and other large sources; in 2003, this program expanded to include 19 states and the District of Columbia. In 2005, the European Union implemented the first mandatory cap and trade program for carbon dioxide. Phase 1 of the program is a trial period due to last through 2007. Phase 2 is designed to coincide with the first budget period under the Kyoto Protocol. Phase 1 has been volatile, which might have been expected given the lack of reporting and monitoring technology and criteria prior to the implementation of the program. Phase 1 is putting in place the methods needed to monitor emissions in Phase 2. Whereas the annual value of allowances in the sulfur dioxide and nitrogen oxide programs to date have been $2–3 billion, the annual value of allowances in Phase 2 of the EU Emission Trading Scheme will be at least 10 times that value.

The Role of Cap and Trade on a Crowded Stage

Although the cap and trade approach has been very effective, the most important reductions in pollution over history have been achieved with traditional prescriptive approaches to regulation. Where they have been rigorously applied, traditional regulatory approaches, such as building standards and efficiency measures, have made a huge contribution to pollution reduction in general and even to greenhouse gas emissions. Figure 2 offers one example. The figure depicts electricity consumption per capita over a period of four decades. At the national level, electricity consumption per capita has increased by more than 50% since the early 1970s because of increasingly widespread use of appliances and air conditioning, as well as larger building structures. In Texas, as the figure shows, starting from a much higher level, consumption per capita has also increased by more than 50% since the early 1970s. But in California, electricity use per capita has remained essentially constant since 1970.

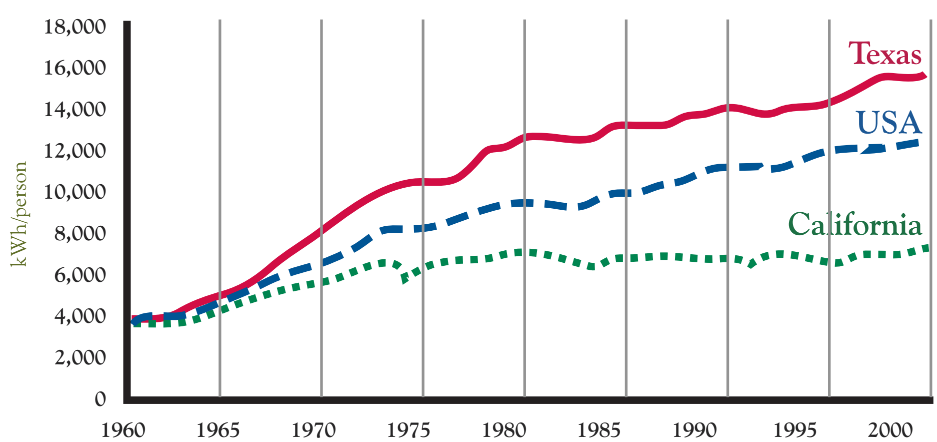


Figure 2. Per capita electricity consumption

One obvious question is whether California's moderate climate helps to explain its stabilization in per capita electricity use. The nation's population increasingly has migrated to lower latitudes where more air conditioning is required. Could this

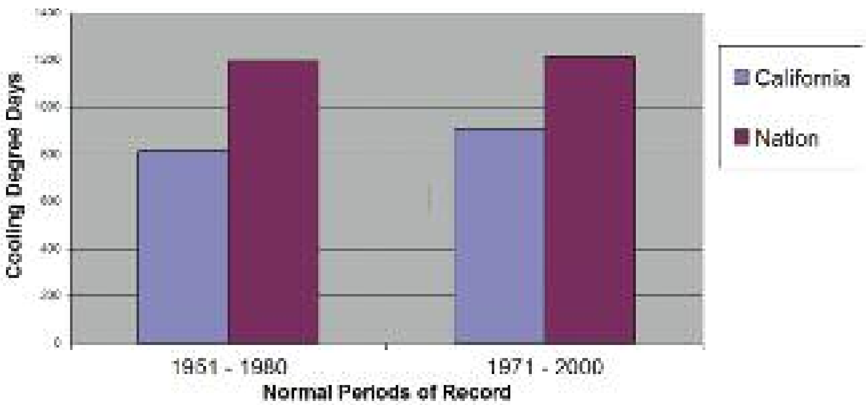


Figure 3. Per capita cooling degree days in California and the nation (Source: National Climatic Data Center, National Environmental Satellite, Data, and Information Service, National Oceanic and Atmospheric Administration, Historical Climatography Series Nos. 5-1 and 5-2)

account for the relative trends in California and in the nation as a whole? Figure 3 shows per capita cooling degree days for the nation and for California.[2] At the national level, per capita cooling degree days have remained constant over this time period, but California shows a 9% increase resulting from migration to the hot interior sections of the state. California's electricity use efficiency did benefit from a moderate climate during the historical period when air conditioning penetrated the market, but the gap between California and the nation has been closing.

Other factors, such as the de-industrialization of the state, also contribute to the trend in California. But the primary explanation for the stability of California's per capita electricity use appears to be the conscious choice made in the 1970s that no new large power plants would be built in the state. Transmission from out of state was not sufficient to make up for supply that would not be built, so the state was compelled to take measures to reduce electricity demand. This was done through a combination of deliberate policy and associated changes in the price of electricity.

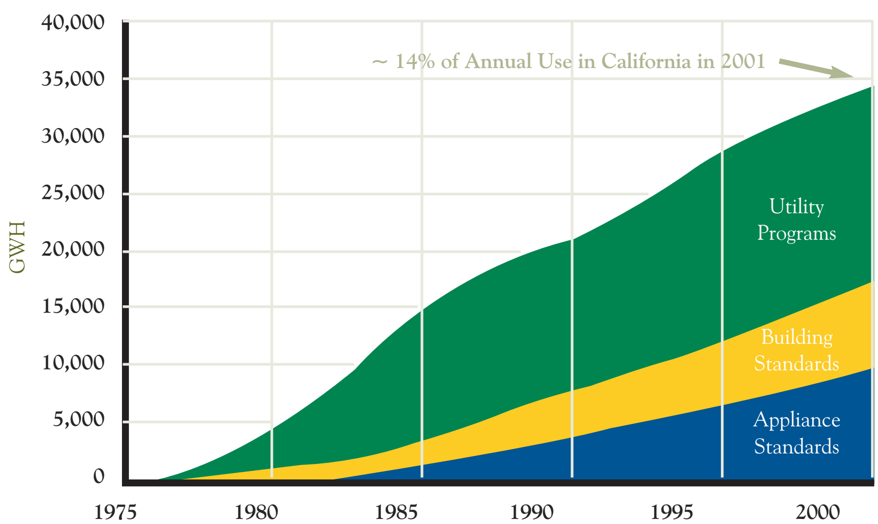


Figure 4. Electricity savings from programs in California (Source: Mike Messenger, California Energy Commission Staff, April 2003)

Over the last few decades, California has led the nation and the world in measures promoting energy efficiency, such as building and appliance standards and land-use planning measures.[3] Figure 4 illustrates one measure of the energy savings from these programs in the state. But the behavior of consumers also has been affected by electricity prices in California that are now as high as prices anywhere in the nation. Figure 5 shows how prices have changed in California, and in the nation, over recent decades. It remains to be seen whether policies or prices have had the more potent effect, and whether policies have achieved the greatest possible reductions for the cost they have imposed on consumers through building standards and other regulations. Clearly both policies and prices have combined to keep electricity consumption in California level on a per capita basis.

As the California example suggests, prescriptive regulatory policies have an effect on prices that helps to achieve overall energy efficiency. Cap and trade represents another way to use prices to affect behavior. By creating an intangible property right for emission allowances and creating conditions for a market for these allowances to exist, regulators create the conditions for a price to emerge. The price represents the opportunity cost of emissions and, as is the case for other costs of production including fuel and labor costs, this price will be reflected in the price of goods and services and will thereby provide an incentive to minimize these costs. Consequently, cap and trade is thought of as an incentive-based approach to environmental regulation because it will affect behavior through changes in relative prices.

Ultimately, a dramatic reversal of emissions may be required and, if so, this would no doubt require new technologies. Is cap and trade policy adequate to achieve this result as well? Economists tend to believe that, given sufficiently long time and sufficiently high prices, economic forces created by cap and trade would achieve this outcome. However, carbon emissions will continue to accumulate over long time frames. And with high prices come economic impacts that may be perceived as unfair or unsustainable politically.

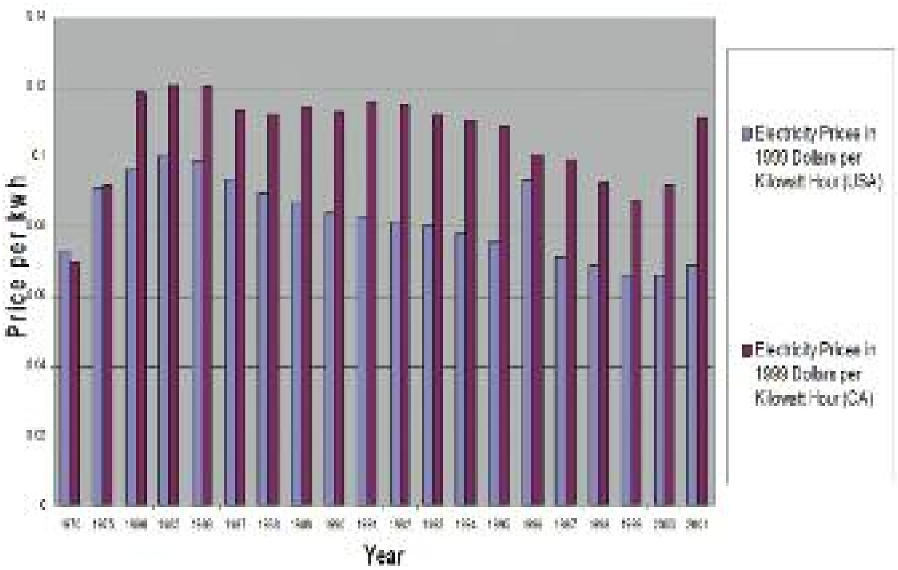


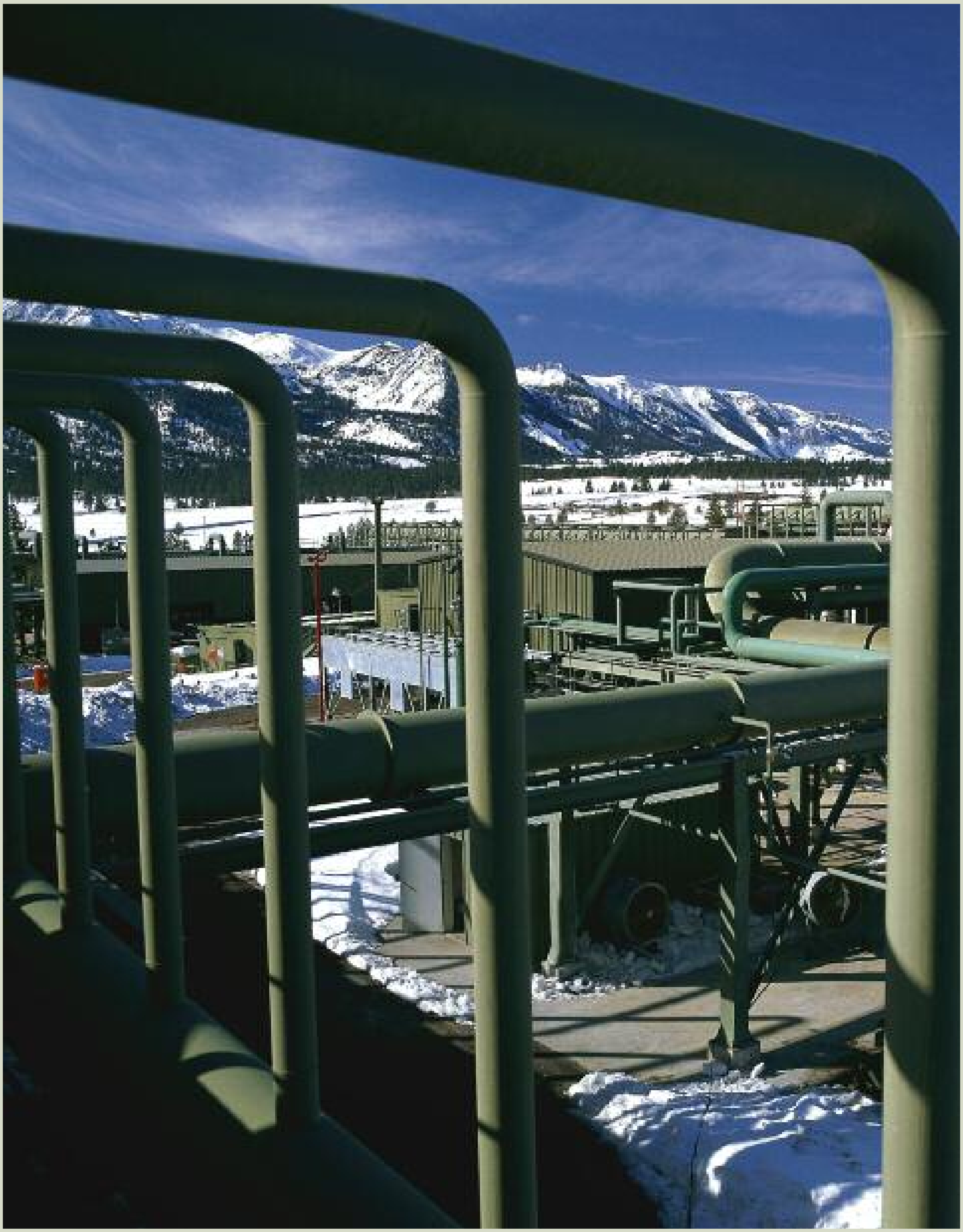
Figure 5. Electricity prices for California and the nation

There may be other reasons why incentive-based policies such as cap and trade are, by themselves, inefficient for supporting the amount of research and development that may be necessary. Prices associated with cap and trade programs tend to be a very effective way to move new technology into the market, but they are not efficient as a way to develop these technologies. For instance, firms may not be able to capture all of the benefits from research and development activities because the benefits of innovation tend to spill over to other firms. Consequently, rather than investing in research and development activities to an extent that would be socially desirable, each firm attempts to free ride on the investments made by others.

Some other reasons to consider policies other than cap and trade include the plethora of ways in which agents in the economy do not have the benefit (or burden) of seeing the full cost of the choices they make. For example, renters may not see the cost of their energy use if apartments are not individually metered. Electricity prices in general reflect average costs per unit of consumption over a season rather than the cost at a particular point in time. Such a list can go on and on, and each item reflects one or another type of failure of economic markets to perform perfectly. For all these reasons, environmentalists may argue that cap and trade is not a sufficient tool for achieving all of the long-run outcomes required to address climate policy goals.

Despite these potential limitations, cap and trade policies have their own unique justification, which is cost effectiveness especially in the short term. Achieving climate policy goals will require changes in behavior and economic decisions by millions of actors. History has shown that prices are especially good at efficiently coordinating the behavior of diverse agents in the economy in a way that prescriptive policies cannot do.

Furthermore, cap and trade policy helps to solve limitations associated with prescriptive regulation. One type of failure of regulation stems from asymmetric information between the firm and the regulator: governments have limited access to information that is uniquely and privately known by industry. A firm is likely to know much more than the government does about its costs of emission control, and its emission-reducing options for changing processes or investment plans. A prescriptive regulation can do no better than provide a one-size-fits-all approach that does not take advantage of the unique situation of an individual facility. Cap and trade, on the other hand, can give firms the incentive to reveal their true costs by giving them the flexibility to minimize those costs.



Another motivation for cap and trade is the incentive it provides for innovation that will lower costs over time. Under prescriptive regulation, after a firm has achieved a technological standard, it has no incentive to go beyond that standard. But in a cap and trade program, an emission allowance saved is a dollar earned. Even if firms lack the incentive to invest in basic research and development because the benefits of that research may spill over to other firms, the marketplace provides firms with the incentive to continue to find ways to adopt new technology when it is mature. A firm has the incentive to reduce emissions to consume fewer emission allowances, and this can help to ignite a process and culture of efficiency and innovation. Moreover, under a technology standard, emissions will continue to grow with expansion of economic activity; in contrast, a cap imposes the constraint that the emission intensity of economic activity must continue to fall to make way for economic growth.

In summary, a cap and trade approach is not likely to be perfectly efficient in achieving dramatic emission reductions or in affecting behavior in all sectors of the economy. For these purposes, direct technology policies or prescriptive policies may be useful. However, cap and trade is especially useful for affecting the broad swath of behavior that must change if climate policy goals are to be achieved in a cost-effective manner. For its part, cap and trade can be thought of as a policy to “leave no low-cost emission reductions behind.”

Should Cap and Trade Start in the Electricity Sector?

All cap and trade programs to date have targeted the electricity sector—along with some other large sources—because it is an important source of emissions. About 40% of carbon dioxide emissions in the United States come from the electricity sector. That amounts to roughly 8.8% of global energy-related carbon dioxide emissions.

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Just over 51% of the electricity generated in this country is produced using coal, which has a CO_2 emissions rate of roughly 1 ton per MWh. Natural gas, the second most important fossil fuel used to generate electricity, accounts for roughly 19% of electricity generation nationally, but has a CO_2 emission rate that is roughly half that for coal. Nuclear power and renewables including hydro are important non-emitting sources of generation.

Table 1 (following page) shows the potential changes in technology and fuel use in the electricity sector as a result of a national carbon policy. The left-hand panel in the table indicates the generation mix for 2004 and the Energy Information Administration’s (EIA) forecast for 2030 under a business as usual scenario, e.g. no climate policy. The Electric Power Research Institute (EPRI) has conducted a study of the opportunity for advanced technologies that would enter given climate policy. The increase (+) or decrease (-) that they project for each power generating technology (as compared to the base case EIA projection for 2030) is shown in the right-hand panel of Table 1. EPRI projects a dramatic increase in nuclear and natural gas, a decline in new coal, and a shift in the coal-fired power plants that do get built toward the use of carbon capture and storage technology. The EIA has analyzed a price-based policy that would impose a cost of $35per ton CO_2 by 2030 (2004 dollars). The right-hand panel of Table 1 summarizes their results.

EIA finds a similar growth in nuclear, but a much smaller growth in natural gas generation made up by a growth in non-hydro renewables. They also find a much larger decline in coal generation under a climate policy and a bigger decline in total energy generation. By 2030, most analysts would agree, these are the technologies that are relevant and there is little additional supply side technology that will be practical by that time. Even before that time we may see important upgrades in the transmission grid that can improve the efficiency of the grid and reduce line loss dramatically.

Table 1. Technologies for Electricity Generation in 2030

	Generation		Change in Generation from EIA Reference Case	
(billion kWh)	Data	EIA Reference Case	EPRI Advanced Technology Targets	EIA Cap-Trade Case (CT-3)*
Year	***2004***	***2030***	***2030***	***2030***
Technology				
Nuclear	789	871	506	547
Renewables**	323	504	123	687
Total Cost	1,954	3,205	-310	-1.439
Coal w/ CCS			789	***
Natural Gas	619	822	-352	48
Petroleum	115	101		-74
TOTAL	**3,800**	**5,503**	**-102**	**-231**

* Allowance price in Cap-Trade Case (2004 dollars): $22.09/ton CO_2 in 2010 and $35.23 in 2030.
** Includes hydro.
*** Except for plants currently under construction, the only coal plants built have CCS technology.

Sources: 2004 Generation Data: Total Electric Power Industry data from Table EIA-906: "Net Generation by State by Type of Producer by Energy Source." Available at http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html; EIA Reference Case and Cap-Trade Case: Energy Information Agency, "Energy Market Impacts of Alternative Greenhouse Gas Intensity Reduction Goals," (Table ES 2b) March 2006. Available on the Internet at tonto.eia.doe.gov/FTPROOT/service/sroiaf(2006)01.pdf; EPRI Advanced Technology Target: S. Specker, "Electricity Technology in a Carbon Constrained Future," (page 15) Electric Power Research Institute. February 2007. Available on the Internet at: mydocs.epri.com/docs/CorporateDocuments/Newsroom/EPRIUSElectSectorCO2Impacts_021507.pdf

However, there are also important demand side technologies that many argue could dramatically improve energy efficiency. Energy efficiency will likely be an important part of the activities undertaken to combat climate change as there are few options to reduce emissions associated with generation at existing facilities. Measuring the cost of efficiency programs is difficult. Engineering studies typically identify a vast array of opportunities to improve end-use efficiency at low cost. One study involving three national laboratories identify an achievable energy savings potential for electricity of 24% (Interlaboratory Working Group, 2000).[4] Other studies find similar results for various regions of the country (Nadel et al., 2004). However, a variety of institutional and market barriers impair the ability of investors to harvest these opportunities. In addition, due to the diffuse nature of these opportunities, they are often unrecognized or are given low priority by firms and households whose attention is focused elsewhere.

A cap and trade program raises the cost of delivered energy services and thereby provides an economic incentive to pay attention to ways to reduce energy use. However, an even more potent aspect of how efficiency is harvested in the economy may be through the use of allowance revenue under an auction. The Regional Greenhouse Gas Initiative requires that at least 25% of allowance value created by the program be directed toward strategic energy investments. In modeling on behalf of the State of Maryland, CIER (2007) found that investing this money in end use efficiency could reduce demand to a sufficient degree that it offset the increase in electricity price that otherwise would occur when the state joins the regional initiative.

Another reason that programs have targeted the electricity sector is that the measurement of emissions in the electricity sector is reliable and administratively simple. Carbon emissions can easily be calculated directly on the basis of fuel use, and large fossil sources regulated under the sulfur dioxide program have continuous emission monitors in place that allow for electronic verification of those calculations.

Furthermore, the electricity sector is often the target of new environmental regulation because its generating equipment is long-lived. A coal-fired facility may have an accounting life of 30 years, but its actual physical life may be 60–90 years. Therefore, one cannot rely on the natural turnover of generating equipment, by itself, to lead to emission reductions. But there are many other opportunities for cost-effective emission reductions and many of these opportunities will be cheaper than those being achieved in the electricity sector. Why not start with an economy-wide program?

One rationale for starting in the electricity sector is the lack of emission monitoring or fuel consumption information for other sectors of the economy. To date, cap and trade programs have focused on emission sources where the combustion of fuels actually occurs. If a program were to include the whole economy at the point of combustion, natural gas use by individual households would be included, as would automobiles. This explosion in the number of sources covered would raise costs, as well as both administrative and political issues.

Alternatively, a cap and trade program may achieve economy-wide coverage via application upstream in the fuel cycle, at the point of fuel extraction at the well or mine-mouth and at the border. Some climate policy legislation at the federal level would implement an economy-wide cap and trade program using this approach. Another alternative is a hybrid approach in which the point of combustion serves as the point of regulation for electricity and large industrial sources, but upstream fuel supply or fuel distribution companies serve as the point of compliance for household and automotive emissions. The choice over architecture at this level invites a lengthy discussion that we will not pursue here, but there are a few design elements, common to any of these approaches, that are essential to the success of a cap and trade program.

Design Elements for the Ideal Program

Whether a cap and trade program employs a midstream, upstream, or hybrid approach, it inevitably will start with modest emission reduction goals that can be expected to become more stringent over time. This is one reason why the program should have a simple open architecture that is easy to evaluate and to expand. It is important not to adopt complicated and idiosyncratic measures that make it difficult to tighten the cap or to include other sectors in the future. In addition, experience has taught us that relatively few other design elements are crucial to the success of such a program.

A central element of the initial design of a cap and trade program should be rigorous monitoring and enforcement. If the point of compliance is the point of regulation, as in previous cap and trade programs, then for the electricity sector and other large emission sources, the administrative infrastructure for monitoring is well developed already. Data collection methods, quality assurance mechanisms, and transparent and full access to reported data by all parties can be expected to make monitoring in the electricity sector uncontroversial in the United States. Strong monitoring should easily be achieved whatever the chosen point of compliance in the program. Transparency of data systems and their availability to the public is crucial; and, as noted above, the program must not be overly complicated.

A successful cap and trade program also requires strong—and certain—penalties for noncompliance. The heart of the cap and trade system is the confidence of investors that their efforts to reduce emissions will be rewarded through a reduction in their cost and a payoff with respect to their rivals. Firms may decide to invest substantial capital to reduce emissions, but if the value of the saved emission allowances is eroded by lack of confidence in the penalties and enforcement, then the confidence in the program in general will erode. However, enforcement requires resources and equipment for emission measurement and verification. It also requires political support for the authority to assess and collect penalties automatically in the case of noncompliance. As a consequence of such systems, compliance in the sulfur dioxide program has been virtually 100%. For example, 4 units out of 3,391 were out of compliance in 2004. Those four sources had to surrender allowances the following year and were fined $1.4 million for emitting 465 tons of sulfur dioxide in excess of allowances held in their accounts.[5]

When it comes to applying a cap and trade policy to achieve climate goals, the design element that rises above the rest is the allocation of emission allowances at the start of the program.

Another important issue is the time horizon of the program. Surveys in the United States and the European Union indicate that a long-term planning horizon is one of the most important features by which costs for industry may be reduced. Some firms even argue for a more stringent policy rather than one that is soft but subject to short-term administrative review and changes in program goals. For firms to make investments that might yield important early reductions in excess of what is required in the current year, as happened in the sulfur dioxide program, firms must have confidence that an emission cap will remain at the same or lower level into the future. Almost as important, the program will be on a path toward decreasing costs if firms have the incentive to achieve emission reduction targets early; this can occur because early investments are likely to start a dynamic cycle of innovation, learning by doing, and competition among vendors to further reduce costs. The opportunity to bank emission allowances for use in a subsequent period reinforces the incentive to make early investments in emission reductions without affecting the aggregate emissions over time. Banking ensures that all reductions will have an economic value in the long term even if the short-term gain is small.

In summary, there are just a few design principles that make up the essential elements of a successful trading program:

1. Simplicity
2. Transparency
3. Rigorous monitoring and strong data systems
4. Certain enforcement
5. An adequate horizon with banking so investments retain their value
6. Allocation

The issue of allocation is a crucial element for the design of climate policy that deserves an extended discussion.

Allocation is the Crucial Element

When it comes to applying a cap and trade policy to achieve climate goals, the design element that rises above the rest is the allocation of emission allowances at the start of the program. Allocation is especially important in the context of cap and trade for CO_2 because the value of emission allowances is potentially so much greater than in any previous trading program. It is estimated that even a modest policy targeting only the electricity sector in the United States will create an intangible property right with a value of $40 billion every year; and that value will grow as the stringency of the program grows over time. If allocation is not done correctly, it could undermine the other virtues of a cap and trade approach to climate policy.

One of the key considerations in allocation is that the total dollar value of the emission allowances that is created by the formation of an emission market is not proportional to the cost of achieving the required emissions reductions. Figure 6 is a hypothetical diagram that illustrates why the two measures are not comparable. In this figure the horizontal axis is the reduction in emissions (moving to the right implies lower emissions). The upward sloping line denotes the increasing costs of a schedule of measures that can be adopted sequentially to achieve ever greater reductions in emissions. It starts at zero, indicating that the first unit of pollution reduced is not very expensive, and then it increases with the stringency of the program. At a given emission cap, the marginal cost of emission reduction is the cost of the most recent measure adopted. This cost sets the price in the allowance market because it represents the cost for the next unit of reduction and the benefit of avoiding further reductions. If the market is efficient, this price is what anyone in the market would have to pay to obtain additional emission allowances. The vertical line (from the horizontal axis to the upward sloping line) indicates the emissions cap (the maximum amount of emissions allowed). At the level of the emissions cap, a triangle is formed that represents the total cost of reducing emissions to achieve compliance; the area of the triangle to the right of the emissions cap is the sum of the resource costs for each incremental measure adopted, starting from zero and ending at the emissions cap.

To the right of the level of emissions set by the cap, a rectangle is formed in the picture. The height is the marginal cost of reduction (or equivalently the price of an allowance); the width is the allowable emissions (or equivalently the number of emission allowances). The price of allowances multiplied by the quantity of emission allowances equals the value of emission allowances. Panel A in Figure 6 characterizes the situation for the sulfur dioxide program created under the 1990 Clean Air Act Amendments, which called for a roughly 50% reduction in emissions. In this case, the value of emission allowances (the area of the rectangle) is roughly twice the resource costs of reductions (the area of the triangle).

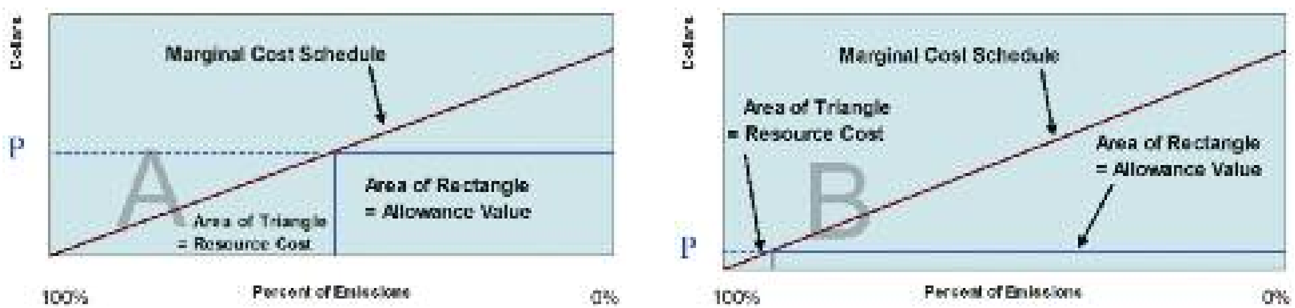

Figure 6. The value of emission allowances significantly exceeds compliance cost; Panel A: Allowance value is roughly twice compliance cost with the sulfur dioxide trading program; Panel B: Allowance value is roughly eighteen times compliance cost with a modest carbon dioxide trading program.

Panel B of Figure 6 illustrates why the situation is different for carbon dioxide. Imagine that, in this case, we set a moderate goal targeting a 10% reduction in the first phase of a federal program. For such a reduction, the area of the allowance value rectangle is about 18 times the size of the resource cost triangle! In other words, the value of emission allowances is much greater than the cost of emission reductions. Furthermore, the value of the allowance (the rectangle) continues to grow faster than the cost of emission reductions (the triangle) until reductions of roughly one-third, when that trend begins to reverse.

Two factors contribute to the importance of allocation specifically for a CO_2 cap and trade program, more so than for previous cap and trade programs. One is the overall magnitude of the program and of the allowance value. The second is that the allowance value is so much greater than compliance costs, at least for the level of emission reduction we can reasonably expect will be targeted in the early years of even an aggressive climate policy.

Economic theory suggests that the creation of this value and its recognition in the market is important to creating long-run incentives for investment in new, more climate friendly equipment to replace older equipment that pollutes more. The manner in which allowance value is initially distributed does not have to correspond to the way in which emission reductions occur. Regulators could target responsibility for compliance at one point in the emission or fuel cycle, and they could target another point for the allocation of emission allowances as a way to compensate for the change in costs. In the electricity sector, some generators are hurt more than others as a result of an emission trading program, so they may have a stronger justification for compensation. However, detailed modeling indicates that, in fact, electricity consumers are hurt the most by far because most of the costs of the program—both the costs of reducing emissions and the cost of emission allowances—are passed on to consumers through higher prices (Burtraw and Palmer, 2007). Consequently, free allocation of emission allowances to electricity generators can dramatically overcompensate generators and lead to substantial windfall profits. Evidence in the EU Emission Trading Scheme verifies this, where free allocation of emission allowances during the first phase of the program is widely recognized to have led to windfall profits (a revenue increase in excess of the cost increase under the program).[6]

Instead of giving emission allowances away for free, the distribution of emission allowances through an auction is an approach that is increasingly receiving attention. For many, this approach seems fairer, and virtually all economists argue that it is more efficient. An auction can be more efficient for at least three reasons. First, it generates new government revenues that can be used to reduce other taxes, such as pre-existing labor taxes, or to help fund research and development for carbon reduction and new energy technologies. Second, an auction is the best way to ensure appropriate prices in the electricity sector—that is, prices that reflect the true costs of providing electricity with different forms of technology.[7] Third, an auction avoids an administrative procedure for allocations based on deal-making and special privilege that has been likened to a "beauty contest" and shown in other contexts (such as allocation of licenses for telecommunications) to be very inefficient.

If a modest policy in the electricity sector would create substantial allowance value, it is just a portion of the wealth that would be created under an economy-wide policy. For the nation, it is estimated that an economy-wide policy could create an asset of well over $125 billion in annual value to achieve reductions of 4.8% from baseline by 2020 (EIA 2006). The crucial feature, as noted above, is that this value exceeds the cost of achieving emission reductions.

A perception of fairness is essential to the political will to move forward, and the distribution of allowances is key to this perception. Indeed, the institution that would be created under a cap and trade program is analogous to the government creation of wealth in the 19th century through the establishment of property rights in the great western United States and the distribution of those rights. The value of emission allowances is on the same order of magnitude as the value of social security; as a program that will be in place for a century, a cap and trade program is likely to be the most important governmental creation of wealth of the 21st century. All these factors make the design of allocation the most important feature of a cap and trade program. Getting everything else right and allocation wrong would make cap and trade not worth doing. Indeed, getting allocation wrong would erode public sentiment and would be counter productive to the long-run goals of climate policy. However, getting allocation right can reinforce program goals and help to achieve them in an efficient manner.

The Role for Cap and Trade in Climate Policy

Cap and trade is an important tool in the national and international effort to reduce greenhouse gases. Despite its many virtues, however, it will be unable to accomplish all of the goals and tasks that researchers feel are necessary to mitigate climate change. Cap and trade is naturally complementary with other types of regulation meant to promote the development of specific technologies or to overcome specific market failures that might persist under a cap and trade approach.

The role for cap and trade could grow over time if the nation's commitment to mitigating climate change grows stronger. For this to be possible, a cap and trade program should strive, at the outset, to establish public confidence in the allowance market with transparent rules and an open architecture that allows for the program to expand over time.

Even when other regulatory approaches are in some cases indispensable, the implementation of a cap and trade strategy for achieving broad-scale emission reductions offers efficiency advantages. Ultimately, decisions of millions of businesses and individual households will be affected. By using prices associated with the emission allowances as a mechanism to coordinate the efforts of agents throughout the economy, our climate goals can be achieved at lower cost, which will allow room for still more stringent environmental policies, should they become necessary.

ENDNOTES

[1] See Burtraw, et al. 2005 for more background.
[2] A cooling degree day is a quantitative index reflecting demand for energy to cool houses and businesses. These indices are derived from daily temperature observations.
[3] Hanemann (2007) provides an excellent review of policy in California over this period.
[4] The achievable potential is constrained by the rate at which homes and business will actually adopt energy saving technologies and practices.
[5] U.S. EPA, 2005.
[6] For example, in 2005 power generators in the UK made around 1 billion euros in profit from the way that carbon prices fed through to electricity prices (The Carbon Trust, 2006)
[7] Because electricity for much of the nation is based on the cost of service regulation rather than competitive prices, electricity price does not reflect the opportunity cost of allowances that are distributed for free.

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Author Biography

Dr. Dallas Burtraw is a Senior Fellow at Resources for the Future. He holds a Ph.D. in Economics and a masters degree in Public Policy from the University of Michigan.

Dr. Burtraw has a long-standing interest in the design of incentive-based environmental policies in the electricity industry and has authored extensively on the performance and design of emission trading programs in the US for sulfur dioxide and nitrogen oxides and the EU's Emission Trading Scheme for carbon dioxide. In 2004, Burtraw and his colleagues completed a major project on estimating benefits of the value of natural resources in the Adirondacks Park through surveying residents of the area on their willingness to pay for improvements. Current work is extending this methodology to measure the benefits of ecological improvements in the southern Appalachian mountain region. He also led the economic component of an integrated assessment that examined the pollution pathways linking changes in emissions under Title IV of the 1990 Clean Air Act Amendments and health and environmental endpoints. He also participated in the development of a comprehensive seven volume study, conducted jointly by Resources for the Future and Oak Ridge National Laboratory, on the environmental impacts of electricity generation.

Burtraw currently serves on the EPA Advisory Council on Clean Air Compliance Analysis, on the National Academies of Science Board on Environmental Studies and Toxicology. He recently served on California's Market Advisory Committee for implementation of Assembly Bill 32, the states greenhouse gas legislation.

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