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**Designing a Carbon Dioxide Trading System:
The Advantages of Upstream Regulation**

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Executive Summary

The US is likely to employ a cap and trade system for carbon dioxide emissions when we become willing to face up to the realities of climate change and the risks it poses. This paper argues that the US should use an upstream system for administering this program. An upstream system would measure carbon, and trade the right to use that carbon, at the point where fossil fuels enter the economy. This system will work better than a downstream system, where emissions are measured and rights are traded at the point where carbon dioxide is released into the atmosphere. The choice of where and how to administer a cap and trade system should be based on efficiency, transparency, and breadth of coverage. Choices about how stringent the cap should be, and who gets the initial allocation of carbon rights, are independent of the choice between upstream and downstream systems.

An upstream system would be administered at natural gas pipelines and gas processing plants, oil refineries, coalmines and coal processing plants, and all points where fossil fuels are imported or exported. Because carbon emissions can be accurately predicted from the carbon content of fuel, it is not necessary to actually monitor the emissions from final end users to know how much carbon dioxide will be released into the atmosphere. Compared with systems that regulate carbon dioxide at the point of combustion, such a system would

- Regulate far fewer companies and individuals -- about 2,000, compared to hundreds of millions. As a result, this system would be far less intrusive and require less paperwork than a downstream system with comparable coverage.
- Regulate a larger share of carbon dioxide emissions with less risk of omission or evasion
- Give the same incentives for carbon dioxide reduction to all fossil fuel users, maximizing the potential for technological innovation and conservation
- Cost less money to achieve a given level of emissions reductions
- Achieve greater reductions for the same economic cost
- Be consistent with any pattern of allocating carbon dioxide emissions rights as in any other system
- Demonstrate US leadership in implementing the first true economy-wide system to quantitatively limit carbon dioxide from fossil fuel use

The choice of the point of regulation for a carbon dioxide control program should depend on how to get the most reductions for the money, with the least chance of evasion and the least possible paperwork and hassle for American companies and citizens. How stringent the system should be, and who should get the initial rights to emit carbon dioxide, are independent of this choice. Carbon dioxide limits will be a long-term feature of our response to the risks of climate change. It is important to choose the right institutional structure from the beginning.

Designing a Carbon Dioxide Trading System: The Advantages of Upstream Regulation

Introduction:

Although the Bush Administration has declined to offer or support a mandatory program to reduce carbon dioxide emissions from the use of fossil fuels, there remains a strong desire for such a program in Congress, the NGO community, and the nation at large. Even among many entities that would prefer to avoid mandatory carbon reductions, there is an expectation that eventually the US will have such a program. There is also general support for the idea that any such effort should take the form of a carbon dioxide cap with an emissions trading system. The benefits of efficiency, transparency, and flexibility of such a system have been convincing to businesses, NGOs, academics, and authors of the main congressional bills currently under consideration.

The purpose of this paper is to discuss a somewhat technical but extremely important design parameter of a national-level cap and trade system for carbon dioxide emissions. The issue is at what point in the US energy markets should carbon be measured against the permits necessary for its use in the US economy. **Downstream** systems require permits to be held, and carbon to be measured, at or near the point of final use. **Upstream** systems are based on measuring carbon at or near the first point that it is introduced into the economy.

This paper argues that an upstream system is the right choice for the United States. Most important, it provides the most comprehensive coverage of fossil fuel use by focusing on the limited number of points where fossil energy enters (or is exported from) the US economy. For this reason, it is best suited to continue to be comprehensive as the energy production and delivery system go through anticipated and unanticipated changes. It also promises to be the least expensive and least confusing system to operate, and the system that makes evasion the most difficult. Further, a comprehensive upstream system would be the first of its kind, and would demonstrate US leadership in going about climate change mitigation in the right way.

The choice of the point of regulation is only one key design element for a cap and trade system. The degree of stringency – the overall cap on carbon -- is fundamental. Perhaps even more important is the way that rights to emit carbon are given or sold to energy companies, utilities, and other institutions and individuals affected by such a system. This paper emphasizes that these essential choices are independent of whether an upstream or a downstream design is adopted, and therefore should not drive the decision about the best point of regulation.

There is widespread support for a downstream system in the proposals that have been put forth in Congress and by NGOs. This is true in part because of the success of another downstream system – the Acid Rain Trading Program created by the 1990 Clean Air Act Amendments. The success of this program in achieving significant emissions reductions effectively and efficiently has made it a model for regulatory programs to deal with many other environmental problems. It is important to recognize that the idea of cap and trade regulation can be implemented in different ways depending on the nature of the pollution problem and the organization of economic activity. This paper argues that the success of the acid rain program can best be duplicated in a carbon control system by adapting it to the specific circumstance of fossil fuel carbon emissions, and not by replicating it as closely as possible.

The paper proceeds by briefly describing upstream and downstream systems. It then discusses the alternative designs in light of important performance characteristics. It concludes by

emphasizing that the design of a carbon reduction system should be made with special attention to the long-term and systemically broad nature of the problem.

Upstream and Downstream Systems

Cap and trade systems work by issuing a given number of total allowances. All entities in the system that emit – in this case, carbon dioxide—must possess an allowance for each unit of emissions. Total emissions from covered entities cannot exceed the cap, but allowances may be bought and sold as individual parties in the system pursue their emissions reduction strategies.

Downstream Systems

Downstream systems track allowances and measure emissions at the point where they are released into the atmosphere. Electric utilities, for example, measure sulfur dioxide at the point of combustion. The cost of allowances is incorporated into pollution control, production, and pricing decisions of the utilities. For the majority of pollution control systems based on the measurement of actual emissions, downstream systems are the only feasible systems. Quantitative limits, whether implemented through cap and trade programs or some form of command and control, can only be implemented and enforced at the point where emissions are released into the ambient environment. This is because the level of emissions depends not just on input use (e.g. coal quantities and type) but also on post-combustion control devices or combustion process engineering parameters. For example, the same quantity of coal can produce drastically different quantities of sulfur dioxide or nitrogen oxide emissions.

Upstream Systems

Upstream systems work by regulating and measuring emissions at the point where polluting substances enter the economy. In the case of fossil fuels, this means that carbon emissions are measured at oil refineries, natural gas pipelines and processing plants, coalmines and processing plants, and importing and exporting facilities for these fuels. This only works because the carbon content of fuel is a very good predictor of the carbon emissions from combustion.

Actual measurement of emissions is not necessary; all that is required is for the carbon content and the quantity of fuel to be measured. This makes the problem fundamentally different than other emissions. It is this characteristic that makes an upstream system possible. In an upstream system, the cost of emissions allowances is incorporated into the price of fuel to wholesalers and then to end-users.

Hybrid Systems

Hybrid systems are a combination of upstream and downstream systems. Some subset of energy users would be governed by a downstream system, and would be required to hold permits that match their emissions. Other energy users would be required to buy from supply chains where an allowance for the carbon content of fuel is required when it enters the energy delivery system.

Measurement and Reporting

Measurement in a Downstream System

One important characteristic of any emissions control system is the complexity and expense of administering it. In the case of carbon dioxide emissions, the cost and difficulty of measurement is a central consideration. Electric power plants already have the equipment to measure CO₂ emissions because of the requirements of other air pollution control programs. Other large industrial processes that use large amounts of fossil fuels could measure carbon emissions by keeping track of and reporting fuel use through the extension of existing energy survey and reporting procedures. If they were the only CO₂-emitting sector of the US economy, a

downstream system would work well. However, they represent only about 48% of CO₂ emissions.

Transportation, home heating, and other industrial processes comprise the remaining 52% of emissions. It is clearly impractical to measure actual emissions from the transportation and home heating sectors. The idea of requiring individual homeowners with gas furnaces and water heaters, individual drivers, and users of lawn mowers and powerboats to measure the carbon emissions from their fossil fuel use is prohibitively expensive. Such a system would have to be designed around having these hundreds of millions of entities measure the volume of different types of fuel as a proxy for carbon content (as in an upstream system). Even then, requiring each individual to buy and sell permits, and report all of this use to a central entity, is overly burdensome and costly. A downstream system for these entities is simply infeasible. For this reason, downstream systems can be designed to cover only about half of carbon dioxide emissions from fossil fuel use.

Measurement in an Upstream System

An upstream system is based on measurement of the carbon content and volume of fuel entering the economy. For this reason it has very straightforward measurement and reporting characteristics – allowances must be held for all fuel that is sold. There are still design and implementation problems that make this more complex. For example, refined petroleum products and natural gas that are used as manufacturing feedstocks rather than for energy generation should be exempt from allowances if they do not result in CO₂ emissions. However, the relatively limited number of entities (estimated at around two thousand, as opposed to the hundreds of millions of fossil fuel users) in an upstream system make measurement and reporting fundamentally simpler and less costly than in any system with similar coverage that has a significant downstream component.

Coverage and Leakage

The foremost and largest problem with downstream systems is incomplete coverage. If a downstream system covers only a portion of carbon emissions, then it will be more expensive to achieve any given level of emissions reductions for the US as a whole. Relatively cheap emissions reductions from uncovered sectors -- for example, home heating – will not be made, so much more expensive reductions in covered sectors – e.g. electric utilities – will be required. The economic costs of greenhouse gas mitigation will be significantly higher as a result.

Even if non-covered sectors were covered by other forms of regulation – for example, energy efficiency standards for vehicles and furnaces – these alternatives would be less efficient and less certain tools for carbon reduction than cap and trade systems. Such regulatory systems do a poor job of encouraging firms within a given economic sector to concentrate emission reductions where they can be accomplished most inexpensively. And they almost inevitably result in the cost of reducing an additional ton of emissions being higher in one sector of the economy than in the other.

When costs of controlling an additional unit of production are unequal among sectors, the result is analogous to that of leaving some sectors uncontrolled. In this case, some sectors are compelled to make relatively expensive control measures while relatively less expensive control measures in other sectors are neglected. Either a) the total costs of control are higher than need be or b) less reduction of emissions than could be achieved occurs or c) there is a combination of a and b.

Consequences of Incomplete Coverage

This inefficiency can be expected to become worse as a system of partial coverage distorts the incentives for organizing economic activities based on energy use. Suppose that the electric

sector is covered but the home heating sector is not. Individuals facing a choice between electric heating and cooling will pay a premium for electricity because of the additional costs added by the cap and trade system, and so more people than otherwise will choose gas. The electric utilities will still emit CO₂ up to their cap, but more and more emissions will result from home heating from gas. This is called leakage – energy use, and therefore carbon emissions, will leak from regulated to unregulated entities.

The more stringent the cap, and the higher the price of carbon allowances, the more pronounced the price difference and the larger the amount of leakage. This effect may initially be small, but over time – as people make capital choices and controls may become more stringent – it would become extremely important. The end result would be increased difficulty in meeting national climate goals. The emissions reductions achieved by this system would cost more than under an efficient system with broader coverage. Put another way, this system will not squeeze the maximum amount of carbon reductions out of the significant economic resources invested in meeting the goals of the cap and trade system.

There is a particular risk of skewed incentives in industrial applications. If there is a statutory demarcation between entities covered under the program and those that are not (for example, a minimum threshold for size or energy use), then new manufacturing capacity will be built in reaction to these rules. Already, small-scale production energy from natural gas is relatively economic. If fuel cell technology becomes economically viable (with the hydrogen production coming from processes powered by fossil fuels), then electricity can be generated at an even smaller scale.

The fact that an industrial upstream system may now capture a large share of emissions is not the problem – it is that future economic development decisions will be affected by differences in relative prices. The result will be a competitive disadvantage for covered sectors, and greater overall carbon emissions in the US. Any trend toward decentralized energy production – whether it be combined cycle natural gas turbines, fuels cells, or some other fossil fuel-based system – will make considerations of leakage and coverage even more important in a system which does not cover all fossil energy use in the US economy.

Challenges to Complete Coverage in an Upstream System

Upstream systems face two kinds of complexity relating to coverage that do not affect downstream measurement systems. If end users discover ways to sequester CO₂ after burning fuel, then they should not have to pay indirectly for the allowance used to introduce that fuel into the economy. This could be handled by giving these end users allowances equal to their verified sequestration, which would then be sold to upstream entities. Secondly, some fossil fuels are used as chemical feedstocks, and therefore do not produce CO₂ emissions. These substances should not require allowances. However, the system must be able to make sure these exempt fuels do not “leak” their way into energy production in order to avoid paying the allowance price.

Hybrid systems

Since the limited coverage of downstream systems will inevitably result in inefficiency, leakage, and skewed incentives, one solution is to use a downstream system for electric utilities and large industrial emitters, and create a modified upstream system for all other fossil fuel users. Transportation, home heating, and other sectors would be have a cap and trade system that would be administered either fully upstream, or at intermediate points such as natural gas delivery companies and gasoline distributors. Such a system is probably feasible, but would be both complex and expensive to run. For example, natural gas delivered to electric utilities would not require a gas pipeline to hold a permit, but gas delivered via that same pipeline to domestic

distribution companies would require a permit. Further, fuel re-sold from one distributor to another before its eventual use would necessitate careful tracking to avoid either never requiring a permit, or requiring an allowance more than once.

In addition to being administratively complex, such a system would run some risk of being evaded, either through cheating or through manipulation of loopholes. Entities that found ways around requiring an allowance for each unit of carbon would make unfair profits, gain a competitive advantage, and increase their market share. This would lead to leakage – which, again, causes larger quantities of emissions, punishes those covered by and complying with the system, and increases the overall costs of any given level of carbon emissions reduction. Such a result would be regarded as unfair, and make it more difficult to hold together a national consensus to bear any short-run economic losses from climate change mitigation. A hybrid system is probably workable, and is certainly preferable to one that covers only utilities and large industrial users. An upstream system would provide the same coverage with lower risk of evasion and loopholes.

Arguments for a Downstream System

There are two oft-stated reasons why a downstream system is the right way to proceed in carbon mitigation: the contention that the incentives and behavior are different in a downstream system, and the idea that we should begin with a system that has already demonstrated its feasibility and efficiency. There is a third reason that is extremely important but often not discussed directly – the idea that the allocation of allowances would be very different in upstream and downstream systems.

Effective Incentives for Reduction

One line of reasoning used to argue for a downstream system is that it provides more effective incentives to innovate and conserve. Individuals and institutions are more responsive to the costs of buying and selling permits than they are to changes of the same magnitude of the prices of the energy they buy. There are two reasons given why this might be true. One of these – the economic rationale – is a misunderstanding of how these systems actually work. The second is a behavioral argument.

The economic argument suggests that if firms making decisions about fuel use and conservation can free up permits that they can sell, they have greater financial incentives to reduce carbon than if they simply save money by using less (or less carbon intensive) energy. For the same price of a unit of carbon emissions, this is simply not true. The price of carbon permits will have the same effect on final energy prices independent of where in the supply chain permits are held and traded. As an example, take a situation where fuel costs \$90 per unit, and each unit contains one ton of carbon. Let's say that a company can invest \$1,000 in energy efficiency to reduce fuel use by 10 units of fuel, thereby reducing carbon emissions by 10 tons. Assume that the price of a carbon permit is \$30 per ton. In a downstream system, the company faces a price of \$90 per unit, and so benefits \$900 from fuel cost savings and \$300 from the sale of permits they no longer need; after subtracting the \$1,000 dollar investment they are better off by \$200. In an upstream system, the fuel seller would need to buy a \$30 permit for each unit of fuel sold, and so the cost of fuel to the firm is \$120 per unit. The benefit of the investment would be the same: \$1200 - \$1000, or \$200. The financial incentive to engage in the project is identical.

The behavioral argument is that managers will be more conscious of energy saving opportunities if they are buying and selling permits than if they are simply paying a higher price for energy, even if the financial consequences are identical. There is no way to confirm or refute this argument without a controlled experiment or trial. However, as long as the carbon cap for the

covered sector is the same under both systems, overall carbon emissions will be identical. The fact that managers miss opportunities in an upstream system would be reflected in greater demand for permits and a higher permit price. This would increase the costs of the system, but the higher price would also give a greater incentive for those energy managers to look harder for energy saving opportunities.

Ultimately, cap and trade systems work by causing decision makers to consider a direct financial cost of changes in emission levels. Those that respond to the increased cost of carbon emissions most efficiently will be rewarded in the marketplace. In both upstream and efficient downstream systems, trades will likely be frequent and entail low transactions costs, and carbon emissions will become an explicitly priced factor in business decisions. The point at which the system is administered will be far less important than the magnitude of the price signal, the transparency and transactions costs of running the system, and the breadth of the system's coverage.

Start with What We Know

Advocates of a downstream system argue that it is better to start small with what we already know how to do, and then to let the system evolve and expand over time. Since the US has experience in running downstream utility-based cap and trade programs, we should begin with such a program for carbon and then expand after the system has been demonstrated to work. I have argued above that such a strategy is problematic because of the inherent inefficiency of achieving reductions in a narrow sector of the economy while allowing relatively unchecked use in significant activities like transportation and home heating. There is an additional complication in the evolutionary argument – that such a system is likely to involve institutional developments that make such changes difficult.

One potential complication comes from the possibility of offset purchases by the covered sector from uncovered sectors. Offsets will likely be a part of any mandatory carbon cap and trade program as a way of bringing about low-cost reductions in biological sequestration and in non-fossil fuel emissions (for example, landfill methane emissions). Entities that can demonstrate that they have reduced emissions below some baseline, or business-as-usual level would be issued allowances for all or part of that voluntary reduction. These allowances could then be sold to the sectors covered by a downstream system. Uncovered fossil fuel users would have every incentive to try to be covered by an offset system. The businesses providing the offsets are essentially being given a baseline of business-as-usual emissions. They profit from any reductions, and the sectors covered by the downstream system gain because allowances become cheaper and more plentiful as the offset allowances enter the system. Any move toward expanding the system will take away the profits from these offsets, which will magnify resistance to a new regulatory structure. Overall, this situation will make it politically difficult to include these sectors in an expanded system with a level of stringency comparable to the original system.

In addition, a downstream cap and trade system for utilities and large industrial users would entail significant investment and institutional development by both companies and government. Having adjusted to such a system, all parties would be reluctant to invest new resources to learn to manage and cope with a new system.

Reducing fossil fuel carbon needs to be done throughout the economy, and the effort and cost should be shared fairly and efficiently among all users. We have learned a great deal about administering cap and trade systems. In this case, it is best to start at the appropriate, economy-wide level, even if this means engaging in the hard work, careful thought and testing, and education necessary to design a system that best fits the problem.

Allocation of Permits

In any cap and trade system, the way permits are allocated is the central question in how much the system costs businesses. Permits are valuable assets that are expensive to buy, and create revenue when sold. Any individual entity in a carbon cap and trade system will be far better off if they are allocated permits for free than if they have to buy them.

In the Acid Rain Trading Program, utilities were allocated permits for free, and this has worked to their financial advantage relative to alternative allocation possibilities. There is an expectation that they would receive similar treatment in a downstream carbon cap and trade system. If an upstream system had a different pattern of allocating initial allowances – for example, to fuel producers and pipeline operators – then utilities would be significantly worse off than under a downstream system where they were allocated free allowances.

However, this is a question of wealth distribution and fairness, and not of whether an upstream or downstream system is a better design. In either system, permits could be allocated to any combination of energy producers, transporters, and utilities. Permits could also be allocated to areas particularly affected by the policy (coal-producing states, for example), or to any other entities or individuals. The government could also auction some share of permits and use the revenues for debt reduction or to offset income tax cuts, for investments in energy research, or to compensate those most economically affected by a carbon cap and trade system. Revenues could even be used to refund money directly to all citizens in equal shares. The point is that utilities could be allocated the same, fewer, or more free allowances in a downstream system than in an upstream system. In an upstream system, utilities would sell these permits to suppliers or negotiate a price for fuel based on their providing the required allowances.

Whether allowances are given away or sold, and to whom, is a central question for a cap and trade system. There are efficiency and fairness arguments to be made for many different allocation patterns. However, there is no technical or economic reason that any allocation pattern that is feasible in a downstream system could not also be used in an upstream system.

US Leadership

Although the United States has led the world in developing cap and trade pollution control systems, we are not leading the world in any part of efforts to reduce CO₂ emissions. Other industrialized countries have already begun to implement sectoral cap and trade programs as part of their efforts to meet their Kyoto Protocol commitments. However, none of these programs are economy-wide.

The US has an opportunity to show leadership in the area of program design. A national upstream cap and trade would be a simpler and more effective policy than any country to date has taken to limit its CO₂ emissions to a specified level. It would demonstrate what the US has been saying all along: we want to take responsible action on climate change mitigation, but we want to do it in a way that is right for the problem at hand. A downstream system would certainly improve our diplomatic relationships on the issue of climate change. However, there would be nothing innovative or different in such a system compared to the actions of other developed countries. A comprehensive upstream system would give the US a platform to help shape the international climate system after the first Kyoto Protocol commitment period.

Concluding Comments

Reducing fossil carbon emissions can be accomplished best by using clear economic incentives. Cap and trade systems can accomplish this task fairly and transparently. This paper has argued that the US should choose a system that maximizes coverage and efficiency and minimizes

leakage, administrative costs and complexity. Downstream systems will work well for about half of the energy economy, but their failure to address the other half is a fatal flaw.

Hybrid systems combining downstream and upstream approaches are feasible, and are a far better choice than a downstream system that stands alone or is combined with a variety of other policies and measures for other energy users. However, if an upstream system is going to be created for part of the US economy, why impose the expense and complexity of a separate system for utilities and large industrial users? It may be true that a downstream system for utilities is easier and cheaper to begin than an upstream system in terms of administrative expense – but if we are going to eventually have both systems, then it is clear that an upstream system would be less expensive and simpler to run.

The US needs to establish a framework for the future as well as the present. Reducing fossil fuel carbon is not a problem that is going away any time soon. A downstream system will work with compromises, but it isn't going to be as nimble, flexible, or adaptable to unanticipated changes in the structure of the fossil fuel energy market or the organization of American industry. Incentives to reduce CO₂ emissions are going to be a necessary part of our long-term mitigation strategy. It is essential to get the right institutional structure from the beginning.¹

¹ the author would like to acknowledge his reliance on the excellent analysis and description of upstream and downstream carbon dioxide trading systems in the series of papers written by Tim Hargrave for the Center for Clean Air Policy (available at www.ccap.org)