Institute *for* Policy Integrity
New York University School of Law

Unlocking the Green Economy

How Carbon Pricing Can Open the Floodgates of Private Investment in Clean Energy

Michael A. Livermore

Policy Brief No. 2
December 2008

Unlocking the Green Economy

How Carbon Pricing Can Open the Floodgates of Private Investment in Clean Energy

Michael A. Livermore

Unlocking the Green Economy

How Carbon Pricing Can Open the Floodgates of Private Investment in Clean Energy

Policy Brief No. 2
December 2008

Institute for Policy Integrity
New York University School of Law

Printed in the United States of America.

Institute for Policy Integrity
New York University School of Law
245 Sullivan Street, Suite 472
New York, New York 10012

Contents

Executive Summary

There is a broad consensus that America must transition to a lower carbon "green" energy economy—to wean the country from its addiction to foreign oil, to spur jobs, generate growth, and to avoid climate change catastrophe. To make this transition, hundreds of billions of dollars must be invested in energy efficiency and alternative energy technologies in the coming decades.

If this investment is to be made, and made wisely, it will have to be through coordinated economic activity at every level of the American economy: from government, to homeowners, to Fortune 500 companies. Carbon pricing is the only signal that can cut through the noise and direct these diverse economic actors towards smart, green investments—investments that will create jobs, encourage technological development, and maximize returns.

There have been a number of recent proposals to "price carbon." The two leading options are a direct carbon tax and a cap-and-trade system. Both would place a cost on the emission of greenhouse gases into the atmosphere and therefore create an incentive to conserve energy and transition away from fossil-fuel based electricity. Without a pricing mechanism for carbon, private actors have little to gain from investment in clean energy production and energy efficiency.

In addition to carbon pricing, direct subsidies for green infrastructure and technology have also been proposed. While government subsidies may have an important role to play in this transition, the adoption of a carbon pricing policy can be expected to generate vastly larger amounts of investment than any politically feasible portfolio of subsidies—especially over the long term. Any "green energy" policy that does not include carbon pricing will be inadequate.

Prices and Subsidies

In 1932, John R. Hicks—one of the most important economists of the twentieth century—observed that:

> [A] change in the relative prices of factors of production is itself a spur to invention, and to invention of a particular kind—directed to economizing the use of a factor which has become relatively expensive.[1]

Since that time, economists have generally acknowledged that prices affect production processes. If the price of steel rises, automobile producers will figure out how to use less steel per car. If the price of labor rises, firms will invest in labor saving technologies. Firms respond to the relative prices of commodities by adjusting the balance of the commodities in their production processes. Where there are inelasticities in the short-term, so that substitution between commodities is difficult or impossible, they are mitigated through investment in innovation.

The flip side is that when prices of a commodity are low there is less incentive to invest in innovation to reduce use of that commodity. Where labor is cheap, labor-saving devices will not be used. In the American East, water is plentiful. In New York City, it is not uncommon to see someone using a high pressure hose to push a gum wrapper off the sidewalk. In Los Angeles, they sweep.

There are essentially two ways in which an increase in the price of a factor of production can spur investment. First, where there are relatively straightforward substitutes available on the marketplace, there will be investment in production changes—retrofits, retraining, et cetera—to use a greater proportion of the cheaper substitute. Second, where there is sufficient price motivation, investment in research and development starts to make sense to identify and bring online replacements for the more expensive commodity.

Direct government subsidies can also be used to generate investment. Classically, subsidies are best employed in giving a jump-start to primary research. Basic research is most useful when treated as a public good rather than propriety information, creating a need for government funding. Subsidies for technological development may also be needed where there is some public benefit to the technology that will not be captured by producers.

In order to transition away from fossil fuels to lower carbon sources of energy, over $50 billion annual investment over the next two decades is needed.[2] It is not feasible to rely on government subsidies to reach this investment benchmark. Governments have spending constraints, determined, over the long run, by the rate of taxation. More importantly, government is ill suited to making choices between technological investments, and do not have access to the vast amount of information known by private actors. Subsidies are also subject to political whims and therefore form an uncertain basis for private investment decisions.

The remaining choice is to uncover the hidden price of carbon and factor it into the production of energy. For decades the greenhouse gas costs of fossil-fuels have not been incorporated into prices, leaving little incentive for energy efficiency or the development of cleaner, cheaper sources. To end this cycle and shift gears toward innovation and investment, a "green energy" policy must include a cost of carbon.

Carbon Pricing and Energy Efficiency

Carbon pricing will cause the immediate adoption of existing energy efficiency measures, and spur investment in research to bring new technologies to the market.

With so many technologies already on the market, companies would have an easy time instituting significant energy efficiency impacts quickly. Efficient alternatives exist for every-day products: lighting (e.g. compact florescent lights (CFLs) and light-emitting diode (LED) lights); electronic equipment (e.g. personal computers, televisions, and office equipment); heat and power systems in large commercial facilities; building shells (including insulation, air tightening, and reflective roofs); and water heaters and home appliances. Widespread adoption of these technologies has been estimated to generate a potential annual net savings of $37.5 billion for the U.S. economy.[3] The present value of this savings exceeds a trillion dollars.[4]

There are many reasons why such net-cost savings technologies have not been fully adopted. Misalignment of incentives between technology purchasers and electricity consumers, inadequate knowledge of efficiency opportunities, overly restrictive expected "pay-back" periods for homeowners, and uncertainty of future electricity prices could all contribute to under-adoption of energy efficiency technologies, even where they would maximize net present value.

Effective carbon pricing would help overcome several of these barriers. It would likely lead to large scale investments in existing technology for energy efficiency. For example, by increasing the per kilowatt price of electricity, the pay-back period for investments by homeowners is reduced, making investment more likely. Widespread adoption of energy efficiency measure would result in consumer's overall electricity bills remaining stable (or even declining) even as the per unit cost of electricity increases.

A price mechanism would also send a powerful signal—both through the market and political/cultural channels—that could help overcome information barriers to optimal adoption. An increased price of electricity would provide incentives in the marketplace to structure transactions so that the end-users of electricity had power to shape efficiency-affecting purchasing decisions. All of these changes—which would take place throughout the economy on both small and large scales—would generate cost-saving investment in energy efficiency technology.

Where there is uncertainty about future returns on an investment, and the investment option does not expire, there is a range of expected returns for which even net present value positive projects will not be adopted.[5] To the extent that energy efficiency investments fall within such a band—where they have positive expected value, but are not adopted because of future price uncertainty for electricity—carbon pricing can help push rates over the "threshold price" needed to spur investment.[6]

Carbon pricing alone cannot fix every market failure that results in suboptimal adoption of cost-saving energy efficiency technology, but it can play an extremely important role. Historically, energy price increases account for between one-quarter and one-half of improvements in energy efficiency.[7] Price signals can stimulate behavior from actors across the economy, generating investment that cannot be anticipated and matched through subsidies or regulation.

Targeted programs (such as building code requirements) and subsidies (such as programs to facilitate loans to low-income home owners for energy efficiency expenditures) will be helpful to increase energy efficiency. However, there is simply no way that government officials can anticipate the myriad possibilities, existing at every possible economic scale, where efficiency upgrades are needed or useful. Carbon pricing would act as an effective signal to generate investment in efficiency across the economy, something that no amount of command-and-control regulation or government subsidy program can accomplish.

In addition to hastening the adoption of existing technologies, carbon pricing is also likely to spur further innovation by increasing the potential returns to research and development (R&D) expenditures for energy efficiency products. While there will be lag time as products move through the development pipeline, immediate increases in R&D investment in this area are likely.

Empirical research has shown a strong relationship between energy prices and energy efficiency innovation.[8] Prices have been found to have a larger effect on technological change than direct energy efficiency regulation.[9] Further, theoretical research into the effects of command-and-control regulation versus market incentives (like carbon taxes or tradable permits) also finds that pricing carbon is more effective than command-and-control regulation at inducing innovation.[10]

Studies also indicate that R&D expenditures respond *quickly* to price changes: "over one-half of the full effect of an energy price increase on R&D will [be] experienced after just five years."[11] There are positive externalities to research, creating the need for some government support; however, the development of new promising technologies does provide a significant incentive to invest now against future expected returns. Carbon pricing related investment, therefore, will have positive economic stimulus benefits.

Energy efficiency innovation can take place on a variety of fronts. Industrial users of electricity have likely already adopted many of the available cost-effective technologies.[12] Expenditure on R&D to develop more energy efficient production processes will justified by carbon pricing. Additional R&D expenditures for energy-efficient technologies for consumers and home-owners is also likely. Currently, there is sub-optimal adoption of existing energy-efficiency technologies reducing the incentive for producers to develop these technologies. Carbon pricing can overcome some of these barriers, and will almost certainly lead to higher rates of adoption, so the incentive to develop these new technologies is ratcheted up.

Carbon Pricing and Alternative Energy

As carbon pricing increases the cost of fossil-fuel based energy production, existing power plants will switch to a greater proportion of natural gas, and investment in zero carbon generation—like wind and solar—will increase, quickly bringing new facilities online.

Without carbon pricing, there has been little historic incentive to develop low carbon or zero carbon technologies. To the extent that development of low carbon technologies have been spurred because of concerns over climate change, it has been in response to government subsidies, or in anticipation of future carbon pricing policy.

The incentive for the development of alternative energy created by a carbon tax is analytically different from the energy efficiency incentive. In the efficiency context, the incentive to conserve arises because the price of electricity will rise in response to additional costs imposed on producers of fossil-fuel based electricity. Because of these price increases, there will be additional incentives for market participants to reduce their overall energy consumption, regardless of the source of that electricity. For electricity producers, they will have the specific incentive to reduce the carbon intensity of their production processes.

In the short term, it is likely that fuel switching from coal to natural gas will be a significant response to carbon pricing.

Because there is already significant built capacity of gas fired generation, and the fuel source is relatively abundant and inexpensive (compared to other alternatives), facilities can switch quickly and easily to natural gas. However, gas reserves are ultimately finite, and increases to the price of natural gas in response to growing demand will reduce incentives to build additional capacity.

Contrastingly, there is extremely high potential for wind and nuclear power development in response to carbon pricing policy. Both these technologies are currently available, and have proven to be commercially viable, at least at small scales. Experts have estimated that the current capacity for wind power generation could be increased by a factor of ten—to over 100 gigawatts—using only high potential wind locations that would be commercially viable at a carbon price of $50 per ton.[13] There is potential for nuclear power on the order of 25 gigawatts for the same per ton carbon price.[14]

Additional regulatory and structural changes would be needed to fully incentivize development of these energy resources. For example, because wind energy is location specific, expansion of the electricity grid is necessary for full development. Expansion of nuclear power could be facilitated through regulatory changes or alteration of public perceptions of nuclear power. However, by far the most important step policymakers can take is to place an effective price on carbon. This will give market actors the incentive to take all necessary steps to develop these technologies, including pursuing any related structural or regulatory changes needed to facilitate development.

The development of solar power in response to carbon pricing is also likely. The key question for solar is whether marginal costs can be brought down to be competitive with other sources, taking into account the price of carbon emissions for fossil-fuel based generation. There is no clear answer to this question, and key uncertainties leave a wide range of potential future marginal costs for solar.

It is clear that without carbon pricing, it is much less likely that solar can ever be truly competitive, even with significant government R&D expenditures. However, because the potential payoff for innovation is truly enormous, carbon pricing is likely to start off an extremely important wave of R&D expenditures by private actors. Augmented by government subsidies for research—at the very least for continued primary research—carbon pricing will give the necessary incentive for market actors to invest R&D dollars to bring promising solar power technologies to commercial viability.

Carbon capture and storage promises another potential avenue for medium-term innovation in response to carbon pricing. Currently, carbon capture and storage "is an expensive, early-stage technology that has yet to be proven at commercial scale for base-load power generation."[15] However, carbon capture has several attributes that make it a potentially attractive technology, including the widespread availability of coal reserves and the ability to retrofit existing coal-fired power plant facilities.

While there is significant uncertainty surrounding this technology, experts have predicted that with a carbon price of $50 per ton, there is the potential for nearly 300 megatons of annual carbon abatement through carbon capture and storage.[16] Using carbon pricing, rather than direct R&D or technology subsidies, to induce production of carbon capture technology has the added advantage of placing market actors—who have greater levels of expertise and more appropriate risk incentives—rather than government officials, in the position of predicting the viability of this technology.

There are several additional avenues for the development of new power sources or carbon sequestration. Bio-fuels, tidal energy, and carbon sequestering bacteria are all possible technologies that may be on the horizon. While government subsidies for research can be helpful, the innovation engine of the U.S. economy has proven to be extremely successful at developing new technologies, when given proper incentives. The role of subsidies is to facilitate basic research in these areas—they cannot make up for the lack of an effective carbon price. The needed levels of private investment in new technologies cannot be achieved without carbon pricing.

Increased R&D and the development of new technologies could, in the carbon context, be sufficiently large to offset any deadweight loss from carbon pricing.[17] Theoretically, R&D expenditures in the energy sector will not necessarily increase, but instead will shift from expenditures on fossil-fuel to low-carbon opportunities.[18] Even if this is the case, the economic effect from R&D for alternative energy is much greater than from fossil-fuels. There is diminishing marginal return to investment in R&D. Given the long history of fossil-fuel use, the returns to additional research are now relatively low, and technological advancement is slow. Alternatives, however, can show greater returns to investment because they are relatively young technologies.

In addition, there are positive externalities associated with R&D for alternative fuels that do not exist for fossil-fuel research. A significant amount of R&D expenditure in the energy field is spent to identify and develop new fossil-fuel reserves. Thus, while these expenditures may be net present value positive projects for firms, they do not create the kind of technological development that adds to the overall stock of knowledge that can form the basis for future innovation. For this reason, R&D for alternatives—which will largely be used to develop new technologies—will generate greater economic returns. Therefore, even if it is the case that R&D investment is simply shifted from fossil-fuels to alternative energy, there is an significant benefit for the rate of technological development and economic growth.

If a carbon pricing plan is adopted, there are also good reasons to believe that R&D expenditures may increase in the energy sector generally. Because of the regulatory regime currently covering power production—specifically the exemption of older power plants from stricter pollution control standards—there is an important disincentive to develop new technology in this area. Carbon pricing will prompt even these exempted plants to reduce emissions, and therefore begin to correct for legislative disincentives to invest in technological developments in the energy sector. The partial removal of this inefficiency may ultimately increase the total R&D expenditures for energy.

Overall, the effect of carbon pricing on investment in the energy sector will be enormous. There is no politically feasible set of subsidies that could approach the level of private investment that will be spurred through a carbon pricing policy. Subsidies can only play a supporting role—without an effective mechanism to price carbon in the market, it will be simply impossible to unleash the massive investment potential of private markets for the green economy transition.

Conclusion

Energy efficiency and alternative energy are the only ways to reduce dependence on fossil fuels while maintain robust economic growth. The question for policy makers is how best to spur widespread adoption of existing options and the quick development of new technologies. Carbon pricing should be the centerpiece of any green energy plan because it acts across the entire economy, affecting large and small economic actors in various sectors, and incentivizes smart choices.

Given the economic recession, carbon pricing must be implemented wisely to maximize the potential stimulus effects and without causing unnecessary shocks to the economy. Targets for carbon prices can be set ahead of time—either directly through a tax, by identifying cap-and-trade levels, or through "safety value" mechanism—and publicized. This step will give the economy a chance to adjust, stimulating rapid investment and avoiding surprises. Prices can also start small and be ratcheted up automatically over time, so that change is incremental, and new technologies are given time to develop. Finally, the proceeds from carbon pricing can be reinvested directly into the economy either through rebates, tax reductions or spending.

From a stimulus perspective, it will be important to reduce the lag between the introduction of carbon pricing, and the distribution of funds. Even a short lag will have potential negative stimulus consequences. Perhaps the best solution would be a negative lag, where the initial rebate, tax cut, or spending could take place before the price was put in place. This would create an immediate stimulus for the economy, and would then be backed up with the carbon price revenue at a later date. That initial allocation could also be spent—either by government or private parties—to put in place easy energy efficiency measures to reduce energy use in advance of rising prices for fossil-fuel based electricity.

Carbon pricing is the single most important measure that policymakers can take to transition the U.S. economy from fossil fuels to "green" energy sources. Subsidies, changes in regulation, and incentives to states for policy development will all be useful. However, decision makers simply cannot anticipate all of the opportunities for efficient investment, and there is no political will for sufficient subsidies that would mimic the effect of carbon pricing on private investment. Without carbon pricing, any green energy plan will be fundamentally incomplete.

Board of Advisors

Notes

---

[1] JOHN RICHARD HICKS, THE THEORY OF WAGES 124 (1932).
[2] McKinsey & Co., *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?* (Dec. 2007)
[3] McKinsey & Co. *supra* note 2 at 36.
[4] Net present value here calculated simply as the aggregate of the discounted future cash flows on a perpetual stream of $37.5 billion annually. The value exceeds a trillion dollars for a discount rate up to 3.75%. This is obviously a simplified calculation, but it gives a flavor of the stakes involved.
[5] For an extended discussion of such "real options" see AVINASH K. KIXIT & ROBERT S. PINDYCK, INVESTMENT UNDER UNCERTAINTY (1994).
[6] The threshold price for an investment, in the real options context, consists of the price that is sufficiently large that it offsets the value of the option to wait. For more in depth discussion, see generally *id.*
[7] Richard G. Newell, Adam B. Jaffe, & Robert N. Stavins, *The Induced Innovation Hypothesis and Energy-Saving Technological Change*, 114 Q. J. ECON. 941 (1999).
[8] *See* David Popp, *Innovation in Climate Policy Models: Implementing Lessons from the Economics of R&D*, 28 ENERGY ECON.596, 600-603 (2006) (summarizing research).
[9] *See* Newell et al. *supra* note 7.
[10] Adam B. Jaffe & Karen Palmer, *Environmental Regulation and Innovation: A Panel Data Study* 4 REV. OF ECON. & STATISTICS 610 (1997).
[11] Popp *supra* note 8 at 601.
[12] While the effect of option value and price volatility can be expected to depress the rate of technological adoption, even for firms that do not face the same problems of information and rationality (such as overly restrictive

pay-back periods) that may prevent full adoption of cost-effective technologies in households.

[13] McKinley & Co. *supra* note 2 at 61.

[14] *Id.*

[15] *Id.* at 60.

[16] *Id.*

[17] Ian Sue Wing, *Induced Technological Change and the Cost of Climate Policy* (MIT Joint Program on Science and Policy of Global Change, Report No. 102, 2003).

[18] *Id.*

Institute for Policy Integrity
New York University School of Law
245 Sullivan Street, Suite 472
New York, New York 10012
www.policyintegrity.org