Five Characteristics of an Economically Efficient LCS

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Reductions in emissions associated with a Low Carbon Society (LCS) will require dramatic changes to the global energy and land-use systems. Carbon emissions reductions needed to achieve that goal globally could be 50 percent or more by 2050 and emissions reductions could be greater in developed nations. The challenge of affecting such changes cannot be overestimated.

Economics offers several important insights that can help minimize the cost of achieving such dramatic transformations. Here we articulate five.

1. *Carbon emissions should be priced.* The global climate is a public good. Anthropogenic climate change is therefore a public goods problem in which private decisions taken in the context of private markets will not achieve a socially optimal solution. The anthropogenic climate change problem cannot be adequately addressed by simply asking individuals to make better private decisions. Better and more environmentally aware private decision making helps, but public intervention is required to create a market consistent with the public interest in the climate that in turn reflects the social value of carbon. Until carbon is valued, emissions will always exceed the socially desirable level and key technologies, such as CO_2 capture and storage, that directly address climate change but at additional cost, will remain on the shelf.

2. *All carbon emissions count the same to the atmosphere.* All carbon affects the Earth's climate and the introduction of an additional ton of carbon from any source has exactly the same effect regardless of the activity that produced it or the location of the emissions. Whenever the marginal cost of emissions reductions varies from one activity to another or one place to another, there is room for society to have more reductions and at lower total cost. This means that costs are higher every time an exemption is granted to an individual economic sector or particular regions or countries undertake emissions reductions while others do not. This also means that all of the carbon in the terrestrial biosphere needs to carry the same value as fossil fuel and industrial carbon emissions. Leaving that carbon unvalued creates the potential for ancillary environmental consequences from over-deployment of bioenergy in the context of a LCS.

3. *Expectations should be that the price of carbon will rise at a regular rate.* Unlike other airborne pollutants, such as NO_X and SO_X, CO_2 is a stock pollutant. To stabilize CO_2 concentrations at any level, emissions must eventually be driven to **zero**, requiring increasingly stringent emissions reductions over time and, therefore, an increasing price of carbon. Cost minimization over time calls for a price path that rises at roughly the rate of interest adjusted by the rate of ocean carbon uptake. This does not mean that future prices can be set today at this rate and be entirely predictable for a century. Uncertainty about a range of factors, including improvements to technology and the damages from climate change, will necessitate

regular review of the adequacy of policies and measures; however, it does mean that subsequent to each time the price is revised that the price rate of change of the price over time should return to its upward trajectory roughly consistent with cost-effective reductions over time.

4. *Climate policy should be predictable.* Many elements of energy and related infrastructure have lifetimes in excess of 50 years. Decisions regarding investment in this infrastructure are based primarily on expectations about future economic conditions, including the price of carbon. If decision makers anticipate substantial uncertainty in the viability or character of future carbon policy, it will retard critical investments needed to address climate change. If decision makers can anticipate that prices will rise at a regular rate, the date at which emissions reducing technologies will be selected will be earlier and the present price of carbon and other GHG's can be lower and still induce investment consistent with an economically-efficient path towards stabilization. A succession of a dozen emissions limitation regimes that each last five years without a meaningful expectation about the consistency between regimes is a recipe for high cost and delayed introduction of technologies associated with capital stocks living longer than five years.

5. *Technology instruments are fundamental to a climate policy portfolio.* The role of technology is to help control the cost of achieving an LCS. While it is always feasible to stabilize concentrations of CO_2 at any level with any technology, the cost society bears will depend to a large extent on the suite of available technologies. Near term emissions mitigation must inevitably rely on existing technology, but in the mid- and long-term, better technologies could potentially be made available. Policies are needed to establish the conditions that encourage the creation of improved versions of existing technologies and completely new technologies can come into being. Both public and private sector investments will be needed. This includes public sector investments in the basic sciences. Basic science is a field of human endeavor in which the private sector classically under-invests because no individual firm can fully appropriate the benefits of its investments. More than two thirds of all emissions mitigation in an LCS occurring after 2050, more than enough time for investments in science and technology to lay down the foundations for lower cost, better technologies of the future—and not simply improved versions of today's technologies, but also potentially completely new technologies for which there are as yet be no names.

In addition to the characteristics noted above, technology will never deploy absent facilitating institutional infrastructure. Large-scale deployment of any technology will be mediated by institutions. And, while the particular institutional requirements will be different for such technologies as bioenergy, hydrogen systems, CO_2 capture and storage, nuclear power, wind, solar and end-use energy technologies, institutions will play a critical role in shaping deployment. The choice of institutional mechanism will vary both from place to place and over time.