Policy Brief

NUMBER 4, 2009

Overview

The current financial crisis has tended to sap the momentum of industrialized countries' policy steps to address climate change. Given the threat of runaway global warming, adopting a "minimax-regret" strategy is the best policy response: aim to stabilize GHG levels close to present levels. This requires accelerating R&D expenditures targeting technologies that radically reduce marginal costs of GHG emissions control. Making severe emissions cuts less burdensome would reinforce efforts to achieve that goal by "cap-and-trade" programmes and carbon taxes. The global community should commit itself to making major, coordinated investments in a diversified portfolio of climate change R&D, and to providing global access to the emerging technologies.

Written by Paul A. David, Can Huang, Luc Soete and Adriaan van Zon

ISBN 978-92-808-3073-6
ISSN 1814-8026

UNITED NATIONS UNIVERSITY
UNU-MERIT

Toward a Global Science and Technology Policy Agenda for Sustainable Development

THE CURRENT ECONOMIC CRISIS HAS TENDED TO sap the policy momentum that had developed during 2006 and 2007 behind public R&D programmes and institutional initiatives to expand the portfolio of affordable technological means of controlling global warming. This is unfortunate, since the international negotiations about concerted actions among the leading industrial countries to reduce greenhouse gas (GHG) emissions have so far proceeded very slowly – too slowly, considering both the global nature of the problem and the size of the stakes involved. The initial "bargaining" stance taken by some important players, notably Japan and the United States, was in some respects disappointing in that it appears to fall far short of the EU member countries' endorsement in December 2008 of the package of EC directives designed to activate its "20-20-20" renewable energy strategy – a 20 per cent reduction of GHG emissions, and 20 per cent of energy consumption from renewable sources, by the year 2020. While there have been more promising developments recently, in the convergence towards that target in some of the legislation introduced in the US Congress, and the Obama administration's issuance of US Environmental Protection Agency (EPA) regulatory directives requiring the use of the latest emissions control technologies on new and retrofitted electricity power plants, the outcome of the Copenhagen conference in December 2009 remains uncomfortably uncertain.

Climate Change: Crisis upon Crisis?

The biggest threat of the process of global warming is precisely the lack of long-term policy commitment to minimize the likelihood that delays in checking the growth of GHG concentration levels could allow the warming process to run irreversibly out of control, even if zero CO_2 *emissions* were eventually achieved. It is likely that there are some critical threshold levels of GHG concentrations or temperature thresholds that, when crossed, will impart a self-reinforcing momentum to the process, setting in motion large-scale events that will have direct and damaging consequences, and that will absorb resources in "coping" with the environmental damage and the ensuing economic and socio-political disruptions – thereby impairing further efforts to slow and halt the warming process.

At present the science of global warming doesn't permit one to say with complete certainty that thresholds of that kind exist, much less at what critical GHG concentration levels or temperatures they would be passed. That is precisely the worry, because in such situations there is a strong temptation to "wait and see". But in the nature of the process, the risk is that when the critical points are identified it will be too late for the world's population to do anything except attempt to manage the escalating damage and "adapt" to the profound alteration of its environment.

What is known is that the physics of these mutually reinforcing sequences of events tends to *accelerate* global warming, so that initial estimates of the degree of control of GHG emissions that would suffice to slow and halt the global rise in temperature will become more and more inadequate, and the costs of stabilizing the GHG concentrations at tolerable levels with known technological and economic measures will rise inexorably.

A striking example of that positive feedback, or dynamic self-reinforcement, is already developing through the observed reduction in ice coverage in the Arctic regions, leading to a greater absorption of infra-red solar radiation, and therefore an even faster reduction of ice coverage. The induced rise in temperature leads, in turn, to the release of methane from melting permafrost and potentially from hydrates stored in the deep sea. Methane is a much stronger greenhouse gas than CO_2, and at present enough methane is stored in the permafrost alone to more than double the total cumulative GHG emissions resulting from all the fossil fuel that has been burnt so far. The amount of methane stored in the form of hydrates is much larger still. Worryingly, the rate and scale of these self-reinforcing and mutually reinforcing processes are hard to estimate and project on the basis of recorded past experience. Consequently, the degree to which they are unaccounted for by the projections of the global warming trends remains unclear, and the projected restrictions of "intended GHG emissions" that would be required to stabilize the earth's temperature could well be seriously understated.

The Need to Apply the Precautionary Principle

A robust response to the challenge of ongoing global warming must therefore make every effort to avoid those critical thresholds from being crossed. The problem is that the effects of any policy action, including those aimed at climate change control, are prone to unpredictable statistical variations, and the down-side "failings" to check warming contribute to making the later achievement of even the same target more difficult and hence more costly. Aiming for some stable level of GHG concentration with an a priori optimum set of policy instruments may lead to falling short of the appropriate (moving) target defined in terms of emissions reduction. Given the insurmountable adaptation costs involved in switching from a stable climate mode to one of irreversibly accelerating global warming, the only sensible course of action is to adopt the precautionary principle and commit to pursuing what are known as *minimax-regret* policies. These aim to minimize the likelihood of the worst-case outcomes, i.e. those that would cause the maximum regret.

The appropriate minimax-regret climate change strategy derived from application of the precautionary principle focuses on doing whatever is feasible to stabilize GHG concentrations *at present levels*, or *as close to the present as possible* – in the hope that there is still enough surplus environmental absorption capacity left to accommodate the additional warming that is already in the pipeline due to past and present emissions. The fact that news items about thawing permafrost in the tundra of Siberia and Canada and sliding and crumbling ice sheets in Greenland and the Antarctic seem to become more frequent year-by-year suggests that the environment is more fragile than earlier Intergovernmental Panel on Climate Change (IPCC) targets for emissions control, GHG levels and warming had supposed. In our opinion, this simply reinforces the urgency of formulating a "prudential global strategy".

Three Ways to Manage the Climate Crisis

Broadly speaking there are three ways in which governments can attempt to respond constructively to the climate change crisis.

The first of these, which appeals to a wide consensus of academic economists and environmental experts, is to put a price on actions causing GHG emissions, through the introduction of "carbon taxes" or "cap-and-trade" programmes that induce the formation of a market for transferable emissions licences. If the issuance and trading of such licences would constrain a sufficiently large number of enterprises, the rising prices of emission permits, or the part of the imposed tax that could not be shifted to customers through higher product prices (without losing revenues), would create a growing demand for more efficient technical methods of reducing emissions. Private investment in developing and commercially introducing such technologies into the growing market would then be stimulated – so long as the necessary size of the predictable R&D expenditures was not excessively large and highly uncertain.

Unfortunately, there is nothing to guarantee that the market for licences would set just the right future prices on emissions to induce curtailed consumption of goods and services produced by processes yielding high GHG emissions. The "cap-and-trade" approach supposes that the "free market" can allocate efficiently the resources used directly and indirectly in activities that produce GHG emissions, as well as for investments that will affect the future costs of reducing such emissions. That supposition is questionable, firstly, because it disregards the conclusion (widely accepted among economists) that competitive markets cannot be relied upon to set prices that will guide rational actors to a socially efficient allocation of goods when the goods in question are "public goods" – i.e. when their benefits can be freely enjoyed by others besides the parties that pay to obtain them. Averted tonnages of GHG emissions certainly qualify as global public goods and one should therefore expect "free riding", resulting in an under-reduction of emissions. A second dubious assumption which, given the uncertainties involved, may be the more critical one, is that the government actually "knows" where to set the caps on the deliberate emission of each of the several varieties of destructive greenhouse gases. Obviously this problem is not simply due to the usual uncertainties about how particular economic agents will respond to specific incentives. As was pointed out, there is also the difficulty posed by major uncertainties about the need to offset non-volitional releases of CO_2 and methane driven by rising GHG concentration levels in the atmosphere. Analogous considerations of the uncertainties of the changing environmental system and the economic agents that are interacting within it occasion similar doubts about the ability of scientifically informed governments to set appropriate levels of tax rates on carbon (or other) emissions. Furthermore, con-

About the Authors

Paul A. David is professor emeritus of economics at Stanford University, emeritus fellow of All Souls College (Oxford), *professeur titulaire* at the Ecole Polytechnique & Telecom Paris Tech and professorial fellow at UNU-MERIT.

Can Huang is researcher at UNU-MERIT.

Luc Soete is the director of UNU-MERIT and professor of international economic relations (on leave) at Maastricht University.

Adriaan van Zon is senior researcher at UNU-MERIT and associate professor at Maastricht University.

tinually correcting the tax rates will be a cumbersome legislative or administrative process, far less "automatic" and more sluggish than changing prices in a market.

Still another problematic point to consider in this connection is that tradable permissions to emit are as abstract as negotiable financial assets, and just as subject to being made objects of speculation; because they will have future prices that are subject to fluctuations, they could be a basis for new, related assets, i.e. "derivatives" that also would be tradable. Today there are very real concerns about the trouble that can ensue when complex and novel financial instruments are traded in markets that are not adequately regulated. Yet, the institutional specifics of the future markets for the emissions licences that are to be issued by a variety of distinct political entities with corresponding distinct regulatory domains remain "sketchy" at best.

But even if the patchwork of markets for emissions licences is well-behaved and each performs as its designers intended, one should expect that the emergence of high future prices for emissions will impose severe costs on the mass of (low-income) consumers, as well as reduced profits and more disruptions for energy-intensive producers. The prospects of these "effective" results will be unwelcome and create strong and recurring temptations for governments to hold back from setting the caps (or the emissions taxes) at levels that really "bite". The risk is that government agencies will postpone needed but politically unpalatable actions – thus leaving an even bigger challenge for successor administrations.

Viewed from the foregoing perspective, the enthusiastic reception that has greeted government announcements that the first-line public response to the climate change crisis will be to rely on a new market, and the absence of scepticism and precautionary attention by economists to the institutional structure and regulation of emissions-permission markets, are quite remarkable.

"The absence of scepticism and precautionary attention to the institutional structure and regulation of emissions-permission markets is quite remarkable"

The second mode of response to climate change is through publicly-funded programmes that aim to stimulate the search for new knowledge and novel combinations of existing technologies. The immediate goal here is to generate a broad portfolio of R&D programmes, seeking technologies that directly or indirectly could yield very significant reductions in GHG emissions. The R&D process itself is of course inherently risky; in times of financial crises, private firms may find it hard to fund such risky ventures, but even in the best of times few businesses have the resources and freedom from competitive pressures to commit major funding to the still more uncertain but required, exploratory projects in quest of major scientific and technical breakthroughs. Nevertheless, the uncertainties involved in climate change call for decisive actions to address the brutal fact that a large part of the climate problem solution will have to come from the creation and timely diffusion of new technologies (rather than from fundamental changes in lifestyles). This implies that building an R&D portfolio covering this area *in extenso* is of strategic importance, now more than ever.

A third line of response is precautionary in a different sense. However unlikely *ex ante*, the worst-case scenario could arise *ex post*, and one would have to cope with that situation of "forced adaptation" by undertaking and encouraging the development of technical and organizational expertise. The latter would have to reduce the future costs of actions aimed at mitigating the disruption and damage that would ensue from the rise in GHG concentrations during the coming decades. Here too there is a need for knowledge-portfolio widening and deepening, to which a differently focused category of R&D programmes can contribute by exploring the possibilities of reducing vulnerabilities of structures and people to "extreme weather". These would include adaptive population redistribution and geo-engineering. Projects of this kind are highly context-sensitive, and call for close interaction and knowledge exchanges, and extensive feedback among solution providers and solution users in a multiplicity of specific industrial and environmental settings.

Existing Technologies: Is it Easy to Be Green?

Using the most efficient technologies currently available to control emissions, alongside the "emissions-pricing" measures reviewed above, seems to make perfect sense. But it could err by fixing the energy consumption characteristics of our global production system at a level dictated by the present state of technology. Energy conversion equipment, such as a coal-fired or gas-fired power plant, has a technical lifespan of three decades or more, and investment in current technologies therefore entails some loss of the option to invest in superior future techniques – for what (potentially) might be quite a long time. When such improvements are in view, rational private actors are likely to postpone investment not just because of an aversion to risk, but to preserve their "option value".

As global warming is a truly global problem, it seems to be in the global interest that current publicly-subsidized investments in energy conversion equipment should be focused on the most efficient equipment that is presently available, because otherwise one would be stuck with the less efficient equipment for decades to come. This course of action would be relatively straightforward, but in the end it could also prove to be more costly than delaying investments until significantly improved technologies emerge. A large commitment

Useful Sources

20-20 by 2020: Europe's Climate Change Opportunity (EU)
http://www.energy.eu/directives/com2008_0030en01.pdf

Stern Review on the Economics of Climate Change (HM Treasury)
http://www.hm-treasury.gov.uk/sternreview_index.htm

It's Easy Being Green (P. Krugman, *New York Times*, 25 September 2009)
http://www.nytimes.com/2009/09/25/opinion/25krugman.html?_r=1

A Statement on the Appropriate Role for Research and Development in Climate Policy (K. J. Arrow, L. Cohen, P. A. David et al., *The Economists' Voice*, 6(1): Article 6, March 2008)
http://www.bepress.com/ev/vol6/iss1/art6

Irreversible Investment under Uncertainty in Electricity Generation (A. van Zon and S. Fuss, UNU-MERIT)
http://www.merit.unu.edu/publications/wppdf/2006/wp2006-035.pdf

Analysis on Environmental Problems and Sustainable Development of Contemporary Economics (Z. Yang and Z. Guo, Renmin University of China)
http://www.cpeer.org/shell/main?appHandler=cencms&pageHandler=metainfo&id=ABC00000000000004305

Transition Management as a Model for Managing Processes of Co-evolution Towards Sustainable Development (R. Kemp, D. Loorbach and J. Rotmans, *The International Journal of Sustainable Development and World Ecology*, 14(1): pp. 78–91, 2007, DOI: 10.1080/13504500709469709) of investment resources to deploying the immediately available "green technologies" would reduce the size of near-term technology markets and weaken private incentives for R&D performance, and, by extension, the chance to acquire dramatically improved technologies. Hurrying to pick the low-hanging fruit may be attractive simply because it is quick and easy, but it may well be better to wait for the higher-hanging fruit to ripen, or even to further that process.

"A commitment to lowering the actual costs of complying with GHG reductions is a prerequisite for an international agreement on policy"

A Real Commitment and Long-term Investments

A commitment to lowering the actual costs of complying with GHG reductions is a prerequisite for an international agreement on "STI (science, technology and innovation) policies", emphasizing basic and applied research. This would require major coordinated investment in basic and applied research aimed specifically at cutting the costs of drastically reducing net GHG emissions. This R&D effort needs to be large, broad and diversified. Diversity in R&D is important, both from the perspective of avoiding committing resources too early in the face of ongoing knowledge creation and from the perspective of reducing the risk of betting on the wrong technology horse. Weight should therefore be given in government climate change and energy strategies to undertaking major programmes of both exploratory and more focused scientific and technological R&D investment at this time.

Such programmes would seek new technologies that would make it affordable to actually achieve the required GHG reductions, and make it rational to delay the most lumpy and irreversible among the necessary capital formation commitments – thus preserving the option of implementing more efficient technologies when those emerge. Since exploratory research is particularly uncertain, one wants to make an early start with a diversified research portfolio from which the more promising lines can subsequently be selected for further development.

To make this R&D hedge work, a globally supported commitment is needed that would devote major investments to implement future compliance with "prudential" reductions in GHG emissions. For that effort to be credible, the R&D effort must be large and collateral R&D will be needed to curtail the implementation costs so that they will not reduce consumption to unacceptably low levels. Given the scale and complexity of the R&D efforts required, it is worthwhile considering measures that would enhance the effectiveness of both public and private R&D investments and technology transfers in a wide array of "green technologies", facilitating also knowledge-sharing, adaptation and the broad diffusion of innovations. This calls for a critical rethinking of ways to mitigate the inhibiting effects upon R&D of excessive protection of intellectual property rights (IPR). Targeted domains for research exemptions, liability approaches to IPR infringement, and competition policy adjustments to permit efficient pooling of patent, copyright and database rights, all deserve consideration under this heading.

Importantly, this proposed R&D effort must be made part of a collective race against the clock of rising GHG concentration levels, instead of fuelling races among "national champions" in quest of exclusive rights to exploit "green technology".

Private Sector Involvement

In view of the required scale of R&D activities involved, the necessary resources cannot come from the public sector alone. For private sector commitment to creating more efficient green technology options to occur soon, firms must expect that there will be a market for such technologies. Yet private sector investment is unlikely to be forthcoming as long as there is no commitment to setting an effective price on GHG emissions – by setting tight caps that will not be quietly loosened by the issuance of additional emissions permits to alleviate industrial "distress".

The international community thus could find itself caught in an "low-effort level equilibrium trap", as exemplified by the case of carbon-capture technologies: because current costs of carbon-capture pilot operations are too high to make it believable that firms facing CO_2 emissions limits would adopt these methods, countries with coal deposits and the coal industry would resist tight caps on CO_2 emissions – because, in the absence of affordable carbon capture, they would lose access to that source of energy, and profits, respectively. But since they will not agree on effective caps, the necessary investment in R&D (required to create the expectation that those caps would turn out to be tolerable) simply is not going to be forthcoming.

Quite strikingly, China has recently embarked on a course that points the way to escape that dismal scenario. By adding major stimulus funds to ongoing programmes of focused investments in a range of GHG emissions-reducing technologies – from nuclear power plants to wind turbines and low-cost carbon-capture and sequestration techniques – China is opening a path permitting eventually greater exploitation of its abundant coal resources without further degrading its own environment. More striking still is the recent report of the International Energy Agency that these efforts have yielded such rapid advances that China could be in the forefront of the world's green technology movement by 2020, providing methods that would permit carbon capture at commercially affordable costs in other similarly endowed regions, including the United States.

> "The diversity of scientific and engineering capabilities relevant for concerted global actions in this regard offers opportunities for mutually advantageous cooperation"

Conclusion: The Need for a Global Coordinated Push for Climate Change R&D

There is an evident need for international coordination on the part of governments at different levels regarding the funding of climate change R&D programmes, and the sharing of the resultant advances in technological knowledge. The diversity of scientific and engineering capabilities relevant for concerted global actions in this regard offers opportunities for mutually advantageous cooperation. In view of the large scale of the investments that will be needed to achieve "game-changing" technological advances, a compelling case can be made for raising the social pay-offs from those global R&D expenditures – by avoiding excessive correlation of public and private research portfolios, and by suppressing the unnecessary duplication of domestic as well as international R&D efforts. Research contributions can then be fruitfully combined, and generic principles and research tools integrated with specific knowledge developed in particular localized environments and industrial contexts.

In a certain sense the international financial crisis and the looming crisis of climate change have brought to the front an understanding that the realistic solution to a truly global sustainable development strategy is not simply to give the world's investors global access to affordable finance. Having access to the fruits of expanded public and private investments in science and technology at the global level will probably be far more critical in the long run.

What makes the "climate crisis" a unique opportunity, if a perilous one, is that citizens in the United States, Europe and Japan are crucially dependent in their sustainable future on the speed of (green) knowledge diffusion throughout the rest of the world as well as in their own countries. Therefore, the strategic fixation with national science and technology policies that aim to "appropriate" the benefits of greater access to new knowledge that could be exploited for purposes of enhancing international competitive advantage is not merely a "dangerous obsession" among economic advisers and policymakers. It should be recognized as a real danger to all of the world's peoples.

UNITED NATIONS UNIVERSITY

UNU-MERIT

UNU-MERIT is the United Nations University Maastricht Economic and social Research and training centre on Innovation and Technology. It integrates the former UNU Institute for New Technologies (UNU-INTECH) and the Maastricht Economic Research Institute on Innovation and Technology (MERIT). UNU-MERIT provides insights into the social, political and economic contexts within which innovation and technological change is created, adapted, selected, diffused, and improved upon. The Institute's research and training programmes address a broad range of relevant policy questions dealing with the national and international governance of innovation, intellectual property protection, and knowledge creation and diffusion. UNU-MERIT is located at, and works in close collaboration with, Maastricht University in The Netherlands.

INSIDE:

Policy Brief

Toward a Global Science and Technology Policy Agenda for Sustainable Development

A large part of the climate problem solution will have to come from the creation and timely diffusion of new technologies, rather than from a fundamental change in lifestyle.

UNITED NATIONS UNIVERSITY
UNU-MERIT

UNU—Maastricht Economic and social Research and training centre on Innovation and Technology
Keizer Karelplein 19
6211 TC Maastricht
The Netherlands