THE IPCC ENERGY ASSESSMENT

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John P. Weyant

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Commentary

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John P Weyant
Stanford University

I was asked to comment on the first two papers in this special issue – those dealing with 'conceptual issues' authored by Hourcade and Robinson, and Richels and Sturm, but to read all ten papers and bring in insights and issues from the other eight papers in so far as they are relevant to issues and insights raised in the two conceptual pieces. This set of papers is impressive; the editors – Erik Haites and Adam Rose – along with the ten sets of authors, should feel a sense of accomplishment in pulling together this excellent set of contributions in such a timely fashion. Clearly this effort was facilitated by the work of Working Groups II and III of the Intergovernmental Panel on Climate Change, for which most of the authors were lead authors, but the group generally went beyond what was in those reports as the editors had instructed.

These papers provide many policy relevant analytic insights, and good discussions of a number of key policy issues, but in line with my assignment to comment on the broadest conceptual pieces I will discuss only three major policy insights – timing of emissions reductions, international cooperation in controlling emissions, and hedging against low probability high consequence climate events, and three important underlying technical issues – top-down versus bottom-up modeling, revenue recycling and the role of R&D as a climate change policy option. However, I would like to start with an observation about the policy guidance proffered in this issue and what has actually been proposed thus far in the international negotiation process, and that is that there is at present little connection between the two. The analyses presented here suggest comprehensiveness and flexibility in the design of climate change policies, with frequent modifications based on new information and analyses, whereas the policy proposals put forward thus far have tended to be fairly rigid and permanent. It is almost as if the policy process has unwittingly framed the climate change problem as an all or nothing choice concerning whether or not substantial reductions in carbon emissions should be undertaken immediately, whereas most analyses suggest that we ought to proceed incrementally toward a long-run transition to a less carbon intensive world economy.

Policy relevant results

Timing of emissions reductions

The sensitivity of the costs of mitigation to the timing of the imposition of emission controls is a persistent theme in most of the papers in this issue. If controls can be phased in gradually rather than imposed abruptly, the cost of limiting the atmospheric concentration of CO_2 below a specific threshold can be greatly reduced. This point is explicitly analyzed in Richels and Sturm, mentioned in the Hourcade and Robinson, and Montgomery and Jaccard papers, and implicitly mentioned in most of the other country study and sectoral pieces. Climate change and, therefore, the damages resulting from it are more directly related to the concentration or stock of CO_2 in the atmosphere than the flow of emissions into the atmosphere year by year, so the incremental exposure to damages resulting from a more gradual approach to a common limit may be worth enduring to achieve these substantial cost savings. The slow turnover rate of the existing energy using and energy consuming capital stock, the lead time for developing new carbon free energy supply technologies, the opportunity cost of capital invested in carbon abatement versus other societal investments, and the process whereby new additions to the atmospheric stock of carbon are slowly removed from it via the operation of the carbon cycle. Most analyses of the timing issue have been done with full employment models, which Montgomery and Jaccard report may lead to significant understatement of the short-run costs of the abrupt imposition of carbon emission limits. According to results from the macroeconometric simulations reported in their paper the cost of an immediate stabilization of emissions might be several times higher when account is taken of the unemployment that is created when the macroeconomic system is subjected to sudden shocks (see also Rose and Liu, 1995). Moreover, the political system may be more sensitive to additional unemployment *per se* than the reductions in economic output they induce.

Some have pointed out that more substantial early control of emissions might stimulate the development of new carbon free energy technologies more rapidly than would a phase in of controls. At this point it is not clear that this would be the case given the impact this would have on the allocation of society's R&D resources, and, even if the new technologies were relatively inexpensive to develop, it is not clear that intervention in the market (as opposed to direct support of the R&D) is the best approach (see the section on R&D below).

Finally, most studies of climate impacts have concluded the costs of climate change are highly uncertain and currently not expected to be catastrophic for CO_2 concentration levels expected to be observed over the next 50–75 years. Given their long list of pressing priorities, it is not clear that national and international policy makers will ultimately favor abrupt imposition of substantial reductions in carbon emissions without more substantial evidence about the magnitude of climate damages. Ironically, those who have pushed for more aggressive and immediate controls and therefore contributed to the all or nothing framing of the current policy debate may not be taking a position that is in their own interest; given the current state of information, policy makers may decide that nothing is superior to all in the current debate. This would be a very unfortunate outcome because each of the authors who has contributed to this issue has concluded that the climate problem is solvable at relatively low costs to society, if we start working on it gradually, but purposefully, and consistently over the next few decades.

International cooperation in reducing emissions

Another theme seen in several of the contributions to this issue, but most explicitly addressed and analyzed in the Richels and Sturm contribution is the potential for international cooperation to significantly reduce the cost of climate change mitigation policies. Regardless of who is responsible for paying for the emissions reductions deemed to be appropriate, it makes sense to take them wherever it is least expensive to do so. And heterogeneity in energy resource bases, economic development profiles, tax systems, available infrastructure etc among countries leads to wide variations in the incremental costs of emissions reductions. Surely, implementation will be difficult as each country has its own objectives based on its own assessment of the costs and benefits of climate change policies, but the benefits are large enough that even partial coordination (say among the dozen or so major emitters) could have substantial benefits. Indeed, this is one area where negotiations are proceeding, albeit slowly, as 'measures implemented jointly' are now part of the official parlance of the climate treaty implementation negotiation process. The time required to analyze and implement detailed cooperative measures is yet another justification for slow, but sure, rather than abrupt implementation of climate change policies.

Hedging against extreme climate outcomes

A point stressed by Hourcade and Robinson is that additional costs may be imposed on society if a decision is made today to proceed slowly with climate change policy and then it is determined that the damages resulting from climate change are much more substantial than previously thought. Although not addressed explicitly in this issue this argument is at the heart of several recent studies (among them Manne and Richels, 1992; Nordhaus, 1994), which have looked at balancing the expected costs of over controlling emissions against those of under controlling carbon emissions in light of the underlying uncertainties about climate change, climate change costs and mitigation costs. As a general rule, these studies do suggest the desirability of more immediate control (perhaps 50% more reductions relative to baseline emissions than in the case of perfect information, representing a further reduction in the rate of growth of emissions), but not an immediate reduction in emissions rates. Only a very high probability of severe damages emerging within a few decades and very low discount rates lead to a more Draconian optimal emissions reduction program. This suggests a high premium on research on potential climate surprises resulting from greenhouse gases over the next 10–20 years, as a more gradual and comprehensive control program is being phased in.

Key technical issues

Bottom-up versus top-down modeling

Pleasingly, the disconnect between top-down and bottom-up studies of mitigation seems to be disappearing rapidly as most of the contributions to this issue indicate. This follows a trend previously chronicled in the 1994 special issue of *Energy Policy* on 'Markets for energy efficiency' (Huntington *et al*, 1994; see particularly the unifying framework papers by Jaffee and Stavins, Sanstad and Howarth, and Huntington in that issue). Most authors in this volume recognize that each approach has its strengths and limitations, making a careful combination of information from both approaches superior to either one pursued independently. The one exception seems to be the Chandler *et al* piece on economies in transition. Since these economies are currently in between market economies and planned economies and it is not clear which direction they will take, it will be difficult to sort out the appropriate balance between the top-down and bottom-up approaches for them. Clearly, their is a higher premium for cross checking results from top-down models with those from bottom-up models in studying centrally planned economies. On the other hand, complete abandonment of the top-down perspective makes it difficult to insure that polices taken in the energy environment area will be consistent with the long-run economic growth objectives of the countries involved; there is too much potential for major efficiency losses across markets for non-energy goods, and sub-optimality in the rate of capital accumulation and its allocation to different industries. Moreover, the historical propensity for leaders in the economies in transition to overlook or ignore these factors was one of the main reasons they ultimately found themselves motivated to change to more market based systems of economic organization.

As pointed out by Hourcade and Robinson, both top-down and bottom-up modelers have adjusted their emissions projections towards each other, although the top-down modelers have come down more than the bottom-up projections have come up. A complicating factor in that assessment though is that economic growth prospects are felt to be significantly lower than envisioned 10–15 years ago. In general both types of modeling approaches take these projected economic growth rates as inputs. Indeed a typical outlook for the OECD other than Japan 15 years ago might have been 3.5% GDP growth rate per year relative to 2.5% per year or less now, while Japan might have been projected to grow at 4.5% to 5% per year relative to 3.5% or 4.0% now, with projected GDP growth in the developing countries dropping from 6–7% per year in 1980 to 4–5% today (the difficulties in projecting economic growth in the economies in transition have already been discussed).

The top-down models have been significantly influenced by results from bottom-up analyses over the last 10–15 years.

First, many of the top-down models have had process sector detail drawn from bottom-up studies in their representation of energy supply technologies. Second, through the introduction of aggregate energy demand-side trends unrelated to energy price changes, the baseline energy demand projections in these models has come down significantly, in large part due to the influence of results from bottom-up modeling. Many top-down models use a parameter called the Autonomous Energy Efficiency Improvement (or AEEI) factor to represent the annual rate at which energy demand declines independent of the effects of any price changes. Ten years ago, this factor was not typically in most top-down models, primarily because it is difficult to estimate it with historical data (indeed the most careful attempt to measure this trend using historical fuel price data by Jorgenson (1994) suggests that the effect actually increases rather than decreases energy demand over time). Nonetheless, the typical top-down model now uses an AEEI value of say 0.7% per year (with many as high as 1% per year). This value implies a 19% reduction (26% for a 1% AEEI) in baseline energy use by 2030 (implying that the actual projections would be 28% (42%) higher if not for the inclusion of this factor), and a 34% reduction (45% for a 1.0% AEEI) by 2050 (with actual projections 47% (73%) higher than without the AEEI factor). Through these assumptions large amounts of no regrets opportunities, technical improvements and structural shifts are projected to occur. Third, most models incorporate the possibility of lower than world level energy prices in some regions, so that additional no regrets options are assumed to be undertaken if these price differentials are eliminated.

As pointed out by Hourcade and Robinson and re-enforced by several of the country study and sectoral authors, behavioral information from sociological and psychological research is starting to be integrated into both bottom-up and top-down analyses. This type of research may be the only way that the relative contributions to the energy efficiency gap of market failures and hidden costs can be diagnosed (see Huntington *et al*, 1994). This process will take some time though as most of that research has been done at the micro-level, and ways will have to be developed to scale it up to the aggregation required by most of the models.

Finally, there is a useful difference in the policy measures suggested by the results of the two types of analyses. The 'energy efficiency gap' refers to the difference in the aggregate energy efficiency results from the two types of models. It results from a combination of hidden costs (ie costs left out of the bottom-up analyses like search and decision making costs, financing costs etc) and market failures (like imperfect information regarding the characteristics of new technologies, and agency problems where landlords make energy efficiency investments and tenants pay energy bills). Thus, the results from the bottom-up models can be used to identify market failures and to design policy measures to counteract them (as Jaffee and Stavins, 1994, note, it is important to make sure the costs of the polices are less than the expected efficiency gains). These policies directed at specific market failures are a much better way to correct them than the imposition of carbon emissions limitations, which cannot separate hidden costs from markets failures as the causes of the energy efficiency gap.

Revenue recycling

The idea of reducing the net costs of carbon emission reductions by using the tax revenues collected by the control program to reduce more distortionary taxes in the economy is highlighted by both Hourcade and Robinson, and Montgomery and Jaccard, with the former somewhat more optimistic about the potential than the latter. This is a complicated issue about which the basic conceptual ideas are still being refined. Several observations can be made given the current state of understanding of the potential for revenue recycling. Raising tax revenues imposes costs on the economy. The current tax system is the result of a complicated many party political–economic negotiation. The result of that negotiation process is a system with wide differences in the costs of raising tax revenues in different ways (eg personal and corporate income taxes, excise taxes, social security taxes).

If new revenues are raised through energy–carbon taxes and they are used to eliminate more expensive taxes this can reduce the net cost of the energy–carbon taxes to the economy. However, the existence of pre-existing taxes throughout the economy complicate the calculation of net benefits, making a general equilibrium approach desirable. Nonetheless, net costs can be reduced if the indicated policies are socially feasible (eg reductions in taxes on capital).

There is also a political economy challenge to be faced in using revenue recycling as part of a carbon emission reduction strategy. I would not go quite as far as Montgomery and Jaccard in recommending complete separation of a carbon taxation program from more general tax reform. A carbon tax would provide a new source of substantial government revenues creating the opportunity to redo the complicated political–economic negotiation underlying the existing tax system. On the other hand, rather than using the new tax revenues to reduce other more distortionary taxes, they could easily be used to support additional government spending on programs that have lower productivity than if the private sector spent the same amount of money. In this case, the net cost of the carbon tax would be larger rather than smaller than the cost when the recycling is done in a way that has the same average cost as revenues raised though the existing tax system.

Technological change

Energy–carbon taxes may stimulate the development of new technologies that use less energy and produce less carbon emissions. But, for both direct support of R&D and that induced by higher taxes, the net benefits of this induced technical change depends on how large the benefits are and whether the opportunity cost of the funds used for the R&D is higher or lower than those benefits. Energy R&D could reduce energy use and carbon emissions. However, the results of R&D in other areas could lead to more or less energy use, and these outcomes could be more important than the energy sector R&D outcomes.

The returns to R&D are very uncertain, but most empirical studies suggest under investment in R&D (see, for example, Sakurai *et al*, 1996). This under investment is probably the result of private sector's assessment that many of the benefits of the R&D would not be appropriable by them, and government and the public not believing or understanding this rationale for government R&D support. Direct public support for R&D would involve large direct costs to the government, but avoid the indirect market costs (ie deadweight costs) resulting from energy–carbon taxation. On the other hand, the public R&D support might simply displace private support for R&D. Moreover, the track record for government selection of large-scale RD&D technologies to fund has not been very good at times, which suggests funding more concepts at the small-scale demonstration level and letting the private sector determine which of the successful ones to fund at the next stage.

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