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G | M | F The German Marshall Fund of the United States
STRENGTHENING TRANSATLANTIC COOPERATION

REFLECTIONS ON CLIMATE-RELATED R&D

By
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EXECUTIVE SUMMARY: ACTION ITEMS AND GUIDING IDEAS

A long and lively discussion prevailed during the course of the joint Climate Policy Center/ German Marshall Fund workshop on R&D related to climate change., The following four points emerged as being especially relevant either as next steps or as longer-term principles.

- Governments doing important amounts of climate-related R&D should publish strategic plans of the kind that the US has recently drafted. These plans should include R&D spending estimates disaggregated technology-by-technology. This may be an effort that could be stimulated by the process launched at the Gleneagles G-8 summit.
- Climate-related R&D strategy must be anchored in a larger vision of climate policy. Defining the relationship between emission limits and R&D is an especially important step in setting a strategy for R&D.
- The G-8 countries may wish to conduct several case studies of how successful past R&D efforts were organized. These case studies would pool lessons from history and form a basis for evaluating the relevance of these experiences to climate-related R&D.
- In climate-related R&D, achieving the right division of labor between the public and private sectors (and finding the best possible institutional arrangements) requires ‘muddling through’. Both private and public institutions have serious limitations. Policy makers need to retain realistic expectations about institutional limits in order to achieve the best possible results.

INTRODUCTION

The relationship between technology and climate policy is certain to be a main item for discussion at the impending follow up G-8 meeting in London. The US Climate Change Technology Program (CCTP) has released its draft strategic plan, and public comment is underway. The new Asian Pacific Partnership Agreement is focused heavily on issues related to technology transfer. The recent British House of Lords report on the economics of climate change provides still further evidence of technology policy’s rising profile in the larger climate policy debate.

The joint Climate Policy Center/German Marshall Fund workshop on technology and climate policy emerged, in part, from the awareness of this intensifying action. Concerns about the difficulty of 'getting technology policy right,' however, add urgency to the inquiry. Although it is now obvious that technology is a crucially important source of climate policy solutions, how to maximize its contributions is not at all obvious.

The workshop sought to explore some of the basic questions about how R&D and other technology policies should fit into the larger climate policy context. The immediate goal was to generate concrete ideas that might contribute to the upcoming G-8 session in London. The longer-term consideration is that a small informal expert group with representation from Europe, Japan, and the United States might contribute to the larger process of improving the cost-effectiveness of climate-related technology policy.

PANEL ONE:

The workshop was organized into four panels. The first of these focused on describing the 'baseline'. It presented three snapshots of American, Japanese, and European climate-related R&D and other climate-related technology policies.

In the US, annual expenditures are around $3 billion. However, various subsidies boost the scale of the actual resource commitment. The total will depend in part, on how the recently enacted energy bill is implemented.

The European presentation highlighted the tension between economic development goals and climate change. This tension may be heightened by efforts to reinvigorate the Lisbon Process. Technology development has great appeal as a means of reconciling these goals. Similar considerations have also impelled the Japanese government to a strong emphasis on technology and the development of a robust technology development portfolio.

One participant observed that the three presentations indicated that, cumulatively, a lot of government sponsored climate-related R&D is in progress**.** However, except in the US, an exact calculation of the amount being invested in climate-related R&D has not been conducted. In Japan, the difficulty is, in part, that R&D expenditures are not monitored and measured as a separate category but are included in program budgets mixed with expenditures for other purposes. In parts of Europe, accounting is complicated by the lack of a clear distinction between climate-related R&D and R&D irrelevant to climate solutions.

The overviews suggested both similarities and differences among the various R&D programs. For example, European, Japanese, and US programs all officially embrace the principle of funding a diversified portfolio of technologies. However, the recent British House of Lords report on climate change criticized the UK national climate change technology program for implementing a technology strategy that was, in fact, too narrow in its technological emphasis.

Data on the actual spending patterns disaggregated by technology would be helpful in assessing the reality behind the claims of portfolio diversification. None of the summaries, however, presented such disaggregated spending data. Present government accounting practices also do not allow such calculations in Japan and much of the EU. The US data may be available, but has not been released in this form.

One participant suggested that the major governments should publish strategic plans on climate-related R&D of the kind that the US has recently drafted. Workshop participants doubted that there was much duplication of efforts among governments. Greater transparency in the international distribution of effort might improve resource allocation in all of the programs. The G-8 working group should consider a recommendation of this type as it meets next month.

American, European, and Japanese governments all appear to support the commercialization of those technologies that government deems to be socially desirable. In Japan, METI's technology roadmaps offer a particularly striking example in that it seems more systematic than are some of the other efforts.

The US government boosts commercialization of favored technologies through regulatory standards (i.e., CAFÉ) and through a panoply of subsidies, including tax subsidies. These activities, though, emerge as more as 'bottom up' or *ad hoc* initiatives rather than as results of a comprehensive planning process. Thus, the various subsidies built into the new energy bill preceded and were entirely independent of the CCTP strategic plan. This process is very different from METI's coordinated model. Because these differences are deeply rooted in ideology and governmental institutions, international cooperation on climate-related R&D must somehow circumvent the large stylistic differences.

Finally, the presentations emphasized R&D directed toward mitigation. R&D directed at adaptation or geoengineering was mentioned only in passing. Indeed, in the US, the current draft of the CCTP explicitly excludes work on adaptation and geoengineering. At least in some European nations, various adaptation schemes are afoot. <u>Perhaps the G-8 process might profitably inquire into the current global R&D spending balance between mitigation on the one hand and adaptation and geoengineering on the other</u>.

<u>PANEL 2</u>

There is a lively dispute between those who argue that a climate-related technology strategy should emphasize incremental improvements in existing technologies, and those who regard more radical technological innovation as vital to success. The second panel focused on this controversy.

This point emerged as a major theme of the second panel discussion. During this discussion, a presentation on the economics of climate policy made the following points:

- Current emission controls create little incentive for private sector firms to develop radically new technologies. (A European participant in the first panel had noted this aspect of the European ETS as constituting a troubling climate policy gap.)
- The costs of existing abatement technologies are so high that, if limited to these technologies, societies are unlikely to buy significant reductions in GHG emissions.
- Experience suggests that learning-by-doing will be insufficient to make today's technologies adequate for achieving large cost-beneficial emission reductions.
- The optimal sequence for climate policy is to concentrate initially on R&D needed to develop new, far less costly abatement technologies and to implement emission limits only after such technologies become available. (Another participant argued that these policy tools should be employed simultaneously even if the short-run gains from emission controls were minimal.)
- Threatening high future penalties on emissions will not encourage sufficient private sector R&D. Private sector investors will not make R&D investments based on

expectations of future high emission tax rates or allowance prices, because government will have incentives to lower these penalties once successful innovation has occurred.

The last point resembles the dilemma posed by research on cures for some epidemic diseases. Drug producers must anticipate that success will lead governments to infringe on their patent protection in order to maximize the availability and cost-effectiveness of the cure. But that anticipation discourages the drug makers from investing in research in the first place.

The discussion also raised several factual questions about the adequacy of existing technology. Several participants argued that the issue was cost, not availability. One person noted that some estimates show that current technologies could make large inroads in emissions at modest costs. This point drew the rejoinder that such analyses assumed cooperation of China, India, and other LDCs – cooperation that is, in fact, neither occurring, nor – in the view of many – likely to occur.

A participant advanced the case for a greater emphasis on advanced renewable energy sources. This participant believes that IPCC assessment of existing technologies is overly optimistic. Moreover, he asserted, trends toward the 'decarbonization' of the global economy could be on the verge of reversal. It was possible, therefore, that the need for new zero emission energy sources would be much larger than is now projected. Limitations on other technologies suggested that advanced versions of renewables warranted increased investment. Super-efficient long distance electricity transmission and energy storage technologies were key enabling technologies required for the successful exploitation of renewables, a point that had been adumbrated in the discussion of the CCTP.

Another expert (who was not able to attend the session but who commented upon issues raised by the agenda) expressed strongly contrasting views. He argued that learning by doing would be so powerful that existing technologies would be sufficient to dramatically slow the growth in emissions during the next fifty years. In this time frame, the existing technologies would not become 'saturated', i.e. they would not encounter diminishing marginal returns.

Interestingly, two participants suggested that Europe largely still has not addressed the questions of long-run versus short-run. One ascribed this omission to the availability of natural gas and fuel switching as a short-run option. However, both participants felt that as Europe begins to consider GHG controls in a longer time frame, the potential choices would begin to emerge.

These rich and interwoven debates suggest that today's apparent consensus that 'technology is the answer' masks very large disagreements about which technology, when, and produced by what policies. Among the many key questions on which there was either explicit or implicit disagreementwere:

- What could we expect from existing technologies, especially given the economic literature on learning by doing?
- Is there a risk of locking-in inferior technologies from this same phenomenon?

- If the large LDCs will not participate in GHG limitation policies, will they nonetheless adopt carbon capture and storage (CCS) technologies which necessarily suffer cost penalties vis-à-vis the same energy sources without CCS, and what is the policy mechanism for encouraging such use?

- What is the optimal division of labor between emission limits or taxes and policies to encourage R&D?
- What are the natural limits at which existing abatement technologies encounter diminishing marginal returns and how resistant are those limits to further technological progress?

While some of these issues have been vigorously debated in the scientific literature, that debate has often involved tacit assumptions about economics (almost unlimited learning by doing) and politics (global reach of international GHG control regimes). One workshop participant urged a more multi-disciplinary approach to planning climate-related technology development. Climate-related R&D strategy must be anchored in a larger vision of climate policy. Defining the relationship between emission limits and R&D is an especially important step in setting strategy for R&D.

LUNCH PRESENTATION AND DISCUSSION

The presentation of the lunch speaker and the subsequent discussion focused on international dimensions of climate-related R&D. The speaker was a senior US official with responsibility in this area. He observed that it is important to continue asking what our efforts at international cooperation are achieving and whether they can be improved.

There are four areas where international cooperation already is underway.

- International Energy Agency (IEA). This effort emerged in response to the energy emergencies of the ‘70s. IEA brings together member agencies, universities, and others on collaborative research projects, and helps to establish new energy-related initiatives (currently managing 42 agreements). Up to $500 million a year goes into this for groups focusing on projects such as: fossil fuel working technology (i.e., clean coal projects); renewable energy technology; end-use technology efficiency; and fusion power coordination. The IEA also is funding the Epcot Group on Science and Technology, which looks at informing policy of promising new technologies. The IEA is an umbrella organization under which nations organize multilateral and bilateral arrangement to their mutual benefit.

- International Partnership for the Hydrogen Economy (IPHE): IPHE is only two years old. This group is beginning to organize around the theme of developing a technology roadmap for the future, and to identify projects that can help to move forward in certain technology areas. IPHE also is working on codes and standards to facilitate the introduction of new technologies globally. This is a key test in the advance toward the hydrogen economy. Developing countries have been very active in this group.

- Carbon Sequestration Leadership Forum (CSLF): This organization identifies gaps where knowledge is needed to make new CCS technologies into a reality. It is assessing the earth’s overall carbon storage capacities, and is promoting carbon sequestration as a viable climate change mitigation option.

- Gen IV Technologies: This project is looking into the future for new nuclear technologies that will simultaneously reduce costs, generate less waste, and reduce proliferation risks. It is working to develop a framework agreement (5 countries already have signed) and to date several projects are underway. This is probably the most mature of the various agreements. The methane to markets project, as the newest, may be the least developed.

The challenge for all groups is to decide how and to identify which strategies will work best for injecting findings into the decision-making process.

PANEL 3

The lunch discussion focused on international institutional arrangements. Panel 3 brought that discussion into focus on the national level. It described three possible models for organizing climate-related R&D.

One possible model is the Defense Advanced Research Projects Agency (DARPA). (By chance, on the day of the workshop, a panel of the US National Research Council announced a set of recommendations for boosting US technological and scientific performance. One of these recommendations was for the creation of an Advanced Research Projects Agency within DOE to speed the development of new energy technologies and to meet the challenge of climate change. Thus, the workshop's discussion of this option is not an isolated manifestation of interest in this particular organizational model).

DARPA was created in 1958 in response to the scientific challenge posed by the launch of Sputnik. Its important spin offs and successes are myriad. They include incubating the organization that was to become NASA, creating stealth technology, nurturing early information technologies, spawning the internet, importantly advancing the Global Positioning system, drones, precision strike stand-off weapons, Ballistic Missile Defense, and other technologies.

DARPA's mission concentrates on high payoff revolutionary technologies. It pursues this strategy despite the relatively high risks associated with the search for large breakthroughs. The philosophy is that a relatively few large scale successes will more than pay for many failures.

DARPA's philosophy entails finding brilliant people and giving them substantial autonomy. By design, work force turnover is relatively rapid. The organization has successfully resisted 'bean-counting' measurements of success. Other features that have contributed to organizational success include:

- Large scale organizational evolution is essential to preserving productivity. DARPA has undergone several major new incarnations in its organizational life.
- DARPA organization is relatively simple and flat – with few management layers.
- The criteria, by which project successes are measured, although ambitious, are clear.
- DARPA creates ideas so that <u>others</u> can implement them.
- The organization searches for talent in many places and, hence, maintains a workforce of people of mixed professional backgrounds.

Appealing as the DARPA model is, energy and climate-related technology development would present new and different challenges. For example, DARPA does not create for the market –

even though technology developed by DARPA has succeeded in the marketplace. Its customer is the Secretary of Defense and ultimately the armed services. Most of the technologies relevant to energy and climate solutions will have private sector customers. This is a problem that DARPA has not had to confront. Still, DARPA offers valuable lessons concerning managing and spurring successful technological innovation. It may be that an imperfect solution to the challenge of technology development still might improve on the record of existing institutions.

Another somewhat related organizational innovation is also receiving current consideration in the US. This is the idea of 'exploratory research'. It is related to the DARPA concept in that it emphasizes the pursuit of revolutionary advances rather than incremental changes. It does not, however, require the creation of the entire DARPA paradigm of personnel and structural policies.

The CCTP's draft strategic plan proposes the creation of such a program. The basic idea is to create a merit-reviewed program to provide seed money to innovative ideas offering a promise of large advances in key technologies. DOE has recently had success with such a program in the area of fossil fuel technology.

A small group of non-governmental observers (which includes the current author) have recently proposed one way of implementing such a concept. This approach starts from the assumption that current technologies are inadequate for reducing emissions at economically rational and politically realistic costs. This is why exploratory research is so essential.

- Research needed in several key areas: adaptation and geoengineering, vehicles that are more efficient; coal gasification; building efficiency; carbon capture and storage.
- There is a need to find technological 'silver bullets' that can help to leapfrog over current technologies and achieve needed reductions.
- The task of exploring new ideas could be organized under an entity separate from CCTP – perhaps a quasi-independent structure outside DOE?

A participant from the UK described their government's efforts to create organizational structures that explore technology and innovation. One of these is the UK Energy Research Council (UKERC). It explores collaborations to develop new technologies. It also is taking the lead in proposing policy instruments that can encourage and help build markets for new technologies. It was not entirely clear what kinds of policy initiatives were meant. Nor did the discussion reach the question of how the process compared costs and benefits of the technologies and the policy initiatives to foster them.

The Carbon Trust is a second separate institution. It was founded by the government, but is now semi-independent. Its goal is to move innovative new technologies to market. The Carbon Trust facilitates private sector investments in technologies deemed climate-friendly. The goal of these investments is to encourage the flow of private sector venture capital into the commercialization of these technologies. This activity has resulted in the rapid growth of a 'clean technology' sector in the UK. So far, the CT has leveraged £1 billion in private investment into clean technologies. Experience so far has been that commercialization has been a non-linear process (*i.e.* advances are happening in different areas and at different speeds).

How to organize successful public sector R&D may be one of the most important challenges facing climate policy. Yet it has received almost no attention. The G-8 countries may wish to conduct several case studies of how successful past R&D efforts were organized. These case studies would pool lessons from history and form a basis for evaluating the relevance of these experiences to climate-related R&D.

PANEL 4

Panel 4 explored the division of labor between the public and private sectors in the promotion of climate friendly technologies. A German participant explained that in the Federal Republic, the government regards its role as investing in the long-term energy future. The private sector's role is to address the short-term.

This division of labor occurs in an economic environment in which 1/3 of all electricity generating capacity must be replaced within the next 20 years. (It was unclear if an assumption about the future of existing nuclear power plants significantly influenced this estimate.) The past German government determined that renewable energy must replace much of this capacity. Another participant noted that in Germany the wind power association possessed a very high level of political influence. Currently 11% of Germany's electricity comes from renewable sources.

Government uses a panoply of tools to implement its preferences. For example, under the 'feed in,' law grid operators must purchase electricity from renewable sources at fixed (above market) prices. An eco-tax has been imposed. This levy is designed to penalize energy consumption. The application of the tax is, however, capped – greatly weakening its impact on energy intensive industries. The result is to significantly diminish the measure's environmental effectiveness. Revenues from this tax defray parts of the costs of financing the state-run pension system. It is claimed, therefore, that the eco-tax shifts tax burden favoring the substitution of labor for energy.

Recently the European Emissions Trading System (ETS) has been added to this array (which also contains 'voluntary' automobile standards, subsidies for retrofitting buildings, and building codes). The structure of this plan, in particular the allowance allocation system, has produced a sharp increase in electricity prices combined with the generation of significant economic rents among electric power producers.

Such a multiplicity of instruments inevitably distorts incentives for technological choice and technological innovation. The shadow price of a ton of carbon abated under these diverse policy measures must vary widely. The German system seems to reflect extensive government pre-emption of market decisions, but with little economic coherence in its implementation.

In this panel, a second presentation suggested that no perfect solutions were possible in organizing energy R&D. The presenter suggested that a major reason is the absence of a shared view of the level of risk. MIT scientists, he noted, believe that the range of possible temperature increase this century falls between 2 and 9 degrees Fahrenheit. At the low end of the range, the technology challenge is not daunting. At the high end, we would face what some have called the "technology challenge of the century." Until the range of uncertainty narrows, it is hard to make the case for a Manhattan or Apollo scale technology effort.

Technological advance offers the best hope for addressing the climate change risk. Nevertheless, our ability to significantly improve the effectiveness of national energy R&D and to accelerate the pace of technological development is doubtful. Both the public and private sectors play critical roles in promoting new technologies. But both are imperfect instruments. Problems include:

- Government is best suited to support basic research. At a time of large and growing deficits, however, there is no major constituency for investing in more R&D.
- Short electoral cycles encourage politicians to prematurely pick winners or narrow the range of options. R&D is always susceptible to political manipulation as politicians seek a ‘fair share’ for their constituents.
- Although discovery is unpredictable, the political process forces the bureaucracy to plan and manage programs to minimize uncertainty. That extreme risk averseness inevitably wastes resources and limits the potential for discovery.
- The private sector, while doing and supporting some basic research, places most of its emphasis on applied research that pursues incremental change. As a rule, technologies developed by business enable companies to improve the performance of their current systems.
- While companies investigate potential new energy systems, the scale of the R&D is too small to yield major near-term system transformations. Thus, oil companies did most of the early work on solar technology. These companies later concluded that solar power’s potential lay well beyond their planning horizons.

Public-private sector collaboration makes sense given their areas of comparative advantage and the skills each brings to R&D. Collaboration has sometimes succeeded. But, in the energy field, the history has not been encouraging.

In the real world with conflicting incentives and agendas, muddling through may be the best available option. If we learn from the past and have realistic expectations, we can probably do better and possibly avoid wasting too many resources.

CONCLUSION

The discussions produced a set of recommendations that the organizers believe would be useful ground work for the G-8 talks on climate change. They are as follows:

- Governments doing important amounts of climate-related R&D should publish strategic plans of the kind that the US has recently drafted. These plans should include R&D spending estimates disaggregated technology-by-technology. This may be an effort that could be stimulated by the process launched at the Gleneagles G-8 summit.
- Climate-related R&D strategy must be anchored in a larger vision of climate policy. Defining the relationship between emission limits and R&D is an especially important step in setting a strategy for R&D.
- The G-8 countries may wish to conduct several case studies of how successful past R&D efforts were organized. These case studies would pool lessons from history and form a basis for evaluating the relevance of these experiences to climate-related R&D.
- In climate-related R&D, achieving the right division of labor between the public and private sectors (and finding the best possible institutional arrangements) requires ‘muddling through’. Both private and public institutions have serious limitations. Policy

makers need to retain realistic expectations about institutional limits in order to achieve the best possible results.