Climate Technology Innovation

A NEW GLOBAL STRATEGY AND STRUCTURE

Lewis Milford, President
Daniel Dutcher, Project Director
Clean Energy Group

WITH

Todd Barker, Partner
Meridian Institute

May 2008

TABLE OF CONTENTS

Technology is a key to mastering climate change as well as enhancing energy security. We have urgently to develop, deploy and foster the use of sustainable, less carbon intensive, clean energy and climate-friendly technologies in all areas of energy production and use. We have to develop and create supportive market conditions for accelerating commercialization of new less carbon intensive, clean-energy and climate-friendly technologies. Furthermore, to ensure sustainable investment decisions worldwide, we need an expanded approach to collaboratively accelerate the widespread adoption of clean-energy and climate-friendly technologies in emerging and developing economies. Therefore, we will

- *stimulate global development, commercialization, deployment and access to technologies,*
- *promote major emerging and developing economies' participation in international technology partnerships and collaborations,*
- *scale up national, regional and international research and innovation activities*
- *and undertake strategic planning and develop technology roadmaps to strengthen the role of advanced technology in addressing climate change.*

Heiligendamm G8 Summit Declaration (June 7, 2007)[1]

We are in danger of learning the wrong lessons about innovation. As a result, we risk neglecting those capabilities that are the real wellsprings of creativity…the capacity to integrate across organizational, intellectual, and cultural boundaries, the capacity to experiment, and the habits of thought that allow us to make sense of radically ambiguous situations and move forward in the face of uncertainty.

MIT Professors Richard Lester and Michael Piore

Innovation, The Missing Dimension[2]

Breakthrough innovations depend on ordinary people, bridging their expertise and building communities around their insights. They can be managed. Breakthrough innovations may never become routine, but they can certainly become more likely…Strategy too often neglects the question of how to get there. Yet, especially when innovation matters, the strategy is the organization.

Professor Kathleen Eisenhart

Forward to *How Breakthroughs Happen*,
by Prof. Andrew Hargadon[3]

SUMMARY

A top Chinese climate official recently asked the international community to establish a "special body" to transfer existing low carbon technologies and accelerate breakthrough technology change.[4] At the same time, a key climate adviser to the Japanese Cabinet has called for "a new mechanism" to "scale up and accelerate research, development and deployment and commercialization programs of key breakthrough technologies" for reducing emissions in the next two decades.[5] These proposals echo the June 2007 Heiligendamm Declaration, in which the G8 countries recognized the need for "an expanded approach to collaboratively accelerate the widespread adoption of clean energy and climate friendly technologies."[6]

There is now near universal consensus on the need for new technology approaches in the post-Kyoto 2012 process. Calls for a new climate technology innovation framework were given more urgency by recent evidence that the technology scale-up needed for stabilization is much greater than experts previously thought.[7]

Despite this unanimity, what is missing is any agreement on how to do it. To address this shortcoming, we propose: (1) a new *strategy* for climate technology innovation, and (2) a new *structure* to support its implementation.

This paper proposes a structure and strategy for climate innovation, with an explanation of the gaps in the current system, and the pathway forward to introduce these new recommendations into the post-2012 climate negotiations.

Strategic Principles. We propose several core principles to support a new strategic direction for global climate technology innovation.

First, the planet needs new, rapidly scaleable and powerful technologies in the next 10–20 years that fundamentally "change the game." Carbon price incentives will not on their own produce breakthrough technologies or lead to necessary scale.[8] The current international research development and deployment (RD&D) system for energy is not adequate to the task of massive scale up and breakthrough technology development. Companies that once were involved in R&D have left that space, government R&D programs are rarely connected to commercial pathways and commercialization strategies, and there is no international climate process to address global technology innovation from a new strategic or structural direction.

Second, given the extraordinary complexity of the problem, which is multi-faceted, new tools and strategies must meet the unique demands of individual technologies. Solutions will vary from technology to technology based on the technical, institutional, financial and other constraints that limit or inhibit scale-up or breakthrough advances.

Third, new innovation strategies will rely on public and private sector innovation disciplines. Ideas will inevitably come from conventional energy technology areas, but they also will come from other technology innovation areas, including those in the information technology and pharmaceutical sectors and those that involve "public goods" or "market failure" challenges such as public health, drug development and agricultural productivity. Over the last decade, private companies, foundations, and governments in other sectors have employed multiple global strategies, tools, institutions and partnerships to accelerate product development and commercialization that have not been used for low carbon technologies.

Fourth, technology strategies should focus on rapid product innovation, development and diffusion, going beyond top down research programs or conventional "information sharing of best practices" that are not linked to clear, time-bound, commercial pathways; new actions must be based on the climate science that demands immediate greenhouse gas reductions within the next two to three decades. For purposes of this paper, the term "innovation" means: "putting ideas into commercial use" that includes "creation of new products and services, the use of new production technologies and techniques and the implementation of new ways to organize work and business processes."[9]

Fifth, these approaches recognize that the old-fashioned, post-World War II idea of innovation moving in lockstep down the chain of abstraction from research, to applied research, to development and then diffusion is no longer accurate. As Nathan Rosenberg, professor emeritus of Stanford University, bluntly put it, "everyone knows that the linear model of innovation is dead."[10] As a result, strategies that put these innovation elements in separate silos and then create discrete policy and institutions around different elements of this dead innovation model are unlikely to succeed. In its place, is a more dynamic model that links all elements of the innovation chain through a networked process, moving back and forth, up and down, in real time, among research, development and diffusion activities.

Sixth, these approaches also represent a significant departure from typical energy programs that subsidize "one off" technology projects—in order to have impact, the technologies must move well beyond the prototype or single demonstration project stage. Commercialization strategies should be an integral part of the innovation process from R&D through deployment. Without attention from the start of a project to the end goal of commercialization, funders may find they have financed good, but ultimately unmarketable solutions—or solutions that cannot be developed at sufficient scale to make a difference in the time needed for rapid and declining emissions reductions to occur.

Seventh and finally, these new strategies can promote private and public sector technology product development, but they also can enable collaborative finance and policy efforts. They can identify and refine new finance tools to support rapid technology commercialization, and address new policies where the private market cannot deliver the products needed to move quickly enough to reach mainstream markets without government support.

Structural Principles. These strategies also call for a new structural framework to address global climate technology innovation—strategy should drive a new structure for technology collaboration.

There are several principles for this new architecture of climate innovation.

First, a new global institutional framework should be created for low carbon technology innovation. It should be an independent, nonprofit global institution *outside of but linked to* the existing climate entities such as the United Nations Framework Convention on Climate Change (UNFCCC), the International Energy Agency (IEA) or the World Bank. One potential structural model for climate technology is *The Global Fund to Fight AIDS, Malaria and Tuberculosis*, an independent foundation founded by major governments, which has international organizations and national donors on its board. It addresses persistent global public health "public goods" problems through new tools, strategies, funding and partnerships.

Second, this new climate institution should support a globally distributed network of experts and collaborators, located within existing public and private sector institutions in both developing and developed countries that are linked together

within technology-specific projects. The institution could be structured as a "hub and spoke" network (i.e., a hub with numerous, technology-specific initiatives as the spokes). A small core management group would link existing efforts, ensure cross-fertilization of ideas and strategies, and be the institutional "glue" connecting these widely disaggregated and globally distributed innovation activities. The core management group would not be a large bricks and mortars operation, but a nimble coordinating team. The parties to the larger climate technology network would include governments, NGOs, clean energy technology experts, private sector, donors and finance institutions, as well as international climate agencies.

Third, this new entity would require global funding. It should enlist the joint financial support of governments, private donors and the private sector, in the same way *The Global Fund to Fight AIDS, Malaria and Tuberculosis* has been funded (US$10 billion to date).

Fourth, because the linear model of innovation is "dead," research, development and deployment are no longer discrete activities in modern innovation. Governments should not assign responsibilities for these different tasks to different institutions, assuming that it will produce an effective technology result. Rather they should look to create institutions and frameworks with broader missions that coordinate and work on these actions together, to create complementary benefits. As Paul Romer, one of the leading U.S. economic theorists has put it,

> From an economic perspective, it remains the case that the division of labor increases efficiency…However, if we aim to complete the arc – to bring abstract research generation by real-world observations back down to the real world for practical application – the individuals who work in real world contexts in one camp, and those work at high levels of abstraction in the other, need to be committed to communication on the upward and downward portions of the trajectory.[11]

Fifth, in addition to product development, this independent entity also could be responsible for supporting both policy and finance strategies. It could help develop and promote cooperation and coordination on government policy measures, leading to needed technology policy agreements and implementation activities among governments.

Conclusion. With this proposed strategy and structure, this paper turns to a more in-depth discussion of the rationale for this proposal and its components, and offers suggestions for a pathway for future consideration and adoption by the global community. The remainder of the paper is organized along the following topics:

1. *Needs and gaps*—this section addresses why this new strategy and structure are needed due to the gaps in the current global system for climate policy.
2. *Strategy, Policy, Finance and Strucutre*—this section describes in more detail a new innovation strategy and global structure; it also explains how these approaches could be used to develop coordinated policy measures for climate, as well as new finance tools.
3. *Pathway to the Post-2012 Architecture*—this section explores the various pathways for moving these approaches through the international level, the obstacles to doing so, and where there might be some common ground for next steps to achieve consensus for further action.

NEEDS AND GAPS

While there are numerous international climate initiatives in many institutions, they generally have not been assigned missions to aggressively accelerate low carbon product innovation, development and deployment at a global level.[12] This leaves a massive global climate technology strategy and structure gap.

This analysis applies to organizations such as the United Nations Framework Convention on Climate Change (UNFCCC), and the World Bank Group (WBG), as well as the 15 or so bilateral and multilateral energy partnerships and initiatives. (A more thorough gaps analysis appears in the Appendix.) In general, these institutions and initiatives, while serving important roles, are missing the following elements:

- No global infrastructure in place today provides the strategy and financial support for low carbon technology innovation, scale-up, and related institutional frameworks needed to provide long term stabilization of climate through expedited technology RD&D.
- The absence of that infrastructure means that there are, at best, a series of fragmented and uncoordinated efforts to promote low carbon technology

activity, which is inadequate to the historic task of climate stabilization through technology innovation and scale-up.

- Moreover, none of the existing international clean energy RD&D activities are designed to leverage private sector investment at the levels needed to meet the stabilization challenge, take advantage of other analogous technology strategies, bring together OECD and developing countries, or provide a way to link technology development with other climate strategies such as cap and trade or carbon offsets finance measures.

- While efforts at the UNFCCC and Global Environment Facility (GEF) represent important components of a global climate strategy, their missions do not principally focus on technology innovation and scale-up for mainstream commercialization. The UNFCCC supports treaty negotiations and related technology analysis. GEF provides financial assistance for "additional" emissions reductions in projects using existing technology in developing countries.

- A similar situation exists at the WBG. With its development mission in the poorest developing countries, it generally focuses on financing existing technologies in an overall country-specific economic aid strategy, rather than on innovation for technology breakthroughs to create a global impact on climate stabilization of emissions.

- Overall, the existing international clean energy RD&D landscape is characterized by modest initiatives with short-term goals, fragmented research, no link to activities for commercialization pathways, and no strategy for rapid scale up of existing and breakthrough low carbon technologies.[13]

- In particular, with regard to the 15 or so bilateral and multilateral clean energy research and development initiatives around the world that range from the Asia Pacific Network for Energy Technology (APNET) to the Asia-Pacific Partnership on Clean Development and Climate (APP) (formerly AP6),[14] they generally lack a strong strategy or structure for long term commercial success.

  — Each initiative employs a different approach with a different target audience and strategy, with most generally organized around conventional information networks of research centers or other entities "sharing best practices."

  — There is no evident linking strategy or coordinated process to learn from

successes and failures, and implement improved strategies on a global, regional, or national scale.

— Of the 15 initiatives, only one or two (such as the APP) are in any way "operational"—that is, *almost none are actively focused on funding real world technology research, development, and deployment with public and private funding.*

— In total, the 15 initiatives appear to have an aggregate global budget of approximately US$200 million (with the bulk of that amount from US$175 million dedicated to the APP); so that the collective global budget for non-APP activities appear to be about US$25 million a year, a meager public financial commitment to climate coordination on technology worldwide.[15]

These gaps explain why there is a flurry of demands to create new mechanisms for technology innovation and deployment. The next section explains how new climate strategies and structures could be developed to meet these demands.

STRATEGY, POLICY, FINANCE AND A NEW STRUCTURE

Current evidence suggests the climate technology challenge is even greater than experts have thought. A recent article in *Nature* reports that Intergovernmental Panel on Climate Change (IPCC) models seriously underestimate how much new technology is needed to achieve emissions stabilization. This is because the models assume a "majority" of the emissions reductions will occur through spontaneous technology change without any technology policy.

> There is no question whether technological innovation is necessary—it is. The question is to what degree should policy focus on directly motivating such innovation? The IPCC plays a risky game in assuming that spontaneous advances in technological innovation will carry most of the burden of achieving future emissions reductions, rather than focusing on creating the conditions for such innovations to occur.[16]

To date, discussion about solutions to climate change has focused on cap and trade; relatively little effort has been devoted to develop the strategies and structures to directly support rapid technology development and deployment. Given studies like the recent *Nature* article, it is time now to rethink our energy

innovation agenda, and consider new approaches for technology innovation and deployment.

In order to develop a new, comprehensive, complementary and integrated approach to climate technology innovation, a key goal is to provide academics, companies, donors, and others with as many useful tools as possible to address low carbon technology innovation and deployment. We start with the following assumptions in this area:

- The technical, policy, finance and political challenges will vary from technology to technology (e.g., carbon capture storage (CCS), solar, biomass); each technology will require its own customized approach.
- Technology strategies should focus on rapid product innovation, development, and diffusion, and go beyond research strategies or information networks of experts that are not linked to clear, time-bound, product development, commercial pathways.
- These new technology innovation approaches must be applied to a full range of climate-friendly technologies. Any future scenario must include commercial strategies for many technologies that should include at least the following five technology sectors: (1) CO_2 capture and storage (CCS); (2) biomass; (3) hydrogen systems; (4) renewables, including wind and solar power next generation systems; and (5) end-use energy technologies. Emerging areas of research such as nanotechnology may also offer as yet unrecognized opportunities.[17]
- Innovation strategies will come from the energy as well as the non-energy sectors. Climate technology challenges may benefit from innovation and product development strategies used in other sectors such as information technology, health and agriculture, either where new private sector technology strategies have been developed that harness "open innovation," or in "market failure" or "public goods" global problem areas such as AIDS, malaria, and agricultural productivity.
- Some of these private and public sector approaches, whether designed for profit or for solving global public problems, have loosely been grouped under the heading of "distributed innovation."[18]
- For climate, a proposed "structure" for this strategy could rely on elements of

independent international institutions such as *The Global Fund to Fight AIDS, Tuberculosis and Malaria* to organize the collaborative efforts needed in this area—a new institutional structure is needed to catalyze the strategy needed for technology innovation.

- While each technology may require its own approach, these individual initiatives would benefit from coordination that helps catalyze, support and sustain global innovation and technology deployment.
- These new strategies and structures can be used not only to promote private and public sector technology collaboration, but also to support cooperative finance and public policy development and collaboration.

STRATEGY

Distributed Innovation Strategies. The term "distributed innovation" encompasses strategies ranging from the following: open source approaches used to develop the Linux computer operating system; open innovation approaches used by individual companies such as Proctor & Gamble to supplement their own in-house research and development capacity; and global, collaborative product development initiatives, such as the Generation Challenge Program (GCP) that link together numerous people working in different institutions and countries, but united together under a single project focused on product development and deployment.[19]

These strategies take advantage of the rapid increases in knowledge and advances in electronic communication that characterize our modern world and recognize that solutions to problems often come from unexpected places.[20]

In multiple sectors including health, agriculture and information technology, governments, companies and donors have created new strategies to accelerate technology innovation and development, including efforts directed at overcoming "global market failures." They often rely on "distributed innovation" strategies to tap and bring together innovators and researchers from around the globe to develop and deploy new technologies. They link R&D to viable commercialization strategies. These are not conventional information networks that typically link "bricks and mortars" centers of researchers to share "best practices" or policy information, but an entirely new approach focused on collaborative R&D and product development worldwide.

The driving objective for "distributed innovation" is to accelerate deployment of a specific technology by attacking the problem from multiple intervention points including, but not necessarily limited to, technical, market and financial, policy, regulatory, legal (including intellectual property rights issues), and institutional.

Participants in these distributed innovation projects could come from across the globe; teams of experts assemble around specific technologies and are supported by a global innovation community. Such efforts are structured in a hub and spoke fashion, and often include a diverse portfolio of technology-specific projects on different time scales.[21]

There are numerous examples of how these strategies are being used. They now range from global, collaborative projects addressing public goods problems to the use of open innovation tools by private companies.

The Generation Challenge Program (GCP), for example, is a global project involving well over 100 scientists in more than 30 countries collaborating to develop improved crop varieties including rice and maize. It exemplifies how a global, collaborative distributed innovation approach could be applied to a climate technology effort:

> Created explicitly to better link "upstream," research activities…and "downstream" activities (product development, testing and deployment) the Generation Challenge Program (GCP) is designed at every level to drive research from the laboratory to the "market"…As no single institution could command the breadth of expertise and resources necessary to achieve these objectives, the GCP employs a distributed innovation strategy that leverages significant intellectual and physical resources—funds, skills, equipment, knowledge, and social capital—through numerous projects that each involve many institutions and initiatives, public and private…This structure provides the agility needed to capture emerging opportunities, promote innovative partnerships, and develop appropriate product delivery schemes.[22]

While some distributed innovation approaches involve multiple institutions from around the world, distributed innovation strategies can also be used by single companies operating in a highly competitive environment. Proctor and Gamble, for example, has been tremendously successful using open innovation approaches to supplement its in-house research and development capacity.

> We tap closed proprietary networks and open networks of individuals…we look for ideas in governments and private labs, as well as academic and research institutions; we tap suppliers, retailers, competitors, development and trade partners, VC firms, and individual entrepreneurs.[23]

Probably one of the most celebrated private sector examples of a company that supports distributed innovation is the company InnoCentive, which was spun off by Eli Lilly and Company. According to the co-founder of InnoCentive,

> The business offers firms that encounter difficult science problems an alternative to devoting laboratory time and resources to the search for a solution. Firms can now post such problems, together with a designated cash prize (typically ranging from $5,000 to $100,000) for an acceptable solution, on InnoCentive.com. Problem posters and prospective solvers, who self select to the attempt to devise or formulate a solution, remain anonymous to one another throughout the process. InnoCentive's role is that of knowledge broker, providing the seeker firms that post problems with solutions solvers have been motivated to submit. The seeker firm chooses the most appropriate solution, if any, and receives from the solver, in return for the prize money, all rights to the intellectual property related to the solution.
>
> InnoCentive's solver network includes more than 120,000 scientists from around the world. More than 400 problems that could not be solved by the R&D laboratories of some 50 firms have been posted. Each problem piques the interest of more than 200 scientists, about ten of whom submit solutions. About one-third of the problems posted by seeker firms have been solved and the associated prizes awarded. Solutions arrive from unexpected sources and are typically not what the originating problem holder scientists had envisioned as possible.[24]

Finally, these new collaborative models are now an established part of the modern corporate innovation process. According to two Harvard University experts on public and private innovation practice,

> Underlying and driving these changes is the increasingly distributed and decentralized nature of technology. Industry is shifting from the central R&D laboratory to the global R&D network. In the past, corporations could internalize research and technology development, but as the sources of technology have become more

> decentralized and distributed, the challenge has become how to manage external sources of technology. To cope with these changes, corporations are developing new collaborative relationships, alliances and partnerships relying more upon their suppliers, and users as sources of technology; establishing more overseas R&D labs; and increasing their partnerships with universities and government laboratories.[25]

But none of these innovation strategies have been applied to low carbon technologies. For climate, such a strategy would include a diverse portfolio of technology innovation and development approaches on different time scales—from short-term solutions to reduce emissions almost immediately to mid-range commercial opportunities in the next 5–10 years, to longer term, disruptive (or radical) innovations not yet imagined for energy—all designed to create the framework for a 50-year transitional plan to stabilize greenhouse gas (GHG) concentrations in the atmosphere.

What these new innovation strategies teach us is that technology solutions for climate stabilization are likely to come from unexpected sources—from the "connections" between a wide range of industry, academic, government, and technology sectors and disciplines.

POLICY

Climate and Energy Policies. For the last twenty years, the policy debate around climate has focused almost exclusively around cap and trade (C&T). While C&T is likely to remain and expand, there is a clear need for a complementary and separate technology policy strategy to achieve emissions stabilization. This policy dimension would complement the "product development" focus of the distributed innovation strategy already outlined.

There is an increasing interest in complementary technology sharing and collaborative strategies that can be achieved at a global level:

> Meanwhile, an array of climate technology policies has emerged, at both national and international levels. Such policies include government funding for research, development, and demonstration of new technologies, subsidies and mandates for the production of alternative fuels and associated technologies (e.g., renewable portfolio, building, and biofuel standards), loan guarantees for investments, technology performance standards (e.g., for energy efficiency), and the provision of

> information to encourage improved decision making by equipment purchasers. Following these developments, growing attention has turned to the possible role of international technology-oriented agreements (TOAs) as part of the architecture of international climate-change policy.[26]

The proposed initiative described here could address technology product development in a non-policy framework, but it also can be a vehicle for just this kind of policy coordination and cooperation among countries and other partners. Professor David Victor of Stanford University has noted that energy, and therefore its climate impacts, is decidedly a local affair, so linking those local, regional and national efforts is a key challenge in climate.

> Although the problem's effects are inherently global, its causes are resolutely local. In most of the world, including many developing countries, domestic authorities choose what energy system to use, and because they decide how much fossil fuel to consume, they effectively control emissions of carbon dioxide…. Because local needs and interests will necessarily vary, sustainable development must be redefined repeatedly, from the bottom up, wherever it is to be put into practice.[27]

The opportunity for coordination is important because, in many countries, there is a growing movement to develop new regulatory policies (beyond cap and trade) and "technology forcing" measures to reduce carbon emissions. These disparate policy efforts could benefit from more national and global cooperation and coordination, where new policies can be developed, and other measures can be cooperatively pursued. An umbrella strategic role of this new climate institution could support collaborative policy examination and possible joint adoption of technology or industry-specific standards, protocols and agreements. Former Ambassador Richard Benedick, who negotiated the Montreal Protocol for the United States, has written,

> In order to influence long-term private investment decisions in energy, transport, and infrastructure, policy-oriented parallel regimes should be reinforced… Parallel regimes would enable motivated governments to move away from the mega-conference syndrome and its accompanying trade-off mentality, and instead to focus on pragmatic problem-solving coalitions in smaller and less formal settings. Public-private partnerships drawing on industry expertise, local communities, and civil

society would be characteristic of this approach. Negotiations and consultations would be reduced to a manageable number of countries and delegations, and would be more specialized and technical in their scope.[28]

In particular, substantive policies, both established and emerging, are available to accelerate climate technology development and innovation but they generally are not now pursued on a collaborative basis among interested nations to reach accelerated agreements on the time frames needed for climate stabilization reductions. Here we provide an initial summary. While not all-inclusive, this list contains examples of the kinds of policies that might populate a complementary technology-based component of a new international climate and energy framework within the structure proposed here.[29]

Technology Bans or Phase-Outs

Policies that ban or phase out obsolescent products and processes can accelerate the deployment of climate-friendly policies. Australia, for example, has announced plans to phase out incandescent light bulbs, which will be banned from sale in Australia beginning in 2010. The United States, as well as the European Union and Canada, have been considering similar legislation.

Another approach to eliminating harmful technologies is to phase out harmful product components rather than entire products. The Montreal Protocol on Substances that Deplete the Ozone Layer has been phasing out ozone-depleting chemicals, including chlorofluorocarbons (CFCs) and hydro chlorofluorocarbons (HCFCs). HCFCs not only contribute to the destruction of the earth's ozone layer, but also represent powerful greenhouse gases that contribute to global climate change.[30]

Technology and Building Mandates

Numerous climate technology mandates are already in place or under consideration around the world. For example, the EU is engaged in continuing discussions to mandate universal carbon capture and storage for new coal plants. Canada already has imposed such a deadline on the federal level, while British Columbia has proposed eliminating carbon emissions from new power plants by 2016.

Building codes will become an important strategy in the effort to stabilize energy supplies and curb greenhouse gas emissions. Spain requires solar energy in new commercial and residential buildings. Germany is working on a regenerative heat

law that would require new and renovated buildings to source certain percentages of their heat requirements from renewable energy. The American Institute of Architects is working with other professional organizations and the U.S. Department of Energy on a strategy for designing only no-carbon homes and offices by 2030.[31] Many U.S. states have enacted renewable portfolio standards (RPS) for their electrical energy requirements.[32] A possible federal RPS is garnering considerable attention in the U.S. Congress.

Sectoral No-Net-Carbon-Emission Technology Commitments

Carbon neutral or low carbon industrial or geographic sectors represent the first pieces of a carbon neutral or low carbon jigsaw puzzle that will eventually encompass the planet. Technology-oriented agreements can help reduce emissions in industrial sectors not otherwise covered by emissions trading programs, sectors that could benefit from international coordination, and sectors in which technology policies could help support emissions trading systems by providing the means to lower emissions. Industrial sectors include, for example, transportation, landfills, agriculture, cement, steel, power generation and transmission, aluminum, coal mining, building, appliances, and end-users.[33]

Technology Performance Standards

Technology performance standards, while different from technology mandates, can serve the same purpose, if implemented properly and at sufficiently rigorous levels. Performance standards may be attained through existing technologies or through new technologies. Performance standards include energy efficiency standards for buildings, appliances, vehicles, and industrial facilities and sectors.[34]

California has adopted a greenhouse gas emissions performance standard for certain power plants. Under California law, utilities and other entities are prohibited from entering into long-term financial commitments for base load generation such as coal without complying with a greenhouse gas performance standard to limit emissions to levels comparable to cleaner combined cycle gas turbine technology.[35]

The International Energy Agency (IEA) has recommended improving energy efficiency through the Gleneagles G8 dialog. In a 2007 communiqué, the ministers of IEA member countries called on the IEA to promote efficiency goals at all levels of government and to establish sector-specific benchmarks to spread efficiency best practices across the globe.[36]

Early in 2007, California established the world's first greenhouse gas standard for transportation fuels with its Low Carbon Fuel Standard. California Governor Arnold Schwarzenegger signed an Executive Order establishing a statewide goal of reducing the carbon intensity of transportation fuels by at least ten percent by 2020. The California standard will help bring alternative fuel and vehicle technologies (including biofuels and electric vehicles) to scale and drive innovative new low- and zero-carbon transportation technologies.[37] Similarly, New York City has updated its performance standards for taxis that will not just allow but require all NYC cabbies to drive hybrids or other low-emissions vehicles.[38]

Government Procurement

Government spending is enormous. By bolstering demand, government procurement helps bring innovative technologies up to scale. Hybrid or electric government vehicles, for instance, would be practical for many applications. USAID provides municipal governments, federal agencies, and other local organizations in developing countries guidance and technical support for energy efficient procurement. U.S. law requires federal agencies to buy energy efficient products. A number of states, including New York, have adopted similar policies.

Also, public procurement is in use in public health in the form of "advance market commitments." Advance Market Commitments (AMCs) are a new approach to public health funding designed to stimulate the development and manufacture of vaccines for developing countries. Donors commit money to guarantee the price of vaccines once they have been developed, thus creating the potential for a viable future market.[39]

Transition Management

Transition management policies promote both clean-technology supply and pulls clean-technology demand by focusing on technology pathways for long-term mainstream market acceptance. The Netherlands is pursuing technology-transition management strategies—with different transition plans for different technologies—that will help move the nation from a carbon-dependent to low carbon economy. Within its broad framework, the transitions approach can accommodate and invigorate other policy tools, including market-based instruments, technology subsidies, and regulations. The objective of the transition management strategy is to move beyond incumbent R&D programs to structural change.[40]

Feed-In Tariffs

Many European countries have adopted feed-in tariffs requiring utilities to finance independent alternative energy production systems. The success of feed-in tariffs in Europe is attracting the interest of some U.S. states. British Columbia Premier Gordon Campbell's Technology Council has recommended the adoption of feed-in tariffs to help commercialize emerging sources of renewable energy.

With all this low carbon policy activity, there no coordinated process to discuss or establish any coordinated policy development on a global or a regional level.

FINANCE

Low Carbon Technology Finance. A transition to a low carbon future needs more than only current technologies. New technologies also must be developed, to move from the lab to mainstream markets. Billions if not trillions of dollars of new public and private funding and supporting governmental policy are needed to support the innovation, deployment and diffusion of both existing and new technologies.

But there are unique finance barriers to this challenge. Fledgling companies have difficulty financing their initial commercial deployments of a new technology or system. Although there is a great deal of venture capital (VC) money moving into the clean energy sector, a major problem remains. This VC money funds start-ups to deploy "one off" prototype operating technologies. But VC funding does not finance full scale, commercial technologies. That financing usually comes from larger, project finance firms. However, those project finance firms require a company to have established at least 2–3 successfully operating, commercial-scale installations to get conventional financing. They simply will not take the technical risk of new technology failure.

This is the finance "valley of death"—a classic "Catch 22" gap between the current finance world and the future, where new finance vehicles are needed to support technologies from the lab to the marketplace. This "valley of death" will make it hard to raise the billions or trillions of dollars needed for new climate technologies. But it must be overcome to finance the many new capital-intensive technologies such as carbon capture and sequestration, and second- and third-generation solar technologies that do not exist today.

What is needed to create a consensus and collaborative process to develop new and innovative commercialization finance tools. A collaborative process could conduct collaborative research on the nature of the problem and potential solutions. It could identify successful and unsuccessful early-stage technology projects in the recent history of the energy industry as well as assess current clean energy finance strategies approaches to establish best practices and common pitfalls. It could also recommend a list of promising early-stage energy technology commercialization and finance strategies.

These are likely to include measures such as dedicated funds for specific technologies (a global solar or carbon capture and sequestration fund); government loan guarantees to minimize technology risk; new insurance measures, and other mechanisms not yet applied to climate technologies.

There is an enormous of work required to determine the appropriate public finance mechanisms needed to support breakthrough technologies, as well as to fund scale-up of existing technologies, while at the same time leveraging the necessary private capital needed for both purposes. At this time, there is no coordinated mechanism that is focused on that important public and private finance challenge for climate.

A NEW STRUCTURE

New Global Climate Innovation Structure: The Rationale. A purely disaggregated approach to technology development and diffusion would argue for no additional global, institutional coordinating role for these or other strategies. But if time is crucial and coordination offers benefits, alternatives must be considered.

If there is value in a catalytic, linking role at the global level, there is now no global institution to support these new strategies. A key issue is where in the global architecture such a strategic role should be placed—in existing institutions or in a new structure to support technology innovation, policy and finance activities?

The default position is to simply add new functions to existing entities such as the UNFCCC, IEA or the World Bank. However, there are good reasons to reject that status quo position, and to create a new independent global mechanism for this new climate innovation mission.

First, existing global institutions do not have missions to be "operational" on these new technology innovation challenges—to coordinate and help support the array of related technology innovation, policy and finance functions that climate innovation demands. Either their "treaty type" obligations have little do with technology development and deployment, their "analytical" roles do not constitute the requisite skill set for financing, deployment and innovation implementation, or their "financing" obligations are dedicated to poor country economic development needs that could be met with existing technologies, not technology innovation for breakthroughs. The missions of these existing institutions are designed for other important tasks, not accelerated innovation and scale up of breakthrough and existing low carbon technologies.

Second, innovation works most successfully when managed by independent institutions. They can operate nimbly, quickly and with the ability to rely on changing market conditions to rapidly scale up new technologies. One of the world's leading theorists of technology innovation, Harvard Business School Professor Clayton Christensen, notes that managing for disruptive change in the private sector, which has strong parallels to public institutions, usually requires new and independent institutions.

> Companies that have tried to develop new capabilities within established organizational units also have a spotty track record, unfortunately. Assembling a beefed up set of resources as a means of changing what an existing organization can do is relatively straightforward. People with new skills can be hired, technology can be licensed, capital can be raised, and product lines, brands and information can be acquired. Too often, however, resources such as these are then plugged into fundamentally unchanged processes —and little change results…
>
> When disruptive change appears on the horizon, managers need to assemble the capabilities to confront the change *before* it has affected the mainstream business. In other words, they need an organization that is geared toward the new challenge before the old one, whose processes are tuned to the existing business model, has reached a crisis that demands fundamental change.[41]

That innovation institutions should be independent entities is an established view in the business literature. There are several other reasons for this conclusion.

> …A firm that invests in augmenting its current capabilities and maintaining its current focus might perform rather poorly in generating ideas that are outside its core capabilities…To stimulate radical innovations, researchers are often isolated from the influence of the rest of the organization. This has become known as the 'skunk works model' of innovation. The skunk works model was the organizational design followed by IBM to nurture the by then revolutionary PC, and it is employed by many large innovative firms, such as Intel, HP and Apple, to develop potential breakthroughs… [I]t gives researchers the necessary autonomy, independence and freedom to escape the established lines of thought and produce novel ideas…[I]t can also help to overcome the resistance that radical innovations meet inside the organization.[42]

This independent innovation model is prevalent throughout Europe; from Denmark to Finland to the UK, "these nations have made an explicit decision not to place their innovation-promotion activities under the direct control of large government departments," experts have noted, but they "usually have a substantial degree of independence."[43]

Third, such independent institutions also serve an important goal of bringing together upstream researchers with downstream development and diffusion experts. They create institutional frameworks for these new non-linear and dynamic models of technology innovation. Instead of handing out work to disparate existing international institutions, which some have proposed for energy and climate, a single innovation institution creates synergies that would be lost if climate change is parceled out to give old institutions new missions in the hope that success miraculously will occur.[44] The best thinking in innovation theory suggests otherwise.

Fourth and finally, the strategy described above—a more distributed and disaggregated approach with a clear mandate for implementation and results—calls for a loose, innovative structure. It would accommodate a collaborative and non-bureaucratic institutional model. In other words, to be successful at innovation, structure follows strategy.

> [O]rganizing structure can dominate individual creativity. Years of academic research suggest that, beyond some fairly low threshold, successful innovators are not really more gifted or creative than the rest of us. Rather, they simply better

> exploit the networked structure of ideas within unique organizational frameworks. [S]trategy too often neglects the question of how to get there. Yet, especially when innovation matters, the strategy *is* the organization.[45]

A New Climate Institution Based on *The Global Fund*. After reviewing many options, an independent structural model for climate innovation could be based on *The Global Fund to Fight AIDS, Malaria and Tuberculosis* (*Global Fund*) (See http://www.theglobalfund.org).[46]

The *Global Fund*'s purpose is to attract, manage and disburse resources to fight AIDS, tuberculosis and malaria. It does not implement programs directly, relying instead on the knowledge of local experts. As a financing mechanism, the *Global Fund* works closely with other multilateral and bilateral organizations involved in health and development issues to ensure that newly funded programs are coordinated with existing ones. In many cases, these partners participate in local country activities providing important technical assistance during the development of proposals and the implementation of programs.

While it would have to be refined and adapted to the unique demands of climate technology innovation, important attributes of the *Global Fund* lend itself well to this new global climate structure.

- The *Global Fund* is set up as an *independent non-profit organization*, but linked to the UN and other global entities; it is less bureaucratic and nimble, and open to private partnerships. Initiated by Japan and the UK, it was approved by OECD donor governments, including the U.S. and others, in a formal agreement in 2002—the same governments now struggling with climate. More than 43 governments now support the Global Fund's work.
- Funds contributed to the *Global Fund* are managed by the World Bank as Trustee, so there is assurance of financial controls and accountability.
- The *Global Fund* supports practical programs geared to capacity building, and provision of services and innovation into the marketplace, and coordinates with many global efforts.
- A small governing Board consists of developing countries, donors, civil society, and NGOs, with ex-officio members from the UN and World Bank Group. There-

fore, there is a strong linkage to the UN institutions, where the developing countries feel their interests are best protected.

- The foundation Secretariat manages the Fund, with outside technical review panels.
- The Fund has disbursed pledges of about US$10 billion; a small organization of this kind is capable of handling and deploying significant sums of donor funding.
- The overhead costs that pay for the Secretariat and other expenses for the operations are low, about 3% per year of funds pledged.

The key feature of the *Global Fund* is that it represents a creative structure that is *independent of but linked to* the same international bodies now working on climate. Such a creative, hybrid system has been working in other "global public goods" areas, especially in attracting developing country support through the UN connection, and could work for climate. The *Global Fund* also has been offered as a model to solve other major problems; Professor Jeffrey Sachs recently called for a new green revolution in Africa with a fund modeled on the *Global Fund*.[47]

A new climate technology structure modeled on the *Global Fund* should have clear operational responsibility. Such a new institution—call it a *Global Climate Innovation Initiative*—would tell the world that something dramatically innovative, collaborative and unique must be established to meet this unprecedented challenge. It could be a comprehensive mechanism on global technology innovation policy and finance to promote technology strategy cooperation among both developed and developing countries. Existing institutions are not up to this challenge; climate needs new global institutional responses just like other problems like AIDS have demanded.

This new Initiative, with its operational "distributed innovation" strategy, could constitute the "complementary technology track" envisioned as part of the post-2012 climate framework.

Organizational Elements of New Global Mechanism. This new global climate mechanism needs to respect the new functions proposed for technology innovation—a more collaborative and distributed strategy that focuses on product development, relying on a global group of experts, with differentiated strategies depending on the unique demands of each technology.

To accommodate these many diverse demands, this new institutional structure would have these basic organizational elements:

Oversight Bodies: the Executive Board and Science Advisory Committees

The organizational bodies of this new global climate mechanism would operate in a "virtual network." Thus, this new structure, tasked with major responsibilities, would operate without the need to create or enlarge an unwieldy centralized bureaucracy. Indeed, this new institutional structure for climate would be purposefully designed to operate without significant bureaucratic control in order to most effectively capture global talent. The distributive innovation strategy driving this new climate technology initiative means that a light and adaptable management structure would choreograph outside expertise.

The key management players would fall into two groups, the donors (represented through the Executive Board) and the Science Advisory Committees (represented through outside technology experts), both served by a small Core Team further defined below. Both bodies would focus on global, national and sub-national activities designed to link energy technologies to regional economies, cultures, and policy frameworks. (Different technology and science committees would be constituted so that experts would decide which technologies to pursue, while funding priorities could be established through the donor groups that would serve on the Board.)

The donor group would be brought together through a virtual information network to be kept informed of regular activities of the initiative. A manageable number of donor representatives, as an Executive Board, would meet at a frequency to be determined (e.g., twice a year) to oversee the initiative and discuss new broader strategic directions, based on advice and analysis provided by the a Core Team. In the same way, the Science Advisory Committees would operate virtually, connected through a network, and would meet with the Executive Board of donors to discuss areas of mutual interest. The Executive Board would also coordinate with the Core Team to provide funding and strategic guidance for regional initiatives, with the input of the Science Advisory Committees.

Core Team Composition and Functions

Core Team members would be chosen by the Executive Board. The Core Team would consist of energy, management, technical, policy and finance experts,

including developing country representatives, along with a small, nimble group of expert staff providing support and assistance.

The Core Team would have several key responsibilities: (a) provide day-to-day management; (b) develop and implement an evolving strategy; (c) make connections and facilitate "cross-learning" between and among the modules of activity by focusing on specific strategies developed by the Technology Nodes; (d) link individuals within the Technology Nodes with innovation and network experts to apply cutting-edge IT tools, business models, and other innovation techniques; and (e) provide strategic and management support for activity modules.

Strategically, the Core Team would focus on product development and deployment by building linkages among key players in the low carbon technology RD&D process; this would link the upstream research community with the downstream finance and deployment community (e.g., companies, universities, governments, foundations, financial institutions). It would also focus on policy development and coordination, as well as work on collaborative finance strategies.

Technology Nodes

The Core Team would create separate Technology Nodes that would function as the engine of the Initiative. Each Node would focus on accelerating the development and deployment of a specific technology. While the Core Team would be tasked with overall strategy for the Initiative, the Technology Nodes would perform the substantive work of the Initiative by devising ways to accelerate product development of specific low carbon technologies by working with the different activity modules. Technology Nodes will need wide latitude for adopting both a structure and strategy that is tailored to their specific technology. Each Node will likely have a different scope, time frame, and direction based on the commercial status of that technology field and the unique barriers facing widespread commercialization and diffusion. Each Node will employ strategies for the modules. A different Science Advisory Committee for each Node would advise the core Team on Node-specific technology strategies.

Objectives

The driving objectives for each Technology Node would be to accelerate the development and deployment of a specific technology, to identify investment needs,

and to create sustainable business models for technology commercialization.

Operating Method

These objectives can be achieved if Technology Nodes have certain characteristics:

- That team of experts that comprise the Node members will determine the substantive work of each Node.
- Technology Nodes will have separate budgets to support their activities.
- To ensure that the Nodes optimize their learning, they will be networked with the Core Team, other Technology Nodes, and other modules and experts throughout the world to enable diffusion of data, expertise, resources, and strategy successes and failures.

Candidate Technology Nodes

Experts in the Technology Nodes who would come from around the globe would establish a technology selection, strategy, and specific tools that would be employed for each technology. Successful scale-up of these technologies will have a major impact on climate reduction goals.

Five Operating Tools

At least five implementation elements could be used to support the development and deployment of the selected technologies. These tools and strategies, now employed in other sectors, have never been applied collectively to climate technology.

1. *Commissioned projects.* Members of specific Technology Nodes would have funding to commission research and analysis on specific issues they deem critical to the development and commercialization of a technology. These commissioned projects would be used when members of a Technology Node are certain who in the global community would be best positioned to address a specific issue.
2. *Competitive projects.* Members of specific Technology Nodes would have funding to issue competitive requests for proposals. These competitive projects would be used when leadership members of a Technology Node are confronted with a problem, but are uncertain about who is best positioned to address the challenge and/or they want to encourage competition among teams. Typically, the requests for proposals (RFPs) would be issued to a limited number of

institutions. Competitive grants of this kind assume that the problems identified have been sufficiently shaped by the Core Team so that the responses productively address well-defined problems.

3. *Open innovation, challenge, and prize tools (match-making infrastructure).* New tools and strategies designed to support innovation, including "challenge" and "prize" tools (e.g., InnoCentive, NineSigma), are used in other sectors (e.g., agriculture, health, manufacturing). These tools and strategies have never been applied strategically to a broad selection of low carbon technologies; this effort would use these tools to connect people who are encountering specific technology development challenges (in this case with clean energy technologies) with "solution providers" who can help address these problems (these solution providers could be, for example, other companies or academics). These tools, which could be called the "match-making infrastructure", would enable potentially tens of thousands of people to review challenges and propose solutions. Right now, there is no such systematic global structure in place for climate (although similar approaches are used in other sectors). A range of financial incentives will be employed, including financial rewards to "solution providers" and cash rewards or a negotiated value for intellectual property rights.

4. *Information Technology (IT) tools and other strategies for creating a community of practice in a virtual network.* To build more robust linkages between individuals and institutions with interest and relevant expertise in the development and commercialization of clean energy technologies, a virtual network would employ IT tools and other strategies (e.g., face-to-face design charrettes) to create a global community of practice. Among other things, this network would allow for people from throughout the globe to identify problems and solutions that are not developed through the process.

5. *Policy and finance development.* The Core Group and Technology Nodes also would serve as a catalyst to work with governments to develop, refine and coordinate proposed international government policies and finance tools to support widespread diffusion of the subject technologies.

Other Structural Models. There are two other structural models that have functions and characteristics that could be mixed and matched with the attributes of the Global Fund as applied to climate, which is the preferred institutional structure.

Montreal Protocol Technology Panels

There are lessons to be learned from the Montreal Protocol that controlled CFCs in the atmosphere, considered perhaps the most successful global environmental treaty ever negotiated. How that protocol successfully led to technology innovation is the subject of a book by Professor Edward Parson.[48]

As Parson explains, the key to the eventual ban on ozone destroying chemicals in the Montreal Treaty was the novel way it handled technology solutions. Put simply, it created a set of independent technology assessment panels to consider solutions. These eventually became known as TEAPS—Technology and Economics Assessment Panels. They were set up in haste by the Protocol and were permitted to choose participants, carry out their work, and prepare reports to the parties with little political oversight—"independence that greatly enhanced their effectiveness," according to Parson.[49]

Importantly, TEAPs allowed for significant participation of the private sector. They organized into separate work groups for each type of ozone-depleting chemical, and they evaluated the potential of specific technologies and operational changes that might reduce chemical use in specific applications. Participants came from industry but also from academia, government, and NGOs. According to Parson, these TEAPs panels "were strikingly successful."

> In four full assessments, and many smaller tasks, it presented a huge number of specific technical judgments that were, with few exceptions, persuasive, technically supported, and consensual.[50]

Importantly, motivating private sector participation was based explicitly on the private benefits to be derived from the process.

- Companies facing stringent possible reductions mandates needed to comply fast, and the panels were set up with antitrust protection to allow them to evaluate options in a problem solving capacity greater than even the largest firms could do individually.
- They helped manage the business risk of regulations.
- The players gained key information that had clear commercial value, which helped participants project market trends and identify new sales opportunities.

- This work gained the participants industry prestige in having an elite group of peers throughout their professional careers.
- These processes helped advance the margins of what was feasible, essentially altering the reality of what was being assessed.
- At the same time, a combination of professional norms, explicit ground rules and personal integrity avoided conflicts of interest and bias, it has been uniformly agreed by students of the process.

While Parson acknowledges the differences between climate and CFCs, he believes that such differences "need not preclude the application of the model of technology assessment developed for ozone" from being applied to climate.[51] Others have noted that the Montreal Protocol essentially created a "decentralized implementation" system that evolved over time to tackle challenges and respond to opportunities to make the treaty effective.[52]

Generation Challenge Program

The Generation Challenge Program (GCP) offers another other example of the application of distributed innovation strategies to a global market failure outside the energy sector.

GCP "has developed an extensive consortium partnership and leveraged its resources to establish a broad network of R&D participants with extensive capability and capacity to support the GCP objectives."[53] GCP creates and provides a new generation of plants to meet farmers' needs through five subprograms: 1) genetic diversity of global genetic resources, 2) genomics towards gene discovery, 3) trait capture for crop improvement, 4) bioinformatics and crop information systems, and 5) capacity building and enabling delivery. These subprograms, which span product development to delivery, represent practical analogies to technology nodes for energy and a coordinated effort to match advances in climate technology with regional opportunities and constraints. GCP includes a comprehensive delivery strategy that bridges the gap between labs and communities to ensure that research is actually implemented. Obviously, a similar strategy is essential for a climate technology initiative.

CGP describes itself as "a multinational, multisectoral and multidisciplinary 'true'

collaboration in the plant sciences."[54] A realistic technology-based strategy to stabilize the climate must embody the same characteristics—multinational, multisectoral, multidisciplinary, and truly collaborative. CGP relies on a network of partners in the Consultative Group on International Agricultural Research (CGIAR) as well as both public and private partners, to bring global expertise to bear on its mission.

GCP's R&D program involves more than 90 projects and 70 participating institutions. R&D partners collectively bring a broad set of technical knowledge and skills to GCP. The institutional affiliations of GCP partners are broad-based, and the roles of researchers are defined according to the particular research project. Tools used to initiate projects include competitive grants, commissioned grants, and special project grants. GCP relies on IT platforms to access and build capacity and works to acquire and maintain international-public-good status for many of its informational, analytical, and biological products.[55]

GCP's governance and administrative structure includes a Program Steering Committee, a Review and Advisory Panel, a Management Team, a Stakeholders Committee, and Staff. "GCP functions according to the principle of 'lean and mean': a lean governance and administrative structure allows for quick implementation of good new ideas and agile negotiation of obstacles."[56] GCP embodies the light, flexible organizational structure that we have suggested for an international climate technology initiative.

The GCP is an important, step change evolution in innovation strategy and structure. GCP goes beyond the conventional "information network" approach to technology development, which typically creates loose collaborations of experts, usually housed in universities or research centers, to share "best practices" or other information. But these approaches do not have a mission like the GCP of product development within a certain time frame, with research linked to commercial pathways, and funding and related tools to support such results.

That is why GCP presents another unique analogy for a climate technology initiative. GCP may offer important lessons learned for building a nimble climate technology architecture that taps global expertise to develop a new generation of energy systems.[57]

PATHWAYS TO THE POST-2012 ARCHITECTURE

If the consensus is that a new climate strategy and structure are needed, the challenge is to get these proposed recommendations introduced into and adopted by the international climate process.

Even though the UNFCCC and G8 countries have endorsed more technology innovation and cooperation, there are many competing pressures to focus on other issues, especially the extension of the cap and trade policies post-2012. As a result, the technology options proposed to date have not been as dramatic or far reaching as the science of stabilization requires.

Certainly, there has been no discussion of any new global strategies about how an "independent" entity could be created to address this innovation mission, even though the same governments created an independent entity for AIDS and other "public goods" health issues only a few years ago.

Developing such a new strategy and structure to adopt in the post-2012 process, will be a significant challenge. At best, there are a number of approaches to establish a pathway to this end.

First, the most obvious route is to advocate for this work through the existing UNFCCC/G8 process from now through the Copenhagen meetings at the end of 2009. Some of that advocacy has gone on already. But to date, there has not been any formal recognition of these recommendations in this process. To make progress, a larger and more recognized group of individuals must work for their adoption.

Second, one example of this approach is that the work pursued by the UN Foundation/ Club of Madrid process, which has developed a credible presence in the UNFCCC/ G8 process. Though the group has not endorsed this approach, there is a clear sense from the group that more work is needed on the role of technology innovation and the positions that must be advocated in that regard.

Third, the UNFCCC process is stalled if not stalemated somewhat by the uncertainty over the U.S. election outcome. So if this approach is pursued, more direct education of the players in the next Administration and Congress might the best way to influence the outcomes of the UNFCCC/G8 process in 2009.

Fourth, outside of trying directly to influence the day to day UNFCCC process, a strong effort must be made to better explore and articulate these recommendations with global opinion makers of all types.

Fifth, regardless of the specific pathway, a dedicated rump group of technology experts should commit to ongoing future work toward these ends. Funding should be secured and a commitment made to develop a serious suite of technology innovation strategies and structures. This proposal is made with the understanding that no matter what occurs through the official UNFCCC/G8 process through 2009, it is unlikely that definitive conclusions will be reached on all issues by that time. That is, additional work is likely needed post-2009 to work on these issues no matter the outcome of the Copenhagen meetings.

CONCLUSION

This paper is designed to address critical gaps in the current global climate process and to propose creative new strategies and structures to fill those gaps in the time needed for accelerated climate technology change:

- There are growing demands for a new global mechanism for technology innovation and scale up to address long term climate stabilization.
- There is no consensus on how a strategy and structure can be devised to meet those demands.
- Existing institutions do not appear equipped to meet this challenge.
- Innovation experts suggest that new strategies and structures will be needed for such challenges, which should be informed by private sector innovation approaches and by non-energy "public goods" areas that have created groundbreaking innovations.
- Climate could benefit from a new "distributed innovation" technology strategy geared to specific technologies, with a collaborative mission of rapid product development and commercialization in the time frames demanded by the climate science.
- To catalyze these strategic approaches, a new global institution patterned after *The Global Fund to Fight AIDS, Tuberculosis and Malaria* should be created. It would have an independent status linked to existing global agencies and a focus on technology specific collaborations structured to meet the different demands of low carbon technologies.
- This new approach could constitute the key element of the "technology track" in the post-2012 process.

To further explore these recommendations and bring about a change in direction in the climate discussions on technology strategy, several next steps are needed:

- A broader network must be established to work on these issues and achieve consensus on the appropriate strategy and structure for technology innovation.

- Such a process must lead to a consensus that some variation of these or related approaches have merit and deserve wider circulation.
- A strategy must be established to identify key intervention points, agree to advocate for the adoption of this consensus in climate forums and make the case that the time is now to create such new strategies and structure, if the world is serious about establishing a post-2012 technology innovation framework by 2009.

APPENDIX
ANALYSIS OF EXISTING INSTITUTIONAL RD&D ACTIVITIES

UNFCCC and Related Organizations and Activities[1]

UNFCCC. The main task of the UNFCCC is to coordinate negotiations of the global climate treaty that has continued to focus almost exclusively on a post 2012 framework for a cap and trade system. It is basically a "legislative" type body with a charge to successfully complete treaty negotiations. Operational technology strategy, financial support, and deployment are simply not primary obligations of the Convention, although there are elements of the Convention that have been delegated minor obligations regarding technology analysis and information sharing.

There is no "technology track" that exists at the UNFCCC level that complements the ongoing negotiations over the cap and trade system. The main gaps that exist at this level include the following: (a) lack of an infrastructure to develop a global technology innovation strategy, financial support, and the innovation and diffusion of climate technology on a scale required for stabilization, (b) lack of any sustained funding to support such an infrastructure or strategy, and (c) lack of any support for large scale, actual in-country technology development and deployment with any element of technology transfer from the OECD.

GEF. The Global Environment Facility (GEF) is an arm of the UN that is a grant making institution providing "incremental" financial support for developing country environmental projects in six, varied areas, including biodiversity, climate, and land degradation. Since its inception in 1991, GEF has funded 1300 projects in 140 countries for an average of 100 projects per year scattered across the globe. It has had an "individual" project by project focus—a "one off" approach to project development.

Given its individual project focus, GEF has never been charged with, and understandably has not implemented, a larger strategic initiative that focuses on technology innovation and the wide scale development and deployment of low carbon technologies. This strategy to widely disperse projects by country interests is somewhat in conflict with specific technology development. Finally, there has been concern in the past with the delays and requirements for individual project approval. New management has begun to address those issues.[2]

EGTT. The Expert Group on Technology Transfer (EGTT) is principally an analytical and information sharing entity serving the parties to the Convention on issues of technology transfer. EGTT has no operational role within the UNFCCC to support actual funding and deployment of low carbon technology.

CDM. The clean development mechanism (CDM) defined in Article 12 of the Kyoto Treaty provides for Annex I Parties to implement and fund project activities that reduce emissions in non-Annex I Parties, in return for certified emission reductions (CERs).[3] The CERs generated by such project activities can be used by Annex I Parties to help meet their emissions targets under the Kyoto Protocol. To date, there have been approximately 1,000 registered projects that have generated some 135 million CERS.[4] The annual value of CDM exchanges amounts to some US$4.4 billion per year.[5]

There have been criticisms of the CDM process as to whether it is actually meeting its "additionality" requirement that the project would not have occurred but for the CDM funding. In any case, while the system as developed might be a growing revenue stream to provide for technology transfer to developing countries, it has not demonstrated any ability to strategically drive breakthrough technology innovation or scale up of technologies as an emissions stabilization strategy. Indeed, due to market forces, the CDM targets the cheapest possible abatement options, rather than more expensive investments in climate technologies that will be necessary to stabilize global carbon emissions over the long term. Further, the CDM allows developed countries to meet their carbon targets without making any changes to domestic energy technologies, thereby perpetuating entrenched, carbon intensive energy infrastructure.[6]

While efforts at the UNFCCC and Global Environment Facility (GEF) level represent good faith attempts on climate, their missions lead these organizations to focus principally on support for negotiating treaties in the case of the UNFCC and to conduct related technology analysis, or in the case of GEF to support with financial aid "additional" emissions reductions in projects using existing technology, rather than focus on technology innovation and scale up for mainstream commercialization.

World Bank Group and Related Activities

World Bank Group (WBG) is a key financier of renewable and energy efficiency projects in developing countries. Although WBG is working to bring clean energy technology and other environmental concerns into its development programs, WBG's focus is on economic development, not technology innovation. This has led, and is likely in the future, to lead the bank in the climate area to focus on funding mechanisms in support of the cap and trade system, such as the Prototype Carbon Fund, and to transfer of existing technologies to developing countries on a one-off, or project-specific basis.[7] It has never focused on breakthrough technologies or innovation. Overall, the limits of the WBG climate activities can be grouped in the following categories:

- There is no systematic strategic process that identifies priority technologies needed for stabilization in developing countries (such as carbon capture and storage in rapidly developing countries like China and India), or directs financial support to these technology needs.
- With its development mission in the poorest developing countries, WBG focuses on financing existing technologies within an overall country specific aid strategy, rather than on an innovation strategy for technology breakthroughs that would have a global impact on climate stabilization of emissions.
- There is no technology strategy that addresses these issues of "scale," or one that incorporates the "time" dimension of climate change—no strategic plan for technology breakthroughs.
- Finally, there is no multi-donor group committed to pursue these strategies with WBG.[8]

Bilateral and Multilateral Activities

There are many international clean energy research and development initiatives around the world. We have surveyed the following[9]:

- African Energy Policy Research Network (AFREPREN)
- Africa Rural Energy Enterprise Development (AREED)
- Asia Pacific Network for Energy Technology (APNET)
- Asia-Pacific Partnership on Clean Development and Climate (APP) (formerly AP6)

- The Cooperative Technology Implementation Plan (CTIP) for Southern Africa
- The Climate Technology Partnership (CTP)
- The European Renewable Energy Centers (EUREC) Agency
- The Global Network on Energy for Sustainable Development (GNESD)
- International Electric Research Exchange (IERE)
- International Network for Sustainable Energy (INFORSE)
- Information Gateway for Renewable Energy and Energy Efficiency (REEGLE)
- The International Energy Agency (IEA) Implementing Agreements
- The IEA Network for Expertise in Energy Technology (NEET)
- Renewable Energy and Energy Efficiency Partnership (REEEP)
- Renewable Energy Policy Network for the 21st Century (REN21)

On the whole, these initiatives:

- Focus on R&D of clean energy technologies.
- Include developed and developing countries.
- Engage in collaborative activities among public and private actors.
- Pursue some R&D and limited demonstration and deployment projects.

Rather than describing individual gaps in these initiatives, there are "collective gaps" left by these initiatives in the global system for low carbon technology innovation and deployment.

Lack of coherent strategy. The fact that there are at least 15 different, overlapping and potentially inconsistent initiatives suggests a lack of coherent strategic direction for technology innovation and deployment.

Disparate approaches. Each initiative employs a unique approach with a different target audience and strategy: (a) capacity building in individual countries; (b) enterprise creation in select countries; (c) research collaboration across national research centers; (d) sectoral or technology based pilot projects, information sharing, and

skills training; (e) regional technology cooperation; (f) bilateral technical partnerships offering technical assistance; (g) associations of university research centers; (h) global "knowledge networks" focused on Millennium Goals and barriers to adoption of technologies; (i) electric company consortia that share best practices and information; (j) networks of NGOs to raise awareness and build local capacity; (k) web based links to provide information on policy in renewable energy; (l) IEA country implementing agreements for cooperation on energy technologies to share views and experiences through studies and workshops; (m) linkage of the IEA network to Brazil, China, India, Mexico, Russia, and South Africa; and (n) networks to share information on finance mechanisms through consultations and reports.

No linking strategy. There is no evident linking strategy among these efforts. There is no coordinated process in place designed to learn from their successes and failures, and implement improved strategies on a global, regional or national scale.

Few are operational regarding deployment. Of the 15 initiatives, only one or two (APP and/or CTP) are in any way "operational"—that is, *almost none are actively focused on funding real world technology research, development, and deployment with public and private funding in developing countries.*

Most are information sharing efforts. Virtually all the initiatives are information sharing, capacity building, or partnership efforts, with little or no funding for applied research and deployment.

Inadequate funding. In total, the 15 initiatives appear to have an aggregate global budget of approximately US$200 million (with the bulk of that amount from US$175 million dedicated to the APP); so that the collective global budget for non-APP activities amounts to about US$25 million a year, a meager financial commitment to climate coordination worldwide.

Pilots not up to scale or time requirements. Even with the deployment targeted APP, the projects are generally "pilot" in nature, with no commitment of funding to scale up successful projects, or to develop technology with any "time" dimension consistent with the two to three decade emissions reduction trajectory required by the UNFCCC science. And with the APP, there have been public reports about

many problems regarding intellectual property rights (IPR) and the lack of strategy to overcome IPR problems associated with technology transfer.

Little leverage or links to other climate efforts. Moreover, none of the existing activities appear to leverage private sector investment at the levels needed to meet the stabilization challenge, take advantage of other analogous technology strategies from other areas such as public health, bring together OECD and developing countries in a more comprehensive way, or link technology development with other climate strategies such as cap and trade and carbon finance.

No identification of priority strategies. From the initiatives, and except for the APP, there is no strong evidence of any systematic strategic process that identifies priority technologies for stabilization in developing countries.

No link between upstream innovation and downstream deployment. None of the projects appears to link upstream innovation to downstream deployment and diffusion of those technologies needed in unique developing country contexts—there is no focus on the value chain that must be developed to create real scale and mainstream diffusion of low carbon technologies.

ENDNOTES

1 G8 Summit Declaration 2007, *Growth And Responsibility in the World Economy*, available at http://www.g-8.de/nn_220074/Content/EN/Artikel/__g8-summit/anlagen/2007-06-07-gipfeldo kument-wirtschaft-eng.html.

2 Richard K. Lester and Michael J. Piore, *Innovation: The Missing Dimension* (Cambridge, MA: Harvard Univ. Press, 2004).

3 Andrew Hargadon, *How Breakthroughs Happen: The Surprising Truth About How Companies Innovate* (Boston, MA: Harvard Business School Press, 2003).

4 "China Calls for Technology Transfer, Fund to Address Climate Change." *Xinhau Press* 24 April 2008.

5 Nishimura, Mutsuyoshi. "Innovation Strategies to Achieve GHG Peak and Decline: A Proposal," April 2008 paper presented at the Climate Innovation Meeting of May 28, 29, 2008, sponsored by the UK DEFRA agency.

6 *G8 Summit Declaration 2007*, par. 54.

7 Roger Pielke, Jr., Tom Wigley, and Christopher Green, "Dangerous Assumptions," Commentary. *Nature* April 2008.

8 There is a growing body of academic literature to support that position. See, for example, Knut A. Alfsen and Gunnar S. Eskeland, "A Broader Palette: The Role of Technology in Climate Policy" (2007); "Report of the Climate Dialogue at Pocantico: International Climate Efforts Beyond 2012," Pew Center on Global Climate Change, (2005). Available at http://www.pewclimate.org/docUploads/PEW_Pocantico_Report05.pdf; Lewis Milford, "From Here to Stabilization: A Call for Massive Climate Stabilization," Clean Energy Group (September 27, 2006), available at http://www.cleanenergystates.org/international/techdiffusion.html.

9 Robert Atkinson and Howard Wial, "Boosting Productivity, Innovation, and Growth Through a National Innovation Foundation," Information Technology and Innovation Foundation and Metropolitan Policy Program of the Brookings Institution April 2008 at 5, available at http://www.itif.org/files/NIF.pdf.

10 Stokes, *Pasteur's Quadrant*, citing Rosenberg (Brookings Institution Press 1997) at 87.

11 Paul Romer, "The Arc of Science," (Stanford University, June 2005). Incomplete manuscript available at www.crei.cat/activities/sc_conferences/23/papers/romer.pdf.

12 It is important to note that this "gaps" analysis is of the public sector climate institutions operating at a global level. It is not an attempt to identify the key gaps that exist in the private sector technology and finance "system" that now controls energy technology development, a point made well in a paper, "Climate Technology Challenges," delivered by Joe Chaisson of Clean Air Task Force at the Climate Technology Innovation Meeting in Washington, DC, hosted by Clean Energy Group, Meridian Institute, and the Clean Air Task Force (May 28-29, 2008). The report provides a brief overview of key challenges to developing and deploying the technology needed to effectively address climate change and includes a case study on low-carbon coal technology.

13 We do not discuss the limitations of cap and trade in any detail in this proposal because these limitations have become widely recognized. Many experts have called for complementary technology policies and strategies, including Sir Nicholas Stern. See Sir Nicholas Stern, *Stern Review on the Economics of Climate Change* (October 30, 2006), available at http://www.sternreview.org.uk/.

14 Again, more detail on these issues is contained in the Appendix of this report.

15 New initiatives are announced quite frequently, so this snapshot is current as of early March, 2008.

16 Pielke, Wigley, and Green at 531.

17 Earlier this year, James A. Edmonds, Laboratory Fellow and Chief Scientist for Battelle's Global Energy Technology Program, with other researchers, released a report, "Global Energy Technology Strategy: Addressing Climate Change (Phase 2 Findings from an International Public-Private Sponsored Research Program.)" The report argues that these five technologies, plus nuclear power, could make a critical contribution to climate stabilization.

18 Karim R. Lakhani and Jill A. Panetta, "The Principles of Distributed Innovation," Harvard Business School Research Publication No. 2007-07 (October 2007), available at http://cyber.law.harvard.edu/publications.

19 William C. Taylor, "Here's an Idea: Let Everyone Have Ideas," *New York Times* 26 March 2006.

20 The term distributed innovation and related terms like open-source approaches "describe models of innovation that are characterized by distributed peer production and license conditions/legal strategies that are designed to ensure that a platform or enabling technology, and any improvements made to that technology, remain freely available for other people to use, disseminate and improve. "Open Source Models of Collaborative Innovation in the Life Sciences," Sept., 2005, Bellagio, Italy, p. 14 n.1, available at http://www.merid.org/OS/bellagioOS-report.pdf.

21 This straw proposal cites numerous models from both climate and energy and other sectors that can be used as building blocks for a new international climate technology initiative. Organizing funding for climate and energy technology around technology-specific activities, like other elements of the proposed initiative, is not a blank slate. The Clean Energy States Alliance (CESA), which is managed by Clean Energy Group, is a multi-state coalition of U.S. state funds that develop and promote clean energy technologies through information exchange and analysis, partnership development, and joint projects. The CESA coalition consists of 22 funds from 18 states with a total of nearly US$6 billion to invest over the next ten years. See Clean Energy States Alliance Home Page, available at http://www.cleanenergystates.org. As an example of a technology-specific CESA project, see Mark Sinclair and Steve Weisman, "Clean Energy State Program Guide—Mainstreaming Solar Electricity: Strategies for States to Build Local Markets," April, 2008, available at http://www.cleanenergystates.org/case.html. A similar organization up and running on the international level is the United Nations Environment Programme Sustainable Finance Initiative Public Finance Alliance, modeled after CESA and managed by the Basel Agency for Sustainable Energy with the assistance of Clean Energy Group. See www.sefalliance.org.

22 Summary from *Generation Challenge Program Strategic Framework* (February 2007).

23 Larry Hurston and Nabil Sakkab, "Connect and Develop," *Harvard Business Review* March 2006: 58.

24 Lakhani and Panetta at 6-7.

25 Lewis M. Branscomb and James H. Keller, eds., *Investing in Innovation: Creating a Research and Innovation Policy that Works* (MIT Press, 1999) at 22 (emphasis added).

26 Heleen DeConnick et al., "International Technology Oriented Agreements to Address Climate Change," *Resources for the Future* (January 2007) at 2, available at http://www.rff.org/rff/Documents/RFF-DP-06-50.pdf.

27 David Victor, "Recovering Sustainable Development," *Foreign Affairs* January/February 2006.

28 Richard E. Benedick, "Avoiding Gridlock on Climate Change," *Issues in Science and Technology* (October 2007) at 40, available at http://findarticles.com/p/articles/mi_qa3622/is_200701/ai_n18708963.

29 In 1995, the UNFCCC parties developed a list of several hundred policies and measures that could be used to accelerate emissions reductions. Ad Hoc Group on the Berlin Mandate, Synthesized List of Policies and Measures Identified by the Annex I Parties in their National Communications, FCCC/AGBM/1995/6 (October 23, 1995), available at http://unfccc.int/cop5/resource/docs/1995/agbm/06.htm.

30 Cheryl Pellerin, "Montreal Protocol Could Be Model for Addressing Climate Change: Unique Treaty Accommodates New Knowledge, Developing Country Economies," U.S. Department of State (2007), available at http://usinfo.state.gov/xarchives/display.html?p=washfile-english&x=20071018145531lcnirellep0.7443964&m=October.

31 American Institute of Architects, Building Design Leaders Unite on Energy Reduction Targets (May 4, 2007), available at http://www.aia.org/press2_template.cfm?pagename=release%5F050407%5Fbldg.

32 U.S. Department of Energy, Energy Efficiency and Renewable Energy, *State Activities and Partnerships, States with Renewable Portfolio Standards*, available at http://www.eere.energy.gov/states/maps/renewable_portfolio_states.cfm.

33 DeConnick. While this paper prefers cap and trade, its description of technology agreements approach is nevertheless useful.

34 Hoff Stauffer, "A New Standard for Preventing Global Warming," *Strategic Dialog, Foreign Policy in Focus* October 2006, available at http://www.fpif.org/fpiftxt/3562.

35 California Public Utilities Commission Press Release Docket # R.06-04-009, "PUC Sets GHG Emissions Performance Standard to Help Mitigate Climate Change" (January 25, 2007).

36 International Energy Agency. Communiqué, Meeting of the Governing Board at Ministerial Level (May 15, 2007), available at http://www.iea.org/Textbase/press/pressdetail.asp?PRESS_REL_ID=225.

37 "California Governor Sets Low Carbon Fuel Standard" *Environment News Service.* 18 January 2007. Available at http://www.ens-newswire.com/ens/jan2007/2007-01-18-02.asp.

38 Thomas L. Friedman, "Save the Planet: Vote Smart," *International Herald Tribune* 22 October 2007.

39 See http://www.vaccineamc.org/about.html.

40 See Sussex Energy Group, "The 'Energietransitie': Analysing the Socio-Technical Turn in Dutch Energy Policy," Current Research at the Sussex Energy Group (2007) available at http://www.sussex.ac.uk/sussexenergygroup/documents/energietrans_dutch.pdf; Adrian Smith and Florian Kern, "The Transitions Discourse in the Ecological Modernisation of the Netherlands," Paper No. 160, University of Sussex (2007), available at http://www.sussex.ac.uk/spru/documents/sewp160.pdf; Florian Kern and Adrian Smith, "Restructuring Energy Systems for Sustainability?: Energy Transition Policy in the Netherlands" (University of Sussex 2007), available at http://www.sussex.ac.uk/sussexenergygroup/documents/kern_smith_restructuring_energy_systems_for_sustainability_v3.pdf; Jan Rotmans, René Kemp, and Marjolein van Asselt, "More Evolution than Revolution: Transition Management in Public Policy," *Foresight*, vol. 3, no. 01 (Feb. 2001), available at http://www.icis.unimaas.nl/publ/downs/01_12.pdf.

41 Clayton Christensen, *The Innovator's Dilemma* (Harvard Business School Press 2000) at 174-175.

42 Fosfuri and Ronde, "Leveraging Resistance to Change and the Skunk Works Model of Innovation," Center for Industrial Economics Discussion Papers, 2007-10., University of Copenhagen at 9, 11. The term "skunk works" comes from the name of the windowless facility built by the Lockheed Corporation in California during the Cold War to develop secret military projects separate and apart from the established business operations.

43 Atkinson and Wial, at 26.

44 With all due respect, there are problems with two recent climate proposals that do just that – they suggest that existing institutions are sufficient, at least for now, to take over these many, discrete technology activities along the innovation chain. See Nicholas Stern, "Key Elements of a Global Deal on Climate Change," London School of Economics (2008) at 45-46 (Arguing to give technology responsibilities to existing institutions now but with the expectation that this "may evolve into a single International Climate Change Organization…"); Global Leadership for Climate Change/Club of Madrid, "Framework for a Post-2012 Agreement on Climate Change, 2008 Update," at 17-19)(the report describes "distinct phases" of the innovation chain and though it recognizes "overlaps and feedback loops," it then recommends one new but mostly existing institutions take responsibility for the discrete innovation activities.) GLCC does call for close collaboration for how these activities would be governed and managed. Both reports then move incrementally toward a "new" institution focus, but opt for short term use of existing institutions, a position that deserves some further examination given the short time frames for widespread innovation to occur and the issue of whether innovation is best assigned to organizations with different missions, a point examined elsewhere in this report.

45 Eisenhardt, Foreward to *How Breakthroughs Happen: the Surprising Truth about How Companies Innovate*, by Andrew Hargadon (Harvard Business School Press 2003) at viii, x.

46 As indicated, there are many other new "distributed innovation" structures that could serve as a model for climate that also deserve serious scrutiny. They provide options to open up participation and are alternatives to simply placing responsibility solely within the UNFCCC or similar entity. CEG has written on these issues in greater depth for G8 ministers in Berlin in September 2007. See http://www.cleanegroup.org/Reports/Gleneagles_Statement_Climate_Technology_Innovation.pdf.

47 Jeffrey Sachs, "The African Green Revolution," *Scientific American* (May 2008) at 42.

48 Edward Parson, *Protecting the Ozone Layer, Science and Strategy* (Oxford 2003).

49 The shorter version of this story can be found in Parson, "The Technology Assessment Approach to Climate," *Issues in Science and Technology* 18 no. 4 (2002) at 65-72.

50 Ibid.

51 Ibid.

52 Owen Green, "The System For Implementation Review in the Ozone Regime," in Victor et al, eds, *The Implementation and Effectiveness of International Environmental Commitments* (MIT Press 1998) at 89.

53 Wallace D. Beversdorf, Markus A. Palenberg, and Jennifer A. Thomson, "Report of the First External Review of the Generation Challenge Program," Science Council Secretariat (March, 2008), p. A-1, available at http://www.sciencecouncil.cgiar.org/meetings/meeting/SC9/GCP%20Review%20Report%20for%20SC.pdf.

54 Generation Challenge Programme, "Who We Are", available at http://www.generationcp.org/index.php#Subprogrammes.

55 Wallace D. Beversdorf, Markus A. Palenberg, and Jennifer A. Thomson, ibid.

56 Generation Challenge Programme, GCP Governance, available at http://www.generationcp.org/gen.php?da=0785125.

57 GCP is one of four challenge programs within the CGIAR. In addition to the challenge programs, CGIAR as a whole may represent a useful model for constructing a new international climate technology initiative. CGIAR describes itself as "a strategic alliance of members, partners and international agricultural centers that mobilizes science to benefit the poor." See http://www.cgiar.org/. Looking to programs like CGIAR as models, the Club of Madrid and the United Nations Foundation, acting through the Global Leadership for Climate Action (GLCA), have proposed a Consultative Group on Clean Energy Research. See Global Leadership for Climate Action, Club of Madrid, United Nations Foundation, "Framework for a Post-2012 Agreement on Climate Change," Sept. 10, 2007. Building on the GLCA idea and the CGIAR organizational model, Clean Energy Group proposed a more expansive Consultative Group on Climate Innovation. See Lewis Milford, "Consultative Group on Climate Innovation: A Proposed Complementary Technology Track for the Post-2012 Period," presented to the Road to Copenhagen 2009 Conference on Leadership, Sustainable Development and Climate Change, Brussels, Belgium, Nov. 23, 2007. Examples of public goods initiatives like CGIAR, GCP, the Montreal Protocol, and the Global Fund to fight AIDS, Tuberculosis and Malaria can serve as building blocks for a new international climate technology initiative.

APPENDIX ENDNOTES

1 This discussion is not intended as a criticism of these organizations, that they are not fulfilling existing missions. Rather, this is simply an assessment that none were designed for the tasks required for rapid global technology development and innovation or have evolved their missions to meet these challenges.

2 See a recent paper on "Revitalizing the GEF," at http://thegef.org/interior.aspx?id=208.

3 See http://unfccc.int/kyoto_protocol/mechanisms/clean_develop ment_mechanism/items/2718.php.

4 See UNFCCC Press Release (April 14, 2008), available at http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/pressrel_080414_1000.pdf. See also UNFCCC CDM Statistics, available at http://cdm.unfccc.int/Statistics/index.html.

5 David G. Victor and Danny Cullenward, "Making Carbon Markets Work," *Scientific American* (Dec. 2007), pp. 70-77.

6 See Global Issues, Climate Change and Global Warming, Flexibility Mechanisms, Clean Development Mechanism, available at http://www.globalissues.org/EnvIssues/GlobalWarming/Mechanisms.asp.

7 See http://carbonfinance.org/Router.cfm?Page=PCF.

8 There has been a recent announcement that the WBG will manage a new energy transformation fund. The details of that fund have not yet been announced.

9 This assessment is based on secondary source material we do not have first hand knowledge of all of these programs.

ABOUT THE AUTHORS

Lewis Milford is President and founder of Clean Energy Group (CEG) and the Clean Energy States Alliance (CESA), two nonprofit organizations that work with state, federal, and international organizations to promote clean energy technologies. He also works with many public agencies in the U.S. and Europe that invest in clean energy, including public pension funds. He is frequently asked to appear as an expert panelist at energy conferences throughout the U.S. and Europe. His articles promoting clean energy have appeared in *The New York Times*, *Boston Globe, Electricity Journal* and *Solar Today*.

Prior to founding CEG in 1998, Mr. Milford was a Vice President of the Conservation Law Foundation where he worked on a variety of energy and environmental issues, including litigation, advocacy and testifying before numerous legislative and regulatory agencies. Also, Mr. Milford was a New York Assistant Attorney General representing the State of New York in the Love Canal hazardous waste case, and a law professor and director of the Public Interest Law Clinic at American University in Washington, D.C., where in federal court and before Congress he represented Vietnam War veterans harmed by Agent Orange. Mr. Milford also is the co-author of *Wages of War*, a social history of American war veterans, published by Simon and Schuster in 1989. He has a J.D. from Georgetown University Law Center and is a Phi Beta Kappa graduate of Rutgers College.

Todd F. Barker is a Partner at Meridian Institute, a nonprofit organization that specializes in helping people solve problems and make informed decisions about controversial and complex issues. For nearly fifteen years Mr. Barker has served as a respected and trusted facilitator and mediator of numerous dialogues, public processes, and negotiations. These projects have addressed a wide array of issues related to the environment, agriculture, health, science and technology, and security.

In recent years, he has worked extensively on the introduction of emerging technologies such as nanotechnology and biotechnology. He has been involved with the creation of new institutions such as the African Agricultural Technology Foundation and is working with other institutions such as the Public Intellectual Property Resource for Agriculture and the Generation Challenge Program. Most recently, Mr. Barker helped organize and facilitate a meeting for The Rockefeller Foundation

that examined open source models of innovation in the agriculture and health fields. Prior to joining Meridian, Mr. Barker worked for The Keystone Center as a mediator. Mr. Barker received a Master of Science from the University of Michigan where he focused his studies on environmental policy and dispute resolution.

Daniel Dutcher is a Project Director with Clean Energy Group. He brings his expertise in integrating the law, the natural sciences, and the social sciences to the development and deployment of clean energy technology in the United States and internationally. Dan works on international and domestic technology policy projects and also provides assistance to CESA projects as needed. In addition, Dan serves as CEG's liaison to the Sustainable Energy Finance Initiative (SEFI) of the United Nations Environment Programme (UNEP). Dan works with the Basel Agency for Sustainable Energy (BASE) on managing the UNEP-SEFI Public Finance Alliance, a new international consortium of publicly backed funding agencies dedicated to building sustainable energy markets. Dan received his B.A. from Ithaca College in 1981 and his J.D. from Cornell Law School in 1985. In 2000, Dan received his Ph.D. in forest resources from Penn State University. Dan has previously practiced civil and environmental law in Maryland, Pennsylvania, and Vermont.

Clean Energy Group (CEG) is a nonprofit organization established in January 1998 to increase the use of cleaner energy technologies in the U.S. and abroad through creative financing, business partnerships, public policy and advocacy.

CEG works with state and nonprofit officials from around the U.S. that are responsible for over $6 billion in new clean energy funds. CEG manages the Clean Energy States Alliance (CESA), a new nonprofit organization assisting these funds in multi-state strategies. A key project of CESA is the Public Fuel Cell Alliance, a state and federal fuel cell and hydrogen infrastructure collaboration. CEG also works with public officials in Europe interested in trans-Atlantic efforts to build clean energy markets.

CEG, including its related work through CESA, is supported by the state funds, and by major foundations including the Energy Foundation, Rockefeller Brothers Fund, New York Community Trust, Educational Foundation of America, and others.

www.cleanegroup.org
www.cleanenergystates.org
www.climate-tech-policy.org

CleanEnergyGroup
Innovation in Finance, Technology & Policy

50 State Street, Suite 1
Montpelier, VT 05602 USA
Phone +1 802.223.2554
Fax +1 802.223.4967
Email ceg@cleanegroup.org
Web www.cleanegroup.org