Clean Energy Group
Innovation in Finance, Technology & Policy

Climate Crash Course for Copenhagen – The Six Simple Reasons Why We Need Global Technology Collaboration

By Clean Energy Group
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December 6, 2009

Introduction

This paper will review the major reasons why the world needs coordinated and collaborative climate technology innovation and product research and development – in addition to emissions cap and trading. The public, and even public climate officials, may find it hard to follow the many reports on the technology innovation debate. To simplify core principles, this paper explains why technology innovation is needed and why countries should pursue complementary technology innovation policies on a coordinated, global basis. The paper supports the arguments with experts' quotations and then provides a comprehensive list of citations and key reports for further reading on each point in the Appendix.

Summary

A market-based cap-and-trade system alone will not deliver emissions reductions and climate technology deployment at the scale and speed necessary for climate stabilization. A successful international climate agreement should commit to pursue additional policies to accelerate climate technology innovation nationally and internationally through more aggressive, creative, and collaborative research and product development.

The rationale for a complementary technology policy approach is clear – it has been made time and again by leading energy and political institutions, including the G20, the Stern Review, the World Bank, the International Energy Agency, and the United States Climate Action Partnership, an alliance of major U.S. businesses and leading climate and environmental groups, along with other authoritative academics, economists, and scientists. In summary, they argue for a separate technology innovation strategy for the following reasons:

1. **The technology challenge to stabilize climate is unprecedented.**
2. **Existing low-carbon technologies cannot meet this challenge – breakthroughs in cost, performance, and scalability of existing and new technologies are needed.**
3. **There has been a significant under-investment in low-carbon technology research, development, and deployment (RD&D).**
4. **Cap-and-trade policies alone will not create incentives for adequate investment or technology innovation for expensive breakthrough technologies.**
5. **Collaborative international RD&D is essential to overcome the underinvestment challenge and the other barriers to technology scale.**
6. **A global facility dedicated to climate technology RD&D using modern, corporate innovation strategies could radically speed up and reduce the cost of mitigation.**

The following sections go into more detail on each of the six points above, with supporting citations and further reading to be found in the Appendix.

POINT #1: CLIMATE STABILIZATION REQUIRES A TECHNOLOGICAL REVOLUTION

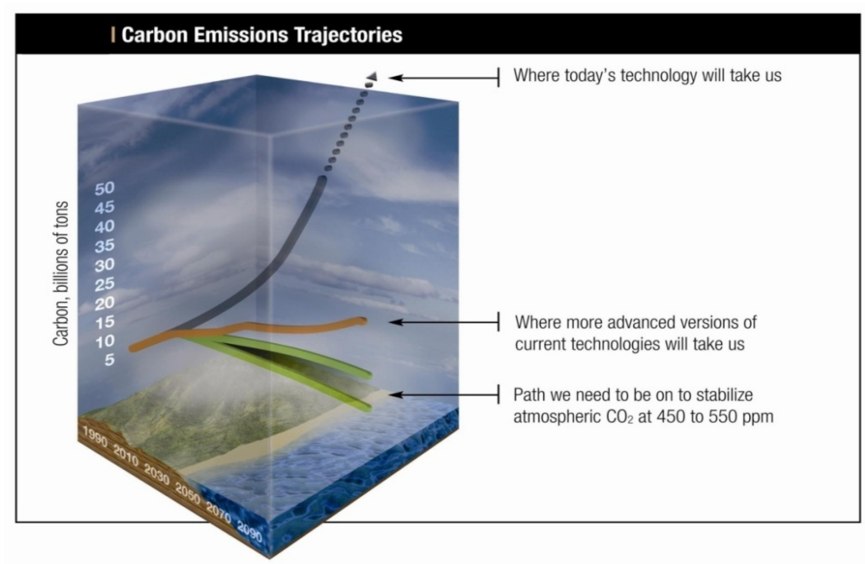
> *If we want to hold CO_2 even to 550 ppmv, even with aggressive energy efficiency we will need as much clean, carbon-free energy within the next 40 years, online, as the entire oil, natural gas, coal, and nuclear industries today combined – 10 to 15 terawatts. This is not changing a few lightbulbs in Fresno, this is building an industry comparable to 50 ExxonMobils.*
>
> - **Professor Nate Lewis, Caltech**[i]

> *Emissions of CO_2 and other greenhouse gases can be reduced significantly using existing technologies, but* ***stabilizing concentrations will require a technological revolution*** *– a "revolution" because it will require fundamental change, achieved within a relatively short period of time* [emphasis added].
>
> - **Professor Scott Barrett, Columbia University**[ii]

Global energy demand is projected to more than double by 2050 and to more than triple by the end of the century.[iii] At the same time, annual global emissions need to stabilize at more than 80% below current levels. Assuming significant improvements in energy efficiency, in 2050 the world still will consume between 30 and 40 Terawatts (TW) of energy, more than half of which must be carbon neutral.[iv] Today, less than 2.5 TW of global energy consumption is carbon neutral. Thus, by 2050, we must develop and deploy on the order of 20 TW of new carbon-free energy, an 8-fold increase.

To put this starkly, we must develop a carbon-free energy infrastructure in 50 years that is larger than our entire existing energy infrastructure, which includes all power plants, vehicles, industries, and buildings on the planet today. To meet this massive challenge, we must not only accelerate deployment of existing technologies but also radically speed up technological breakthroughs.

All of this must happen while we are also providing cheap energy technology to billions of people emerging from poverty in the developing world. In a 2008 *Nature* article, scientists suggest that the scale of the "technology challenge" to resolve the climate change problem while meeting growing energy needs has been "seriously underestimated" by the Intergovernmental Panel on Climate Change."[v]



Source: Clean Energy Group, 2009

The bottom line is that today's technologies, at current price points, are not sufficient to meet these growing energy demands while reducing emissions as needed.

Point #2: Climate Stabilization Presents an Unprecedented Technology Innovation Challenge

> *Another myth is [that] we have all the technologies we need to solve the energy challenge. It's only a matter of political will…. I think political will is absolutely necessary…but we need new technologies to transform the energy landscape.*
>
> - **U.S. Secretary of Energy Steven Chu, 2008**[vi]

> *The fight against climate change will not be won without a revolution in the use of existing low-carbon technology and a tidal wave of new inventions.*
>
> - **The Global Climate Network**[vii]

Breakthroughs in the cost, performance, and scalability of climate technologies are necessary. The reason is simple – existing climate technologies at current costs and performance cannot meet the demand for carbon-neutral energy. Innovation in all phases of technology development is important, from basic research and development to commercialization and dissemination.

A 2007 study found that existing carbon-neutral energy sources could only supply 10-13 TW of power by 2100 – less than half that needed to stabilize CO_2, even at an unacceptable level of 550 ppm concentration in the atmosphere.[viii]

TECHNOLOGY INNOVATION

For purposes of global collaboration, what do we mean by technology innovation?

We do not mean just an invention of a new idea. Rather, we mean the commercial use of that idea as a product in the marketplace. "An *innovation* in the economic sense is accomplished only with the first *commercial* transaction" (West 2009).

So in this paper, climate technology innovation is not meant to be just a lab invention or sharing of a new idea, but rather widespread application of new ideas in a low-carbon market, as a product that customers will use and purchase. Most efforts at collaboration are information sharing through networks. We mean much more – climate technology product development on a global scale to achieve climate stabilization.

West, Joel. Presentation to the University of California, Haas School of Business, September 24, 2009, citing other sources at http://openinnovation.haas.berkeley.edu/speaker_series/OISS_Sep_14_2009.pdf.

Major breakthroughs in new as well as existing energy technologies and sources will be required for stabilization at 550 ppm, and even more so for stabilization at 450 ppm, the level many scientists cite as critical to stabilization. Unfortunately, breakthroughs are severely limited by underinvestment and numerous barriers to low-carbon technology commercialization, as noted next.

Point #3: Underinvestment and Other Hurdles Hamper Low-Carbon Technology Innovation

> *Carbon pricing is only in its infancy, and even where implemented, uncertainties remain over the durability of the signal over the long term…. This means* ***there will tend to be under-investment in low-carbon technologies****.*
>
> ***- Stern Review***[ix]

> *R&D tends to be underprovided in a competitive market because its benefits are often widely distributed and difficult to capture by individual firms…* ***private-sector investment in technology innovation is likely to fall short of what may be desirable over the long term, particularly given the fragility of expectations concerning future GHG prices and the uncertain credibility of near-term policy commitments.***
>
> - **Resources for the Future**[x]

According to leading studies on clean energy by the World Bank[xi] and the *Stern Review*, there are several barriers that inhibit needed public and private investment in clean energy R&D, as well as the cost reduction and scale-up of existing technologies. The recognized barriers include:

- ***The patchwork of climate policies around the world and consequent political and financial risk:*** Carbon emissions are priced variably or not at all, creating considerable risk in climate policy that limits private investment in climate technologies. Experience has shown in the EU, for example, major fluctuations in carbon prices fail to provide security for medium- and long-term investment in low-carbon technologies.
- ***Climate change mitigation is a global public good*****:** "Information is a public good. Once new information has been created, it is virtually costless to pass on. This means that an individual company may be unable to capture the full economic benefit of its investment in innovation. These knowledge externalities (or spillovers) from technological development will tend to limit innovation."[xii]
- ***Technology risks associated with the "valleys of death"*****:** There are two recognized "valleys of death" in the technology development chain – first at the early product development stage between public and private sector funding and later at the commercialization stage, when first- and second-of-kind plants require large-scale investments.
- ***Energy RD&D can require large sunk capital investments:*** It is difficult to attract sufficient capital without actions to reduce investor risk through specific government technology support.

Additionally, underinvestment is particularly acute in developing countries. The technology needs of developing countries are especially underserved because of many other barriers specific to their condition, according to the World Bank:

> *The vast majority of resources and expertise for technical innovation are in the OECD countries, which are rarely motivated to develop products suited solely for the poorer countries. OECD governments will naturally promote research that serves their own citizens and economies. Similarly, private industry often regards markets in developing countries as less attractive due to lower capacity to pay, higher transaction costs, weaker contract law and intellectual property rights, and general unfamiliarity.*[xiii]

The result, according to longstanding consensus opinion from economists and energy experts, is that these and other barriers lead to significant underinvestment in climate technology RD&D.[xiv] Virtually every reputable organization that has studied clean energy agrees with this list of barriers and gaps, the problem of underinvestment, and the need to overcome the barriers with technology-specific measures in both OECD and developing countries.

POINT #4: CAP AND TRADE ALONE WON'T SPUR A CLIMATE TECHNOLOGY REVOLUTION

> *Market-based abatement policies are effective mechanisms for bringing about the diffusion of existing technologies and can even spur incremental improvements through learning and induced applied R&D. Thus abatement policy is a mechanism for getting technologies 'off-the-shelf.' However, because of long time frames and limited appropriability in basic research, a second mechanism is required to put new abatement technologies 'on-the-shelf.' The implementation of a technology strategy for a long-term environmental problem such as climate change is a challenging policy task.*
>
> \- **Geoffrey Blanford, Electric Power Research Institute**[xv]

Authoritative global experts agree that a market-based cap-and-trade system alone will not deliver emissions reductions and technology innovation at the scale and speed necessary to fully address climate change. **In fact, carbon pricing, such as cap-and-trade systems, typically encourages the deployment of the cheapest existing low-carbon technologies and energy-efficiency measures (often called "no regrets" policies). Such systems do not create incentives for investment in expensive breakthrough technologies.** They tend to drive incremental technical improvements and marginal cost reductions.

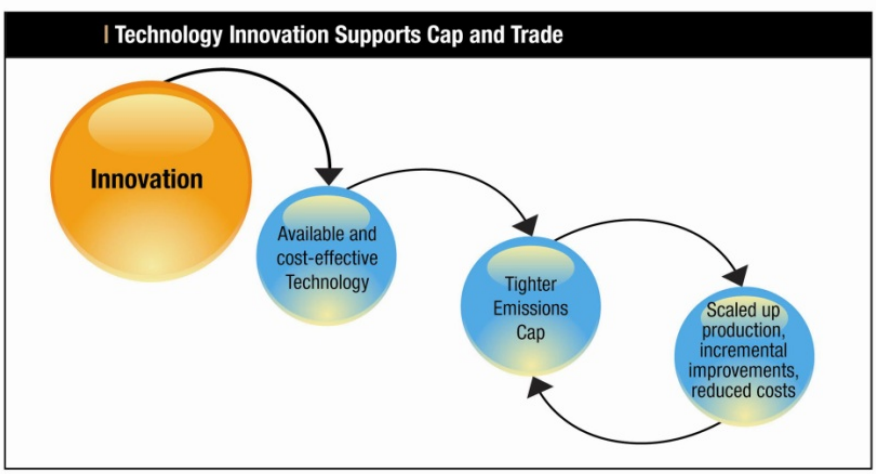
The *Stern Review* agrees that carbon pricing must be complemented by measures to directly develop technologies. Stern writes, "uncertainties and risks both of climate change, and the development and deployment of the technologies to address it, are of such scale and urgency that the economics of risk points to policies to support the development and use of a portfolio of low-carbon technology options."[xvi]

The United States Climate Action Partnership, an alliance of major U.S. businesses and leading climate and environmental groups, supports cap-and-trade legislation in the U.S., but it also proposes that, "Advancing technology research, development, demonstration and deployment, and promoting technology transformation...are critical needs that will not be adequately spurred by the cap alone....***Rapid advancement and deployment of new, breakthrough technologies are also core elements of any climate change solution***"[xvii] [emphasis added].

A 2009 Deutsche Bank report, "Investing in Climate Change," makes the same case for technology innovation policy because, "some mitigation technologies have high RD&D costs, long lead times and would require extraordinarily high carbon prices before they are profitable, potentially leading to politically unacceptable transfer costs and overall drag on the economy."

In fact, specific technology innovation measures could break the current deadlock in international negotiations, as they can drive down the current cost of more-expensive technologies, which would make it possible to adopt tougher emissions targets in the future.

Many other studies support the same position that complementary, technology support measures will be needed in addition to carbon pricing. There is virtually no dispute about that proposition from any reputable organization, including the G20, the World Bank, the IPCC, the IEA, and the UNFCCC's Expert Group on Technology Transfer.[xviii]



Source: Clean Energy Group, 2009

The Case for Radical Solar Innovation

"Public research and development is justifiable when:

- *A technology promises to achieve a large reduction of emissions;*
- *It has high startup costs and lower marginal mitigation costs thereafter;*
- *The potential for reducing startup costs through learning, scale, or network effects is high.*

*Under these circumstances the government may need to assume some of the investment risk in research and development…. **The advantage is that expensive technologies will achieve large-scale feasibility at a lower carbon price and become operational faster.**"*

- Deutsche Banke*, "Investing in Climate Change 2009" (Fulton 2008)*

These characteristics are all true in the case of solar photovoltaics (PV).

Although PV may be considered an "existing technology," solar PV today has a levelized cost of \$0.25 to \$0.30 per kilowatt-hour (kWh) to recover the initial capital investment and cost of money over the lifetime of the PV installation (Lewis 2009), compared to \$.03-.05 per kWh for coal base-load power. This cost is politically untenable, particularly in developing countries.

A radical reduction in the cost of PV is needed for a meaningful level of deployment. The industry needs breakthroughs in the materials, manufacturing, installation, and storage. For example, shipped PV modules now have efficiencies of 15% to 20% in many cases. The theoretical efficiency limit for current solar devices is 31%. Improvements in heat loss and design could reach closer to this limit. But a greater improvement could be made using new nanotech materials and systems, which have been demonstrated in laboratory settings to have theoretical efficiencies in excess of 60%. Advances in basic science are needed to enable all such nano-structured systems to truly offer a practical, ultra-low-cost option for solar electricity production. Any of these systems will also require substantial reductions in manufacturing costs, as well as cost-effective and efficient storage, through break-throughs in battery costs and performance or fuels productions.

According to Caltech Professor Nate Lewis, a leading solar expert in the U.S., "Each of these functions has its own challenges, and integration of them into a fully functioning, synergistic, globally scalable system will require further advances in both basic science and engineering." (Lewis 2009)

According to Stern, "an estimate of the learning cost of reducing the price of… solar PV to the point of market competitiveness is €20 billion. Costs savings alone of this scale provide a rationale for international cooperation." (Stern 2006)

Fulton, Mark. "Investing in Climate Change 2009: Necessity and Opportunity in Turbulent Times." Deutsche Bank Advisors. October 2008. Web. 3 December 2009. http://dbaadvisors.com/climatechange.

Lewis, Nathan. "Toward Cost-Effective Solar Energy Use." *Science 315* (2007): 798-801.

Stern, N. *Stern Review Report on the Economics of Climate Change.* London, UK: HM Treasury, 2006.

Point #5: Collaborative Technology Innovation Could Break Through Technological, Economic, and Political Roadblocks

It is the need for international cooperation that makes the climate-technology revolution unprecedented.

- **Professor Scott Barrett, Columbia University**[xix]

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.

- **Heiligendamm G8 Summit Declaration (June 7, 2007)**

The scale of the technology innovation problem is significant enough to demand intervention at the international level. There are four main reasons why experts support coordinated technology development at a global level:

1. **Cost Reduction:** Coordination on technology makes more efficient use of scarce public RD&D funds. The amount of funding necessary to shift the globe to a low-carbon future is more than any country alone can invest, particularly with today's economic challenges. Moreover, according to Stern, "co-operation to accelerate…technologies is likely to reduce the cost of achieving overall emission and stabilization objectives."[xx]

2. **Tapping the "Global Brain":** Cooperation will take advantage of the best minds to solve the world's toughest technology challenge, to tap the experts from many countries in a global research and development strategy.

3. **Scale**: The only way to get to technology scale is to cooperate on joint problems at same time, not sequentially; this level of investment will require international collaboration.

4. **Cooperative Goodwill:** Technology collaboration builds international cooperation and goodwill for moving forward on tough political agreements. Technology cooperation is an easy win-win on which to build further consensus and agreements and hopefully help to break the current deadlock in the negotiations.

Indeed, many countries, such as members of the EU, are already well aware of the benefits of international collaborative R&D including "pooling financial resources, sharing risks and setting common standards for large or relatively risky R&D projects… and supporting technology deployment in and technology transfer to developing/emerging countries."[xxi]

Having noted the value of international collaboration, it is important to note that national scale-up efforts are important. This is not an either-or proposition: both are needed. International collaboration links national efforts and helps to better coordinate them in order to accelerate technology breakthroughs. Global collaboration promotes and enhances national energy innovation.

Point #6: A new International Climate Innovation Facility will Accelerate Innovation

We will also aim to develop cleaner, more affordable and renewable energy sources…. We must explore global mechanisms through which those identified technologies can be disseminated as rapidly as possible.

- **Commonwealth Statement, November 2009**[xxii]

Climate talks must move from technology transfer to "innovation cooperation" to develop and deploy technologies effectively.

- **Professor Ambui Sagar, Indian Institute of Technology Delhi**[xxiii]

While there are existing international R&D programs that focus on information sharing and best practices, what is needed is to work together aggressively on global and **collaborative product development**. A number of groups and countries have recommended the creation of a new climate technology institution, including China, the G77, and, more recently, the U.S.[xxiv]

An international climate technology facility does not require the commitment of large amounts of new funding or the creation of a large new bureaucracy. An international collaborative policy could take a mostly **virtual approach** to leverage and better coordinate existing resources and institutions. Its functions could largely choreograph the innovation actions of others, including capacity building, supporting technology innovation all along the value chain for key climate technologies, creating solutions to intellectual property rights (IPR) problems, and developing finance and new business models.

A new framework could be modeled after the CGIAR (the Consultative Group on International Agriculture Research) Generation Challenge Programme,[xxv] which employs a distributed innovation strategy for agricultural product development in new markets and is a collaboration of the same donors and governments now part of the Copenhagen process. Another successful model is the Global Fund to Fight AIDS, Malaria and Tuberculosis (Global Fund), an existing global "public goods" partnership institution linked to but independent of the UN, along with other global and national agencies. In contrast, virtually every other developing country energy partnership is an information sharing and best practices network rather than a product development focused initiative.[xxvi]

Conclusion

Recognition and acceptance of these six points should lead to a commitment to a new technology collaboration strategy through the Copenhagen process.

Rarely is there such a consensus on so many fundamental positions. An international collaborative technology innovation process – and a new facility-- could reduce the cost of mitigation by billions, encourage innovation, and ultimately make it politically feasible to agree to even more stringent targets with less costly technologies.

IEA Implementing Agreements: Complementary but Different Approaches

The International Energy Agency Implementing Agreements, which tend to focus on supporting research, analysis, and best practices, will play a key role in any international collaborative RD&D approach. But they do not meet the need for technology product development and collaboration described above. Moreover, the IEA is primarily an OECD organization and therefore does not focus on the needs of developing countries. A review of a sample of results from the existing IEA implementing agreements suggests that the IEA tasks are generally confined to two basic areas:

- Creation of networks of learning where basic technology and policy information is shared among participants; and
- Creation of best practices from this learning network that also are then shared among participants.

It is rare that these agreements are designed to or in fact lead to cooperative action on commercialization and market introduction of new products and technologies. (IEA HIA 2008)

Indeed, the IEA's own description of its technology implementing agreements makes clear that product development and commercialization are not typically core features of these collaborations. Rather, analysis and information sharing are the key function. (IEA 2007)

While the work of IEA could complement an initiative focused on collaborative product development, as proposed here, IEA implementing agreements alone would not likely achieve that objective, nor are they designed to do so.

"IEA Hydrogen Implementing Agreement, Task 26: Advanced Material for Hydrogen Water Photolysis." *IEA Hydrogen Implementing Agreement*. International Energy Agency. 2008. Web. 3 Dec. 2009. www.ieahia.org/pages/static/task26.htm

"International Energy Technology Co-Operation: Frequently Asked Questions." International Energy Agency. 2007. Web. 3 Dec. 2009. www.iea.org/papers/2007/impag_faq.pdf

Appendix A - Further Reading and Other Resources

For Point #1: Climate Stabilization Requires a Technological Revolution

For a global average GDP growth rate of 2.4% (1990-2100) estimates of the carbon-free power required by 2100 generally fall in the range of 25-40 TW, the amount depending on the global average annual rate of energy intensity decline. (At a 1.5% GDP growth rate energy consumption in 2050 would be about 31 TW. A more likely 2.0% growth rate would raise energy consumption in 2050 to almost 39 TW.)

To get on a stabilization path, at least half of the energy used in 2050 will have to be carbon emission-free; by 2100 almost all of it would have to be emission-free. Assuming 31 TW of power will be needed in 2050, implies a six fold rise in carbon neutral energy to 15 TW by 2050. Is that feasible? And what is needed to make it feasible? By 2100 upwards of 30 TW of carbon-free power will be required.

- Isabel Galiana & Christopher Green, *Copenhagen Consensus*

Further Reading

- "**An Analysis of Technology as a Response to Climate Change**," by Isabel Galiana and Prof. Chris Green (August 21, 2009). Copenhagen Consensus Center.
  Available at: http://fixtheclimate.com/#/component-1/the-solutions-new-research/research-and-development/

- "**Energy implications of future stabilization of atmospheric CO_2 content**," by M.I. Hoffert, K. Caldeira, A.K. Jain, and E.F. Haites (1998). *Nature*, 395: 881-884.
  Available at:
  http://stephenschneider.stanford.edu/Publications/PDF_Papers/HoffertEtAl.pdf

For Point #2: Climate Stabilization Presents an Unprecedented Technology Challenge

It's not true that all the technologies are available and we just need the political will to deploy them… My concern, and that of most scientists working on energy, is that we are not anywhere close to where we need to be.

- Professor Nate Lewis, Caltech[xxvii]

Investments in and worldwide deployment of low-GHG emission technologies as well as technology improvements through public and private research, development, and deployment (RD&D) would be required for achieving stabilization targets.

-The Intergovernmental Panel on Climate Change[xxviii]

Further Reading

- **"Powering the Planet,"** by Nathan S. Lewis (2007). *Engineering & Science*, 2: 12-23.
  Available at: http://pr.caltech.edu/periodicals/EandS/articles/LXX2/lewis-web.pdf

- **"The Coming Global Climate-Technology Revolution,"** by S. Barrett (2009). *Journal of Economic Perspectives*, 23: 53-75.
  For purchase at: http://www.aeaweb.org/articles.php?doi=10.1257/jep.23.2.53
- "**Dangerous assumptions,**" by R.A Pielke,. Jr., T.M.L. Wigley, and C. Green. 2008. *Nature*, 452: 531-532.
  Available at: http://thebreakthrough.org/blog/dangerous%20assumptions.pdf
- "**No Green Growth without Innovation,**" by Philippe Aghion, David Hemous and Reinhilde Veugelers (Nov 2009). Bruegel Policy Brief, Issue 2009/07. Available at: http://www.bruegel.org/fileadmin/files/admin/publications/policy_briefs/2009/pb_climaterv pa_231109.pdf

For Point #3: Underinvestment and Other Hurdles Hamper Low-Carbon Technology Innovation

*The **many** uncertainties now inherent in the power sector create risks for investors. These risks may lead to underinvestment – too little, too late, in the wrong location and with the wrong technology.*

- Claude Mandil, Former Executive Director of the Paris-based International Energy Agency[xxix]

*Private firms tend to under-invest in technology development, making government policy for technological innovation necessary. This under-investment occurs because environmental externalities (such as climate change) are undervalued. In addition, firms that invest in technology innovation cannot retain all of the benefits of their expenditures because the knowledge that they gain "spills over" to competing firms… **Global research and development (R&D) funding trends indicate that both governments and private firms are under-investing in energy technology R&D**.*

- Pew Center on Global Climate Change[xxx]

Further Reading

- ***Accelerating Clean Energy Technology Research, Development and Deployment,*** by Avato, Patrick and Jonathan Coony. (2008) World Bank, Washington D.C.
  http://www.esmap.org/filez/pubs/78200895253_accelerating_clean_energy.pdf
- ***Stern review report on the economics of climate change, Chapter 16 Accelerating Technology Innovation,*** by N. Stern (2006). HM Treasury, London UK.
  http://www.hm-treasury.gov.uk/d/Chapter_16_Accelerating_Technological_Innovation.pdf

Point #4: Cap and Trade Alone Won't Spur a Climate Technology Revolution

While pricing carbon will be central regulatory tool for mitigating climate change, other policies are necessary including traditional regulation through mandates, as well as innovation policy. "some mitigation technologies have high RD&D costs, long lead times and would require extraordinarily high carbon prices before they are profitable, potentially leading to politically unacceptable transfer costs and overall drag on the economy. If it is reasonable to expect research and learning to bring down the implementation costs, the prospects for carbon mitigation are substantial, and there are spillover benefits of innovation *("learning externalities") there may be a case for publically subsidized research and development, as well as concessionary financing and subsidies for implementation costs.*

- Deutsche Bank, "Investing in Climate Change 2009"[xxxi]

Advancing technology research, development, demonstration and deployment, and promoting technology transformation and avoided deforestation are critical needs that will not be adequately spurred by the cap alone.

- United States Climate Action Partnership[xxxii]

There is little logic in trying to price carbon emissions out of the market instead of developing good, cost effective carbon neutral alternatives that can be priced in.

- Isabel Galiana & Christopher Green, *Copenhagen Consensus*[xxxiii]

Further Reading

- **"Breaking Through on Climate: Overcoming the Barriers to the Development and Wide Deployment of Low-Carbon Technology,"** by the Global Climate Network (July 2009). http://www.globalclimatenetwork.info/publicationsandreports/publication.asp?id=680
  "**Investing in Climate Change 2009: Necessity and Opportunity in Turbulent Times,**" by Deustche Bank Advisors (October 2008). http://www.dbadvisors.com/deam/dyn/globalResearch/1113_index.jsp

POINT #5: COLLABORATIVE TECHNOLOGY INNOVATION COULD BREAK THROUGH TECHNOLOGICAL, ECONOMIC, AND POLITICAL ROADBLOCKS

International technology cooperation, by sharing information, costs, and efforts, might accelerate and facilitate technical change towards more climate-friendly technologies. Cooperation between countries should not preclude competition between companies, and may drive governments to increase their efforts, especially in supporting basic research and development. Increased technology cooperation between countries could help engage more countries into action to mitigate greenhouse gas emissions.

- Cédric Philibert, International Energy Agency

Our central argument is that there exists today a set of inescapably global environmental threats that require international "collective action." They demand an institutional mechanism at the global level, we argue, but one quite different from traditional international bodies. We propose not a new international bureaucracy but rather the creation of a Global Environmental Mechanism that draws on Information Age technologies and networks to promote cooperation in a lighter, faster, more modern, and effective manner than traditional institutions.

- Daniel C. Esty and Maria H. Ivanova

Further Reading

- **"International Energy Technology Collaboration,"** by Cédric Philibert (2004). OECD Environment Directorate, International Energy Agency. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.121.7418&rep=rep1&type=pdf
- **"Revitalizing Global Environmental Governance: A Function-Driven Approach,"** by Daniel C. Esty and Maria H. Ivanova (2002). New Haven, CT: Yale School of Forestry &

Environmental Studies. Available at: http://www.environmentalgovernance.org/cms/wp-content/uploads/docs/revitalizing_geg_esty_ivanova.pdf

- **"Accelerated Climate Technology Innovation Initiative (ACT II): A New Distributed Strategy to Reform the U.S. Energy Innovation System,"** by L. Milford, J. Morey, T. Barker, K. Locklin, S. Boetigger, and J. Panetta (2009). Clean Energy Group. Available at: http://www.cleanegroup.org/Reports/ACTII_Report_Final_November2009.pdf

Point #6: An International Climate Innovation Facility to Accelerate Innovation

A new or existing international institution with a budget of US$5 billion per year should be charged with the responsibility of coordinating research and development, strengthening regional centers for clean energy technologies, and conducting policy assessments in developing countries. A Consultative Group on Clean Energy Research could leverage the work of existing institutions through active coordination, knowledge sharing, and virtual networking.

- Global Leadership for Climate Change Action[xxxiv]

Further Reading

- **"From Positions to Agreement: Technology and Finance at the UNFCCC,"** by Britt Childs Staley, Jenna Goodward and Hilary Mcmahon (December 2008). World Resources Institute. Available at: http://www.wri.org/publication/from-positions-to-agreement
- **"Innovation and Technology Transfer: Framework for a Global Climate Deal,"** by Shane Tomlinson, Pelin Zorlu and Claire Langley (November 2008). E3G and Catham House. Available at: http://www.e3g.org/index.php/programmes/climate-articles/e3g-report-launch-innovation-and-technology-transfer-framework-for-a-global/
- **"Climate Choreography: How Open and Distributed Innovation Could Accelerate Technology Development and Deployment,"** by L. Milford, D. Dutcher and T. Barker (2008). Clean Energy Group Report. Available at: http://www.cleanegroup.org/Reports/Climate_Choreography_July08.pdf

ENDNOTES

[i] Lewis, Nathan S. "Powering the Planet." *Engineering & Science 2* (2007): 12-23.

[ii] Barrett, S. "The Coming Global Climate-Technology Revolution." *Journal of Economic Perspectives 23* (2009): 53-75.

[iii] Lewis 2007: 12-23.

[iv] Ken Caldeira et al. "Energy implications of future stabilization of atmospheric CO_2 content," *Nature 395* (1998): 881-884.

Ken Caldeira, K. et al. "Advanced technology paths to global climate stability: energy for a greenhouse planet." *Science 298* (2002): 981-987.

[v] Roger Pielke et al. "Dangerous assumptions." *Nature* 452 (2008): 531-532.

[vi] Chu, Steven. "Panel 4: The Visible Hand: Government's Role in the Clean Energy Transformation; Opportunities to Accelerate Deployment of Energy." *National Clean Energy Summit*. August 18, 2009. Web. 3 Dec. 2009. www.cleanenergysummit.org/video/video.html

[vii] The Global Climate Network. "Breaking Through on Technology." Global Climate Network. 2009. Web. 3 Dec. 2009. http://www.globalclimatenetwork.info/%2Fecomm%2Ffiles%2Fbreaking_through.pdf

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A comprehensive list of existing energy related partnerships can be found in the Clean Energy Group's 2008 report, "Gaps Analysis for International Clean Energy: What is Missing in the Research, Development, and Deployment Landscape for Climate Stabilization?" prepared for the World Bank Group. Contact the authors for more information.

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