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Testimony of Dr. Jonathan Pershing before the U.S. Senate Environment and Public Works Committee Climate Roundtable: Exploring Greenhouse Gas Technologies

May 25, 2006

Thank you for the invitation. My name is Jonathan Pershing, and I am the Director of the Climate, Energy and Pollution Program at the World Resources Institute, a non-partisan research and policy think tank here in Washington.

This is a critical time to discuss greenhouse gas mitigation technologies: science is telling us that action is urgently needed if we are to forestall the worst of climate change-related damages.

In my testimony, I would like to highlight three main points, based on analysis by WRI and others:

1. Perhaps the most important element of a long-term solution to global climate change rests on shifts in technology, especially for power generation and transport. Changes in government policy, business investments and consumer behavior are important because they offer a means to effect technology shifts.

2. There is no single technology – no silver bullet – that can drive the scale of emissions reductions that are required; we must be prepared to rely on a portfolio of options. But there are many important and promising technologies – some ready today, and others on the verge of economic and technological breakthroughs – that have the capacity to reduce emissions cost-effectively.

3. The government has a critical role to play, both in funding early stage research and development to cultivate new technologies, and even more importantly, in establishing price signals that are required to stimulate the markets and investment behavior that can pull new technologies at a sufficient rate and scale.

The majority of greenhouse gas emissions in the United States (and globally) arise from burning fossil fuels to provide electric power and transportation. In the US, about 70% of all greenhouse gas emissions come from transport, electricity and heat, and other fuel combustion (see figure 1). If we in the US are to successfully contribute to solving the problem of global climate change, we must develop and globally deploy zero- to low-emitting technologies for vehicles and power plants.

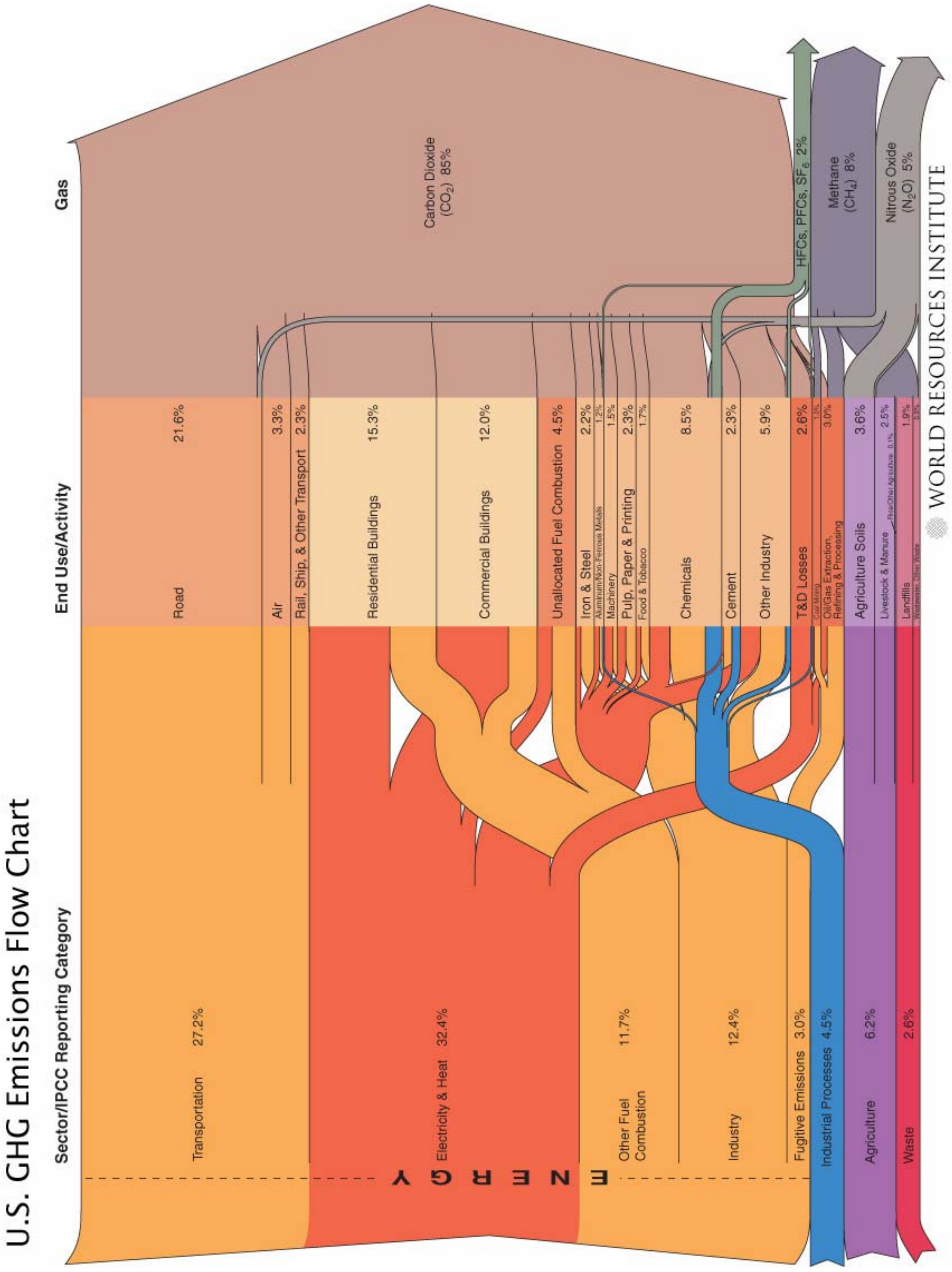


Figure 1. US Greenhouse gas emissions, indicating relative share by sector, sub-sector and gas. Data from WRI, Climate Change Indicators Tool, http://cait.wri.org

The scale of change required is significant. Keeping to the historical path of development of energy efficiency, new energy technologies and changes in behavior will virtually guarantee a future of high emissions, and high concentrations of greenhouse gases. Global economic models incorporating our best estimates of technology change and projections of growth in population, energy demand and GDP, suggest that in the "business-as-usual" case, emissions of CO2 will grow more than 300% from current levels.

However, several comprehensive and authoritative studies on technological feasibility – including those by the U.S. Department of Energy,[1] the Intergovernmental Panel on Climate Change,[2] and the Princeton University Carbon Mitigation Initiative[3] – give us reason for optimism. The United States has the technologies to significantly reduce greenhouse gas emissions. Employing the same modeling tools, but assuming an aggressive push to develop and promote the use of such existing and new low-emitting technologies, the future looks much brighter: under this scenario, emissions could decline by as much as 50% while the economy continues to boom and general welfare improves (see figure 2).

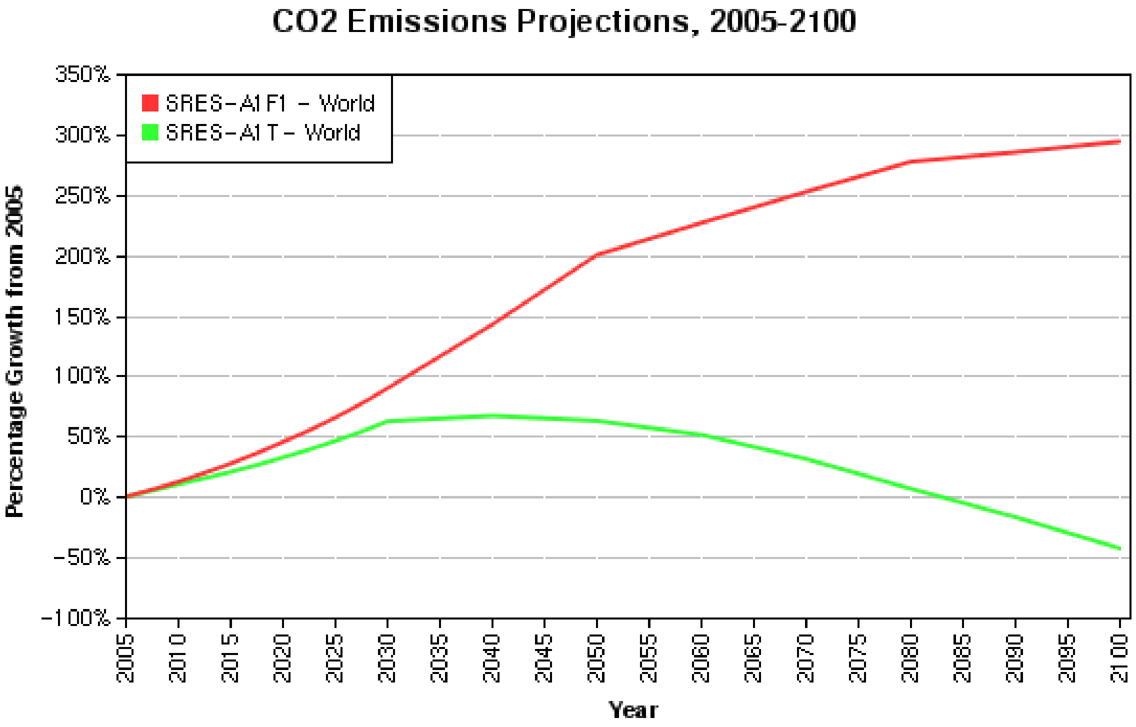


Figure 2. CO2 projections showing the world assuming (a) continued intensive use of fossil fuels (A1F1 scenario), and (b) with aggressive development of advanced technology (A1T scenario). Source: IPCC 3rd Assessment Report, 2001.

While the scale of effort is large, and the policy requirements to implement such changes likely to be difficult, I would like to underscore that the problem confronting us is not principally about technical know-how; it is a problem of implementation. We have technologies that can cost-effectively reduce emissions. We need to bring them to market and greatly accelerate their deployment.

To illustrate, I will draw on research from WRI to briefly describe three promising technologies – biofuels, carbon capture and storage, and renewable power.

Biofuels

Starch-based ethanol, such as ethanol from corn kernels, is an example of a mature alternative fuels technology that has the potential to reduce greenhouse gas emissions, as well as meet other national energy goals such as security and diversification. Since the late 1970s, the federal government has encouraged the production of ethanol primarily through tax incentives for producers and blenders[4]. Nevertheless, as recently as a year ago, the long-term commercial prospects of ethanol remained uncertain. The "push" policies used by the government to ensure development of the technology were not sufficient to ensure widespread adoption. With no guarantee of long-term markets for ethanol, uncertainty regarding the extent to which the federal government would ever commit to development of that market, and no price signals demonstrating to consumers the need for a gasoline substitute, use of ethanol as a fuel remained largely restricted to a niche market in the mid-western states. In April, 2004, there were only 180 gas stations in the entire nation that sold an E85 ethanol blend, and 80 of them were in Minnesota[5].

The autumn of 2005, however, witnessed an explosion of commercial ethanol activity. The ethanol industry is scheduled to increase production capacity by more than 40% within two years[6]. What changed? In the summer of 2005, an industry that had been struggling to expand commercially was handed two of its three missing development elements. Few would dispute that one important element has been increasing average prices of gasoline. Signals finally emerged from the market place that, given political and environmental volatility, having substitutes for gasoline would be prudent.

But an even more important element was the government's passage of the renewable fuels standard, which mandates use of specific amounts of renewable fuels between 2006 and 2012. That action gave the industry information about the long-term prospects of the market, sending signals that the government was committed to helping develop the "pull", or demand, factors that would enable a commercial ethanol market to mature.

Would high oil prices alone have been enough to unleash the industry's potential? It is possible, if the price signal itself had reflected a government demonstration of commitment. Price signals carry the full weight of government priorities behind them if they are the result of a regulatory policy such as a standard, a tax, or a market-based tool such as a cap-and-trade system. Temporary spikes in oil prices due to non-policy factors, however, don't carry the types of long-term price or market information that are useful to alternative fuel industries in making investment decisions; for that reason, the RFS was an essential element in stimulating rapid industry growth.

Obstacles and opportunities in the ethanol industry remain, however, as does the potential for a government role. Although starch-based ethanol technology has reached maturity, cellulosic ethanol technology has not, and technological adoption could be expedited by public R&D. If the ethanol market matures smoothly, and oil prices remain high, public R&D in cellulosic ethanol will likely be eclipsed by private R&D, but even for those technologies with significant incentive for private R&D, obstacles remain for commercialization. Pioneers in efforts to commercialize cellulosic ethanol cite difficulty in obtaining financing as a major obstacle in their commercialization efforts, often due to the lack of demonstration plants. Cellulosic technology is therefore likely to require continued push-oriented policies in order to establish itself as a viable investment opportunity, first through applied R&D and then through a government commitment to demonstration.

Ultimately, the sustainability of biofuels as a substitute for petroleum will depend on policies that ensure that feedstocks are grown responsibly with minimal impact on land, water, and soil resources.

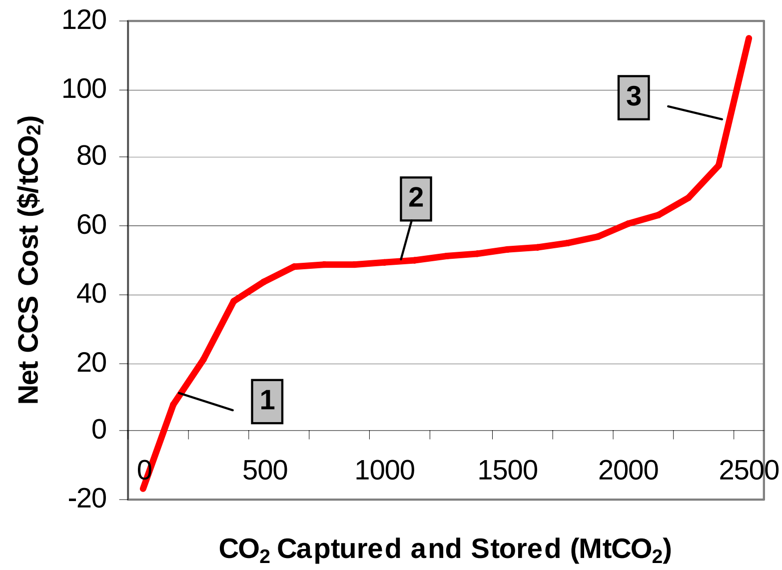
Carbon Capture and Storage

Turning to carbon capture and storage, this technology offers the potential to reduce carbon emissions without a dramatic change in the existing fossil fuel infrastructure. Someday, it may also help us produce climate-friendly alternatives to petroleum. In theory, the U.S. has the potential to store roughly 4,000 billion tons of carbon dioxide underground, or enough to sequester hundreds of years of current emissions.[7]

CCS faces significant economic and social challenges. The elements of a carbon capture and storage system (capture, compression, transport, injection, and monitoring) all exist today, but we need more experience combining them together in a full process. In a typical coal- or gas-fired power plant today, the cost of generating electricity with CCS is roughly 50 percent higher than without.[8] Injecting the captured CO2 into depleted oil and gas fields to enhance resource recovery can offset some costs, but this option has limited application in the larger climate challenge. Additionally, public acceptability of CCS is still an open question. Any mistake in early deployment of CCS could result in widespread public opposition.

Several large scale CCS projects are underway in North America, Europe, and Africa.[9] So far, they have demonstrated that storage of large quantities of CO2 is possible without leakage – or escape of the gas – although it is too early to draw final conclusions from these limited observations. The projects are commercially viable through a combination of fiscal incentives and cost-recovery from enhanced oil recovery. BP's planned Carson project, for example, will take advantage of incentives provided in the Energy Policy Act of 2005 for improved gasification technologies.

There is no single cost estimate for CCS, and hence no single price signal that would indicate when it would deploy widely. CCS costs depend on the quantity to be sequestered, which in turn depends on the specific application. (See Figure 3)



1 - Natural gas processing facility with EOR

2 - Large coal-fired power plant with deep saline formation

3 - Gas-fired power plant with deep saline formation

Source: Battelle, "Carbon Dioxide Capture and Geologic Storage," 2006.

Figure 3: Net Cost of CCS in the U.S.: Current Sources and Technology

Today, a natural gas processing facility that sells its carbon dioxide for enhanced oil recovery may cost a net $10 per ton of CO2 stored, although the quantity available is limited. A large coal-fired power plant injecting its carbon dioxide into a saline aquifer might cost $50 per ton and provide much larger quantities for storage. These costs have the potential to decline by perhaps half over the coming two decades, but most CO2 capture and storage efforts will always remain a cost-plus activity.[10]

Like other technology innovation chains, CCS development can be encouraged by a mixture of price signals, standards, and government-direct research.

Renewable Power

Another strategy for reducing our nation's greenhouse gas emissions is to increase our use of renewable energy, that is, heat and electricity generated by renewable resources such as wind, solar, and biomass. These forms of energy produce little to no greenhouse gas emissions.

Renewable energy already plays a role in America's energy supply; in 2004, renewable energy comprised 6% of total primary U.S. energy supply (both heat and electricity)[11], and 9% of total U.S. electricity (3/4 of this was hydropower[12]).

In fact, among sources of electricity generation, solar and wind have experienced the fastest growth over the past decade: solar photovoltaic has experienced a 21% compounded annual growth rate (CAGR) in capacity (1995-2004)[13], and wind an 18% CAGR in generation (1995-2005)[14]. In contrast, this might be compared to only a 5% CAGR for natural gas and 2% CAGR for coal generation.[15]

However, the United States is nowhere near its potential for utilizing its homegrown renewable resources. The U.S. has sufficient natural resources to dramatically increase installed capacity of renewable energy. According to the Wind Energy Association, we could grow from the current 9,150 MW[16] (2005) to 100,000 MW by 2020[17], while the Solar Energy Industries Association suggests we could grow from the current 385 MW (2005) to at least 8,000 MW by 2020[18]

In the past, some have argued that renewable energy technologies are too expensive. Times have changed. The costs of renewable power generation have decreased significantly over the past 20 years (and the cost of fossil-fired power generation has increased in recent years). For instance, the cost of generating power from wind turbines (excluding the production tax credit) has declined by over 80% since 1980 due to numerous factors including improved turbine designs, larger turbines (typical turbines being 100 kW then vs. 1,500 kW now), and increased manufacturing scale.[19] Similarly, the cost of generating power from solar photovoltaic systems (i.e., solar panels) has declined by 60-75% since 1980.[20]

The R&D investments that have been made by the federal government and private sector are paying off. Several forms of renewables are now approaching cost competitiveness with conventional forms of power generation (levelized costs, assuming no direct subsidies, see table below). However, for most renewables there still is a slight cost premium that is preventing these technologies from playing a bigger role in reducing U.S. greenhouse gas emissions.

Carefully designed public policies could address this obstacle. The R&D investments of the past 30 years have been relatively successful in kick-starting renewable energy technologies. "Deployment" is the name of the game for the next 10 – 25 years. There are a suite of policies that we need to enable renewable energy to fulfill its potential, including standards, incentives and price signals. All should be employed. For example:

- While 20 or more states have already implemented a renewable portfolio standard (RPS), a national RPS would be even more efficient, encouraging renewable power facilities to locate where the resources are most cost-competitive
- The production tax credit (currently 1.9 cents/kWh) has proven to be a successful policy for supporting the growth in wind power in this country. But the fact that the PTC historically has been extended only for 2 year intervals (and sometimes has been allowed to expire) has led to boom and bust cycles for wind suppliers and developers. For the market to perform most efficiently, the PTC would need to be authorized for longer time periods, say 5-10 years.
- Finally, the environmental benefits provided by renewable energy currently have no monetary value and therefore are not incorporated into energy price comparisons or investment decisions. Market-based emissions trading systems would be an efficient and transparent mechanism for placing financial value on these positive attributes.

The Critical Role of Government

I would like to take a moment to reflect on the critical role that government plays in driving technology deployment – a role that is necessary if we are to succeed in avoiding the destabilization of the climate system.

Ideally the government would not be called upon to stimulate technology development. In reality, however, market failures, distortions, and economic externalities – or the extent to which the true social costs of a product are not reflected in its price – compel the government to intervene and nurture technologies that have important social benefits, such as avoiding dangerous climate change. Ironically, government support to emerging technologies may be necessitated by existing patterns of government subsidies that strongly favor very mature and profitable industries, such as oil and gas, while creating market barriers to promising new technologies[21].

In this context, it is clear that the low costs of some existing technologies may in fact represent an incomplete valuation – or at least one that does not include the negative environmental effects. For example, today's market price for pulverized coal suggests it is the least cost option to produce electricity; the US DOE estimates levelized costs to be approximately $0.042/kwh (see table in Appendix). This compares to the least costly renewable energy option, wind, at $0.051kwh. However, if we add the costs of carbon dioxide capture and storage to the coal plant – a technology that does not yet exist at commercial scale for pulverized coal – we would add at least another $0.02/kwh to the coal price. The coal plant, once the least cost option, now must compete with other fuel choices. (see figure 5 for a sampling of the relative emissions of CO2 from various fuel choices).

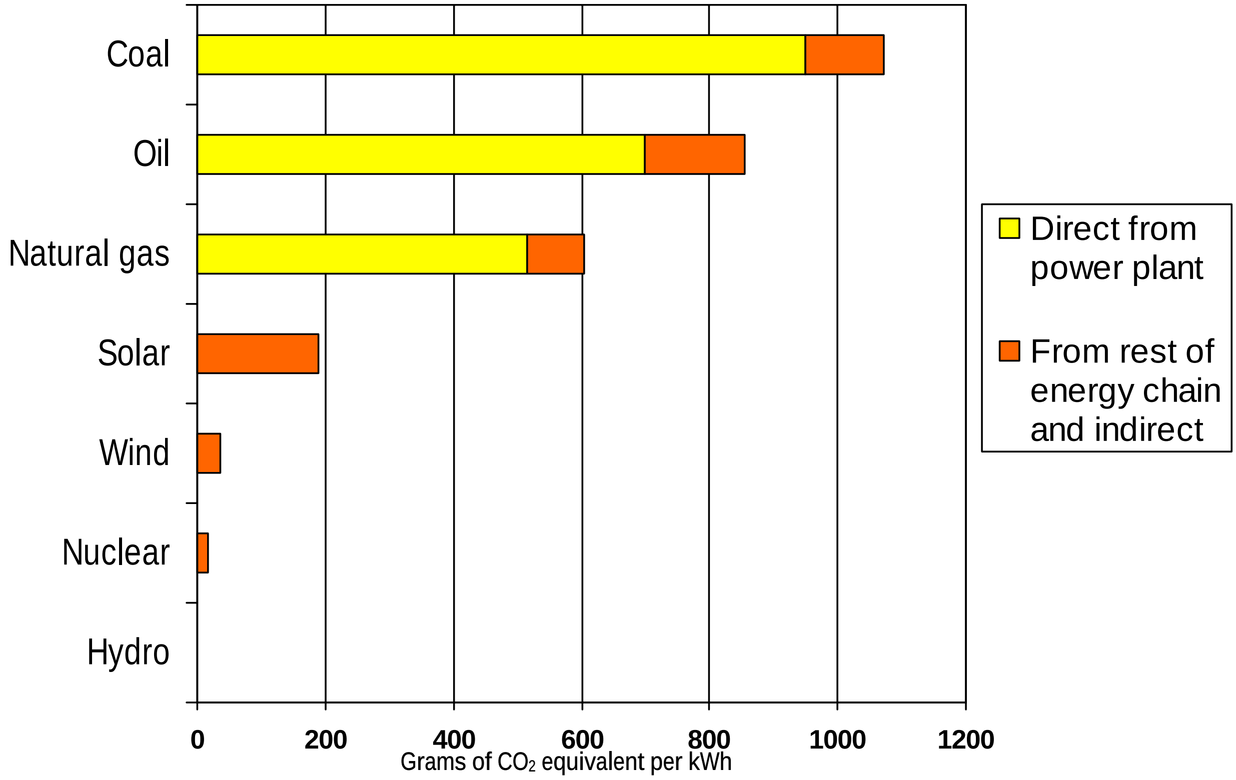


Figure 4. Lifecycle emissions of various electricity sources. Source: GaBE Project: Comprehensive Assessment of Energy Systems, Mar. 2002, Paul Scherr Institut, online at http://gabe.web.psi.ch/lca.html

In moving technologies forward, the government has a dual role – one the hand using its resources to push new technologies into the marketplace, and, on the other hand, creating the price signals that allow markets and investors to take over, ultimately pulling the technologies across the threshold of cost-competitiveness and allowing for full commercialization.

A government “push strategy” could center on R&D and technology standards, such as efficiency standards, whereas a “pull strategy” could center on economic incentives through regulation, taxation or guaranteed purchase agreements. The two methods are not mutually exclusive but rather complimentary. Of the five distinct phases in the chain of technological transformation – basic R&D, applied R&D, demonstration, commercialization, and diffusion (see figure 5) – government and the private sector both play a role in each stage, but with government investment more prominent initially and private sector investment (coupled with government regulation) playing a stronger role in the later stages.

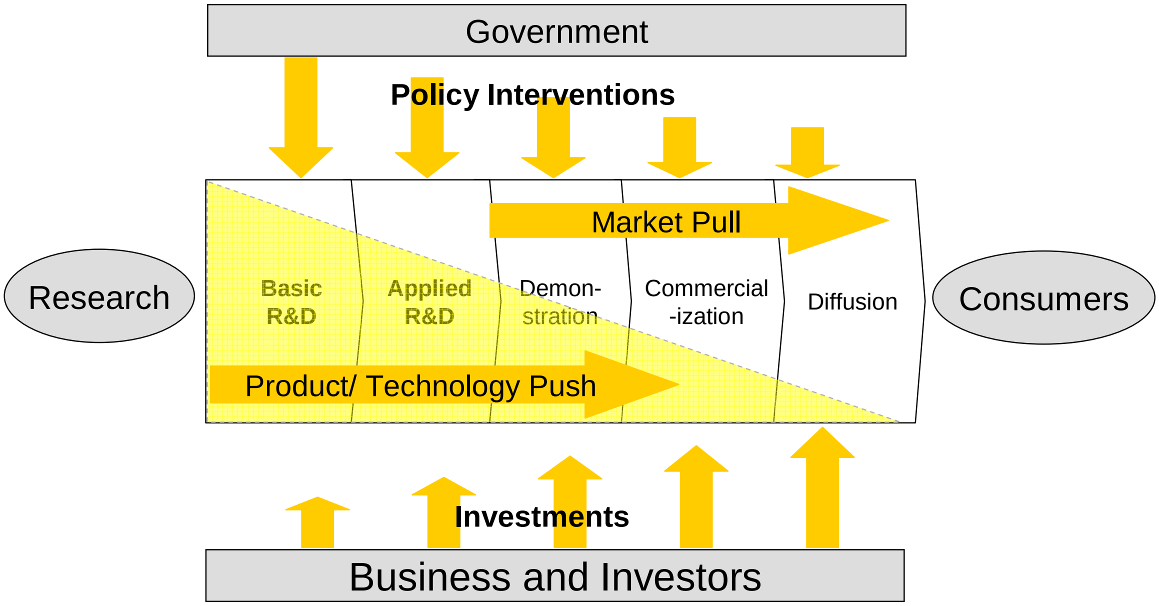


Figure 4. Technology Innovation Chain. Source, Grubb, 2003[22]

Thus, the issue is not whether to chose between an R&D or an incentive-based approach, but how to balance the two. Either operating alone is probably insufficient. Government-funded energy R&D plays a critical role in solving difficult technical problems that markets may fail to address. Also, full scale "in the field" demonstration projects are critical for learning. Conversely, regulatory standards, such as those currently used to drive energy efficiency and renewable energy investment, are good at ensuring penetration in a complex, uncertain world.

Some of the most promising climate-friendly energy technologies are already in the latter stages of the chain of transformation. Here, R&D will be less effective in increasing market penetration rates than a market pull strategy, where the government promotes diffusion through fiscal and regulatory mechanisms. The logic of a market pull strategy is that the government establishes price signals, and private firms respond to economic incentives by developing technologies at the lowest possible costs. In this way, the government avoids having to "pick winners." Price signals, which may take a variety of forms – including market-based signals and taxes – allow market forces to decide the best solutions. These signals will need to be substantial, however, to drive market penetration at the required scale.

Price signals are especially important when considering the diversity of greenhouse gas emissions sources, which are connected to many different economic activities (shown in figure 1). There is no "silver bullet" in terms of technology development. A broad price signal, therefore, has the virtue of covering a great many different activities and thus stimulating a diverse array of technologies.

Conclusion

In conclusion, I would like to reiterate several key points:

First, while the climate is changing, we do have a set of technologies that are already available, and that can significantly forestall the worst of the potential future damages. The key will be to move them to the market quickly.

Second, I would like again to note that it will not be one technology, but a full complement – across the energy, transport, industrial and other sectors of the economy – that will be needed. Greenhouse gas emissions are pervasive – and technology and policy efforts must match that scope and scale.

Finally, I would like to note that the full penetration of these low GHG technologies will not likely occur without government intervention. It will be critical that we send the right signals to the market if we want to change from our current path to one that is more energy efficient, and more climate friendly. In particular, we need broad price signals over extended period of time to provide the right conditions for business investment.

Thank you. I would be pleased to answer any questions you might have.

Appendix: Cost Comparison of Electricity Resources, updated May 2006

	Installed U.S. Capacity (MW)	Year	Source		Levelized Cost (cents/ kWh)	Year	Source		Capital costs ($ / kW)	Year	Source
Coal (pulverized)	335,243	2004	EIA (2005) "Existing Capacity by Energy Source"		4.2	2002	MIT (2003). *The Future of Nuclear Power*		1,189-1,338	2003	University of Chicago (2004). *The Economic Future of Nuclear Power*
Natural Gas (simple cycle)	256,627 (simple and cc)	2004	EIA (2005) "Existing Capacity by Energy Source"						571	2003	University of Chicago (2004). *The Economic Future of Nuclear Power*
Natural Gas (combined cycle)					3.8-5.6	2002	MIT (2003). *The Future of Nuclear Power*		472-590	2003	University of Chicago (2004). *The Economic Future of Nuclear Power*
Nuclear (conventional)	105,560	2004	EIA (2004) "Existing Capacity by Energy Source"		4.2-6.7	2002	MIT (2003). *The Future of Nuclear Power*		1,853-2,000; 1,900 1,365 (Pebble Bed Modular Reactor)	2003	University of Chicago (2004). *The Economic Future of Nuclear Power; OECD (1999). Electric Power Technology*
Nuclear (advanced)	0	2005	Energy Information Administration (2006) "Levelized Cost Summary for NEMS"		6	2013	Energy Information Administration (2006) "Levelized Cost Summary for NEMS"		2,117	2007	EIA (2003) "2002 Overnight Capital Costs"

	Installed U.S. Capacity (MW)	Year	Source	Levelized Cost (cents/ kWh)	Year	Source	Capital costs ($ / kW)	Year	Source
Hydro	78,703	2004	EIA (2005) “Table 12. U.S. Electric Net Summer Capacity”	6.0	2002	California Energy Commission (2003)			
Wind	9,150	2005	EERE (2006)	5.1	2005	EIA (2004) *Assumptions to the Annual Energy Outlook 2004*	1,000-1,200	2005	EIA, 2004, private wind developers
Solar PV	397	2004	EIA (2005) “Table 12. U.S. Electric Net Summer Capacity”	20- 31	2003	University of Chicago (2004). *The Economic Future of Nuclear Power*	3,500 (modules) 6,500 (total installed)	2002	suppliers
Biomass	9,709	2004	EIA (2005) “Table 12. U.S. Electric Net Summer Capacity”				1,763	2002	EIA (2003) “2002 Overnight Capital Costs”
Landfill gas	1,050	2003	U.S. EPA Landfill Methane Outreach Program (2004)	4.8	2006	EIA (2004) *Assumptions to the Annual Energy Outlook 2004*	1,477	2006	EIA (2004) *Assumptions to the Annual Energy Outlook 2004*
Geothermal	2,133	2004	EIA (2005) “Table 12. U.S. Electric Net Summer Capacity”	4.8	2009	Energy Information Administration (2006) “Levelized Cost Summary for NEMS”			

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