

CLIMATE CHANGE AND TECHNOLOGY: AN AUTO PERSPECTIVE

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U.S. Policy on Climate Change

After nearly a decade of challenging negotiations to reach consensus on an international treaty on climate change, events are moving. Following a failure to reach final agreement on the elements of the Kyoto Protocol at The Hague in November 2000, President George W. Bush announced in March that the United States would not ratify a “fatally flawed” Protocol. Contentious issues such as limits on the use of emissions trading, credits for carbon sequestration, the operation of the Clean Development Mechanism, compliance and penalties, harm to the U.S. economy, and the vexing issue of global participation could not be resolved satisfactorily.

The United States stated that it took climate change seriously, would not interfere with efforts by other nations to implement the Protocol, and would stay engaged in the process started in Rio in 1992. The United States also said it would demonstrate the leadership in addressing climate change that is expected from the world’s largest economy.

Some view the U.S. withdrawal from the Kyoto Protocol with great alarm and pessimism; others are optimistic that it represents a much-needed new and more pragmatic approach to concerns about climate change. The case for optimism is strong. Henry Jacoby and David Reiner at the MIT Joint Program on the Science and Policy of Global Change stated in their review of the actions taken at The Hague: "It is not clear that short-term failure is irreversible, or even undesirable, if what replaces the grand deal is a period of national experimentation that can then be knit back together into a more effective international system. Progress might well be found in a transitional period of modest domestic actions among the major developed-country emitters rather than in an effort to resolve all the outstanding issues of the Kyoto process."

It is thus important that the United States implement effective domestic actions to address concerns about climate change during this period of transition. The seven fundamental principles set down by the United States in June 2001 for addressing climate change provide a solid foundation for effective domestic action:

- The goal is long-term stabilization of greenhouse gas concentrations in the atmosphere.
- Policies for achieving this goal must be science-based.
- Policies must be flexible.
- Policies must utilize market-based incentives.
- Policies must spur technological innovation.
- Policies must provide for continued economic growth.
- A global effort is needed to address climate change effectively.

These seven basic principles provide bases for both effective domestic actions, and for effective future global accords that will benefit greatly from demonstrated success at the domestic level.

Climate change is a century-long issue that requires a long-term focus and long-term goals. Much of the debate over targets, timetables, and short-term actions has only distracted the world community from the sustained, long-term effort needed to address climate change.

Advancing the science of climate change broadly and resolving uncertainties about the impacts of natural variation on climate, future changes in climate, what constitutes a dangerous change in climate, and even how policy actions affect climate are essential to formulating effective long-term policies. Flexible policy formulation and implementation are needed to enable us to respond and adapt continuously to new scientific knowledge as it is generated.

The private sector can play a key role in meeting the challenges of climate change. Tapping the power of markets is thus essential. Market signals provide powerful incentives to those in the private sector to conserve energy and to use it efficiently. Market incentives are also essential to spurring the technological innovations that will enable us to meet the challenges of climate change while maintaining the economic growth that is essential to any effort to address greenhouse gas emissions.

Energy is critical to the economic growth that is essential to meeting environmental, health, and social needs. Economic development and population growth, especially in developing countries, will double the demand for energy by 2030. Despite alarms that we were running out of oil four years after Colonel Drake drilled the first oil well in Pennsylvania, there are no signs of shortage. Forecasts of oil prices for the next 15-20 years are in the \$20 a barrel range (after inflation). As a result, fossil fuels, which account for 85 percent of today's energy supplies, are forecast to account for 87 percent by 2030, with some shifting from coal to natural gas.

Despite the abundance of oil, over two billion people today lack access to commercial energy, and the number could reach three billion over the next several decades. Continued reliance on traditional forms of energy in developing countries (wood, and coal for cooking) is a serious threat to human health and the environment. Economic growth and access to commercial energy would improve human health, relieve many stresses on the environment, and generate the wealth, demand, and technology needed to address climate change.

Finally, an effective long-term effort to address climate change must truly be global. It must include actions to reduce greenhouse gas emissions in the United States and actions to reduce or limit the growth in GHG emissions in developing

countries where emissions are growing rapidly with economic development and population growth.

The Role of Technology

Supporting the development, commercialization, and global diffusion of advanced technologies is essential to the success of U.S. domestic actions, and to international accords to address climate change. Eileen Claussen of the Pew Center writes: “Climate change policy analysis is fraught with uncertainty and controversy, but at least one thing is perfectly clear: technological innovation is the key to addressing climate change.”

Some estimates of the returns on investments in advanced technology are enormous. Jae Edmonds of Battelle writes: “It is hard to overestimate the importance of developing and commercializing new and improved energy technologies over the course of this century. The value of future improvements in GHG related technologies, relative to the present set of technologies, has been estimated to be in the trillions of dollars.”

One of the main issues with the Kyoto Protocol was always its inadequate treatment of technology and insufficient focus on policies to stimulate the development of new technologies. Technology cannot simply be mandated. A study by The Business Roundtable concluded: “The Kyoto Protocol provides neither the time nor the appropriate policy environment to develop, commercialize on a large scale and disseminate worldwide the innovative energy technologies that would be needed to make such large reductions in greenhouse gas emissions without serious harm to the world’s economy.” Indeed, the short-term focus of the Protocol impedes the development of needed technologies by forcing a myopic search for short-term fixes that come at the expense of true innovation.

The Protocol does not speak directly to the essential role the private sector plays in the development, commercialization, and global diffusion of technology. Discussions of technology transfer, the Clean Development Mechanism, emissions trading, and other mechanisms are focused on government-to-government interactions. The role of the private sector is unclear despite the fact that it is primarily the private sector that will develop, finance, and implement the technologies that are needed to address climate change.

Climate change is a classic problem of the global commons. A lack of private market demand for climate-friendly technologies requires government support for technology development across a broad front, including mitigation, carbon sequestration, capture and storage, and adaptation technologies. Supportive government policies are essential when lead times are long, risks are high, market pull is weak, and social benefits are thought to be great. It is thus essential that what comes next are policies that promote the development, commercialization, and global diffusion of new and breakthrough technologies for addressing climate change. Some specific, important policies that would encourage technological innovation include:

- Government should increase funding for energy research and development to a level commensurate with the challenge. The federal government spent over \$83 billion on research in fiscal year 2000. A greater portion of these funds needs to be focused on energy and climate change challenges. Increased funding is especially critical given declining public and private expenditures for energy research in recent years throughout most OECD nations. The research agenda should be focused more on long-term technological development and breakthrough technologies. This long-term orientation requires continuity and sustained funding. There also should be a broader and more balanced research agenda because innovation often occurs at the boundaries of emerging technologies. For example, support is needed for automotive research for clean diesel and lean-burn technologies, lightweight structures, on-board hydrogen storage, and for a hydrogen re-fueling infrastructure.
- Government should stimulate private demand for advanced technologies with consumer incentives such as tax credits for the purchase of hybrid and fuel cell vehicles.
- The federal government can play an important direct role in creating markets for new technologies as major purchasers of goods and services. Government purchases of innovative technologies can stabilize emerging companies, facilitate scale economies, and stimulate broader private market demand.
- Government should accelerate the transfer of technology from the National

Labs to the private sector by increasing their orientation towards the commercialization of cost-effective energy technologies. These Labs spent \$25.7 billion dollars for research in 1995 – 14 percent of total U.S. R&D expenditures. Importantly, the National Labs allocated 23 percent of their budget to basic research compared with 4 percent in the private sector.

- Government should foster the development of public-private research partnerships, domestically and internationally, as key tools for moving promising technologies to the marketplace.
- Government should increase input from the private sector into the national research agenda to help ensure that input is received from experts in the private sector, and that the needed focus on effective and practicable energy and environmental technologies is maintained.
- Government should reinstate investment tax and energy credits, and shorten the period for depreciating investments in climate-related and energy-efficient investments in vehicles, plants, and equipment.
- Government should begin planning for the considerable infrastructure needed to support advanced technologies, e.g., a hydrogen re-fueling delivery system.
- Government should eliminate regulatory, tax, and trade impediments to the development and global deployment of advanced energy technologies. U.S. regulatory, tax, and trade laws make important contributions to a cleaner and healthier environment, facilitate an effectively functioning economy, and an efficient global trading system. Too often, however, these policies “lock-in” current technology rather than support innovation. They unintentionally discourage research, innovation, and capital investment by increasing uncertainty, risks, and costs. One environmental organization concludes: “The current legislative framework represents the biggest obstacle to a coherent, vigorous environmental technology policy.” Statutory reforms are needed to “turn environmental law’s pervasive bias against innovation into a demand pull for new technology.” A recent study by The Business Roundtable identifies thirty-eight specific regulatory, tax, and trade impediments to innovation and proposes concrete solutions to each.

Among them are the following:

- Interpretation of the Clean Air Act's New Source Review (NSR) provisions discourages improvements in energy efficiency because changes trigger permitting reviews, require the installation of additional pollution control equipment, and can invoke additional emissions reductions. The EPA should implement NSR in ways that avoid triggering permitting requirements for changes necessary to maintain and repair existing facilities, and for changes that do not increase emissions.
 - The narrow focus of technology-specific standards such as best available control technology (BACT) or reasonably available control technology (RACT) often forces manufacturers to use technologies that result in greater overall costs, wastes, and energy consumption. Government should establish performance standards and allow companies to select appropriate technologies.
 - Reduce delays and uncertainties resulting from multiple layers of permit reviews under the Clean Air Act.
 - Reform antiquated standards, building codes, and zoning ordinances that discourage improvements in energy efficiency.
 - Make the R&D tax credit permanent, and allow credits for every dollar of research expense rather than for the increment over an arbitrary base amount.
 - Eliminate taxation on international, intra-firm transfers of environmental and energy-efficient technologies.
 - Lessen restrictions on the export and import of advanced energy and environmental technologies. Reduce tariff and non-tariff barriers to energy-efficient technologies in future WTO negotiations.
- Accelerate the global diffusion of technology to developing countries where the biggest environmental gains can be achieved. There are commercially available technologies that could reduce greenhouse gases cost effectively in

developing countries today. Improve the financial, physical, technical, legal, and regulatory infrastructures in developing countries to encourage innovation and to allow these countries to assess, implement, operate and maintain advanced technology systems. We should press international financial institutions to provide special focus on energy technologies and supporting investments. Numerous trade policies also impede the transfer of state-of-the-art environmental technology to developing nations. Tariffs imposed by foreign governments, restrictions on market access, closed government procurement practices, and inadequate enforcement of intellectual property rights all impede global technology diffusion. Excessive U.S. controls on the export of technology and restrictions on immigration also impede international technology transfer.

- Accelerate research to resolve uncertainties in climate change science. Improve the science of climate change, the accuracy of general circulation models, long-term monitoring of the climate, and our ability to forecast future changes in climate, and their environmental, health, and social impacts.
- In the long term, technological innovation requires strong Federal, state, and local support for education in math, science, and engineering. Our education system must produce the inventors of tomorrow's technologies and the skilled workforce that can work with increasingly sophisticated technologies.

Technology in the Auto Industry

The development of advanced technology vehicles is certainly the key to responding effectively to concerns about climate change in the automotive industry, which is a critical sector for both the environment and the economy. Cars and light-duty trucks account for 20 percent of U.S. man-made emissions of carbon dioxide. Highway vehicles, worldwide, account for about 11 percent of man-made CO₂.

The automotive industry is a powerful engine for economic growth. The U.S. auto industry accounts for nearly 4 percent of U.S. GDP and about 6.5 percent of U.S. manufacturing output. More than 600,000 people are employed in the auto

industry. Related employment at upstream suppliers and downstream sales and service facilities adds another 1.8 million workers for a total of 2.4 million jobs. In 1998, average compensation (wages plus benefits) in the auto and parts manufacturing industry was \$65,000 per worker compared with \$48,000 for all manufacturing and \$38,000 nationwide. With R&D expenditures exceeding \$18 billion in 1997, the motor vehicle and equipment industry ranked first in the nation.

Over the past 30 years, fuel economy has improved 130 percent in passenger cars and 75 percent in light-duty trucks, while emissions of hydrocarbons, carbon monoxide, and oxides of nitrogen have been cut dramatically. Additional gains in fuel economy were offset by consumer demands for larger vehicles that provide greater performance, safety, and convenience.

General Motors is fully committed to improving the energy efficiency of its plants and vehicles while continuing to produce a broad line of cars and trucks that meet customers' needs for safety, performance, and reliability. It is necessary to develop a broad portfolio of conventional and advanced technologies because the future success of competing technologies is uncertain, and because significant regional and international differences in infrastructure, road conditions, performance requirements, fuel prices and government transportation and environmental policies create demands for alternative technologies in different geographical or niche markets around the globe.

We at GM see hydrogen as the long-term solution to climate change in the transportation industry. We also envision a period of transition characterized by continuous improvements in conventional vehicle technologies, modern diesel technology, and the introduction of a variety of hybrid vehicles for different consumer and commercial markets.

Conventional vehicles are continuously being improved, and will co-exist with advanced technology vehicles for many years. Lean burn technologies like clean diesel and direct injection gasoline, displacement on demand, continuously variable transmissions, lightweight structures, and mass reduction are important conventional technologies for increasing energy efficiency.

Displacement on demand, which GM will introduce in 2004, saves fuel by using only half the engine cylinders during normal driving conditions. The sys-

tem automatically reactivates the other cylinders when full power is needed for acceleration or for carrying heavy loads. Continuously variable transmissions save fuel by providing an infinite set of gear ratios so that the engine always operates at its most efficient speed.

Diesel engines, which account for about a third of new car sales in Western Europe, can improve fuel economy 30 percent over comparable gasoline engines and reduce carbon dioxide emissions. Sales of diesel engines and lean-burn technologies in high volumes are not feasible in the United States, however, without some adjustments to forthcoming requirements for nitrogen oxide emissions under U.S. clean air rules.

Electric drive technology is the foundation for all advanced vehicle technologies, including battery, hybrid electric, and fuel cell vehicles. GM introduced a battery electric concept car in 1990, the first modern, production electric vehicle in 1996, an electric pick-up truck in 1997, and a second-generation electric drive vehicle in 1999 that is half the size and cost of its predecessor.

Hybrid technologies can improve energy efficiency and lower emissions without sacrificing the vehicle performance consumers expect. GM's Precept, developed as part of the former public-private research Partnership for a New Generation of Vehicles, employs a four-wheel drive parallel hybrid diesel propulsion system. The Precept met the program's fuel-economy target of 80 mpg. The Precept uses lightweight components such as carbon fiber bumper impact beams, and weighs only 2,600 pounds. It has zero drag brakes and is the world's most aerodynamic vehicle. The Precept is not an affordable vehicle, but the technological advances in this vehicle are critical to the development of future advanced technology vehicles that are commercially viable.

GM's hybrid system for commercial applications is already in service on urban transit buses in California. It is estimated that replacing the 13,000 metro buses in service in the nine largest cities in the United States with hybrid systems would save as much fuel as 500,000 small hybrid electric cars. GM will also offer a hybrid system as an option on a 2004 model year full size pickup truck in 2003.

Hydrogen is expected to be the fuel of choice for the long term. Fuel cell vehicles fueled by hydrogen are more than twice as energy efficient as internal

combustion engines and produce zero emissions – only heat and water leave the tailpipe. Fuel cell vehicles can also provide distributed electric power to homes and worksites.

The fuel cell supplies electricity to an electric motor that powers the wheels. It produces electricity by stripping electrons from hydrogen that passes through a membrane, combines with oxygen and forms water. The transition to a hydrogen economy may be led by on-board reformulation of gasoline, which utilizes the existing re-fueling infrastructure.

GM introduced the AUTOmomy concept fuel cell vehicle at the Detroit Auto Show on January 7, 2002. The AUTOmomy combines a hydrogen fuel cell with drive-by-wire technology that eliminates the need for steering columns, foot pedals and many other mechanical systems and components.

All of the propulsion and control systems, including the fuel cell stack and hydrogen storage system, are packaged within a six-inch thick skateboard-like chassis. Customized and even multiple bodies, freed from traditional design constraints, can then be coupled to this universal chassis.

The AUTOmomy provides substantial benefits for consumers as well as for the environment. The vehicle can provide greater flexibility, convenience and passenger comfort. The vehicle lasts longer and requires less maintenance, oils and fluids. The stiff chassis, absence of steering columns and pedals, and the low center of gravity provide greater safety. Decoupling the universal chassis from the body increases manufacturing efficiency, making an affordable all-wheel drive vehicle possible.

Larry Burns, GM's Vice President for Research and Development and Planning, summed it up this way; "AUTOmomy is more than just a hot new concept car, it's the beginning of a revolution in how automobiles are designed, built and used. If our vision of the future is correct – and we think it is – vehicles such as AUTOmomy will ultimately reinvent the automobile and our entire industry."

A hydrogen vehicle such as the AUTOmomy has great potential benefits, but also poses a number of significant technical challenges. On-board hydrogen storage requires a completely new type of fuel tank that can store enough hydrogen for

normal driving ranges. A second challenge is clean and efficient methods of producing hydrogen. Hydrogen is an energy carrier, not a source. It takes energy, ideally from a renewable source, to release hydrogen. A third critical issue is the need for a hydrogen re-fueling infrastructure. Affordability is also a major challenge that must be overcome to produce commercially viable fuel cell vehicles.

General Motors, Ford, Chrysler and the U.S. Department of Energy have entered a new public-private research partnership – FreedomCAR – to address these challenges and accelerate the development of fuel cell vehicles and the necessary hydrogen infrastructure. FreedomCAR replaces the former Partnership for a New Generation Vehicle that was focused on developing hybrid vehicles.

GM has a company-wide effort to find innovative ways to reduce its energy bill and its greenhouse gas emissions from its plants. In 2000, GM produced 9.8 million metric tons of CO₂ from its operations in the United States, down 14.6 percent from 1990 levels, and down 15 percent on a per-vehicle-produced basis.

The GM plant in Orion Township, Michigan provides an example of an innovative way to reduce emissions. This plant lies between two public landfills that produce large amounts of methane gas. The Orion plant is now recovering methane from the landfills that was vented into the air and using it as a source of power for its boilers.

Summary and Conclusions

The development, commercialization, and global diffusion of advanced technology is the key to responding effectively to concerns about climate change. It is certainly the key in the motor vehicle industry that is investing heavily in advanced technology vehicles. Technological innovation is at the core of both the success of the twentieth century and the promise of the twenty-first. It is easy to exaggerate its importance in the short term, but difficult to overestimate it in the long term. And the technological potential in the United States has never been greater. Exciting new technologies are on the horizon in every sector of the economy from smart buildings to smart ships to smart automobiles and smart highways to drive them on. Public policy for addressing concerns about global climate change should be inspired by this enormous technological potential.

The focus of U.S. climate change policy on market incentives, flexibility, science, and on unleashing the innovative spirit is thus cause for great optimism. We do not need to choose between the environment and the economy if what comes next are policies and actions, such as those outlined here, that will turn the promise of technology into reality.