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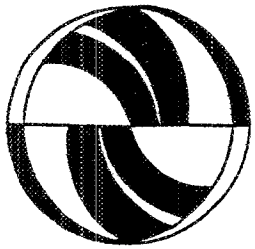

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Daniel Sperling

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The University of California
Transportation Center

University of California
Berkeley, CA 94720

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DANIEL SPERLING

# Rethinking the Car of the Future

*The government-industry partnership to develop a revolutionary fuel-efficient vehicle is in need of a midcourse correction.*

On September 29, 1993, President Clinton and the chief executive officers of Ford, Chrysler, and General Motors (the "Big Three") announced the creation of what was to become known as the Partnership for a New Generation of Vehicles (PNGV). The primary goal of the partnership was to develop a vehicle that achieves up to three times the fuel economy of today's cars—about 80 miles per gallon (mpg)—with no sacrifice in performance, size, cost, emissions, or safety The project would cost a billion dollars or more, split fifty-fifty between government and industry over a 10-year period. Engineers were to select the most promising technologies by 1997, create a concept prototype by 2000, and build a production prototype by 2004

As the first deadline approaches, PNGV shows signs of falling short of its ambitious goals Little new funding has been devoted to the project More important, the organizational structure that seemed appropriate in 1993—its design goals, deadlines, and funding strategies—may prove to be counterproductive The program designed to accelerate the commercialization of revolutionary new technologies has focused instead on incremental refinement of technologies that are relatively familiar and not particularly beneficial for the environment

Major adjustments are needed in order to realize the full potential of this partnership. A reformed PNGV would be capable of efficiently directing funds toward the most promising technologies, the most aggressive companies, and the most innovative research centers. Now is the time to update the program by incorporating the lessons learned during its first few years

## The politics of partnership

A confluence of circumstances drew government and industry together into this historic partnership

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In addition to the political benefits of forging a closer relationship with the automotive industry, the Clinton administration saw an opportunity to provide a new mission for the nation's energy and weapons laboratories and sagging defense industry And, at Vice President Gore's instigation, it saw a means to strengthen its public commitment to environmentalism.

The auto industry was motivated in part by the promise of financial support for long-term and basic research In addition, according to press reports, the three major automakers hoped that by embracing the ambitious fuel economy goal, they might avoid more stringent and (in their view) overly intrusive government mandates: in particular, the national Corporate Average Fuel Economy (CAFE) standards and the Zero Emission Vehicle (ZEV) mandate that had recently been adopted in California, New York, and Massachusetts. They looked to PNGV to spur the development of so-called leapfrog technologies that would make incremental fuel economy standards and battery-powered electric vehicles superfluous

An overarching objective for both parties was to forge a more positive relationship. Inspired by the Japanese model, they sought the opportunity to transform a contentious regulatory relationship into a productive partnership In the words of a senior government official, "We're trying to replace lawyers with engineers"

Both parties were also aware that the U S automobile industry risks ceding global leadership if it fails to meet the anticipated demand for efficient, environmentally benign vehicles Automobile ownership has escalated worldwide from 50 million vehicles in 1950 to 500 million vehicles in 1990 and is expected to continue increasing at this rate into the foreseeable future At the same time, growing concern about air quality and greenhouse gas emissions has led a number of cities to take measures such as restricting automobile use In response, a number of automakers have begun to develop cleaner, more efficient vehicles Hybrid vehicles combining internal combustion engines with electric drive lines have been developed by a handful of foreign automakers and Toyota and Daimler-Benz have unveiled prototypes of fuel cell cars in the past year.

The automotive industry appears to be on the threshold of a technological revolution that promises rapid improvements in energy efficiency as well as reductions in greenhouse gas emissions and pollution U S companies will have to make major changes if they expect to gain a piece of the potentially huge international market for environmentally benign vehicles This transformation can be accomplished only with government involvement, in part because individual consumers are perceived as unwilling to pay higher prices for cleaner, more efficient cars In a joint statement to Congress in July 1996, the Big Three said, "Although the market does not presently demand high fuel-efficiency vehicles, we believe that PNGV research goals are clearly in the public's broad interest and should be developed as part of a mutual industry-government commitment to environmental stewardship"

Despite such lofty proclamations, the government's anticipated financial commitment to PNGV never materialized—a casualty of the growing federal budget deficit and the election of a Republican Congress in 1994 In the partnership's first year, the federal government awarded only about $30 million in new PNGV-related funds Indeed, only aggressive behind-the-scenes lobbying by the Big Three automakers managed to save PNGV funding Instead, PNGV has become an umbrella for a variety of existing programs, including about $250 million in hybrid-vehicle research already in place at Ford and General Motors (GM) Most of the government support is in the form of basic research grants only indirectly related to vehicles that was awarded before the advent of PNGV and administered by the National Science Foundation, the National Aeronautics and Space Administration, and other agencies

With modest funding have come modest accomplishments PNGV has eased somewhat the adversarial relationship between automakers and regulators it may have helped the Big Three close a gap with European companies in advanced diesel technology, and it stimulated some advances in fuel cell technologies. For the most part, however, the accomplishments attributed to PNGV, such as those featured in a glossy brochure it published in July of 1996 appear to be the results of prior efforts by the Big Three and their suppliers For instance, the brochure features GM's EV1 electric car, unveiled as the Impact prototype in 1990, and hybrid vehicle designs that were also funded before PNGV

## Problematic goals

PNGV has three fundamental problems First are the project's design goals to build an affordable, family-style car with performance equivalent to that of today's vehicles and emissions levels that meet the standards planned for 2004 Each of these goals—affordability, performance, and reduced emissions—is defined and pursued in a way that effectively pushes the most environmentally promising and energy-efficient technologies aside

Take affordability New technologies are almost never introduced in mainstream products such as family cars; they nearly always enter in products at the upper end of the market such as luxury cars By pegging affordability to the middle of the market. PNGV managers are, intentionally or unintentionally, discouraging investment in technologies that are not already approaching commercial viability.

Similarly, PNGV defines equivalent performance in terms of driving range per tank of fuel This requirement is intended to ensure that the vehicle is suitable for the mass market Recent evidence indicates, however, that for a substantial segment of the U.S. car-buying public, limited driving range might be a minor factor in the decision to purchase a vehicle. More than 70 percent of new light-duty vehicles in the United States are purchased by households owning two or more vehicles A limited-range vehicle can be readily incorporated into many of these household fleets Market research at the University of California—Davis estimates that limited-range (less than 180 kilometers per tank) vehicles could make up perhaps a third of all light-duty vehicles sold in the United States, even if they cost somewhat more than comparable gasoline cars

PNGV's range requirement directs R&D away from some innovative technologies and designs that are highly promising from an energy and environmental perspective These include pure electric cars that use ultracapacitors and batteries. certain hybridized combinations of internal combustion engines and electric drivelines. and environmentally friendly versions of small safe vehicles such as the Smart "Swatchmobile" of Mercedes-Benz.

The emissions goal is equally problematic. but the problem is a different one The standard is too lax The national vehicle emissions standards planned for 2004 (known as "tier 2") are less stringent than those already being implemented in California and far less stringent than California's proposed "Equivalent zero-emission vehicle" standards If history provides any lesson, it is that the California standards will soon be adopted nationwide. the Environmental Protection Agency has consistently followed California's lead

Taking advantage of PNGV's unambitious emissions requirement, automotive managers and engineers have indicated that they almost certainly will select the most-polluting technology in the PNGV tool box as the platform for the concept prototype This is a diesel-electric hybrid. a direct-injected diesel engine, combined with an electric driveline and a small battery pack

Diesel-electric hybrid technology represents only a modest technological step. The automotive industry is already well along in developing advanced diesel engines, similar to what PNGV envisions, for the European market. Production prototypes using hybridized diesel and gasoline engines have already been unveiled by several foreign automakers, including Audi, Daihatsu, Isuzu, Mitsubishi and Toyota. In fact, Toyota reportedly intends to start selling tens of thousands of hybrid vehicles to the U S. market in late 1997

Because this hybrid-vehicle technology is relatively well developed, it would be easy to build a concept prototype within the PNGV time frame In addition, these engines achieve relatively high fuel economy (though probably far short of a tripling) However, diesel engines inherently produce high levels of nitrogen oxide and particulate emissions. the most troublesome air pollutants plaguing our cities Because lax emissions goals permit this choice. other more environmentally promising technologies such as fuel cells, compact hydrogen storage, ultracapacitors, and electric drivelines hybridized with innovative low-emitting engines, run the risk of being pushed aside

Big Three automotive engineers argue that the advanced direct-injection diesel engines they are contemplating are far different from today's diesel engines and that significant emission improvements are possible, but it is uncertain whether such engines could ever meet today's national emission standards much less the tier 2 standards or California's tighter "ultra-low" emission standards. They will never match the emissions of fuel cells and advanced hy

brid vehicles that use nondiesel engines Given the ground rules established in 1993, PNGV managers are behaving rationally But are the rules rational, given that this program is the centerpiece of advanced U.S. automotive R&D?

### Deadline pressures

The second major problem with PNGV is the procedural requirement that the technology to be used in the 2004 production prototypes must be selected by the end of 1997 At first glance this requirement seems reasonable It ensures that industry will stay on track to meet subsequent deadlines But the actual effect may be to thwart the development of more advanced technology Because the deadline is approaching rapidly, PNGV managers are put in the awkward position of having to favor incrementalism over leapfrogging. They find it safer to choose a prototype they know can be built but that falls short of the 80 mpg goal (that is, the diesel-electric hybrid) than to pursue technologies such as fuel cells that are less developed but environmentally superior.

PNGV managers insist that the Big Three will select more than one technology in 1997 and that they will not abandon fuel cells and other potentially revolutionary technologies. The reality, though, is that the limited funds and the looming requirement for a concept prototype in 2000 will most likely cause automakers and government agencies to concentrate their efforts on a single powertrain design, diesel-electric

The third fundamental problem with PNGV is its funding strategy. Rob Chapman, the government's technical chairman of PNGV, testified to Congress on July 30, 1996, that of the approximately $293 million per year that the government is spending on PNGV-related research, about a third goes to the federal labs, a third directly to automotive suppliers, and a third to the Big Three.

This breakdown greatly understates the real role of the Big Three Most of that $293 million is administered through a variety of programs that have only indirect relevance to automotive applications Only about $70 million is targeted directly at PNGV's primary goal of achieving a highly fuel-efficient vehicle. The vast majority of this $70 million has gone to the Big Three. The Big Three also control, directly and indirectly, a substantial share of lab funding. For instance, until mid-1996, government funding of fuel cell research at Los Alamos National Laboratory was administered through a subcontract from GM

At first glance, it seems logical to let the Big Three play a leading role in designing the R&D agenda. After all, they are likely to be the ultimate users of PNGV-type technologies But for a variety of reasons, it is in the public interest to downplay their role in government R&D programs.

First of all, most innovation in advanced technologies is now being conducted outside the Big Three, who increasingly rely on suppliers to develop and manufacture components The leading designer of vehicular fuel cells, for instance, is Ballard Power Systems, a tiny $20-million company located in Vancouver The shift toward new technologies (batteries, fuel cells, electric drivelines, flywheels, and ultracapacitors) with which today's automakers have little expertise, will accelerate the trend toward outsourcing technology development and supply It is not surprising that three-fourths of all PNGV funding sent to the Big Three is being subcontracted to suppliers.

Not only do the Big Three lack expertise in advanced PNGV-type technologies, they also have little incentive to bring significantly cleaner and more efficient technology to market Fuel prices are low and CAFE standards frozen, there are no carrots and only a politically uncertain ZEV mandate as a stick. Indeed, companies routinely delay commercialization of significant emissions and energy improvements for fear that regulators will codify those improvements in more aggressive technology-forcing rules (This attitude is exemplified by GM's former CEO, Roger Smith, who rhetorically asked at the end of his 1990 press conference announcing the Impact electric car prototype, 'You guys aren't going to make us build that car, are you?")

Understandably, the leading companies in this mature industry are reluctant to aggressively pursue the very technologies that will render much of their physical and human capital obsolete The automobile manufacturers of the future will need to work with an entirely new set of high-technology supplier companies, as they shift to composite materials, the absence of economies of scale will cause them to forgo mass production in favor of smaller-scale, decentralized manufacturing, and as vehicles become both more reliable and more specialized, they will need to overhaul their marketing and distribution systems Be-

cause the $70 million or so in annual PNGV funding amounts to only 0.5 percent of the Big Three's $15 billion annual R&D budget, it is unlikely to provide sufficient motivation for them to embrace these changes.

A more effective strategy would be to provide government R&D funds for advanced technology directly to technology-supplier companies, with smaller amounts awarded to universities and independent research centers. In fact, this is the approach PNGV is beginning to pursue with its fuel cell program. Although the Department of Energy (DOE) initially awarded contracts multiyear contracts for fuel cell research to each of the Big Three companies, it soon became apparent that this was an inefficient use of funds. Nearly all of the research in each of the three separate programs was carried out by subcontractors, meanwhile, the extra layer of management consumed a large share of the funds. As a result, DOE and the Big Three jointly agreed that when the current contracts expire in 1997, it will open the bidding to fuel cell developers. The Big Three will monitor the activities of the fuel cell developers but will not be the prime contractors nor receive any government funds. The fuel cell companies will then be able to sell to any or all of the Big Three or any other automaker. By funding the fuel cell companies directly, DOE hopes to spur competition, speed innovation, and improve efficiency as those companies achieve greater economies of scale. The fuel cell program demonstrates the kind of partnership that provides a framework for efficiently accelerating technology development and should serve as a model for PNGV as a whole.

*The fundamental flaw in PNGV is that it was designed to pursue long-term technologies in a near-term time frame.*

## More productive partnerships

The fundamental flaw in PNGV is that it was designed to pursue long-term technologies in a near-term time frame. This has forced it to focus on technologies that are already close to commercialization. But the technologies that are closest to commercialization are least suited to government-industry partnerships, because companies do not want to share innovations that might be central to their future prospects. This near-term technology focus is especially problematic for partnerships involving huge industrial corporations, whose aggressive political agenda is driven by the interests of their shareholders. In cases where there are large market externalities, such as the costs and benefits of cleaner, more efficient technologies, shareholder interests probably do not match the public interest.

If PNGV continues along its current path, it will likely direct funds toward neither the right technologies nor the right organizations. Major changes are needed if it is to foster the rapid commercialization of clean and efficient vehicle technologies. More government funding would certainly help. But equally important are fundamental changes in the design and organization of PNGV and how government uses and awards its funds. Here are four recommendations for making PNGV more effective.

Impose more stringent emissions requirements and less stringent performance requirements. Renew the program's emphasis on cleaner and more promising long-term technologies by aiming for emissions levels more stringent than California's current "ultra-low" standard and by encouraging engineers to design very efficient, clean, limited-range vehicles.

Remove the 1997 deadline but preserve the 2004 deadline. Engineers need more time to explore, test, and design the most promising technologies. If forced to choose in 1997, they will likely discard the riskier but more promising options. Relaxing the 1997 deadline should not preclude meeting the 2004 deadline.

Direct all PNGV funding to independent technology companies and research centers. Eliminating management and contracting oversight from the Big Three will leave suppliers with more funds and allow them to determine the best way to disseminate and commercialize new technologies, whether through joint ventures, licensing, or go-it-alone manufacturing. Government funds are not needed to elicit Big Three participation, they will surely be willing to monitor the research and provide vehicle-integration advice in order to benefit from early access to new

technology Foreign automakers with a significant domestic presence could also be involved in this process if they make the commitment to manufacture the technology in the United States

Funding of independent research centers and universities would provide a benchmark that regulators and funders can use to evaluate the major automotive companies' progress in adopting new technologies In addition, university research can help to train tomorrow's automotive industry workforce

Eliminate all but the most advanced technologies from PNGV. An industry-government partnership will function most effectively only if the technologies being developed are far from commercialization. The federal government should create an independent expert panel to determine which technologies should be included in PNGV Fuel cells, for example, should be included, incremental improvements in gasoline and diesel engines, or even in electric hybrid vehicles, should not The panel can decide whether to include technologies such as lightweight materials, flywheels, ultracapacitors, and hybrid vehicles with nonconventional engines (such as gas turbines and Stirling engines)

*An industry-government partnership will function most effectively only if the technologies being developed are far from commercialization.*

It is with some reluctance that I criticize PNGV, for I am firmly convinced that advanced vehicle technologies can and will play a leading role in preserving the environment Moreover, I believe that the country would benefit from considerably greater public support of advanced automotive R&D But if PNGV cannot be reformed in accord with the kinds of changes suggested here, perhaps it should be allowed to die a peaceful death On the other hand, if changes are made, then the argument for substantial increases in PNGV funding becomes more compelling

*Recommended reading*

National Research Council, *Review of the Research Program of the Partnership for a New Generation of Vehicles, Second Report* Washington, D C. National Academy Press, 1996

Daniel Sperling, *Future Drive: Electric Vehicles and Sustainable Transportation* Washington, D C Island Press, 1996

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