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Hearing on
Plug-in Hybrid Electric Vehicles

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Introductory remarks. Madame Chairwoman, Representative Honda, and Members of the Subcommittee, it is my pleasure to submit this written testimony in support of my more brief oral testimony concerning plug-in hybrid electric vehicles. I respond to the questions posed in your letter of invitation and provide requested discussion of a draft of the bill "Plug-in Hybrid Electric Vehicle Act of 2006." I believe that my comments on the discussion draft bill will be more clearly understood if they come after my responses to the questions. Note that the substance of my answers to the questions was developed before I saw the draft legislation.

1. What major research, development, and demonstration (RD&D) work remains on plug-in hybrid electric vehicle technologies? How should this work be prioritized?

In recent presentations at meetings organized by the Society of Automotive Engineers in January and May, I included very similar lists of major research needs, without providing an explicit priority ordering. However, it was not a coincidence that lithium ion battery research and development was first on the list. In my latest presentation, I listed lithium-ion battery cost, longevity, and safety as the key priorities.

Concerning the setting of priorities, I participated in the May 4-5 *Workshop on Plug-in Hybrid Electric Vehicles* at the Department of Energy. This workshop's purpose was to provide expert guidance to DOE on the priorities for the planned plug-in hybrid research program. Before that workshop a "Discussion Issues and Questions" paper was circulated to participants to stimulate discussion. I enclose that document as supporting

written testimony. Although results of that workshop remain to be documented, I think the consensus view of participants was that plug-in hybrids belong in the research portfolio of the federal government and Department of Energy. I also anticipate that the well-chosen national and international experts will provide excellent guidance on research priorities.

I am confident enough about the potential of plug-in hybrid technology to recommend that Congress and DOE make a long-term commitment to research and development of lithium-ion battery chemistry R&D in particular, and energy storage in general, with a focus on needs of plug-in hybrids. I am also optimistic that the workshop participants will agree with my opinion that a second high priority is the conduct of a comprehensive assessment to determine where plug-in hybrid technology should be in the current RD&D portfolio of federally supported advanced 21st Century transportation powertrain and fuel options. Included in this assessment must be an examination of continuation along the present path. Costs and environmental effects of such options as oil shale, coal-to-liquids, natural-gas-to-liquids, heavy oil, deepwater oil, and arctic oil should be compared with those of improved conventional powertrains, hybrids, plug-in hybrids, and fuel cell hybrids. Ethanol and hydrogen should be evaluated as possible fuels for any of these powertain options.

In my professional judgment "demonstration" is a very important part of RD&D. Sustained, *but steadily declining* real subsidies for critical technologies are very valuable in creating a "learning-by-doing" cost reduction path that cannot be obtained any other way. I believe that plug-in hybrids should remain on the nation's list of critical transportation energy technologies for a long while. In effect, what government researchers think of as "demonstration" is often in reality the proper handing over of research and development to the private sector.

2. What are the largest obstacles facing the widespread commercial application of plug-in hybrid electric vehicles and what steps need to be taken to address these hurdles? (batteries, infrastructure, consumer preference, automotive inertia, cost-competitiveness, etc.)

Batteries. I quote the aforementioned white paper "battery technology could be a show-stopper for plug-in hybrids." In fact, value to the customer is the crucial hurdle. Lithium-ion batteries have swept past nickel metal hydride battery technology in consumer electronics. This could happen in hybrid vehicles, but the challenges are great. Lithium-ion is clearly superior to nickel metal hydride in terms of gravimetric and volumetric specific energy and specific power, features that have allowed the packs to be "dropped into" spaces developed for less-capable batteries and thereby enhance value to the consumer by extending operating time. "Time is money" as they say, so even though the cost per unit of energy stored ($/kWh) is presently higher for lithium-ion than nickel metal hydride, it is the runaway winner in consumer electronics. For plug-in hybrids, optimism about lithium-ion competing with nickel metal hydride batteries arises in part because the costs per unit of energy of nickel metal hydride batteries have gone up, as a result of rising materials costs. Switching battery chemistry because of increasing battery cost is not the way to build a quick mass market for hybrids, but may get potentially more

attractive long-term battery chemistry into the plug-in hybrid market, which would be beneficial.

Cost-competitiveness. The fundamental battery discoveries that enabled today's hybrids were achievement of specific power and longevity far in excess of the expectations of all battery experts that we surveyed in the mid-1990s. Further, the parallel hybrid powertrain allowed effective use of much less electric energy storage for hybrids than the 1990s experts anticipated. Effective use of very small amounts of energy allowed a narrow state-of-charge swing, which allows battery life to be extended dramatically. The experts we surveyed had anticipated a series hybrid powertrain that would cost more than an electric vehicle. Instead, the technology commercialized by the Japanese that succeeded was a parallel hybrid powertrain that costs far less than a comparable electric vehicle, and also costs less than a series hybrid. This commercial hybrid succeeds economically in part because there is no attempt to make the electric drive suitable for all-electric operation serving universal customer needs.

Consumer acceptance. Therein are problems limiting consumer acceptance of the plug-in hybrid. Adaptation of current parallel hybrids will not allow consumers to drive all-electrically with performance suitable for universal use. The need to fully deplete batteries should reduce battery life relative to conventional hybrids. Top all-electric operations speeds would not match required current urban and highway test speeds. There are multiple ways to deal with these limitations, too numerous to mention here. All will add cost, but if adopted successfully could add significant consumer value and marketability to a plug-in hybrid concept.

Nevertheless, a key question is whether we should ever expect or require a plug-in hybrid to operate all-electrically on our current test cycles. It may be far more cost effective to recognize that we cannot afford this capability and develop new test cycles legitimate for a totally new kind of vehicle. Test cycles are, after all, a reflection of the behavior of the technology being tested. If a combination of attributes of plug-in hybrids can be found that makes consumers more satisfied, then regulations and legislation should be adapted to allow this satisfaction to be realized.

In the short-run, DaimlerChrysler is not attempting to make its plug-in hybrid Sprinter serve all needs when operating all-electrically. Selection of the plug-in option by customers using all-electric operation in slow stop-and-go driving may create a profitable niche market.

An alternative battery charge depletion strategy. DaimlerChrysler and the Electric Power Research Institute also plan to evaluate intermittent electric operation with charge depletion, which would allow electricity to replace gasoline or diesel fuel use without sacrifice in vehicle performance. But this option cannot be guaranteed to provide the extremely low emissions that California Air Resources Board (CARB) regulators originally hoped for when creating its first emissions credit system for plug-in hybrids required to operate continuously in all-electric mode for 20 miles or more. Note that CARB has since modified the credit system to allow plug-in hybrids with 10 miles of all-

electric range on the city test cycle to obtain credits. A sliding scale of increasing credits as range increases remains in CARB's plug-in credit system. I recommend a sliding scale of grants increasing with range in the draft legislation.

For the nation as a whole, where all-electric operation may seldom be needed for air quality purposes (many hybrids are already among the cleanest light duty vehicles), charge depletion with intermittent engine operation might be the most attractive approach to consumers. Such hybrids would still have to have emissions as low as for conventional vehicles. Charge depletion with intermittent engine operation could be implemented in places and at times when emissions would be low enough to cause no air quality deterioration.

Infrastructure. Infrastructure is adequate to support a far larger market penetration of plug-in hybrids than is likely to be seen for decades. Interim reports from ongoing analyses by colleagues at Argonne National Laboratory, the National Renewable Energy Laboratory, Pacific Northwest National Laboratory and the Electric Power Research are all highly supportive of the argument that the electric infrastructure — both powerplants and grid — is adequate on a national average basis to serve any plausible plug-in hybrid market for many years. There are likely some regional exceptions, but not many. Avoiding charging at times when the grid is at peak load is important, but I am confident that creative minds will readily determine how to avoid charging at critical times and places. I am also confident that such restrictions will prove quantitatively paltry relative to annual hours of charging and operation of plug in hybrids and to total national electricity generation.

To enable any automakers to take advantage of the capability of our infrastructure we need to develop economically legitimate model off-peak incentive rate structures and encourage utilities and Public Utilities Commissions across the nation to adopt such rates. This is a critical path item that should be done as rapidly as possible; to assure automakers that the national power generation and distribution industry does support the introduction of plug-in hybrids. Commitment to retention of the rate structures for a long period is highly desirable.

Automotive inertia. In my opinion, under the current fuel price environment, and given the level of political as well as geological uncertainty about availability of oil supplies, automotive inertia is no longer the primary problem constraining the development of plug-in hybrids. Time and scarce resources are now a problem. For U.S. motor vehicle manufacturers, the traditional preference of consumers for large vehicles means that a shift in oil and gasoline prices has a larger effect on U.S. producers than on vehicle manufacturers in competing nations. Losses of market share for large domestically produced vehicles occur at the same time that investment in production of more fuel efficient technology becomes increasingly desirable to U.S. consumers. This puts U.S. producers in a bind with respect to profitability and capability to develop new technology, even if they are willing.

Because of limited resources, it seems likely that U.S. automakers will be less likely to develop a plug-in hybrid in new purpose-built platforms such as the Prius. Instead, if trying to get a plug-in hybrid vehicle to market promptly, they would be likely to try to adapt the coming full hybrid powertrains and a vehicle containing them. DaimlerChrysler is adapting an existing vehicle platform's powertrain its plug-in Sprinter program. Adapting existing vehicle models implies limitations on battery space and all-electric range that could be provided. One recent paper study by Siemens implied that a lithium ion battery pack option in place of a nickel metal hydride pack could lead to a hybrid with between 10 and 20 miles of all-electric range, which is comparable to the expectations for the plug-in Sprinter. Such a capability would be consistent with adoption of cheap 120V overnight charging, with little or no modification of the wiring in most modern houses, at least for the first plug-in hybrid in the household. Promotional information on a SAAB hybrid show-vehicle indicated that if a breakthrough in lithium-ion batteries were achieved in the next few years, their vehicle could use such a battery and operate all-electrically at speeds up to about 30 mph and travel 6-12 miles in all-electric mode under those conditions.

These are the kinds of plug-in hybrids that I would expect to initially emerge in the market. They may not pass the current California Air Resources Board's test to allow plug-in hybrid emissions credits, but they could offer many consumers in the United States the opportunity to decide whether they would like to have a capability to save gasoline by using electricity and perhaps drive to nearby destinations all-electrically.

Consistent with my professional judgment that demonstration in market niches is a critical path step to widespread market success for a technology, I am encouraged by the possibility that such plug-in hybrids produced by original equipment automakers will emerge within a few years. An obstacle would be for the government to try to alter this evolutionary path and push the industry to develop plug-in hybrids with so much range and/or all-electric operations capability that major redesigns of vehicle platforms would be required to accommodate large enough battery packs to comply, and/or powerful enough electric motors.

3. How does the federal government support the development of plug-in hybrid electric vehicle technologies? What can the federal government do to accelerate the development and deployment of plug-in hybrid electric vehicles?

The authorizations related to research on plug-in hybrids contained in the 2005 Energy Policy Act (EPACT05) are an excellent first step. Funds should be allocated to allow the work. Although I may be premature in saying this, since I'm a scientist committed to the value of peer review, I do believe that as mandated studies of plug-in hybrids called for in Section 705 are completed, the wisdom of focusing on plug-in hybrid vehicles will be strongly supported.

In trying to prepare summaries of ongoing activities by the federal government and private sector for the recent meeting at DOE, I have been very encouraged by the response to EPACT05. From my perspective as an analyst EPACT05 appears to have

caused a shift in thinking and priorities among the many key parties that must work cooperatively to make plug-in hybrids succeed. I have found the recent dialogue very valuable, in that it answers a lot of my questions and strengthens my opinion that this technology deserves a high priority in a portfolio of options to ensure that U.S. consumers continue to enjoy a high level of transportation services in the 21st Century, with far less environmental damage.

I believe that the studies that EPACT05 is promoting can be very valuable by illustrating the potential benefits of plug-in technology. In the white paper we mentioned that the enthusiasm for plug-in hybrids that caused the legislation in EPACT05 arises from promising implications for oil savings, greenhouse gas reductions, timely and well placed zero emissions capability, energy savings, improvement in electric utility system efficiency, and provision of emergency services. In my opinion, comprehensive confirmation and testing of existing and emerging estimates, with thorough peer review, will reassure the public, electric utilities, automakers, government employees, elected representatives and the scientific community that there is significant merit to steady, deliberate pursuit of success for this technology. Although the process is often slow, I have always been optimistic that careful technology assessment can result in the most desirable technologies, and eliminate those that lack merit.

Thus, I believe that Congress should allow RD&D to proceed for a while and then review the plug-in hybrid RD&D programs for a more detailed needs assessment, in light of the evolution of events (and battery technology) over the next few years.

I am concerned about EPACT05 Sec. 706 (b) (2). Requiring a minimum of 250 miles per gallon of petroleum consumption to provide funding for plug-in hybrid demonstrations could cause adversely affect RD&D. In my view, for near-term technology, the only way to meet this requirement would be for the plug-in hybrid to also be able to run primarily on ethanol, probably as E85.

Emissions with charge depletion and intermittent engine operation may involve difficulties for current hybrid emissions control systems running on gasoline, much less E85. Our experience with flex fuel gasoline/ethanol vehicles whose emissions control system was originally designed for gasoline was that when adapted for E85 they generally had higher emissions running on E85 than on gasoline. Thus, forcing plug-in hybrids to simultaneously develop an ability to use both electricity and E85 might create a major “show slowing” impediment to implementation, requiring far more costly emissions control and implementation delays. I would emphasize that a plug-in hybrid is a multi-fuel vehicle, even if it does not have the ability to run the engine on an alternative fuel. Further, for many years hence the E85 fueling capability of conventional powertrain flex-fuel vehicles already in and entering the market will greatly exceed the quantities of E85 available. Thus the EPACT Section 705 (b) (2) requirement satisfies no useful near-term commercialization need. In my opinion, this requirement should be repealed. I am pleased to see that this requirement does not carry over into the present draft of the Plug-In Hybrid Electric Vehicle Act of 2006.

4. Does the "Discussion Issues and Questions" paper address the most significant technical barriers to the widespread adoption of plug-in hybrid electric vehicles?

I believe that the "Discussion Issues and Questions" paper and the affiliated morning presentations did properly address the most significant technical and cost barriers, identified opportunities, and educated participants concerning important considerations outside their field of expertise. However, the reasons for the workshop were to assure that we had not missed anything, confirm that our best judgment was legitimate, and help set priorities among items on our list. Based on my recollection of the reports of the breakout sessions on May 5, the discussion paper did set the stage well, but a number of excellent comments and suggestions were developed by the experts, which will lead to desirable modifications and refinements.

5. If a standard ZEV range was needed to facilitate the commercial application of PHEVs, what would be the optimal ZEV range that would still allow users to meet their driving needs? What would be the likely impact on fuel economy and oil savings?

One point made at the DOE meeting is that there is no single ZEV range that will suit all consumers. The ideal range will vary by consumer, depending upon driving patterns. According to the Electric Power Resarch Institute's 2001 study *Comparing the Benefits and Impacts of Hybrid Electric Vehicle Options,* consumers with relatively short commutes would always prefer a plug-in hybrid with a relatively short all-electric range, while consumers that had a long commute became more interested in plug-in hybrids with a lot of all-electric range as the theoretical cost of the plug-in powertrains came down. Since batteries will probably always be relatively expensive, it will always be smart to only purchase as much electric range as you can use in everyday travel. So, just as consumers have a choice of engines in most vehicle models, the participants thought that consumers should be given options in battery size and electric range capability. In one trade-off analysis by scientists at the National Renewable Energy Laboratory, if a single range were picked, a range between 10 and 20 miles seemed most likely to be cost-effective to the largest number of consumers. If the range of the plug-in hybrid were 20 miles, then those who only needed 10 miles might not benefit. However, of those being able to use perhaps 15 miles or more, all were estimated to benefit from a plug-in hybrid with 20 miles of all-electric range.

Effects of plug-in hybrids on oil savings will depend dramatically on future oil prices and on regulatory priorities with regard to all-electric operation. Although the vehicles have so far been evaluated under the assumption of one or less charges per day, this perspective is too narrow. Possibly a more important question is what is the plausible range of electricity substitution for gasoline in the event of a range of gasoline prices? What is the degree of resilience of our economy that would be provided by the flexibility of consumers owning plug-in hybrids to shift from less than one charge per day to more than two per day? Could such an increase in charging frequency be accomplished with battery life remaining proportional to total energy throughput?

Oil Savings. The total national benefits depend on two interacting factors — how many vehicles can be sold, and once they are sold, how much oil each vehicle can save (a

variable quantity, as discussed in the prior paragraph). While plug-in hybrids with a lot of all-electric range could save more oil per vehicle than plug-in hybrids with only a small amount of electric range, we don't know if enough of the vehicles with a lot of range would be sold. The short term risks to the automobile industry of "jumping" to plug-in hybrids with a lot of all-electric range instead of making less-challenging adaptations of existing powertrains has not been evaluated in prior studies, but this would also be a factor to consider.

I believe we should start with plug-in hybrids with an "electric equivalent" range between 10 and 20 miles, try to learn to use them as cost-effectively as possible to reduce oil consumption, and hope that RD&D can lead to a steady sequence of battery improvements and cost reductions that allow platform changes to be planned in advance to take advantage of emerging battery improvements. Perhaps the number of electric range options available to customers in a single vehicle platform could thereby be expanded.

I am familiar with one idea that might nearly double the energy storage capability of a lithium-ion battery pack of a given amount of material, if successful. If such a development were to occur, we could nearly double the range of a plug-in hybrid model by simply switching to a new battery technology, with minimal adaptation of the vehicle. Admittedly, this may not happen, and it may be that the only way to extend range would be with physically larger batteries. Nevertheless, the possibility does illustrate that early emphasis on 10-20 miles of all-electric range may not be inconsistent with a long-term R&D effort whose goal is to achieve double that range.

6. How large an impact could PHEVs have in reducing oil consumption over the next 10 years?

7. How long will it take before we begin to see PHEVs in the marketplace?

The impact on oil consumption is unlikely to be large in the next decade because the plausible market share of *new* plug-in hybrids would be hard pressed to exceed 1-2% at the end of the next decade, with essentially no significant penetration early in the decade.

To help understand how long it takes for a more efficient, but significantly more costly vehicle to affect total fleet fuel consumption, consider hybrids. Hybrids, available for about a decade, have only reached a little over one percent of the *new* light duty vehicle market in 2005. At this rate, to reach 1% of the *total fleet* of cars on the road (the vehicle stock) would take nearly one more decade, at which time hybrids might reduce light duty vehicle oil consumption by about one third of one percent. Since light duty vehicle oil consumption is about half of total national oil consumption, this would be one sixth of one percent of national oil consumption.

However, since hybrids are expanding their share of the new light duty vehicle market, and since consumers drive new vehicles more miles per year, the reality will be better than this. Nevertheless, this discussion demonstrates limitations involved in turning over

the vehicle stock. Successfully penetrating the new vehicle market is the first step, but it takes several years of continued success to affect the entire fleet and its oil consumption.

EPACT05 calls for plug-in hybrid commercialization within five years. If the Prius history is used as a model, the first Prius factory produced 30,000 commercial vehicles per year in 1997. The 2004 Prius comes from a new factory that can produce well over 100,000 per year. It took over five years to "mass market" sales of Prius hybrids, after the first model was commercialized. Thus, the Prius path to commercialization implies at least a decade before a tiny fraction of national oil consumption reduction could result from plug-in hybrids. The point is that the process will be slow during a peaceful, deliberate expansion of the technology.

During a true international crisis with oil supplies restricted for long periods, the contributions could be far more significant. Though subject to verification in the market, it does appear that retrofit of a Prius to become a plug-in hybrid is possible. If research promoted by EPACT05 — or by private sector innovators — suggests that simple plug-in retrofits of several existing and coming hybrids would be possible, then an option would be to provide incentives for manufacturers to allow for such retrofits when they produce and sell hybrids, so that such retrofits could be accomplished in the event of a prolonged emergency, or — more optimistically — in the event of battery breakthroughs during the life of the vehicle.

Alternatively, if the plug-in option becomes "fashionable" to consumers for reasons other than just saving fuel, the technology could "take off" within the hybrid powertrain category. My opinion is that, *if* battery technology does improve enough, switching from a focus on hybrids to a focus on plug-in hybrids would be a far less daunting step than was switching from conventional powertrains to hybrids. Further, we must acknowledge that the sense of urgency about reducing oil use is greater now than in the 1990s when the Prius was developed, so the level of effort on plug-in hybrids across automobile manufacturers could be significantly greater in the next decade than for hybrids in the last.

Comments on the draft "Plug-in Hybrid Electric Vehicle Act of 2006"

While I have emphasized that a focus on lithium ion batteries is desirable, it is wise to allow administrative flexibility for energy storage research, as has been done in the legislation. This flexibility could be extended even further by deleting the word "electrochemical" in Sec. 2 (1), or substituting "electrical".

It is good that hybrid fuel cell vehicles are included. For Sec. 2 (a) (7) (A) I suggest "provides motive power by converting either liquid or gaseous fuel to power and/or uses electric power extracted from an on-board battery." I recommend this or a similar change to make it clear that a hybrid fuel cell vehicle capable of using hydrogen is included in the umbrella definition of a hybrid electric vehicle.

For Sec. 2 (a) (5) (B) I suggest "that uses a fuel cell and stored battery energy for motive power". It is fair to call this a flexible fuel vehicle because there are a number of possible original fuels from which hydrogen can be derived.

In Sec. 2 (a) (8) I suggest a bit of "word engineering" to allow the flexibility that I suggested is desirable in my prior answers to questions. Recall that CARB will now provide credit for 10 miles of all-electric range on the city cycle. If the types of plug-in hybrids I discussed are to be allowed under this bill's research umbrella, I suggest that a lesser range and less difficult driving cycle be allowed for. I recommend that you change "20 miles under city driving conditions" to "15 miles under most urban driving conditions". Note that average daily miles driven are about 30 miles. Based on EPRI's preferred estimate, if a plug-in hybrid with 15 miles of range were charged once a day, gasoline use would be reduced by 31%. This would be equivalent to a miles per gallon increase of 45%.

I like the sliding subsidy scale in Sec. 2 (d). Consistent with the argument that multiple plug-in hybrid ranges should ultimately be offered to consumers, I suggest a tiered subsidy. If we think about evolution from 15 to about 40 miles of range, it is likely that one would go from congested urban driving for the 15-25 mile range, to relatively free flowing, higher speed suburban cases with 40 miles of range. I expect that, as range goes up, top electric-only speed to cover usual trips would also increase. To illustrate, for the initial $10,000 per vehicle from 2007 to 2009, one might allow $3000 for a plug-in hybrid with 15 miles of urban range, $5000 for a plug-in with 20 miles of city test cycle range, and $8500 for a plug-in with 40 miles of highway test cycle range. If any of these vehicles were flex fuel vehicles the subsidy could be increased by $1500. This would allow an automaker to take advantage of up to $10,000 of subsidy per vehicle. If this idea were acceptable, then similar allocations could be made for remaining years.

Concerning the funding levels that are to be authorized if the draft bill becomes law, I note that if these funds were appropriated, expenditure on the plug-in program would be comparable to the President's Hydrogen Fuel Initiative. I also note that by including fuel cell hybrids the draft bill supports the Hydrogen Fuel Initiative and may enhance the odds of success of that program. I like the fact that the funds would do "double duty" providing another path away from oil dependence via plugging into the grid, for either combustion engine or fuel cell motive power. Our ongoing R&D on pathway energy use and greenhouse gases indicates that this may be a desirable combination even if hydrogen fuel cell breakthroughs are realized. There are some pathways where generation and use of electricity for a plug-in hybrid will be a better choice than producing hydrogen for a fuel cell, whether or not the plug-in hybrid uses a fuel cell or combustion engine.

It is quite difficult when attempting to cause technological breakthroughs to know the probability of success as a function of the amount of money assigned to the task. I defer to battery and electric drive experts with respect to judgment on how much money is necessary to cause needed breakthroughs. With regard to oil prices and energy security, concerns are greater today than when the hydrogen fuel initiative started, and the circumstance of domestic automobile manufacturing is more precarious. Due to a

scarcity of automaker resources and a greater national need, and due to a degree of optimism about plug-in-hybrids which started several years ago and which has increased significantly over the last several months, I am supportive of a very significant increase in funding for plug-in hybrid research, development and demonstration.

As I have stated, I believe that learning-by-doing is critical, so I support the grants provision.

It is possible that the allocation of funds might be better tilted toward production subsidies. $50,000,000 per year, if allocated at $10,000 per plug-in hybrid, would support only 5000 vehicles. On the other hand, if $3000 were to be adequate to create an incentive for a 15 mile hybrid suitable to run electrically for most urban driving, then one manufacturer's production run of about 17000 vehicles could garner the present draft's total subsidy for each vehicle produced. Most factories produce hundreds of thousands of vehicles, while the initial Prius factory produced 30,000 per year. So, if the intention is to cause multiple factories to produce plug-in hybrid powertrains, the incentives may not stretch far enough. One positive feature of incentives of this nature is that the government only has to pay them if vehicles are produced. If production capabilities with economies of scale are an intended outcome, I would suggest after 2010 that no manufacturer be allowed any subsidy unless a minimum of 10,000 plug-in hybrid powertrains were produced and sold per year. Total subsidies, which may need to be larger, could be allocated among all manufacturers meeting this criterion.

The first steps toward mass production of plug-in hybrids are likely to involve limited runs of prototype vehicles. In its Sprinter program, DaimlerChrysler intends to follow a sequence from less than five vehicles to 30, then hopefully large fleet tests, and finally commercialization. This process was anticipated to take four years. Thus, it might be desirable to alter the subsidy authorization schedule to allow for significantly higher per vehicle subsidies in the first four years for prototype vehicles produced in the dozens. You might consider subsidies as high as $100,000 per vehicle, up to a total of 50 vehicles per manufacturer from about 2007 to 2010. Thereafter, impose the 10,000 unit production volume requirement and a per vehicle maximum grant schedule similar to the present one for any further subsidy. This would be consistent with the Energy Policy Act goal of commercialization within five years.

Encl:

Workshop on Plug-in Hybrid Electric Vehicles: Discussion Issues and Questions. U.S. Department of Energy Plug-in Hybrid Workshop white paper, 4/28/06

Broad Overview of Plug-in Hybrids and Analytical Studies, presentation by D. Santini, 5/4/06

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Danilo Santini obtained his Ph.D in Urban Systems Engineering and Policy Analysis from Northwestern University in 1976, a Masters in Business and Economics from the Illinois Institute of Technology in 1972, and a Bachelor of Architecture from MIT in 1968. From 1968 to 1970 he taught Physics and Math at George Washington High School in the Kanawha County school district in West Virginia. He worked at three Architectural firms over the period 1963-72. He began working at Argonne National Laboratory in 1974. Dr. Santini was chair of the Chicago Chapter of the International Association of Energy Economists from 1985-86. From 1992-2004 Dr. Santini was section leader of the Technology Assessments section within the Center for Transportation Research at Argonne National Laboratory, and now is leader of the Technology Analysis section. He served as chair of the Alternative Fuels Committee of the National Research Council's Transportation Research Board from 1996-2002. In 2003 he was awarded the title senior economist. Since May of 2001 he has been the Department of Energy's primary technical representative for the U.S. to the International Energy Agency Implementing Agreement on Hybrid and Electric Vehicles. In 2003 he became a member of the American Transportation Research Institute's Research Advisory Committee. Dr. Santini has authored, co-authored or edited 150 articles, reports, and conference papers.