H.R. 5143, THE H–PRIZE ACT OF 2006

HEARING

BEFORE THE

COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES

ONE HUNDRED NINTH CONGRESS

SECOND SESSION

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H.R. 5143, THE H–PRIZE ACT OF 2006

THURSDAY, APRIL 27, 2006

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENVIRONMENT, TECHNOLOGY, AND STANDARDS,
COMMITTEE ON SCIENCE,
Washington, DC.

The Committee met, pursuant to call, at 9:30 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Sherwood L. Boehlert [Chairman of the Committee] presiding.

HEARING CHARTER

COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

H.R. 5143, the H–Prize Act of 2006

THURSDAY, APRIL 27, 2006
9:30 A.M.–11:30 A.M.
2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Thursday, April 27, 2006, the House Science Committee will hold a hearing on H.R. 5143, the *H–Prize Act of 2006.* The bill is intended to create a new incentive to achieve scientific and technical breakthroughs required to make the transition to a hydrogen economy.

2. Witnesses

Mr. Phillip Baxley is the President of Shell Hydrogen, L.L.C., a separate business unit established by Shell in 1999 to pursue new business opportunities in hydrogen fuel and fuel cells.

Dr. David Bodde is the Director of Innovation and Public Policy at Clemson University's International Center for Automotive Research (ICAR). He was a member of the National Academy of Engineering Committee on Alternatives and Strategies for Future Hydrogen Production and Use, which issued the 2004 report *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs.*

Dr. Peter Diamandis is the Chairman of the X Prize Foundation, a non-profit organization dedicated to fostering innovation through the use of competitions. The foundation awarded its $10 million Ansari X Prize to promote the formation of a commercial space flight industry. Prizes for genomics, energy and education are under development.

Dr. David L. Greene is a corporate fellow of Oak Ridge National Laboratory with the Center for Transportation Analysis, National Transportation Research Center. He is an expert in transportation and energy policy issues.

3. Overarching Questions

The hearing will address the following overarching questions:

1. Are any changes needed in H.R. 5143?
2. Does H.R. 5143 provide the right incentives to address the most significant technical barriers to the widespread use of hydrogen as a fuel source?
3. How can the Department of Energy (DOE) best use prize competitions to complement more traditional research support mechanisms, including contracts and grants, as a way to develop the hydrogen economy?

4. Brief Overview

On April 6, 2006, Research Subcommittee Chairman Bob Inglis; Science Committee Chairman Sherwood Boehlert; Environment, Technology and Standards Subcommittee Chairman Vernon Ehlers; Congressman Roscoe Bartlett; Congressman Michael McCaul; Congressman Daniel Lipinski; and nine other co-sponsors introduced H.R. 5143, the *H–Prize Act of 2006.*

Inspired by the successful Ansari X Prize, which awarded $10 million to Burt Rutan for sub-orbital space flight, the H–Prize is designed to accelerate the drive to a hydrogen economy by creating an incentive for new, entrepreneurial players to join the race to break down technical and other barriers to the advancement of hydrogen technologies.

The Science Committee, at the Administration's request, created a prize program for NASA in the *NASA Reauthorization Act of 2005.* The language of H.R. 5143 is largely based upon that of the NASA Act (P.L. 109–155).

A summary of H.R. 5143 and a section-by-section analysis are included in Part 7 of this charter.

Hydrogen gas is considered by many experts to be a promising fuel, particularly in the transportation sector. When used as a fuel, its only combustion byproduct is water vapor. The widespread adoption of hydrogen as a transportation fuel has the potential to reduce or eliminate air pollution generated by cars and trucks.[1]

However, unlike harvested wood or mined coal, the hydrogen gas used as a fuel is not a naturally occurring energy resource. Hydrogen must be produced from hydrogen-bearing compounds, like water or natural gas, and that requires energy—and, unlike gasoline, more energy is always required to produce it than is recovered when hydrogen is burned in a fuel cell. Hydrogen has the potential to reduce America's dependence on foreign oil, but the degree to which hydrogen will displace foreign energy supplies depends on what energy source is used to generate hydrogen gas in the first place.

If hydrogen can be produced economically from energy sources that do not release carbon dioxide into the atmosphere—from renewable sources such as wind power or solar power, from nuclear power, or possibly from coal with carbon sequestration, then the widespread use of hydrogen as a fuel could make a major contribution to reducing the emission of greenhouse gases.

While the promise of hydrogen is great, so are the technical challenges. Experts suggest that major advances will be required across a wide range of technologies for hydrogen to be affordable, safe, cleanly produced, and readily distributed. The production, storage, and use of hydrogen all present significant technical challenges. While DOE research programs have produced promising advances, those programs are still a long way from meeting their goals of developing economically viable hydrogen technologies. Indeed, the American Physical Society in a 2004 report stated that "no material exists today that can be used to construct a hydrogen fuel tank that can meet the consumer benchmarks," that is for affordably storing enough fuel on-board a car or truck to enable a long enough ride between refuelings.

5. Issues

What could be gained by establishing a prize program to promote advances in using hydrogen as a fuel?

Traditionally, DOE has relied upon established researchers in national labs, industry, and academia to carry out its mission of developing energy technologies for use by the private sector. Most commonly, DOE identifies a technical hurdle and then issues research solicitations of varying specificity. These solicitations detail the type of technologies the agency wants to fund and the performance goals the agency anticipates the technology will meet when introduced to the marketplace. For example, DOE might issue a solicitation for automotive fuel cell technologies. Such a solicitation may include the requirement that the fuel cells be a particular type of fuel cell, or may be targeted at known technical problems. Projects are then selected against the criteria set out in the original solicitation. DOE may use grants, cooperative agreements or contracts to carry out projects, and industrial participants are required to share costs.

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[1] The Science Committee and its Subcommittees have held numerous hearings on the use of hydrogen since the announcement of the FreedomCAR Initiative by then-Secretary of Energy Spencer Abraham on January 9, 2002. The FreedomCAR program was centered on fuel cell vehicles, which use hydrogen as fuel.

The Full Committee held the following hearings:

February 7, 2002—Full Committee Hearing on *The Future of DOE's Automotive Research Programs*

April 2, 2003—Full Committee Markup of H.R. 238, *Energy Research, Development, Demonstration, and Commercial Application Act of 2003*

March 5, 2003—Full Committee Hearing on *The Path to a Hydrogen Economy*

March 3, 2004—Full Committee Hearing on *Reviewing the Hydrogen Fuel and FreedomCAR Initiatives*

The Energy Subcommittee held the following hearings:

June 26, 2002—Subcommittee on Energy Hearing on *FreedomCar: Getting New Technology into the Marketplace*

June 24, 2002—Subcommittee on Energy Field Hearing on *Fuel Cells and the Hydrogen Future*

There was one hearing held jointly with the Energy Subcommittee and the Research Subcommittee:

July 20, 2005—Joint Hearing—Subcommittee on Energy and Subcommittee on Research—*Fueling the Future: On the Road to the Hydrogen Economy*

In addition, these programs were also subject to scrutiny during hearings on budget priorities and within the Administration's Climate Change Technology Program. Transcripts of these hearings are available on the Committee website or from the Congressional Research Service.

Prizes would presumably involve less direct DOE involvement in day-to-day research activities than would any of the traditional technology development routes. Instead, DOE would offer a prize for the development of a particular technology or for a particular achievement, and then would wait to see what contestants produced. Proponents of prizes argue that this would be less costly and less bureaucratic, and might spur more creative thinking. In addition, they argue that inventors and entrepreneurs (as opposed to national labs or major energy companies) would be more inclined to compete for a prize than compete for more traditional grants and contracts.

Proponents of prizes further argue that traditional peer review processes tend to favor proposals that seem safe over those that may produce surprising and potentially more innovative results. Many have commented—in a wide variety of contexts—that the federal procurement system can be intolerant of risk, and can place costly bureaucratic demands on private-sector contractors.

Other advocates cite prizes as having additional benefits. Prizes are seen as mobilizing much more private capital than matching grants, since numerous contestants all spend their own money on technology development while they vie for the same funds. (Traditional grant processes usually have at most a one-to-one funding match.) Prizes allow the Federal Government to shift much of the risk and the financial burden of technology development from the government to the contestants. For some, the most important aspect of prizes is their ability to educate, inspire, and mobilize the public for scientific, technological, and societal objectives.

How does a prize program need to be structured to be successful?

Prize contests can be less clear-cut than they first appear. Problems can develop in the design of the contest, the selection of a winner, and in the aftermath. A National Academy of Engineering (NAE) panel examining the use of prizes by federal agencies[2] suggested the following design principles for prize programs:

- Treatment of intellectual property resulting from prize contests should be properly aligned with the objectives and incentive structure of the prize contest.
- Contest rules should be seen as transparent, simple, fair, and unbiased.
- Prizes should be commensurate with the effort required and goals sought.

DOE would have to design its prize contests carefully. The goal for which the prize was being awarded would have to be clearly enough described that contestants (and DOE) had a firm sense of what DOE was seeking and why. On the other hand, too detailed a description by DOE would limit the kinds of ideas that a contest could yield. A very detailed description would not end up being much different than contract specifications.

The selection of a prize winner can also be difficult. Judges need to be open to unexpected ideas. There are historical examples of revolutionary ideas losing prize contests because the judges were not open to unexpected ways of achieving the stated goals.[3] Decisions also need to be made about who is allowed to compete for a prize. For example, H.R. 5143 does not allow federal employees to compete except on their own time. It is silent on whether entities receiving federal funding can compete. Should entities that are already receiving federal backing be able to compete for a federally funded prize?

The award of a prize does not guarantee, by itself, that the social benefits of the technology will be realized or that the technology will be commercialized. In the wake of the award of any prize, DOE would not be the entity to decide how to put a winning idea into actual use. A prize winner might not have the financial wherewithal or even the technical capacity to actually turn their winning idea into a viable product. It may therefore be necessary for DOE to take additional actions to promote technologies after the award of prizes.

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[2] *Concerning Federally Sponsored Inducement Prizes in Engineering and Science,* Steering Committee for the Workshop to Assess the Potential for Promoting Technological Advance Through Government-Sponsored Inducement Prizes in Engineering and Science, Washington, DC: National Academy of Engineering (1999).

[3] The best-selling book *Longitude* by Dava Sobel describes just such a case. John Harrison developed method for measuring exact longitude based upon a clock that kept time accurately even during a ship's pitching and rolling at sea. However, despite the proven test of his invention at sea, the group administering the prize (the Board of Longitude) refused to award him the prize money—which historians attribute to the Board's domination by astronomers who favored a rival, astronomy-based method of determining longitude.

Finally, it is unclear whether prizes would be a less costly way of doing business once all the costs DOE would have to incur in running a successful contest are taken into account.

How dependent upon prizes should DOE be for the development of critical technologies?

Prizes are being proposed as a supplement to, not a substitute for traditional R&D programs. Indeed, H.R. 5143 makes that point explicitly in the last section of the bill. Traditional programs are especially important if developing a specific technology on a specific timetable is critical to a DOE objective, such as development of a coal-fired power plant with zero carbon emissions. The timing of technology development may be easier to control through traditional solicitations and research awards.

What kinds of goals are appropriate for prize contests?

Prizes benefit from clear-cut goals. In general, the more complex the goal of a contest, the more complex DOE's role would likely be. (For example, evaluating a set of integrated technologies that radically change hydrogen distribution and use is a more demanding undertaking than evaluating the performance of a hydrogen storage tank.) At some point, the complexity might eliminate the advantage of a contest over traditional means of technology development. If appropriately designed, prize contests can reveal important information, particularly about the failures that emerge upon integration of subsystems, that can inform the plans and priorities of the Department's on-going hydrogen research program.

How large does a prize need to be to induce investment?

One of the key objectives of some prizes is to induce investment. Often, the prestige of having won the prize is seen as having greater value than the prize itself. Winning contestants, as in the Ansari X Prize, have been known to spend more in an effort to win a prize than they gained from the prize itself, and several contestants that did not win also invested. Thus, the prize level must be high enough to garner attention and prestige. But at the same time the prize amount must be realistic enough to be appropriated. Also, if there is a limited pool of potential contestants, even a large prize may not induce more investments.

6. Background

Prizes

There are two types of technology prizes: recognition and inducement prizes. Recognition prizes are post-facto prizes, intended to reward a past accomplishment. The Nobel Prizes are the most famous prizes of this type. Inducement prizes are awarded to an individual or group who has the best entry in a defined contest or who first meet some specified technical goal.

The NAE report specifically recommended that federal agencies experiment with inducement prizes. Among other things, inducement prizes may best serve "to 'stretch' the state of the art in technology." As an example, the Defense Advanced Research Projects Agency awarded $2 million in 2004 for its Grand Challenge Prize to Stanford University researchers for their design and construction of an autonomous ground vehicle that was able to navigate a 131.2 mile course through the Mojave Desert.

Typically, inducement prize contests are either best-entry contests or goal-oriented contests.

H.R. 5143 includes both types of prizes. In a best-entry contest, a prize is given for the best entry submitted during a given time period, even if the winning entry in a given year falls short of the ultimate technical objective. DOE's Solar Decathlon competition, held on the National Mall last summer, is a good example in the energy R&D arena. Decathlon teams must design and build fully-functioning houses powered exclusively by the sun.

By contrast, goal-oriented contests have a clear technical objective. The prize is awarded only if a pre-determined goal is met and verified. The $10 million Ansari X Prize was awarded in 2004 after SpaceShipOne, a privately built three-person craft, made a required second flight 62 miles (100 km) above the surface of the Earth within a two-week period. The ability to meet a bright-line technical objective does not necessarily guarantee economic viability.

Inducement Prizes can be divided further into four different types of objectives:

- *New or Best Invention* prizes reward the first new technology or technique that meets some technical objective. The Ansari X Prize falls in this category.

- *New Application* prizes reward refining or integrating existing technologies to meet a new objective. The previously mentioned DARPA Grand Challenge Prize is this type of prize.
- *Performance Improvement* prizes reward improving the performance of an existing product used for an existing application.
- *Technology Diffusion* prizes reward the diffusion of new innovation, for example requiring that a specified number of units be sold in the commercial marketplace.

H.R. 5143 contains three prizes. The first is a set of $1 million prizes for advancements in hydrogen storage, hydrogen production, hydrogen use and hydrogen distribution. This is a best-entry contest that rewards performance improvements. The second prize rewards prototypes that meet objective contest criteria established in advance. This is a $4 million goal-oriented contest for a new application, namely the use of hydrogen in vehicles or other energy use applications. The third prize is a $10 million goal-oriented contest for the best invention that leads to transformational changes in the distribution or production of hydrogen. Winners of the third prize would become eligible for up to $90 million in matching funds for every dollar of private funding raised by the winner for commercialization of their winning technology.

Existing Energy Prizes

Section 1008 of the *Energy Policy Act of 2005* authorizes DOE to spend $15 million to carry out a more general prize program for "grand challenges of science and technology" including to reduce U.S. dependence on foreign oil. DOE is said to be studying this authority for use in the hydrogen arena. In addition, the Federal Government already operates a number of competitions and contests in the energy R&D area. For example, DOE's Solar Decathlon, mentioned above, is a best-entry "design" competition.[4] Entrants must provide enough solar power to perform all the functions Americans have come to expect at home—washing clothes, running the dishwasher, powering computers, and, of course, maintaining a comfortable temperature. Winners are selected in subcategories—architecture, livability, comfort, power performance, etc.—and an overall winner is determined as well. Competitions of this type are often particularly useful for demonstrating how a technology can be incorporated into a commercially attractive product. In fact, the University of Colorado's winning *BioS[h]IP* house was designed for and will be delivered to a client.

As with the Solar Decathlon, many existing energy R&D prize competitions focus on student competitions. In DOE's Future Truck competition, teams of students from 15 top North American universities refined their re-engineered Ford Explorers to achieve lower emissions and at least 25 percent higher fuel economy, without sacrificing performance, utility, safety, and affordability. DOE and Natural Resources Canada help sponsor the North American Solar Challenge, a competition to design, build, and race solar-powered cars. Solar Challenge teams, primarily from universities, compete in a 2,500 mile race from Austin, Texas to Calgary, Alberta. A number of American Solar Challenge teams go on to compete in the biennial World Solar Challenge—a 3,000 kilometer (1,863 miles) race across Australia. And the American Forest and Paper Association and DOE Office of Industrial Technologies have sponsored student competitions to find novel uses for the more than two billion tons of waste every year produced by the forest products industry.

In at least one recent case, a government-sponsored energy competition involved industry contestants. The California Energy Commission and the Environmental Protection Agency's ENERGY STAR program jointly sponsored Efficiency Challenge 2004, an international design competition for energy efficient AC/DC power supplies. In two award categories, power supplies were judged on different criteria. The market-ready category weighed practical factors such as power supply cost and packaging, along with energy efficiency. In the open category, power supplies entered were evaluated without any cost or packaging constraints. This latter category was intended to showcase the most efficient power supply designs from both industry and academia.

Hydrogen

In his 2003 State of the Union speech, President Bush announced the creation of a five-year, $1.2 billion Hydrogen Fuel Initiative, which built on the FreedomCAR initiative announced in 2002. Together, the initiatives aim to enable the transition

[4] The Solar Decathlon was the subject of a November 2, 2005 Energy Subcommittee hearing, *Winning Teams and Innovative Technologies from the 2005 Solar Decathlon.*

to a hydrogen-based transportation economy, by developing technologies for the production, transportation and distribution of hydrogen, and the vehicles that will use the hydrogen. Fuel cell cars running on hydrogen would emit only water vapor from the tailpipe and, if domestic energy sources were used to produce the hydrogen, would not be dependent on foreign fuels. The Administration has requested $289.5 million for the Hydrogen Fuel Initiative in Fiscal Year (FY) 2007, an increase of $41.8 million over the FY 2006 funding level. Federal funding for the Hydrogen Initiative totals $631.7 million for FY 2004–2006, about 52 percent of the proposed initiative. Of that total, $121.5 million (19 percent) has been earmarked by Congress for specific projects.

Major advances are needed across a wide range of technologies if hydrogen is to be affordable, safe, cleanly produced, and readily distributed. The production, storage and use of hydrogen all present significant challenges.

- **Lowering the cost of hydrogen:** At present, hydrogen (when produced from its most affordable source, natural gas) is three to four times more expensive to produce than gasoline. Current DOE research efforts seek to lower that cost enough to make fuel cell cars cost-competitive with conventional gasoline-powered vehicles by 2015; and to advance the methods for producing hydrogen from renewable resources, nuclear energy, and coal.
- **Creating effective hydrogen storage:** Current hydrogen storage systems cannot deliver the vehicle driving distance that automakers say consumers demand. New technology is needed.
- **Creating affordable hydrogen fuel cells:** Fuel cell-based propulsion is now up to 10 times more expensive than internal combustion engines. A major goal of current DOE research efforts is to reduce the cost of fuel cell propulsion to affordable levels.

Analyses of the Hydrogen Fuel Initiative by the American Physical Society (APS)[5] and the National Academies of Science (NAS)[6] note that meeting the goals of the overall hydrogen initiative will require fundamental breakthroughs—not just incremental improvements. For example, storing hydrogen gas requires too large a volume for practical on-board storage in vehicles. New materials would be required to store hydrogen in more condensed form and release it when needed—a very difficult technical problem. The APS study states, "No material exists today that can be used to construct a hydrogen fuel tank that can meet the consumer benchmarks." The NAS estimated that fuel cells themselves would need a ten- to twenty-fold improvement before fuel cell vehicles become competitive with conventional technology. Current fuel cells wear out quickly, and lifetimes are far short of those required to compete with a gasoline engine. Large improvements have been made since the NAS report was released, but additional improvements are still needed. DOE estimates that roughly a five-fold decrease in fuel cell cost will be required, while at the same time increasing performance and durability.

Both reports recommended changes to the hydrogen initiatives, particularly arguing for a greater emphasis on basic, exploratory research because of the significant, perhaps insurmountable, technical barriers that must be overcome. DOE has responded, in part, by expanding the hydrogen program to include work in the Office of Science focused on design of new catalysts, solar hydrogen production, and the study of ion transport in fuel cell membranes.

Even if the technology advances to a point at which it is competitive, the transition to a hydrogen economy will require an enormous investment to create a new infrastructure. Changes in regulation, training and public habits and attitudes will also be necessary. Estimates of the cost of creating a fueling infrastructure (replacing or altering gas stations) alone are in the billions of dollars.

As currently envisioned, the transition won't happen quickly. According to the NAS study, significant sales of hydrogen vehicles are unlikely before 2025 even under the most optimistic technology assumptions.

7. Section-by-Section Description of H.R. 5143

Section 1. Short Title.

The H–Prize Act of 2006.

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[5] *The Hydrogen Initiative,* APS Panel on Public Affairs, Washington, DC: The American Physical Society (March 2004).

[6] *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs,* Committee on Alternatives and Strategies for Future Hydrogen Production and Use, Washington, DC: National Research Council and the National Academy of Engineering (2004).

Sec. 2. Definitions.

Sec. 3. Prize Authority.

Requires the Secretary of Energy to create a prize to advance the research, development, demonstration and commercial application of hydrogen energy technologies.

Requires the Secretary to advertise the prize competitions widely to encourage broad participation, including a specific direction to announce the prize competitions through publication of a *Federal Register* notice. Requires the Secretary to enter into an agreement with a private, non-profit entity to administer the prize competitions. Authorizes the Secretary to use funding directly appropriated for such purposes to DOE or other agencies and to accept funds provided by private entities or individuals. Prohibits the announcement of any prize competition until sufficient funds are available. Sunsets the authority to award prizes in 2017.

Sec. 4. Prize Categories.

Defines prize categories for:

(1) **Components or Systems.** Establishes up to four $1 million prizes awarded every other year to the best technology advancements in components or systems related to hydrogen production, hydrogen storage, hydrogen distribution, and hydrogen utilization. Provides the Secretary the discretion to reduce the amount or number of prizes based upon the availability of funds.

(2) **Prototypes.** Establishes one $4 million prize for prototypes of hydrogen-powered vehicles or hydrogen-based products that best meet or exceed objective performance criteria. Awards prototype prizes in years alternate with the technology advancements prize. Prohibits the Secretary from awarding the prize if no entrant meets the objectively defined performance criteria.

(3) **Transformational Changes.** Establishes a $10 million prize for transformational changes in technologies for the production and distribution of hydrogen that meet or exceed far-reaching objective criteria. Authorizes the Secretary to provide up to $90 million more in matching funds for every dollar of private funding raised by the winner for the continued development of their winning technology. Authorizes prize winners to accept these additional funds as cash or as a government contract equivalent to the prize amount. Limits the total award to $100 million.

Requires the Secretary to establish contest criteria through consultation with the Hydrogen Technical Advisory Committee, other federal agencies including the National Science Foundation, and private organizations including the National Academy of Sciences. Requires the Secretary to appoint contest judges from the private sector and agencies outside DOE. Excludes judges who may have a personal or financial relationship with any contest participant.

Sec. 5. Eligibility.

Requires contestants to register through the process published in the *Federal Register*. Requires contestants be incorporated and maintain a primary place of business in the U.S. if a private entity, or must be a U.S. citizen if an individual. Excludes from participation any federal entities or federal or national lab employees while on duty.

Sec. 6. Intellectual Property.

Waives claims by the Federal Government to any intellectual property rights derived from participation in the prize competitions.

Sec. 7. Liability.

Requires contestants to waive claims against the Federal Government resulting from participation in prize competition activities. Requires contestants to have liability insurance against damages resulting from participation in any prize competition activity and to name the Federal Government as an additional insured entity.

Sec. 8. Authorization of Appropriations.

Authorizes $55 million for each of fiscal years 2007 through 2016. Limits the use of appropriated funds for administrative expenses to no more than $1 million in any fiscal year.

Sec. 9. Nonsubstitution.

Expresses a sense of the Congress that the prize competitions shall not act as a substitute for any R&D programs.

8. Witness Questions

Mr. Phillip Baxley , Dr. David Bodde, Dr. David L. Green

- Are there any changes you would recommend making to H.R. 5143?
- Does H.R. 5143 provide the right incentives to address the most significant technical barriers to the widespread use of hydrogen as a fuel source?
- How can the Department of Energy (DOE) best use prize competitions to complement more traditional research support mechanisms, including contracts and grants, as a way to develop the hydrogen economy?

Dr. Peter Diamandis

- Are there any changes you would recommend making to H.R. 5143?
- What are the advantages of using prize programs to encourage technological progress in areas like the use of hydrogen as a fuel source?

Chairman BOEHLERT. The Committee will come to order.

I want to welcome everyone here today for what has turned out to be a very auspiciously timed hearing.

Suddenly, the whole Nation is focused on gas prices and in a panic on our "addiction to oil" and the Congress is in a panic trying to figure out how to respond. Our options in the immediate future are limited, but our options in the mid- and long-term are not. And unless we exercise those options, we are going to lurch from oil crisis to oil crisis and each one is going to get worse, and the toll on our economy will grow. The future will be grim if we don't act now. If we fail to act now, we will have to pay later.

There are many steps we need to begin to take. For starters, we need to reduce demand by means such as imposing tighter fuel economy standards. That is a mantra for me, and I suppose people are getting a little bit used to me repeating that over and over, but it is an issue whose time has come. But over the longer run, we need to find ways to run our transportation system on substances other than petroleum, including biofuels and, perhaps, hydrogen.

The hydrogen economy holds out great promise, but it also presents great hurdles. We are pretty far away from knowing how to create, store, distribute, and use hydrogen cleanly and efficiently. We need to devote all of the ingenuity we can muster to attack this problem.

That is why I was so pleased when Chairman Inglis introduced H.R. 5143, an innovative approach to encouraging innovative research. The bill is carefully crafted to encourage ongoing work that can lead to incremental improvements in hydrogen technology, and to draw more scientists and engineers into trying to remove the highest hurdles on the hydrogen highway.

We know from history that prizes can help solve tough technical problems. And this committee has a record of promoting the use of prizes; we created the highly successful Malcolm Baldrige Award and most recently we established a prize program at NASA. Prizes can draw more money and more people into the search for technical solutions, and they can provoke more inventive thinking.

Now, no one is suggesting that this prize substitute for the existing hydrogen R&D programs, which the President and this committee have strongly supported. Those programs are necessary to make sure the Nation has a cadre of experts engaging in ongoing work in this area. But we can expand the pool of financial and human resources further with prizes.

So I am eager to hear today from our experts on the specifics of the bill. I expect that this bill will move through the House swiftly, and we want to make sure we have got this program written in exactly the right way. We also have to examine the funding levels in the bill: we want them high enough to make a difference, but not any higher than that, given how tight the federal budget is. My guess is that the top prize could be reduced to $10 million without reducing the program's impact.

But while we work out the details, we shouldn't miss the larger message. This committee is committed to moving forward with new ways to promote new technologies, and I think the H–Prize fits that bill.

I congratulate Mr. Inglis for proposing it, and as a matter of fact, I have nominated him personally for the X Prize for Legislative Initiative. And I want to congratulate him for working so closely with the Committee in drafting this bill.

And I will yield the remainder of my time to Chairman Inglis.

[The prepared statement of Chairman Boehlert follows:]

PREPARED STATEMENT OF CHAIRMAN SHERWOOD L. BOEHLERT

I want to welcome everyone here today for what has turned out to be a very auspiciously timed hearing.

Suddenly, the whole Nation is focused on gas prices and our "addiction to oil" and the Congress is in a panic trying to figure out how to respond. Our options in the immediate future are limited, but our options in the mid- and long-term are not. And unless we exercise those options, we are going to lurch from oil crisis to oil crisis and each one is going to get worse, and the toll on our economy will grow. The future will be grim if we don't act now.

There are many steps we need to begin to take. For starters, we need to reduce demand by means such as imposing tighter fuel economy standards. But over the longer-run we need to find ways to run our transportation system on substances other than petroleum, including biofuels and perhaps hydrogen.

The hydrogen economy holds out great promise but it also presents great hurdles. We are pretty far away from knowing how to create, store, distribute and use hydrogen cleanly and efficiently. We need devote all the ingenuity we can muster to attack this problem.

That's why I was so pleased when Chairman Inglis introduced H.R. 5143—an innovative approach to encouraging innovative research. The bill is carefully crafted both to encourage ongoing work that can lead to incremental improvements in hydrogen technology, and to draw more scientists and engineers into trying to remove the highest hurdles on the hydrogen highway.

We know from history that prizes can help solve tough technical problems. And this committee has a record of promoting the use of prizes; we created the highly successful Malcolm Baldrige Award and most recently we established a prize program at NASA. Prizes can draw more money and more people into the search for technological solutions and they can provoke more inventive thinking.

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But while we work out the details, we shouldn't miss the larger message. This committee is committed to moving forward with new ways to promote new technologies. I think the H–Prize fits that bill.

I congratulate Mr. Inglis for proposing it and for working so closely with the Committee in drafting his bill. And I will yield the remainder of my time to him. Mr. Inglis.

Mr. INGLIS. And that is the prize that I get, and I thank you very much, Mr. Chairman, for yielding to me. Thank you very much for holding the hearing as well.

I thought I would show just a couple of slides, because I know a picture is worth a thousand words.

[Slide.]

We know that we have got some surface waves about interruptions in supply, and those are causing some of our price increases. But underlying those surface waves is this sea of rising demand. That is a gas line at a gas station in China. We expect—Exxon Mobil says within the next—well, about 2030, worldwide energy de-

mand will increase by 60 percent. That will necessitate a 40 percent increase, says Exxon Mobil in their report, in OPEC oil production. Even if they have got it, do we really want to be that much more dependent on them?

So the question is how to move to something else, how to break this addiction to oil. Our goal has been to develop the most non-governmental way for the government to help achieve the result of breaking through to hydrogen. So the idea is to take the "can-do" American spirit, put it with the prize and the recognition of winning the prize, some financial incentives, and hopefully bring the best and the brightest to bear on these technological challenges.

As we have proposed it, there would be a million-dollar prize every other year for breakthroughs in production, storage, distribution, and utilization of hydrogen, every other year a $4 million prototype prize, and then within 10 years, if you can transform from well to wheels the—our use of hydrogen, you would get $100 million. But since this is a non-governmental approach, it wouldn't exactly be $100 million. It would be $10 million in cash and then up to $90 million, dollar-for-dollar match for your venture capital. So it is a way of testing to see if the market agrees that you have got a product to sell. If you don't, and you can't find $90 million worth of venture capital, then you don't get the $90 million. It is a way of getting all of the way to the government's interest, which is a product on the market. We are not interesting in developing technology and putting it on the shelf. The government's interest is to get all of the way to the market.

We have done it before, as the Chairman alluded to that we have had prizes before and very successful prizes. The Transcontinental Railroad involved some prizes, if you will, given to the railroad companies, cash, stipends, $48,000 a mile, plus 33 million acres of land given to those companies. So we can do this, because we have. We have also done it before with flight—transatlantic flight, the Orteig Prize was won by Charles Lindbergh. It rewarded his going across the Atlantic and back. And then, of course, as we will hear from Peter Diamandis, we are going to hear about the wonderful work of the Ansari X Prize. This is, of course, the—a picture of Burt Ratan's SpaceShipOne, which was the first one to go into space and back within a two-week period.

So, Mr. Chairman, I would thank you again, for holding the hearing and for advancing the bill. I think we have got to breakthrough to hydrogen. We can, because we must. And I thank you for yielding.

[The prepared statement of Mr. Inglis follows:]

energy security

H-Prize

energy prize security

H-Prize

- The most non-governmental way government can achieve clear results.
- Provides results-based financial incentives to harness the creative, can-do spirit of Americans.

energy prize security

H-Prizes

1) Technical Breakthroughs

2) Prototypes

3) Transformational Technologies

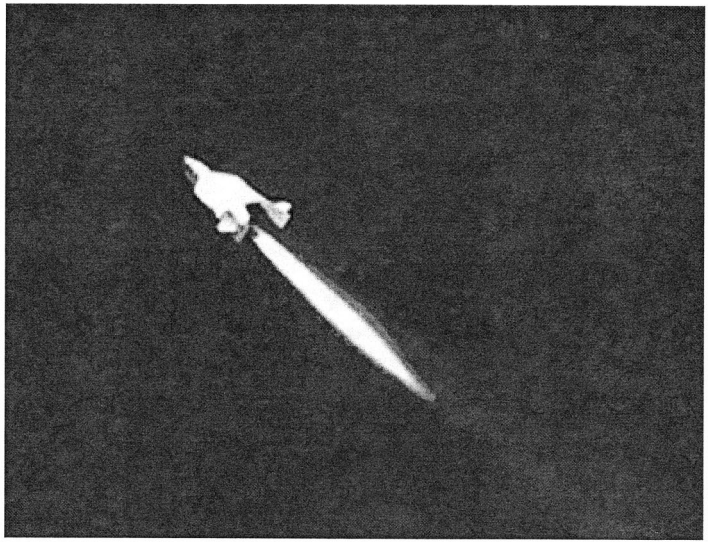
We can. Because we have.

Transcontinental Railroad last spike on May 10, 1869, at Promontory Summit, Utah

We can. Because we have.

May 20, 1927 Charles Lindbergh wins the Orteig prize for the first successful roundtrip transatlantic flight.

We can. Because we have.



October 4, 2004 Burt Rutan's SpaceShipOne became the first private spacecraft with commercial potential.

We can. Because we must.

energy prize security

Chairman BOEHLERT. I thank you very much. And now you know why, my colleagues, I have nominated Chairman Inglis for the X Prize for Legislative Initiative.

Now, Mr. Lipinski.

Mr. LIPINSKI. Thank you, Mr. Chairman.

I—as—keeping with usual here, would like to certainly associate myself with all of the comments of the Chairman of the Committee and also with Mr. Inglis. I would like to thank Mr. Inglis for his leadership on this very important issue and I am pleased to be here for the hearing on Mr. Inglis' *H–Prize Act of 2006*. I would like to welcome the witnesses and look forward to hearing all of your testimony. And I apologize that I am going to have to leave early, because I have other commitments to be at after this.

Energy is on the mind of all Americans right now, especially with them being very upset about the current gas situation. Gas prices have risen to record highs, and oil companies are reporting record profits.

Our natural gas prices concern many of my constituents in Chicago this winter. And for some families, it makes hard choices to keep their heat on during the coldest months. We can be thankful it was a relatively mild winter in Chicago, but that may be a bad sign related to global climate change.

We are also becoming increasingly aware of the threats posed to our national security by our continued reliance on foreign fossil fuels. Our main proposal in the Congress is to help relieve the pressure of energy prices. These range from short-term solutions, such as ending tax subsidies for oil companies or easing various regulations, to long-term approaches like research in hydrogen fuel, biofuels, and other renewables.

No one idea or program is going to solve all of our energy problems, but if we do not start to assemble the tools and build an energy model for the future, we will be no better 20 years from now than we are today. We will likely be much worse off.

An economy based on energy outside the fossil fuels is no longer implausible, but to get there, we must invest in research and development now to be able to sustain our economy. Research grants are a basis of this process, but we, in Congress, have a responsibility to find creative and new ways to inspire researchers, business leaders, and our youth to solve the problems their society faces.

One such example of innovative thinking is a bill introduced by Ranking Member Gordon that replicates the successful DARPA program model and puts it to work in the Department of Energy. H.R. 4435, which I am proud to support, would establish a new ARPA–E function at DOE to speed the commercialization of innovative energy ideas and help reduce our dependence on foreign fuel.

Today's legislation, H.R. 5143, seems to inspire researchers, entrepreneurs, and other competitive spirits in an effort to find specific solutions to the major challenges facing development and commercialization of hydrogen fuel. The H–Prize will help expand the possibilities of hydrogen research, promoting people not normally involved in the federal research and development to explore one of the greatest challenges facing us today. This prize will help us take

advantage of America's greatest resource, our ingenuity and our creativity, in order to tackle the problems before us.

We have some of the best and brightest minds in the world in the United States as well as an economy that supports and encourages entrepreneurship, and the H–Prize will focus our inventiveness to address the greatest challenge that faces our country.

Hydrogen holds enormous potential as the base of our future economy, a potential we cannot and must not ignore.

Again, I thank Mr. Inglis for introducing this legislation, and I look forward to hearing the testimony of our witnesses today.

[The prepared statement of Mr. Lipinski follows:]

PREPARED STATEMENT OF REPRESENTATIVE DANIEL LIPINSKI

Thank you, Mr. Chairman; I am pleased to be here today for this hearing on H.R. 5143, the *H–Prize Act of 2006.* I would like to thank Mr. Inglis for taking leadership on this important issue. I would also like to welcome the witnesses and I look forward to hearing their testimony. I apologize that other commitments will unfortunately prohibit me from staying for the full hearing today because the topic is an important one.

Energy is on the minds of many Americans right now and they are very upset about the current situation. Gas prices have risen to record highs and oil companies are reporting record profits. High natural gas prices concerned many of my constituents in Chicago this winter and forced some families to make hard choices to keep their heat on during the coldest months. We can be thankful that it was a relatively mild winter, but that may be a bad sign relate to global climate change. We are also becoming increasingly aware of the threats posed to our national security by our continued reliance on foreign fossil fuels.

There are many proposals in Congress to help relieve the pressure of energy prices. These range from short-term solutions, such as ending tax subsidies for oil companies or easing various regulations, to long-term approaches like research in hydrogen fuel, biofuels, and other renewables. No one idea or program is going to solve all of our energy problems, but if we do not start to assemble the tools and build an energy model for the future, we will be no better off 20 years from now than we are today, and likely we will be much worse off.

An economy based on energy outside of fossil fuels is no longer implausible. But to get there, we must invest in research and development now to be able to sustain our economy. Research grants are the basis of this process, but we in Congress have a responsibility to find creative and new ways to inspire researchers, business leaders, and our youth to solve the problems that society faces.

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Today's legislation at hand, H.R. 5143, seeks to inspire researchers, entrepreneurs, and others competitive spirit in an effort to find specific solutions to the major challenges facing development and commercialization of hydrogen fuel. The H–Prize will help expand the possibilities of hydrogen research, promoting people not normally involved in federal research and development to explore one of the greatest challenges facing us today.

This prize will help us take advantage of America's great resource—our ingenuity and creativity—to tackle the problems before us. We have some of the best and brightest minds in the world in the United States, as well as an economy that supports and encourages entrepreneurship, and the H–Prize will this focus inventiveness to address the greatest challenge that faces our country.

Hydrogen holds enormous potential as the base of our future economy—a potential we cannot and must not ignore.

Thank you, Mr. Chairman, and I yield back the remainder of my time.

Chairman BOEHLERT. Thank you very much, Mr. Lipinski.

Ms. Biggert.

Ms. BIGGERT. Thank you, Mr. Chairman. I want to thank you for holding this hearing today and giving the Committee an opportunity to discuss the creation of an H–Prize.

I also want to thank the bill's sponsor, Mr. Inglis, for sharing a draft of his legislation with me and seeking my input prior to its introduction.

As Chairman of the Energy Subcommittee, I participated in a meeting of various hydrogen and fuel cell stakeholders that Mr. Inglis convened in December of last year to discuss the idea.

At that meeting, I urged all involved to keep in mind the recommendations included in a 1999 National Academy of Engineering report on inducement prizes. The Academy recommended that prizes should complement, not substitute for, direct federal support of research and development. The Academy also advised that rewards should be commensurate with the effort required and the goal sought. To me, this advice is just good common sense.

Unfortunately, I do not believe that this legislation meets these criteria. I do not believe that authorizing a $100 million prize for the development of "transformational technologies" meets either of these criteria. This is a criticism that I shared with the bill's sponsor well in advance of the bill's introduction.

According to the Organization for Economic Cooperation and Development, the market for fuel cells and related products is projected to reach $29 billion by 2011. With potential applications in transportation, power generation, and portable power, the market for fuel cells and related products, the OECD estimates that this market could grow to over $1.7 trillion by 2021.

Isn't a billion- or trillion-dollar market prize enough? Isn't this enough of an incentive to encourage scientists, engineers, entrepreneurs, and energy companies, large and small, to invest in the development of fuel cells and new and innovative ways to produce and store hydrogen?

The 2005 Solar Decathlon, while structured differently than the H–Prize, attracted 20 qualified teams. Each team received $5,000 in federal funds to leverage between $200,000 and $300,000 in outside investment for their prizes—for their projects. The result was a diverse combination and outstanding display of solar and other advanced energy technologies. The total cost to the DOE: $1 million.

According to press accounts, two dozen teams from five different countries competed for the $10 million Ansari X Prize, and we will hear more about that later, but the best part about that prize is that it didn't cost taxpayers a penny.

I think that it is safe to say that the market for hydrogen and fuel cell technologies dwarfs the market for spaceships, and yes, even solar technologies combined.

To put this in another context, the prize of all prizes, the Nobel Prize, is only a $1.3 million prize.

Why haven't we ever offered a prize to find a cure for cancer? Don't we already know more about hydrogen and fuel cells than we know about cancer?

In addition, the Energy Policy Act of 2005, which just became law in August of last year, authorized over $3.3 billion for research into the production and distribution of hydrogen and the development of fuel cells.

I also want to observe that while the last section of the bill does explicitly prohibit any H–Prize program from substituting for fed-

eral research and development programs, in no way does this provision prevent the substitution of funding. Substituting direct federal support for research and development with a prize is exactly the opposite of what the National Academy of Engineering recommended. Neither the President nor Congress is going to be able to find the money for such a prize without taking funds out of other vital energy research and development programs.

Properly designed, an H–Prize could provide useful feedback and constructive direction to the Hydrogen Fuel Initiative. Designed with a specific goal in mind, prizes could spur the development of technologies linking the critical pieces of the hydrogen economy, those that make, move, store, and burn hydrogen. But I am in no way convinced that we need to spend $100 million on such a prize.

Before closing, I want to acknowledge Mr. Inglis' insight. We too often focus exclusively on whether research programs are meeting milestones and timelines, but forget to keep in mind the goal of fostering innovation. We also tend to focus on the dominant funding mechanisms—grants, contracts, and cooperative agreements—without considering the full range of options. Mr. Inglis is making us consider our decisions more fully, and rightly so. So I look forward to continuing to work with the bill's sponsors to address my concerns, and I yield back the balance of my time.

[The prepared statement of Ms. Biggert follows:]

PREPARED STATEMENT OF REPRESENTATIVE JUDY BIGGERT

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Chairman BOEHLERT. Thank you very much.

Dr. Baird.

Dr. BAIRD. I appreciate the Chairman. I appreciate the gentlelady's comments and would associate myself with them.

I applaud the gentleman from—for coming up with great ideas for how to stimulate exploration in hydrogen. I just would question how we call it a non-governmental modality when the government is going to be putting up the funding. It always seems to me that the prize for innovation, under a free market system, should be that you profit from your invention. And while we have a host of ways to stimulate that at the federal level, I think we need to acknowledge that they are government ways and be honest with that.

So I will look forward, actually, and my main question will be: what will be the cost-benefit ratio here? What are we investing? What will the return on investment be? And frankly, what would that return on investment be if we didn't have such a prize? Would not the free market incentive, as we see the escalating cost of gasoline, be sufficient without this expenditure, and might it be expended in a different manner?

But I look forward to this debate, and I am glad we are having it.

I thank the Chairman.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Good morning. I want to thank the witnesses for appearing before our committee to discuss H.R. 5143, the *H–Prize Act of 2006.* The bill intends to create a prize to advance the research, development, demonstration and commercial application of hydrogen energy technologies.

Traditionally, the Department of Energy (DOE) has relied upon established researchers in national labs, industry, and academia to carry out its mission of developing energy technologies for use by the private sector. Most often, DOE identifies a technical hurdle and then issues research solicitations to detail the type of tech-

nologies the agency seeks to fund. Moreover, DOE may use grants, cooperative agreements or contracts to carry out projects.

While this method has worked well to advance scientific technology, H.R. 5143 also intends to meet the same goal by offering a prize for the development of a particular technology or for a specific achievement. As we have seen in the past, several prize programs were established to encourage the development of science and technology through a competitive process.

I recognize that prize competitions benefit from clear-cut goals and have inspired research to accelerate the advancement of hydrogen technologies. However, I believe it is important that prizes act as a supplement to, not a substitute for traditional research and development programs. I encourage continued advancements in research, development, demonstration, and commercial application projects and will work with my colleagues to attract our country's best and brightest minds to address U.S. energy challenges.

I look forward to hearing from today's panel of witnesses.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF REPRESENTATIVE EDDIE BERNICE JOHNSON

Thank you, Mr. Chairman and Ranking Member.

I would like to commend the Chairman, Ranking Member and staff for arranging today's hearing and always enjoy discussing how Congress can work better to spur innovative technologies.

Clearly, our nation faces an energy crisis. Oil prices are skyrocketing, and as the hot sun bakes my home state of Texas this summer, energy prices will become as unbearable as the Dallas heat.

I am glad my colleagues have been forward-thinking to introduce legislation to stimulate research and development of a hydrogen economy.

The Science Committee has held hearings in the recent past on the issue of the hydrogen economy. What I have heard witnesses say is that technology is not developed enough for America to benefit from a hydrogen economy for many years.

I fear the consequences of a "head in the sand" approach, with energy prices as they are. We must invest in alternative fuels such as hydrogen to address this crisis.

H.R. 5143 has been compared with the X Prize, but I want to point out that the X Prize was funded with private resources.

I believe the Committee should consider what unintended consequences could arise with a prize administered by a federal agency, rather than by private industry.

Thank you, Mr. Chairman. I yield back the balance of my time.

Chairman BOEHLERT. Thank you very much.

And now to our very distinguished panel. And every time I look at a panel of experts that come before this committee, I am reminded that Washington is not the source of all wisdom. As a matter of fact, I would like to add more wisdom here, but one of the ways we get it is by having experts like you. So we thank all of you for being facilitators and of counsel to the Committee, if you will.

Our witnesses include Dr. Peter Diamandis. He is Chairman of the X Prize Foundation, a non-profit organization dedicated to fostering innovation through the use of competitions. The Foundation awarded its $10 million Ansari X Prize to promote the formation of a commercial space flight industry. Prizes for genomics, energy, and education are under development. Thank you, Dr. Diamandis, and we understand another commitment forces you to have to leave at 11:15, so don't think as he departs he is boycotting the rest of the meeting.

Dr. DIAMANDIS. Thank you, Chairman.

Chairman BOEHLERT. Our second witness is Dr. David Bodde. He is the Director of Innovation and Public Policy at Clemson University's International Center for Automotive Research. He was a member of the National Academy of Engineering Committee on Alternatives and Strategies for Future Hydrogen Production and Use,

which issued the 2004 report *"The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs."*

Our third witness is Dr. David Greene. He is a corporate fellow at Oak Ridge National Laboratory with the Center for Transportation Analysis, National Transportation Research Center. He is an expert on transportation and energy policy issues. Dr. Greene.

And finally, Mr. Phillip Baxley, the President of Shell Hydrogen, L.L.C., a separate business unit established by Shell in 1999 to pursue new business opportunities in hydrogen fuel and fuel cells.

Gentlemen, thank you very much for participating in this and being willing to serve as counsel and educators for this committee.

Dr. Diamandis, you are first up.

STATEMENT OF DR. PETER H. DIAMANDIS, CHAIRMAN OF THE X PRIZE FOUNDATION

Dr. DIAMANDIS. Thank you.

Chairman Boehlert, members of the Committee, I thank you for permitting me to come here and give testimony today on prizes and the H–Prize.

My name is Peter Diamandis. I am the Founder, Chairman, and CEO of the X Prize Foundation.

We started the Foundation in 1995. In fact, the first public discussion ever on the X Prize was in this room in testimony to Congressman Walker at that time. Our mission is to bring about radical breakthroughs by using prizes. And in fact, we believe that inducement prizes, versus recognition prizes, like the Nobel Prize, have the chance to bring huge returns for immediate change versus something achieved 30 years ago.

Incentive prizes have a tremendous history, as we have heard some from Chairman Inglis' presentation early on, and it was reading about Lindbergh's flight across the Atlantic that actually inspired me. I read that this $25,000 prize offered in 1919 sparked $400,000 in expenditures. Literally 16 times the prize amount was spent. And they didn't spend $1. And in fact, the most unlikely winner, Lindbergh, called the "flying fool" the day before he took off, changed the course of history and ignited a multi-hundred-billion-dollar industry of aviation.

When he landed in Paris, he was swamped by crowds. What followed after that was tremendous. Within 18 months of his landing, the number of passengers in the United States went from 5,700 to 180,000, a 30-fold increase in passenger traffic in the United States. The number of airplanes quadrupled. The number of pilots tripled. It was not the technology. It was a paradigm shift that occurred. The prize changed the way the public thought about aviation. That is very important. Prizes not only cause technology to be brought into existence, but they change the way we think about these subjects.

My passion since the age of nine has been going into space, and for 40 years, I have watched the cost of space flight go up and reliability not change at all. And I became, you know, disenchanted with waiting for NASA to open up space. And it was that reading of the Lindbergh book that caused me to build this Ansari X Prize.

I offered out a $10 million purse. We picked $10 million so that it was not too large; we didn't want the Boeings and Lockheeds

competing, but large enough to incentivize those entrepreneurs, those hungry, risk-taking entrepreneurs willing to risk everything to change what they believed in—offering for three people to go into space, come back down, and within two weeks make that trip again. We had 26 teams from seven countries compete for this coming from places I had no expectation, from Romania, from Israel, from Russia, from Great Britain, from Canada, from the United States competing to win this $10 million prize and spending $100 million to win it.

The results were fantastic. With 50 times the prize—our seed capital yielded 50 times the amount spent to try and win that $10 million prize. And you go now to the Air and Space Museum and see SpaceShipOne, the winning vehicle, hanging next to the Spirit of St. Louis. And for me, that was the prize in my heart, to see that happen. It was spectacular. October 4 of 2004, SpaceShipOne made two flights into space.

When that happened, for me, what occurred was we changed the paradigm that space flight was not just for 100 very smart, government-selected astronauts. Now kids believe that they can fly into space. That was the most important thing: changing the paradigm. I can't focus on that enough.

We also launched an industry. You know, Branson is now committed to over $100 million to go after SpaceShipTwo. Of the 26 contenders, at least eight or nine of them are bringing their vehicles into commercial practice. That would not have happened. You know, the X Prize drove that breakthrough. The technology had been around for decades to have this happen, but the Prize, literally, caused the spark. It was the crucial seed required to galvanize that to happen.

So successful prizes that are well designed, well timed, and appeal to the audience can have huge returns on investment.

Why do prizes work? Let me offer out the following four things that are very important as to why prizes work.

One, they attract alternate funding. Prizes have to be an amazing story. They are about the human drama. They are about the risk. And they attract different flavors of money, not your traditional venture capital. They attract risk-taking money. I call it "ego money." The Larry Ellisons who backed an America's Cup team and spent $70 million for a trophy. Twenty billion dollars a year is spent paid in sponsorship dollars for car races, boat races, bike races, or whatever it is. It attracts that kind.

The media spotlight. Prizes have to create heroes. It is never about the technology. The heroic element drives people to think in the shower around the clock. You can't buy that level of dedication.

It bypasses bureaucracy. A lot of the most brilliant people will never, ever, ever apply for a grant, because they could not stand the process of going through that. But a prize says you win if you do this. You know. Bypass all of the bureaucracy and go directly to the solution and you will win the money. And that allows the most brilliant, and sometimes the most radical thinkers, to enter and solve the problems that we have.

Most importantly, prizes elevate a problem so high that it attracts people from outside the discipline. We all know how to think the way we think. You know. Biologists approach things from a bio-

logical problem. But if you put up a prize, you have a physicist come in or a historical person come in. So it attracts solutions outside disciplines and outside nations.

We, at the X Prize, have dedicated ourselves. We have grown the organization. Larry Page, a co-founder of Google, has joined our board. Craig Venter discovered—you know, cloned the human genome, and we are building ourselves into a world-class prize institute, focusing on developing prizes for different areas. We are working on an automotive X Prize we hope to launch this year for cars that significantly exceed 100 miles per gallon. We are going to be launching a genomics X Prize. We are looking in entrepreneurship and education and other arenas.

In closing, let me highlight our work with NASA.

In 2003, prior to the winning of the Ansari X Prize, some of my friends at NASA headquarters approached us and asked, "What can we do to help?" I said, "NASA should be doing prizes." They hired us to do a study. We spent about six months working and going through all of the agency elements and came up with 100 prize ideas. To do a prize properly is not picking a target. We have developed a prize innovation process that figures out, first, what is the problem you are trying to solve. Understand that first. Is it CO_2 emissions? Is it energy independence? Is it energy storage? What is the problem? And then it—and then basically drive it forward.

So we have developed this process, and we are pleased to be able to bring that technology and bring that capability to the Committee.

Thank you for your time.

[The prepared statement of Dr. Diamandis follows:]

PREPARED STATEMENT OF PETER H. DIAMANDIS

Chairman Boehlert and members of the Committee, thank you for permitting me to submit this testimony on the use of inducement prizes for advances in hydrogen technology. My name is Peter H. Diamandis. I am the Founder, Chairman, and CEO of the X PRIZE Foundation.

Founded in 1995, the X PRIZE Foundation fosters innovation in a unique way. Rather than awarding money to honor past achievements or directly funding research with uncertain outcomes, the X PRIZE Foundation creates high profile competitions that attract and motivate creative solutions to important problems. Our mission is to bring about radical breakthroughs for the benefit of humanity utilizing prizes.

Incentive prizes have a history stretching over several hundred years, with successful prizes having dramatic effects. One of the most famous—and the one that personally inspired me to start X PRIZE—was the Orteig Prize, won by Charles Lindbergh in 1927 for his dramatic non-stop flight from New York to Paris in 1927. This $25,000 prize caused nine teams to spend $400,000. Lindbergh's, the most unlikely of the nine teams, won the purse and ignited an aviation renaissance.

The huge crowd that mobbed Lindbergh in Paris was just the first indicator of the impact his achievement would have. Within eight months of his flight, the number of airplanes in the U.S. quadrupled, the number of pilots tripled and the number of individuals buying airline tickets increased 30-fold from 5,700 to nearly 180,000.

Lindbergh's success in winning the Orteig Prize gave a jump-start to commercial aviation. It was the efficiency of the Orteig Prize and the tremendous leverage it offered that drove me to create the Ansari X PRIZE to solve the problem of private space flight.

Since the age of nine, my passion has been space flight. I'm a child of the Apollo vision that this country once had. However, as I watched the aerospace industry develop over the past few decades, it was evident to me that innovation in space flight had stalled. During the past 40 years the cost of space flight has gone up, but the

reliability has not improved. To disrupt these trends, I created an international competition with a $10M purse, for the first privately-funded team to develop and fly a three-person, reusable spaceship to 100 kilometers altitude, twice within two weeks. The prize was announced under the arch in St. Louis, 10 years ago next month (May 18th, 1996), along with 20 astronauts, the NASA Administrator, the FAA Associate Administrator and the Lindbergh Family. During the following decade I raised the $10 million purse, recruited 26 teams from seven countries to compete and built a world-class team of individuals who became expert in how to create, manage and award Inducement Prizes.

As you may know, the Ansari X PRIZE was won on Oct. 4, 2004, by Mojave Aerospace Ventures, led by designer Burt Rutan and financier Paul Allen. The competition caused teams to spend over $100 million to win the $10 million purse, and attracted over five billion media impressions that changed the public paradigm that space flight is only for government employees. The winning spacecraft—SpaceShipOne—now hangs next to the Spirit of St. Louis and the Wright Flyer in the Smithsonian National Air & Space Museum.

The long-term effects won't be known for years, but it's already clear that X PRIZE helped spawn a new industry with dramatic technological, social and investment opportunities. Richard Branson paid $121M for the winning technology, and thousands of consumers have paid deposits for space tourism tickets. Several other commercial space flight companies were spawned by the X PRIZE competition and are still operating.

Inducement prizes are fundamentally different than conventional R&D funding. Inducement prizes define a problem and pay for successful solutions—they do not pay for the work itself, they do not define or pre-judge technical approaches, and they do not pre-judge qualifications.

Successful prizes are well-designed, well-timed, appeal to a broad audience, and offer potential rewards—prestige, publicity, and future business—far in excess of the purse itself. Inducement prizes have a unique ability to efficiently drive research that leads to high-leverage breakthroughs. The return-on-investment can be huge; the Ansari X PRIZE leveraged seed capital 50-fold. Why is that? Why can inducement prizes work so well? There actually is a science to this process, something with the X PRIZE Foundation has spent 10 years learning. Following are some the important reasons:

1. **Prizes Attract Alternate Funding Sources:** Prize teams are able to attract risk-taking capital which is put up by corporate sponsors or wealthy individuals who actually encourage risk-taking because they seek the publicity and desire to win. Prizes tap into the $20 billion pot of money spent each year on event and sports-related sponsorship.

2. **Media Spotlight:** The intense media spotlight and opportunity to become a global hero, drives teams to work around the clock. Incentive prizes cause these teams to work harder than any employment contract could ever achieve. If leveraged correctly, the media can also play a key role in educating the public about each team and their breakthroughs.

3. **Bypassing Bureaucracy:** Many brilliant individuals abhor bureaucracy and would rather not go through the paper work and peer-review process that would completely and totally frustrate them. Prizes set up a clear process: Solve the problem, by what-ever means, and you win the money and the fame.

4. **Crossing Disciplinary & National Boundaries:** Most importantly, prizes encourage innovators from outside the typical fields or nations to address your problem. Breakthroughs typically come when a fresh mind, without preconceived biases, looks at the challenge.

Creating and managing successful inducement prizes is much harder than it looks. There have been many attempts in the past which have failed. Prizes must not be about technology alone, they must be structured to create and follow heroes, have dramatic and demonstrable conclusions, and must be something the public and media are made to care about. Success requires a carefully structured and balanced approach that involves expertise in many areas, including science, technology, rules & competition design, event management, arbitration, financing, sponsorship, media relations, public relations, and government relations.

Since the awarding of the $10 million Ansari X PRIZE we have focused on building the X PRIZE Foundation into a world-class prize institute using best practices and its 300 man-years of experience, to create, administer and award prizes that will help change the world. We are currently working on inducement prizes in sev-

eral areas, including automotive, genetics, education, entrepreneurship, and—of course—space.

In closing I would like to highlight our work with NASA, since I believe it provides a useful model for the type of prize creation and management contemplated by the H–Prize Act. In 2003, prior to the winning of the Ansari X PRIZE, the leadership of NASA asked the X PRIZE to conduct a study on how prizes could be used to support their mission. Under contract to the Agency, we came up with over 100 prize ideas and helped them structure the Centennial Challenges Program, which is now funded annually to approximately $10 million per year. The X PRIZE Foundation now works closely with NASA assisting and advising, and in a number of cases managing their larger prizes. In this situation, NASA puts up the prize purse and the X PRIZE Foundation is responsible for raising the sponsorship funds to manage the prize, writing the rules, attracting the teams, and following through to a successful conclusion.

It is important to note that NASA does not manage the prizes themselves; they identify the prize area and secure the prize purse. They depend on an independent partner like X PRIZE to write the rules and implement the competition. In my view this separation of responsibilities is fundamentally important. The prize organization must often act quickly, with authority, and must be able to assure potential competitors that they will be treated fairly and without political bias. Thus, for example, once a particular prize has been established and the management plan approved, one should avoid mixed responsibilities for rule-creation, committee selection, judging, and arbitration.

Inducement prizes are well-suited to stimulate innovations in the fields of both energy and transportation, and for that reason towards the long-term goal of a hydrogen economy. Technology advances are plausible, large markets are possible, investors are poised, and there would be great public interest in fundamental breakthroughs. The multi-billion dollar question, of course, is what are the prize rules, who will compete, and when will it be won. The H–Prize Act would hasten the needed breakthroughs, and the X PRIZE Foundation is ready to help.

Thank you for your time and attention.

BIOGRAPHY FOR PETER H. DIAMANDIS

Dr. Diamandis is the Chairman and CEO of the X PRIZE Foundation *(www.xprize.org),* which awarded the $10,000,000 Ansari X PRIZE *(www.xprize.org)* for private space flight. Diamandis is now focused on building the X PRIZE Foundation into a world-class prize institute whose mission is to bring about radical breakthroughs for the benefit of humanity. The X PRIZE is now developing X PRIZEs in fields such as Genomics, Automotive, Education, Medicine, Energy, and Social arenas.

Diamandis is also a leader in the commercial space arena, having founded and run many of the leading companies in this sector. He is the Chairman & Co-Founder of the Rocket Racing League *(www.xracing.com).* Diamandis also serves as the CEO of Zero Gravity Corporation *(www.nogravity.com)* a commercial space company developing private, FAA-certified parabolic flight utilize Boeing 727–200 aircraft. Diamandis is a co-founder of Space Adventures, Inc. *(www.spaceadventures.com),* the company which brokered the first launches of private citizens to the International Space Station.

In 1987, Diamandis co-Founded the International Space University (ISU) *(www.isunet.edu)* where he served as the University's first managing director. Today he serves as a Trustee of the $30M ISU that is based in Strasbourg, France. Prior to ISU, Diamandis served as Chairman of Students for the Exploration and Development of Space (SEDS) an organization he founded at MIT in 1980. SEDS is the world's largest student pro space organization.

Dr. Diamandis attended the Massachusetts Institute of Technology (MIT) where he received his undergraduate degree in molecular genetics and graduate degree in aerospace engineering. After MIT he attended Harvard Medical School where he received his M.D. In 2005 he has was also awarded an honorary Doctorate from the International Space University.

He is the winner of the Konstantine Tsiolkovsky Award, twice the winner of the Aviation & Space Technology Laurel, and the 2003 World Technology Award for Space, the 2006 Orbit Prize and the 2006 Lindbergh Award. In 8th grade, while living in New York, Dr. Diamandis won first place in the Estes rocket design contest.

Diamandis' personal motto is: "The best way to predict the future is to create it yourself!"

Chairman BOEHLERT. Thank you very much.

I think—mark him down as a supporter of the concept.

Dr. Bodde.

STATEMENT OF DR. DAVID L. BODDE, DIRECTOR OF INNOVATION AND PUBLIC POLICY AT CLEMSON UNIVERSITY'S INTERNATIONAL CENTER FOR AUTOMOTIVE RESEARCH (ICAR)

Dr. BODDE. All right. Thank you very much, Mr. Chairman. And thank you, also, for the opportunity to discuss this very creative and innovative piece of legislation.

I think this does offer great hope for removing from this country the curse of oil dependence and for moving us then into an energy economy that is founded on domestic resources and on our own technology advantages.

The H–Prize would accomplish this, in my judgment, through two principle mechanisms.

First, it would stimulate and nurture the research base from which these innovations are drawn. It will do this by attracting new researchers and innovators and by calling public attention to that.

Second, it would perform one of the most difficult feats in our economy, and that is accelerating research, in this case hydrogen-related research, across the gap between innovation research, that is innovation funding—excuse me, between research funding and new venture kinds of funding. These communities move in parallel. They don't communicate well. And that gap between research funding and innovation funding is a very large one. This would help move across it.

Now to achieve that, we have to bear in mind, I think, three fundamental principles.

First, continuity. To have this effect, the prize has got to be continuous, it has got to be reliable, and it has got to be predictable across the 10-year course of it.

Second, additionally. It has got, of course, to attract risk capital, but it should not do this at the expense of the basic funding for research for the hydrogen programs.

And finally, learning and adaptation over the course of the 10 years that this program would be in operation. We are going to learn a lot of things about prizes and a lot of things about this, and we need to have a conscious mechanism for adaptation.

Now, as requested, I would like to offer some suggestions for the operation of the program, and I would like to do this in the context of each of the three principle prize components or prize categories, I should say.

The first prize category is for advancements in components or systems. Now this is where you get the chief effect of the expansion of the research base, the attracting of new researchers into hydrogen-related activities. I would like to offer three suggestions for your consideration in looking at this part of the program.

One, to include in the criterion for eligibility, scientific discoveries that lead directly to components and systems. Now I know the point of the legislation is to provide an incentive for innovation and not for science, for applications and not for basic discovery. But in some cases, the applications themselves will be relatively

straightforward and fall right out from the scientific discovery once that discovery is announced, and so if we were to add directly related scientific discoveries to the criterion for eligibility, that would not only do justice in connecting reward to benefit, but would also remove any possible incentive for a discoverer to sequester a discovery until it could be embodied in some kind of device or component. And it would also increase the talent pool available for hydrogen-related research.

The second suggestion, allowing enabling technologies to be eligible. Now, by an "enabling technology," I mean an advance in a seemingly unrelated field that springs forward the advances in the field that one is seeking. Take battery technology, for example. Improved batteries would relieve pressure on the—for performance of a fuel cell and would have a dramatic effect in accelerating the hydrogen economy. And so this is what I mean by an enabling technology. Likewise, software for on-vehicle energy management, another kind of enabling technology. Hydrogen safety, carbon sequestration, there is a list of things that could significantly advance a hydrogen economy, but—and in my judgment, should be a part of the eligibility requirements.

The third suggestion that we apply the principle of continuity most strongly here. In order to attract people to an H–Prize competition, we need to build the pipeline of researchers and investigators, and that, frankly, starts at the high school level. It starts with interesting kids in science, showing them career opportunities in science, nurturing that through college through a graduate degree, and then into the research community. This pipeline takes a long time to build, and it takes continuity and assurance that that career will be there at the end of the pipeline to have the effective incentive.

Now the second prize category, that of prototypes, addresses one of the most important difficulties in science and innovation in this country today, and that is the gap between research programs and innovation funding. What is called, or what I call, maturation funds, perhaps seed capital for innovation is another way to think about it, are needed here to move across the gap between the two cultures. Some federal programs already provide this. The SBIR, STTR, ATP programs are certainly very capable in providing this, but here the reward is given—or the award, I should say, is given before the performance in anticipation of the performance. In contrast, the H–Prize would complement these by being given after the performance, and so it could be a very powerful supplement to these kinds of programs in providing this bridging funding.

The first prize category is that for transformational technologies for the distribution or production of hydrogen, which is, in my view, the most challenging. And I think special thought and care has to be put into the implementation criteria for this.

Finally, learning and adaptation is one of the most important parts of this program. Certainly the awarding foundation should report its results periodically and follow up the awards given to understand systematically what has come from this program.

In conclusion, I think this is a very valuable program and one that will help our energy security, the environment, and our competitiveness.

[The prepared statement of Dr. Bodde follows:]

PREPARED STATEMENT OF DAVID L. BODDE

Thank you, Ladies and Gentlemen, for this opportunity to discuss the *H–Prize Act of 2006,* now before this committee. I believe the H–Prize offers an innovative policy that could accelerate our nation's transition toward more secure and sustainable energy by:

- Stimulating and nurturing the relevant science and engineering research from which innovation must spring; and,
- Accelerating hydrogen-related research to cross the gap from science opportunity to investment opportunity.

To fully accomplish this, the H–Prize program should operate with several principles in mind.

- Continuity. The prizes must be offered reliably and for a period long enough to build the technology pipeline, rather than simply create a windfall for those already there.
- Additionality. The funds needed to support the H–Prize must supplement rather than compete with the core funding appropriated in support of hydrogen-related research and development.
- Learning. We cannot now anticipate the changes, social as well as scientific, that will occur over the 10-year life of the H–Prize program, and so the administration of the prize program must carefully document its experience, learn from that experience, and adapt accordingly.

In what follows, I will set out my reasoning in support of these summary points, and offer suggestions for the operation of the H–Prize program.

Building the Foundation: Advancements

The first category of the H–Prize structure, "advancements in components or systems," can serve to expand the research base upon which innovations will draw. These prizes would accomplish this by drawing attention to the importance of the hydrogen revolution, and by combining prestige with monetary value in attracting additional researchers into the field. To achieve the greatest benefit, however, I would suggest that consideration be given to:

- Including scientific discoveries that lead directly to components or systems in the eligibility for an "advancements" prize;
- Allowing enabling technologies to be included in the award criteria; and,
- Ensuring continuity over the ten-year life of the program to lower the career risk for technologists considering hydrogen-related research.

Including Directly Related Scientific Discoveries

The intent of the H–Prize is to accelerate the hydrogen transition by focusing on the application of technology, not the creation of new knowledge-and properly so. Yet the boundaries between science and innovation remain indistinct,[1] and in some cases a science breakthrough could directly release a wide array of components and systems. For example, Wilhelm Roentgen's announcement of the discovery of X-ray phenomena in 1895 was followed quickly by a host of applications in medical and other fields, none of which would have occurred in the absence of this seminal announcement. To allow this possibility for hydrogen, I would suggest including directly supporting science discoveries in the eligibility for this category of H–Prize.

Including directly connected science might offer two ancillary benefits as well. First, it could broaden the pool of researchers who would find the H–Prize relevant. And second it would remove any possible incentive to sequester a discovery until an applications device could be made.

Including Enabling Technologies

Technology revolutions often build upon combinations of advances in seemingly unrelated fields—often termed "enabling technologies." Consider home refrigeration,

[1] Research in science yields an understanding of the natural world and the laws that govern the behavior of materials, complex systems, living organisms, and so forth. In contrast, innovation concerns the man-made world and the creation of devices and methods that improve our daily lives. More so than science, innovation brings with it entrepreneurial and market considerations, thus making the real-world connections between these two phenomena complex and varied.

for example. When the mechanical refrigerator swept into the market in the 1930s and 1940s, it destroyed an industry (ice manufacturing and delivery), reshaped another (the corner grocery became the supermarket), and improved the productivity of homemaking enormously. Yet this innovation depended upon several enabling technologies for its success—efficient, small scale refrigeration cycles; widespread availability of electric energy; and compact, powerful alternating-current motors.

In the case of hydrogen, enabling technologies can prove powerful also. For example, a technology that greatly enhanced the safety of hydrogen use would serve the transition well even if it were not strictly related to any single component or system. Similarly, a breakthrough in carbon sequestration might allow coal, shale, and other abundant hydrocarbons to be used for hydrogen production without environmental damage. Such a breakthrough, though not strictly hydrogen production, would advance the transition markedly. Thus, I would encourage a very broad interpretation of the term "related to."

Providing Continuity

The general principle of program continuity applies most strongly in this first prize category. That is true because human beings must invest many years of preparation as their entry ticket for any field of technological research. For the prize program to draw additional entrants to hydrogen-related research fields, it must be perceived as stable over the time required for preparation and career launch—and for that reason, this category of H–Prize might diminish in attractiveness to new entrants as its ten-year "sunset" approaches. None of this militates against learning and adaptation in the awards process; rather, it suggests that greater predictability will make the awards more attractive to those considering a career in the field. Less predictability would have the opposite effect.

Crossing the Gap: Prototypes

The second category of H–Prize addresses one of the most important problems in science and innovation—the availability of maturation funds to move a technology across the gap between research funding and investment funding. This gap arises because research funding tends to asks questions of discovery, seeking knowledge of how the natural world works. Answers to these questions do not always illuminate how the constructed world—that of the devices and systems that serve humans—can be improved through innovation. In too many cases, potential investors cannot translate readily from scientific possibility to a marketable innovation, and so they await a prototype or some other evidence to help them judge the risks and returns from innovation. Thus a technology, even with ongoing research support, can languish in the chasm between research support and venture development funding. To be sure, some companies and foundations do invest in technology maturation research, but the resources are generally below the amount needed for greatest benefit. Thus, the prize would most probably add to the total resources available for innovation.[2]

The prototype category of the H–Prize could provide incentives for private parties—perhaps foundations, research corporations, or first stage investors—to commit technology maturation investments. In effect, it lowers the risk for investors funding a technology maturation project by offering the possibility that its cost can be recovered. The most astute of these investors would find their technology "bets" effectively hedged by the prize. The least astute would not—and, of course, should not.

Transformational Technologies

The third category of prize—a $10 million cash prize and a match for private investment funds up to $90 million—would reward major ". . .transformational changes in technologies for the distribution or production of hydrogen. . ." Thus it would provide incentives for the infrastructure side of the hydrogen market, which is likely to prove a highly capital-intensive undertaking. However, this prize category also poses challenges that appear greater than in the previous categories.

First, the prize might prove redundant. Entrepreneurs and venture capital investors seek opportunities with demonstrable potential for exponential growth—exactly the kind of venture that appears to be contemplated in the prize description. A new venture meeting these objective criteria would probably have little difficulty attracting venture capital, especially in view of the increasing risk aversion now characterizing the venture investment industry.[3]

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[2] The "prototype" prize category would also complement the SBIR, STTR, and ATP programs, which serve much the same function but with awards given in anticipation of success rather than after it occurs.

[3] The most urgent need is for early stage funding. In 2005, for example, only three percent of venture funds committed went for startup and seed capital investments. Early stage invest-

Second, one cannot know in advance the appropriate scale of investment, and hence the size of the award might not mesh well with the need. If the winning venture were small, the availability of a large federal match might tempt its owners to accept too much capital. Experienced venture investors recognize that too much funding can be as inimical to long term success as too little. On the other hand, if the winning venture were on the scale of, say, a shale oil plant (tens of billions of dollars), the prize would add little beyond prestige to the total incentive.

Learning and Adaptation

Learning and adaptation should be designed into the H–Prize process from the beginning for three reasons. First, the awards program will learn from its own experience, and can improve in response to that learning. Second, the ten-year duration of the H–Prize program will surely see significant advances in every field of science, especially the hydrogen-related technologies. Award categories most relevant at the beginning might well recede in importance 10 years into the future. And third, an evolving public recognition of the scope and urgency of the worldwide energy-environment-economy trilemma could lead to changes in energy policy over the period. Because of such changes, the award criteria (and possibly the administrative processes) that are most appropriate at the beginning of the program might become less so by its end.

For these reasons, I suggest that some formal process for learning and adaptation be included in the H–Prize program. An annual or biennial report of progress, to be submitted by the administering institution, could establish the factual basis for learning. These reports should surely include a follow-up analysis of each award to ascertain its outcome as measured against progress toward a hydrogen transition. To be sure, there is some tension between the earlier-mentioned principle of consistency and the desirability of adaptation with learning. The core idea should be to adapt the means but hold constant the ends.

In Summary

Reducing our nation's dependence on oil will improve the environment, relieve the economy of large income transfers to oil producers, and strengthen our national security. I believe the H–Prize, as set out in H.R. 5143, could do much to accelerate this greatly needed transition from petroleum to a hydrogen economy. This is a constructive and innovative proposal, and it deserves your fullest consideration.

BIOGRAPHY FOR DAVID L. BODDE

Senior Fellow and Professor, Arthur M. Spiro Center for Entrepreneurial Leadership, Clemson University. Research and expertise in:

- Intellectual property management
- Markets for new energy technology
- Corporate entrepreneurship
- Next-generation hybrid electric and hydrogen fuel cell vehicles.

PREVIOUS PROFESSIONAL EXPERIENCE

University of Missouri–Kansas City, July 1996 to September 2004

Charles N. Kimball Chair in Technology and Innovation at the University of Missouri, Kansas City. Joint appointment as Professor of Engineering and Business Administration.

Midwest Research Institute (MRI), January 1991 to July 1996

Corporate Vice President and President of MRI's for-profit subsidiary, MRI Ventures. Responsible for new enterprise development through cooperative research, new ventures, licenses, and international agreements. Managed technology development consortium of five private companies to commercialize technology from the National Renewable Energy Laboratory (NREL). Worked with Department of Energy and senior NREL management on strategic initiatives for the laboratory.

National Academy of Sciences, April 1986 to January 1991

Executive Director, Commission on Engineering and Technical Systems. Directed research and studies on public and private issues in science and technology.

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ment occupied another 16 percent. The remaining 81 percent went for expansion and late-stage investments. Data from National Association of State Venture Funds.

U.S. Government, March 1978 to March 1986

Assistant Director, Congressional Budget Office, United States Congress. Directed economic analyses of legislation affecting energy, industrial competitiveness, agribusiness, science, technology, and education.

Deputy Assistant Secretary, Department of Energy. Policy research regarding nuclear energy, coal, synthetic fuels, electric utilities, technology transfer and national security. Emphasis on nuclear breeder reactors and nuclear non-proliferation. U.S. delegate to International Nuclear Fuel Cycle Evaluation, which sought an international agreement on plutonium recycle and measures to slow the proliferation of nuclear weapons.

TRW, Inc., January 1976 to March 1978

Manager, Engineering Analysis Office, Energy Systems Planning Division. Built business using systems analysis and engineering studies. Emphasis on application of aerospace technology to energy problems, especially radioactive waste disposal and synthetic fuels.

U.S. Army, 1965 to 1970

Captain. Platoon leader, company commander, and battalion operations officer. Airborne and Ranger qualified. Service as combat engineer in Vietnam (1968–69). Bronze Star, Army Commendation Medals. Remained in the Army Reserve as an R&D officer advising on the management of defense laboratories and nuclear research programs.

EDUCATION

Harvard University

Doctor of Business Administration, March 1976. Doctoral thesis on the influence of regulation on the technical configuration of the commercial nuclear steam supply system. Thesis research cited in subsequent books on nuclear energy. Harding Foundation Fellowship.

Massachusetts Institute of Technology

Master of Science degrees in Nuclear Engineering (1972) and Management (1973). Atomic Energy Commission Fellowship. Experimental thesis on irradiation-induced stress relaxation.

United States Military Academy

Bachelor of Science, 1965. Commissioned Second Lieutenant, U.S. Army.

CORPORATE BOARD MEMBERSHIPS

Great Plains Energy

Board member of electric energy company, 1994–present. Chair, Nuclear Committee; Chair, Governance Committee; Member, Audit Committee.

The Commerce Funds

Founding director of family of mutual funds, currently with $2.2 billion assets under management. Growth and Bond Funds achieved Morningstar 5-Star ranking. 1995–present.

PERSONAL BACKGROUND

Grew up in Kansas City, Missouri. Married (since 1967) with four children. Enjoy competitive athletics, especially racquetball and tennis. Frequent backpacker, amateur historian, bad poet, and worse musician.

Author of The Intentional Entrepreneur (M.E. Sharpe 2004); co-author of *The Hydrogen Economy* (National Academies Press 2004); and editor of *Managing Enterprise Risk: What the Electric Industry Experience Implies for Contemporary Business* (Elsevier 2006). Additional publications in technology management, energy, and policy.

Chairman BOEHLERT. Thank you very much, Dr. Bodde.

Dr. Greene.

STATEMENT OF DR. DAVID L. GREENE, CORPORATE FELLOW, OAK RIDGE NATIONAL LABORATORY, CENTER FOR TRANSPORTATION ANALYSIS, NATIONAL TRANSPORTATION RESEARCH CENTER

Dr. GREENE. Yes, thank you.

Good morning, Mr. Chairman and Members of the Committee and all of those others present today.

We all are aware that our country faces serious energy problems, and I would like to thank Congressman Inglis for putting up this graph of Exxon Mobil's view of the world in the future, because I think it shows us three really important things that we need to keep our eye on. One is that demand for transportation fuels and petroleum fuels is going to continue to grow in the future. The second is that, even in Exxon Mobil's view, production outside of OPEC will reach a peak and they believe plateau, others believe decline. And the third is that the source of supply for the rest of that energy is OPEC, although it is highly unlikely that they will supply that energy, because, as the Department of Energy has shown in their own analysis and Professor Dermott Gately at NYU has shown, it—they can make more money—more revenue by leaving a good bit of that oil in the ground.

Our energy situation changed dramatically 35 years ago when oil production in the United States peaked in 1970, and it has never returned to that level. That and the formation of OPEC fundamentally changed the world oil markets. The peaking or the plateauing of oil production for the entire world outside of OPEC is going to make an enormous difference as well.

Now I don't know of anything that could do more to solve our nation's energy problems in the long run than the creation of technologies to enable clean and efficient, economical hydrogen-powered transportation. However, there are major technological barriers, independent technological barriers that stand in the way of doing this. And here, I would like to read from the report that—from the National Academies that Dr. Bodde participated in. They said: "There are major hurdles on the path to achieving the vision of the hydrogen economy. The path will not be simple or straightforward. Specifically, for the transportation sector, dramatic progress in the development of fuel cells, storage devices, and distribution systems is especially critical. Widespread success is not certain."

The Department of Energy's own Hydrogen, Fuel Cells and Infrastructure Technologies Multi-Year Plan echoes these same three technological challenges. They say: "Hydrogen storage systems for vehicles are inadequate to meet customer driving range expectations without intrusion into the vehicle cargo or passenger space. Hydrogen is currently three to four times as expensive as gasoline." And I think in saying that, they mean also delivery of hydrogen and including the cost of that. "Fuel cells are about five times more expensive." Some people say ten times more expensive. I would say in each of these areas, we are facing approximately order of magnitude challenges to changing the technology. Very difficult. And these technologies are not likely to be self-reinforcing. That is, we need, essentially, independent scientific breakthroughs in each of those three areas.

I think the H–Prize categories correspond well to these key areas in which breakthroughs are needed.

Another area that the National Academy Committee cited was the sequestration of hydrogen or production of hydrogen from renewables. Sequestration is not a part of this even though it would be a supporting technology, but I think that is appropriate as well, because sequestration is needed—going to be needed by many other fossil-fuel-using technologies, and I personally do not think the challenges there are as great as the ones for hydrogen that I have noted above.

I think this bill will increase the likelihood of overcoming these technological barriers by mobilizing creative minds that might not otherwise tackle them. And I think the—I would endorse their—the arguments given by Dr. Diamandis and Dr. Bodde on these points.

I would like to emphasize strongly, as strongly as I possibly can, that creating the H–Prize cannot substitute for adequately funding research, development, and demonstration. I realize coming from a National Lab that is a little bit self-serving, but nonetheless, I think it is true.

It is sometimes said that science is 95 percent perspiration and five percent inspiration. We have heard a lot about inspiration, but I want to emphasize that the perspiration is just as important. And there is simply no substitute for a sustained and concentrated effort. Thus, I see the H–Prize as a useful supplement to a well designed and adequately funded R&D program, and I think the writers of this bill have recognized that appropriately.

I have some other recommendations on specifics of how judges might be selected. I think that it would be appropriate for the judges to be selected independently rather than by a government agency. I think that clearly would show people that there is no political influence in this and that the prize is going to be awarded fairly.

Finally, I just wanted to congratulate the Committee and its staff for listening to the expert panel that it convened previously and reflecting those recommendations in their—the legislation, and I want to wish them every success with this important initiative.

Thank you.

[The prepared statement of Dr. Greene follows:]

PREPARED STATEMENT OF DAVID L. GREENE

Good morning. My name is David Greene. I am a Corporate Fellow of Oak Ridge National Laboratory where I have researched transportation energy policy since 1977. The comments I offer the Committee today are mine alone and do not necessarily reflect the views of Oak Ridge National Laboratory, UT–Battelle or the U.S. Department of Energy. I am also a National Associate of the National Academies. I point out these two affiliations in the interests of disclosure since some of my comments below pertain to these institutions.

We are all aware that our country faces serious energy problems. Despite world oil prices at or near historic highs, U.S. net oil imports averaged 60 percent for the year 2005 and for the first three months of this year, as well (USDOE/EIA, 2006). According to estimates by the Energy Information Administration, oil imports added $230 billion to our balance of trade deficit in 2005. By my own estimates, U.S. oil dependence costs, comprised of transfer of wealth to oil exporting countries and negative impacts on our Gross Domestic Product, amounted to approximately one quarter of a trillion dollars last year (Greene and Ahmad, 2005). By my best estimates, the economic costs of our oil dependence over the past three decades exceed $3.5 trillion. These estimates do not include political, strategic and military costs which are difficult to estimate but clearly very large.

I know of nothing that could do more to solve our nation's energy problems *in the long run* than the creation of technologies to enable clean, efficient, economical hydrogen-powered transportation. However, major technological barriers stand in the way of achieving this goal. I endorse the following conclusions of the National Academies Committee on Alternatives and Strategies for Future Hydrogen Production and Use (NRC, 2004) with respect to the technological barriers to hydrogen powered transportation.

> "There are major hurdles on the path to achieving the vision of the hydrogen economy; the path will not be simple or straightforward.
>
> Specifically for the transportation sector, dramatic progress in the development of fuel cells, storage devices, and distribution systems is especially critical. Widespread success is not certain." (NRC, 2004, p. 116)

The Department of Energy's Hydrogen, Fuel Cells and Infrastructure Technologies Multi-Year Research, Development and Demonstration Plan identifies three key "technology barriers" that must be overcome if the vision of hydrogen-powered vehicles is to be achieved.

- "Hydrogen storage systems for vehicles are inadequate to meet customer driving range expectations (>300 miles) without intrusion into vehicle cargo or passenger space.
- Hydrogen is currently three to four times as expensive as gasoline.
- Fuel cells are about five times more expensive than internal combustion engines and do not maintain performance over the full useful life of the vehicle." (USDOE/EERE/HFCIT, 2005, p. ii)

The H–Prize categories correspond well to the key areas in which breakthroughs are needed. As stated above, these are, (1) hydrogen storage, (2) fuel cell power train cost and durability, and (3) the cost of producing hydrogen, especially from renewable energy resources. A fourth critical area noted by the National Academy Committee is the sequestration of carbon if hydrogen is produced from fossil fuels. While this is indeed key to achieving the full environmental benefits of a hydrogen economy, I believe that the technological challenges in this area are not as great and, in addition, that it is not a problem peculiar to the use of hydrogen as an energy carrier. Other uses of fossil fuels will also likely require carbon sequestration.

From a scientific and engineering point of view, the needed technological breakthroughs appear to be independent. That is, a breakthrough in one area, e.g., onboard hydrogen storage, will not necessarily increase the likelihood of a breakthrough in fuel cells or hydrogen production. The fact that multiple, independent breakthroughs are needed magnifies the technological challenge. For this reason it is wise to mobilize creative thinking throughout our society.

I believe that H.R. 5143 would increase the likelihood of overcoming these technological barriers by mobilizing creative minds that might not otherwise tackle them. A substantial, prestigious prize provides motivation that an R&D contract cannot: a challenge with the promise of public recognition for scientific achievement. The H–Prize will also cast a wider net, potentially including individuals and organizations that would otherwise not be part of the hydrogen R&D effort.

Let me emphasize as strongly as possible that creating the H–Prize cannot substitute for adequately funding research, development and demonstration. It is sometimes said that science is 95 percent perspiration and five percent inspiration. The fact is, there is simply no substitute for sustained and concentrated effort. Thus, I see the H–Prize as a useful supplement to a well-designed and adequately funded R&D program.

H.R. 5143 clearly intends to isolate the H–Prize competition from political considerations and conflicts of interest. This is not only the right thing to do but is essential if the H–Prize is to provide the intended incentives for innovation. With this in mind, I believe it would be wise to specify in the legislation the independent third party to be responsible for selecting award winners. Designating an institution such as the National Academies that has a long and well established history of independent, objective assessment would make clear, in advance, that neither politics nor special interests would influence the selection of winners.

The draft bill states that the Secretary of Energy, through an agreement under section 3(c), shall assemble a panel of qualified judges to select the winner. . ." It is not clear to me from this language whether the Secretary of Energy has authority to appoint the judges or whether this authority would reside with the third party administering the competition. In my opinion, in order to avoid even the appearance of political influence in the selection of winners, the authority should be given to the independent third party.

Finally, I congratulate the Committee and its staff for listening to the expert panel it convened on the H–Prize, digesting their recommendations and incorporating them in this draft legislation. I wish you every success with this important initiative.

Thank you for your attention. I look forward to answering any questions you may have to the best of my ability.

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BIOGRAPHY FOR DAVID L. GREENE

A Corporate Fellow of Oak Ridge National Laboratory (ORNL), David Greene has spent 25 years researching transportation energy and environmental policy issues. Dr. Greene received a B.A. degree from Columbia University in 1971, an M.A. from the University of Oregon in 1973, and a Ph.D. in Geography and Environmental Engineering from The Johns Hopkins University in 1978. After joining ORNL in 1977, he founded the Transportation Energy Group in 1980 and later established the Transportation Research Section in 1987. Dr. Greene spent 1988–89 in Washington, DC, as a Senior Research Analyst in the Office of Domestic and International Energy Policy, U.S. Department of Energy (DOE). He has published more than one hundred seventy-five articles in professional journals, contributions to books and technical reports, and has authored or edited three books (*Transportation and Energy, Transportation and Global Climate Change,* and *The Full Costs and Benefits of Transportation*). Dr. Greene served as the first Editor-in-Chief of the *Journal of Transportation and Statistics,* and currently serves on the editorial boards of *Transportation Research D, Energy Policy, Transportation Quarterly,* and the *Journal of Transportation and Statistics.* Dr. Greene has been active in the Transportation Research Board (TRB) and National Research Council (NRC) for over 25 years, serving on several standing and ad hoc committees dealing with energy and environmental issues and research needs. He is past Chairman and member emeritus of TRB's Energy Committee, past chair of the Section on Environmental and Energy Concerns and a recipient of the TRB's Pyke Johnson Award. In recognition of his service to the National Academy of Science and National Research Council, Dr. Greene has been designated a lifetime National Associate of the National Academies.

Chairman BOEHLERT. Thank you very much, Dr. Greene. Don't worry about being a little self-serving with your testimony. On occasion, we are noted for that, too.

Mr. Baxley.

STATEMENT OF MR. PHILLIP BAXLEY, PRESIDENT OF SHELL HYDROGEN, L.L.C.

Mr. BAXLEY. Thank you.

Good morning, Mr. Chairman, Members of the Committee. I want to thank you for your invitation to testify here today. Let me just, one more time, repeat, I am Phillip Baxley. I am President of Shell Hydrogen with responsibility for Shell's hydrogen business activities in North America.

Shell Hydrogen's global business was set up more than seven years ago to pursue and develop business opportunities related to hydrogen and fuel cells. In fact, I am pleased to note that Shell Hy-

drogen was actually asked to testify before this same distinguished Committee over six years ago on the emerging issue and the emerging importance of hydrogen.

A hydrogen economy, Shell believes, provides benefits through economic growth, job development, investment opportunities, and a sustainable, secure energy supply. Additionally, hydrogen can directly address air pollution and provide many pathways to address the reduction and eventual elimination of greenhouse gases.

The primary challenges, at this time, are to further develop fuel cell vehicle technology and achieve mass production levels. I believe the development of a Hydrogen Prize can supplement and extend the great work that is already being done in these areas.

The goal of providing hydrogen as a fuel on a significant scale requires a coordinated undertaking within all levels of government, the automotive industry, the energy companies, and the supply network.

From a fuel supply perspective, there has been a hydrogen economy, and is a hydrogen economy, and hydrogen infrastructure in place for decades. Globally, 50 million tons of hydrogen are produced and consumed every year, mainly in our own refineries and chemical plants, and mostly used for producing clean traditional fuels. Just to put this number in perspective, this amount of hydrogen could power all the family vehicles in the United States if they were fuel cell vehicles.

Additionally, most areas of significant population are close to hydrogen production facilities now. The challenge, then, is to bring hydrogen into the everyday lives of consumers in convenient locations.

[Slide.]

This can be done, and it is already being demonstrated conceptually, at Shell's Benning Road station right here in Washington, DC, which you can see on your monitors here. And I would also point out that this is an example from Shell, who has been working on this over seven years, of an example of actually going out and doing it and trying to make this happen. And I would also invite those of you who haven't had the opportunity to come out and visit the Shell hydrogen station on Benning Road to do so, to drive a fuel cell car, and to fuel up with hydrogen.

Our Benning Road station is a part of a longer-term goal of establishing a number of large-scale, integrated pre-commercial activities, which we call "Lighthouse Projects."

Last year, through the passage of the Energy Policy Act, Congress demonstrated a commitment to producing commercial fuel cell vehicles and developing a hydrogen infrastructure. I would like to commend Representative Inglis for his leadership in introducing H.R. 5143. The Federal Government can have an important role in fostering technological innovation. The creation of the Hydrogen Prize is an important step in that direction.

In support of an H–Prize, I want to highlight three areas: leadership opportunities and significance of visible Congressional support, involvement and innovation across a broader community, and commercialization and the growing global market.

First, the H–Prize will raise the profile of hydrogen on the national stage and demonstrate visible leadership from Congress on

an important issue for the economy, the environment, and from a national security perspective. The Energy Policy Act helped the hydrogen economy emerge in a larger, more substantial way. A Hydrogen Prize demonstrates further leadership to increase public awareness around hydrogen, thereby working towards a successful evolution of hydrogen commercialization.

Secondly, an H–Prize will stimulate involvement and innovation across a much broader community than the Department of Energy programs or funding alone can provide. The incentives outlined in the H–Prize Act are competitive, but it is imperative that the H–Prize is well managed so we do not weaken the Department of Energy program when we are appropriating these funds. It is important to expand on the progress being made to the implementation of the energy bill and continue to develop clear, consistent government policy for hydrogen so the market can thrive.

One of the strongest points in support of the H–Prize is the ability to stimulate involvement and innovation across a much broader community than it is possible with DOE funding. For example, student competitions at universities, at small labs, at start-up companies, and my favorite is even the folks in their garages will be able to participate, which has been a hallmark of American ingenuity and competitiveness in so many other pioneering areas. And perhaps not just in the United States, but such a prize would likely attract interest and talent from around the world.

Finally, an H–Prize can only accelerate commercialization and support the growing global market. The race for global dominance in the hydrogen economy has begun. Shell believes that hydrogen will likely be widely used commercially within the next generation in the United States, Western Europe, China, and Japan. An H–Prize can play a role in assuring U.S. leadership in the development and deployment of a hydrogen economy by attracting world talents to the United States. The market applications are the ultimate prize for many of the participants, however, the criteria established to award prizes needs to be considered well in order to properly stimulate innovation in the marketplace. The scope of the prizes awarded through the H–Prize also need to be well defined and well thought out.

This issue is more important than ever, and we need to do it right.

Thank you all for the opportunity to testify here today. This concludes my testimony. I would be happy to answer any questions you have.

[The prepared statement of Mr. Baxley follows:]

PREPARED STATEMENT OF PHILLIP BAXLEY

Good morning Mr. Chairman and Members of the Committee, thank you for the invitation to testify today. I am Phillip Baxley, President of Shell Hydrogen LLC, with responsibility for Shell's hydrogen business activities in North America.

Shell Hydrogen's global business was set up more than seven years ago to pursue and develop business opportunities related to hydrogen and fuel cells. Our goal is to bring hydrogen into commercial use for transportation and other related needs. Through existing and planned demonstration projects Shell Hydrogen is bringing hydrogen out of its industrial settings to places where consumers can access it as a fuel for their vehicles.

You are all aware of the energy challenges we face here in the U.S. and around the world. In North America, Shell is a leader in the development of unconventional

hydrocarbon resources, like shale oil and tar sands, as well as renewable energies and hydrogen technologies. We remain committed not just to increasing the world's energy supply, but to broadening its portfolio as well. A national energy portfolio that includes significant use of hydrogen fuel and fuel cell applications will make lasting contributions to our future energy needs. Last year, through the passage of the Energy Policy Act, Congress demonstrated a commitment to producing commercial fuel cell vehicles and developing a hydrogen infrastructure. We are pleased to see further congressional support through legislation complementing ongoing activities put in motion by the energy bill.

The goal of providing hydrogen as a fuel on a significant scale requires a coordinated undertaking within all levels of government, the automotive industry, and energy companies. Most of the research and development attention is focused on finding an inexpensive on-board hydrogen storage solution, and I hope the development of a hydrogen prize can supplement the work that is already being done. We must also address the technical and operational challenges through public-private partnerships and identify what is needed to accelerate the commercialization of hydrogen fuel cell technology. In many respects, hydrogen vehicles must be part of our primary focus because it is the vehicles themselves that are furthest from commercial readiness.

From a fuel supply perspective, there has been a hydrogen economy and hydrogen infrastructure in place for decades. Globally, 50 million tons are produced and consumed every year, mainly in our own refineries, for producing clean traditional fuels. To put this number into perspective, this amount of hydrogen could power all the family cars in the U.S. if they were fuel cell vehicles.

Additionally, most areas of significant population are close to hydrogen production. [Images 1 and 2] Now the test is to bring hydrogen into the everyday lives of consumers in convenient locations.

This can be done and is already being demonstrated, for example, with our Benning Road station here in Washington, D.C. [Image 3] As you may know, President Bush and a number of Members, staff and agency officials have visited the facility—over 1,400 visitors since the November 2004 opening.

The Benning Road station is part of our longer-term goal of establishing a number of large-scale, integrated pre-commercial activities, which we call "Lighthouse Projects." We are focusing on a limited number of projects—mainly transportation applications involving hundreds of vehicles and several combined hydrogen and gasoline refueling stations. Because significant numbers of vehicles are required for 'real world' operational experience in order to validate network supply and refueling operations, we are focused on the northeast and west coast corridors at this time. Before the end of the year, we plan to have two more stations on-line in New York and Los Angeles.

The Hydrogen Prize Act of 2006

I would like to commend Representative Inglis for his leadership in introducing H.R. 5143. The Federal Government can have an important role in fostering technological innovation—the creation of the Hydrogen Prize is an important step in that direction.

My remarks will cover the following areas:

1. Leadership opportunities and the significance of visible congressional support.
2. Involvement and innovation across a broader community.
3. Commercialization and the growing global market.

First, the H–Prize will raise the profile of hydrogen on the national stage and demonstrate visible leadership from Congress on an issue that is important for the economy, the environment and from a national security perspective.

A hydrogen economy will not emerge by virtue of technology alone. Any development will be a combination of technology, economics and policy decisions.

The Energy Policy Act helped the hydrogen economy emerge in a larger, more substantial way. A Hydrogen Prize demonstrates further leadership to increase public awareness around hydrogen, thereby working toward a successful evolution of hydrogen commercialization.

Shell sees hydrogen as an important part of our future energy mix. To market hydrogen within the foreseeable future, we working along two channels—first, to increase public awareness of hydrogen-based projects and further explore retail hydrogen fueling stations, and second, by actively supporting technological development essential for rendering hydrogen accessible to a broader market. We work with partners to promote and support the development of the infrastructure and technical so-

lutions that the world needs because we know we cannot do it alone. On the basis of raising the awareness of hydrogen and promoting it as a stable energy carrier, this legislation will provide an opportunity to address these challenges, as well as allowing for new technical jobs and building new supply chains.

There are several critical hurdles to overcome before hydrogen can reach its full potential in the market. Shell will continue to work together with our partners in the industry and different areas of government to achieve sufficient levels of mass production to drive down costs while meeting the energy needs of the country. It will be helpful to open up to a broader group through the management of a prize because prize incentives have a place in conquering our emerging technology hurdles.

Secondly, an H–Prize will stimulate involvement and innovation across a much broader community than the Department of Energy programs and funding alone can provide.

The incentives outlined in the H–Prize Act are competitive, but it is imperative that the H–Prize is well managed so we do not weaken the existing Department of Energy program budget when appropriating these funds. It is important to expand on the progress being made through the implementation of the energy bill and continue to develop a clear, consistent government policy for hydrogen that the market can thrive in.

One of the strongest points in support of an H–Prize is the ability to stimulate involvement and innovation across a much broader community than is possible even with DOE funding. For example, student competitions, universities, small labs, startup companies, even folks in their garages can participate—which has been a hallmark of American ingenuity and competitiveness in so many other pioneering areas. And perhaps not just in the U.S., but such a prize would likely attract interest and talent from around the world as well.

A hydrogen economy provides benefits through economic growth, job development, investment opportunities, and a sustainable secure energy supply. Additionally, hydrogen can directly address air pollution and provides many pathways to address the reduction and eventual elimination of greenhouse gases. The primary challenges at this time are to further development fuel cell vehicle technology and achieve mass production levels. Commercialization will not be achieved without these two components working with our effective utilization of refueling facilities and supply systems.

The current Department of Energy funding and fuel validation program are extremely important technology development programs. To move research to reality now requires further attention to the bridge that needs to be built in the next ten years from small-scale demonstrations toward commercial operation.

Finally, an H–Prize can only accelerate commercialization and support the growing global market.

The race for global dominance in the hydrogen economy has begun. Shell believes that hydrogen will be widely used commercially within the next generation—in the United States, Western Europe, China and Japan. An H–Prize can play a role in assuring U.S. leadership in the development and deployment of the hydrogen economy by attracting world talents to the U.S.

The benefits of hydrogen as a clean, competitive energy solution can be delivered to millions of people around the world in the next twenty years. Any innovation requires time because of technical issues, public acceptance and practical experience.

It is often said that developing the hydrogen economy will be a marathon, not a sprint. The course will not be completed quickly; we need to prepare for a long commitment. This is an evolution; we cannot switch to the new vehicles or construct a whole new infrastructure of hydrogen filling stations and distribution networks all at once.

As with all energy transitions, this transition will take time and occur in phases. Technological advances and market acceptance are expected to define the phases. In addition, a corresponding education effort in hydrogen safety will ensure public readiness as hydrogen becomes increasingly available.

The use of hydrogen will accelerate over the next 10 to 20 years as the technologies and infrastructure evolve. The market applications are the ultimate prize for many of these participants. The criteria established to award prizes needs to be well understood in order to be valuable in the marketplace. The scope of the prizes awarded through the H–Prize Act need to be well defined. This issue is more important than ever and we need to do it right.

Conclusion

Increased use of hydrogen as a fuel provides benefits to energy security, the environment and economic growth. Developing a Hydrogen Prize is attractive from a public policy standpoint because hydrogen can be produced from a wide range of primary energy sources—finding the most efficient and marketable way to do this is definitely something the government is in the position to promote and lead. The future is in our hands and the obstacles can be overcome if we make the right choices about hydrogen today.

Thank you for the opportunity to appear before the Committee today. This concludes my testimony. I would be pleased to answer any questions you may have.

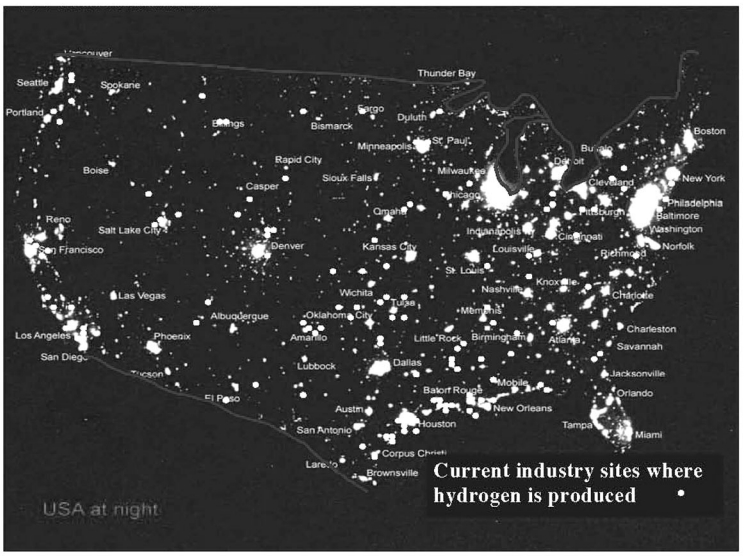

Image 1: Satellite image of the USA at night overlaid with the major areas of hydrogen production facilities.

Image 2: Satellite image of the USA at night overlaid with the areas within 60 miles of current production sites.

Image 3: Shell's Benning Road Retail Facility, Washington, D.C.

BIOGRAPHY FOR PHILLIP BAXLEY

Phil Baxley is President of Shell Hydrogen LLC and General Manager of Business Development for Hydrogen in North America. Shell Hydrogen, a unit of Royal Dutch Shell's global Renewables and Hydrogen business, was established in 1999 to pursue and develop business opportunities related to hydrogen fuel and fuel cells. Mr. Baxley has been with Shell Hydrogen for six years, with prior Shell assignments in Exploration and Production, Business Development, Research & Development and Engineering. Before joining Shell, he was an Environmental Consultant with Intera Technologies of Austin, Texas. Mr. Baxley has degrees in biomedical engineering (Rice University) and chemical engineering (University of Florida) and serves on the Boards of Questair Technologies and the National Hydrogen Association.

DISCUSSION

Mr. INGLIS. [Presiding.] Thank you, Mr. Baxley.

The Chairman put me in the Chair, so that means I get to ask questions first, which is a wonderful opportunity.

And I would take us back to 1957. Sputnik has just been launched, and you know, maybe it doesn't matter. Maybe we should just let the Russians go to the moon, and perhaps the market will come up with a solution. Perhaps someone will want to go to the moon and compete with the Russians. And maybe it doesn't matter. Maybe the government doesn't need to do anything.

That is not exactly what happened in 1957 and following. What happened was we in America responded and began an enormous race, a race that has benefited us ever since with all of the technology that we are enjoying even as we sit here.

So to those that missed the national security implications of our current posture from reliance on a fuel source that we don't control, I would encourage them to think beyond the possibility that maybe the market can come up with a solution to that. Perhaps there is a role for government in getting us, as quickly as possible, beyond this danger point that we are in.

So that is not a question. That is further commentary.

But Mr. Baxley, why is it important to accelerate the commercialization? Maybe the market is just going to get there. The market, as you said, is the prize. Why accelerate to commercialization?

Mr. BAXLEY. Well, for us, for me, as a businessman, Shell is in this as a business, and we view hydrogen, biofuels, solar, wind, all as business opportunities for the future. We see the need for those businesses. And so in any of those businesses, we are looking for opportunities as to how do we move that towards commercial reality sooner than later. How do we take those investments and make them real? So for hydrogen specifically, I think the challenge is, a lot of—in a lot of cases, there is great technology work being done. There is a great deal of work being done on how to make this happen within companies, within the government, but I think there is also a need to address many of the other aspects of hydrogen. That is, raise the awareness on the part of the public, in terms of consumers about hydrogen and the realities, and the H–Prize is one way, among many, that we might do that.

So one of the attractive features of us as the Hydrogen Prize, and by the way, the Hydrogen—a Hydrogen Prize is something that we in Shell have been thinking about, actually, for some time would be a good motivator. If done properly, a Hydrogen Prize would be

a good motivator to inspire to engage a much broader community to work on not only the technical challenges but also to drive to bring this to reality. Because what we found is that when you get technology to the marketplace, that is when the real innovation happens. So as soon as possible, they are looking for ways to inspire people to put the technology, to get it applied, and let the innovation happen after that.

Mr. INGLIS. Dr. Diamandis, is that inspiring the public, what you are talking about, with a paradigm change?

Dr. DIAMANDIS. It is, and the question, sir, is the prize has to be simple and well defined. And for example, when we did the Ansari X Prize, there were so many different ways we could go. And there is an issue of what I call sufficiency. We didn't shoot, for example, for the Prize to go to orbit. In fact, originally, we were shooting for a Prize to go to 100 miles altitude, and we backed it off from 100 miles to 100 kilometers, 62 miles. Most people don't know the difference between the two, but we did. The energy requirements were significantly more. And by taking 100 kilometers and three people, which took us a year of work to figure out that one crisp, clear goal. We were—it was achievable. It was sufficient—it was an issue of sufficiency. It was sufficiently large enough to capture the passion and get things going. And now that that is in place, the industry has ignited. We are talking to NASA about a $50 million orbital prize.

So my question is, you know, to pick the right problem to solve to get people thinking about this stuff differently. In space tourism, or personal spaceflight, 10 years ago, was a laughable matter. People, you know, thought it was this far away thing, not possible. The—you know, the Ansari X Prize brought it into, "Oh, yeah. It is now possible." And it changed the way people thought about that.

So I would say in issue of energy independence and so forth, you know, what is that right first prize that is achievable in the near term and, once achieved, then ignites people and people say, "Oh, of course we can get independent of oil. Of course we can reduce CO_2 emissions." So I—those are my thoughts on that.

Mr. INGLIS. Thank you.

I think my time has expired.

Dr. Lipinski.

Mr. LIPINSKI. Yeah. Thank you.

Thinking about the X Prize makes me go back to—it probably was the late '70s, not that anyone remembers the TV show "Salvage 1" where, essentially, that was it. Some people put together in their backyard a—some sort of rocket ship. That is about all I remember about it, but it certainly, as a kid, really got me even more interested. I was interested in the space program and everything, but that idea really did resonate with me. I don't think it resonated with too many viewers, because I don't think it was on too long, but—so I like that idea.

But I want to go to Mr. Baxley who sort of brought this up and suggested that we will have people with this H–Prize, you know, working on—in their garages. And it will bring all kinds of people into working on this hydrogen project because of the H–Prize.

My big question is: is it going to really be—I want to hear what everyone has to say about this. Okay. Mr. Baxley, from Shell, certainly Shell is on a different—completely different playing field than someone in their garage or any other researchers probably. Who is really going to be inspired to get involved in this? Is it actually going to wind up being the big corporations who are already doing some of this research who are really going to be the ones who are doing this? Or is this—and so it is not going to really make a difference. Or are there going to be other people who the prize actually gets them interested in it, and do they actually have a chance to make the type of breakthrough that someone with a company with a large amount of money behind it has the ability to do?

So I just wanted to go and I want to ask each of the witnesses what their thoughts are on this. So we will start with Mr. Diamandis.

Dr. DIAMANDIS. Thank you, sir.

I think, again, if the prize is well structured and dramatic enough, there are enough billionaires and multi-millionaires out here that would love to go and win this. Paul Allen gives credit to the X Prize for the $25 million investment he put into SpaceShipOne's development. He read about it on the internet and said, "Wow, this is a really cool thing." You know, "Who can I get to go and win this?" And he teamed with Burt Ratan, who had presented it to him, and he went and pursued this.

So again, it has to be something that is dramatic. It has got to be something that evokes heroism. And it can't just be about a technology. You know, GE's efficient refrigerator did not make front pages, but humans risking their lives and doing something amazing does.

Dr. BODDE. Sir, I recently had the privilege of talking to a group of high school students in Greenville, South Carolina, and this was after Congressman Inglis had just introduced the idea of the H–Prize. And I think, starting not from the billionaires but from the other end of the market, I want to be able to look at a class of students and say, "Look, this is important stuff, and there are career opportunities for you in this. And if you are good enough, and I want all of you to be good enough, you can win this prize, and here is what it is. And it is going to be available for you, and you can work your way through this lengthy pipeline, from difficult science classes to difficult college science classes to a doctorate to a research institute, and you could win this thing." I want to be able to say that. And if I can say that with credibility and people all over the country can do that, I think we will have considerable motivation.

Mr. LIPINSKI. Dr. Greene.

Dr. GREENE. Well, I think I agree with both of these points. Entrepreneurs, with some money to risk and the desire to take a risk and see if they can achieve, that is one. People at—professors at universities who might be inspired to try this with an idea that doesn't require a lot of money but is something no one else has thought of. Through—I think the motivation for a large company like Shell and their research laboratories is smaller but still there. They would like to win the prize, I think, and get the recognition

for that. Of course, for us, National Laboratories, we are specifically excluded, but I think that is okay.

Mr. LIPINSKI. Well, Mr. Baxley, does it make a—does this really make a difference to Shell? And the other question would be—I would—I don't know enough to know specifically, but I would imagine, okay, you are with Shell Hydrogen. There must—you must be at a point and have information, have the research done that would put you ahead of others, at this point, being able to reach the—this prize. I—so does it make a difference? You had said it would make a difference. So for a second question, do you think your company and other companies are probably far ahead of anyone else in being able to reach this?

Mr. BAXLEY. Well, let me just make a couple of comments.

I think, first of all, Shell, very much, is focused on, you know, how do we bring the fuels our customers are going to need to the market for the 15,000 retail outlets we have in the country. How are we going to make a business out of that? But there are many, many more aspects to doing that. This is not just about the technology. It is about the market acceptance. It is about all of the codes and standards that have to be developed. It is about awareness on the part of fire marshals, awareness on the part of consumers. It is really an exposure of all of this stuff that has to happen, and we are working on that, not just on technology but we are working on outreach programs through the National Hydrogen Association and others. But the Hydrogen Prize, to us, is much more about raising—simply raising the debate, raising the dialogue, raising the awareness that hydrogen is not only challenging, but is also attainable, and it is also something that is something that this country should pursue as one option, as one big option, and try to make that happen. No assurances it will happen. We are committed to it. The Hydrogen Prize is really a testament to the government and to the government's leadership in trying to make that happen, not only in the way that it inspires entrepreneurs to participate. I will give you a specific example for Shell Hydrogen. We are not only doing hydrogen stations, we are the only ones setting up joint venture companies to work on technologies with other partners. We also have set up two venture funds, one here in North America, and one in Europe, and we are setting up one in Asia. Those venture funds that we invest with other companies specifically for the purpose, not only of understanding what other technologies are out there, what other opportunities there are to invest in, but to seed the things that need to happen that—we can't do all of that ourselves. There are so many things that need to happen. And such a large undertaking is moving—this is really an unprecedented undertaking, if you think about it, to move from where we are with petroleum-based fuels, to move to a hydrogen fuel infrastructure with hydrogen-fueled vehicles. There are so many aspects to that. A Hydrogen—the Hydrogen Prize touches on many, many of those things, not only in technology, not only public awareness, it also touches on an incredibly important issue to us, as a business, and that is inspiring people like you, Congressman, but scientists and engineers we are going to need in the future to—aspiring them to get into this business. So many, many positive aspects from a fairly modest investment.

Chairman BOEHLERT. Thank you very much.

Mr. LIPINSKI. Thank you.

Chairman BOEHLERT. The gentleman's time is expired.

We want inspiration and incentives, and this is a combination of the two.

Dr. Diamandis and Dr. Greene, here is one for you.

You both mentioned the important need to clarify and clearly divide responsibility for the Prize between DOE and whatever entity is chosen to administer the Prize. First, we may need to make even clearer that we do expect an outside entity to administer the award. At what division do you recommend? And what if DOE established a criteria for the Prize and some criteria for selecting judges, such as avoiding conflicts of interest, which is a natural, and then let the administering organization pick the judges and the winner. Would that work? And does that description leave out any task?

Dr. Diamandis.

Dr. DIAMANDIS. Thank you, Mr. Chairman.

I think your point is a very, very important one.

The DOE, using them as the example, should really be defined—it should be, really, in charge of providing the capital, the Prize money, and helping to define what are the problems they want to solve. After that, I believe that the hand-off should take place to an organization that can manage and run the Prize.

What do I mean by that?

The rule development is something that from—in our organization, we bring—my vice chairman, for example, is the Fellow Bob Weiss, who has produced 26 motion pictures. The human drama element, the story line of the Prize is very critical. The technology development is the package in the middle and wrapped around it is the human story. And if that is not taken properly—I—so I don't think the engineers in DOE are going to worry about that part, how it is portrayed on television or the front page in newspapers or talked about on the—around the water cooler. And in fact, it is that packaging that really allows the marketing and the expansion and generates the paradigm shift. The technology comes along for the ride.

So the rules development, I agree with the comments made earlier, that the judging should be completely independent, so it is a group—the outside managing organization selects qualified judges——

Chairman BOEHLERT. So the administering organization picks the judges——

Dr. DIAMANDIS. Yes.

Chairman BOEHLERT.—and the winner?

Dr. DIAMANDIS. Yes. Should select the judges. The judges would then select the winner. The rules have to provide for very clear-cut, measurable results that the judges can say they either met or not. Period.

Chairman BOEHLERT. So the Prize selection criteria would be developed by the administering agency?

Dr. DIAMANDIS. Yes, sir.

Chairman BOEHLERT. Okay.

Dr. Greene.

Dr. GREENE. I think that is about right. That satisfies my concern that despite the fact that the Secretary of Energy is obviously a person of great integrity, you don't want to put him in the position of being political appointees selecting the judges for the technical contests. Rather, that should, I think, be done independently so that it is very clear to everybody involved there is no politics in this. There is no bias. There is no anything. This is going to be a fair and open competition. I think that is absolutely essential. And I think it is correct that the Department of Energy should say, "These are the things we want to get out of this Prize." They have very carefully developed an R&D plan that, with consultation with industry, with consultation with the universities and all across the board, they know what the technical challenges are.

And I guess my only issue is that it must be that the administering organization understand those technological questions as well.

Chairman BOEHLERT. Another comment?

Thank you very much.

Mr. Udall.

Mr. UDALL. Thank you, Mr. Chairman.

I want to welcome the panel. Thank you for your time today.

There are, as you all know, a number of myths associated with hydrogen and the hydrogen economy. And as you point out in almost all of the testimony today, we have a long road to travel to build the infrastructure, to educate citizens. But in particular, in that spirit, I want to focus on the question of should the Prize be targeted explicitly at renewable hydrogen production. Right now, most of the hydrogen, as I understand it, that is produced, is produced by reforming conventional fossil fuels. And if that is the road down which we are going to travel, I think the benefits are less, obviously, than if we move to a—truly a new energy regime, a new hydrogen energy regime.

So I wanted to direct that question at the panel. And also, if you could, talk about any technological hurdles that we would expect to overcome.

Maybe I can start from right to left, my right to left, Mr. Baxley, and then move across.

Mr. BAXLEY. Well, thank you, Congressman.

I would say that, certainly, Shell believes that the road to a hydrogen economy has to go through sustainability, and it ultimately has to be delivered—renewable hydrogen. And that is a challenge we are working on. I think, and though we haven't worked out the—I would fully support that an aspect of the Prize has to be about, you know, how do we do that. How do we get the sustainable green hydrogen?

Mr. UDALL. Next, Dr. Greene.

Dr. GREENE. I agree with that. I think all of the analyses we have done indicate that the cheapest way to make fossil—to make hydrogen is from fossil fuels, in the future from coal rather than from natural gas, as it is made today.

I think we face a question as to how important it is to keep the price down in—especially in the early stages of introduction versus have renewable. But it is clear that if we make hydrogen from coal and we don't sequester the carbon, we will increase greenhouse gas

emissions rather than decrease greenhouse gas emissions, even with the efficiency improvements that hydrogen fuel cell vehicles would offer.

Mr. UDALL. Dr. Greene, is it—technological research suggests that it is easier to sequester that carbon than it would be in a conventional power plant today?

Dr. GREENE. Yes.

Mr. UDALL. Yes.

Dr. Bodde.

Dr. BODDE. Well, I certainly agree with those comments, but I would just add one other thing, and that is that the beginning of a hydrogen economy will probably produce hydrogen very differently than we will in a mature, steady state hydrogen economy, and we ought to allow for that prospect as well in thinking about the H–Prizes, because we have to remember what these H–Prizes do. This is seed capital. This is the very earliest innovation capital into an area. And if done right, it springs loose the rest of the whole thing. But if we go right for the end state at the very beginning, we may never get there. It may be too hard.

And so I certainly agree with the other comments, but I would at least allow a possibility for production of hydrogen from fossil fuels, properly sequestered as well.

Mr. UDALL. I apologize if I mispronounced your name.

But what you are saying is you want to spread the technology, get people excited, demonstrate it, and if that involves the traditional approaches to producing hydrogen today, you think that is a trade-off worth accepting, knowing that over time we can move to the more visionary hydrogen economy that we all are excited about?

Dr. BODDE. Yes, sir. I believe that is the case. I believe there will be a transition period in which we will have to do things that will be, perhaps, less than optimal from the ultimate hydrogen economy perspective, but those will fade eventually.

Mr. UDALL. Doctor?

Dr. DIAMANDIS. Sir, one of the best points about prizes is if they are properly structured, and I can't stress that enough, they don't prejudge the solution, and they allow for radical ideas to come bubble up from outside the normal industry. Again, one of the difficulties, of course, is that we are humans and we have developed industries, and we have—we tend to see things within the way we are used to. But if a prize is properly structured and the rules are set, you really have the ability for something to blindside you out of no place: genetically engineered algae or microbes that generate hydrogen or new physics, a new chemistry that comes from a laboratory some place in the middle of, you know, a small town in India. You know, those are the things that you hope for. And everything—the entire success of the Prize 5 or 10 years out all depends on what is done in the first six to 12 months of writing those rules. But if the rules are written properly, great. But the chances are very much against those. And there are some great stories I can tell you about rules properly—not properly written that would waste $100 million.

Chairman BOEHLERT. Well, we can tell you some of those rules, too.

Mr. UDALL. I would——

Chairman BOEHLERT. The gentleman's time has expired.

Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you very much, Mr. Chairman.

I would like to thank you, Mr. Chairman, for your leadership on this and other issues dealing with energy and trying to find answers to the challenges that we face in the future.

And special thanks to Chairman Inglis and the leadership he is providing specifically on this issue. And I look forward to working with you and developing this concept and getting this through the process.

Let me start, however, with one fundamental question about hydrogen that is actually stemming from Mr. Udall's questions, and that is: we do have to have a fundamental other energy source in order to make the hydrogen before that becomes anywhere near economically feasible, is that correct? Well, we—as we just heard. Why is nuclear energy not one of the things that is being on the plate here? I mean, I didn't hear any discussion about nuclear energy. Isn't that the ideal, if we are talking about greenhouse gases, which I may or may not be concerned about in terms of global warming, but I may be concerned about getting things going into the air for other reasons? Isn't nuclear energy the ideal source of energy for producing hydrogen?

This is to the panel. And of course Mr. Diamandis doesn't want to comment on that, but what about the other three? And then I will have one for you, Mr. Diamandis.

Dr. BODDE. Well, I—in my judgment, sir, I certainly think that is on the table. I certainly think it should be one of the competitors. But as my colleagues have said, one does not want to prejudge the solution. One wants an open competition for these kinds of early stage breakthroughs without any bias toward one or another of the contestants.

Dr. GREENE. There are, essentially, two pathways that are being considered in the research program with respect to nuclear energy. One is nuclear energy via electrolysis to produce hydrogen. That has very serious cost problems. Nuclear energy is a relatively expensive way to make electricity in the first place, and electrolysis is currently the most expensive way to make hydrogen, so you have a very difficult problem on that path.

In the long run, there are thermochemical processes that are being worked on, but most, including the National Academy report, consider these to be among the most long-term future technologies for producing hydrogen. That would be where you would like to go, an efficient means of using nuclear energy to thermochemically dissociate water and produce hydrogen. But that is two, three—some number of decades off, according to best judgment.

Mr. ROHRABACHER. However, the use of nuclear energy to do this would—I mean, we have that technology and that knowledge now, correct?

Dr. GREENE. Via electrolysis.

Mr. ROHRABACHER. Right.

Dr. GREENE. It is just very expensive.

Mr. ROHRABACHER. How expensive are we talking about?

Dr. GREENE. I will have to get back to you on that, but I think it is several times more expensive than, say, producing from coal or natural gas.

Mr. BAXLEY. Congressman, I appreciate you raising that issue, because the point I want to make, just to reiterate, is that we view hydrogen very much like we do electricity. It is what I call "liquid electricity." So hydrogen is a universal—the universal power fluid. And the attractiveness of hydrogen is that it allows for the potential to make fuel and other uses from a wide diversity of domestic supply. Nuclear is just one of them.

Mr. ROHRABACHER. Right.

Mr. BAXLEY. I couldn't tell you whether it is nuclear, coal, solar, wind. I can't even predict the price of oil a year in advance, so I want to—don't want to prejudge that, but certainly nothing, that we know of now, and certainly nuclear and coal are two obvious ones that we have large domestic reserves of. They are not off the table.

Mr. ROHRABACHER. Okay.

Mr. BAXLEY. But in the near-term, I think, you know, we are more pursuing how do we make sure it is safe, how do we make sure it is available for the customers, how do we make it affordable, and in the long-term, how do we make it sustainable.

Mr. ROHRABACHER. All right.

Well, let me put, for the record, Mr. Chairman, that the high pressure helium reactor that I have mentioned in this committee once before offers the production of energy and electricity. This is a new reactor system developed by General Atomics in San Diego, which currently has reactors working in Japan and in one other location. The—this reactor, and I remember that you had followed up on that question the last time we had a hearing on this, offers an opportunity to provide that energy without the byproduct of plutonium, which actually this reactor actually eats plutonium, so thus we could produce hydrogen and energy in the third world without leaving the remnants over that could be used for nuclear weapons.

In terms of the actual Prize itself, Dr. Diamandis, you have been very successful. I remember we had a meeting in, I think, my backyard on this years ago. You have been very successful in the goals that you have set out and the methodology that you have achieved, but you were very specific in what you wanted to have achieved. And it was the first people who achieve the goal, rather than having a panel of judges deciding which of many people have met the standards, do you find this approach so far to be less definitive than what your operation was?

Dr. DIAMANDIS. Good to see you again, Congressman Rohrabacher.

Mr. ROHRABACHER. Good to see you.

Dr. DIAMANDIS. The—as I mentioned, understanding the problem set was very important for us. For example, for the Ansari X Prize, it wasn't developing a new rocket engine. You know. It was—the problems we were trying to solve were that the public didn't believe that private people could fly into space. That was the biggest problem. The capital was not ever being invested in this arena. The regulatory laws didn't exist to allow private industry to do these things. These were the problems that we were—we decided what

the problem statements were, okay, and whether that comes from DOE or it comes from yourselves, the—those problem statements, and then we went through this iterative process of coming up with prize ideas, taking those prize ideas, testing them with the public, with sponsors, with potential contenders, and then iterating it until we came up with a clear set of rules. And I do think, because of our genetic inbreeding as humans, we compete. And that is where—we do the best when we compete, whether it is on the football field or whether it is wherever. It——

Mr. ROHRABACHER. Is it important to do the first person who achieves this or is it to have——

Dr. DIAMANDIS. I think you get the——

Mr. ROHRABACHER.—a judgment as to who best achieves it?

Dr. DIAMANDIS. We have studied this in great detail, and our feeling is that having the first person to achieve but having a second- and third-place prize as well, but you have a frontrunner out there and a second and third place allows those who might not think they can win first prize still to come and you double and triple the number of competitors that way.

Mr. ROHRABACHER. Thank you very much.

Chairman BOEHLERT. The gentleman's time is expired.

And if I am interpreting correctly what the gentleman said in his preamble to his question, he is arguing for a balanced portfolio as he introduces the subject of nuclear into the equation. And I think we can all agree that a balanced portfolio is absolutely essential, and I thank the gentleman for acknowledging some leadership. The test of leadership is whether there is followership, so I would be more than willing to meet with the gentleman in his backyard, as he did with Dr. Diamandis, to talk about such things as CAFE standards, because I know the gentleman is concerned about national security issues, and that is a national security issue.

Mr. Miller.

Mr. MILLER. Thank you, Mr. Chairman.

And Mr. Chairman, I am going to be—I am going to try to be on my best behavior today.

I want to pursue questions very like the questions that others have pursued and several of you have referred to. Dr. Diamandis, you said that a prize should not prejudge the solution, that you should account for the possibility that the solution that emerges is not one that you expected. Dr. Bodde, is it? Dr. Bodde, you said that the outcome should not be biased by the prizes.

I am concerned that by pursuing a hydrogen economy we are already biased towards a solution, because the real challenge before us, I agree with what Mr. Inglis said that we need to have a response to our energy needs that is similar to what happened after Sputnik, but I am not sure that that quest is for a hydrogen economy specifically but for some approach to energy that is sustainable, that makes us energy-independent and that does not produce greenhouse gases that I do worry are going to affect the climate.

And not everyone is sold that the hydrogen economy is the way to go, that the hydrogen economy will be the winner of the various competing forms of energy. The problems are actually pretty well described in the prize categories. The advancements for hydrogen production. Well, several had pointed out that hydrogen is not ac-

tually a source of fuel, that there are not large reserves of hydrogen. Hydrogen has to be stripped from another fuel source.

At other hearings before this committee, witnesses have testified that hydrogen is not actually a source of fuel, it is a method of—or not a source of energy, but is a method of transporting energy, and we are going to have to find the hydrogen from somewhere. And if it comes from finite sources of energy, not renewable, sustainable sources of energy, perhaps we are not making that great an advance in going to a hydrogen economy.

Also, the present methods for stripping hydrogen out of other fuel sources is pretty dirty. And yes, hydrogen may only produce water, but the process of getting the hydrogen is dirty.

Hydrogen storage. There have been plenty of suggestions, or some suggestions, at least, that leaks hydrogen, that is widely being used, that there is a—that there are thousands or millions of hydrogen cells in the economy in the United States. Small leaks will actually have a pretty significant environmental impact there.

Hydrogen distribution. We have got a lot tied up in an infrastructure for fuel that is a liquid on planet Earth, which hydrogen is not. Hydrogen utilization may be the easiest problem to solve.

By making this Prize about hydrogen, are we not already biasing towards hydrogen as a solution to our energy needs instead of the other solutions that may be out there?

Mr. Boehlert mentioned conservation, mentioned CAFE standards. He—I have sponsored the legislation that he is one of the principle authors of to require fuel efficiency standards I think by 2013 but we can easily achieve with existing technologies. Why are we not doing more about conservation? Are we biasing our energy approach by focusing this Prize and so much that we are doing that focuses on the hydrogen economy?

Dr. Diamandis.

Dr. DIAMANDIS. Thank you, sir.

I should say that for many of those same reasons, we believe that a new generation of automobiles that significantly exceed 100 miles per gallon equivalent is possible, and we are looking to launch this year an automotive X Prize along those lines, specifically for the—I think a lot of the issues driving this legislation: reduction of CO_2 emissions and energy independence. So you know, we have attacked it based—we are looking, in our foundation, to attack that specific niche in the near term, because while we are talking about, you know, generational solutions here in this committee, we are trying to focus on what can be done in the next three years. And we do believe a prize for the design, development, marketing, and putting cars on the road, not just prototype cars, is possible through a prize area.

What you are talking about is an E–Prize, an energy prize, versus an H–Prize.

Mr. MILLER. Right.

Dr. DIAMANDIS. And it depends, again, where the DOE wants to draw the circle. Does it want to draw it specifically on hydrogen or around energy? And of course that problem statement then defines the competition you are going to run.

Mr. MILLER. Dr. Bodde.

Dr. BODDE. Yes, sir. I think there are—a lot of the ability of the Prize to incentivize a variety of technologies, a portfolio of technologies, will come from the way the boundaries are drawn on—around what is eligible and what is not. That is what I argued for, including enabling technologies, battery technologies, for example, that are perfectly fungible for all electric vehicles versus hydrogen vehicles. Either way, we need good battery technology. Either way, we need good energy management systems onboard vehicles.

So I think if the boundaries are drawn properly that an H–Prize can incentivize many of the technologies we would want in an E–Prize in general.

Mr. MILLER. Do you think, Dr. Bodde, that it should be an E–Prize instead of an H–Prize? Is what we are getting at not—really an energy solution, not a hydrogen solution? Are we not biasing this towards hydrogen among the various options that—we are not sure which one is going to work, which—as you said earlier, we shouldn't bias the outcome.

Dr. BODDE. Well, I think either one would work, quite frankly.

Mr. MILLER. An E–Prize as well as an H–Prize?

Dr. BODDE. Yes, but it is important to do something. It is important not to let this whole thing pass and not take some action, in my view.

Mr. MILLER. Dr. Diamandis, should it be an E–Prize?

Dr. DIAMANDIS. It depends on what this—what the Congress, what the White House wants to achieve. At the top of the game, it may well be both, and I shouldn't—you know, my favorite saying is: "If you are given a choice, take both." An E–Prize, in the near-term, in terms of looking at biofuels and renewables and so forth where hydrogen is one of the solution sets for the long-term, may be the most efficient way to go.

I do know we have an immediate problem, and entrepreneurship in this country can bring about immediate solutions, if we properly incentivize them.

Mr. MILLER. And if I—just one more second, Mr. Chairman.

Mr. Baxley said that he could not predict petroleum costs a year in advance. The people in my district can't predict the price at the pump in the morning what it will be at in the afternoon, so yes, we do have an immediate problem.

Chairman BOEHLERT. You are darn right we do.

Thank you very much, Mr. Miller.

Mr. McCaul.

Mr. MCCAUL. Thank you, Mr. Chairman.

I want to thank Chairman Inglis for introducing the legislation. I am proud to be an original co-sponsor on the bill. I think hydrogen does provide a great promise. And just thanks for your leadership on this.

Universities provide great research and development throughout this country. They, in some instances, have a relationship with the private sector. In my own district, the University of Texas is researching hydrogen fuel cells on monies provided by the National Science Foundation and the Department of Energy.

I have got, really, two questions. The first one is: what role do you see the universities playing in this, and would they qualify?

And then the second question is probably more technical. I have actually driven a hydrogen car, so I—we know the technology is there. It is there today. The problem, as I was told, is that it costs about $1 million to build one of these cars. And I know one of the metals used currently is platinum, which increases the cost. But I understand there is also more research being done to develop another alloy that could be used.

What do you see—in this Prize, it calls for, in 10 years, wheel-to-wheels transformation. What do you see as some of the challenges that we need to overcome to bring down that cost? And I know, providing the infrastructure throughout the country for hydrogen is an important issue as well and the storage issue. But if you could sort of comment, the whole panel, on the technology challenges and then also on the university issue.

Anybody who wants to answer that.

Dr. BODDE. Well, let me begin, sir, if I may with the university side.

The—it is first important to realize that technology is all a people game. It is all about who you have on the court, and that determines the style of play, for any particular technology. And so it is helpful to think of universities as basically "people factories." They are things that draw together not only the people that we move through the pipeline in the university, but also people from overseas, guest researchers, and so forth, into a community of interest focused around a particular problem.

Now out of that are bound to come the solutions that come when you have bright, creative people that are gathered together.

Certainly, university researchers should be included within the category of those eligible for the Prize whether they are on research grants from the Federal Government or not, in my opinion.

Dr. GREENE. I think the greatest technological challenge is storing this hydrogen on a vehicle. We have ideas of carbon nanotubes. We have metal hydrides. We have high pressure compression. We have liquefied hydrogen. All of these have very, very serious problems and, in my opinion, are not really close to providing the functionality that a consumer expects on a vehicle. This is a very, very difficult problem. And it is the kind of thing that we almost need a solution that nobody has even thought about yet.

I mean, I—what I say about it is I haven't seen any good ideas. So I think this is the most serious technological challenge. The platinum and the fuel cells is certainly a problem, the durability of membranes and those kinds of things. Those, to me, look like the kinds of things that will be solved with continued research and learning and that sort of process. I am really worried about storage of hydrogen.

Mr. MCCAUL. The oil industry will tell you it is a 20-year—this won't happen any sooner than 20 years. Do you agree with that or disagree? I know it is very speculative.

Dr. GREENE. I am surprised they will predict that but not the price of oil. I can't say. I am——

Mr. MCCAUL. Is it 10 years that we are—this is obviously a goal. It is an aspiration. Do you think this is achievable?

Dr. GREENE. I think, you know, what is trying to be accomplished here is to make some of those things happen that we don't

know how to make happen yet, to see what kind of creative ideas people will come up with.

Mr. MCCAUL. Mr. Baxley.

Mr. BAXLEY. As a representative of an oil company, let me just make a comment.

First of all, I do very much hope and anticipate that universities would participate in this program. I think it is tremendously important for them to do that. I think it is tremendously important to overcome a whole host of technical challenges. We have got a whole host of them, storage being, obviously, the most prominent.

But in terms of the timing, you know, we didn't set up Shell Hydrogen seven years ago just to have fun. We set up Shell Hydrogen seven years ago to really figure out how we could go forward and make this happen, how we could make it into a business. Based on everything we have seen, we are still here after seven years. We are growing. We are going to continue to be here, from everything I have been told. We see the potential for hydrogen to be introduced in the next five to seven years in selected markets around the world. So this is not a situation where everybody is going to wake up one morning and go down to the Chevy dealer and there are going to be fuel cell cars. This is going to be more a situation like the Prius or the other hybrids where there are going to be limited markets where it is going to be introduced. We are working hard to figure out how do we introduce that, for example, on the West Coast and the East Coast of the United States in, you know, the period of the next 10 years.

So the other point I would make is that we keep saying, you know, this is far out, and we use that as an excuse not to work on it. It is important. It is important to work on all of the other things, the nearer term: better fuels, better fuel supply. Biofuels is a solution in the interim. There are other solutions, but we have got to make sure that we keep the focus on hydrogen, and that is why I think the Hydrogen Prize is so important, because hydrogen is the one thing that has so many big technical challenges. It is a big step for man. The other ones we think we have a clear path to how to achieve in the biofuels and some of the other areas, but hydrogen has so many challenges, you really need to get all of the brainpower you can focused on this——

Chairman BOEHLERT. Thank you.

Mr. BAXLEY.—as soon as possible.

Chairman BOEHLERT. Thank you very much, Mr. Baxley.

Mr. MCCAUL. Thank you, Mr. Chairman.

Chairman BOEHLERT. Thank you, Mr. McCaul.

Mr. Green.

Mr. GREEN. Thank you, Mr. Chairman. And I thank the Ranking Member, as well. We appreciate greatly having the opportunity to hear quite an outstanding panel.

I would like to address my first comment, if I may, to Dr. Diamandis. Good morning, sir, and I commend you on how well you have handled the X Prize. I was fascinated by it as I saw it unfold.

Dr. DIAMANDIS. Thank you.

Mr. GREEN. I am concerned, first, with the separation of responsibilities that you make reference to. Could you kindly explain how you envision this working, please?

Dr. DIAMANDIS. Sure. I think that we have a current working relationship with NASA that is appropriate to use as a model. We assisted the agency in setting up what is called a centennial challenge program. They had a law passed and signed into law allowing them to do prizes of any size. Prizes above $10 million require additional authorization from Congress, but they can do larger prizes.

The way it works is NASA identifies an issue, a problem. We are going to be announcing a prize with them next year, which is—I mean next week, which is about a $2.5 million prize involving lunar landing technology, but I can't say more than that. And they basically say we are interested in—here are the problems we have. We don't have technology developing in this area. We then take that problem and we go out, we write the rules, we go bring in the advisors, we set up, actually, sometimes if a chunk of money is available, we will say this is first and second and third-place prize amounts that we recommend, and then we do it in an iterative process where they come back and give us their input. It has been a very cooperative process so far.

Once that is set, we go out and find a set of independent judges. We go and register the teams. There is a whole legal structure of master team agreements, liability issues. It is—you know, 10 years of work has shown us where the problems have been in these scenarios. But that independence, if—we are not going to sell our soul, so if the rules that they want are something that we believe doesn't make sense, we will say we are not interested in managing the competition.

Mr. GREEN. In managing the competition and selecting the winners, are we limited in terms of who can win?

Dr. DIAMANDIS. Again, that is a very good question, because one of the places you get your greatest, greatest success is when you open up. You don't—in the world of aerospace, you don't want to turn away those pesky bicycle mechanics from Dayton, Ohio, you know, when you have got an aviation competition. Because really, again, perfect example, out-of-the-box thinking coming in to solve and beating the government's funded Langley approach.

So one of the issues we deal with from NASA, for example, is is it domestic only. You know. Again, Congress writing a check to a Chinese team winning this is not, probably, something you want in headlines, but making a global competition is where you are going to have the greatest benefits. Universities are going to be a key element of this, without any question. And you are going to have alliances between a Shell and a university and a wealthy backer. That is going to happen. You want a free market economy bringing together unlikely teams and allowing for crazy ideas to surface. Remember, the day before something is a breakthrough, it is a crazy idea, otherwise, it is not a breakthrough.

Mr. GREEN. Back to your comment about the possibility of a winner being less than the most popular person on the planet, how do we—how do you envision dealing with that one concern?

Dr. DIAMANDIS. I am not—when you say the not—I mean, one of the things, for example, is that in the Orteig Prize for crossing the Atlantic, the most likely winner was Admiral Byrd who had flown to the North Pole. And Lindbergh was an upstart. In fact, people

refused to sell him an airplane, because they thought he would kill himself. And the day before he flew, the New York Times wrote an editorial and said, "Mr. Lindbergh, please don't fly. You are going to kill yourself and set back aviation a decade." And he went anyway and, in fact, changed the course of history.

Mr. GREEN. Well, let me broaden the question. Can a government win?

Dr. DIAMANDIS. I don't think—in the Ansari X Prize, we precluded—we, in fact, required that all teams demonstrate 90 percent or more private financing. We don't want a government coming in here and winning it. We wanted teams worrying about every penny they spent, and we wanted to drive breakthrough by restricting capital. If you have private money, the free market economy will drive you to solutions. I mean, the problem is that we have had bloated government contracts in the aerospace industry, and perhaps in the energy industry as well, I can't speak to that effectively, that haven't driven really, you know, people considering crazy ideas, because they are afraid of taking the risks. You know. I get up and speak in this committee about the fact that we are killing ourselves in this country by being so risk-averse. Prizes allow risk taking.

Mr. GREEN. Thank you, Mr. Chairman.

Chairman BOEHLERT. Thank you very much, Mr. Green.

Ms. Biggert.

Ms. BIGGERT. Thank you, Mr. Chairman.

I just wanted to say that, you know, I think hydrogen is certainly a very, very important concept. We—I keep talking about let us think hydrogen nuclear and not oil and gas, and so this is something that we have got to resolve and very, very soon. But I do think that nuclear, too, is—and the cost of all of these things, nuclear is so important in the long run, and we are working on fast reactors, the recycling, and hydrogen. I mean, we have moved forward. I can remember Secretary Abraham coming to Argonne, which is in my district, and to look at the fuel cells and saying how small—how fast can you make them smaller so that they can go into a car so that we will have it. And that happened pretty fast. I am amazed. And I have driven a hydrogen car, and it was pretty scary, because it is a million-dollar car right now, and I was driving around the streets of Washington, DC, and I wanted to make sure I didn't bump into anything. I think I was more worried about that than the fact that there was liquid hydrogen under the back seat.

So I think that, you know, we are moving ahead, and I guess just my problem—concerns have been just with the amount of money and the—having to refocus from other things, perhaps.

And Mr. Baxley, you mentioned that Shell has been thinking about doing such a—undertaking such a prize. I think that would be a fabulous idea. If you have considered it, why hasn't it gone forward, and would that—could that still be in the future?

Mr. BAXLEY. I will, first of all, say that it was one of a number of things we considered in terms of how to really engage this—the public's imagination, from university sponsorships to television advertisements to printed advertisements. So we didn't develop it a whole lot further until, actually, Representative Inglis suggested

that the government sponsor it, which we think is a great idea. Actually, we think it is an issue of not just industry leadership. It is an issue of government leadership, and we think it is important for—I think it is really great if we can get both the federal level of government and industry all on board by saying this is an important issue to sponsor.

So it is something that, you know, we will look at moving forward with. We are looking at how to structure a prize in other areas as well. But certainly, on this topic, we are—we think it is great if the government can lead the——

Ms. BIGGERT. Well, of course, one of the things that we hear about that so many of the companies is the huge profits that have been made by the oil and gas industry. And why not use the profits to pay for such a prize? It would be good PR.

Mr. BAXLEY. Well, as I said, we are interested in pursuing a prize, and we are interested in sponsoring various initiatives to make sure that we move forward in hydrogen, just as we are sponsoring many other issues on renewables. So I appreciate that comment, and we are seriously considering, you know, and will seriously consider being involved in this Prize or any Hydrogen Prize going forward.

Ms. BIGGERT. It seems like some say that this could be argued to be a handout to the industry, and particularly with the $100 million prize. And Dr. Diamandis pointed out in his opening remarks that he selected a $10 million prize in part because he didn't want the big competitors like Boeing and Lockheed Martin from being the only competitors. And then do you—would you agree—would you all agree with that that this could happen because—if it were to be a $100 million prize, that the big groups would be—in that case, it was Boeing and Lockheed because it was space, but would the big companies get into this and—to use the money?

Dr. GREENE. I don't think this is my area of expertise. I defer to the——

Ms. BIGGERT. Okay.

Dr. GREENE.—people who are in innovation policy and setting——

Ms. BIGGERT. Well——

Dr. GREENE.—up prizes.

Ms. BIGGERT.—Dr. Diamandis, then, do you think that that could happen?

Dr. DIAMANDIS. It is—this may be a little bit different in the aerospace industry, which, again, I have much deeper knowledge there. But again, my—on how much this Prize should be, I think the most important thing that this legislation would go—be—could do to go forward is actually allow an organization, like the X Prize Foundation or someone else you chose, to go through the proper process and not pick a number out of the air. We actually go through a process. It takes us time to figure out what is the right amount. And we go to the innovative—we go to the entrepreneurs. We go to the people in the garage. We go to large corporations and find out where—what peaks their interest. And——

Ms. BIGGERT. You are talking about the X Prize now?

Dr. DIAMANDIS. I am talking about how we do—we are about to launch a genomics prize, an automotive prize. The process we go

through, which part of it includes setting the amount of cash, not too large, not too small, and also setting the—structuring the competition, how it is properly structured. Is it one or multiple?

Ms. BIGGERT. So don't you think that the Federal Government should do the same thing?

Dr. DIAMANDIS. I do. I think there is a process to go through before you launch a 10-year effort. As I said—what I said earlier is investment—proper investment in the next few months will determine the ultimate success or failure of the Prize.

Chairman BOEHLERT. The gentlelady's time is expired.

But to continue on this vein, since we have to do the appropriating, and since these are very difficult times, we are not short of requests for the limited resources we have. Let me put it another way. Would $10 million, as some have suggested, be enough of an incentive to accomplish what you hope to accomplish with the whole Prize activity?

Dr. DIAMANDIS. Sir, let me offer out an idea along those lines.

Ten million dollars is a great starting position. One of the things that is of greatest value in a prize is when you are able to bring a corporate sponsor to the table. So if the government were to say, "We want to do a study to create an H–Prize or an E–Prize and we are going to put $10 million as a starting amount to go this. And then we are going to allow corporations to come in and title that." So, to use my colleague here at Shell, you would want a Shell to come in and say, "Let us make it from $10 million to $50 million. We are going to add $40 million to the equation."

And why? Because a corporation coming in who spends $10 million will typically spend $30 million promoting the fact that they invested $10 million. Very important, because the promotion part of this is——

Chairman BOEHLERT. The bill does allow that. Mr. Inglis' bill does allow that.

Dr. DIAMANDIS. Yeah, and I think that is a very important part that—and also it may be—one of the things we are considering , for example, in our automotive and such is that allowing the public to contribute to the amount of the prize. They are the ones who want the breakthroughs in the automotive industry, want the breakthroughs in energy. And these are things we think about night and day in my organization for the last 10 years. How do you—where do you get the greatest effect? Having a corporate sponsor where it is titled, the X, Y, Z, H–Prize, whatever, will give you the greatest benefit. You know, we had the Ansari family. I wish we had a corporation.

Chairman BOEHLERT. Thank you very much.

The gentleman's time has expired. The gentlelady's time has expired. My time has expired.

It is time for Honda.

The Chair recognizes Mr. Honda.

Mr. HONDA. Thank you very much.

And just a comment on disclosure. This Honda was made in America.

And I do have a hybrid Toyota. And all of the questions I was prepared to ask have been asked and responded to, but there is one

thing that does kind of nag at me, and I am sorry I missed your initial testimony.

But at the risk of looking a little ignorant, let me go ahead and ask the question.

It sounds like we are—we want to use taxpayer monies to create an incentive program from which, if there are any benefits to be accrued from the contest, it doesn't appear that there is any return on the investment to the public in terms of revenues back to the government in this kind of a program, whereas if it were done as you had done it previously, which attracted a lot of attention and a lot of sense of competition and accomplishments, too, that even though the government wanted to sort of insert themselves in the area of security and safety, what benefits does the general public accrue in terms of return on investments in terms of revenue and—you know, because we are looking at the size of the Prize and the kinds of prizes that are out there. And I believe in incentives. I am a schoolteacher. I believe in incentives, intrinsic and extrinsic. But where is the return on investment of this?

Dr. GREENE. I think the major motivation of the government being interested in hydrogen has to do with what economists would call public goods: protect the environment, energy security. And deal with the market failure of imperfect competition as the OPEC cartel and the world oil market and the problems that causes. These are the benefits, I think, as I see it, that the government and the public expect from an eventual successful hydrogen-powered transportation and energy system. And that is the return that we are looking for, and it is trillions and trillions of dollars.

But as far as return in the near term, I don't know the answer to that.

Mr. HONDA. I don't disagree with your response, it is just that I think that is what we look at anyway when we try to put appropriations or bills together for purposes of R&D at the—at least at the nascent stage, and we are looking at also considering doing some for developmental stages where we can bridge the gap towards commercialization.

But—yes, sir. Mr. Baxley.

Mr. BAXLEY. I think, if I understood the question, and it is actually a very, very relevant question. And I have to agree with what Dr. Greene said, but I also would point out that it is more than just the public good issues. It is more than just the environment, the effects of climate change, which we are still trying to figure out what that is, and the effects on our national security, which are all huge dollar impacts. But I would also point out another thing that I think all of you are aware of, and that is job creation and new industry creation. Hydrogen has the potential to create whole new industries and whole new technology platforms, like other transformations, that would create jobs. So that is a tremendous benefit to the economy. And I viewed the Hydrogen Prize legislation as seed money. This is the government putting in a limited amount of seed money, and I don't think it has to be $100 million. I think something in the order of $10 million would be sufficient seed money, presuming that you also get sponsorship from private sector and other organizations.

But the important thing is the leadership putting the seed money in and getting it started and helping them to make that happen. That is what I think is the important part.

Mr. HONDA. Thank you, Mr. Baxley.

And to the Chair, if I may, I have a bill called H.R. 1491, which addresses incentives in terms of looking at research and having—the Federal Government having a role in bringing research to commercialization and, at a certain point, engaging the private investors at a certain point in time, because there are many research that it is going to take more time than the private industry are comfortable with. So I figure that we should partner with them to bring that research to a point where it becomes commercially viable.

So if you would look at H.R. 1491 and see how that fits with your concepts, I would appreciate any feedback that you might have, because I believe that in the times when we have scarce resources in our country for whatever reason, people can argue about why we have scarce resources, I do believe that we should invest, as we did in the Internet, on behalf of the Federal Government, to promote new ideas and create jobs, as you have said.

Yes, sir.

Dr. DIAMANDIS. Mr. Honda, I might ask you to think about a prize as almost fixed-cost science or fixed-cost engineering. You have a specific goal you want to achieve, you don't pay it until it is done. If you think about it, you know, it would be the most efficient way to implement NIH and NSF type funding programs, but clearly you can't do that. But I am just saying in terms of use of money for the best public good, it is the most highly-leveraged, most efficient way the government could ever use its funds.

Mr. HONDA. Thank you. And it helps me feel better about the word "prize" and leveraging, so that is a good way to think about it.

Thank you.

Chairman BOEHLERT. Thank you very much, Mr. Honda.

And Mr. Wu advises that all of the pertinent questions have been asked. He is just here because of his deep and abiding interest in the Committee's activities, and we thank you for being here.

And I thank all of my colleagues for being here.

Now, Dr. Bodde, I can't let this end. Chairman Inglis has told me you have got a great story about how your mother inspired you to be a scientist. Would you share that with the Committee?

Dr. BODDE. Sir, this happened one summer in 1959, I guess it was, driving across Kansas. And of course, those were the days where there was no air-conditioning, and so all of the windows were open. And mom says, "Well," you know, "look up there. There is a Soviet satellite circling the Earth, and it is the duty of every patriotic young American to go out and study science and engineering so we can beat the Russians." Well, sure enough, I went out and studied science and engineering, and sure enough, we beat the Russians.

So the chief lesson I draw from that is: mom is always right.

Chairman BOEHLERT. You are darn right, and I hope we can energize the mothers of America to give that same message to the young students and our educational system, because we are being

challenged as never before. We are still number one, but we have got a lot of work to do to maintain that number-one position.

Is there anything else for the good of the order, because our distinguished witnesses have other activities? But——

Mr. INGLIS. Mr. Chairman, if I could indulge just a couple minutes to——

Chairman BOEHLERT. A couple of minutes for the distinguished Chair.

Mr. INGLIS.—follow up on your comment and Chairman Biggert's comment, they were very helpful, about the amount of the Prize, because, you know, my goal in setting a prize, initially, is up to $100 million. And of course the Secretary has, under our bill, the discretion to do what Dr. Diamandis described, and that is to set the amount up to $100 million. If in consultation, I would hope with somebody as knowledgeable as Dr. Diamandis, the Secretary of Energy decided, "No, all you need is $10 million," or maybe you need $10 million from government and $50 million from private enterprise, then the Secretary has that flexibility under the bill.

Chairman BOEHLERT. Yeah.

Mr. INGLIS. It could also enable us to appropriate only smaller amounts in the initial year and then larger amounts when the Secretary of Energy reports back.

Chairman BOEHLERT. Thank you.

Mr. INGLIS. So that is——

Chairman BOEHLERT. Point well taken.

Mr. INGLIS.—certainly a doable objective, and working with, as I said, somebody as expert as the X Prize Foundation could get us there.

My goal in setting $100 million, as throwing it out there, is to avoid a middling Department of Energy program, because a middling Department of Energy program is nowhere near the threat level that we are dealing with. We are at great risk, and it is the kind of risk that Dr. Bodde just described from his mother. Her perception of how at risk her country was and inspiring her son to get involved in science is the kind of reaction we need to be having, less we end up 20 years from now in the same spot that we could have—we were after the 1973 oil embargo, which is all a lot ado about nothing, and then we fell back into our old ways.

So I think that we can find a way to do this using the expertise of people like the X Foundation—X Prize to get us there.

Chairman BOEHLERT. Thank you very much.

I don't mean this to be a point-counterpoint, but I do want to recognize the distinguished gentlelady, Ms. Biggert.

Ms. BIGGERT. Thank you, Mr. Chairman.

I think when Mr. Inglis talked about making the—in frontloading it, that is a very important concept to keep in mind, because when we appropriate money, we put it in the Treasury until somebody claims it. And those appropriated funds really cost us money, because we—right now, the government has borrowed $297 billion from the public in 2005, and interest on the—on public debt is a major expenditure, so not putting the money in prior to, you know, when we need it is important.

Chairman BOEHLERT. Thanks for the intervention.

Thank you all very much, my colleagues, and thank you, distinguished witnesses. We really appreciate it.

Stay tuned.

Hearing adjourned.

[Whereupon, at 11:35 a.m., the Committee was adjourned.]

Appendix:

Additional Material for the Record

I

109TH CONGRESS
2D SESSION

H. R. 5143

To authorize the Secretary of Energy to establish monetary prizes for achievements in overcoming scientific and technical barriers associated with hydrogen energy.

IN THE HOUSE OF REPRESENTATIVES

APRIL 6, 2006

Mr. INGLIS of South Carolina (for himself, Mr. LIPINSKI, Mr. KINGSTON, Mr. WAMP, Mr. WOLF, Mr. BOEHLERT, Mr. EHLERS, Mr. BARTLETT of Maryland, Mr. WYNN, Mr. DENT, Mr. LARSON of Connecticut, Mr. MCCAUL of Texas, Mr. BROWN of South Carolina, Mr. WILSON of South Carolina, and Mr. TERRY) introduced the following bill; which was referred to the Committee on Science

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A BILL

To authorize the Secretary of Energy to establish monetary prizes for achievements in overcoming scientific and technical barriers associated with hydrogen energy.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "H-Prize Act of 2006".

SEC. 2. DEFINITIONS.

In this Act:

(1) DEPARTMENT.—The term "Department" means the Department of Energy.

(2) SECRETARY.—The term "Secretary" means the Secretary of Energy.

SEC. 3. PRIZE AUTHORITY.

(a) IN GENERAL.—The Secretary shall carry out a program to competitively award cash prizes only in conformity with this Act to advance the research, development, demonstration, and commercial application of hydrogen energy technologies.

(b) ADVERTISING AND SOLICITATION OF COMPETITORS.—

(1) ADVERTISING.—The Secretary shall widely advertise prize competitions to encourage broad participation, including by individuals, universities, and large and small businesses.

(2) ANNOUNCEMENT THROUGH FEDERAL REGISTER NOTICE.—The Secretary shall announce each prize competition by publishing a notice in the Federal Register. This notice shall include the subject of the competition, the duration of the competition, the eligibility requirements for participation in the competition, the process for participants to register for the competition, the amount of the prize, and the criteria for awarding the prize.

1 (c) ADMINISTERING THE COMPETITIONS.—The Sec-
2 retary shall enter into an agreement with a private, non-
3 profit entity to administer the prize competitions, subject
4 to the provisions of this Act.

5 (d) FUNDING SOURCES.—Prizes under this Act may
6 consist of Federal appropriated funds and funds provided
7 by private entities or individuals for such cash prizes. The
8 Secretary may accept funds from other Federal agencies
9 for such cash prizes. The Secretary may not give any spe-
10 cial consideration to any private sector entity or individual
11 in return for a donation.

12 (e) ANNOUNCEMENT OF PRIZES.—The Secretary
13 may not issue a notice required by subsection (b)(2) until
14 all the funds needed to pay out the announced amount
15 of the prize have been appropriated or committed in writ-
16 ing by a private source. The Secretary may increase the
17 amount of a prize after an initial announcement is made
18 under subsection (b)(2) if—

19 (1) notice of the increase is provided in the
20 same manner as the initial notice of the prize; and

21 (2) the funds needed to pay out the announced
22 amount of the increase have been appropriated or
23 committed in writing by a private source.

(f) SUNSET.—The authority to announce prize competitions under this Act shall terminate on September 30, 2017.

SEC. 4. PRIZE CATEGORIES.

(a) CATEGORIES.—The Secretary shall establish prizes for—

(1) advancements in components or systems related to—

(A) hydrogen production;

(B) hydrogen storage;

(C) hydrogen distribution; and

(D) hydrogen utilization;

(2) prototypes of hydrogen-powered vehicles or other hydrogen-based products that best meet or exceed objective performance criteria, such as completion of a race over a certain distance or terrain or generation of energy at certain levels of efficiency; and

(3) transformational changes in technologies for the distribution or production of hydrogen that meet or exceed far-reaching objective criteria, which shall include minimal carbon emissions and which may include cost criteria designed to facilitate the eventual market success of a winning technology.

(b) AWARDS.—

(1) ADVANCEMENTS.—To the extent permitted under section 3(e), the prizes authorized under subsection (a)(1) shall be awarded biennially to the most significant advance made in each of the four subcategories described in subparagraphs (A) through (D) of subsection (a)(1) since the submission deadline of the previous prize competition in the same category under subsection (a)(1) or the date of enactment of this Act, whichever is later. No one such prize may exceed $1,000,000. If less than $4,000,000 is available for a prize competition under subsection (a)(1), the Secretary may omit one or more subcategories, reduce the amount of the prizes, or not hold a prize competition.

(2) PROTOTYPES.—To the extent permitted under section 3(e), prizes authorized under subsection (a)(2) shall be awarded biennially in alternate years from the prizes authorized under subsection (a)(1). The Secretary is authorized to award up to one prize in this category in each 2-year period. No such prize may exceed $4,000,000. If no registered participants meet the objective performance criteria established pursuant to subsection (c) for a competition under this paragraph, the Secretary shall not award a prize.

(3) TRANSFORMATIONAL TECHNOLOGIES.—To the extent permitted under section 3(e), the Secretary shall announce at least one prize competition authorized under subsection (a)(3) as soon after the date of enactment of this Act as is practicable. To the extent permitted under section 3(e), the Secretary may announce additional prize competitions authorized under subsection (a)(3) as appropriate to accelerate the development and adoption of hydrogen technologies. A prize offered under this paragraph shall be in the amount of $100,000,000. The Secretary may allow the winner of a prize under this paragraph to receive up to $10,000,000 of the prize in a lump sum as cash. Any portion of the prize not received as a lump sum in cash shall be paid to the winner as a Federal match for each dollar of private funding raised by the winner for the hydrogen technology beginning on the date the winner was named. The match shall be provided for 3 years after the date the prize winner is named or until the full amount of the prize has been paid out, whichever occurs first. A prize winner may elect to have the Federal match amount paid to another entity that is continuing the development of the winning technology. The Secretary shall announce how much of

a prize will be available as a lump sum and the rules for receiving the Federal match in the notice required by section 3(b)(2). The Secretary shall award a prize under this paragraph only when a registered participant has met the objective criteria established for the prize pursuant to subsection (c) and announced pursuant to section 3(b)(2).

(c) CRITERIA.—In establishing the criteria required by this Act, the Secretary shall consult with—

(1) the Department's Hydrogen Technical and Fuel Cell Advisory Committee;

(2) other Federal agencies, including the National Science Foundation; and

(3) private organizations, including professional societies, industry associations, and the National Academy of Sciences and the National Academy of Engineering.

(d) JUDGES.—For each prize competition, the Secretary, through an agreement under section 3(c), shall assemble a panel of qualified judges to select the winner or winners on the basis of the criteria established under subsection (c). Judges for each prize competition shall include individuals from outside the Department, including from the private sector. A judge may not—

(1) have personal or financial interests in, or be an employee, officer, director, or agent of, any entity that is a registered participant in the prize competition for which he or she will serve as a judge; or

(2) have a familial or financial relationship with an individual who is a registered participant in the prize competition for which he or she will serve as a judge.

SEC. 5. ELIGIBILITY.

To be eligible to win a prize under this Act, an individual or entity—

(1) shall have complied with all the requirements in accordance with the Federal Register notice required under section 3(b)(2);

(2) in the case of a private entity, shall be incorporated in and maintain a primary place of business in the United States, and in the case of an individual, whether participating singly or in a group, shall be a citizen of, or an alien lawfully admitted for permanent residence in, the United States; and

(3) shall not be a Federal entity, a Federal employee acting within the scope of his employment, or an employee of a national laboratory acting within the scope of his employment.

SEC. 6. INTELLECTUAL PROPERTY.

The Federal Government shall not, by virtue of offering or awarding a prize under this Act, be entitled to any intellectual property rights derived as a consequence of, or direct relation to, the participation by a registered participant in a competition authorized by this Act. This section shall not be construed to prevent the Federal Government from negotiating a license for the use of intellectual property developed for a prize competition under this Act.

SEC. 7. LIABILITY.

(a) WAIVER OF LIABILITY.—Registered participants shall be required to agree to assume any and all risks, and waive claims against the Federal Government and its related entities, except in the case of willful misconduct, for, any injury, death, damage, or loss of property, revenue, or profits, whether direct, indirect, or consequential, arising from their participation in a competition under this Act, whether such injury, death, damage, or loss arises through negligence or otherwise. For the purposes of this subsection, the term "related entity" means a contractor or subcontractor at any tier, and a supplier, user, customer, cooperating party, grantee, investigator, or detailee.

(b) LIABILITY INSURANCE.—

(1) REQUIREMENTS.—Participants shall be required to obtain liability insurance or demonstrate

1 financial responsibility, in amounts determined by
2 the Secretary, for claims by—
3 (A) a third party for death, bodily injury,
4 or property damage or loss resulting from an
5 activity carried out in connection with participa-
6 tion in a competition under this Act; and
7 (B) the Federal Government for damage or
8 loss to Government property resulting from
9 such an activity.
10 (2) FEDERAL GOVERNMENT INSURED.—The
11 Federal Government shall be named as an additional
12 insured under a registered participant's insurance
13 policy required under paragraph (1)(A), and reg-
14 istered participants shall be required to agree to in-
15 demnify the Federal Government against third party
16 claims for damages arising from or related to com-
17 petition activities.

18 **SEC. 8. AUTHORIZATION OF APPROPRIATIONS.**

19 (a) AUTHORIZATION OF APPROPRIATIONS.—There
20 are authorized to be appropriated to the Secretary for car-
21 rying out this Act $55,000,000 for each of the fiscal years
22 2007 through 2016, of which no more than $1,000,000
23 for any fiscal year may be used for administrative ex-
24 penses.

1 (b) CARRYOVER OF FUNDS.—Funds appropriated
2 pursuant to this Act shall remain available until expended.

3 **SEC. 9. NONSUBSTITUTION.**

4 The programs created under this Act shall not be
5 considered a substitute for Federal research and develop-
6 ment programs.

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