Testimony of Mary Ann Wright

Before The United States House of Representatives

Science Committee

Concerning: Storage Battery Technology for Electrified Vehicle Powertrains

October 3, 2007

Mr. Chairman and members of the subcommittee, my name is Mary Ann Wright. I am the Vice President and General Manager of the Hybrid Battery Systems business at Johnson Controls, headquartered in Milwaukee WI. I also serve as the Chief Executive Officer of the Johnson-Controls Saft Advanced Power Solutions (JCS) joint venture. JCS was formed in January of 2006 specifically to address our customers' needs for advanced battery systems for hybrid vehicles, plug-in hybrid vehicles, and electric vehicles. In addition, I serve on the Board of Directors of the Electric Drive Transportation Association (EDTA).

I greatly appreciate the opportunity to discuss with you today the options and challenges that America faces as it moves down the road towards the goal of a sustainable transportation future. I am honored that you have asked me to speak before you today on a topic so critical to the security, economic vitality, and environmental stability of our country and planet.

Electrification of Vehicles

Clearly, the United States is at a crossroads. We face a double-edge sword: the world's supply of crude oil is approaching maximum output while the specter of an environmental future compromised by green house gas-induced global warming continues to grow. As President Bush stated in his 2006 State of the Union speech we must change the way we power our buildings, homes, and vehicles. Today, I would like to discuss specifically what can be done on the vehicle side of the ledger.

The focus of my discussion will be vehicles with electrified drivetrains, powered by advanced battery systems. A key to this discussion will be differentiating hybrid battery applications in the range of micro to full hybrids, that have been proven using NiMH chemistry and are in the final validation phase using Li-Ion, from battery applications which have not yet been fully validated for functional performance and life; plug-in hybrids and pure electric vehicles. However, first I would like to comment on other credible powertrain technologies that can help us transform the way we power our automobiles, trucks, and buses. Given the continuing upward trend in vehicle miles driven annually in the United States, incremental increases in spark (gasoline/ethanol) and compression (diesel) ignition engine efficiency, while desirable and attainable, will not be sufficient to substantially reduce America's dependence on crude oil. Increased production and use of *biomass derived motor fuels (e.g., ethanol)* are important from an energy security standpoint, and have the potential to significantly advance progress towards the President's 20 in 10 goal. Affordable Fuel Cell (H_2) vehicles and an

infrastructure to produce and distribute hydrogen are many years away from commercial viability.

I passionately believe that *electrification of the vehicle powertrain* in part or in whole can make a dominant contribution to America's energy security and transportation sustainability. Electric powertrains by nature are incredibly more efficient than their internal combustions counterparts. This efficiency prowess is the foundation of the hybrid advantage. The additional benefit of electrified powertrains is that they can be used as complementary technology to internal combustion engine drivetrains or as stand-alone technology, e.g., pure electric vehicles. Despite the proven benefits in terms of fuel economy and emissions, we face substantial challenges to widespread adoption of hybrid vehicles in the United States. Currently, neither the domestic market-pull nor the domestic manufacturing technology-push is sufficient to drive a sustainable electrified powertrain vehicle industry. Contrary to a popular notion, battery performance is NOT the barrier to widespread adoption of standard hybrid vehicles. In fact, Johnson Controls is the leading supplier of advanced lead-acid battery technology, called AGM, for use in micro hybrid automobiles as well as hybrid transit buses. Next year Johnson Controls will launch its first production Li-Ion battery system for the Mercedes-Benz S-Class mild hybrid. You may be familiar with Nickel-metal hydride (NiMH) batteries. NiMH battery technology is a proven, mature technology that to date has captured nearly 100% of the HEV battery market. Yet Li-Ion, due to its lower mass, reduced volume, higher power and energy, faster recharging, and lower cost potential is expected to overtake NiMH as the battery technology of choice by 2012. From 1988 to 2005, I worked for Ford Motor Company. I was the Chief Engineer for the Escape Hybrid SUV, the first

domestic hybrid which was successfully launched in 2004. Since then total global sales for the hybrid Escape and it sister vehicle, the Mercury Mariner hybrid, have exceeded 59,000 units. The Escape hybrid utilizes NiMH battery technology. I also led the team that launched the first hydrogen fuel cell demonstration fleet. These vehicles also use the same NiMH battery technology as in the Ford Escape. Please see Figure 1 on page four for a comparison of the NiMH and Li-Ion technologies.

Figure 1: Li-Ion versus NiMH Technology

Rather than battery technology, the major issues impeding broader acceptance of HEVs in the United States are:

1) Relative insensitivity to motor fuel prices on the part of the American consumer, thus inhibiting the desire to purchase a hybrid vehicle at a cost premium.

2) An underdeveloped domestic industry for manufacturing raw materials and key components necessary to produce hybrid powertrains.

To better understand the domestic factors currently suppressing hybrid vehicle sales, it is helpful to look at the hybrid advantage from a global perspective. In Europe, the vehicle manufacturers are aggressively pursuing the spectrum of near-term hybrid technologies-micro, mild, and full, while continuing to improve the diesel engine technology that has traditionally enjoyed tremendous popularity. Because of the high fuel prices and CO_2 reduction targets self-imposed by European OEMs, the incremental costs of hybrid technology is less daunting to would-be purchasers. In Asia, and particularly China, there is a tremendous amount of activity focused on the rapid development of hybrid and fuel cell vehicles. In the People's Republic of China, the government has set very aggressive goals for the introduction and proliferation of ultra-efficient and clean vehicle technologies.

The United States is somewhat unique in that our relatively low motor fuel prices and current lack of CO_2 emissions reduction mandates also contribute to stunted demand for high efficiency vehicles such as hybrids. Fortunately, there is a remedy, but it will

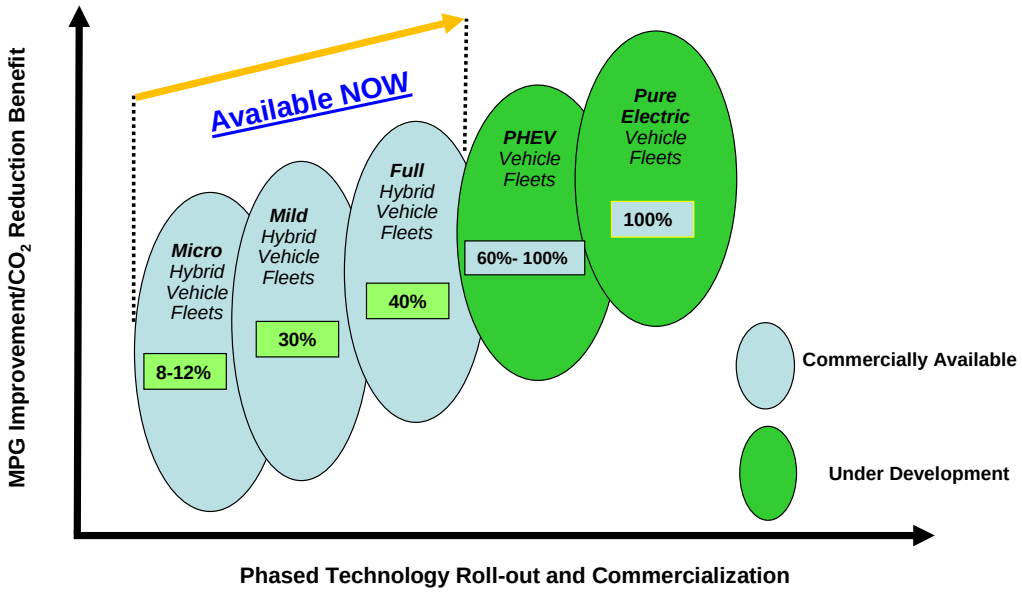
require a phased-technology plan and government assistance at the federal and perhaps state and local levels as well.

Phased Technology – A Journey

I see the development of a strong hybrid vehicle industry and market in the U.S. as a journey, not just a destination. As is the case with most journeys there are key achievements points or milestones along the way. Figure 2 on page six illustrates the ***Hybrid Journey*** – a technology evolution that builds on hybrid technologies available today – **yes, today**. I urge the Congress to implement policies that accelerate the commercialization of micro, mild and full hybrid vehicles in the United States.

Figure 2

The Journey to Plug-In Hybrids



The plug-in hybrid concept has garnered substantial attention over the last 18 months and deservedly so. Congress has heard testimony extolling the virtues of plug-ins and their promise to eradicate our energy and environmental problems. Without question, plug-in hybrids are a promising technology. The plug-in approach has the potential to double vehicle fuel economy while displacing imported oil with domestically produced electricity. The environmental benefits could be massive, particularly if recharging is done using predominantly renewable energy sources for electricity generation. Demonstration vehicles, like those being operated by Sacramento Municipal Utility District are registering fuel economy over 90 mpg. The key tasks needed to make PHEVs a reality are: 1) accelerated technology, particularly the Li-Ion battery development; and 2) further assessment of the commercial opportunities and issues by the public and private sectors. The assessment phase should include a plan for the development of a recharging infrastructure throughout the country to ensure that the benefits of PHEVs could be maximized. Also, because PHEVs by definition will at times be "on the grid", it is imperative that all stakeholders, but in particular, the vehicle OEMs, the supply base and the utility industry, engage in frank discussions about the cost/benefits that will be encountered. Unlike the case for micro, mild, and full hybrids, there are significant battery technology barriers to the commercialization of PHEVs. A strong partnership between the public and private sectors will be needed to tear down these barriers. A successful outcome from this endeavor would serve as a giant step forward in achieving the ultimate embodiment of highly efficient and environmentally responsible transportation – the pure electric vehicle.

Johnson Controls has a development contract with General Motors to furnish PHEV battery systems technology for the Saturn Vue Green Line vehicle. We are also partners with Southern California Edison and Ford to deliver PHEV demonstration fleets. Earlier this year, Johnson Controls announced a partnership with Daimler and Chrysler to provide Li-Ion batteries for Sprinter van demonstration fleets. In addition, the Department of Energy announced on September 25th that Johnson Controls will be awarded a PHEV battery development contract for 10 mile and 40 mile electric range vehicles. We are proud to continue our mutually beneficial relationship with DOE and the United States Advanced Battery Consortium, and look forward to *accelerating* the development of *commercially feasible* technologies for PHEV battery systems. Next, I'd like to concentrate on two words from the previous sentence – *commercially feasible.*

Reducing the Cost of Battery Systems

During my stint as Chief Engineer for the Escape hybrid SUV my team had to focus on the same acceptance criteria demanded by purchasers of conventional automobiles: style, performance, comfort, convenience, reliability, quality, serviceability, safety, and last but not least, *cost*. There is certainly a place early in the product development cycle for demonstration vehicles produced with recognition that costs will be high, but the bottom line is this: A successful HEV (all types of HEVs) vehicle industry and market in the United States must be based on satisfying these required criteria. These requirements are demanded by our customers and/or mandated by the government and they must be delivered at an affordable cost and acceptable market price.

So, although the battery technology is in the final validation phase to drive forward the market for micro, mild, and full hybrid, other elements needed for marketplace success, notably cost, are in a very early stage of development. The resolution path to ensure a long-term economically successful HEV industry in the United States must elevate *cost reduction* to the highest priority. Johnson Controls is confident that there are no insurmountable technical issues prohibiting the eventual widespread use of Li-Ion battery technology as the heart of standard hybrid vehicle drivetrains. Other issues separating it from commercial viability are:

- insufficient field experience,
- lack of domestic manufacturing infrastructure
- adequate sales volume to achieve economies of scale
- supply base diversity beyond Asia
- technical standards to drive common architectures

These challenges can be overcome in a compressed timeframe with sufficient federal assistance. Specifically, we propose a partnership between the appropriate federal government agencies, the battery manufacturers, and the lower Tier supply chain companies to drive down costs by focusing on the three following elements: 1) Material and component manufacturing and supply base development, 2) Process development and recycling, and 3) Equipment development.

1. Material and Component Manufacturing and Supply Base

Currently, we obtain almost all of our critical battery materials and system components from Asia. We need to develop a North American supply base for:

- Cell materials
    - Oxides
    - Carbonaceous and graphitic additives
    - Separators
    - Electrolyte
    - Roll stock aluminum and copper

Although the battery system is central to this discussion, other HEV system components are of similar concern from the standpoint of an insufficient domestic manufacturing base including:

- Power electronics
- Drivetrain electromechanical devices
- A secure supply of strategic materials, e.g., lithium ore

2. Process Development and Recycling

Another cost reduction opportunity is in the processes used to convert the basic battery materials and components into finished products. For example, today the electrode manufacturing process is time intensive, energy intensive, and environmentally challenging. A new electrode manufacturing process can be developed that would be a lower cost process, which is more environmentally friendly, saves energy and could potentially enhance battery life. Also, significant economic and environmental advantages can be realized through recycling spent battery systems. This can involve

both re-use of certain components and re-processing of components containing strategic materials; e.g., nickel and lithium. Currently, over 97% of all lead-acid automotive batteries are recovered for recycling. Although recycling processes exist today for NiMH and Li-Ion batteries, technology development programs aimed at cost-reductions goals should include recycling.

3. Manufacturing Equipment Development

To achieve an optimal balance between product cost and creation of a sustainable domestic manufacturing base we must also focus on the equipment needed to execute the advanced processes discussed above. We need to work with domestic equipment manufacturers to develop large, production-scale equipment with a high degree of automation capable of obtaining higher speeds compared to the smaller prototyping and development-scale equipment currently in use.

There is also a large cost savings potential in improving the design of the cell for manufacturing. Identifying a design change might save several steps in the manufacturing process, thereby saving time and cost. In addition to the electrochemical cells, the battery system requires additional components and subsystems to provide critical functions, such as thermal management. Domestic manufacturing of non-cell componentry should also be factored into policy-enabled mechanisms to advance the commercial viability of hybrid vehicle technologies. A high level listing of the barriers to sustainable commercialization of hybrids in the United States and proposed enabling countermeasures are shown below in Figure 3.

Figure 3: Commercialization Barriers and Enabling Countermeasures

Barrier/Challenge	Key Enabling Countermeasure
Insufficient market pull	Consumer purchase tax incentives
Underdeveloped manufacturing technology	Funding for advanced manufacturing development Loan guarantee programs for capital investment
Relatively low motor fuel prices	Carbon content based fuel economy or CO_2 emissions mandates
Supply base development	Lower tier supplier access to federal programs
Technical Standards development	Government enabled collaboration between OEMs, suppliers & standards organizations
Insufficient pace of technology development	Government support for demonstration programs
Accelerate application of innovative technologies	Direct collaboration between battery manufacturers and the federal laboratory network
Battery functional/life performance for PHEVs/EVs	Sustained DOE funding for battery storage R&D programs
Infrastructure for broad market penetration by PHEVs	Collaboration between OEMs, supply base and utilities to develop the value proposition

We would urge Congress to consider legislation to stimulate advanced battery development, including the following detailed provisions:

- ✓ Research and development programs to maintain our nation's competitive advantage in the basic and applied areas of energy storage R&D
- ✓ Demonstration programs to accelerate the development of batteries and battery systems
- ✓ Demonstration programs to accelerate the development of advanced manufacturing technologies to reduce production costs
- ✓ Loan guarantees for capital investment
- ✓ Battery industry and supply chain programs to secure a low cost economically competitive industrial base in the United States
- ✓ Strategies to secure long-term critical material supplies
- ✓ Fleet programs to prove-out advanced technologies
- ✓ Tax incentives for micro, mild, and full hybrids
  - o Automotive manufacturer incentives to drive domestic production and supply of hybrid systems
  - o Consumer purchase incentives
- ✓ Carbon-based fuel efficiency regulations (miles per carbon content rather than liquid volume)
- ✓ Increased role of the battery manufacturers in determining the goals and technical direction for development programs including more direct interaction with national laboratories and institutions of higher learning
- ✓ Integrated activities involving all stakeholders:

- OEMs
- Battery manufacturers
- Federal government agencies
- Consumers
- Electric Power industry
- Fuels industry
- Labs
- Academia

In closing, I would like express my gratitude to this committee for taking the time to hear my testimony. I hope that you consider my comments in the spirit of cooperation guided by the goal to secure the economic and environmental future of the United States.

Johnson Controls looks forward to taking the hybrid journey with Congress. We are energized and ready to go.

Thank you for your time and attention.