Written Testimony
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By

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Chairman Baird, ranking member Inglis, and members of the Committee. Thank you for the opportunity to provide testimony before your subcommittee on near-term priorities and future directions for the Vehicle Technologies Program within the US Department of Energy. It is a privilege to be here. My name is Tom Baloga and I am the Vice President, Engineering – US for BMW of North America, LLC. My key messages for the subcommittee are:

1. Please don't pick technology winners or losers yet; we need an effective palette of solutions that should include an appropriate mix of vehicles powered by highly efficient internal combustion engines, powered by batteries, and powered by hydrogen.
2. Research on batteries for vehicles is a high priority issue.
3. Funding for vehicle on-board storage of hydrogen should continue.
4. Without a developing infrastructure for hydrogen refueling, companies like ours are severely challenged to continue investments into hydrogen-powered vehicles.
5. To the extent possible, please allow research funding support for companies like ours that have made investments in manufacturing and jobs in the US even though our global headquarters is not located in America.

BMW Presence in America

The BMW Group, comprised of Rolls Royce cars, BMW cars and motorcycles, MINI, and Husqvarna motorcycles, is the world's largest manufacturer of premium automobiles. In the United States, about 8,000 people work directly for us in our offices, research facilities, and manufacturing plant. We have been a manufacturer in the USA since 1992. Our Spartanburg, SC plant produced more than 170,000 vehicles in 2008 and we exported about 70% of the total production around the world. This makes BMW the largest vehicle exporter in the United States.

We are investing $1 billion to further our commitment to America by building an all-new assembly facility and thereby expanding the capacity at our Spartanburg plant by 50 percent. We've doubled the size of our NJ Headquarters by adding a state-of-the-art Engineering Center, Technical Training facility, and a new home for our Eastern Region. An independent study reported that our plant has already provided an additional 23,000 jobs in the US. When you combine all this with our distribution and dealer network, we are directly or indirectly responsible for close to 50,000 jobs in America. The United States is our largest market, and we are very happy to play a role in creating new jobs here and leading the global auto industry to innovate and promote sustainability.

Leadership in Sustainability Technology

Sustainability is the degree to which natural resources are conserved and environmental impact minimized. BMW has been a leader in sustainability technology for many years. This means that as a company, we have not only achieved continuous improvements in fleet fuel economy and CO2 reductions, but we have also achieved significant improvements to minimize our impact on the environment. For example:

- The US EPA awarded BMW's plant in Spartanburg, SC "Energy Partner of the Year in 2007" in recognition of BMW's implementation of one of the most ambitious landfill-gas-to-energy projects in North America. The Spartanburg plant pipes in methane gas from a landfill ten miles away to supply about two thirds of its power needs. The amount of recovered energy could heat about 15,000 homes per year. Furthermore, methane is a "greenhouse gas" and removal of this emission from the landfill is a further benefit.
- The BMW Group has been named "the world's most sustainable automotive manufacturer" for four years in a row by the Dow Jones Sustainability World Index (DJSI World).

Leadership in Fuel Economy Improvement and CO2 Reduction

- In its 2007 report for 1990 – 2005 results entitled "Automakers' Corporate Carbon Burdens" the Environmental Defense Fund identified BMW as the company that improved its US average fleet fuel consumption by more than any other firm, reducing CO2 emissions by 12.3% and improving fuel economy by 14%.
- In its August 2008 report for EU countries entitled "Reducing CO2 Emissions from New Cars: A Study of Major Car Manufacturers' Progress in 2007" the European Federation for Transport and Environment concluded that "BMW is the carmaker that made by far the greatest year-on-year CO2 and fuel efficiency improvement in 2007." Fleet CO2 was reduced by 7.3%.

The Five Elements of BMW EfficientDynamics

In 2000, before many were taking CO2 emissions seriously, BMW management conceived and implemented a company program called "EfficientDynamics" to reduce CO2 emissions and improve fuel economy, while at the same time preserving the Ultimate Driving Machine performance our owners have come to expect. So far, we have invested about $1 billion in this program and equipped well over 1 million vehicles worldwide with this technology. The results of this EfficientDynamics program can be directly correlated to the industry-leading reports from EDF and the European Federation mentioned previously. The five elements of the BMW EfficientDynamics program are:

- Powertrain Optimization
- Energy Management with Hybridization
- Weight Reduction
- Aerodynamic Improvements
- Hydrogen Power

The multitude of leading-edge technologies that are part of the BMW EfficientDynamics philosophy are as diverse as they are innovative. From new fuel combustion technologies to lighter construction materials, low-friction components and improved aerodynamics all the way to comprehensive and highly sophisticated energy management. However, the aim of each of these innovations is the same: to deliver maximum driving pleasure from a minimum of fuel.

To achieve this aim, new engines have been developed: gasoline engines with lean-burn technology and High Precision Injection. Diesel engines with third-generation common rail injection and light-weight materials.

An Auto Start Stop function and Brake Energy Regeneration make more of every drop of fuel. Improved aerodynamics - such as an innovative air vent control - together with tires with reduced rolling resistance and a range of efficiency-enhancing modifications to the drivetrain all lead to the same result: more dynamic performance from less fuel.

To assist the Subcommittee with near-term priorities and future directions for the Vehicle Technologies Program within the US DOE, I would like to briefly focus on Powertrain Optimization, Energy Management with Hybridization, and Hydrogen vs. Battery Electric Power, followed by a recommendation for expanding research collaboration to companies based outside of the USA.

Powertrain Optimization

This past December, BMW launched 2 new vehicle models equipped with clean diesel engines. The X5 diesel built in America and the 335d are available in all 50 States and use the latest clean diesel engine technology to meet even California's stringent emission requirements. In a modern internal combustion engine, only about one third of the fossil fuel energy is used to drive the engine crankshaft. This means that approximately two thirds of the fuel's energy is lost via friction plus engine heat into the exhaust and coolant. More efficient use of this lost energy is a high priority at BMW; we already use sophisticated engine management technology and turbo charging to extract as much energy as possible from the burned fuel, but we just recently announced something new at the Geneva Auto Show.

We will be launching a full hybrid X6 model built in the USA later this year so we are far along with hybrid technology. Hybrids use methods to recharge a battery when the vehicle is braking or coasting, but not under acceleration. Since BMW is known as the "Ultimate Driving Machine" we are also focused on EfficientDynamics when the vehicle is accelerating and typically wasting significant heat energy from the exhaust. To recover some of this exhaust heat, BMW has been leading a pioneering effort to bring a "thermoelectric generator" to market. The system is connected to the vehicle exhaust and using a material called Bismuth Telluride (plus other materials under investigation), the difference in temperature of the exhaust and ambient air can generate an electrical current to recharge the battery. We have reason to believe that under certain conditions of using this "Seebeck Effect" more than 10% savings in fuel use could be realized. Waste heat is converted into electricity stored in the battery that relieves the normal charging system and reduces fuel consumption. In operation, the exhaust gas is being further cooled as heat energy is extracted and, as expected, the higher the exhaust temperature such as in acceleration, the more electricity is produced. We hope to be able to bring this system to market in perhaps five years. This research was made possible through financial support of the DOE which we acknowledge and appreciate. We had been working on a "turbo-steamer" project to evaluate the potential for converting exhaust heat into steam to power a turbine and supply

additional propulsion to the vehicle, and these concepts are mutually complementary. The turbo steamer concept is more complicated, but still worthwhile to investigate because the potential benefits in recaptured energy look significant and very promising.

It's important to note that we see the internal combustion engine itself available for high single digit percentage increases in efficiency, and we continue to actively research further improvements. Furthermore, extraction of exhaust heat is only one of many projects in process for powertrain optimization.

Energy Management with Hybridization

Hybridization means converting and storing some of the "moving" (kinetic) energy of the vehicle to electrical energy that can be used to charge the battery, power accessories or power the vehicle. Later this year, we will launch a full hybrid X6 model Sports Activity Vehicle built at our plant in South Carolina, then followed by a 7 Series mild hybrid sedan. For better understanding, a "full hybrid" can operate using only battery power; a "mild hybrid" uses a battery to provide a boost to save fuel, but cannot use a battery alone for propulsion. These models use hybrid technology that came from a consortium of partners working together in Troy, Michigan. The three partners BMW, Daimler, and GM collaborated, on the one hand, to developing a common shared technology, and on the other hand, to develop a unique application and integration of the technology into our own company vehicles based on our individual philosophies and technical needs. The partnership worked very well, and we are grateful to our partners.

Even before we launch our hybrid vehicles, BMW is using one hybrid principle, brake energy regeneration, to improve fuel economy and reduce CO2 emissions. Today's vehicles require much more electrical energy than older models, due to the much wider array of electric and electronic on-board comfort and safety systems. This energy is created by the alternator which converts the engine's power output into electricity. In conventional systems, the alternator is permanently driven by a belt connected to the engine. A system we call BMW's Brake Energy Regeneration operates differently: the alternator is activated only when you take your foot from the accelerator or apply the brake. The kinetic energy that would otherwise go to waste is now used efficiently, converted into electricity by the alternator and stored in the battery. Producing electricity in this highly efficient way delivers an additional advantage: when you apply the accelerator, the alternator is deactivated - so the full power of the engine can be directed to the drive wheels. Brake Energy Regeneration thus increases fuel efficiency while simultaneously enhancing driving dynamics. As an extra precaution, the Brake Energy Regeneration system monitors the level of battery charge and will, if necessary, continue to charge the battery even during acceleration to prevent a complete discharging of the battery.

We have many other technologies for saving fuel and reducing CO2 and I would be pleased to forward this information to members of the Subcommittee.

Hydrogen vs. Battery Electric Power

- Hydrogen has no carbon so hydrogen by itself will not generate air pollution.

- Hydrogen can be generated using clean and sustainable sources like hydro, wind, solar, and biomass sources.
- Hydrogen can be produced in this country and other locations away from troubled parts of the world.

Based on the above listed circumstances, BMW has worked to gain more than thirty years of experience with hydrogen powered automobiles. We have just completed a successful global "Hydrogen 7" Program in which 100 hydrogen powered BMW 7 Series cars were equipped to run on either gasoline or hydrogen. (A few cars equipped to run exclusively on hydrogen were also built in order to explore the state-of-the-art in emission reductions and exhaust measurements.)

These "bi-fuel" hydrogen/gasoline cars were very successful to demonstrate that a hydrogen-powered internal combustion engine can operate today, and in the bi-fuel configuration, can help bridge the gap until a hydrogen refueling infrastructure is available.

To expand on our battery powered vehicle knowledge, the BMW group has just launched a battery electric vehicle (BEV) program with approximately 500 battery electric "MINI E" cars. These cars are being deployed in the US (about 480) and in Germany to gain insight into this unique technology.

When comparing the technology of hydrogen power versus battery power, the similarities and differences must be considered. A similarity is for example that hydrogen is an energy carrier just like a battery. A battery is charged to store energy, while water is split to make energy available as free hydrogen. A major difference is that hydrogen refueling can be performed in a few minutes, while a battery "fast charge" today takes several hours.

While the current electric grid provides a limited infrastructure for charging a BEV, a far greater infrastructure is needed. Likewise, there is a very limited hydrogen refueling infrastructure, and a far greater hydrogen refueling infrastructure is needed.

While expanded infrastructures are needed, the critical challenge for the auto industry with both BEVs and hydrogen powered vehicles is in energy storage. Furthermore, an infrastructure of BEV charging stations and hydrogen refueling are necessary if the auto industry is expected to continue to invest in these technologies.

Today's BEV batteries are too large, too heavy, too limited in range, and far too expensive. Our MINI E BEVs were changed from 4-seaters to 2-seaters because of the battery size and weight, and the effective range of the vehicles is relatively good, but only equivalent to approximately two gallons of diesel fuel. There can be no debate on the merits of battery research and we fully support efforts by the DOE to fund battery research, but doing this with the complete elimination of hydrogen storage funding would be very unfortunate. BMW has partnered with US companies to collaborate on projects involving storage of hydrogen for use on-board vehicles and we see hydrogen as playing an important role in the future as a means to become independent from fossil fuels.

1. Hydrogen powered internal combustion engine vehicles consume air with nitrogen and thus are not 100% zero emissions vehicles, but they are virtually emissions-free.
2. Hydrogen powered internal combustion engine vehicles consume the surrounding air including methane, hydrocarbons, and other pollutants and exhaust water vapor you can drink and cleaner air than the air we breathe.
3. Hydrogen powered bi-fuel internal combustion engine vehicles can provide a critical bridge solution to getting a hydrogen infrastructure in place. Drivers can seamlessly select between super clean hydrogen power or fossil fuels as necessary to reach available gasoline or hydrogen refueling stations.
4. Hydrogen storage on-board is a critically important element for the success of hydrogen, and it is prudent to continue to invest in this technology for the future.

Despite our thirty years plus of hydrogen-powered vehicle experience, we have an increasingly difficult challenge to justify investments in hydrogen power without evidence that a hydrogen infrastructure is being developed.

Thank you for the opportunity to provide testimony to the U.S. House of Representatives Committee on Science and Technology, Subcommittee on Energy and Environment.