

Testimony for the hearing,

“The Road to Tomorrow: Energy Innovation in Automotive Technologies”

Before the

Senate Committee on Energy and Natural Resources

Offered by

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Chairman Murkowski, Ranking Member Cantwell, and Members of the Committee, thank you for inviting me to share Eaton’s experience with innovation in the automotive industry. The U.S. and global automotive industry are in a period of rapid change and development, which this Committee has correctly identified as an enormous opportunity, as we move into the next generation of truck and passenger vehicles. At the same time, these rapid changes in the industry also present challenges. I look forward to discussing both the opportunities and challenges that Eaton sees with the Committee.

Eaton is a leading Tier 1 supplier that competes in the global market by consistently driving technology innovation. For over 100 years, Eaton has helped our customers grow their business profitably through innovation that drives results. With 10,800 patents, Eaton is focused on developing technology solutions for our customers’ toughest power management challenges. We have 28,000 associates in more than 110 facilities throughout the United States. Eaton’s Vehicle Group employs nearly 3,000 associates in manufacturing and research and development centers of excellence in Georgia, Indiana, Nebraska, North Carolina and Michigan.

We are part of a motor vehicle parts manufacturing industry that is a driving force in transforming mobility through innovation and technology, while leading greater environmental improvements through sustainability around the global economy. Motor vehicle component manufacturers are the nation’s largest direct employer of manufacturing jobs in the U.S., employing over 871,000 workers in all 50 states. Together with indirect and employment-induced jobs, the total U.S. employment impact of the supplier industry is 4.26 million jobs. The total jobs in the supplier industry saw nearly 19 percent growth between 2012 and 2015.

As an independent supplier, Eaton’s technology innovations are incorporated into a large number of vehicles, delivering significant fuel consumption improvements in the U.S. and world-wide.

Light-duty suppliers alone account for 30 percent of total automotive investment in research and development and continue to take on a greater role in the design, testing, and engineering of new vehicle parts and systems in the United States. Motor vehicles suppliers provide the technologies and components that make up more than 77 percent of the value of a new vehicle. Development and manufacturing of these advanced products have also provided a robust domestic supply base that generates jobs and investment while boosting U.S. competitiveness.

Regulatory pressure, technological innovation, and customer expectations are driving adoption of clean and intelligent products, challenging traditional notions of mobility and creating exceptional growth opportunities for well-positioned companies.

Eaton's advanced products help customers increase energy efficiency through a portfolio of solutions dedicated to enabling sustainable businesses. Whether a vehicle covers 50 or 500 miles a day, or makes five or 500 stops, it needs to be safe, reliable, and efficient. Our technology solutions offer improved fuel efficiency, enhanced vehicle productivity and performance, and safety and comfort enhancements that protect vehicle operators, the environment, and our customers' business investment. Our technologies also enable businesses to meet regulatory requirements and performance goals, ensure reliability and uptime, and lower fleet operational costs. Our experience tells us that new product developments will only succeed when all of these customer expectations are met. Our approach to innovation begins and ends with these requirements.

At the vehicle level, the need to simultaneously reduce carbon dioxide (CO<sub>2</sub>) and nitrogen oxide (NO<sub>x</sub>) emissions drives advanced internal combustion technologies and powertrain electrification as a means to improve efficiency. Light-weighting and aerodynamic solutions are also applied to reduce vehicle energy demand.

The vehicle transportation industry will continue to seek clean and intelligent solutions. Vehicle electrification will play a key role in reduced emissions and improved fuel economy -- with 12% of global passenger cars projected to be battery electric by 2030. Eaton will provide original equipment manufacturers with innovative power management, distribution and protection technologies for electrified vehicles. Emerging markets for fuel cell vehicles also provide additional opportunities for zero-emission mobility solutions in the transportation sector.

We will also continue to improve the efficiency and fuel emissions of internal combustion engines through an extensive portfolio of powertrain solutions. At the transportation systems level, connectivity and embedded electronics and controls enable step-changes in the utilization of vehicles, including levels of autonomy ranging from driver assistance to full autonomy, optimized routing and platooning, enhanced fleet management, and increased productivity.

Eaton recognized early that the vehicle sector was on a trajectory of increased CO<sub>2</sub> emissions and petroleum-based fuel burn, and that market, societal and regulatory forces will need to come together to reverse that trend. We positioned our entire advanced research and technology portfolio to address vehicle energy efficiency, along the following three directions:

- Improving the efficiency of vehicle power creation, both conventional and electrical;
- Efficiently distributing that power from creation to the wheels, and
- Optimizing the power usage for increasingly diversified needs.

The key technologies we invest in are engine air management and controls, through variable valve actuation and precise air flow control; efficient transmissions and torque control devices, including electrified powertrains; automation and deep integration of powertrains, as well as power electronics systems for charging, conversion, distribution and protection.

For example, Eaton led the global market in introducing hybrid electrical systems for heavy duty commercial vehicles in North America, followed by exports world-wide. Recently, we found ways of improving the efficiency of electric commercial vehicles, helping customers reduce battery sizes and extend range. Technology innovation in air management systems improves fuel consumption by increasing heavy duty diesel engine efficiency and enabling novel highly efficient combustion cycles for passenger cars, such as gasoline compression ignition. We introduced the first commercial vehicle dual

clutch transmission, as well as heavy duty high efficiency automated transmissions deeply integrated with diesel engines. These advanced products reduce fuel consumption and vehicle down-time, while increasing performance and safety.

#### Working with the National Laboratories and the Department of Energy

In the past decade, we have worked closely with several government agencies that also are pursuing advances in vehicle energy use. Our public-private collaborations, with National Laboratories, such as Oak Ridge National Laboratory in Tennessee and the National Renewable Energy Laboratory in Colorado, accelerate innovation and promote U.S. competitiveness.

Eaton benefits from access to leading edge facilities, such as high-performance computing or vehicle testing equipment, as well as pre-competitive results, such as agency research on new battery technologies. These benefits enhance our global competitiveness. At the same time, we contribute our expertise and research direction, materials, and funding, to the Labs' efforts. The result is that, working together, we create and demonstrate new technologies and jointly advance state of the art technologies and enhance American competitiveness.

We also work closely with the Department of Energy, through its Vehicle Technologies Office and Advanced Manufacturing Program. In partnership with the Department of Energy, we successfully developed the fundamentals of new technologies that have become essential elements of advanced products. For example, the SuperTruck programs became testbeds for multiple technologies that are now entering the heavy duty market and are enabling U.S. manufacturers and suppliers, for the first time, to take the lead in efficient trucks over our European competitors.

From our perspective, the vehicle programs play a vital role in maintaining U.S. technology leadership in global markets, especially through private-public partnerships. These partnerships accelerate innovation in several ways:

1. Public private partnerships foster collaboration across the industry in a way that is not easily achieved with separate commercial entities acting independently, thus creating new opportunities and new products. As an example, engines and transmissions are traditionally designed by different organizations that aim to maximize generic pairings. SuperTruck allowed Cummins and Eaton to consider the engine and transmission as an optimized and deeply integrated powertrain, resulting in significant fuel consumption reduction, and ultimately a new product line: the SmartAdvantage powertrain.
2. They connect basic research capabilities in universities and National Laboratories with industrial research and development organizations, accelerating the pace of innovation. As an example, battery life extension methodologies developed by NREL were integrated with optimized hybrid powertrain controllers, resulting in reduced battery needs for hybrid buses.
3. Public private partnerships connect technology start-ups developing new ideas to industrial players that have manufacturing capabilities and scale. As an example, advanced air breathing technologies enable novel 2-stroke opposed piston engine concepts with a promise for both low fuel and low emissions breakthroughs in diesel technology.
4. They also demonstrate the potential of new technologies, enabling product development investment decisions that otherwise would not be made in a conservative industry. As an example, the benefits of multi-speed transmissions for electrical trucks and buses are enabling a shift towards commercialization by significantly reducing motor and battery needs.

The vehicle industry is facing significant challenges. As it is very capital intensive, the industry has historically been relatively conservative in investment. However, the technology landscape is changing rapidly and forward-looking investment is imperative. The industry is responding to the challenge of reducing fuel burn, which adds cost and complexity throughout the supply chain. Evolving markets are also creating industry challenges as we face increased technology competition from Europe and pressure from emerging markets. Vertical integration is putting additional pressure on independent manufacturers.

Our successful response to these challenges lies in our commitment to innovation and to the quality and vitality of the U.S. vehicle technologies and workforce. The vehicle programs at the Department of Energy and National Labs are key to maintaining U.S. industry's leadership position at all levels of the supply chain. The public-private partnership model is proving particularly effective in guiding investments in areas that have the promise of high impact in the market but are perhaps too early, too broad or too unproven for industry alone to pursue.

We work continuously with government agencies to identify critical areas for technology investments that are potential game-changers. In our case, that means advances that can significantly reduce transportation energy consumption and costs, and at the same time increase the competitiveness of U.S. manufacturers.

It is essential that those investments are balanced between growing the fundamental research capabilities of the nation and funding technology demonstration programs. Without proper support for demonstration, particularly through various forms of public-private partnerships, the potential breakthroughs identified by basic research can be lost. I have witnessed technologies, which were successfully developed, only to be trapped in the so-called "Valley of Death." The technologies failed to gain a sustainable market - not due to lack of merit, but rather due to insufficient attention in demonstrating value to the stakeholders who are responsible for much larger product development investment decisions.

In my experience, it is easy to recognize fundamental science, typically the domain of public investment, and new product introduction, which is typically the job of industry. However, the challenges of transitioning between these areas are not trivial. It is at this juncture of innovation that public-private partnerships are most effective.

In closing, I would like to thank you again for the opportunity to testify on this important topic. As we can see by the automotive innovation that surrounds us here today, the industry is moving forward at a rapid pace. We applaud your efforts to understand these emerging trends and to support American innovation in this field.

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