Abstracts

SESSION 1 – Emerging Diesel Technologies

Chair: **Carl Maronde, National Energy Technology Laboratory**

The Myth of Engine Maturity and the Reality of Engine Efficiency, Durability, Commercial Viability, and Potential Improvements

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The Diesel engine is viewed by some as mature technology. It is viewed as a transportation propulsion engine that has already maxed out its potential efficiency because of its age and current number of applications. Reviewing the chronological history of the current and future transportation propulsion engines shows this to by a myth. The Diesel engine was patented in 1893; 44 years after the invention of the fuel cell and nearly 20 years after the invention of the "Otto cycle" or the gasoline engine.

Diesel engine applications increased dramatically through the last century. Diesel powered locomotives began replacing steam powered locomotives in the 30's and today Diesel engines power about 99 percent of non-electrified trains. Diesel engines power almost all of the inland marine fleet such as the tow boats, tugs, ferries, and personal yachts and have systematically replaced steam turbines in deep water cargo and passenger ships. Virtually all heavy duty class 7 & 8 trucks, off-highway vehicles, most school and transit busses, and utility trucks are Diesel powered.

Improved efficiency and reliability over other propulsion engines has been the reason for its further increased usage. Thirty years ago, the Diesel engine was typically 20 to 30 percent more fuel efficient than competitive engines. Since then, the Diesel engine has had a 25 percent increase in fuel economy while engine life has been improved by a factor of 4. No heat engine or potential propulsion engine has shown this sustained rate of improvement. The Diesel engine has consistently become the cost effective surface transportation engine of choice for most applications except personal transportation in the United States.

Where can the Diesel go from here? In Europe, Diesel engine powered personal transportation sales are approaching 50 percent of the market with current technology. New technology has the potential to improve the current efficiency of 40 percent to approach an efficiency of 60 percent. This can theoretically be accomplished with advances in electric turbocompounding, high efficiency thermoelectrics, lightweight materials, low friction coatings, more efficient turbochargers, and advances in combustion (which could lead to reduced or no aftertreatment requirements for emission compliance).

Will the personal transportation market in the United States accept the Diesel in the near term to reduce oil consumption? What are the fuels of the future? Currently in the light truck industry, Diesels are about 50 percent more fuel efficient and emit 37 percent less carbon dioxide. Future vehicle propulsion selection will be primarily influenced by the availability and cost of the vehicle and fuel.

Future Potential of Hybrid and Diesel Powertrains in the U.S. Light Duty Vehicle Market

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Diesel and hybrid technologies each have the potential to increase light-duty vehicle fuel economy by a third or more without loss of performance, yet these technologies have typically been excluded from technical assessments of fuel economy potential on the grounds that hybrids are too expensive and diesels cannot meet Tier 2 emissions standards. Recently, hybrid costs have come down and the few hybrid makes available are selling well. Diesels have made great strides in reducing particulate and nitrogen oxide emissions, and are likely though not certain to meet future standards. In light of these developments, this study takes a detailed look at the market potential of these two powertrain technologies and their possible impacts on light-duty vehicle fuel economy. A nested multinomial logit model of vehicle choice was calibrated to 2002 model year sales of 930 makes, models and engine-transmission configurations. Based on an assessment of the status and outlook for the two technologies, market shares were predicted for 2008, 2012 and beyond, assuming no additional increase in fuel economy standards or other new policy initiatives. Current tax incentives for hybrids are assumed to be phased out by 2008. Given announced and likely introductions by 2008, hybrids could capture 4-7% and diesels 2-4% of the light-duty market. Based on our best guesses for further introductions, these shares could increase to 10-15% for hybrids and 4-7% for diesels by 2012. The resulting impacts on fleet average fuel economy would be about +2% in 2008 and +4% in 2012. If diesels and hybrids were widely available across vehicle classes, makes, and models, they could capture 40% or more of the light-duty vehicle market.

How Exhaust Emissions Drive Diesel Engine Fuel Efficiency

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A key defining attribute of Diesel engines is its ability to produce shaft power efficiently. This efficiency advantage has led to its widespread application in transport, construction, mining, and agriculture. Traditionally, Diesel engine efficiency was dominated by three key physical processes - 1) effective expansion ratio of the power cylinder, 2) transport of air into and exhaust out of the engine, and 3) parasitic losses. Over many years of development, these three processes were improved upon through the use of better materials, higher cylinder pressure capabilities, improved turbocharging, and more sophisticated fuel systems. However, in the last twenty (plus) years nothing has impacted the design of the Diesel engine more than exhaust emission constraints. This influence will only be increasing over the next ten years as future regulations cascade through the various Diesel markets. This presentation will give a simple tutorial on how Diesel engine efficiency has and will be influenced by new combustion strategies, nitrogen oxides aftertreatment devices, and particulate controls. The presentation will give easy "rules of thumb" that will describe how and why fuel penalties are incurred. And finally, a discussion of the "art of the possible" will be given.

Design & Development of e-Turbo™ for SUV and Light Truck Applications

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The purpose of the project is to develop e-Turbo™ technology for application to light truck class passenger vehicles. Earlier simulation work had shown the benefits of e-Turbo™ system on increasing low-end torque and improving fuel economy by possibly 6 to 17 percent over and above the advantage that turbo Diesel engines offer compared to conventional gasoline engines.

In order to fully demonstrate the benefits of e-Turbo a simultaneous development of five technology elements is being undertaken. These five technologies are being developed in parallel on independent platforms in order to speed up the development process and minimize the effect of uncertainty of one technology on another. At a suitable stage of demonstration these technologies will be integrated into a single system suitable for light truck class Diesel engines. The five technologies under development are.

- Development of base electrical machinery integrated into a turbocharger to meet rigorous design requirements of shaft stability at high speeds, temperature tolerance at realistic duty cycles, power electronics, and controls capable of handling required power level. This was done on a small turbocharger in order to minimize design and development issues by leveraging the large base of technology and experience available for smaller turbo-Diesel engines.

- Development of a control system for integrated control of VNT, EGR, electrical power, and battery charge management.

- Development of a variable geometry compressor to take full advantage of the flow capability provided by electric assist at low speeds.

- Development of an innovative design turbocharger of matched compressor and turbine wheel sizes in order to provide flow range and flow control and minimize inertia so that electrical power demands are reduced.

- Development of turbine wheels made of low inertia materials such as high ductility ceramics and Titanium Aluminide to minimize power demand from electric assist.

These five technologies are under various stages of development. The paper will report the status of each, preliminary results, future plans, and estimations of benefits of using it on light truck class turbo Diesel engines.