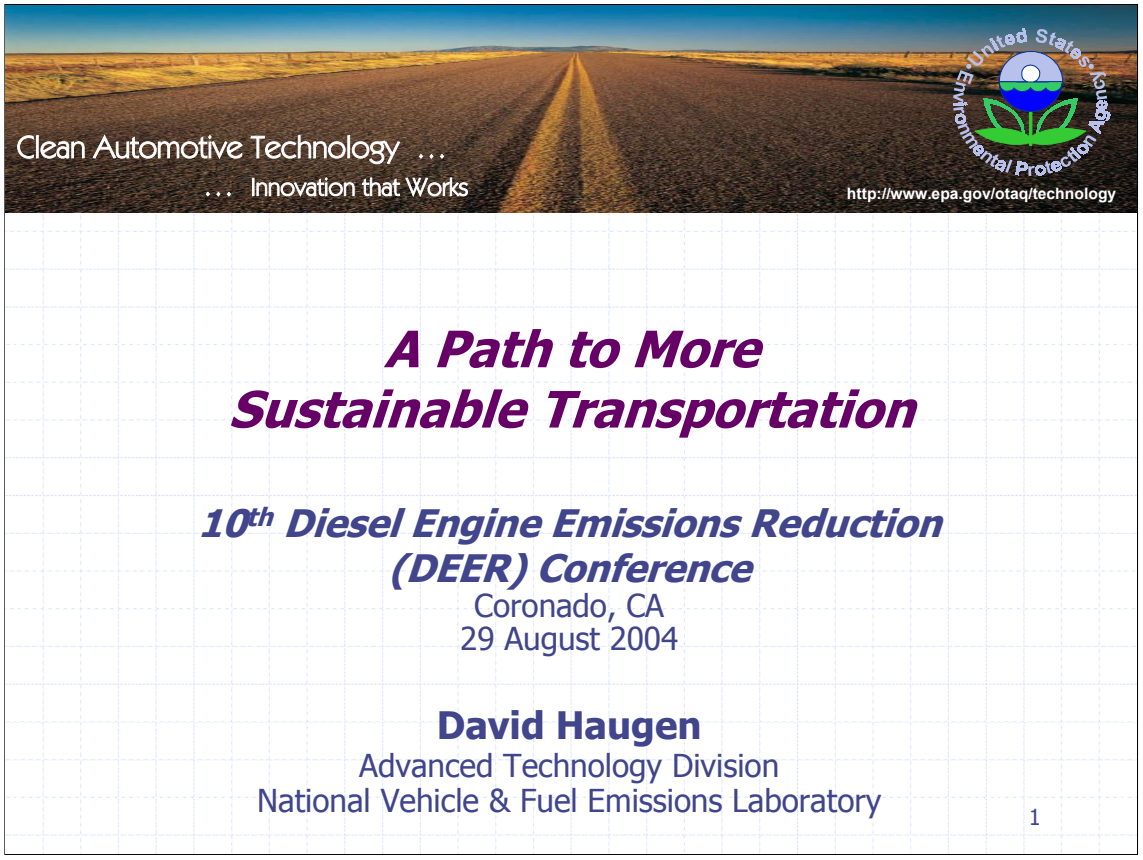
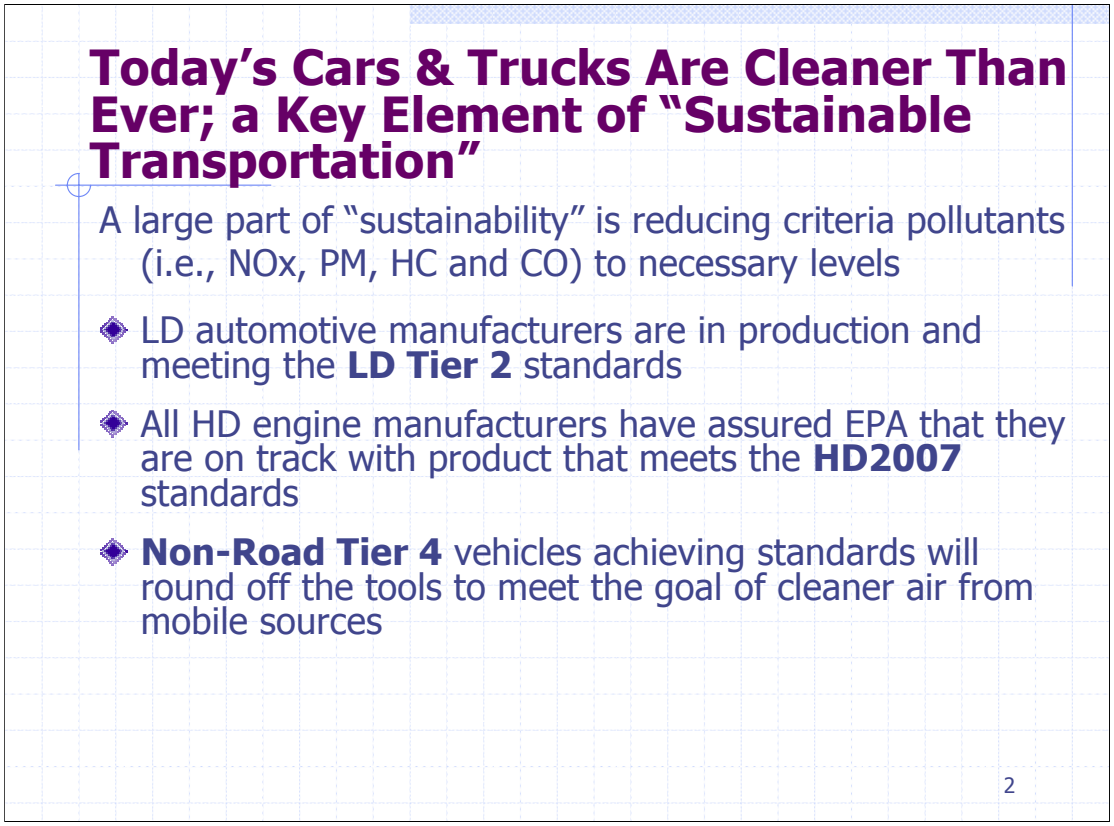


1)Thank you for the opportunity to …

We are all here at the 10th DEER Conference to discuss diesel engines and diesel emissions, with an overarching objective of discussing where diesel engine technologies can, should and will fit into a longer term solution for the transportation network. Only a few years ago, you would not have heard an Environmental group talk about the diesel as a solution to environmental problems – in fact, many environmentalists considered the diesel one of the biggest environmental transportation problems, with their high NOx emissions leading to smog in urban areas and the high particulate emissions associated with cancer and other respiratory illnesses.

But environmentally responsible actions require identification of a problem, and then setting health based – technology neutral – standards that allow "sustained use" of the solutions. When I use the term "sustainable solutions", I do not only mean that our resources are not depleted, but also mean to describe solutions that are *safe* for both users and non-users, and are solutions that are really *viable* in that they are also *available, stable and affordable*. And that is why the EPA has an interest in diesels. We want to see transportation solutions that offer the public continued use of the automobile as we have come to expect as Americans, while moving us closer to sustainable goals, and diesels look as though they could be a bigger part of that solution.



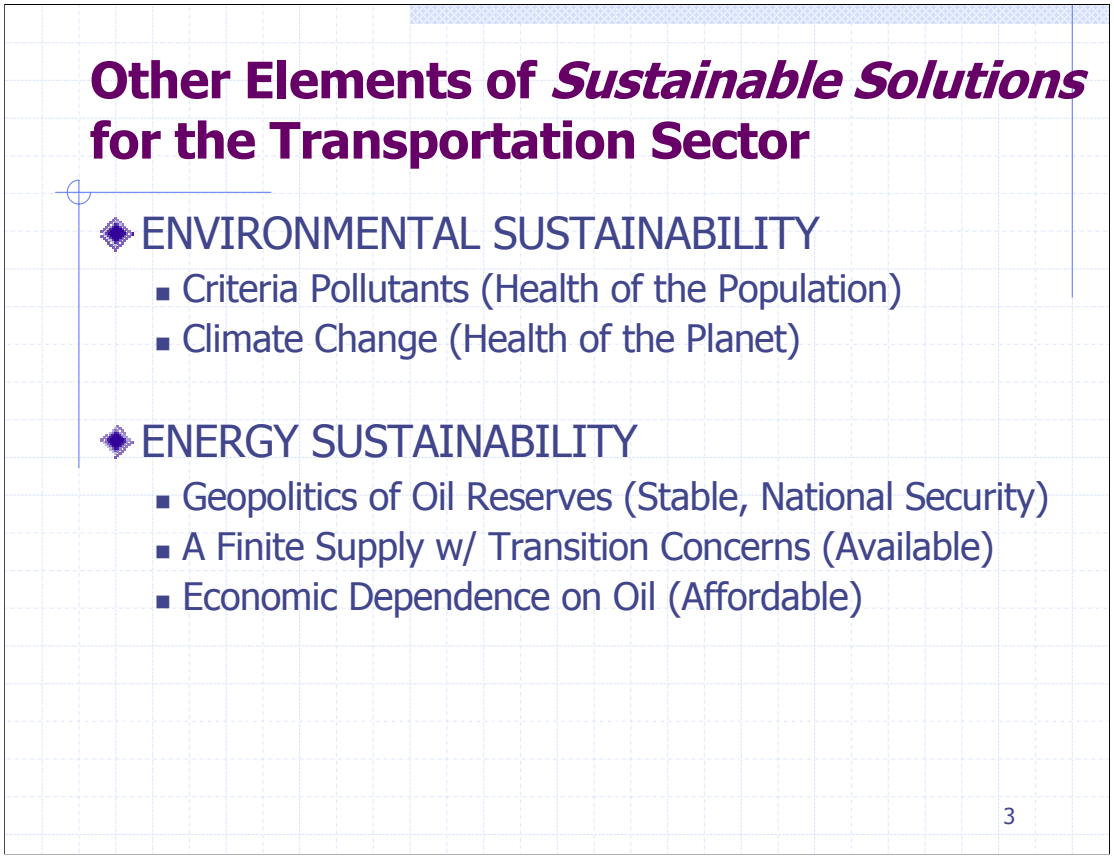
2) Progress Has Been Made …

I will begin with a quick review of where EPA views diesels in current state of transportation emissions regulations. It is almost unbelievable progress that has been made in the automotive sector over the last 35 years. Compared to the cars and trucks made and sold in the 1960s when tailpipe emissions were unregulated, cars sold in America today are over 98% cleaner. Unfortunately, the hard earned gains that have been made as seen on a car-by-car and truck-by-truck basis have been partially offset by tremendous 160% growth in our economy over the same period, along with a 40% increase in our population and 150% increase in number of vehicle miles traveled (all since 1970).

And as we look forward with the current set of emissions regulations, we should expect this same type of economic, population and VMT growth to diminish the hard earned gains we are now striving to meet in our current emissions standards. The three sets of current tailpipe pollution standards– the Tier 2 program for cars that includes low sulfur gasoline, the 2007 Heavy Duty program for diesel trucks and buses that includes ultra-low sulfur diesel fuel, and the recent non-road Tier 4 program – these three programs will reduce pollution by another 80-90%, which is millions of tons per year.

The health benefits from these programs will prevent over 22,000 premature deaths per year and prevent hundreds of thousands of respiratory illnesses. In monetized terms, the "value" of these standards to society ($170B/yr), relative to the added cost to these cars and trucks to meet these standards ($11B/yr) achieves a 16:1 ratio, making these programs some of our most cost-effective public health investments.

EPA's long standing approach for establishing cost-effective and health-based regulations to vehicle and fuel emissions, and industry's ability to consistently implement changes at costs lower than EPA's estimates, is something we should stop to recognize as we work so hard today to meet these current regulations. We all know that the job of meeting these standards isn't easy. And the best, lowest cost path isn't always obvious from the start. But the Light Duty Tier 2 automotive standards are being met with this year's 2004 production vehicles – with the real news being that industry has done this so effectively. As we look toward the Heavy Duty On-Highway market, we see a similar outcome ahead with all engine manufacturers assuring us that their product will meet the 2007 standards. And, of course, the recent Tier 4 non-road rule was developed through very productive interactions with industry, as the emissions standards for that segment of the transportation sector are brought to an equal level "playing field," so that the comprehensive package of this trilogy of rules can dramatically reduce tailpipe pollution in the coming years.



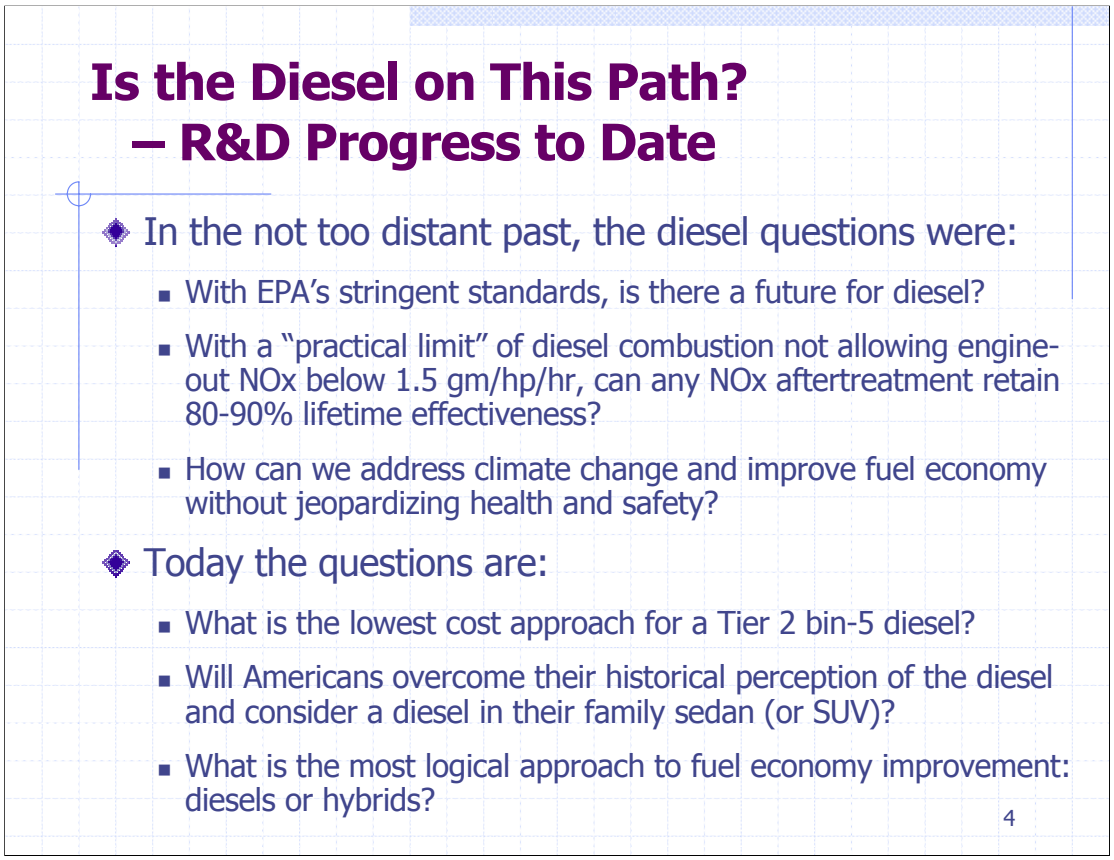
3) Sustainable Transportations Solutions …

At the beginning of this discussion, I mentioned *Sustainable Solutions* as solutions that are safe for use for both users and non-users, available, stable and affordable.

With EPA's technology neutral pollution standards, there is no longer a need to apologize for the diesel's tailpipe emissions. Under these new standards, all cars, SUVs, pick-up trucks, and heavier trucks, diesel or otherwise, are emitting at or below the same low health-based levels for criteria pollutants. But *Sustainable Transportation Solutions* extend beyond criteria pollutants. As we continue to learn more about Climate Change, the risks that CC brings and the trade-offs in all of societies' sectors that contribute to the CC risk, we might see climate change as a sustainability concern. With mobility services expected to increase by 50% globally over the next 20 years, coupled with a continuation of the trends seen in the US toward higher fuel consumption (a 6% increase in fleet average consumption over the last 15 years), it seems obvious to me that a substantial change for increased efficiency is needed now, in the near- to mid-term.

There are other factors in sustainable transportation that are captured on the "Energy" side of the "Sustainable Transportation" discussion. We need to have a stable, available and affordable source of energy as we look toward future transportation options. While there **may** be time to work toward the "best solution" we engineers all strive for, we might expect that at least one of these factors: climate change, the geopolitics of oil reserves, a limited oil resources or economic dependence on oil, **may not** wait for the "best solution" to arrive.

The diesel engine is one of the most promising technologies available today to reduce the environmental footprint of the transportation sector. Increasing the awareness of "Sustainability Issues" through the sharing of ideas and discussions of our progress at this DEER conference, as at the past nine DEER conferences, are a part of all of our responsibility to move us toward finding a more "Environmentally Sustainable Transportation" solution.



4) Is the Diesel on the Path …

So, as we spend the next few days together talking about the topics and issues on the conference agenda, we can be motivated knowing that a critical need for our work grows ever stronger. During our search for cost-effective nearer term transportation technologies that really are clean – very **low criteria pollutants** and with **lower carbon emissions** and higher fuel economy – we need to also appreciate the progress that has been made in the diesel area in just the last few years.

In the not too distant past, the questions were:

• With EPA's stringent standards, is there a future for diesel?

• With a "practical limit" of diesel combustion not allowing engine-out diesel NOx below 1.5 gm/BHP/hr, can any NOx aftertreatment retain 80-90% lifetime effectiveness?

• How can we address climate change and improve fuel economy without jeopardizing health & safety?

Today the questions reflect our advancements in diesel technologies, as being:

• What is the lowest cost approach for a Tier 2-bin 5 diesel?

• Will Americans overcome their historical perception of the diesel, and consider a diesel in their family sedan (or SUV)?

• What is the most cost-effective approach to fuel economy improvement, diesels or hybrids?

As I mentioned, further advancement of the diesel engine, as well as other variants like HCCI or Low Temperature Combustion approaches which preserve the diesel cycle efficiency while reducing its combustion products, are really – really important. It is great to see the focus being brought to Thermal Electrics (and other exhaust waste-heat recovery devices) and some of the alternate fuels like the Gas-to-Liquid Fischer-Tropsch diesel fuel. And although we won't be talking much about hybrid drivetrains at this conference, we need to keep in mind the fact that they aren't necessarily just competitors to diesel technologies – although the competition is good and should drive us to the best solutions – we need to recognize that the path and need for even more sustainable transportation solutions could very well lead to a combination of hybrid powertrain and drivetrain technologies. By combining these technologies, there are some synergistic opportunities to enable some of the engine, combustion and heat recovery approaches that will be discussed at this conference.

Clean Automotive Technologies
Under Development at the U.S. EPA's National Vehicle & Fuel Emissions Laboratory

- Advanced Engine Concepts
  - Clean Diesel Combustion
  - HCCI
  - Free Piston Engines
  - (Alternative Fueled Engines)
  - (Efficiency Improving "Bottoming Cycles")
- Advanced Hydraulic Hybrid Vehicles & Components
  - Improved Hydraulic Components (pumps, motors, valves, accumulators, etc.)
  - Sport Utility Vehicle DEMO (Class 2)
  - Urban Delivery Vehicle DEMO (Class 5-7)
  - Heavier Utility Vehicles DEMO (Trash Trucks, Dump Trucks, Buses)

5

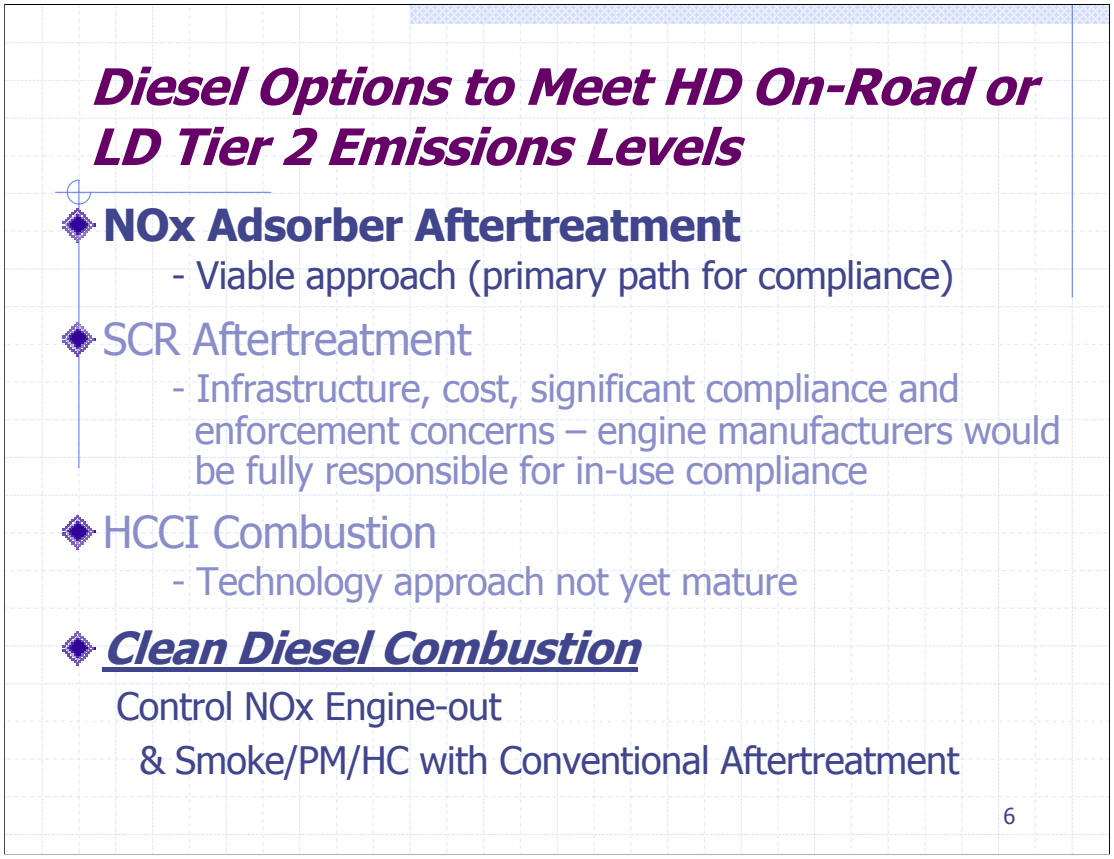
5) Clean Automotive Technologies …

I would now like to take some time to introduce you to the automotive technologies that EPA believes could become sustainable transportation solutions in the near-term to mid-term time frame.

At EPA's Ann Arbor Laboratory, the National Vehicle and Fuel Emissions Laboratory, we are focused on just a few technology areas, in the fields of Clean Combustion Engines and Hydraulic Hybrid Drivetrains. Our selection of these two technical areas is based on our prioritization for technologies that meet environmental needs for ultra-low emissions and ultra-high fuel efficiency, while at the same time remaining affordable.

Within the Clean Combustion engine arena, today we are focused on Clean Diesel Combustion and HCCI engines, which I will talk about in a minute. We are also running and developing Free Piston Engine technologies which complement our Hydraulic Hybrid work, and which we will be talking more about later this year and early next year. We have, in the past, developed a very deep understanding and involvement in Alternative Fueled Engines and "Bottoming Cycles" or Waste Heat Recovery cycles and devices, but at this time our limited resources aren't able to be broadly applied in these two areas.

We have also become a "center of excellence" in the area of hybrid vehicles, with an exclusive focus on hydraulic hybrid drivetrains. Applying our efforts on larger personal vehicles and the full range of commercial vehicles, from SUVs and pick-up trucks to Urban Delivery Vehicles and on up the scale to Heavier Utility Vehicles, such as refuse haulers and buses, where large percentage improvements in fuel economy translates into very large reductions in carbon emissions and fuel consumption, has taken the form of demonstration platforms and upcoming durability testing programs that are being discussed at other venues.

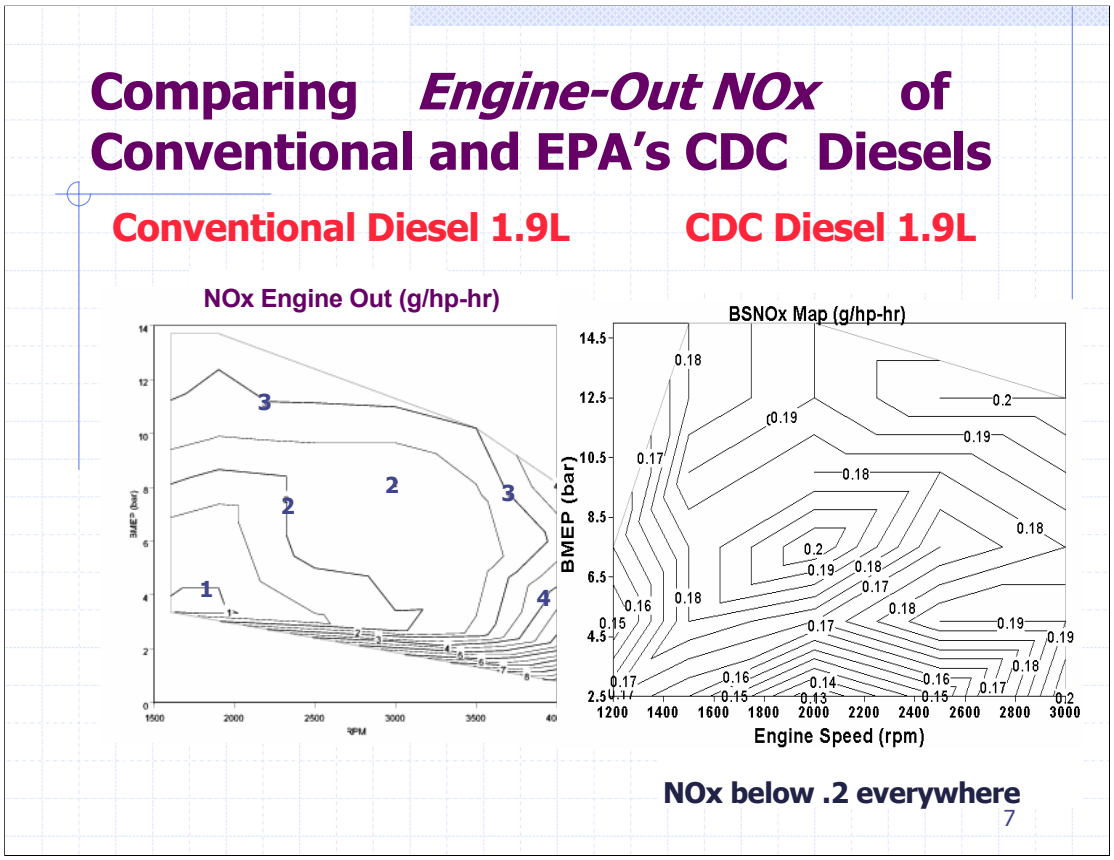


6) Diesel Emissions Compliance Options …

I would like to spend the rest of these few minutes I have with you, talking about EPA's approach to Clean Diesel Combustion. Clean Diesel Combustion technology began to take form and be appreciated as we were looking for alternate technical paths to support EPA's HD 2007 rules. More specifically, we were looking for combustion approaches that enabled the engine to exhaust the combustion products with engine-out NOx emissions at or below a 0.2 gm/BHP/hr level at every point where the engine was required to operate. This NOx emissions target is the ultimate level of the HD 2007 standard, and will be required for HD engines sold after 2010. From a light duty perspective, this is approximately equivalent to a diesel SUV or light pick-up truck emitting at the Tier 2-bin 5 level.

Although NOx adsorber aftertreatment was, and still is, on the prime path for diesel compliance for these emissions levels and standards, CDC has found a place – a very good place - in the competition for alternatives to NOx adsorber approaches.

The other approaches of SCR aftertreatment and HCCI each have their own story, but I am going to follow on with a short update on the Clean Diesel Combustion.

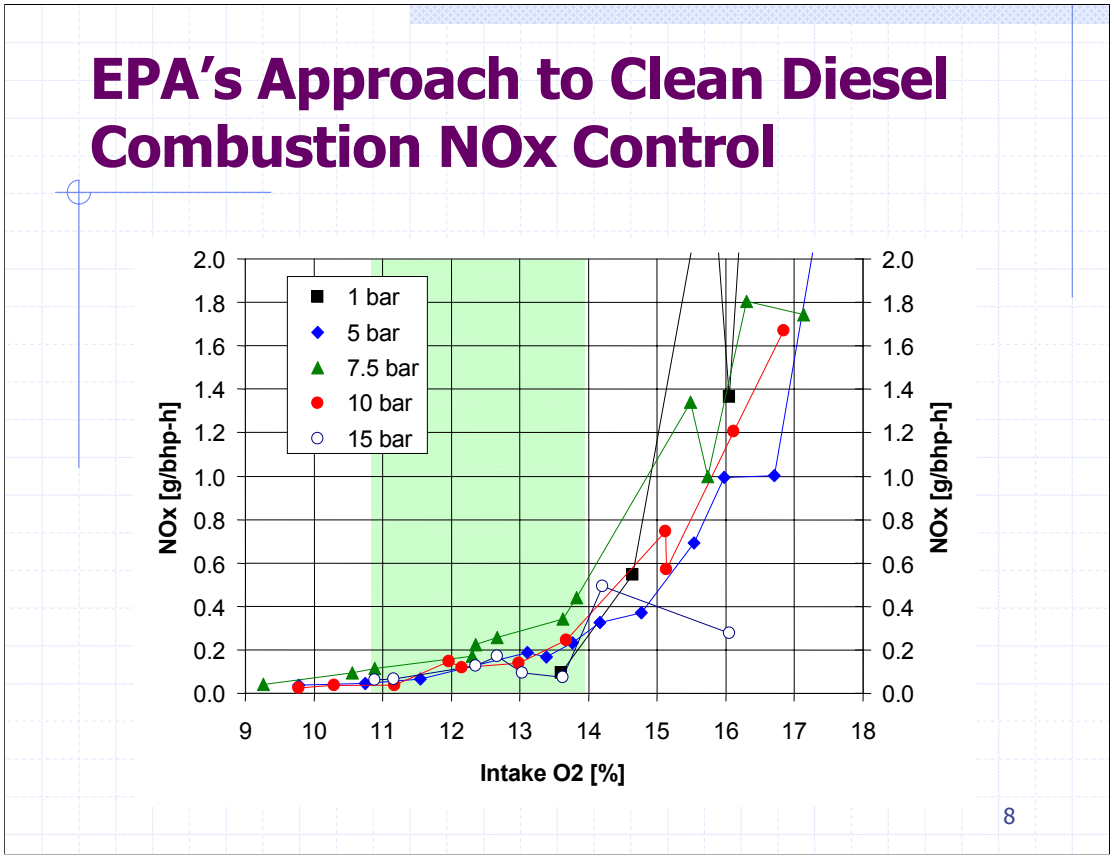


7) CDC – Engine Out NOx …

The key result of interest in Clean Diesel Combustion is the ability to efficiently operate at engine-out emissions at a very low NOx emissions levels.

The graph on the left shows the specific NOx emissions levels for a typical diesel engine that might be found in a diesel passenger car (in this case a 1.9L VW Jetta engine) sold today in Europe or the U.S. It has NOx emissions that are in the 1, 2, 3 or higher (gm/BHP/hr) range for engine-out NOx emissions, depending on where it operates to meet the driver's requirements.

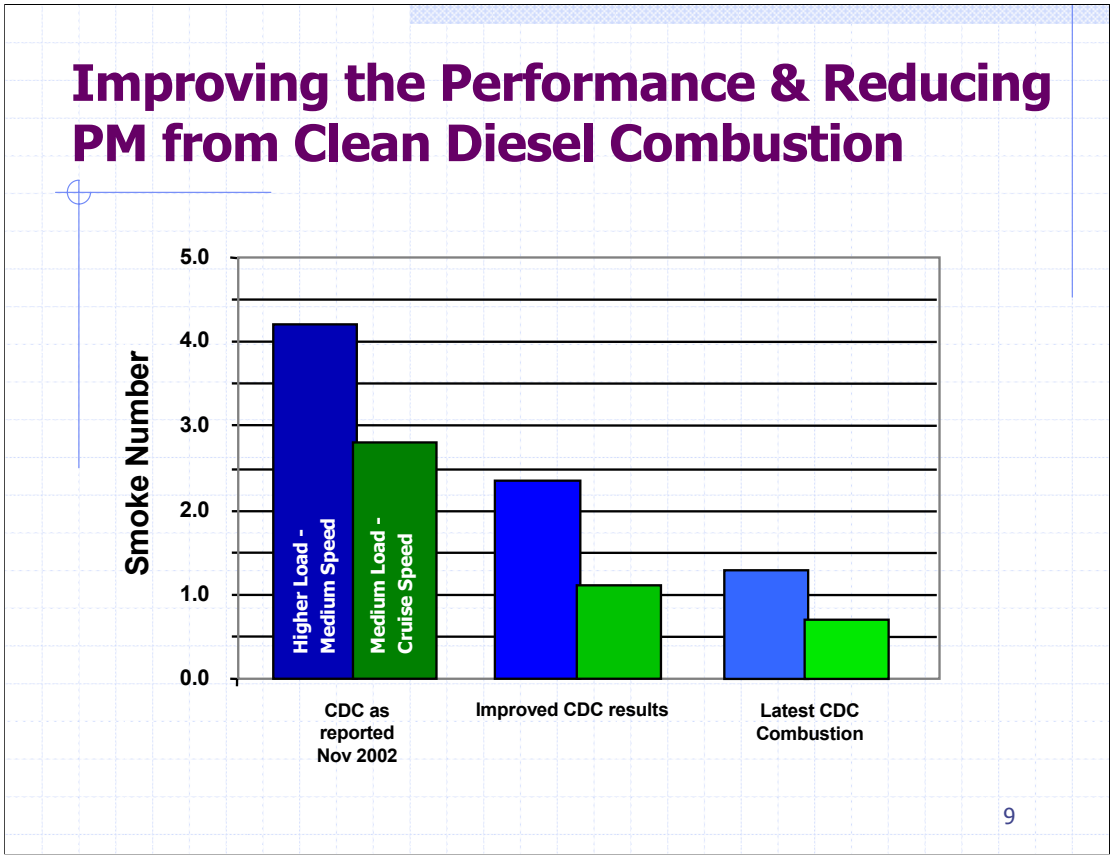
The graph on the right is the specific NOx emission levels for the same bore-stroke-displacement 1.9L engine that was modified to run with CDC technology. The map is quite busy, but actually very boring – it is everywhere at or below 0.2 gm/BHP/hr NOx, and this NOx level is because that is the emissions target not because that is a limitation of the engine or combustion system. We have run CDC engines at NOx levels that are 50% lower than this to demonstrate the ability to further reduce NOx levels, if there is ever a requirement.



8) CDC – Controlling NOx Formation…

So how is NOx control over every operating condition achieved with stratified, mixing controlled, diffusion limited diesel combustion? The key to EPA's approach of achieving the low engine out NOx emissions is to prevent NOx from forming during the combustion process in the first place. By keeping the local temperature of the reaction process below the critical NOx formation temperature – around 2100°K – we avoid high rates of oxidizing nitrogen. This can only be achieved if we limit the reaction rate locally by managing the oxidation of fuel in the diffusion flame region, and that is accomplished by operating at a reduced global and local oxygen concentration.

Our work has found that by operating in a region of 11% to 14% intake oxygen, we are able to achieve engine-out NOx levels low enough to meet the level of the diesel emissions standards. Of course, in order to reduce the intake oxygen from 20.9% down to this target range of intake oxygen, substantial levels of EGR are required. And as we all know, moving more charge mass -- the fresh air plus higher EGR rates -- puts burdens on the boosting system and can make smoke reduction more challenging.

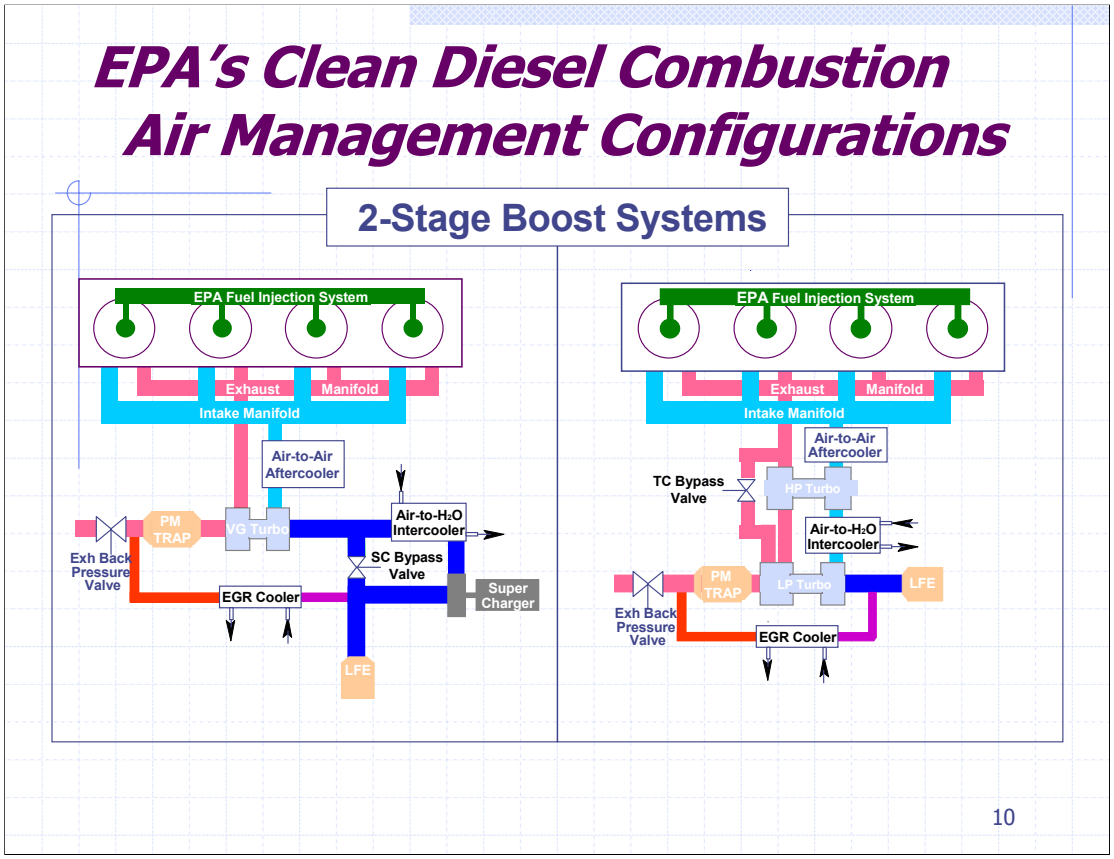


9) CDC – Engine-Out PM …

Now for those of you who have seen our earlier public reports on this work, you know that the smoke emissions were very high. At that time, we said that there were ways to reduce the engine-out particulate emissions, and that further technology development should be able to reduce this area of concern down to levels with which we would all be more comfortable.

Starting with the left most pair of bars on this plot, we see the smoke numbers as reported about one and a half years ago. The blue bars indicate the level of smoke at a higher load, moderate speed operating point and the green bars represent smoke emissions at a moderate load, cruise speed operating condition.

Moving from the left most first reported results, we see in the center pair of bars on this chart that there has been a nice reduction, almost 50% reduction in PM/smoke emissions at the same operating conditions. And when we look at the most recent combustion results shown in the right most bar-pair on the plot, we see a smoke level that is starting to look very pleasing and potentially very manageable. Unfortunately, in spite of the great progress we've made, we are not yet to the point where we can avoid using exhaust PM aftertreatment, and I don't know if we ever get to the point where we won't need PM aftertreatment, but these results show that we are approaching a good place in this area.



10) CDC – Engine Air Management Approaches …

Moving this technology from single-cylinder and multi-cylinder steady-state testing to vehicle viable, transient capable engines, we have found that the greatest challenge in preserving the fuel economy potential of the diesel is related to the air management system, or the boosting system. We are currently testing and developing two primary thrusts in our air-management approaches.

First, I want to point out that we are using what is generally referred to as a "low-pressure EGR loop," The EGR is tapped off of the exhaust stream post catalyzed diesel particulate filter, so it is very clean. It is controlled with a back-pressure valve that provides a relatively low pressure differential that is sufficient to drive a controlled amount of clean exhaust gas over to the inlet of the low-pressure boosting stage. To improve the boosting system efficiency, the EGR is cooled. The charge mass is then boosted up to the level required for the desired load.

The system shown on the right is a two stage turbocharging boost system, and looks to be the most promising approach for boosting systems, and we are working that system hard. However, because the best turbo-matching hardware was not available for our first demonstrations, we used the hardware shown on the left for initial testing. That boosting system consists of a shaft driven mechanical supercharger as the low-pressure boosting stage and then a turbocharger in the higher pressure boosting stage, with inter- and aftercooling used to control the charge temperature. We have found that, because there is a target range of intake oxygen, the simple ability to hold to a target intake oxygen range over all operating conditions enables the combustion system to achieve very low NOx levels even through transient operation.

Now, with all all of this explained, the real questions are: "Does Clean Diesel Combustion work in a vehicle?" and "How does it drive?" and" What is the fuel economy at these ultra-low emissions levels?"

Clean Diesel Combustion
Initial Vehicle Test Results

Engine	Test	Fuel Economy (mpg)	HC(g/mi)	CO	NOx	PM
Stock	FTP city	32	0.05	0.10	0.8	0.028
	FTP hwy	49	0.01	0.02	0.7	0.027
	US06	32	0.01	0.03	1.8	0.069
Tier 2	Bin 5 (120k mi)		0.09	4.20	0.07	0.010
CDC	FTP city	30	0.23	1.12	0.06	0.001
	FTP hwy	47	0.10	0.18	0.05	0.0004
	US06	26	0.20	0.07	0.14	0.008

VEHICLE: ~ 4,200 lb test weight

a larger-wagon or mini-van

11

11) CDC – Initial Vehicle Test Results …

The data shown on this slide are from some early initial tests of a Clean Diesel Combustion engine running in a vehicle. I can share this information with you courtesy of one of our CDC CRADA partners. The vehicle tested was a typical family type wagon or small minivan with a diesel engine as is sold in Europe today (by our standards, the vehicle is slightly under powered by our standards but has really good fuel economy). The vehicle weighed in at 4200 lbs and ran through one of our certification chassis dynos to baseline the emissions and fuel economy performance. That initial configuration is shown at the top of the slide in the blue box, with results from the EPA's city, highway and aggressive driving US-06 cycles. As can be seen, lab fuel economy is really quite good, with a respectable 32 mpg city and 49 mpg highway *(these numbers would need to be adjusted down city-10% & hwy-22% from the lab values to be sticker values … another story for another day)*. Unfortunately, the NOx emissions are well above even the highest temporary bins for Tier 2.

The tan box shows the levels of the Tier 2 bin 5 for reference, and then below in the green box we see the initial results from the Clean Diesel Combustion engine running in the same vehicle. For this test vehicle, the base engine and the CDC engine were both the same displacement. The expedient choice was to use EPA's high pressure diesel fuel injection system and the shaft driven supercharger-turbocharger boosting system. This initial configuration resulted in a measured fuel economy loss of about 2 mpg over each the city and highway test cycles. We are quite confident that some of the improvements we are working on now will at least reclaim this fuel economy loss. But more importantly, you can see that the NOx emissions, with no NOx aftertreatment, are more than a full order of magnitude below that of the "stock" configuration and fall under the full life "bin 5" levels. There is still substantial work to be done on cold start, and this test configuration did not have an oxidation catalyst to help clean up the HC & CO down to the "bin 5" levels. As I said, these are initial results - we are really quite pleased with this as a starting point for this vehicle's initial demonstration.

12) CDC – Our Research is Continuing …

Since we first publicly discussed our Clean Diesel Combustion in late 2002 and early 2003, we have had discussions with nearly every major automotive and heavy duty engine manufacturer about this technology. Some of those have chosen to work with us on advancing the technology and looking to see if it has potential in their products and applications - in fact five companies are working with us to see if this technology has the potential to transfer into their business plans. International Truck and Engine Corporation announced their efforts early this summer, and you will hear another partner make an announcement in a month or two.

At this point, we continue to work on the combustion system and process, the air management and boosting system and the fuel injection system, as all of these trade-off performance vs. cost vs. effectiveness. We were anticipating a significant challenge in moving from steady-state operational mapping to transient performance work, but have found that some of the trade-offs might actually improve transient performance compared to the conventional diesel's load acceptance rates. Improving on drivability and addressing the concerns of diesel NVH will continue to be a focus. We are also working to extend the performance range of Clean Diesel Combustion in the calibrated demonstration vehicle and are looking at all of the options to find the best solution for managing and reducing the PM, HC and CO to the levels required to meet Tier 2-bin 5.

13) Conclusions …

In summary, it looks that diesel engine technology offers tremendous opportunity to take great strides toward a more sustainable transportation system.

Tomorrow morning we will hear our Chair (John Fairbanks) discuss how "mature" the internal combustion engine technology of today really is, and to what extent it might be improved. My personal view is that new advances in ICE combustion and controls, and the synergistic combination of these technologies with advanced hybrid drivetrains can continue to breathe new life into these "mature" technologies that are so familiar to us.

From where I stand, things are looking bright for the diesel. Over the next couple of days, I look forward to hearing and learning more about how the rest of you see diesel technology's trajectory and potential.

I have included a few websites that will allow you to check back on any of the information I have discussed and want to thank you for the opportunity to talk to you tonight.