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# Fuel Efficiency for HDVs Standards and Other Policy Instruments: Towards a Plan of Action

*This document contains the summary and proceedings of the IEA/International Transport Forum Workshop on Standards and Other Policy Instruments on Fuel Efficiency for HDVs, which took place on 21-22 June 2007, at the International Energy Agency in Paris. The purpose of this workshop was 1) to bring together policy makers, technical experts, manufacturers and other stakeholders in Heavy Duty Vehicle transportation, 2) to exchange the latest information on policies to improve HDV fuel efficiency, and 3) to share experience with fuel efficiency standards for HDVs, including in relation to effectiveness and test procedures. This document reflects the presentations and discussions of the participants at the workshop. The views expressed in this paper do not necessarily represent those of the International Energy Agency or the International Transport Forum. All information is available at the IEA ([http://www.iea.org/Textbase/work/workshopdetail.asp?WS\\_ID=306](http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=306)) and International Transport Forum ([www.internationaltransportforum.org](http://www.internationaltransportforum.org)) web sites.*

## **Key Messages**

### ***The Context***

- The workshop challenged the conventional wisdom that commercial operators are more conscious of fuel costs than private drivers, obviating the need for policy intervention. Participants pointed out that potential HDV fuel efficiency improvements were not necessarily being delivered as quickly or as broadly as the conventional wisdom would suggest.

### ***Technology***

- There are many engine and non-engine innovations that have the potential to deliver significant fuel efficiency gains. These include aerodynamic improvement, downsizing, selective catalytic reduction, hybrid drivetrains and telematics.

- The stringent NOx and PM regulations planned in the near future in the EU, Japan and the US may impact fuel efficiency gains. It should be noted, however, that stringent emission regulations in the past have not resulted in reduced fuel efficiency despite similar fears.
- Driving behaviour, aerodynamic improvements and better managed tyre pressure could significantly improve on-road fuel efficiency.
- Running auxiliary equipment off of the main engine results in efficiency losses. Diesel auxiliary power units are a more efficient way to operate auxiliary equipment, such as cab heater and air conditioners used when the vehicle is stationary, and pay for themselves over time.
- In order to improve fuel efficiency of HDVs, it is important to involve a broad range of stakeholders -- including trailer manufacturers.
- Engine downsizing compensated for through increased turbo charging will deliver large efficiency gains.
- Given that the cumulative impact of small improvements has the potential to deliver significant fuel efficiency gains, it is important that manufacturers and operators have some method of tracking and aggregating these. Providing information on the cumulative impact of small improvements is very important.

### ***Costs and Potential Savings***

- Not all fuel efficiency improvements come at a cost (e.g. improved tyres and lubricants) – and yet these “free” fuel savings are not always acted upon – perhaps because of the relatively small efficiency improvements they deliver or because of a lack of information.
- While it is likely (but not necessarily certain) that fuel efficiency improvements with a payback period of 3-4 years will be implemented by commercial operators, measures with a payback period of 4-6 years will probably require some form of support.
- Operators are sensitive to overall operating costs and not just fuel costs (which represent only approximately 30% of the total). Policies should account for total truck productivity, not only fuel efficiency.
- Given the compound effects of NOx and PM reductions and fuel efficiency improvements, separating the cost of each will be difficult in ex-post evaluation.
- While ex-ante evaluation generally shows that technology has a significant potential to reduce fuel use by individual HDVs, these gains are likely to be overcome by increased vehicle travel volumes and fuel consumption. Additional measures will therefore be necessary if overall GHG emission levels are to be cut.
- The potential for improving the energy efficiency of HDV use is great – in some instances similar operators in the same markets display a 50% difference in energy intensity.

### ***The Policy responses***

- Japan in 2006 introduced fuel efficiency standards for HDVs and tax incentive measures for vehicles meeting the fuel efficiency standards alongside more stringent NOx and PM emission regulations.
- The Japanese standards will require a 12% fuel efficiency improvement over 2002. Manufacturers have been able to introduce some vehicles meeting the new standards.
- Manufacturers’ response to these standards may illustrate the availability of unexploited fuel efficiency technologies.
- Manufacturers may have been able to meet the standards earlier than expected because technology transfer is extremely fast in the HDV industry as a result of its collaborative global ownership structure.
- In India, truck kilometres have been growing very fast. In response, the government has introduced a truck engine efficiency test to track fuel use by different models.
- HDV fuel efficiency policies should be comprehensive, addressing advanced engine technology, non-engine components, auxiliary equipment as well as transmission and aerodynamic improvements. Care should be taken to address the role of telematics, driver behaviour and logistics. Addressing the rise in vehicle kilometers will also be necessary.

- Fuel economy improvements might potentially be increased by a factor of 1.5 to 2 with some level of government support or regulatory “push”.
- Eco-driving has been promoted in Europe and Japan as one effective means of increasing fuel efficiency. Eco-driving will be looked at the next IEA-International Transport Forum workshop in November.

### ***The Challenges***

- Better reflecting real traffic conditions and HDV operating conditions through improved testing cycles can result in better information to policy-makers.
- Finding cost-effective way to promote investments in research and development for new technologies which at present have longer pay-back periods (more than 6 years).
- Addressing lighter van (under 3.5 ton) fuel efficiency will also prove important as this is the fastest rising commercial vehicle segment.

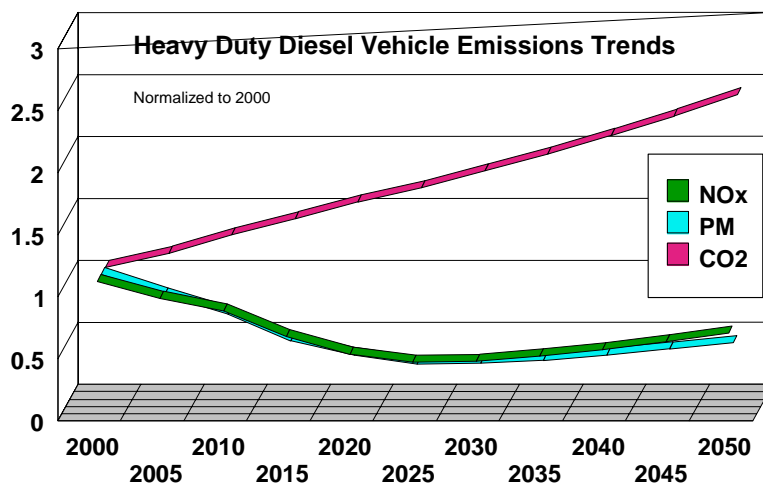
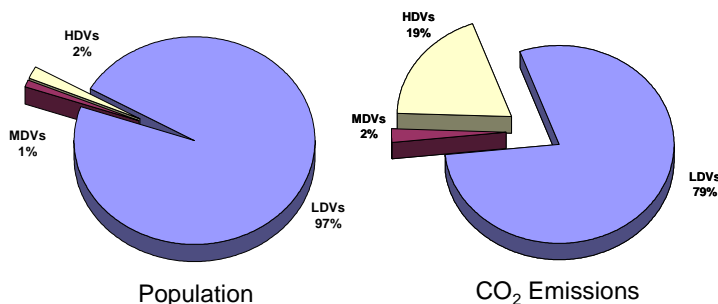
## The Context

Around 60 percent of the world oil was consumed by the transport sector in 2004. More exactly, heavy duty vehicles are responsible of almost 20 percent of oil consumption in the world, while trucks account for the largest share, around 80 percent.

Based on a conventional wisdom, commercial operators are more conscious of fuel costs than private drivers, and therefore, policy intervention is not needed in this area because the market ensures optimum fuel efficiency. It seems, however, that there are some market failures. Emissions from the heavy duty vehicles are a major source of PM, NO<sub>x</sub> and Greenhouse Gas emissions. Even though cleaner heavy duty vehicles are entering markets because of new standards (for example Japanese standard to be introduced in 2009 and the US standard in 2010) set for PM and NO<sub>x</sub>, CO<sub>2</sub> and fuel consumption both continue to increase rapidly. Even with new developments, such as hybrid vehicles entering the markets and reduced ton-kilometers, we will likely only see a leveling of the CO<sub>2</sub> emissions by 2020 at a level 1.5 times higher than in 2000. CO<sub>2</sub> emissions will continue grow in the OECD countries but the biggest growth will be coming in the future from Asia and Latin America.

In this context, it would appear that policy intervention is indeed needed. Last year, the Japanese government introduced new standards for fuel efficiency. The world's first fuel economy target standard values for heavy-duty vehicles (diesel vehicles that weigh more than 3.5 ton), based on "Top-Runner Program", was promulgated on March 2006. Manufacturers are required to improve fuel economy of heavy duty vehicles until target year 2015.

### California Vehicle Population and Vehicle CO<sub>2</sub> Emissions (2010)



## The Potential

HDV fuel efficiency has historically improved at a rate of approximately 0.8%-1% per year. This trend would likely continue, though there may be a temporary drop-off in response to mandated emission controls.

There remains a large potential for near-term energy efficiency improvements in heavy-duty vehicles on the order of 10-20%. Reaching this potential, however, requires concerted action on a number of HDV sub-systems including engines, integrated cab and trailer aerodynamics, drivetrains, tyres and embarked auxiliary systems. Of these, the greatest *absolute* increases in energy efficiency are likely to stem from advances in engine design. However, improvements in the energy efficiency of engines will be somewhat offset by increases in fuel consumption resulting from mandated NO<sub>x</sub> and particulate matter emission reductions. The greatest *relative* improvements in energy efficiency are likely to stem from improvements in auxiliary systems (up to a 50% increase). Reductions in total vehicle weight (tractor plus trailer), decreases in tyre rolling resistance and drivetrain improvements can also contribute to improved energy efficiency. Regular maintenance and vehicle upkeep are also important to achieve better fuel efficiency – e.g. simple wheel and chassis alignment can result in up to an 18% improvement in fuel efficiency.

There also exists a significant potential for increasing the efficiency of HDV use through better operational practices, improved driver training and enhanced logistics management.

### *Engine Systems*

The greatest potential for *absolute* fuel efficiency improvements in HDV's rests with improved engines and exhaust treatment – accounting for up to ~66% of the total HDV efficiency improvement projected by the US Department of Energy. HDV engine system designs have and will continue to change over the next few years to account for two sometimes contradictory objectives: increasing engine fuel efficiency and decreasing harmful exhaust pollutants – most notably NO<sub>x</sub> (disproportionably produced in the high temperature combustion typical of HDVs) and fine particulate matter. Mandated anti-pollution engine design modifications and exhaust controls can result in up to a 7-10% increase in fuel consumption – holding engine size and power constant.

Against this backdrop, a number of engine advances can improve fuel economy. These include engine downsizing (low speed/high torque engines with smaller displacement), low pressure superchargers, multi-speed transmissions, serial intercooling and lower engine weight. These advances result in smaller engines that consume less fuel (e.g. 15% improvement in fuel economy in the case of a 2-ton delivery vehicle) and yet that have greater power and torque as a result of turbocharging. In addition to these changes, simply switching lubricant oils can result in 1-3% fuel savings at no extra cost. Another promising set of technologies are anti-idling devices that automatically switch engines on and off according to traffic and operating conditions (fuel consumed by idling can be significant – e.g. 30% of overall fuel consumption in Canada).

A promising strategy to reconcile engine fuel efficiency and pollutant emissions is to tune HDV engine performance for increased fuel economy and introduce post-combustion exhaust gas treatment to reduce NO<sub>x</sub> and particulate emissions. Selective catalytic reduction (SCR) systems are especially effective for large trucks but they require fine tuning to the actual engine operating cycle which can be especially problematic for certain HDV operating practices (e.g. deliveries). Exhaust gas recirculation (EGR) is better suited to smaller diesel HDVs and LDVs. However, EGR, results in higher emissions of particulate matter requiring the installation of post-combustion filters and traps which, themselves, incur a slight fuel efficiency penalty. Build-up of soot on particle filters must also be burned off and given that many HDV and LDV operating cycles preclude passive catalysation (short distance urban stop and go traffic), active filter regeneration systems are necessary.

## ***Aerodynamic Performance***

Improvements in truck-trailer aerodynamic profiles have the potential to significantly improve fuel efficiency and can account for 10-20% of overall potential HDV fuel efficiency improvements. However, the specific duty cycle of the LDV/HDV in question can greatly impact this fuel economy potential with long haul trips experiencing the greatest improvements. Low-speed urban cycles, on the other hand, will see relatively little improvement and may even incur a weight penalty. While cab-over/front fairings and cab-trailer spoilers have traditionally been the focus of HDV aerodynamic designs, the trailer can represent up to 85% of the aerodynamic improvement potential. Trailer improvements include aerodynamically optimized undercarriages, sideskirts and, most importantly, rear diffusers and spoilers. These improvements add weight (e.g. up to 530 kgs), costs and may be prevented by current safety-related regulations.

## ***Drivetrains***

Reduced bearing friction and increased drivetrain efficiency can result in ~2% fuel economy improvements (US DOE)

## ***Auxiliary Systems***

HDV's employ a number of embarked auxiliary systems that typically do not factor into engine fuel efficiency tests. While the overall absolute impacts of efficiency improvements in auxiliary system is lower than for other systems (~7% of overall potential efficiency improvements according to USDOE), the relative improvement potential can be quite high (up to a 50% improvement). Improved electronic control and more energy efficient components can improve the fuel efficiency of air conditioning, air compressors, air control units, water and steering pumps, and fans and other embarked electronic engines. Furthermore, installing separate engine for auxiliary power systems for tanker pumps, boom operation + cab comfort systems, or even designing batteries to store and release energy for these systems can reduce the need to generate power directly from the engine. This can also have major advantages for meeting local air quality regulations.

## ***Tyres***

Reduced rolling resistance due to improved and properly inflated tyres represents an important source of fuel economy improvements and can account for approximately 8-14% of overall fuel economy gains. This potential is greatest for motorway-type operating conditions and reduces to zero for slow speed urban driving cycles. Functionally equivalent "next-generation" tyres can deliver 3.5% to over 8% fuel efficiency improvements with the remainder of the potential being delivered with properly controlled inflation pressures. Running wider "super-single" tyres instead of double tyre sets can also improve fuel economy but may pose safety issues. Running seasonally appropriate tyres can also play an important role; winter tyres have a 9% fuel efficiency penalty over normal tyres.

## ***Weight Reduction***

Reducing the weight of individual HDV components can contribute to improved fuel economy and can, in part, counter fuel consumption increases stemming from NOx and PM reduction strategies at constant engine power. One manufacturer has calculated that up to 260 kilos can be relatively easily pared from the engine and cab unit while up to 530 kgs can be removed from the trailer chassis. However, adding aerodynamic fairings to the cab and trailer unit will add 530 kgs resulting in a total saving of 260kgs. Depending on the duty cycle, the fuel efficiency impact from improved

aerodynamics can be greater than the fuel efficiency impact of the weight taken by the aerodynamic improvements.

### ***Eco-driving***

Eco-driving is a way of driving that reduces fuel consumption and greenhouse gas emissions. Smart and safe driving techniques can lead to significant fuel savings. Eco-driving has become an integral part of transport sector fuel consumption and CO2 emissions reduction strategies in several countries such as those in Europe and Japan. It remains, however, in the margins of transport policy development in many other countries. Eco-driving will be looked at an IEA-International Transport Forum workshop in November.

## **The Costs**

Not all fuel efficiency improvements come at a cost (e.g. tyres and lubricants) – and yet these “free” fuel savings are not always acted upon – perhaps because of the relatively small efficiency improvements they deliver or because of a lack of information.

Most commercial operators expect a 3 year payback for fuel economy improvements. Measures that fall within this range are likely to be implemented by industry without any support or regulatory pressure. However, the implementation of measures with a payback period of 4-6 years (e.g. multiple turbo chargers) are likely to require some form of intervention – bearing in mind that operators are sensitive to overall operating costs and not just fuel costs (which represent approximately 30% of the total). Accounting for speed and total vehicle use over a 24-hour cycle are important in this respect.

Measures that deliver fuel economy payback over more than 6 years would be for all practical purposes not commercially viable and would require support for their implementation. At present, several options for advanced fuel economy improvements are technically feasible but their costs are such that they do not represent commercially viable options. The target of a 60% improvement in HDV fuel economy by the US DOE is an ambitious one at the outer edge of what is achievable by 2020-2030 – delivering the last 15% will likely be prohibitively expensive. Likewise, many hybrid systems currently on the market or near market readiness embody such a price premium that some form of support will likely be necessary if they are to be deployed at a large scale in the near to mid-term.

The following table sets out some estimated payback periods and associated need for some form of support for implementation for a range of potential fuel economy improvements in different HDV and LDV subsystems for the years 2010, 2020 and 2030. According to this table, probable fuel economy improvements can potentially be increased by a factor of 1.5 to 2 with some level of government support or a regulatory “push”.

	Heavy Duty Vehicles: Delivered fuel economy improvement			Light Duty Vehicles Delivered fuel economy improvement		
	2010	2020	2030	2010	2020	2030
Engine/Exhaust systems		4%	6%		3%	4%
	2%	8%	10%	2%	7%	8%
		13%	17%		12%	15%
Aerodynamics	3%	6%	6%	1%	2.5%	2.5%
	5%	10%	10%	2%	4%	4%
Rolling Resistance Coefficient (tyres)	2%	4%	6%	2.5%	5%	7%
Auxiliary Equipment	1%	3%	3%	1.5%	3%	3%
		5%	5%		5%	5%
Payback period	<3 years	No support necessary	3-6 years	Support helpful	>6 years	Massive support necessary

Source: Duleep

## The Policy Responses

Relatively few policies have directly targeted HDV fuel economy. The exceptions are Japan, and California.

### *Japan*

Japan introduced the fuel-efficiency target standard values for heavy duty vehicles in 2006 as a part of measures to reduce fuel consumption and to address global warming. Based on the “Top Runner Program” (that requires current best in class performance to become the average performance level by a target date), manufacturers are required to improve the fuel economy of heavy duty vehicles until the target year 2015. In practice, this means an average improvement of fuel efficiency from 6.32 km/liter in the base year 2002 to 7.09 km/liter in 2015 for trucks. For buses, target standard value is set for 6.30 km/liter in 2015 from the base year 5.62 km/liter. Target values correspond on average to over 12 percent improvements in fuel efficiency. Target values are set by category of gross vehicle weight. For some categories, there are sub-categories divided based on pay loads.

Japan also introduced tax intensives for vehicles that meet both fuel economy and low emission standards. It is possible to have 1-2 percent reduction in the acquisition tax of new vehicles if the standards have been met. Based on the early results, 13 percent of different types of trucks and more than 25 percent of types of buses have met the new fuel standards.

### *California*

The State of California has successfully upheld its right to regulate CO<sub>2</sub> and other GHG emissions as pollutants in front of the US Supreme Court – thus superseding the Federal Government’s role in this sector and opening the way for California to mandate strict emission cuts.

The State has passed legislation that allow it to carry out this authority – in particular in relation to GHG emissions from light and heavy duty vehicles:

*Assembly Bill 1493 – Vehicle Climate Change Standards:*

This Bill passed in 2004 gives the California Air Resources Board (CARB) the authority to limit the amount of CO<sub>2</sub> emitted from new model cars and LDVs (weighing less than 8500 lbs) as well as other GHG emissions. The Bill expressly targets the maximum feasible and cost-effective GHG reduction from vehicles introduced from 2009-2016 with a gradually increasing stringency – maximum 323 g/mile in 2009 to 205 g/mile in 2016). The vehicle-class based standards are based on computer modeling of GHG reduction technologies and indicate a potential for up to 30 MMT to be reduced in 2020. Ten other states have adopted California's Vehicle Climate Change Standards.

*Assembly Bill 32 – The California Global Warming Solutions Act of 2006*

This Bill targets a statewide and cross-sectoral reduction of GHG emissions to 1990 levels by 2020 (approximately a 25% reduction from 2006). It allows for direct emission reduction measures, alternative and/or market-based compliance measures and incentives. The State's operational guidance for this Bill – the Climate Protection Plan – is still under development.

*Statewide Anti-Idling Ordinance*

The State has specifically addressed HDV idling as a potentially important source of GHG savings and air quality improvements. A recent State ordinance applicable to HDVs of 14 000 lbs and over requires operators to shut down their engines after 5 minutes of idling – including during rest periods – or, alternatively, to certify that their engine meets a Statewide idling emission standard. The ordinance calls for a vehicle label indicating compliance and certifying the presence of a low-emission alternative power source for trucks needing to run equipment on auxiliary power. The ordinance also requires that all trucks of over 14000lbs sold in 2008 and thereafter integrate a tamper-proof automatic engine shut-down device, or, alternatively, certify that they meet the State idling emissions standard. The State estimates that by 2010, this ordinance will result in a reduction of 1.2 MMT of CO<sub>2</sub> per year.

## Summary of presentations

### Technologies

**Takao Onoda, IEA, gave an introductory presentation** explaining why the workshop focuses on HDV technologies. While HDV's dominate global oil consumption, they are also one of the fastest growing energy end-users. The presentation showed that the aggregate freight energy has declined between 1990 and 2004 and analysed the factor contributing to this decline. It also argued that technologies are necessary conditions for realization of this trend also in the future.

**K.G. Duleep, Energy & Environmental Analysis, Inc,** showed some historical trends and future forecasts of the HDV fuel economy in the USA. The presentation further analyzed the Bureau of Census 2002 Vehicle Inventory and Use Survey data of heavy -duty trucks operating in the USA. According to the data, the heavy trucks have improved their fuel economy at the annual rate of 0.8 - 1.1% for each sub-class during the last 20 years. These improvements have been mainly due to technology improvements. Analysis of available technology in the next 20 years shows that there will be zero or even negative change in fuel economy to 2011 due to stringent new emission standards. However, fuel economies will most likely improve again after 2011 as new technologies for both drivetrain and body are introduced.

**Nils-Olof Nylund, TEC TransEnergy Consulting Ltd,** presented a methodology, vehicle performance and potential for fuel savings of HDVs. The Technical Research Centre of Finland (VTT) has developed a methodology to establish accurate fuel consumption values for HDVs since 2002. VTT's methodology is based on a transient-type testing of complete HDVs on a chassis dynamometer using truthful load patterns. The accuracy for fuel consumption measurements is estimated at +/- 1%. Since the start of testing, VTT has evaluated more than 150 HDVs, including buses and HD trucks. Fuel consumption commonly varies some 10% from one vehicle brand to another for corresponding vehicles. VTT has also evaluated the potential for fuel savings through e.g. optimization of vehicles, lubricants or tyres.

**Enrico Durelli, from Iveco,** presented their transport concept. Commercial vehicles operating costs are the most important issue for a high productivity of the customers. Fuel consumption represents the main issue about cost. Consumption increase factors where the manufacturers can play a role of optimization are: engine, aerodynamics, auxiliaries, tyres and other minor tasks. A system approach leading IVECO to important results will be described in the presentation

**Kazutoshi Tokimatsu, JAMA,** presented latest HDV fuel efficiency technologies in Japan. To prevent global warming, Japan introduced the world's first Fuel Efficiency Standard for HDV in April 2006. In addition, the Government has already announced to implement a more stringent emission regulation starting 2009 which may strongly effect against the fuel efficiency of HDVs. Based on above mentioned backgrounds, Japanese HDV manufactures are promoting fuel efficiency technology developments with every effort.

### Standards and Other Policy Instruments

**William Ramsay, IEA,** explained the participants, as an opening remarks, why the IEA is concerned about energy use in transportation. The urgency of the need to address global energy issues, the share of transport sector in global oil consumption, and the importance and benefit of policy measures to raise vehicle fuel efficiency were stated.

**Rick Bradley, IEA**, explained why efforts should be focusin on the fuel use of HDVs. Heavy duty vehicles are responsible for around 30% of all fuel use in the transport sector. The presentation also introduced activities to estimate fuel efficiency gains through improvements in technologies and policy measures. It also overviewed current activities in order to improve the HDV fuel efficiency.

**Kenji Wani, Ministry of Land, Infrastructure and Transport, Japan**, presented the Japanese fuel efficiency standards for HDVs. Japan introduced the fuel efficiency standard for heavy-duty vehicles for the first time in the world in 2006. The presentation introduced the general outline of the standards and reviewed some of the preliminary results.

## **Evaluations**

**Yuichi Goto, National Traffic Safety and Environment Laboratory, Japan**, presented ex-post evaluations in Japan. Fuel efficiency standards for heavy duty vehicles were brought into effect on April 2006. The standards require average fuel efficiency improvements of around 12% from the 2002 level. The presentation showed impacts of the new efficiency standards after one year in operation.

**Michael Walsh, International consultant**, presented ex-ante evaluations of world HDV fuel consumption. Globally, fuel consumption and greenhouse emissions from heavy duty vehicles are growing rapidly, especially in rapidly industrializing developing countries such as China and India. A comprehensive strategy encompassing improvements to conventional diesel technology, a shift to hybrids in the near term and to fuel cells in the longer term may have significant potentials to reduce this growth especially if coupled with a strategy to reduce the growth in heavy duty truck ton kilometers.

**Ming Yang, IEA**, presented ex-ante evaluation methodologies for HDV standards. In order to convince the developing countries on the benefits of the HDV standards, the IEA plans to undertake a cost-benefit analysis of the new standards for these countries. In this presentation, the IEA explained the methodology and data requirements for the analysis. Two scenarios, i.e. with and without the standards, will be designed. A methodological framework together with cash flow models were presented both for economic analysis from the government perspective and financial analysis from the transportation company perspective.

**Fanta Kamakate, International Council on Clean Transportation**, presented their activities on understanding current and future trends in the HDV energy intensity. The International Council on Clean Transportation is currently undertaking two major projects to better understand historical trends and future potentials in reducing HDV energy intensity. The first project compares the historical energy intensity of truck freight transportation across several nations, including Australia, France, Japan, the United Kingdom and the United States from 1970 to the present. The second project will model potential HDV energy efficiency and greenhouse gas emission reduction benefits from engine and vehicle technologies in the United States.

**Jonathan James, Faber Maunsell**, presented their research actions to reduce the HDV greenhouse gas emissions in the EU. In December 2006 Faber Maunsell, leading a number of EU research Institutions, was awarded a 12 month contract by the European Commission to research the issue of how the Commission might enact policies to help to reduce Greenhouse Gas Emissions in heavy duty vehicles. The work is being conducted in three phases, researching current actions and policies, testing the validity of the research with industry and finally formulating recommendations as to how the European Commission can influence the operators of HDVs to reduce their greenhouse gas emissions. The presentation reported the first of these phases of work.

## **Current activities and Perspectives**

**Stephan Lemieux, California Air Resources Board**, presented California's efforts to reduce HDV greenhouse gas emissions. For California Air Resources Board, global warming is a key priority, while health protection and air quality remain as other primary missions. With motor vehicles getting cleaner, research seems to be a key component in advancing a science-based policy. The presentation reviewed many of the successes and challenges of California's efforts to reduce HDV greenhouse gas emissions..

**Günter Hörmandinger, European Commission/DG Environment**, presented current activities and perspectives in Europe. Until recently, the HDV greenhouse gas emissions have not been seen as offering scope for significant reductions in the EU because of the high importance of fuel cost in commercial transport, leading to a perception that all practicable options for fuel consumption reduction were already being used in this sector. However, during the second phase of the European Climate Change Programme (ECCP2) it emerged that options for further reduction may indeed exist. The European Commission is currently surveying potential measures and instruments, using an open-ended approach.

**MK Chaudhari, Automotive Research Association of India**, presented India's policies regarding the HDV fuel efficiency as well as standards. The presentation outlined the profile and growth of the Indian automobile industry, reviewed India's transport system and infrastructure development, explained the classification of vehicles and fuel efficiency standards, and concluded some issues for implementation of fuel efficiency standards.

**Nobuyuki Konuma, Ministry of Land, Infrastructure and Transport**, presented current activities for fuel efficiency improvements in Japan and implementation of the top-runner standard. Japan has been promoting measures against global warming under comprehensive plan and the Top-Runner Standard is one of the main measures.

**Jasna Tomic, WestStart-CALSTART**, presented the HTUF process from hybrids to ultra efficient trucks. WestStart-CALSTART operates the Hybrid Truck Users Forum (HTUF) bringing users and suppliers together and creating a successful market for hybrid trucks. The presentation reported their experience with and the momentum of the hybrid medium- and heavy duty truck markets. Hybrid electric trucks provide fuel savings and emission reduction, offering also a good business case. Further growth of the market will rely on assistance from regulations and policy incentives further supporting fuel efficiency.

**Michael Disney, WalMart**, presented company's environmental sustainability initiatives. Wal-Mart's environmental initiatives are to be supplied by renewable energy, create zero waste and sell product that sustains the environment. Wal-Mart's private fleet falls within one of thirteen networks called "Global Logistics" with a goal to double the fleets fuel efficiency by 2015. Current and future concepts are presented that Wal-Mart is pursuing with it's fleet and the direction it may take to meet the 2015 goal.

## **Test procedure**

**Jose-Pablo Laguna-Gomez, European Commission/DG Enterprise**, presented the world wide harmonized test procedure. Global harmonization of test procedures will provide higher level of benefit for the environment while improving energy efficiency and reducing testing cost and here the content of UN-ECE GTR No.4 was described. The Commission's forthcoming proposal on a new Euro VI emission standard will contain the requirement of measuring CO<sub>2</sub> emissions, thus creating a data base of the CO<sub>2</sub> performance of new truck engines.

**Susumu Sato, National Traffic Safety and Environment Laboratory, Japan,** explained Japanese test procedure for HDV fuel efficiency. The test mode named JE05 mode including transient driving conditions is adopted in Japan for the emission test procedure of heavy duty vehicles. The background of JE05 mode and its test procedures for fuel efficiency test of heavy duty vehicles will be shown.